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The aim of the seminar is to present and discuss the latest results obtained by researchers especially at the Czech Technical University in Prague and at collaborating institutions.

The organizing committee has selected a total of 313 contributions divided into 15 different areas of interest:

- **Part A:**
  - mathematics
  - physics
  - informatics and automation engineering
  - electrical engineering and instrumentation
  - materials engineering
- **Part B:**
  - mechanics and thermodynamics
  - mechanical engineering
  - production systems, technology and technological processes automatisation
  - energetics and power engineering
  - nuclear engineering
  - chemistry
  - biomedical engineering
  - civil engineering
  - architecture, town planning, geodesy and cartography
  - transportation, logistics, economy and management

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Section 1

MATHEMATICS

Introduction to the Technique of Superalgebras Applicated to Finding the Index of Solvability of the Alternative Nil-algebras

J. Scholtzová

hrusoj1@feld.cvut.cz

Department of Mathematics, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

The main goal is the study of the skew-symmetric elements using the known technique of superalgebras published by Kemer in his Specht problem, when he applied superalgebras to the investigation of varieties of associative algebras. First step we want to do is about application the same method to try to find the solvability degree in nil-algebras.

The first part of the work concerns with the description of central and nuclear skew-symmetric functions in the free alternative algebra on the countable set of generators. For this purpose we will consider Grassmann algebras in the corresponding varieties. In view of the relation described in [2] this is equivalent to study of homomorphic images of the free alternative superalgebra $A = Alt[x]$ on one odd generator. We will apply the technique similar to that developed in [1]. It seems very useful to start with computer experiments for small n, in order to elaborate proper conjectures and then try to prove them rigorously. Recall, that no base for the free alternative algebra is known. In our approach we will essentially use the knowledge of a base of the free alternative superalgebra A.

Starting with an associative algebra A, let us denote by A^- the algebra obtained from an algebra A by replacing the product xy with the commutator $[x,y] = xy - yx$. One obtains in this way a Lie algebra A^-. Similarly, for any alternative algebra A, the commutator algebra A^- is a Malcev algebra.

At this time an open problem is, whether any Malcev algebra M is isomorphic to a subalgebra of A^- for some alternative algebra A. In case when such an algebra A exists, the Malcev algebra M is called *special*. In order to solve the *problem of speciality* for the superalgebra M, the structure of the corresponding free alternative superalgebra $A = Alt[x]$ should be investigated.

The superalgebra method

The construction of effective bases of free algebras is one of most important and difficult problems in the theory of non-associative algebras. There are not many classes of algebras where such bases are known: free non-associative, free (anti)commutative and free Lie algebras are the most known examples besides polynomials and free associative algebras. A. I. Shirshov formulated the problem of the construction of a base of the free alternative (respectively left alternative, Jordan, Malcev, binary-Lie) algebra on n-generators. Note that, contrary for example to the Lie algebras, the free alternative algebra contains non-trivial nilpotent elements and zero divisors; moreover, the free alternative ring has elements of finite additive order. This makes the problem of the base more complicated, and it seems natural to consider first some special cases.

For every multilinear variety of algebras V, one can consider the corresponding V-Grassmann algebra (see [4, 2]), which is isomorphic as a vector space to the subspace of all skew-symmetric elements of the free V-algebra. Thus, it seems interesting to construct a base for this subspace. Due to [3], the problem is reduced to the free V-superalgebra on one odd generator, which is easier to deal with. Let us recall this reduction. Let $f = f(x)$ be a homogeneous non-associative polynomial of degree n on one variable x. It may be written in the form $f(x) = f^{-}(x, x, \ldots, x)$, for a certain multilinear polynomial $f^{-}(x_1, x_2, \ldots, x_n)$. Define the skew-symmetric polynomial *Skew f* as follows:

$$Skew\, f(x_1, x_2, \ldots, x_n) = \Sigma_{\{\sigma \text{ in } Sym(n)\}} \operatorname{sign}(\sigma) f^{-}(x_{\sigma(1)}, x_{\sigma(2)}, \ldots, x_{\sigma(n)}).$$

Then *Skew* is a linear map which maps isomorphically the homogeneous component of degree n of the free V-superalgebra on one odd generator to the subspace of all multilinear skew-symmetric elements on $X_n = \{x_1, x_2, \ldots, x_n\}$ of the free V-algebra on countable set of generators.

The study of free Malcev superalgebras was initiated, when a base of the free Malcev superalgebra $M = Malc[x]$ on one odd generator was constructed. As a corollary, an infinite family of skew-symmetric elements was found that are central in any Malcev or alternative algebra. Before, only one such central skew-symmetric function was known; it is exactly the first term of the above mentioned family that has degree 7 and was found with a help of computer.

It remained an open question whether the given family forms a base of all the skew-symmetric central elements in any Malcev algebra. In order to answer this question, one should investigate not only the superalgebra M but also its universal multiplicative envelope $R(M)$. This was done in paper [4], where in particular a new series of central skew-symmetric elements in free Malcev and free alternative algebras was found. The results of the theoretical study fit well with computations published in 2006 by Hentzel and Peresi.

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Geomatics - Aplication of Mathematic in Geodesy

F. Rejman, M.Kocurek, M.Kočandrlová

rejman@mat.fsv.cvut.cz

Katedra matematiky, Thákurova 7, 166 29 Praha 6

Department of Mathematic on the Faculty of Civil Engineering in Czech Technical University in Prague began a working on preparing to new pedagogical documentation in educational program Geodesy and Cartography in 2003. Purpose of it is a complete preparation of mathematical tuition. One of task of the menshioned documentation is a preparing of collection of examples, and so this collection could serve as a suitable base for understanding of the individual scientific disciplines. For this purpose we created a project financed by Fund for Development of High Schools in total price of 59 thousand Czech crowns and its produce is an on-line presentation of application exercises. Subsidiary financial means was utilized effectively in extenso. Collection contains both instances which are solving sincerely mathematical problem, which with in geodetic practice often discovery, and namely above all, application exercises. Single exercises was in part found out in instructional texts of revolting articles and subsequently modified, but in particular they were created the new exercises, whereas domestic, but also external publications served like theoretic basis. Argument for this was partly preservation of definite originality and completion of areas, which wasn't enough processed as an examples. Co-autor doc. Kocandrlova attended to methodical and doctrinal processing. Co-autor doc.Kocandrlova and also co-autor Mgr.Kocurek at once A and B contributed by series of instances. End-result is a collection of perhaps 230 instances in electronic shape on address http://mat.fsv.cvut.cz/maG/priklady. All the presence is for reasons of fundamental orientation divided into series of chapters, to student has survey, on which problem is a solving example ties together. Theoretical examples are mostly solved and contains gradual inferences of results, while as for practical examples with the numerical problem, we show in one or two solved exercises followed by several unsolved examples.

In chapter of linear algebra which is an object of the first term there are for example so basic problems as is determining of right size of matrix, explication of unknown matrix from matrix equations or their systems, but also derivation of vector function or finding of mimimum of this function, so students master the base for adjustment calculus. There is also computing of the inverse matrix by dividing in submatrix, which is used for example in Helmert transformation in plane. Students can try an alternative solving of system of the equations through the use of LDL^T factorization of three-diagonal matrix. In geodetic profession we are encountering ellipses or ellipsoides of errors, mainly in adjustment of geodetic nets. For their determination we must compute their elements as is a length of semi-axis and orientation in plane, let us say in the space. In this case it is necessary to know the problems of eigen values and eigen vectors and quadratic forms, so we also gave attention to it. The next part is concerned to usage of differential gear in linearization of functions mainly as for transfer of true errors. Problems are generalized to the vector functions of any more variables and applied to examples from geodetic practice. In connection with it students can try to solve the system of non-linear equations providing that we know the solving approximately. A big attention was given to the least square method, which is probably exerted in all geodetical disciplines. Next to the brief theoretical introduction there is a series of several examples for solving of systems of superfluous numbers of equations and equations with conditions, so students can among

others acquire theoretical base for comprehension of adjustment of geodetical net's problems. All the individual capture which is goes with content of tuition of the third term is devoted to integrals of several variables' functions and also curve and surface integrals. There are examples applied to the sphere and ellipsoid or several physical applications, for example determination of gravitational potential of the Earth, etc. In area of coordinate converting, whether in a plane or in a space, we next to the identical and similar transformation mention conformal transformation which has a significant position in geodesy, but there is also a Helmert transformation, where a least square method and their differential modification are used. We also target the relationships among coordinates which are used in geodetical astronomy. As for differential geometry, we included any examples to transition curves as clotoide, lemniscate, cubical barabola or sinusiodal curves are, so we get to the area of engineering survey. Sphere and ellipsoid are also mentioned. The next capture is aim at the ortogonal systems of functions. At first we defined several conceptions, for example size of function, scalar product, etc. Students can get acquainted with Legendre's and spherical polynomials which occur in physical geodesy and field of attraction of the Earth's theory. Alongside it there are Bessel's functions which are used in a study of planet's movement. Of course we didn't forget to Fourier's progression.

When we completed the examples, we tried to interfere with all the mathematical areas, which have any linking to practical and theoretical geodesy. Working on this collection constituted both using of our experiences and mainly obtaining the new experiences. We hope, suggested project will realize its target and it will a good instrument for students of educational program Geodesy and Cartography, however not only for them.

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Modification of reactivity and catalytic properties of NiO-WO3 mixed oxides by ionizing radiation and ion implantation

Kobliha D*., Pospíšil M*.,Čuba V., Múčka V*., Silber R*., Černý F***.**

kobliha@fjfi.cvut.cz

*CTU in Prague, Faculty of Nuclear Sciences and Physical Engineering, Břehová 7, 115 19 Praha 1, Czech Republic

**CTU in Prague, Center for Radichemistry and Radiation Chemistry, Břehová 7, 115 19 Praha 1, Czech Republic

***CTU in Prague, Faculty of Mechanical Engineering, Technická 4, 166 07 Praha 6, Czech Republic

Heterogenous catalytic reactions in which various catalysts (precious metals, oxides and sulfides of transition metals, silica, zeolites, atc.) are used, are widely utilized in industry. Properties of catalysts determine efficiency and the economic convenience of the whole process. Therefore, it is necessary to study methods of optimizations of the catalyst properties. Among others, the irradiation and/or reduction of the catalysts based on mixed oxides with the hydrogen are such methods. The catalytic activity was studied with the original, with irradiated and with the hydrogen reduced NiO-WO_3 mixed oxides.

The series of 15 samples of NiO-WO_3 mixed catalysts with various composition in the range 0-100 wt.% of both components was prepared. One of the precursors, nickel hydroxide, was prepared from aqueous solution of nickel nitrate by precipitation with potassium hydroxide. The carefully washed and dried precipitated nickel hydroxide was mixed with aqueous suspension of H_2WO_4 in given ratios. The mixed solids were washed, dried and carefully homogenized by grinding in agate mortar. The optimum temperature for full decomposition of precursors to the final oxide was determined by means of thermogravimetric analysis. Calcination was performed at 450°C in air for 5h.

The catalytic activity of all samples was measured by the catalytic decomposition of the aqueous solution of hyrogen peroxide (1.2 mol/l) at different temperatures from 25 to 40°C.

The content of both metals in the mixed oxides was determined chelatometrically. The microstructure of the samples was investigated by X-ray diffraction. The chemical and structure analysis revealed that the samples consist of the cubic nickel oxide, tetragonal tungsten oxide, orthogonal oxide and, in the middle region of composition, nickelous tungstate were found.

Specific surface area of samples was measured by low temperature selective adsorption of nitrogen from N_2/H_2 mixture. The dependence of the specific surface areas on composition has non-monotonous character. The significant maximum in the area of equal amount of both components correlates with presumption that maximum interaction of both components occurs in this area.

The content of chemisorbed oxygen (its ionogenic forms expressed as the surface concentration of O^{2-} ions) was determined by iodometric titration. The content of surface oxygen monotously decreases with decreasing content of nickel oxide with minimum in the middle region of composition and increases in the region with predominant content of tungsten oxide. It can be deduced, that the dissociative chemisorption of molecular oxygen

takes place predominantly on the Ni^{2+}-Ni^{3+} centres or on the centres with higher valency of tungsten.

Catalytic activity was also tested on samples pre-irradiated with gama-rays of ^{60}Co and accelerated electrons. Doses of 1 MGy were applied. The catalytic activity of the all samples monotously decreases with decreasing content of nickel oxide, moreover, the samples containing maximum of tungsten oxide were not measurable. The character of dependence of the specific catalytic activity on the composition of the catalysts was not changed by irradiation. Both types of radiation lead only to small change in surface oxidative properties.

One of the objectives of this study was to investigate the influence of implantation of nitrogen ions into the surface of nickel oxide on its catalytic activity. The implanted sample was introduced into the stainless steel cage with the mesh size of 0.1 mm. The whole cage was incorporated into the chamber of implantation equipment. The N^{2+} and N^{+} ions (in the ratio 3:1, the energy of 90 keV and the whole ion current of 1.5 mA) were implanted into nickel oxide under vacuum of $3x10^{-3}$ Pa during a rotation of the cage for the time period of 2 h. The both non-treated and implanted samples were tested, of course, under same conditions. No changes were observed in the surface area values. Considerable changes of catalytic activity of pure NiO were caused by implantation of nitrogen ions into the surface of NiO, probably due to farmation of new catalytic sites.

The study of hydrogen reduction kinetics was performed using isothermal thermogravimetry in the range 410 to 470°C. Kinetic studies revealed that maximum rate of reduction occurs with samples containing excess of nickel oxide and low amount (about 10 wt. %) of admixture of tungsten oxide. Obtained data were tested in four independent models of reaction mechanism to evaluate which one is best suited for studied system.

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Packing measures and cartesian products

Ondřej Zindulka

zindulka@mat.fsv.cvut.cz

Department of Mathematics, Faculty of Civil Engineering, Czech Technical University,
Thákurova 7, 160 00 Prague 6, Czech Republic

Fractal dimensions play a paramount role in both pure research and many applications, e.g. in physics or economy. The most important ones include

Hausdorff dimension $\dim_H X$

Packing dimension $\dim_P X$

Lower packing dimension $\underline{\dim}_P X$

Given two subsets X, Y of Euclidean spaces, or more generally, separable metric spaces, one may think of how various fractal dimensions of the cartesian product $X \times Y$ and those of the coordinate sets X, Y are related. Many inequalities are known, for instance the so called Howroyd's inequality [1]

$$\dim_H X + \dim_H Y \le \dim_H X \times Y .$$

Quite recently Taylor and Hu [3] and Bishop and Peres [2] studied a similar inequality

$$\dim_H X + \dim_P Y \le \dim_P X \times Y .$$

They showed that if X, Y are Borel subsets of the line, then the inequality can be strengthened to

$$\underline{\dim}_P X + \dim_P Y \le \dim_P X \times Y .$$

The problem we study is the following question of Hu and Taylor [3]: How good is this inequality? In more detail, is it so that

$$\underline{\dim}_P X = \inf\left\{\dim_P X \times Y - \dim_P Y : Y \subseteq \mathrm{R}^n \text{ compact}\right\}$$

holds for each (each compact, Borel …) subset of the line?

We have the following theorem:

Theorem. *Let $E \subseteq X \times Y$ be an arbitrary subset of a product of two separable metric spaces. Then*

$$\int_X \underrightarrow{\underline{v}}^t (E_x)\, \mathrm{d}\, P^s(x) \le P^{s+t}(E),$$

where P^s denotes the s-dimensional packing measure and $\underrightarrow{\underline{v}}^t$ the so called s-dimensional directed Hewitt-Stromberg measure ([4]).

As a corollary we get an improvement of the above inequality, in two directions: The spaces X, Y are not limited by any requirements and the lower packing dimension is replaced by a directed one (see [4] for the relevant definitions).

Corollary. $\underline{\dim}_P X + \dim_P Y \le \dim_P X \times Y$ *holds for any pair of separable metric spaces.*

If one assumes that *X* satisfies a mild geometric condition (met e.g. by all subsets of Euclidean spaces) then this inequality is indeed the best possible:

Theorem. *If X is finite-dimensional, then*

$$\underline{\dim}_P X = \inf\left\{\dim_P X \times Y - \dim_P Y : Y \subseteq \mathrm{R}^n \text{ compact}, \dim_P Y < \infty\right\}.$$

This solves completely the question of Hu and Taylor.

As a matter of fact, these are only samples of the outcomes of the reported research. See [4] for the relevant definitions and more results and references.

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Section 2

PHYSICS

Volatile Organic Compounds Decomposition and Role of Ozone in Decomposition Process

S. Pekárek

pekarek@feld.cvut.cz

Czech Technical University in Prague, Faculty of Electrical Engineering, Department of Physics, Technická 2, 166 27 Prague 6, Czech Republic

Non-thermal electrical discharges are intensively studied for the purposes of volatile organic compounds decomposition. We investigated the increase of *n*-heptane decomposition by the hollow needle to mesh electrical discharge with a layer of TiO_2 photocatalyst on the mesh when additional ozone and other active species were supplied to the discharge. As a source of ozone and these species we used the secondary discharge operating in series with the main discharge. We found optimum operational parameters of the secondary discharge from the standpoint of ozone generation. The parameters of the secondary discharge were then adjusted to these optimum parameters and ozone and other active species produced were supplied into the main discharge. In this way we were able to increase the *n*-heptane decomposition efficiency from 47 % to 53 % with the total specific input energy 287 kJ/m^3. The detailed results of this research are published in [1].

Combination of non-thermal plasma produced by electrical discharge with a catalyst leads to promising results for VOCs decomposition. However during decomposition experiments attention must be devoted to the discharge ozone production, decomposition and its interaction with a catalyst. To clarify the role of ozone we studied ozone decomposition by a stainless steel and by a PtRhPd/Al_2O_3 honeycomb catalyst. The experiments were performed with air that was supplied into the hollow needle to mesh electrical discharge followed by a decomposition chamber formed either by a simple stainless steel tube or a tube with a PtRhPd/Al_2O_3 honeycomb catalyst. We found that in case of stainless steel chamber ozone decomposition does not substantially depend on temperature. Contrary to this in case of the chamber with PtRhPd/Al_2O_3 catalyst ozone decomposition is strongly influenced by the temperature. The detailed results of this research are published in [2].

Environment in the non-thermal plasma produced by electrical discharges in air is strongly oxidizing owing to the presence of energetic electrons and oxygen based reactive species. Electrical energy directed into the process chemistry creates highly reactive free radicals that oxidize/reduce pollutants, fragment pollutants directly, or promote excited-state chemistry. Any kind of volatile organic compounds molecule (VOC) entrained in such an environment can be oxidized according to the following scheme:

$$\text{VOCs} + e^- \rightarrow O^\bullet, OH^\bullet, O_3, O_3^-, \text{ etc.} \rightarrow CO, CO_2, H_2O \ldots$$

As it is seen from this scheme, it can be expected that decomposition efficiency of particular VOC in non-thermal plasma will depend on the production of ozone, production of $^*OH$ radicals and production of other active species.

To clarify the role of ozone in of *n*-heptane decomposition we performed the experiments in which the discharge ozone production was detected together with *n*-heptane decomposition efficiency. We found that ozone is involved in *n*-heptane decomposition for low energy densities, while for higher energy densities the discharge is practically in the state of discharge

poisoning. Thus for higher energy densities the *n*-heptane decomposition can be probably attributed mainly to the presence of OH radicals. As far as the concentration of OH radicals depends on relative humidity, we studied also the role of humidity on *n*-heptane decomposition and ozone production. We found that increased humidity decreases *n*-heptane decomposition efficiency as well as the ozone production. The detailed results of this research are published in [3].

Due to the fact that fundamental knowledge of the underlying chemical processes leading to VOCs decomposition is limited the detailed study of the principal routes for the decomposition of *n*-heptane by non-thermal plasma is still required.

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Another Enlargment of the Program Neutrons for Reconstruction of the Neutron Energy Spectra in D-D Z-pinch Experiments

K. Řezáč, D. Klír, P. Kubeš, J. Kravárik

rezack@fel.cvut.cz

Department of Physics, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

Program Neutrons is using for reconstruction of the time-resolved neutron energy spectra in D-D *Z*-pinch fusion experiments. The reconstruction is based on the kind of the time-of-flight methods which determine the energy spectrum of the particles from the particle flux shape evolution during free propagation. The experiment consists of recording of signals in a chain of detectors placed at various distances from the particle (neutrons in our case) source. Then the energy spectra are reconstructed from time-resolved signals which are recorded by several detectors in one direction at different distances. There are several theoretical approaches for the development of algorithms. One of these techniques, namely a Monte Carlo (MC) which is fully described in [1], was used.

Program Neutrons has been developed in FORTRAN language since November 2005. The basic part of the program and another program for numerical testing was developed in several months (until February 2006). Further we were concentrating on the improvement of the reconstruction methods. The method could give better results when detectors in the opposite direction are also included. If we want to employ both directions of neutron detection, we must know the relation between the neutrons which are emitted in one direction and in the opposite direction. The relation includes the transformation of the neutron energies and anisotropy in neutron yield. The transformation of the neutron energies was examined and included into reconstruction program till the end of the year 2006. The anisotropy in neutron yield [2] was included and influence of the scattered neutrons was examined during year 2007.

If a different number of neutrons could be emitted in one direction with respect to the other direction, we have to recently include the anisotropy of differential cross-section (by extension, anisotropy of neutron yield). There are two approaches of how we can enumerate anisotropy in neutron yield; first, to enumerate the anisotropy from angular distribution of neutron production and to correct this measurement with the influence of the experimental vessel; second, to calculate neutron anisotropy from kinematics of the binary D-D fusion system. We chose second possibility for our calculation of the neutron emission anisotropy.

The process of finding the anisotropy of neutron yields is the following. Neutron yield depends on number of deuterons in volume of plasma with given parameters and depends on D-D cross section. The dependence of the D-D cross section on deuteron energy (nuclear data of the D-D fusion reaction) was measured and tabulated since the discovery of D-D reaction. The nuclear data of the D-D fusion reaction was taken for our calculation from [3]. Therefore the dependence of anisotropy for given angles (for example 0°/180°) on energy of deuteron in D-D reaction can be calculated as ration between values of D-D cross section for this angles. The anisotropy of neutron yields was included during both direction calculations.

The examination of the influence of scattered neutrons has been carried out by using numerical testing of the program Neutrons. The smaller influence of scattered neutrons as far as we used for the reconstruction the neutron signals from both direction of the detection. It follows from the transformation of the neutron energy. If we record scattered neutron (with smaller energy) in one direction we can not find correspond neutron with higher energy in the other direction. The discrepancy between reconstruction from one and both direction is evident. When we use neutron signals from both directions, scattered neutrons do not shift the energy spectrum (as during the reconstruction from one direction) but shift the time of neutron production. The shift of the time of neutron production is not important for us (time of neutron production is determined from the nearest neutron detector not from reconstructed time-resolved neutron energy spectrum).

Program Neutrons has been used in the processing of data from experiments in the PF-1000 facility (placed at IPPLM in Warsaw) and S 300 facility (placed at KI in Moscow). The last paper, where the program Neutrons is used for reconstruction of the neutron energy spectra, can be found in ref. [4].

Future prospects are another improvement of the reconstruction method, where we will include anisotropy of target deuterons. Then the influence of the neutron detection system will be included into calculation. Further, I suppose application of the Genetic algorithm for the optimization of the reconstructed energy spectra.

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Application of plasma for improvement of the polymer powder adhesion

J. Píchal

pichal@fel.cvut.cz

Department of Physics, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

Very effective method for corrosion prevention is the coating of a base material with a suitable substance that extends the base material persistence against corrosion for a much longer time period than in case without protection. Coating shelters base material by performing a barrier between it and its environment. To provide adequate corrosion protection, the coating should be uniform, well adhered, pore free and self-healing for applications where physical damage to the coating might occur. In spite of some improper characteristics (in particular a very low surface energy and poor surface adhesion quality) polymers, among them polyethylenes, have found great attractions in this field, especially due to their excellent corrosion resistance, competitive cost, low weight, easiness of installation, and higher specific strength than many other materials. Technology of the polymer protective layer deposition incorporates also smelting of the polymer on the substrate. Polymer is mostly delivered in form of powder or granules. For technical requirements adhesion grade can be expressed e.g. by force needed for detachment of joint of two materials.

Due to the low adhesion grade of unmodified polymer powder or granules the application of any modification process increasing the adhesion grade is crucial. At present there is no universal approach to polymer adhesion improvement and there have been employed various quite different techniques. Here described research focused on the polyethylene adhesion improvement by plasma modification. There were used two plasma reactors – a microwave low pressure one and an atmospheric reactor employing the dielectric barrier discharge. For evaluation of polyethylene adhesion to a metallic surface a method based on a test method described in [1] was used.

The polyethylene powder Borealis CB 9155-01 was used as the test medium. It was characterized with particle average diameter 250 μm, powder density 950 kgm^{-3} and the mass specific surface area of 0.033 m^2g^{-1}.

All experiments in MW reactor were performed in stationary air under pressure 100 Pa and room temperature (20÷23) °C. Treatment time was (60÷600) s.

Modification in atmospheric dielectric barrier discharge was performed in stationary air under atmospheric pressure (743 ÷ 754) torr, room temperature (18 ÷ 25) °C, and humidity 35-57%. Powder mass flow through the reactor could be estimated as $2{,}5.10^{-3}\ kgs^{-1}$.

The adhesion of the powder was determined by measurement of strength force demanded for displacement of the polyethylene-metal joint. Tests were performed in facility inspired by [1]. There were used polished stainless steel substrates. Specimens were created by smelting powder on the substrate (powder was melted in oven at temperature 200 °C) and after approx. one hour of heating cooled). The force necessary for the separation of the

polyethylene from the substrate was measured by a shredder. For comparison the adhesion values between the stainless steel and special PE copolymers were determined, too.

Maximum reached tensile strength value of the unmodified powder was about 2Mpa. Values obtained for modified Borealis polyethylene powder varied mostly between (6÷7) Mpa. For comparison the adhesion strength of commercially produced PE-copolymers fabricated for metal coatings

a) Flamulit F-HTC 214 (produced by DuPont) and designed for corrosion protection of metal substrate

b) Microthene RL MR SP010, (produced by Equistar Chemicals LP) for interlayer deposition by PE coatings

were analysed, too. The adhesion grade of the plasma-modified conventional polymer was higher than that reached for Flamulit. Obtained modified Borealis powder adhesion values were lower than that of Microthene, but we have to keep in mind that Microthene polymer had been specially designed for adhesion layers to steel substrates.

Very important aspect for practical application of plasma-modified powder is the modification effect time-stability (aging), tested by powder wettability measurements. Powder wettability changes induced by modification were tested almost during 800 days after the modification date. Modification effect reduction was very small, most changes seemed to occur in the first 100 days after the modification date. In this period capillarity values of individual samples had dropped modestly and then remained stable, maximum drop after more than 700 days after the modification date was about 20% .

Modified powder characteristics stability is remarkable and very promising for prospective exploitation. Described long time stability (20% drop after more than two years) of the modification effect was probably up to now not referred in connection to any other way of the polyethylene powder plasma modification.

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XPS and AFM study of Titanium Dioxide Thin Films Deposited in Atmospheric DBD Plasma

Y.Klenko

klenkj1@fel.cvut.cz

Department of Physics, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

Titanium dioxide (TiO_2) films have several potential applications in microelectronics, optical fibers, integrated optical chemical sensors and optical wave guides, etc. [1, 2] due to their high transmittance in the visible and near infrared spectral range, high dielectric constant and refractive index as well as their chemical and thermal stability. Above all, the application of TiO_2 photo-catalysis has received much attention. The TiO_2-anatase powder is frequently utilized for the photo-decomposition of organic pollutants by transformation of organic or toxic substances into CO_2 and H_2O [3]. With the exposure of ultraviolet (UV)-380 nm irradiation and the absorption of effective photons, TiO_2-polymorphs in powder or coating forms are likely to supply two specific properties at substrate: strong oxidation capability competent to kill bacteria that attach on the surface and hydrophilicity allowing dirt and stains to be easily washed away by water or rainfall [3]. There is a vast number of deposition methods available and in use today: PVD, CVD, PECVD, sol-gel etc. [4]. However, all methods have their specific limitations and involve compromises with respect to process specifics, substrate material limitations, expected film properties, and cost. The plasma-enhanced deposition of thin films at atmospheric pressure without any vacuum restrictions is a promising approach to perform the finishing in run-through-process of large-size low-cost products. Presented paper reports results of XPS and AFM studies of TiO_2 thin films deposited by AP PECVD method.

Planar atmospheric pressure DBD device consisted of two plane-parallel brass electrodes: the ground electrode was (45x8x18) mm; the HV electrode (40x17x18) mm was covered by the glass plate (70x46xY) mm, where Y was variable parameter. The inter-electrode distance was 4 mm and applied voltage was 14 kV. The experiments were carried out in a plexiglass chamber with dimensions (90x79x50) mm. As a precursor was used metal organic compound titanium tetraisopropoxide (TTIP). The argon gas (0.5 l/min) was mixed with TTIP in evaporator and introduced into the plasma reactor through the hole (diameter 3mm) in the ground electrode. Gas flow rate was detected by the mass flow controller. The temperature of the precursor was maintained at room temperature (20˚C). Duration of the deposition process was with barrier thickness Y=2 mm 10 minutes and for Y=1 mm 10 minutes, resp. 30 minutes.

The elemental XPS analysis of the powder-like films (Y=2 mm/10 min) proved their chemical composition, they consisted of carbon, titanium and oxygen. Small impurities of silicon and nitrogen were also detected. The Ti 2p XP spectrum consisted of $2p_{3/2}$ and $2p_{1/2}$ spin orbit components located at 458.8 and 464.6 eV, respectively. Such position of the peak maxima indicates that the main titanium species is TiO_2. The small components at the lower binding energy side correspond to sub-stoichiometric titanium oxide TiO_x ($x<2$), probably with small contribution from titanium carbide. Taking into account that the film contains 15 % of Ti, it can be concluded that approximately 30 % of oxygen correspond to titanium and the rest 20 % of oxygen is bound to carbon in a variety of species. This is further supported by the O

1s XP peak. The peak consists of two distinct components at 530.3eV and 532.3 eV. The first component is attributed to titanium dioxide, whereas the second corresponds to the carbon-oxygen species. The C 1s XP spectrum of the deposited film was fitted with five components, the main peak being referenced at 285.0 eV and attributed to the C-C/C-H bonds. A higher binding energy tail is indicative of the carbon atoms oxidation. The peaks at 286.3 (C-O), 287.9 (C=O) and 289.0 (O-C=O) eV are attributed to the carbon atoms in various oxidation states. Furthermore, a peak at 283.3 eV had to be added to get satisfactory fitting. Its location at the lower binding energy side allows assign it to titanium carbide. As it can be seen from the fitting results, the carbonaceous part of the film is dominated by hydrocarbons which are partially oxidized. A small amount of titanium carbide has also been detected.

Results of experiments Y=1 mm/10 min and Y=1 mm/30 min have shown the decrease of the concentration of titanium in these films. The increased amount of silicon together with appearance of sodium can be explained by the inhomogeneous thickness of the coatings. After subtraction of Si, Na and O (glass), the real elemental composition can be recalculated to be 40 % of C, 5 % of Ti and 37 % of O. Hence, the films deposited with barrier Y=1 mm have lower amount of Ti and O, and are richer in carbon content. Given that titanium and oxygen are predominantly bound in TiO_2 species, only 5x2=10 % of oxygen belongs to titanium and 37-10=27 % of it is bound with carbon. This is further supported by the O 1s peak. It was fitted with two components as described above. However, in this case, the ratio between the components considerably changes. The carbon-oxygen species are about three times more abundant than oxygen bound in titanium (24 % against 76 %, respectively), which correlates very well with above mentioned values derived from the elemental analysis. The higher retention of oxygen by carbon atoms is also proved by the C 1s XPS peak. Here, the most distinct changes are detected in the component assigned to C-O-C bonds. Their amount reaches 18 % for the sample Y=1 mm/30 min and it is more than two times higher than for the sample Y=2 mm/10 min.

Based on XPS analysis, TiO_2 component in films was different under different deposition conditions in this case it was different thickness of dielectric barrier Y=1 mm and 2 mm.

AFM topography (scan size 10 μm) shown that grow of the films has tubular structures owing to filamentary regime of discharge.

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Long-wavelength Emission of Quantum Dots

P. Janík, Z. Tomiak, J. Oswald*

p.janik@sh.cvut.cz

CTU, Faculty of Nuclear Sciences and Physical Engineering, Dept. of Solid State Engineering, Trojanova 13, 120 00 Prague 2, Czech Republic

*Institute of Physics, AS CR, v. v. i., Cukrovarnická 10, 162 53 Prague 6, Czech Republic

Semiconductor heterostructures with self-organized InAs/GaAs quantum dots (QDs) seem to be a very perspective for many possible device applications, especially in optoelectronics. The long-wavelength lasers based on InAs/GaAs QDs emitting at telecommunication wavelengths (1.3 and 1.55 μm) are expected to be more effective than today used optoelectronic devices based on InP compounds. The maximum emission wavelength of InAs/GaAs QDs is about 1.24 μm. In order to extend this emission to longer wavelengths, several approaches have been developed, e.g. using an $In_xGa_{1-x}As$ strain-reducing layer [1] or vertically stacked QDs [2].

Measured QD structures were prepared on semi-insulating GaAs substrates in Institute of Physics AS CR using metal-organic vapour phase epitaxy (MOVPE). The principle of MOVPE technique is relative simply. A substrate is placed on a high-frequency heated susceptor in a reactor. Gaseous metal-organic compounds (so called precursors) are carried by hydrogen into the reactor. Due to the heat emitted from the susceptor they break up into components. On the substrate these components create a new layer of required material and waste products which are carried away to the gas scrubber.

$Ga(CH)_3$, $In(CH)_3$, and AsH_3 were used as precursors for growth of InAs/GaAs QD structures. The preparation of samples consisted of the following steps: Two GaAs buffer layers were deposited on the semi-insulating GaAs substrate. The first one was grown at 650 °C. Due to better quality of an InAs layer the temperature was decreased to 490 °C for the growth of the second one and the rest of the structure. After deposition of the buffer layers, the InAs layer was grown. Then the growth was interrupted for 15 s. During that time QDs were forming in the Stranski-Krastanow growth mode. Then the layer with InAs/GaAs QDs was capped by an $In_xGa_{1-x}As$ strain-reducing layer (SRL) and a GaAs cover layer followed.

Two sets of samples were prepared. The first set contained samples with a different mole fraction of indium in the 5nm thick SRL. The mole fraction was 7, 13, 23 and 35 %, respectively. The SRL was capped by the GaAs cover layer of thickness 5 nm. In the second set of samples the thickness of the GaAs cover layer varied from 2.5 nm to 7.5 nm and the 5 nm thick $In_{0.23}Ga_{0.77}As$ SRL was used.

A dependence of photoluminescence (PL) intensity on the emission wavelength was measured. All PL measurements were performed at room temperature. Samples were excited by a continuous semiconductor laser operating at 670 nm. The beam of the laser was interrupted by a chopper. The signal emitted by the sample was analyzed by a monochromator SDL-1 and detected by a germanium detector. Standard lock-in technique was used. The PL signal was measured in the spectral range from 1.1 to 1.7 μm. Measured data were processed by program Origin 5.0. Resultant data are listed in Table 1 and 2.

The measurement of samples with different concentration of indium shows that with increasing mole fraction of indium PL peaks shift towards a longer wavelength. The change of

indium concentration from 7 to 35 % induces the redshift of the ground state emission from 1316 nm to 1565 nm, see Table 1.

The shift of PL peaks is also observed for the samples with varying thickness of the GaAs cover layer; with decreasing thickness of the cover layer PL peaks shift towards a longer wavelength. The situation is shown in Table 2. The change of thickness of the GaAs cover layer from 2.5 to 7.5 nm results in the shift of PL maximum related to the ground state of QDs from 1619 nm to 1457 nm.

Table 1. Dependence of PL emission wavelength on composition of $In_xGa_{1-x}As$ SRL

Concentration of indium in $In_xGa_{1-x}As$ SRL [%]	Emission wavelength [nm]	
	Ground state	First excited state
7	1316	1269
13	1458	1333
23	1551	1411
35	1565	1388

Table 2. Dependence of PL emission wavelength on thickness of GaAs cover layer

Thickness of GaAs cover layer [nm]	Emission wavelength [nm]	
	Ground state	First excited state
2.5	1619	1501
5.0	1552	1411
7.5	1457	1326

We have investigated the influence of indium concentration in the $In_xGa_{1-x}As$ strain-reducing layer and GaAs cover layer thickness on photoluminescence spectra of InAs/GaAs quantum dots. The rise in mole fraction of indium in the $In_xGa_{1-x}As$ strain-reducing layer results in redshift photoluminescence peaks. It was observed blueshift of photoluminescence peaks with increasing thickness of the cover layer GaAs.

In both cases the shift of photoluminescence peaks is caused by the change of the compressive strain within QDs. The increase of indium concentration in the $In_xGa_{1-x}As$ strain-reducing layer results in decrease the compressive strain and the increase of the GaAs cover layer thickness increases the compressive strain. Varying compressive strain leads to the modification of the energy levels of the QDs which define optical transitions within QDs. Moreover, $In_xGa_{1-x}As$ strain-reducing layer helps to preserve original height of QDs due to suppression of indium segregation, and InAs/GaAs intermixing during growth. These effects can be used for tuning QDs emission.

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Filtration of the signals from plasma focus discharge

E. Litseva, P. Kubes, D. Klir, J. Kravarik, K. Rezac,

litsee1@fel.cvut.cz

CTU Prague, Technicka 2 16627 Prague 6, Czech Republic,litsee1@fel.cvut.cz

Last experiments of D-D reactions at the PF-1000 device in IPPLM Warsaw made possible to determine more exactly time and energy distribution of produced neutrons due to ten scintillation detectors placed at the distances between 7 and 85 m from the neutron source in both axial directions. The measurements were performed at the PF 1000 facility [2], which operated at the electrical energy of 500 kJ, the voltage of 27 kV, and the maximum current at about 1.8 MA. We used the diagnostics similar to that described in [2]. Plastic scintillation probes of 5 cm thickness, equipped with fast photomultipliers detected the hard X-ray radiation (HXR) above a few hundred keV and neutron emission. The probes were situated downstream (at distances of 7.0 m, 16.3 m, 58.3 m and 84 m), upstream (at distances of 7.0 m, 16.3 m, 30.3 m, 44.2 m. 58.3 m and 84 m) and side-on (at distances of 7.0 m) and they were shielded again the scattered noise. For the neutron yield measurement, indium and silver activation counters were used.

The presented results were obtained from the detail analysis of signals recorded in the seven shots (6540, 6552, 6555, 6565, 6566, 6567 and 6573). The total neutron yield was between 5×10^{10} and 2×10^{11} neutrons. The signals were filtrated using the discrete wavelet transformation and multiresolution algorithm, with using of wavelet "discrete Meyer". The discrete Meyer wavelet was choused because it's symmetrical and consequent neutron pulse isn't shift by the time axe.

The formula for the wavelet transform may be written as

$$W(s) = \int_{-\infty}^{\infty} x(t) \cdot \psi(\tau, s) dt ,$$

where ψ is a wavelet function, defined as

$$\psi(\tau, s) = \frac{1}{\sqrt{s}} \psi\left(\frac{t-\tau}{s}\right).$$

The wavelet transformation belongs to the group of integral transformations, but, in contrast to, for example, the well known Fourier transform, the best resolution both in time and frequency domain. So, we can to filtrate signals with the minimum looses of useful signal.

Discrete wavelet transformation may be explained (see [1]) as dividing of the signal to the high frequency and low frequency components with the analogy of the filters – high-pass and band-pass filters.

$$S_{m+1}(k) = \sum_{p=1}^{N} h(p-2k) S_m(p)$$

$$T_{m+1}(k) = \sum_{p=1}^{N} g(p-2k) S_m(p) ,$$

where ***S***, ***T*** are decomposition coefficients, ***h***, ***g*** are so called decomposition filters, ***h*** is low-pass filter and ***g*** is a band-pass filter.

The high-frequency vectors (detail coefficients) mostly contains noise, low-frequency coefficients contains useful signal. So, the high- frequency coefficients mostly minimized with using of action called thresholding [1, 3]. The coefficients are multiplying with special function, actually the smaller coefficients are erased.

So why is useful to filtrate neutron signals?

The sources of noise are mostly induced current in electronic circuits and cables, thermal noise of the circuits and low resolution of the scintilators - the number of neutrons in larger distances is smaller, each neutron contribute by chief part, so the signal became a step-like function – this kind of noise is so called quantum noise.

Every kind of noise (especially for signals in larger distances, which have smaller amplitudes) means inaccuracy in determination of maximal energy of neutrons and Width Half Maximum (FWHM) is wider.

The time of production and energy distribution of neutrons were calculated from filtrated signals using Monte-Carlo simulations and time-of-flight method [4].

Signals were reconstructed with using of Monte-Carlo algorithm and percentage of cover of reconstructed signals is approximate 80-90%. The cover of the relevant signals for filtrated input is about some percent better, but the main meaning of the filtration is the much better localization of the neutron energy distribution in time and energy.

The results for confrontation of original (noisy) and filtrated signals and their characteristics can be summarized as follows – the maximum number of neutrons, detected downstream belongs to the energy 2.54 MeV in the downstream direction for both original and filtrated signal. The maximum number of neutrons in filtrated signal is 20% higher, then the original one. The Full Width Half Maximum (FWHM) for filtrated signal is 0.173 MeV, 0.218 MeV for original signal, so about 20% lower. The main advantage of filtration of the signals is in much better localization of maximum of number of neutrons in energy and in time.

Because we have more measured signals, we may compare some characteristics and connection with some of them.

For example, the dependence maximal energy of neutrons on the neutron gain is approximately linear. For more accurately results more measured signals is needed

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Two-Stream Instability in Magnetic Field

M. Bohata, P. Kulhánek

bohatm1@fel.cvut.cz

Department of Physics, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

The two-stream instability is a typical instance of instability in plasma. The plasma consists of two plasma species. Each species has a constant equilibrium velocity $\mathbf{v}_\alpha^{(0)}$ with respect to some reference frame. The plasma species are cold (i.e. the thermal motion of particles is negligible), unbounded and unmagnetized. The dispersion relation for small perturbations is

$$1-\sum_{\alpha=1}^{2}\frac{\omega_{p\alpha}^2}{\left(\omega-\mathbf{k}\cdot\mathbf{v}_\alpha^{(0)}\right)^2}=0,$$

where $\omega_{p\alpha}$ is plasma frequency for the species α and $\mathbf{k}$ is a wave vector. More detailed discussion can be found in [1-4]. However, in the most physical situation in the plasma we cannot omit the magnetic field because the occurrence of the magnetic field leads to new phenomena.

The work deals with a generalization of the two-stream instability on the case with the nonzero magnetic field and thermal processes. The results can be used in astrophysics (e.g. jets from stars and galactic nuclei) where the assumption of the unbounded plasma is acceptable. Note that the magnetic field plays an important role in astrophysical applications. We would also like to apply the results on z-pinch phenomena. However, the condition of the unbounded of the plasma species is uncertain in the z-pinch. Therefore we have to be very careful in using these results on the z-pinch phenomena.

For solving the two-stream instability in the magnetic field we use a magnetohydrodynamics model. The time evolution of a particle concentration is described by a continuity equation for each plasma species. Since the electromagnetic field is nonzero we have to consider Maxwell's equations. Next equations are equations of motion for each plasma species which have to contain the force density due to pressure (because we consider thermal process) as well as the Lorentz force density. In order to close the system of equations we need an algebraic relation for the pressure of each plasma species (i.e. the equation of state). We suppose the equation of state in the polytropic form. Note that polytropic processes contain isobaric, isothermal, adiabatic and isochoric processes as special cases. This system of equations is the complicated system of nonlinear partial differential equations and two algebraic equations. Therefore we still assume that a general solution can be expanded around equilibrium. The equilibrium is the zero order in the perturbation expansion and satisfies the system of equations. We further substitute the perturbation expansion to the system of equations and keep only the first order perturbation term (i.e. the higher order perturbations are neglected). Since the system of equation is linearized by this perturbation method we now apply Fourier transformation. We get the system of linear algebraic equations for the Fourier picture of the quantities in the first order perturbation expansion. For the next simplification we assume an approximation of small frequency. Eliminating some unknown quantities we obtain the system of algebraic homogenous linear equations for the small perturbation of equilibrium velocities of both plasma species. The dispersion relation for the two-beam instability in the magnetic field is obtained from the condition for the nontrivial solution the

system of equations (i.e. from condition nonzero determinant). The dispersion relation can be found explicit considering additional assumption. However, an analytic solution of roots of the dispersion relation is not possible in the general case.

In the future we will want to obtain roots of the dispersion relation for the two-stream instability in the magnetic field using numerical methods. In particular, we will want to find all complex roots because the complex roots lead to instability. Next purpose will be a generalization this results on the case of arbitrary frequency.

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Innovative Advanced Oxidation Processes for Organic Micropollutants

S. Pekárek*, M. Pospíšil

pekarek@feld.cvut.cz

*Czech Technical University in Prague, Faculty of Electrical Engineering, Department of Physics, Technická 2, 166 27 Prague 6, Czech Republic

Institute of Chemical Technology in Prague, Faculty of Environmental Technology, Department of Petroleum Technology and Petrochemistry, Technická 3, 166 28 Prague 6, Czech Republic

Organic micropollutants (OMPs), and in particular volatile organic compounds (VOCs), are among the most commonly emitted air pollutants. In the atmosphere, they contribute to some major environmental issues like global warming, photochemical smog and stratospheric ozone depletion. They do not only pose outdoor concerns, also indoor air pollution by OMPs gets increasing attention. These insights have led authorities to impose strict VOC emission regulations (e.g. European Solvent Directive (99/13/EG), Clean Air Act). In this light, a broad variety of emission control measures have been developed and implemented (e.g. thermal incineration, catalytic oxidation, biofiltration, condensation, active carbon adsorption) and there is a continued effort in the search for innovative technologies. In this context, advanced oxidation processes (AOPs) and particularly non-thermal plasma-based AOPs offer new perspectives with respect to gaseous-phase AOPs. Further development of heterogeneous AOP systems, e.g. dosing oxidants involving membrane contactors and introduction of photocatalysts within plasma-based AOPs offer new perspectives.

Based on the previous long time cooperation and on the common research interests in the above mentioned fields a research team involving scientists from 4 institutions was established to cooperate within a framework of the Czech-Flemish scientific cooperation research program. The collaborating institutions were Faculty of Electrical Engineering of the Czech Technical University in Prague, Institute of Chemical Technology in Prague, Institute of Plasma Physics v.v.i. of the Czech Academy of Sciences in Prague and the Research unit of Environmental Chemistry and Technology and the Research Unit of Plasma Technology both from the University of Ghent, Belgium.

The project of scientific collaboration was focused on the potential of innovative AOPs concepts, in particular plasma-catalytic and membrane integrating technologies. The following targets were solved:

- Development of improved plasma-catalytic designs - the purpose was to explore the synergy between non-thermal plasma and heterogeneous (photo)catalysis and to translate the acquired insights into plasma-catalytic concepts for the energy-efficient total oxidation of VOCs, both in the gaseous and aqueous phase. The institutions involved in these studies were Faculty of Electrical Engineering of CTU in Prague, Institute of Chemical Technology in Prague and the Research Unit of Plasma Technology of the University of Ghent. The synergy between non-thermal plasma produced by atmospheric pressure corona discharge and heterogeneous photocatalysis

was main task studied at FEE CTU. We investigated DC hollow needle to mesh electrical discharge with or without photocatalyst TiO_2. The discharge was enhanced by the flow of air or mixture of air with *n*-heptane through the needle. This allows to extent current-voltage range of the discharge to the values reasonable for VOC decomposition. The experiments were performed for the discharge with stainless steel mesh, mesh coated by the layer of TiO_2 and finally for the mesh with TiO_2 globules. We found that for each of these cases the *n*-heptane decomposition efficiency increases with increased energy density. Maximum decomposition efficiency 50.4 % was obtained for the discharge with a mesh with TiO_2 globules for energy density 350 kJ/m^3 and for relative humidity of the mixture 27 %. We also found that for particular energy density the decomposition efficiency is the smallest for the discharge with an uncoated mesh and the highest for the discharge with the mesh with TiO_2 globules. For the discharge with a mesh with TiO_2 globules we found that humidity increases *n*-heptane decomposition efficiency.

- Membrane development for integration within AOPs for waste gas treatment – the AOP in focus is the aqueous phase-based peroxone process, requiring both VOCs and ozone transfer from gas to water through membranes. This means that the physical and chemical properties that are of primary importance with respect to mass transfer and chemical stability were investigated. The institutions involved in these studies were Institute of Chemical Technology in Prague and the Research unit of Environmental Chemistry and Technology of the University of Ghent.
- Investigation of the innovative thermal plasma-based reactor designs for decomposition of solid wastes – the research in this field was concentrated on the study of processes that are decisive for the decomposition efficiency of solid and liquid substances in thermal plasma flow and processes that determine composition and properties of reaction products with respect to their health-hazardous potential and also their possible practical applications (e.g. synthetic gas). The collaborating institutions were Institute of Plasma Physics v.v.i. of the Czech Academy of Sciences in Prague, Institute of Chemical Technology in Prague and the Research unit of Environmental Chemistry and Technology of the University of Ghent.

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Fusion D-D reaction at the PF-1000 in Frame of ICDMP

P. Kubeš, D. Klír, J. Kravárik, K. Řezáč

kubes@fel.cvut.cz

ČVUT FEL Praha, Technická 2, 166 27 Praha 6

The plasma focuses are simple and effective sources of neutrons produced from deuterium-deuterium (D-D) reaction [1], [2]. Neutrons can be used as a convenient tool for the diagnostics of the fast deuterons with energies above 10-20 keV. The summery of possible acceleration mechanisms responsible for the generation of ions is presented in [3]. These mechanisms are probably composed from different kinds of the high electric field generation, e.g., anomalous resistivity, fast movements of the plasma column, transformation of internal magnetic field and decay of plasma microstructures. The plasma focus PF-1000 device in IPPLM in Warsaw, Poland is convenient for the study of mechanism of D-D reaction due to both the relative high neutron yield (above 10^{11}) and the horizontal position of a discharge axis, the direction of dominant portion of fast deuterons. The positions of scintillation detectors up to 84 m gave unique opportunity to determine energy distribution of produced neutrons in axial directions and compare the time of neutron production with space and temporal characteristics of radiation. It was experimentally measured, that the neutrons are produced from the cylindrical locality at the axis in front of electrodes with diameters and length a few cm. In interferometric measurements the density of the densest part of the pinch was estimated in as 10^{25} m^{-3}. In this paper we used this knowledge for the estimation of localities of neutron production and for evaluation of distribution of fast deuterons. The plasma density in the pinch was not measured till in our experiments, so we used the values obtained with interferometric methods in facilities with similar parameters, where the density of minimum diameter was estimated as 10^{25} m^{-3}. Then we can evaluate the total number of deuterons in the pinch as 10^{20} - 10^{21} .

In this contribution we evaluate the energy distribution of the fast deuterons from the energy distribution of neutrons. Due to differences in the neutron energy distribution obtained in different shots we chose a mean value of 6 shots with the neutron yield in the range 0.2-2x10^{11}. The energy distribution of neutrons was calculated using adapted time-of-flight method and Monte Carlo reconstructions on the recorded 9 signals in different axial distances.

The energy distribution of neutrons was very good reconstructed in the downstream direction. The observed spectrum of neutron energies belongs to the range of 1.9-3.5 MeV with the maximum in the range of 2.55-2,8 MeV, i.e. above the mean value of 2.45 MeV for D-D fusion neutrons in the center of mass system. This difference is interpreted with the dominant deuteron velocity component in the direction downstream (from anode to cathode).

The energy distribution of deuterons producing neutrons was calculated using the energy transformation of neutrons to deuterons supposing the target without motion in laboratory system. From the energy distribution of neutrons we can evaluate the axial component of deuteron energy. The neutrons with energy above 2.45 MeV were produced by deuterons with velocity components downstream and the neutrons with energy below 2.45 were produced by deuterons with velocity components upstream. The ratio of number of deuterons in the energy range of 2- 60 keV is increasing from 1 to 10 and in the energy range of 60-400 keV stays constant. The total number of deuterons is equal to the number of registered neutrons in each shot.

For the determination of the total energy distribution of deuterons it is necessary to know the radial neutron energy distribution as well. At the PF 1000 facility we had to disposal only

one side-on detector, at the same distance of 7 m as the axial ones were. The differences between signals at the same distances are caused by the different energy distribution. But in the waveforms recorded by the detectors near the source, differences are not so substantial. In this distance the differences in neutron spectra relay to the time of 40 ns.

The characteristics of the energy spectrum of fast deuterons can be summarized as follows:

The number of deuterons producing neutrons strongly decreases with the axial energy component of deuterons. The ratio of deuterons moving downstream and upstream increases with energy of deuterons, for the high-energy deuterons it reaches value 4-10.

The fast deuterons produce neutrons at energy above 10-20 keV and the efficiency dominates at energy of 50-60 keV.

It seems probable, that a dominant part of neutrons is produced in localities near at axis in front of the electrodes with the density above 10^{25} m^{-3} and a few cm dimensions.

Supposing the source of neutrons in the dense structure with mean density of $2x10^{25}$ m^{-3} and 2 cm dimensions we can calculate the energy distribution of fast deuterons. It decreases with increasing energy as the function $(E_D)^{-(2-4)}$, considerably slowly than the Maxwell distribution.

The total number of deuterons with energy above 20 keV was 10^{17} and total number of deuterons with energy in the range of 10 – 20 keV was maximally 10^{18}.

The path of deuterons with energies in the range of 10-50 keV can be elongated with internal magnetic fields, it can increase the probability of D-D reaction which can in result decrease the number of deuterons.

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Active Vibration Control Using Piezoelectric Transducers

P. Švec, O. Jiříček

svecp1@fel.cvut.cz

Department of Physics, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

Introduction

Active control of noise and vibration is modern strategy that has been intensively developped during last 30 years. Recently, the control strategy became based on controlling radiated sound as close to its source as possible. In principle, there exist many treatments to achieve this objective, some using active smart skins or cell structures to control sound radiation, others applying secondary forces or moments directly to the controlled structure. One of these approaches is called the active structural acoustic control (ASAC).

Active structural acoustic control is a strategy of controlling sound radiated by a structure through acting mechanically on the structure with secondary actuators. In this paper, we address the problem of minimizing sound radiation by modifying structural vibration pattern.

To achieve this objective, we use specially designed piezoelectric bending actuators. These actuators are placed on the controlled surface and driven by signal, which is correlated with the noise signal that is to be supressed.

Bending Actuator

The secondary actuator was designed using the numerical simulations in ANSYS software. As an active element of the actuator, the strips of piezoelectric ceramics (PZT) are used. The actuator consists of two PZT strips clamped in a metal frame. As the strips oscillate, the line bending moment is generated along the line where the actuator is mounted to the primary structure. The design of the actuator was optimised to increase the efficiency of transmitting line-bending moment to the controlled structure; therefore cantilever mounting of the strips is used. The strips have a relatively small blocking force, but large displacement, so cantilever mounting maximizes their efficiency.

Due to blocking force limitation, only thin or lightweight structures can be controlled by these actuators. It was proved [2, 4] that the effect of the added mass of the actuator is negligible, as is the sound radiation of the oscillating piezoelectric strips. The actuator changes the vibration pattern of the structure and minimizes its mean volume velocity. This leads finally to the reduction of radiated power to the far field.

Model Equation

Let us assume a thin baffled thin plate vibrating due to point force disturbance with one secondary actuator mounted on it. The secondary actuator produces a line bending moment that loads the primary structure (plate). By neglecting the rotary inertia and transverse shear, we can write the resulting wave equation in following form

$$EI\nabla^4 u + \rho h \frac{\partial^2 u}{\partial t^2} = -F\delta(x - x_i)\delta(y - y_i)\mathrm{e}^{\mathrm{j}\omega t} - M\delta'(x - x_k)\mathrm{e}^{\mathrm{j}\omega t},$$

where E is Young's modulus, I is the moment of inertia per unit width, h is the thickness and ρ is the density of the plate, $\delta(\mathrm{x})$ is Dirac's function, $\delta'(\mathrm{x})$ means the derivative of Dirac function with respect to its argument and ∇^4 is biharmonic operator. The force amplitude F has units of force per unit area and the moment amplitude M has units of moment per unit length.

Results

The first experiment, which had to verify the actuator performance, was made with single actuator on thin (0.8 mm) square steel plate, clamped at the edges. The error sensor was a far-field microphone. As a noise disturbance, only tonal signals were used. The plate (controlled structure) was actuated by an incident sound wave radiated by a loudspeaker (primary source) placed in a solid chipboard box.

For the optimization of the actuator position, the modal analysis was performed and the model equation was solved using the finite element method. Vibration distribution on the plate at the major frequencies was also measured. The model results lead to the actuator‘s positions close to the edges, while positions in the central area, especially on the nodal lines were less effective in terms of sound pressure level (SPL) decrease.

In the following experiments, the effect of the number of actuators and their positions with respect to the excitation signals was studied. The actuator position has an important effect on the SPL attenuation, and the best results were observed with the actuator near the edges of the plate or in the antinode, which corresponds well with the FEM model results.

Two actuators were placed in their optimal positions. In the first case, the first actuator was driven at 125 Hz and the second at 163 Hz. The primary source was excited at both of these frequencies 125 Hz and 163 Hz. The reduction of overall sound radiation at both frequencies was similar to the situation when the experiment was performed at one frequency with one actuator. In the second case, the experiment was conducted at a single frequency of 163 Hz.

The actuators were excited either with the same signal (single channel) or with different signals (double channel). The best configuration was placing the actuators rotated by 90 degrees to one other, close to the edges of the plate. It has shown that use of different excitation signals for the actuators brings complication of control algorithm due to the coupling between actuators. The reduction of overall sound radiation was also similar when a single channel system was used. Two actuators were able to reduce the sound power up to 12 dB. Radiated sound power was measured by means of sound intensity.

The last experiments were performed with four actuators acting simultaneously. The experiment was performed at the single frequency 163 Hz. Single channel configuration was used. Four actuators were able to reduce higher sound pressure levels of primary source. The sound power reduction was up to 15 dB.

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PIC Simulations of Ion Acceleration by Femtosecond Laser Pulses

J. Pšikal*, J. Limpouch*, V. T. Tikhonchuk**

psikal@fermi.fjfi.cvut.cz

*Department of Physical Electronics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, V Holešovičkách 2, 180 00 Prague, Czechia

**Centre Lasers Intenses et Applications, Université Bordeaux 1, 351 Cours de La Libération, 33405 Talence, France

Generation of fast ion beams in the interaction of ultrashort relativistic laser pulses ($I>10^{18}$ W/cm^2, $t<1$ ps) with plasma is a subject of interest for several applications. They include the laser-based source for shortlived isotope production (positron emission tomography - PET), proton cancer therapy, isochoric heating of solid-density matter, fast ignition in inertial confinement fusion, proton radiography, neutron production etc. To put them in practice, the ion beams have to satisfy very demanding criteria. For example, the treatment of deep-seated tumours requires monoenergetic proton beams with energies about 200 MeV. To produce practical radioisotope sources for PET, a large flux of protons with the energy about 10 MeV is required. The fast ignition scheme requires a proton source with a very small divergence and a short pulse duration.

Ion acceleration by femtosecond laser pulses is a complex phenomenon depending on many factors, such as the laser pulse duration, intensity and beam width, density distribution and thickness of target, its shape and composition. Recent experiments with thin targets and microdroplets have shown a possibility to control ion energy spectra and to produce quasi-monoenergetic fast ion beams with energies of several MeVs per nucleon.

It has been proposed to use small targets with all dimensions less or comparable to the laser spot size, the so-called mass limited targets (MLT), in order to enhance the efficiency of laser energy transformation into fast ions. The interaction of ultra-short laser pulses with MLT can result in specific phenomena due to their geometry and small size. As these MLT are of near-solid density and of micron sizes comparable to the laser wavelength, high laser absorption and intense laser-plasma interaction are expected without the lateral losses from the interaction region [1].

In this contribution, we are interested in multispecies MLT targets of various shapes. An advantage of those targets is their well defined composition and a possibility to compensate partially the effect of Coulomb repulsion of accelerated ions [2]. Our objectives are to study the efficiency, energy spectrum and focusing of protons accelerated in mass-limited targets.

Numerical simulations have been performed with our newly developed two-dimensional (2D3V) relativistic colisionless particle-in-cell code. The code is parallelized via OpenMP scheme, which enables us to compute on the JUMP cluster in Supercomputing centre Juelich (Germany) on a node with 32 CPUs for maximum 24 hours per simulation. In order to investigate the role of target shape on the proton acceleration, fully ionized homogenous targets of three different shapes have been employed (cylidrical target, flat and curved foils). Additional layers of inhomogenous plasma in the front and rear sides of the target were introduced to study their effect on the fast electron generation and ion acceleration (to investigate the influence of laser prepulse or of insufficient intensity contrast of the main femtosecond laser pulse). In our model, the targets contained two ion species (protons and

"heavy" C^{4+} ions in ratio 1:1) and they were irradiated at normal incidence by a p-polarized laser pulse of the wavelength $\lambda = 800$ nm and peak intensity $I = 4.5\times10^{19}$ W/cm^2. The pulse length was about 30 fs (12 laser cycles) with $\sin^2$ shape and the beam width at $FWHM = 2.5\lambda$ at the focal spot. Initial maximum electron density is set up to 20 n_c (where n_c is critical density).

Our simulation results show that the main mechanism of ion acceleration (under given parameters mentioned above) is the so-called target normal sheath acceleration mechanism (TNSA) [3]. The electrons accelerated and heated by laser pulse on the front side of the target enter the thermal plasma and form a population of hot electrons. These hot electrons cross the target and expand beyond its rear side. There, a sheath layer is formed and a strong electric field ($\approx10^{12}$ V/m - unattainable in conventional particle accelerators) accelerates ions.

The strong electric field provides a spatial separation of fast protons and heavy ions. Their mutual interaction affects strongly the shape of ion distribution and the total efficiency of the process. The presence of heavy ions serving as a piston compensates partially the effect of Coulomb explosion and maintain for a long time a narrow proton energy spectrum.

Concerning maximum energy of protons (which are of order of several MeVs for our simulation parameters), our analysis confirms the qualitative *ad hoc* model by Schreiber *et al.* [4] and shows that the most important parameter defining the cutoff energy is the electrical potential drop $\Delta\varphi$ at the beginning of acceleration process. The potential drop depends on the total absorbed laser pulse energy and the size of cross section of the hot electron cloud behind the target rear side. However, one has to account also for the divergence of accelerated ions (e.g., for the density of those ions).

Various shapes of target were modelled and substantial differences, both in energies and in the divergence of generated proton beams, have been found. The employment of spherical target enhances the proton energy, but produces an undesirable divergence of the beam, which leads to lower densities of fast ions. On the other hand, the employment of curved foil section allows one to focus proton beam at a specific distance determined by the radius of curvature at the rear side of the target and to decrease its divergence afterwards. Moreover, it is pointed out that the absorption of laser beam and energies of fast ions can be also enhanced by the presence of preplasma. On the other hand, longer rear-side plasma density profile can substantially decrease the energy of fast ions and simultaneously enhance their number.

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Study of interaction and propagation of femtosecond laser pulse in capillary discharge as a prospective method of soft X-ray laser pumping

M. Tamáš, P. Vrba*, M. Vrbová

tamas@troja.fjfi.cvut.cz

Department of Physical Electronics, Faculty on Nuclear Sciences and Physical Engineering, Czech Technical University, Brehova 7, 115 19 Prague, Czech Republic

*Institute of Physics, AS CR, Na Slovance 2, 182 21 Prague 8, Czech Republic

In several papers the achievability of the amplified spontaneous emission in the capillary discharge has been demonstrated [1]..[2]. The interest in these so called soft x-ray laser as a source with high brightness compared to other sources of soft x-ray radiation leads to investigation of different pumping schemes. With the availability of the table-top lasers with peak intensity high enough to induce Optical Field Ionization, the so-called hybrid pumping scheme (discharge-laser) became prospective mode of operation.

To achieve short wavelengths of the coherent radiation, the active medium of the soft X-ray lasers is plasma, in our case hot dense plasma created by the high voltage discharge in the volume limited by the dimensions of the capillary. The transitions of the electrons between the energy levels in the highly ionized atoms create the radiation, with correct parameters of the plasma we are able to create population inversion where the amplified spontaneous emission occurs. The existing described pumping modes are recombination [1] and collision [2] pumping. Both are achieved by optimizing the parameters of the discharge such as the voltage of the discharge, the current pulse shape and the density of the gas in the capillary before the discharge. The hybrid pumping scheme allows better control of the plasma parameters by parameters of the laser pulse.

The idea of the hybrid pumping scheme is to use the optical field ionization (OFI) to liberate the electrons from the ions and the following recombination then will lead to population inversion [3]. Using OFI promises good control and knowledge of the freed electrons. Depending on the electrical field intensity of the light we can control the stage of the ionization of the ions in the volume. With higher the electrical field intensity the electrons from the higher energetic levels can tunnel free. This effect has very strong threshold characteristic, when the electric field intensity does not achieve the ionization potential of the electron, there is very low probability of the electron excitation. The polarization of the laser light determines the energy distribution of the freed electrons. Changing it from linearly to circularly polarized light we can chose rather low kinetic energy or high kinetic energy of the freed electrons. The freed low energy electrons have the right parameters for the recombination during which the population inversion might occur.

The laser-plasma interaction however faces dispersion that limits the volume in which the intensity of the laser is high enough for the OFI. One way how to elongate the interaction volume is to pre-form the refractive index profile in the plasma column to achieve a waveguide. The refractive index in the plasma is determined by the electron density of the

plasma. The correct profile of the electron density for the guiding can be achieved in the certain phases of the capillary discharge.

In the contribution we present the spectroscopic measurements that serve as the method of choice to estimate the dynamics and parameters of the plasma in the capillary discharge and in the laser plasma. The capacity of total 36,6 nF is charged to 36 kV and then discharged into3 mm in diameter and 5 cm long capillary filled by nitrogen at different pressures. The measurements of the time integrated spectra are compared with the simulations [4], to estimate the temperature and ionization stage in the capillary discharge. The laser pulse with duration of ~62 fs and energy 6 mJ is focused by a lens to different targets (Nitrogen gas, BN ceramics).The laser plasma spectroscopy is performed to determine the maximum ionization stage of the nitrogen ions freed by the OFI in the plasma and to estimate the maximum electric field intensity achievable in the laser pulse.

The measurements show us the basic characteristics of the parameters of the capillary discharge and the laser pulse, parts that we need for hybrid pumping. They give us the basic assumptions if we will be able to demonstrate the source of the soft x-ray radiation.

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Measurement of the low radon concentrations and its diffusion for the underground experiments

F. Mamedov, I. Štekl, L. Vála, J. Koníček, V. Bočarov

Fadahat.Mamedov@utef.cvut.cz

Institute of Experimental and Applied Physics, CTU in Prague,
Horská 3a/22, 128 00 Praha 2 - Albertov

Abstract

At present, many experiments in particle physics are based on the requirement of the background as low as possible. Typically it is the case of experiments searching for neutrinoless double beta decay ($0\nu\beta\beta$). The IEAP CTU group has been involved for a long time in the NEMO 3 experiment studying neutrinoless and two-neutrino double beta ($2\nu\beta\beta$) decays of several isotopes. The NEMO 3 detector [1] is located is the Fréjus underground laboratory in France. One of the main sources of background in this experiment is radon and its daughters. IEAP CTU is responsible in the NEMO Collaboration for the following tasks: measurements of radon activity, study of radon diffusion through different membranes used in the experiment, and study of radon emanation from construction materials of underground detectors. At first an apparatus for measurement of radon diffusion has been developed in IEAP CTU, in part in the framework of author's Ph.D. study.

Description of the apparatus

For measurements of low activity and diffusion of radon, a special apparatus has been designed. The apparatus consist of two hemispheric stainless steel chambers. The volume a both chambers is 3 l. On the ax of symmetry of these hemispheric chambers are attached semiconductor detectors. Working voltage of these detectors is about 35 V and their energy resolution is around 30 and 35 keV, which is enough to measure alpha particles of 6 and 7.7 MeV from disintegration of daughter products of radon. The detectors are inserted in the chamber through special cutoff point in each chamber and it is possible to change them in the case of necessity. The end caps are covered with a vacuum junction. Each chamber is also equipped with two connectors (inlet and outlet) in order to purge the chambers or to fill it with air to be measured.

The interconnection of each detector is separated with its own line made of pre-amplifier, amplifier, and MCA connected to a PC. Open side of the hemispheric chamber is closed with a metallic net which is providing a good mechanical contact of the two hemispheres.

During measurements, high voltage of +2 kV is applied on the frame of the chamber while the body of the detector is grounded. The optimal hemispherical form and HV have been chosen in order to assure the maximal collection of radon daughters from internal volume of the chamber on the semiconductor detector.

Working principle of the apparatus

During the disintegration of radon, positively charged ions are produced. Thanks to the electric field inside the chambers, ions of ^{218}Po and ^{214}Po are collected from the volume on the active surface of the detector where they subsequently disintegrate via α-decay. The emitted alpha particles of 6.0 and 7.7 MeV respectively are registered with the detector and the

corresponding energy peaks are then analysed from the resulting energy spectrum. In our case, the maximum collection of daughter products of radon is reached after 1500 V applied between the chamber and the detector. Each hemispheric chamber of the apparatus can operate in the continuous mode for the long-lasting measurements of low radon activities in the air.

The set-up allows also measurement of emanation of radon from different materials, as well as diffusion of radon through various membranes. In the latter case, the studied thin foil is placed at the junction between the two hemispheric chambers. So, the two chambers are mechanically separated with this foil. One of the chambers is connected to a radon source operated in the flow mode. After a certain time, radon diffuses through the foil and is then collected thanks to the electrical field on the detector of the other chamber. The diffusion coefficient is deduced from the proportion of radon activities in the two chambers and from the time of diffusion.

Calibration of the apparatus

For the calibration of the apparatus, a standard radon source of 100 kBq is used. An air pump with a flux meter is connected with the radon source and thus air with adjustable activity of radon is sent to one of the chambers of the experimental set-up. The radon activity is controlled with adjustable flux of the air which is sent through the radon source. Then, knowing the activity of the radon source and varying the applied air flux, it is possible to calibrate the response of the detector of each chamber.

Preliminary results and future plans

The current set-up is operational and first measurements have been already performed with both detectors. Electronics is now stable and the peaks of 6.0 and 7.7 MeV from ^{218}Po and ^{214}Po α-decays are clearly visible in energy spectrum. After series of tests with and without radon and, in particular, after a long-term background measurement, the sensitivity of the first prototype has been determined. The obtained value is about 1.5 Bq/m^3 which is however higher than expected. The requested sensitivity for effective measurement of diffusion and emanation of radon is 1 mBq/m^3. Such a high background level is mainly due to insufficient tightness of the chambers. Modification of mechanical construction, especially the connection of the two hemispheric chambers, and improvement of the insulation between the chambers and the detectors are planned for the second prototype which will be built in the course of 2008. Background level can be reduced also by increasing volume of the detection chambers and by polishing their internal surface.

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Optical Properties of Nanodiamond Membranes

Z. Bryknar, Z. Potůček

zdenek.bryknar@fjfi.cvut.cz

Department of Solid State Engineering, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Trojanova 13, 120 00, Prague 2, Czech Republic

Optical absorption, photoluminescence (PL), scanning emission microscopy (SEM), Raman spectroscopy, and dispersion of refractive index have been investigated in thin films of nanocrystalline diamond (NCD). Thin films of NCD can become a preferred diamond form for many future applications. They exhibit excellent optical and electromechanical properties, low surface roughness, and can be deposited at low cost over large area by microwave plasma-enhanced chemical vapor deposition (MWPE CVD) in hydrogen-methane plasma. However, nanocrystalline diamond films grown by MWPE CVD consist of small grains and so large amount of grain boundaries results in increased defect density. Thus, their properties differ in some aspects from those of perfect single crystal diamond and polycrystalline CVD diamond thick layers. The aim of this study was to gain the information about the energy levels and electronic properties of defects in the NCD.

NCD films with thicknesses within the range of 375-1260 nm were grown by MWPE CVD on silicon (100) substrates. The nucleation process and growth were monitored with scanning electron microscopy. Then, windows of (4-5) x (4-5) mm^2 were opened in the substrate by directional etching, leaving perfectly transparent, self-supporting nanodiamond membranes [1]. Some membranes were warped. This effect depends on the grain size and seems to be also influenced by residual nitrogen contamination, the internal stress, and thickness inhomogeneity. Typical nanograin sizes measured by SEM have been found in the range 210-470 nm. The internal stress deformations of NCD films were found to be approximately 0.02 % and 0.25 % for self-supporting membranes and films on Si substrates, respectively, i.e. the films deposited on substrates are influenced by much stronger stresses in comparison with self-supporting membranes.

The refractive index n and the thickness of the NCD thin films were calculated from the measured spectral dependence of their transmittance in the transparent spectral range. Denoting the minima of transmittance in interference fringes T_m, the refractive index n can be expressed as

$$n = \left[M + \left(M^2 - 1\right)^{1/2}\right]^{1/2},$$

where

$$M = \frac{2}{T_m} - 1.$$

We have found that the NCD refractive index at 400 nm increases from 2.38 to 3.06 with an increase of membrane thickness. Transmittance in the interference maximum in the NIR (where the films of good optical quality have no absorption), does not reach 100 %. Suppression of interference fringes in the visible spectral region and disappearance in UV region is due to light scattering for which the roughness to wavelength ratio is the decisive parameter.

Photoluminescence emission and excitation spectra were studied within a wide temperature range (12 – 300 K) and the spectral (220 – 900 nm) region. They do not depend markedly on temperature. PL spectra of self-supporting membranes at RT exhibit under excitation at 514.5 nm two main broad bands. The high-energy bands are distributed near 609 nm (2.04 eV), 596 nm (2.08 eV), and 587 nm (2.11 nm) in membranes with thickness 375, 625, and 890 nm, respectively. The low-energy bands are shifted by approximately 0.3 eV to lower energies. PL of films on Si substrates consists of the same bands; however, their position is shifted to lower energies by approximately 0.15 eV. The luminescence mechanism is supposed as follows: Excitation light generates the electron-hole pairs localized spatially at luminescence centers. These pairs recombine radiatively and emit luminescence. The sp^2 hybridized carbon sites presented in grain boundaries are supposed to behave as luminescence centers. These carbon atoms form π bonds and give rise to electronic density of states. Extent of π electron localization is closely related to the size of structural units containing sp^2 carbon sites. Radiative recombination through these sp^2 hybridized carbon sites depends on the localization extent of π electronic states. Therefore, it is reasonable to suppose changes in the PL emission spectra due to changes of film thickness and excitation energy as it was observed.

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Updated Results from the Double Beta Decay Experiment NEMO 3

L. Vála, J. Jerie

ladislav.vala@utef.cvut.cz

Institute of Experimental and Applied Physics
Czech Technical University in Prague
Horská 3a/22, 128 00 Praha 2 - Albertov

In the last decade the neutrino oscillation experiments demonstrated convincing evidence for neutrino oscillations proving the finite neutrino masses and mixing. However, these experiments are only sensitive to the difference in the square of the neutrino masses and do not provide information on the absolute scale of the masses and are not sensitive to the nature of neutrinos. Nevertheless, the observation and thorough study of neutrinoless double beta decay ($0\nu\beta\beta$) is the best experimental way to answer the fundamental questions about the neutrino nature (Majorana or Dirac particle?), the absolute neutrino mass scale, the type of neutrino mass hierarchy (normal, inverted, or degenerated?), and the CP violation in the lepton sector.

One of the currently running double beta ($\beta\beta$) decay experiments is NEMO 3 [1]. The detector is installed in the Fréjus Underground Laboratory (4800 m water equivalent) in France and is devoted to the search for $0\nu\beta\beta$ decay of ^{100}Mo (7 kg) and ^{82}Se (1 kg) and to the accurate measurement of two-neutrino double beta decay ($2\nu\beta\beta$) of seven isotopes by means of the direct detection of the two electrons emitted in $\beta\beta$ decay. The experiment combines two detection techniques, a tracking wire chamber and a calorimeter, and thus provides simultaneous particle detection together with energy and time measurements. The detector is able to identify electrons, positrons, α-particles, and photons. In addition to the study of different $\beta\beta$ decay modes of several isotopes, it allows also a precise measurement of its internal and external backgrounds.

The NEMO 3 detector has been routinely running since February 2003. Data corresponding to the first running period (Phase I) from February 2003 to September 2004 contain additional background from radon which exceeds required limit for designed sensitivity for the $0\nu\beta\beta$ decay search. Nevertheless, the radon level has been decreased by a factor of ten after the installation of a tent around the detector, which is continually supplied with radon-free air from a radon trapping facility. The latter consists of two tanks filled with 1 ton of charcoal cooled down to −50 °C. Radon from the air is trapped in the charcoal where it decays before getting to the output of the facility. Remaining low radon activity inside NEMO 3 during Phase II of data acquisition (from October 2004 up to now) is due to detector component degassing.

For the study of $\beta\beta$ decay, two-electron events are selected from data. A candidate for $\beta\beta$ decay has to satisfy the following criteria: two tracks coming from the same vertex in the source foils, the curvature of each track corresponding to a negative charge, both tracks have to be associated to fired scintillators, and the time-of-flight has to correspond to the case of two electrons emitted at the same time from the same vertex. In addition, a threshold of 200 keV is applied on energy of each electron. It is also required that there is no delayed track close to the event vertex in order to suppress background from ^{214}Bi decay inside the tracking chamber. Finally, a set of conditions on particle energy, which were optimised with Monte-Carlo simulations with respect to the studied isotope and decay mode, is applied on data.

No evidence for $0\nu\beta\beta$ decay has been found in combined Phase I and Phase II data corresponding to 693 days of effective data acquisition time. In the case of ^{100}Mo, 14 events are observed while 13.4 events are expected from background. The situation is similar for ^{82}Se: there are 7 events observed while 6.2 are expected for the same running period. Thus the derived half-life limits at 90% C.L. are $T_{1/2} > 5.8 \times 10^{23}$ y for ^{100}Mo and $T_{1/2} > 2.1 \times 10^{23}$ y for ^{82}Se. The corresponding limits on effective neutrino mass are then $\langle m_\nu \rangle < (0.6 - 0.9)$ eV for ^{100}Mo and $\langle m_\nu \rangle < (1.2 - 2.5)$ eV for ^{82}Se. However, these results date back to 2006 because the NEMO Collaboration has decided to perform blind analysis with mock data. It is planned to open the box and update the results by the summer 2008 and once again after the end of the experiment by 2010. Limits for alternative models assuming right-handed currents and Majoron emission are also determined from the NEMO 3 data [2].

The $2\nu\beta\beta$ decays of ^{100}Mo and ^{82}Se are measured with high accuracy in the NEMO 3 experiment. The half-lives obtained for the Phase I data (389 days) are $T_{1/2} = [7.11 \pm 0.02(stat.) \pm 0.54(syst.)] \times 10^{18}$ y for ^{100}Mo ($S/B = 40$) and $T_{1/2} = [9.6 \pm 0.3(stat.) \pm 1.0(syst.)] \times 10^{18}$ y for ^{82}Se ($S/B = 4$). The half-lives for the other five isotopes have been also derived from data and are summarised in the following table (see also [3]).

Isotope	$2\nu\beta\beta$ decay half-life, $T_{1/2}$	S/B
^{100}Mo	$[7.11 \pm 0.02(stat.) \pm 0.54(syst.)] \times 10^{18}$ y	40
^{82}Se	$[9.6 \pm 0.3(stat.) \pm 1.0(syst.)] \times 10^{19}$ y	4.0
^{116}Cd	$[2.8 \pm 0.1(stat.) \pm 0.3(syst.)] \times 10^{19}$ y	7.6
^{150}Nd	$[9.7 \pm 0.7(stat.) \pm 1.0(syst.)] \times 10^{18}$ y	2.4
^{96}Zr	$[2.0 \pm 0.3(stat.) \pm 0.2(syst.)] \times 10^{19}$ y	0.9
^{48}Ca	$[3.9 \pm 0.7(stat.) \pm 0.6(syst.)] \times 10^{19}$ y	15.7
^{130}Te	$[7.6 \pm 1.5(stat.) \pm 0.8(syst.)] \times 10^{20}$ y	0.25

The $\beta\beta$ decay of ^{100}Mo to the excited 0_1^+ state of ^{100}Ru has been also studied with NEMO 3. In this particular decay, the emission of two electrons is followed by two γ-rays of 590 and 540 keV respectively which are registered with the calorimeter. The half-life for the $2\nu\beta\beta$ decay mode obtained for Phase I data is $T_{1/2} = [5.7^{+1.3}_{-0.9}(stat.) \pm 0.7(syst.)] \times 10^{20}$ y ($S/B = 3$) [4]. This result is in a good agreement with values measured previously in spectroscopic experiments using HPGe detectors. No evidence for the $0\nu\beta\beta$ decay to the excited 0_1^+ state has been found. So, the half-life limit of $T_{1/2} > 8.9 \times 10^{22}$ y at 90% C.L. has been derived from the Phase I data [4]. At the present time, it is the best experimentally obtained limit.

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Wire-Array Z-Pinch Implosion onto Deuterated Fibre at S-300 Generator

D. Klir, J. Kravarik, P. Kubes, K. Rezac, S.S. Anan'ev*, Yu.L. Bakshaev*, P.I. Blinov*, A.S. Chernenko*, E.D. Kazakov*, V.D. Korolev*, B.R. Meshcherov*, G.I. Ustroev*

klird1@fel.cvut.cz

Department of Physics, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic
*RRC Kurchatov Institute, 1 Kurchatov Sq., 123182 Moscow, Russia

Z-pinches are nowadays the most intensive laboratory sources of soft X-rays and this is also the main reason why they are studied. Whereas a large number of papers are devoted to studies of EUV, soft and hard X-ray radiation, and in some cases electrons, information about fast ions is rather rare. At this point we can mention the recent measurement of an ion temperature in wire-arrays at the Z-machine. The Doppler-width of iron spectral lines indicated that the ion temperature exceeded 200 keV [1]. Such a result suggests that also fusion neutron measurements could provide invaluable data for Z-pinch physics since they give insight into the acceleration of fast ions. For that purpose we carried out Z-pinch experiments in which a wire-array imploded onto a deuterated fibre [2,3].

The implosion of a conical tungsten wire array Z-pinch onto a deuterated fiber was studied on the S-300 device (4 MA peak current, 700 kV voltage, 100 ns rise time, 0.15 Ω impedance) at the Kurchatov Institute in Moscow. The experimental series of 15 shots was performed on the current level of 2 MA. The diameter of a conical wire array was 10 mm and 7 mm at the anode and at the cathode, respectively. The wires were inclined at an angle of 13° to the array axis. The conical wire arrays consisted of 30 tungsten wires of 7 μm in diameter. The deuterated polyethylene $(CD_2)_n$ fibers with diameters between 80 and 120 μm were placed on the axis of the array. The enrichment of deuterium in the polyethylene was higher than 98%. The mass percentage of tungsten, carbon and deuterium ions in Z-pinch load was about 73%, 20% and 7%, respectively.

In order to observe Z-pinch dynamics, various diagnostic tools were used: e.g. an optical streak camera, a 4-frame X-ray pinhole camera, a differentially filtered time integrated pinhole camera, and 5-frame laser shadowgraphy. The neutron emission was measured with an indium activation counter (for neutron yield measurements) and seven scintillator-photomultiplier tubes (for time of flight analysis). This diagnostic set-up enabled us to obtain the following experimental results.

The streak image showed the radiation from the fibre and/or precursor plasma already at 70 ns. At about 140 ns, the tungsten wire-array started to implode. The most intense soft X-rays were emitted at about 170 ns during the stagnation of imploded tungsten wires onto the fibre. The power of soft X-rays (between 0.1 and 10 keV) reached 100 GW. The maximum spectral power density was measured at a photon energy of 120 eV. The radiation was close to the radiation of a black body with a temperature of 40 eV.

Hard X-ray emission started during the stagnation of the wire-array onto the fibre. The rise-time of the hard X-ray signal was very short and usually did not exceed 3 ns. In all shots, this rapid rise of the X-ray emission corresponded to a sharp dip in the dI/dt signal. After that, the hard X-ray emission lasted for about 30 ns, i.e. during the stagnation and expansion phase.

As regards neutron energies in the side-on direction, the neutron energy spectrum peaked at 2.48 ± 0.05 MeV with 450 ± 100 keV FWHM. In the downstream direction, the peak neutron energy and the width of neutron spectrum was 2.65 ± 0.10 MeV and 350 ± 100 keV, respectively. The knowledge of neutron spectra at different directions relative to the Z-pinch axis provided information about the energy of deuterons which produced fusion reactions. The average kinetic energy of deuterons which produced fusion neutrons was about 150 keV. Most of the deuterons were directed towards the cathode. The broad width of neutron spectra implies a high radial velocity of deuterons. Therefore trajectories of deuterons producing fusion reactions seemed to be strongly influenced by magnetic and/or turbulent electric fields. This observation was made also in experiments with an imploding standard wire-array as well as in fiber Z-pinch.

As regards neutron emission time, the neutron pulse temporally correlated with hard X-rays and also with measured voltage. The neutron emission lasted on average 30 ± 5 ns (FWHM) and was observed at the end of implosion and during the expansion of a plasma column. At this moment, the $R_P + dL_P/dt$ term reached the value of 0.2÷0.4 Ω. During the implosion, this value could be ascribed to a time-varying inductance dL_P/dt whereas in the post-stagnation phase the $R_P + dL_P/dt$ term was probably dominated by enhanced resistance R_P. For that reason the neutron emission is supposed to be a multi-phase process and we believe that the prolonged neutron emission is connected with the enhanced resistance. We would like to prove it in future experiments.

Recently, we have prepared a deuterium gas-puff in order to interpret experimental results and to compare them with those obtained in other Z-pinch devices. We expect that the interpretation of Z-pinch experiments with pure deuterium will be more straightforward in comparison with a heterogeneous mixture of tungsten, carbon and deuterium ions. In addition to that, neutron yields could be higher with pure deuterium because radiation cooling rate will be lower and deuterons will not be slow down so rapidly as in the case of a high number of electrons bounded in tungsten ions.

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Feasibility Study and Pilot Testing of the Evaporative Cooling Circuit for TOTEM Experiment

V. Vacek, V. Vinš, M. Doubrava, M. Galuška, R. Marek

vaclav.vacek@fs.cvut.cz

Department of Physics, Faculty of Mechanical Engineering, Czech Technical University,

Technická 4, 166 07 Prague 6, Czech Republic

TOTEM (TOTal Elastic and diffractive cross section Measurement) is one of six experiments being installed along the Large Hadron Collider (LHC) built at international laboratory for nuclear research CERN. Main objective of the TOTEM is to measure the size of the proton and to monitor the LHC's luminosity. It is relatively small experiment compared to other huge projects such as ATLAS, ALICE, LHCb or CMS. Its particle detectors are housed inside special vacuum chambers called "ROMAN POTs'". Twenty four ROMAN POTS in total, mounted in 8 basic units, will be installed along the beam pipes of the LHC near the collision point of the CMS experiment.

As part of the CTU collaboration with CERN, the Department of Physics at Faculty of Mechanical Engineering has been invited to prepare a prototype design and initial verification measurements of the ROMAN POTs' cooling system [1].

Each pot houses a compact stack of 10 detector planes with their hybrid boards and cooling pipes. To keep the total width of the inefficient zone between the outer RP window surface and the active detector area below 0.5 mm, the distance between the thin window and the physical detector edge must not exceed 200 μm. The targeted alignment precision of 30 μm has to hold both at the mounting time and at the operation time. Since the detector modules will be mounted and operated at different temperatures, thermal contractions and expansions have to be taken into account. The hybrid board is made of a processed kapton film laminated on a high thermal conductivity substrate with a thickness of 0.5 mm. The material of the substrate is an Al-Si 70%-30% alloy (CE07), which has the advantage of a high thermal conductivity and a thermal expansion closely matching the one of the silicon sensor. The cooling system integrated in the RP insertion will have to remove the thermal load from the sensors and the electronics. Moreover, to allow operation after high irradiation the RP silicon detectors will be operated at about -10°C to reduce the radiation induced by thermally generated bulk current and to control the reverse annealing after high irradiation. Since the given geometry of the package it will be difficult to keep all modules at the same temperature. A spread of less than 10°C between the ten plates can be tolerated and does not represent a strong constraint. The major contribution to the thermal load of the whole system is given by the readout chips VFAT, where several watts are expected. The total load per pot is about 20 W. Because of the high radiation environment of the LHC tunnel, the main part of the refrigeration system is not installed near the RP but in the underground service area USC55 at IP5, which is a protected and always accessible place.

Following the feasibility study the first version of the cooling system was proposed. Silicon detectors inside the ROMAN POT are cooled down by special vapor cooling circuit working with fluorinert refrigerant R218. This fluid fulfills several specific demands such as dielectric behavior, radiation and magnetic field resistance, chemical stability etc. Our team has realized prototype measurements using the thermal model of the ROMAN POT that was built into prepared cooling circuit during the year 2007. A thermo-mechanical prototype has been assembled to characterize the conceptual design, the choice of the materials and the fluido-dynamic parameters of the cooling system. The VFAT chips on the hybrids were replaced with heaters with equivalent power density.

The prototype was fixed to a vacuum chamber flange and inserted in an experimental vacuum chamber. All the connections of the pressure and temperature sensors were read out through the vacuum feed-through. A capillary tube with inner diameter of 0.55 mm was used.

We had to make up testing cooling circuit which was installed in the laboratory at CERN-Meyrin site [2]. The circuit is based upon the two stage compressor-condenser unit with number of added extensions and control devices bringing up the versatility of the system to the highest possible level. The main modification dealt with interfaces that can enable connectivity of the ROMAN POT and at the same time its geometrical position flexibility against the expected beam location. The new DAQ system had to be prepared to monitor all crucial parameters both inside the POT and outside of it, i.e. main operational parameters of the cooling circuit. The list of the recorded values included the mass flow rate, pressure at the liquid side, the evaporative pressure, adequate pressure drops and important temperatures. Refrigerant flow can be controlled by a set of pressure regulating valves. An excess refrigerant was evaporated and its vapor temperature was elevated above the dew point value with a help of the PID controlled heater.

The first measurements performed with prototype showed that temperature of the particle detectors called “Siliciums” were kept well below -10°C or even lower eliminating the power dissipation in the used electronics. The detector support structure was designed as high thermally conductive evaporator structure having two separate branches with evaporating refrigerant. Since the Siliciums are planned to move up and down to reach a focal point of the particle beam during the measurement flexible interfaces were tested in liquid and vapor lines. The possible effect of capillary tubes being coiled inside the ROMAN POT on the refrigerant flow behavior was also foreseen and tested. No pronounced difference between the design with straight and coiled capillary tubes was detected. The measurements showed that for the expected heating power (of 2W per one silicon module unit) the temperature spread on a single hybrid card is within 3°C, and the maximum temperature difference between detectors is less than 10°C. The final length of the capillary between 1.5 and 1.65 m was the result of an optimization in view of obtaining an acceptable pressure drop [3].

The last task included investigation of thermal effect caused by additional metal part installed inside the ROMAN POT covering the Siliciums support structure. The possible thermal gain from ROMAN POT environment due to the conduction effect could occur because the metal cover is at certain points in direct contact with the support structure. Results from the test have shown almost negligible thermal effect of the latter design change.

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Luminescence Spectroscopy of Transition-Metal Impurity Ions in $SrTiO_3$ Crystals

Z. Potůček, Z. Bryknar

zdenek.potucek@fjfi.cvut.cz

Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering, Department of Solid State Engineering, Trojanova 13, 120 00 Praha 2

$SrTiO_3$ is a perovskite type quantum paraelectric with a temperature-dependent TO_1 soft phonon mode. The paraelectric state is stabilized by the polar quantum fluctuations down to the lowest temperatures. Only cubic-tetragonal structural phase transition $O^1{}_h \rightarrow D^{18}{}_{4h}$ occurs at 105 K. However, even very low concentrations of impurities can induce ferroelectric phase transition. Doped $SrTiO_3$ crystals, ceramics, and thin films have attracted attention in recent years due to the effort to improve properties of this material for device applications.

Manganese doped $SrTiO_3$ is currently widely investigated due to the improvement of $SrTiO_3$ ceramic properties for tunable microwave applications and due to the observation of new manganese related magnetic and dielectric effects. The intriguing low temperature dielectric relaxation observed recently in $SrTiO_3$:Mn ceramics had been attributed to reorientations of O^--Mn^{2+}-O^- and Mn^{2+}-O^- polaronic type defects related with Mn^{2+} ions substituting Ti^{4+} ions or to reorientations of Mn^{2+} ions substituted in Sr^{2+} site in the off-center position. Ferromagnetism was also found in Mn ion implanted $SrTiO_3$ crystals near room temperature. Earlier we have studied and discussed unusual temperature behavior of the zero-phonon line of Mn^{4+} ion photoluminescence in $SrTiO_3$:Mn crystals, which is associated with a strong interaction of the Mn^{4+} impurity center with temperature-dependent TO_1 soft phonon mode and with a local configuration instability of Mn^{4+} ion in the ^2E excited state with respect to TO_1 mode related polar distortions [1]. Having this experience we performed a detailed study of photoluminescence spectra on as-grown and reduced $SrTiO_3$:Mn (280 ppm) crystals within wide temperature (12 – 300 K) and spectral (300 – 1600 nm) regions in order to distinguish centers related to Mn ions in different valence states.

Both as-grown and reduced $SrTiO_3$:Mn crystals showed low temperature photoluminescence in the red and near-infrared spectral region [2]. The emission spectra consist of two strongly overlapping bands. The first one corresponds to the well known emission of Mn^{4+} ions substituted for Ti^{4+} ions with pronounced narrow zero-phonon line peaking near 723 nm and well developed vibrational sidebands extending up to 900 nm. This band is attributed to the $^2E \rightarrow {}^4A_2$ transition of octahedral coordinated Mn^{4+} ions with $3d^3$ electron configuration. The second broad emission band peaking near 870 nm was observed on $SrTiO_3$:Mn crystals for the first time. The dominant excitation band of photoluminescence of Mn^{4+} ions in the as-grown crystal peaking near 555 nm is attributed to the spin allowed $^4A_2 \rightarrow {}^4T_2$ transitions in Mn^{4+} ions. The reduction of the $SrTiO_3$:Mn crystals in the Formier gas at 1450 K considerably decreased intensity of Mn^{4+} photoluminescence in accordance with the decrease of content of Mn^{4+} ions observed by EPR spectroscopy. Simultaneously emission band peaking near 870 nm became more clearly evident in the emission spectra and the excitation band peaking near 555 nm became weak. After reduction Mn^{4+} photoluminescence was most effectively excited via excitation band peaking near 356 nm that extends in the vicinity of the absorption edge of the $SrTiO_3$ crystal. This change of the excitation spectra indicates that Mn^{4+} photoluminescence is in the case of very low concentration of Mn^{4+} centers most effectively excited via crystal lattice absorption when

electrons and holes created by illumination in the conduction and valence bands radiative recombine on Mn^{4+} centers. Study of excitation spectra of photoluminescence of both as-grown and reduced crystals showed that centers responsible for the emission band peaking near 870 nm are predominantly excited by energy transfer from Mn^{4+} ions. Analysis of the influence of the reduction treatment on photoluminescence properties and on content of Mn^{2+} and Mn^{4+} centers in the $SrTiO_3$:Mn crystals detected by EPR indicated that Mn^{2+} ions with the $3d^5$ electron configuration substituted in Ti^{4+} sites are responsible for photoluminescence with the emission band peaking near 870 nm [2]. Strong increase of the concentration of these Mn^{2+} centers after the reduction of $SrTiO_3$:Mn crystals supports such idea.

Nominally pure and doped $SrTiO_3$ crystals often contain unintentional impurities that may markedly influence their properties. Especially chromium seems to be unavoidable impurity. All our $SrTiO_3$, $SrTiO_3$:Mn, and $SrTiO_3$:V crystals showed weak photoluminescence of the octahedral coordinated Cr^{3+} ions with a characteristic pronounced narrow zero-phonon line peaking near 793 nm accompanied by a wide structured emission extending behind 900 nm [3]. The zero-phonon line was attributed to $^2E \rightarrow {}^4A_2$ transition within Cr^{3+} ions substituted for Ti^{4+} ions and structured emission to electron-phonon vibronic sidebands. Although Cr^{3+} ions have the same $3d^3$ electronic configuration as Mn^{4+} ions, vibronic spectrum of Cr^{3+} ions is less pronounced because they interact with a lattice more weakly than Mn^{4+} ions. Photoluminescence of low concentration of Cr^{3+} ions in $SrTiO_3$ crystal is most efficiently excited via the charge transfer excitation band peaking near 380 nm. Moreover, $SrTiO_3$:V crystals exhibited at low temperatures photoluminescence of Mn^{4+} ions and an additional structured emission band in the near infrared spectral region that was observed in $SrTiO_3$ crystals for the first time. This emission band consisting of rather pronounced zero-phonon line near 1159 nm and well developed vibrational sidebands extending in the Stokes side up to 1400 nm has shape typical for photoluminescence of Fe^{3+} ions in octahedral coordination of oxygen ions. Moreover study of $SrTiO_3$:Fe crystals by EPR spectroscopy proved that iron occurs in as-grown $SrTiO_3$ crystals preferentially as Fe^{3+} ions substituted in Ti^{4+} sites. Therefore we suppose that the emission band with the zero-phonon line near 1159 nm corresponds to the $^4T_1(G) \rightarrow {}^6A_1(S)$ transition of Fe^{3+} ions with $3d^5$ electronic configuration substituted for Ti^{4+} ions.

The study of photoluminescence performed on $SrTiO_3$ crystals proved that luminescence spectroscopy allows distinguish between centers related with Mn ions in different valence states in manganese doped samples and detect low concentrations of transition-metal impurities in nominally pure and doped $SrTiO_3$ samples.

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Ultrasonic cleaning

V. Sopko, L. Samek

vit.sopko@fs.cvut.cz

Department of Physics, Faculty of Mechanical Engineering, Czech Technical University, Technická 4, 166 29 Prague 6, Czech Republic

Ultrasonic cleaning is set of processes, using effect of mechanical oscillations of ambient ultrasonic frequency on matter and on physical and chemical processes occurring in the matter. Surface cleaning of solid matters emerged into liquid, in which was invoked ultrasonic undulation, has advantages than other surface cleaning, because of high quality surface cleanness, because of faster progression of cleaning process, because of substitution of combustible or toxic solvent on safer and cheaper ones, because of possibility of ablation impurities firmly bounded to the surface of solid matters or situated in hardly accessible places. During ultrasonic cleaning occurs mechanical erosion of impurity layers by cavitation and simultaneously is speeded up process of chemical interaction of washing liquid with impurities and acoustic stream.

Common types of surface impurities are grease, oil layers, weakly bounded to the cleaned surface (layers of colors or paint strongly bounded to cleaned surface), cavitationaly resistant, chemically reacting with washing liquid. Clinkers, oxide layers, strongly bounded to the cleaned surface, chemically reacts only with aggressive liquid or fine, firm parts (metal dust, chips) easily removable from the surface. Process of ultrasonic cleaning is affected by cavitation, acoustic streams, acoustic pressure emission and sonic capillary effect. Cleaning efficiency depends on intensity and frequency of acoustic field, on viscosity, surface tension and contain of gas in washing liquid.

Collapsing cavitatinons bubbles invoke inside of impurity surface layer micro impact load, which is largely localized and highly uneven, which causes cracks in the impurity layer and its microcorrosion, which appears as small craters on the surface layer. These can damage not only layer of impurities, but also cleaned matter. Exist three mechanisms of removing surface layers by pulsing of cavitation bubbles: removing, cleaning by liquid stream, emulsifying. Oscillating bubble, arisen in cracks between layer of impurity and cleaned surface, acts on layer of impurity with forces, which continue tear off farther layer from the surface of cleaned matter and into the new created crack move bubble. Radiation pressure and soniccapillare effect forward infiltration of washing liquid into poruses, unevenness and dead-end channels and peeling layers of impurities are diffused on the surface of matter or part of peeled layer come off. A thin layers of impurities weakly bounded to the surface of matter are removed by narrow liquid stream, which arose from separation of the big ones, unstable bubbles on smaller bubbles and impacting on the matter surface. It can occur also emulsification of these layers. Operation of acoustic stream causes movement of oscillating bubbles, whereas they take away part of surrounding ambient and so occurs peeling of layer. Simultaneous oscillating bubbles spray small bubbles nearby in liquid to surrounding, and so create emulsion of grease in liquid. Layers of impurities, strongly bounded to the surface of matter can be removed only by microimpacts on the surface in chemically neutral washing liquid, generated by collapsing bubbles.

Cavitaton, with all accompanying effects, has crucial task during cleaning of surfaces of solid matters in liquid by using ultrasonic method. Physico-Chemical process of ultrasonic

cleaning runs on the border of cleaning liquid and cleaned matter. In this process liquid serves as: conductor of ultrasound waves for cleaning surface, disolves impurities, and washes away released nondissolvable impurities from cleaned surface.

Efficiency of ultrasonic cleaning depends first of all on chemical and physical features of cleaning liquid and on its temperature. In liquid with high tension of saturated vapors is speed of bubble collapse slowed down by high tension of vapor in the bubble, so decrease in size of microimpact at collapse and intensity of cavitation. It is used for example for cleanning fine component, where is necessary to decrease erosion impact of cavitation, in order to not damage surface of samples.

With increase of surface tension σ liquid increases also speed of bubble collapse, in consequence of capillary pressure $2\sigma / R$, so increases also cavitation. However with increase of σ decreases number of cavitation bubbles and decrease also wetted surface of cleaned mater, which decreases penetration of washing liquid into tiny cracks and poruses.

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Powder Neutron Diffraction Study of Bi0.04La0.53LiyTiO3 (y= 0.29 and 0.70) Perovskites

S. Vratislav*, M. Dlouhá*, M-L.Martinez, L. Mestres****

stanislav.vratislav@fjfi.cvut.cz

*Department of Solid State Engineering, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University,Trojanova 13, 120 00 Prague 2, Czech Republic
**Dept. of Inorganic Chemistry, Universitat de Barcelona, Martí i Franqués 1-11, 08028 Barcelona, Spain

The binary systems Bi_2O_3/Li_2O, Bi_2O_3/TiO_2, and Bi_2O_3/La_2O_3 are now becoming increasingly important in the technology of new materials used by the electronic industry. The phase diagram of the system $Li_2O/La_2O_3/TiO_2/Bi_2O_3$ has been studied. It was shown that the perovskite compounds with general formula $Bi_yLa_{0.5+x-y}Li_{0.5-3x}TiO_3$ are ionic conductors when the bismuth content in the general formula was less than y = 0.10 [1,2].

In general, the amount of lithium inserted is consistent with the number of vacancies. The knowledge of crystal structure of these compounds is crucial to the understanding of the Li ionic mobility within the La(Bi)-Ti-O framework. The structure analysis of these oxides by X-ray diffraction is difficult as the super lattice reflections associated with the tilting of the TiO_6 octahedra arise from the oxygen atoms, weak scattering if compared with La and Ti. Therefore, powder neutron diffraction measurements [3] are more suitable for these experiments because the scattering amplitude is: b_O=0.581, b_{La}=0.824, b_{Ti}=-0.190, respectively.

The aim of this work is to investigate the variation of the Li atom content within the La (Bi)-Ti-O perovskite framework because the structure parameters are very important to the understanding of the Li ionic mobility in these perovskite compounds. The two members of the $Bi_{0.04}La_{0.53}Li_yTiO_3$ series (y = 0.29 and 0.70) has been analysed at 7 K by powder neutron diffraction and the structure parameters was determined [3, 4]. Composition, lattice parameters and Li-occupancy factors of the $Bi_{0.04}La_{0.53}Li_yTiO_3$ at 7 K for y= 0.29 and 0.70 are given at Tab. 1.

The preparation of the ground state of sample was described at [3, 4]. The Li-rich perovskite samples were prepared by the electrochemical insertion of the Li ions into perovskite-type $Bi_{0.04}La_{0.5}Li_yTiO_3$. Complete structural determination was carried out by powder neutron diffraction on the diffractometer KSN-2 located at the LVR-15 research reactor near Prague. The diffraction patterns were taken at λ = 0.1362 nm over a range 2θ = 10 - 92º in steps 0.1º. The GSAS package was used to refine the structure parameters from powder neutron diffraction data, taking into consideration the absorption correction for the natural mixture of the lithium isotopes.

Tab. 1: Composition, lattice parameters and occupancy factors of the $Bi_{0.04}La_{0.53}Li_yTiO_3$ at 7 K

Sample	Composition	Space group	y /Li occupancy/	a /Å/	b /Å/	C /Å/
1	$Bi_{0.04}La_{0.53}Li_{0.29}TiO_3$	Pnma	0.32(7)	5.4820(21)	7.7429(31)	5.4783(10)
2	$Bi_{0.04}La_{0.53}Li_{0.70}TiO_3$	Pnma	0.75(9)	5.4619(17)	7.7207(14)	5.4886(13)

Lattice parameters at the 7 K temperature were determined in the frame of the Pnma space group and for the composition with y = 0.29 and 0.70 (Tab. 1). The structure contains a three dimensional framework of corner sharing TiO_6 which are almost perfectly regular

octahedra and slightly tilted. Lanthanum are placed close the theoretical A-site in all the compounds [3, 4]. We can conclude that the results obtained from low temperature measurement are in reasonable agreement with room temperature ones. Fourier differential maps were used to determine the positions and the occupancy factors of the inserted Li atoms (Tab.2).

The variation of the occupancy factors with lithium contents indicates that LiA, LiB, LiC, LiD, LiE and LiF are partially occupied; however the LiA and LiC are favourite positions. The further mentioned positions (vacancies) are filled sequentially. If all vacancies around A-site are fulfilled, then for higher lithium content Li ions go to the LiD and LiE positions. Around of the lanthanum atoms are arranged LiA, LiB, LiC and LiD ions at 0.1 nm and LiE at 0.2 nm. The occupation of these sites could origin the displacement of the LiA towards La and O1. We can point out by the Fourier differential maps; in this type of perovskite structure is possible to see the following alignments: the La-LiC-LiF-LiC-La row and the La-LiA-LiE-La one.

Tab. 2: Structural parameters of Li inserted atoms within the La(Bi)-Ti-O perovskite framework of the $Bi_{0.04}La_{0.53}Li_yTiO_3$ at 7 K

Atom	Site	x	y	z	y /Li occupancy/	
					Sample 1	Sample 2
La	4c	0.0123(19)	0.2500	0.9997(14)	0.540(10)	0.537(11)
Bi	4c	0.0123(19)	0.2500	0.9997(14)	0.039(7)	0.041(7)
LiA	4c	0.0000	0.2500	0.8410(23)	0.150(6)	0.217(5)
LiB	4c	0.133(28)	0.2500	0.1348(27)	0.020(14)	0.060(10)
LiC	4c	0.0080(22)	0.3710(27)	0.0061(26)	0.110(12)	0.163(9)
LiD	4c	-0.1430(25)	0.2500	0.0860(28)	0.01(2)	0.142(9)
LiE	4c	-0.2420(24)	0.2500	0.7414(22)	0.02(2)	0.165(8)
LiF	4a	0.0000	0.5000	0.0000	0.01(2)	0.030(10)

It seems to be that in these perovskites the insertion limit not only depends on the A-sites vacancies as well on the possibility of the creation of new lithium sites. We can conclude, it would be possible to investigate the effects of Li-inserted content on the change of structure parameters of the $Bi_{0.04}La_{0.53}Li_yTiO_3$ compounds by powder neutron diffraction and to prepare new Li-rich materials using as cathodes in lithium batteries.

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Compression Anisotropy and Pressure-Induced Antiferromagnetism in $Pr_{0.52}Sr_{0.48}MnO_3$

M. Dlouhá*, S. Vratislav* , Z. Jirák **,B.N. Savenko***

maja.dlouha@fjfi.cvut.cz

*Department of Solid State Engineering, Czech Technical University, Trojanova 13, 120 00 Prague 2

**Institute of Physics, AS CR, Na Slovance 2, 182 21 Prague 8, Czech Republic

***JINR, FLNP, Dubna, Russia

Magnetic state of $Pr_{0.52}Sr_{0.48}MnO_3$ manganite and high pressure effects on the crystal structure up to 31 and 4 Gpa have been studied by means of the *x*-ray and neutron powder diffraction, respectively. At ambient pressure, $Pr_{0.52}Sr_{0.48}MnO_3$ has a tetragonal crystal structure (space group *I4/ mcm*) and exhibits a ferromagnetic state below T_C = 270 K. The lattice compression at ambient temperature is anisotropic at P< 6 Gpa with the most compressible *a* axis and it becomes isotropic with nearly equal compressibilities of *a* and *c* axes at higher pressures. At P < 2 Gpa, an *A* – type antiferromagnetic ground state (T_N ~ 250 K) is stabilized in $Pr_{0.52}Sr_{0.48}MnO_3$ instead of the ferromagnetic one. Itsonset is accompanied by the structural transformation from the tetragonal structure of *I4/ mcm* symmetry to the orthorhombic structure of *Fmmm* symmetry. The role of e_g orbital polarization in the pressure- indused structural and magnetic response of $Pr_{0.52}Sr_{0.48}MnO_3$ is discussed. The observed high pressure effects are compared with chemical substitution effects in $Pr_{1-x}Sr_xMnO_3$ compounds with x =0.48 – 0.6.

The $Pr_{0.52}Sr_{0.48}MnO_3$ compound was prepared by solid state reaction at high temperature. Homogenized mixtures of Pr_6O_{11}, $SrCO_3$, and MnO_2 were first heated three times at 1000^o C with intermediate grinding to active decarbonation. The powders were then pressed into pellets and sintered at 1500o C in air for 12 h. Afterward, the the sintered samples were slowly cooled to room temperature.

The X-ray powder diffraction measurements were made at high pressure up to 31 Gpa and ambient temperature with a diamond anvil cell. The sample was loaded in the Re gasket with a 4:1 methanol-ethanol mixture as a pressure transmitting medium. The x-ray diffraction spectra were measured at the system consisting of high-brilliance FRD rotating anode generator (Mo $K\alpha$ radiation, λ =0.7115 Å),FluxMx focusing optics, and Bruker APEX charge coupled device area detector. The two-dimentional x-ray diffraction images were converted to conventional one-dimensional diffraction patterns using FIT2D program [1]. The data analysis was performed using the GSAS program [2].

Neutron powder diffraction measurements at high pressures up to 4 Gpa were performed at selected temperatures in the range 16- 290 K with the DN-12 spectrometer at the IBR-2 high-flux pulsed reactor (FLNP JINR, Dubna, Russia) using the sapphire anvil high pressure cells. Diffraction patterns were collected at scattering angles of 45.5^o and 90^o with the resolution $\Delta d/d$ =0.022 and 0.015, respectively. Experimental data were analyzed by the Rietveld method using the MPIA program or FULLPROF if magneticstructure was to be included.

Neutron diffraction investigations of the $Pr_{0.52}Sr_{0.48}MnO_3$ specimens at the same temperatures with the KSN-2 diffractometer (LND FNSPE, Rez, Czech Republic) have been performed. The observed patterns have been analysed using Rietveld profile analysing program FULLPROF[3].

The results of our study show that the application of high pressure on $Pr_{0.52}Sr_{0.48}MnO_3$ leads to a suppression of the tetragonal FM metallic state and stabilization of the orthorhombic A-tipe AFM state, presumably with quasi-2D metallic conductivity. The lattice compression anisotropy observed in x-ray and neutron diffraction experiments points to a decisive role of orbital degrees of freedom in the pressure-induced change of the magnetic state. The structural and magnetic response of $Pr_{0.52}Sr_{0.48}MnO_3$ to high pressures is similar to the effect of composition variation in the x = 0.48-0.6 range for $Pr_{1-x}Sr_xMnO_3$ compounds at ambient pressure. The T_N =250 K value found for $Pr_{0.52}Sr_{0.48}MnO_3$ is the largest one for the A – type AFM state among the $Pr_{1-x}Sr_xMnO_3$ compounds (T_N =220 K for x = 0.6 at ambient pressure). The estimated upper value of dT_N/dP~1.5 K/Gpa for $Pr_{0.52}Sr_{0.48}MnO_3$ is compatible with the dominant contribution from itraplanar exchange of the A-type AFM state.

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Accuracy Analysis of Contactless Measuring Tools with CCD Sensor

P. Kajnar, A. Mikš

pavel.kajnar@fs.cvut.cz

Department of Instrumentation and Control Engineering, Faculty of Mechanical Engineering, Czech Technical University in Prague, Technická 4, 166 07 Prague 6, Czech Republic

Nowadays contactless measuring methods with CCD sensor are used more and more. The goal of this work is the particular measuring accuracy influence analysis from geometrical and a wave point of view as well. Today Phase One company (www.phaseone.com) sells array CCD sensors with resolution 7216x5412 pixels (39 Mpx) with pixel size 6,8x6,8μm. Size of this panel is 49,1x36,8 mm and this panel is used for photographic purposes. Company Kodak offer linear CCD image sensors KLI-14403 with 14403x3 pixel size 5x5μm, CMOS sensor KAC5000 with 2592x1944 pixel size 2,7x2,7μm and many other sensors. MagnaChip also produces an image CMOS sensor with pixel size 2,2μm (http://www.magnachip.com). CMOS technology has then many other advantages as compared to CCD technology.

At first let's have an ideal optical system and the ray outgoing from a object point B situated in a distance y from an optical axis and a distance a from an optical system object principal point. Then let's have a datum plane in a distance p from an optical system image principal point. Let B' is a point of intersection (in a distance y' from optical axis) where the ray outgoing from the optical system intersects of this datum plane. Using lens imaging equations we can derive following equation [1]

$$y' = y(p/a) \pm p(f'/2c)(1/p - 1/a - 1/f') \tag{1}$$

where f' is a focal distance of the optical system and c is a f-number of the optical system [1-4]. If the point B′ is the image of the point B ($p = a'$), than we have

$$y' = y(a'/a) = my,$$

where m is lateral magnification of the optical system. Now we change a value of parameter a (a nominal object location) in the axis direction and the value of the parameter p (CCD sensor from optical system distance) remain constant. For a change $\delta y'$ of a distance y' from optical axis we can write

$$\delta y' = \delta y'_O + \delta y'_C \tag{2}$$

where

$$\delta y'_O = y(p/a^2) \cdot \delta a \tag{3}$$

$$\delta y'_C = (f'/2c)(p/a^2) \cdot \delta a \tag{4}$$

The measurement accuracy is also affected by diffraction of light. When we have an object point then its image created by an optical system won't be a point but a spot shaped and sized in dependence on an entrance pupil shape and a f-number. An intensity distribution in diffraction pattern is given by the formula [1,2,4]

$$I(s) = I_0(2J_1(s)/s)^2 \tag{5}$$

where I_0 is the intensity in a center of a diffraction spot, J_1 is a Bessel function of the first kind, $s = \pi r / \lambda c$ $s = \pi r/\lambda c$ and r is a distance from the center of diffraction spot to investigate point. For a diffraction spot diameter (Airy disc) we can write

$$d = 2{,}4\lambda c \tag{6}$$

In case of imaging a half plane (an edge of luminous field), for an interval in which intensity falls from maximum to minimum value we can write

$$\delta y'_D = (3\pi/8)\lambda c \tag{7}$$

Another measurement error sources are light source and detector spectral properties. From formula (7) we can write

$$\delta y'_{D\lambda} = (3\pi/8)\lambda c\left[\delta\lambda/\lambda + \delta f'_\lambda / f'\right] \tag{8}$$

where $\delta f'_\lambda$ is a focal length change in dependence on a light wavelength (focal length chromatic aberration). In case when we have an optical system without focal length chromatic aberration (achromatic optical system) then for $\delta y'_{D\lambda}$ we can write

$$\delta y'_{D\lambda} = (3\pi/8)c\cdot\delta\lambda \tag{9}$$

Further we have

$$\delta y'_\lambda = y\cdot\delta m_\lambda \tag{10}$$

where δm_λ a lateral magnification change in dependence on a light wavelength. When we consider these facts then a general measurement error while using CCD detector is given by the formula

$$\delta y' = \delta y'_O + \delta y'_C + \delta y'_D + \delta y'_{D\lambda} + \delta y'_{CCD} + \delta y'_A \tag{11}$$

where $\delta y'_{CCD}$ is a CCD element size influence and $\delta y'_A$ is an optical system aberrations influence.

Let's have an object in distance *L* from CCD sensor and an optical system with a focal length *f'* and lateral magnification *m*. Then we can write [1]

$$\begin{aligned} a &= L/(m-1) \\ a' &= m\cdot a \\ f' &= -L\cdot m/(1-m)^2 \\ L &= -f'(1-m)^2/m \end{aligned} \tag{12}$$

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Evolution of Internal Stresses in the Plain Ferritic Steel Studied by Neutron Diffraction In-Situ upon Tensile Straining

V. Davydov *, P. Lukáš*, P. Strunz* and S. Vratislav

davydov@fjfi.cvut.cz

Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, Břehová 7, 115 19 Prague, Czech Republic

*Nuclear Physics Institute, 250 68 Řež, Czech Republic

Diffraction methods belong to valuable experimental tools for investigation of internal stresses in materials. Among others, the neutron diffraction technique has a special position due to the deep penetration depth of thermal neutrons in current materials. This advantage provides a large benefit for stress mapping in bulk components and for in situ material testing. The analysis of position and shape of neutron diffraction profiles can yield valuable information on internal macro- and microstress state in polycrystalline materials.

Present *in situ* neutron diffraction study is aimed at investigation of the response of selected lattice planes in the polycrystalline material upon tensile loading. For this purpose, the 0.1C-0.4Mn construction steel was selected as a simple model material. The tensile deformation test was performed in the incremental mode in which each individual deformation step was followed by unloading. The neutron diffraction spectra were collected both upon loading and unloading and behavior of the diffraction profiles in the elastic as well as in the plastic region of the deformation curve was examined in detail.

Whereas the behavior of the lattice strains during straining and the evolution of the residual intergranular strains have been already described in other papers, the present work is focused mainly on profile broadening effects measured in the same deformation regime. The estimate of microstrain evolution was done by using the single-line diffraction profile analysis method. Comparison of microstrain values in loaded/unloaded state in the elastic and plastic region offers an interesting possibility to estimate the contribution of the *type II* microstrains, self-equilibrated over a length scale comparable to that of grain structure, and t*ype III* microstrains, self-equilibrated over a length scale which is smaller than the scale of grain and include stresses due to coherency at interfaces and dislocation stress fields [1].

From the point of view of peak profile analysis, usually two components of line broadening are considered: size effect broadening due to the crystallite size, which is independent on the diffraction vector magnitude, and the lattice distortion, i.e. the broadening component which is diffraction order-dependent and thus increases with the distance from the reciprocal lattice origin. These properties enable the separation of the strain and size effects. Size broadening is caused by the finite column length of coherently scattering domains where this length is parallel to the diffraction vector. Lattice distortions are caused by lattice defects like dislocations, stacking faults, grain boundaries, inclusions, precipitates, *etc.*

The material examined in the present study was 0.1C-0.4Mn plain ferritic steel with a yield strength of 130 MPa. The microstructure of this steel consists of relatively large grains with the grain size of about 30 μm. The rod like specimens of diameter 7 mm and active length of 25 mm were prepared for combined diffraction and mechanical testing experiments. Neutron diffraction profiles were measured *in situ* both upon loading (strain-control regime) and unloading at the dedicated stress/strain diffractometer TKSN-400. Three reflections, 110,

200 and 211 were measured with a relatively high instrumental resolution of $\Delta d/d \sim (2–2.5)\times10^{-3}$ at two different orientation of the specimen, axial and radial, i.e. the axis of applied uniaxial stress parallel and perpendicular to the scattering vector, respectively.

The present incremental deformation experiment yields various information on evolution of internal strains. Comparison of dislocation density curves in loaded and unloaded states shows very interesting effect of reversible changes of microstrain represented the dislocation density. Similar effect was observed by X-Ray diffraction in deformed single-crystals [2]. In this case, the reversible broadening of the diffraction profiles upon unloading was ascribed to glided back dislocations created by the Frank-Read sources. However, in the case of polycrystals, the preferential mechanism of the profile broadening is obviously different. The nature of the observed reversible changes of dislocation densities can be explained by the mixed microstrains of type II and type III in case of straining, and by the microstrain of type III in unloaded state. The latter is ascribed to the pure dislocation density. The pure reversible component of microstrain is assumed to be represented by the heterogeneous elastic strain of type II. This interpretation is supported by strong broadening effect observed in elastic region of the deformed polycrystalline WELDOX steel, reported in previous works.

During mechanical tensile tests performed *in situ* at the high-resolution neutron diffractometer, the reversible changes in neutron diffraction line broadening were observed upon tensile straining and subsequent unloading. The reversible changes in peak width are supposed to be caused by the heterogeneous elastic strain distribution between particular grain families within the strained sample. The proposed interpretation of reversible effects is based on the assumption that diffraction line broadening observed upon loading corresponds to the total microstress of Type II and Type III microstress, where Type II is consists of two subtypes, residual and heterogeneous elastic components. The broadening in the unloaded state pertains to a quantity of dislocation density, and is caused preferentially by Type III plus residual component of type II stresses.

The modified and extended procedure of the single line diffraction profile analysis based on Wilkens dislocation model and the log-normal size distribution [3, 4] was tested in the study of plain ferritic steel. This new single-line procedure is plausibly an effective tool in determination of dislocation densities and could be applied for a set of diffraction profiles as well, using the appropriate contrast (orientation) factors.

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A New Commissioning Test with Repaired SCT Barrel Loops in the Atlas Experimental Cavern

V. Vacek, M. Doubrava,V. Vinš, R. Marek

vaclav.vacek@cern.ch

Department of Physics, Faculty of Mechanical Engineering, Czech Technical University, Technická 4, 166 07 Prague 6, Czech Republic

The ATLAS detector is a multi-purpose detector currently being commissioned at one of the four interaction points of the LHC accelerator at CERN in Geneva. The detector will study interaction products from proton-proton collisions with a 14 TeV centre-of-mass energy at design luminosity of 10^{34} $cm^{-2}s^{-1}$. The most central tracker, the Inner Detector (ID), is situated inside a 2 T central superconducting solenoid magnet. It consists of the silicon Pixel detector closest to the beam, surrounded by the Semiconductor Tracker (SCT) detector and the outer Transition Radiation Tracker.

The safeguarding of the sensitive and expensive semiconductor detectors and electronics in the difficult high radiation environment imposes new and non-standard constraints on the cooling system. The coolant should be electrically non-conducting and chemically inert in the event of a leak. The temperature gradient along the cooling channels should be minimized using a cooling fluid that is non-corrosive, non-toxic and non-flammable. Also, the circuit should operate with oil-free circulation. This has led to the choice of saturated fluorocarbon ($C_nF_{(2n+2)}$) refrigerants, which combine high dielectric strength with good chemical stability under ionizing radiation and compatibility with the materials used in the construction of the ATLAS inner tracking detector. The total heat load that must be removed is almost 60 kW.

An evaporative cooling system, using C_3F_8 as the coolant, has been chosen for the SCT and pixel detector. The main motivation for an evaporative cooling system over a mono-phase system are: the higher heat transfer coefficient between the cooling fluid and the cooling tubes, the smaller temperature gradients along long cooling channels, and the smaller size required for the cooling channels. The smaller size of the system and thus lower coolant mass flows is due to the larger cooling capacity per unit volume in an evaporative system due to the utilization of the latent heat of vaporization rather than a liquids specific heat capacity.

The detailed commissioning is strictly required for such complex cooling system [1]. Our team has been in charge of the complex measurements in the ATLAS experimental cavern since July 2006, when the first stage commissioning runs were conducted at CERN and resulted in heater failure discloser. We have been asked to prepare the new project for the commissioning tests in 2007 that were planed to be preformed just after the necessary heater problem fixation and their replacement in the ATLAS experimental cavern during the autumn 2007.

The last tests took their place already down in the ATLAS PIT and dealt with the modified heaters which were moved into the new position on the cryostat wall. Our work involved preparation of the flexible and easily movable DAQ system within the ATLAS experimental cavern [2, 3]. We have developed a new system based on ELMB, widely used at CERN, for this purpose. The ELMB unit was placed on a platform together with its power supply and RS connectors for signal wires. The new DAQ also involved the calibration of individual ELMB channels and development of a new PVSS software program (reads the data from ELMB).

The testing was oriented on the SCT Barrel heaters during the current commissioning following the main time schedule of the ID installation. Actual installation of these heaters occurred in late November 2007. Inner detector cooling circuits just on A-side of the ATLAS

detector, handling refrigerant flow from distribution racks Q1 and Q4, were tested since the C-side was unapproachable during the period of measurements.

Measurements had 3 different tasks. The first one covered the pressure drop measurement of repaired and modified heaters. We monitored pressures before and after the heater and before backpressure regulator as well as few temperatures (on heater, before/after heater, before/after backpressure regulator) over the selected tube line (B 113 A). These measurements gave us the distribution of pressure drops across the heater and over the rest of vapor line (several tens of meters of piping – connects inner detector with refrigerant distribution rack that stays outside the detector). The cooling system operated in warm mode [4] only as requested. This demand kept the evaporation pressure around 6 bar_a, thus giving us slightly lower refrigerant mass flows. It resulted consequently in low pressure drop of vapor line. Due to the slow progress in installation and space constrains around the pipelines we could perform this type of measurement only with one vapor line (rack Q4) so far.

The second task was to test and to monitor the mass-flow in vapor lines (B 119 A line connected to rack Q1 was investigated). So, we built in a mass flow meter into the line – Swissflow SF 800 (with frequency signal output). We have also monitored several temperatures on that line besides the refrigerant mass flow. Inner detector volume was hardly accessible at the time of our tests, so it was not possible to attach pressure sensors around heater (only temperatures sensors were possible to be moved). The measured mass flow was found to be slightly less then nominal value but still within the tolerances relevant to the system being operated in the warm mode.

The last measurement should verify the driving pressures settings by the PLC control system for the pressure regulators (PR) and backpressure regulators (BPR) those placed at the distribution racks. For that purpose we have added pressure sensor into refrigerant distribution rack manifolds (line B 91 A; Q1 - on liquid line, right after pressure regulator). The second pressure sensor was mounted before adequate backpressure regulator. Temperatures were also monitored before/after backpressure regulator. Several different pressure values were set by PLC control system via pneumatic converters. We have looked after any difference between settings and correctly monitored pressure values close to the PR and BPR. There were some discrepancies observed, mainly for driving PR settings. Some more tuning was recommended to oust of differences.

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Testing of the Repaired Heaters for ATLAS Inner Detector Cooling Loops

V. Vacek, M. Doubrava,V. Vinš

vaclav.vacek@cern.ch

Department of Physics, Faculty of Mechanical Engineering, Czech Technical University, Technická 4, 166 07 Prague 6, Czech Republic

The cooling capacity of the SCT and Pixel cooling system of the ATLAS detector must be sufficient to remove the heat from the detector modules and maintain the silicon temperature at or below -7^{o}C to prevent reverse annealing of the silicon detectors [1].

For the safety operation the cooling loops were additionally equipped with special supplemental heaters. The heating element is in contact with the tube walls and refrigerant as well. The heating length of the heating element, the diameter, the pitch and inner diameter of the coil have been selected in order not to exceed a maximum temperature of the heating element during operation of 100 °C (to avoid the decomposition of the fluid which may start at a temperature higher than 120 °C) and at the same time keep the pressure drops across the heater within a budget of 50 mbar.

It has been shown by us during the early stage of the commissioning in 2006 that all heaters, delivered on site by French manufacturer, did not meet the required specification both from the design and quality point of view. The rescue program had to be prepared to repair these components in order to minimize the time losses during the final assembly in 2007. Our Prague team has been invited to participate in these activities during the last year of ATLAS installation program at CERN.

Our measurements were mainly oriented on commissioning of the cooling system serving the inner detector. Cooling system itself performed well, but the integration of failing heaters caused a lot of troubles. Our group was responsible for the test stand development [2] in SR-1 building facility and for the most of the tests executed there in 2007. The purpose of these tests was to find a proper position of temperature sensors both for control and interlock purposes. A new sensor position should secure the efficient performance of the PLC heaters control. A search for the proper position meant to determine the right place along the heater body and to verify if this new location of the sensors will secure the required performance. There are 2 fundamental sensors on each heater. The first one serves for the PLC control purposes (PLC upon the signal then decides the power to be imposed into the heater reflecting the actual mass flow of the refrigerant through the loop) and the second sensor is used for safety feature (switching off the heater once temperature exceeds its maximal allowed value). Temperature sensors are thermocouples, because they can withstand the working conditions in ATLAS Pit (namely radiation damage). Facilities in the SR-1 building, i.e. cooling circuit of C_3F_8 [3], had to be modified for the tests and the following installation had to be prepared by our team: **(a)** supporting frame for heaters, **(b)** additional piping (to connect heaters with cooling system), **(c)** PLC rack plus the power rack (110 V power sources switched by PLC) and **(d)** reliable DAQ system furnished with adequate sensors.

The DAQ system supplied by our department consisted of MIC 2000 base unit and the Sensortechnics pressure gauges, kapton coated NTC temperature probes plus several of the PT1000 sensors and Bronkhorst mass-flow meter. Pressure and temperature sensors were calibrated at our laboratory at the department of Physics of the CTU Prague.

Following heater types were tested SCT EC (end cap) and pixel ones. The testing procedures had to be established for both types. Thermal imaging camera was used to help us to look after the best placement of the control and interlock thermocouples. Overall testing

program had to simulate different flow regimes, high or low driving pressure and high or low backpressure settings. Our studies also focused on gravity effects, so we have tested different orientations of heaters (refrigerant flow in the direction of gravity, against it or horizontally positioned heaters).

Interlock test procedure was slightly simpler and faster in comparison with the overall heater testing. The procedure was the following: only about 1 bar_a of refrigerant vapor was left inside the heater and verified thermocouple was connected to PLC control channel. Thermocouple was placed in a relatively cold spot of the heater. A consequence of this positioning was that PLC control loop started to "request" more power and the heater body started to heat-up. An impact of the action was monitored with a help of thermal imaging camera. Images revealed if the heater body was heated-up uniformly all along the heating element. Further testing showed that the adequate position sensors for the SCT EC heaters had to be changed compared to the originally adopted solution. Concerning the PLC control thermocouple location, the best results have been achieved for the surface mounted sensor on top of the copper tube right after the heater flange. The flange normally serves as a support for 5 or 6 SERTO unions that holds and connects the heaters with their appropriate vapor lines. Interlock sensor was finally placed on the heater body, just above heating element.

Pixel tests were different than those of the SCT EC. The PLC control thermocouple was placed directly into refrigerant flow. Sensor was brazed into the SERTO union. This modified union serves to connect the heater with the vapor line tube. Interlock sensor was placed again on the heater body in the similar manner as for the case of the SCT EC heaters.

The final measurements in SR-1 Bldg. were dealing with different thermocouples for pixel heaters control. The reasons for further repeated tests were driven by the fact that new type of control thermocouple was prepared for the PLC and length of the heater body was modified (heater was cut shorter, so PLC control thermocouple sits closer to the heating element). The new type thermocouple consists of 2 independent sensors placed in a single shield (so one sensor is spare). Testing procedure resulted in verification of the PLC control parameters (P = 5, I = 25, D = 12). Our testing revealed a small cold spot close to the SERTO union (in the tube bend, where refrigerant wets the tube wall intensively) once the PLC control started to work properly. It appeared that it may cause leak due to an asymmetric temperature distribution and as expected, this phenomenon occurred after 3 hours of running. Further modification and tests will be necessary in an early 2008 [4].

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Enhancement of spatial resolution of roentgenographic methods

F. Krejci*, J.Jakubek**

frantisek.krejci@gmail.com

*Department of Physical Electronics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, V Holešovičkách 2, 180 00 Prague 8, Trojanova 13, 12000 Praha 2, Czech Republic

**Institute of Experimental and Applied Physics, Czech Technical University in Prague, Horska 3a/22, 128 00, Prague 2, Czech Republic

It has been demonstrated [1-2] that the combination of state-of-the-art hybrid pixel semiconductor detectors with newly micro- and nano-focus x-ray sources opens wholly new possibilities in radiation imaging. Semiconductor single particle counting pixel detectors (Medipix2, Timepix [3,4]) offer many advantages for x-ray imaging: high detection efficiency, energy discrimination, noiseless digital integration (counting), high frame rate and virtually unlimited dynamic range. All these properties allow achieving high quality micro radiographs including very low contrast and low absorption objects. It has been also developed [1] a set of techniques for data processing and image correction (flat field correction, beam hardening correction) to eliminate residual drawbacks of pixel detectors and of the usage of polychromatic x-ray sources. The spatial resolution of x-ray micro radiography (alike any other imaging method) is the crucial parameter and its improvement still remains an experimental and data processing challenge. From theoretical principles it is clear, that the lower limit of the spatial resolution of a radiographic method is given by the spot size of the imaging x-ray source (e.g., pinhole collimated x-ray radiation, micro- or nano-focus roentgen tube radiation, divergence of the synchrotron source beam, x-ray laser). The main aim of this work is the development of a method based on the precise measurement of the x-ray spot size and the implementation of deconvolution, which should lead to improvement of the spatial resolution under the theoretical limitation given by the finite source size.

From theoretical principles, the signal on the detector is given by convolution of the spatial intensity distribution of the source and the spatial transmission function of the object. Let h denotes the signal on the detector and let f is the spot intensity distribution, then the object under imaging g (their transmission function) can be reached by solving the convolution equation (e.g. easily in Fourier domain).

$$f * g = h$$

In physical measurements, the situation is usually closer to

$$(f * g) + \varepsilon = h$$

where ε is some type of noise that has entered the recorded signal. However in this case, it is not clear, how this equation should be deterministically solved. Solution to this problem is desired widely in many scientific and engineering disciplines. Therefore, there have been developed a wide number of deconvolution algorithms, which attend specifications of each task. Selection and implementation of the most suitable method for the case of micro

radiography is one of the cardinal parts of our work. In our numerical simulations we have tested the ability of some deconvolution methods (namely deconvolution using FFT, Wiener deconvolution, regularized deconvolution, blind deconvolution, and Lucy-Richardson algorithm) to improve spatial resolution by deconvolution of the image obtained on the detector with the deterministically known point spread function (PSF). The simulation has been performed among others with respect to the photodetection statistics of the row image. According to obtained results, it is evident that the final deconvoluted image shows two types of errors: the first one is the imperfectness in improvement of the spatial resolution (the image remains partially blurred), the second one is the presence of artifacts (i.e. objects on the images created artificially by the deconvolution algorithm). However, it has been demonstrated that both types of errors are reduced by increasing photodetection statistics. The sufficient mean value of the detected photons for all methods under testing (except FFT deconvolution) is about 10^6-10^7 photons. According to the results of the numerical simulation expected, the improved spatial resolution should be 4-5-times better than the resolution of the row image.

For effective running of deconvolution algorithms the precise knowledge of PSF is crucial. At the IEAP** there are two compact x-ray micro radiology systems, on which our experimental work is realized. By imaging the sharp edge (of a 50μm thin iron foil) we have determined the 1-D spot size of both sources. This measurement gives information about the lower limit of the spatial resolution for each system (without using deconvolution) and hence the 1-D profile of the PSF (line spread function). The X-ray spot size is highly dependent on the electrode voltage, current, and finally on the running regime of tube, hence a thorough study of spot size variation on X-ray tube parameters is needed. The spot size determined for our Hamamatsu micro-focus source is 5 μm and for the nano-focus X-ray source is 720 nm.

In the near future we will try to measure complete 2-D PSF for both sources, which should allow full application of tested deconvolution methods and hence improvement of the spatial resolution of real roentgenograms. From our existing spot size measurement and numerical simulations it is evident, that this measurement must be done with nanometer-scale precision. The positive results of our work (i.e. enhancement of the spatial resolution) can be useful in many applications relevant to micro radiography as presented in numerous papers.

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Cosmic Rays & Experiment CZELTA

M. Nyklíček*, K. Smolek* and P. Kovačíková**

nyklicek@utef.cvut.cz

*Institute of Experimental and Applied Physics, Czech Technical University in Prague,
Horská 3a/22, 128 00 Prague 2, Czech Republic
**Faculty of Philosophy and Science, Silesian University in Opava,
Bezručovo náměstí 13, 746 01 Opava, Czech Republic

Cosmic Rays

The study of Cosmic Rays began at the beginning of the 20th century. In the year 1912, Viktor Hess discovered the cosmic rays (CRs). In the year 1938, the secondary air shower of CRs was discovered by Pierre Auger. The biggest observatory of CRs – The Pierre Auger Observatory – was named after this French scientist.

All stable particles are abundant in CRs. In CRs, there are particles like protons, alpha particles, heavier nuclei, positrons, electrons and photons. Particle abundance of CRs depends on energy of the primary particle.

For example, the particle composition of primary CRs in order of about 10 GeV is approximately 90% protons, 7% alpha particles, 1% atomic nuclei, 1% electrons and positrons and small fraction of photons. In energy region from TeV to PeV, the composition is different. Approximately 50% protons, 25% alpha particles, 13 % CNO (carbon, nitrogen, oxygen) nuclei and 13% are nuclei with atomic number closer to Fe [1].

The CRs have a wide range of energies. The energy spectrum begin approximately at GeV region (depends on solar modulation) and reaches energies to hundreds of EeV. At every energy region, there is different flux of these particles. The flux of CRs particles decreases with increasing energy. For example, the flux of the particles with energy above TeV is several particles per m^2 per second, while the flux with energy above 10 PeV is several particles per m^2 per year, the flux with energy above 10 EeV is one particle per km^2 per year and the flux of particles with energy above 100 EeV is one particle per km^2 per century. Primary particles with energies below GeV are deflected by the solar wind and the earth's magnetic field. Open questions remain at energies around PeV and approx. 40 EeV where the slope of the spectrum changes. These regions are called "knee" and "ankle".

Generally accepted view is that CRs particles are created and accelerated in active cosmic objects. The particles with energies around GeV region are accelerated by Sun. The particles with energy between GeV and PeV are mostly from supernovae remnants (SNRs). It is believed, that particles with the highest energies are extragalactic origin. It was recently shown, that there is a correlation between the arrival directions of CRs with energy above 60 EeV and the positions of active galactic nuclei (AGN) lying within ~ 75 Mpc [4].

Due to the interactions of CRs particles with cosmic microwave background (CMB), there is a upper energy limit of CRs particles [2]. This energy limit is called Greissen-Zatsepin-Kuzmin (GZK) cut-off. This GZK cut-off means, that if particle with soever high energy propagate higher distance than approximately 100 Mpc, its energy decreases to a value of 50 EeV.

If the primary CRs particle reaches the Earth, it interacts with the atmosphere and creates a shower of secondary particles. First interaction is at the altitude approximately 20 – 30 km. The shower grows, in its maximum (few kms above the Earth surface) may have from millions to billions of particles.

The detection of CRs particles can be made directly at lower energies. In the highest energies, the detection must be indirect.

Experiment CZELTA

The Institute of Experimental and Applied Physics (IEAP) of the Czech Technical University in Prague (CTU) realizes in collaboration with the Silesian University in Opava a project for the detection of high energy cosmic rays. This project, called CZELTA (CZEch Large-are Time coincidence Array), is realized in cooperation with the University of Alberta, that builds a network of detection stations in Canada (project ALTA). In the project, a relatively sparse network of detection stations is being built. The primary objective of the CZELTA project is to find correlations in the arrival times of air showers over large distances and to find non-random arrival times of air showers arriving at a single site. The detection stations are placed mainly on the roofs of high schools in the Czech Republic.

Each station is composed of three scintillation detectors, which are placed into a triangle configuration and use GPS2 signals for time-labeling of events. The distance between two scintillation detectors is 10 m. One scintillation detector has dimensions of 60 cm x 60 cm x 1 cm and is connected to a photomultiplier, which detects photons originated from the passage of an extensive air shower through the scintillator. The detectors work in coincidence. A shower must hit all three scintillators in order to be stored. In such a case, the energy of primary particle is at least 10^{14} EV. From the time difference among the signals measured among the scintillators, the direction of the extensive air shower and primary particle flight can be determined. Recognition of time of shower event detection is done by GPS (with accuracy 10 ns). This method enables the study of time correlations of data measured with distant stations. The project started in 2004 in Czech Republic. To the nd of 2006, four detection stations were built – one n Prague on the roof of the IEAP CTU, two in Opava at he Silesian University and one high school, and one at a igh school in Pardubice. For the next years, the aim of the project is to build a detection network of 20 stations in Czech Republic.

At present, the binary data from detectors are processed. The program for transformation of the binary data to the user friendly format was done. The software for analyze the data is still being developed. One of the first aim of the analyses was to determine flux of the CRs, and to find the correlation of the flux with meteorological data (pressure, temperature). We found a strong correlation between flux and pressure. Currently, the technique for the analysis of the non-random arrival times of air showers arriving at a single site is being developed.

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Portable Cryogenic Experimental Apparatus

V. Linhart, T. Horažďovský*, V. Sopko*, V. Hric*

Vladimir.Linhart@utef.cvut.cz

Institute of Experimental and Applied Physics, Czech Technical University in Prague, Horská 3a /22 CZ-128 00 Prague 2 - Albertov, Czech Republic

*Department of Physics, Faculty of Mechanical Engineering, Czech Technical University in Prague, Technická 4, CZ-166 27 Prague 6, Czech Republic

The aim of this student project was to construct a portable cryogenic experimental apparatus for laboratory works and to prepare software tools together with manuals. The apparatus is based on a helium cryostat (Janis Research Company, Inc., [1]) equipped by a chamber, a helium compressor, and an electronic unit controlling temperature from 11 to 400 K. The helium compressor of this apparatus is cooled by a water-cooling system (JDK, s.r.o.). The entire setup is designed as a portable experimental system easy to transport even to large distances. The software tools are based on plug-in modules. The tools serve for communication between PC and other electronic devices (e.g., high-voltage sources, electrometer, control units, etc.).

The portable cryogenic experimental apparatus was built and preliminary tested. The tests include (i) determination of limits in temperature controlling, (ii) tryout of material tests, and (iii) verification of spectroscopy-signal quality.

Temperature is lowered by expansion of helium gas in cryogenic chamber. It can be increased either naturally using non perfect thermal isolation or constrainedly using a heater. The time which is need for decreasing of temperature from room temperature to a minimum (11 K) is approximately 2 hours. The natural increase of temperature from the minimum to room temperature takes roughly 20 hours. Rates of the constrainedly temperature increase is determined using power settings of the heater. The tests have proved that the active heater has not measured influence on leakage-current values.

A measurement of thermally stimulated current (TSC) was used for the tryout of material tests. The TSC was done with a GaAs pad detector deteriorated using fast neutrons. The GaAs pad detector was made from a 250 μm thick Semi-Insulating Liquid Encapsulated Czochralski (SI-LEC, produced by CMK Ltd., Zarnovica, Slovakia) GaAs substrate. The detector was irradiated in the neutron field provided by the cyclotron-based fast neutron source of the Nuclear Physics Institute in Řež near Prague. The (p,n) reaction of 37 MeV protons on a thick beryllium target was used as neutron source reaction. The neutron spectral flux data were taken from the work of Lone et al. [3]. Within the energy range (2–30) MeV the spectrum of neutrons arising in the beryllium target is an approximately continuous plateau, which is followed by an exponential decrease up to 37 MeV. The fast neutrons interact with Ga and As atom nuclei via predominantly (n,p) and (n,α) reactions. The recoil nuclei, protons, and alpha particles produce defects in the crystallographic lattice of the GaAs substrate. These defects can cause sharp variations of the TSC. Such variations were measured with the GaAs pad detector. The TSC measurements with radiation detectors are still underway.

A test of the spectroscopy-signal quality was performed with the same GaAs pad detector. The detector was placed inside the cryostat chamber. The spectroscopy signals from this detector were taken out the chamber using coaxial cables. These cables were connected with a charge sensitive preamplifier followed by a linear amplifier with semi-gaussian shaping. The resultant spectroscopy signals were monitored by an analog oscilloscope with band width of 200 MHz. The monitored signals were intensely destroyed during processing of the helium compressor (expansion of the helium gas make mechanical shocks on which the spectroscopy system is very sensitive). The disturbances disappear when the helium compressor is turned off. Therefore, any spectroscopy measurement has to be made only in regime of the naturally temperature escalation.

The portable cryogenic experimental apparatus has great potential for the investigation of semiconductor radiation detectors and other scientific applications as well. Future work will be predominantly oriented on material characterizations and on preparation of special spectroscopy systems with cryogenic radiation detectors. The material characterization will contain (i) Thermally Stimulated Current spectroscopy (TSC), (ii) Deep Level Transient Spectroscopy (DLTS), (iii) Photo-Induced Charge Transient Spectroscopy (PICTS), etc. Furthermore, the portable cryogenic experimental apparatus will be potentially used also in material research oriented on temperature-dependent studies of crystallographic lattices using X-rays (e.g., Debbie-Scherer method) and electric- and magnetic-field distributions using electron-positron annihilation.

An example of the special spectroscopy systems is the utilization of the portable cryogenic experimental apparatus at small particle accelerators. In such case, the apparatus can cool a radiation detector which is situated in particle beam with the aim to measure the spectroscopy response under different temperatures. Another example is a spectroscopy experimental setup of a cooled radiation detector registering photons of X-rays under extreme conditions (e.g., under conditions reign during plasma explosion induced by a short high-intensively laser pulse inside a vacuum chamber of the PALS system, [4]).

The portable cryogenic experimental apparatus can be also used in wide variety of additional experiments and applications. Use of the cryogenic system and collaboration with the Institute of Experimental and Applied Physics of the Czech Technical University in Prague are kindly welcome.

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Network of Radiation Detectors for ATLAS

J. Žemlička*, Z. Vykydal,J. Jakůbek**, T.Holý****

Zemlija2@fjfi.cvut.cz

*Department of Dosimetry and Application of Ionizing Radiation,
Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University
Brehova 7, 115 19 Prague 1, Czech Republic

**IEAP CTU Prague, Horska 3a/22, 128 00 Prague 2, Czech Republic

The aim of the project is to build a network of devices to measure and monitor spectral characteristics and composition of radiation field inside of the ATLAS detector [1] during its operation. The devices are based on silicon pixel detectors MEDIPIX2 [2] adapted for simultaneous detection and identification of different types of radiation. The detectors are fully controlled by devoted interface [3] via Universal Serial Bus (USB), which is presently the most widespread PC interface. The pixel detector together with its USB interface operates as a single MEDIPIX-USB radiation monitoring camera.

The network of monitoring units for ATLAS consists of 14 MEDIPIX-USB devices. Four devices will be located between the moderator (JM) shielding and the liquid Argon (LAr) calorimeter. Similarly, two units will be installed along the tile calorimeter (TileCal) on each side. Another four devices will be placed near the ATLAS muon chambers and two devices will be located near the forward (JF) shielding. Five units will be operated and powered via active USB cables. Remaining 9 units (sitting in the most exposed places) will be equipped with special radiation hard active cables. The network will be controlled remotely by a PC located in the computer room.

From the operational point of view four tasks can be identified:

1) Measurement of composition of radiation field inside the ATLAS detector volume.
2) Determination of background radiation in the experimental hall and in the detector surroundings.
3) Evaluation of real performance of the different subdetectors (e.g. “particle/energy” leakage, punch through, etc.).
4) Studies of SEEs (single event effects) and SEUs (single event upsets) affecting performance and reliability of electronics operating in strong radiation field.

Semiconductor pixel detector Medipix2

The Medipix2-type hybrid silicon pixel device was developed in framework of the Medipix Collaboration [4]. The 300 μm thick sensor chip is equipped with a single common backside electrode and a front side matrix of 256x256 electrodes measuring 55μm x 55μm. Each of these 65.000 elements (pixels) is connected to its respective readout electronics integrated on the readout chip. Configuration of the pulse height discriminators determines the input energy window and provides noise suppression. The pixel counter records interacting quanta of radiation falling within the preset energy window.

For slow neutron detection the silicon sensor was covered with a ^{6}LiF neutron converter. For fast neutron detection the sensor was partly coated with a polyethylene foil of about 1.3 mm thickness.

Current status

The efficiency of the MEDIPIX-USB devices has been successfully calibrated with cooperation with Czech Metrological Institute. The calibration was done for gamma ray photons (^{55}Fe and ^{241}Am sources), slow neutrons (thermal neutron source) and fast neutrons (^{252}Cf and AmBe neutron sources). Further measurements with electrons, minimally ionizing particles (MIPs), energetic ions (protons, alpha particles, and other heavy charged ions) were done to test the behavior of the device in radiation fields similar to radiation environment which is expected inside and around of the ATLAS experiment.

The MEDIPIX-USB device was also successfully operated inside a nuclear reactor (near the active zone) at a neutron flux up to 10^9 n/s·cm^2 (which is about two orders of magnitude higher than the neutron flux expected in the most exposed parts of the ATLAS Inner Detector) demonstrate the high radiation hardness and wide dynamic range of the device.

Currently five devices connected via active USB cables are measuring the background radiation inside the ATLAS cavern. Another three radiation hard setups are mounted on the end cup inner muon detector which is being completed outside the cavern.

Conclusions

The MEDIPIX-USB device based on the Medipix2 assembly is a well-tested and reliable device for position-sensitive detection of single quanta of different types of radiation. Connected to a USB 1.1-based interface, it has been successfully used as a compact and portable detector for different types of application (X-ray and neuron tomography, spectroscopic imaging, observation of material damage evolution etc.). The read-out speed of 5 Mbits/s (5 fps) allows for many real-time measurements. The capability of the MEDIPIX-USB devices to perform real-time identification of neutrons, gamma rays, electrons and heavy charged particles will help us with the direct measurement and spectrometry of radiation field inside of the ATLAS detector when it will be started. It will also contribute effectively to the recognition and estimation of occurrences of SEEs (single event effects) and/or SEUs (single event upsets) affecting electronic signals, circuits and components, possibly caused by radiation in the ATLAS experimental conditions.

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Section 3

INFORMATICS
&
AUTOMATION ENGINEERING

Behavioral Criterions in a Robot Community

V. Svatoš, P. Nahodil

svatosv@fel.cvut.cz

Department of Cybernetics, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

In the light of contemporary trends in mobile robots control we remember an architecture based on Artificial Life (ALife) conception designed in 2001 by us. Our approach takes advantages of common ALife postulates and our reflexions to integrate under common conception multiple particular methods modeling robot a complex behavior from reactive, intentional and social views. We are focused on in-door robot navigation using imperfect perception. Our integral hybrid approach enables overcoming partial observable states and their solution complexity; especially Markov processes [1]. We reuse short-time targeting determines an active behavior as a way of immediate reaction in proximity moving. Mobile robotics interprets such decision in sense and action terms. Moreover, the robot rates efficient actions. Then it locates its local extreme in the criterion. The control system implements behavioral principles: desirability as the criterion, cross reinforcement among consequents and relation-based navigation in the state space.

The first view emphasizes robot individuality and its self competence (role) in each decision. Similar to case-based reasoning methods [2], the one case of robot activity can be derived just from finite cues. It makes a first-order of preprocessing, closed to applied particle filters coordinating the mobile robot teammates the ad-hoc goals or their successive localization in a dynamic game area.

Besides its geometrical application our architecture is focused furthermore. We manipulate not only in target points; even in desirable states, fulfilling such general robot criterions as a reduced uncertainty in decision, long-life no-collision guiding in a closed environment, or meeting attractive extremes. It moves a decision from a frontal verification (known in GA robotic as the test-beds) to a reinforcement optimization.

Second view approximates states out of perception scope. Intentions force in a robot behavior its attention just on relevant signals. It is open to integrate cues coming from neighboring domains. At social domain level, global parameters determine major aims of social behavior. The individual robot domain accepts such parameters to be input cues. Applied reactive action selection mechanism (ASM) for singular robots takes participation in the task according to actual opportunity. It includes also adequate individual robot responsibility for final task achievement. During each derivation step, the control system rates local impact in differential phenomenon (integral one for social impact respectively).

Third view takes into decision auxiliary implicit relations to other robot teammates. There we consider different roles in the multirobot team. Despite of our initiative inspirations by the natural pheromone communication [3] to lead the team (and not only by master robot), practical application of implicit team communication has extended cumulative capabilities of the intentional model. Recent states has represented in flow of intentions closely coupled with available sensors. We have also integrated few reinforcement learning [4] features. In our practical application robot has used trials and punishments to refine its initial knowledge base.

Communication capability allows building pure goal-oriented control system of mobile robots. Proposed control system in hybrid architecture combines top-down sub-goal assignment and bottom-up instinctive response. Such data-driven generative device puts the immediate reaction in actual local context anytime. Active sub-optimal response respects the most frequent trends to come near to required state.

The multi-domain hybrid architecture was formalized in an eco-grammar system framework. The eco-grammatical frame concerns evolutionary rules and action ones of group behavior. Parametrical L-systems make particular elements to describe multiple movements over the shared environment. Evolutionary rules induce an inner string representation from a local perception. Attractive, opposite and coherent communication patterns were introduced to be basic communication channels to goal-oriented ASM. Additive parameters received from participants allow foraging robots, more balanced in the task context.

Experiments with real community of four mobile robots demonstrated key features of the hybrid architecture deployment. There were perceived many attractive cues emerging from the real robot performance. As the social feedback, they allowed next refining reaction. Especially in cases that the reaction was represented by brief sense information.

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Educational Robot Control Using Universal Serial Bus

V. Plaček, F. Zámek

viktor.placek@fs.cvut.cz

Department of Instrumentation and Control Engineering, Faculty of Mechanical Engineering, Czech Technical University, Technická 4, 166 07 Prague 6, Czech Republic

Personal computers have become necessary equipment in research laboratories in the last decade. One of the reasons for such development is their usage in measurement automation and documentation which is achieved with computer-controlled instruments. The Universal Serial Bus (USB) has become the de facto low-cost personal computers interface for consumer applications. But only recently it has become a popular interface for data acquisition and machinery control applications.

In comparison with other buses, the USB offers many advantages. USB modules offer true plug-and-play capability. Modules connect to personal computer USB ports using a standard, low-cost cable. When plugged in, the personal computer automatically identifies the module and installs device driver software, simplifying setup and reducing start up time. This capability eliminates the need to open a personal computer to add a board, configure DIP switches and IRQ settings, search for the right device driver, and reboot the system.

USB modules offer good noise immunity, with performance benefits for noise-sensitive measurements. USB cables are typically one to five meters long, so the I/O circuitry is located further away from the computer's noisy motherboard and power supplies, and closer to the signals they will be measured.

For high-performance applications, USB modules that comply with USB 2.0 and are connected to personal computers with a high-speed USB 2.0 port can attain data transfer rates of up to 480 Mbits/s. The increased bandwidth enables multiple I/O operations simultaneously at throughput rates up to 500 kHz in each direction, similar to PCI measurements systems.

Aim of the work was control of Linxmotion, Inc. Lynx 6 robotic arm from personal computer using Universal Serial Bus. Robotic arm has six degrees of freedom realized with seven direct current servo-motors - two motors are coupled together.

The work should demonstrate our ability to use of Universal Serial Bus in automatic control and became experience in this field of control. Final robotic arm should stand as a platform for easy and quick realization of students' ideas and practical validation of theoretical hypothesis.

Electronic digital controller is embedded system based on Microchip PIC18F2550 microcontroller unit. This is a RISC microcontroller with Harvard memory architecture and hardware support for Universal Serial Bus communication.

Digital controller can work in slave or manual mode. In slave mode is controlled from personal computer using Universal Serial Bus. When switched to manual mode, each of the motors of the robotic arm can be controlled independently with turning knob.

The digital controller is also responsible for guarding of generated position of servo-motors no to exceed its angular range. This information was manually calibrated and compiled into digital controller program. This calibration is important while there is no feedback from the servo-motors to be able to detect such error state.

For communication of digital controller using Universal Serial Bus was used Microchip firmware running on single microchip together with robotic arm control program. This situation requires careful embedded system design because of time-critical nature of both processes running simultaneously - Universal Serial Bus communication and generation of

square pulses for servo-motor control. Mutual interference of the two processes could lead to wrong servo-motors positioning or to disconnection from personal computer as a malfunctioning periphery.

The digital controller program was realized in development environment Microchip MPLab v7.60 with ANSI C extension Microchip PIC-C18 v3.14. The digital controller hardware design was developed in application Eagle v4.16r2 of German company CadSoft, GmbH.

For communication with personal computer was used Communication Device Class of Universal Serial Bus specification revision 2.0. This class is realized by personal computer operating system as virtual serial port. This COM port is in usage very similar to common serial ports. Support of COM ports is widely spread among various automatic control applications thus giving wide realm of possibilities for engineers planning robotic arm control.

As control application in this case was used Mathworks Matlab v7.0 with Simulink module. A Simulink model was made for precomputing of servo-motors position. This data was sampled with 20 ms sampling period. Generated trajectory batch data was then sent as a Byte stream via virtual COM port to the robotic arm digital controller.

The nonreal-time nature of Simulink module was overcome using Leonardo Daga's RTBlock (RealTimeBlock) Simulink library. This library is able to synchronize Simulink numeric model computation to be accomplished in real-time. This enables to send trajectory data on-line as it is being generated.

The program on the side of a personal computer consists just from a block scheme of trajectory generation model and small program responsible for opening and closing of virtual COM port and periodic sending of Byte data stream to the digital controller.

The Virtual Reality Modeling Language toolbox was used for visualization of robotic arm position. As trajectory data is generated it is split to two channels - one sent to the digital controller and second used for control of virtual model. It allows controlling both real robotic arm and virtual model simultaneously.

The work practically demonstrated ways and possibilities of using Universal Serial Bus for automatic control of mechanical process. Robotic arm with control software now serves as teaching aid at Department of Instrumentation and Control Engineering. Software part can be very easily changed to verify theoretical knowledge of students on real mechanical body. Whole control system provides ability for future enhancements like another actuators or feedback equipment e.g. camera, tactile sensors, supersonic proximity sensors etc.

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Anticipation and Artificial Life

K. Kohout, P. Nahodil

kohoutk@fel.cvut.cz

Department of Cybernetics, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

Since the beginning of this decade there has been an increasing interest in the field of algorithms realizing anticipation. This topic is in focus of our group for several years already [1]. Basic definition of anticipatory systems was published in 1985 by biocyberneticist R. Rosen in his book Anticipatory systems [2]. He defined an anticipatory system as follows: "A system containing a predictive model of itself and/or its environment, which allows it to change state at an instant in accord with the model's predictions pertaining to a latter instant". Rosen in his book was inspired by his observation of live organisms, namely the ones with higher intelligence. He was inspired by their ability to predict the future and make adaptations based on them. This ability of live beings was already discovered way before. However Rosen utilizing this knowledge, created a theory which was abstracted for various systems. On the turn of century this definition was revised by D. Dubois. His research showed, that we can observe anticipation even in the systems where the creation of the model is not possible in principle (such as galaxies, electromagnetic systems etc.). Therefore he defined two categories for anticipation strong and weak. Strong anticipation systems are those, which crates the model of the object they are interacting with. Weak anticipation systems do not creates the model, it is part of their structure. The opposite for anticipation behavior is reactive behavior. Another researcher in this field Martin Butz [3] defined four types of anticipation. We will briefly mention them here because we are utilizing them in our research. Animate with implicit anticipation does not perform any prediction about its future states which can influence its future decisions. Sensory inputs (possibly combined with information about its inner state) are directly mapped to actuators of an agent. Evolution is implicit anticipation mechanism which prints the information into genes. In case the agent takes into account the prediction of reward (either positive or negative) for action it is going to execute, we can speak about animate with reward anticipation. Anticipation of senzoric data acquired through sensors does not affect the behavior of animate directly but through the sensoric data processing subsystem. For an animate in order to be able of such prediction we need at least partial model of the environment. One of the most interesting types of anticipation is explicit prediction of future states. These prediction influences directly the decision making process. The expected states can be processed and dealt with much faster than the unexpected and unpredictable ones.

Our research is focused on design and simulation of artificial creatures – animates with anticipatory behavior. First experiments and propositions of anticipatory architectures in our research group were presented in 2004. Several advances have been made on the field of anticipation research since then. It is due to say that there are still more opened questions than answers. These are still being addressed by the researchers worldwide. Designed animates were greatly inspired by sciences such as ethology, biology and psychology. After several successful hybrid animate architectures which combined the top-down and bottom-up approach [4] we have realized, that anticipation would bring another dimension into the decision process and open new possibilities in terms of action selection. The real problem we are facing and working on to solve now is to design fully anticipatory agent architecture as we

call it. This means to find optimal tradeoff between approaches in order to employ the anticipatory mechanism on more than one aspect of the architecture. In terms of four basic types of anticipation defined by Martin Butz (mentioned above) we want to incorporate all these four types in single anticipatory architecture of animate. We had split anticipation into two new categories – conscious and unconscious anticipation. These are more closer to the terms from biology and ethology. As a first rough approximation we can understand unconscious anticipation as implicit and sensory anticipation in sense of Butz definitions and payoff and state anticipation as conscious anticipation. In our opinion there are several basic instruments which each animate needed in order to survive in natural sense: ability to perceive the environment (sensors), ability to influence the environment (actuators), the internal state (self-reflection), possibility of genetic evolution (survival of the species) and learning capabilities (survival of individual). Anticipation can be integrated in all of them. Our work can be understood as anticipatory redesign of so far agent structures. Until today there have been architectures focused on specific area or type of anticipation. What we want to achieve as we already mentioned above is to integrate all this knowledge into one fully anticipation capable animate at all levels of decision making process starting from the very basic approaches with only implicit (built in) anticipation up to the fully conscious and intentional reasoning about future states of self and also others. First step is design of reactive anticipatory agent (agent with implicit anticipation) and its test and comparison in several typical scenarios. This agent can be then further modified with sensory anticipation. Once this step of architecture is tested, proved in simulations and compared with non anticipatory version we can start with further advancements building the learning functions, generalization, planning, reasoning up the high cognitive function such as social interaction, cooperation and collaboration. This structure is quite complex and it needs to be built up slowly and carefully with stress on experiments as confirmation of the functionality of designed architecture and assurance of reusability. This is still the subject of our ongoing research none the less we wanted to share this as an outline of our next activities.

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Implementation of new Measurements on Digital Signal Processors

T. Valenta

valent1@fel.cvut.cz

Department of Telecommunication Engineering, Czech Technical University
Technická 2, 16627 Prague 6, Czech Republic

This paper describes the implementation of new measurement task in the subject Digital signal processing in Telecommunications. The innovation will take place in the education in fall 2007. This paper will state the differences in the lectures and task syllabuses for the experiments performed on real signal processors. The introduction of new Texas Instruments processors (TMS320C6455) is also outlined in the text.

For good understanding of digital signal processing it is necessary to test the implementation in real signal processor, because only theory will not prepare students for practical applications of the subject. For this purpose the subject of digital signal processing offers practical training assignments of common used techniques in voice signals processing. The aim of this improvement is to bring new experience to students through video signal processing examples. It also introduces new hardware equipment and some up-to-date technology to lab use.

Those new examples utilize digital processors from Texas Instruments, which are suitable for use in video signal processing. It is also necessary to create lab materials describing the use of this new equipment.

The aim of the course is to teach students basic techniques of digital signal processing from the analogue-digital transformation towards the simple methods of speech and video coding. Practical experiments consist of several tasks during the term. Tasks helps students to understand the subject. The current syllabus of the term is:

1. Development tools for digital analysis and synthesis
2. Basic work with Matlab system
3. Task 1 – Integral transformation (DFT, FFT, DCT)
4. Task 2 – Analysis and synthesis of filters with infinite impulse response
5. Task 3 – Analysis and synthesis of filters with finite impulse response
6. Task 4 – Decimation and interpolation filters, signal resampling
7. Development tools for realization of digital system on signal processors
8. Basic instruction set of digital signal processors
9. Task 5 – Digital system design and simulation
10. Task 6 – Realization of digital system
11. Task 7 – Compression of speech signals
12. Test
13. Task 8 – Evaluation of designed digital system properties
14. Credits

There are missing practical task dealing with still pictures and video signals. Those are the subject of improvement.

New experiments designed for this course are dealing with video signal processing – first tasks is still image compression and second task is television signal compression. Those task requires new hardware to implement them. After several consideration starter kits type TMS320C6455 from Texas instruments [1] were chosen. Those units are equipped with fixed point signal processors and have a VLIW (Very Long Instruction Word) architecture. Since those units are not equipped with video inputs a daughter cards must be supplied – suitable products are component cards from Einfochips type C6000 EVM/DSK. Those cards have appropriate NTSC/PAL and S-video input and output which will supersede the need of expensive video codecs.

New course will be adjusted for good utilization of the new equipment and to bring the most recent practical experiences to students.

1. Development tools for digital analysis and synthesis
2. Basic work with Matlab system
3. Task 1 – Integral transformation (DFT, FFT, DCT)
4. Task 2 – Analysis and synthesis of filters with infinite impulse response
5. Task 3 – Analysis and synthesis of filters with finite impulse response
6. Task 4 – Decimation and interpolation filters, signal resampling
7. Development tools for realization of digital system on signal processors
8. Introduction to TMS320C6455 starter kit usage
9. Task 5 – Realization of digital system on starter kit
10. Task 6 – Implementation of speech signal compression on starter kit
11. Task 7 – Implementation of still image compression on starter kit
12. Task 8 – Implementation of television signal compression on starter kit
13. Task 9 – Individual task realization on starter kits
14. Tasks evaluation, credits

The hand-on experience on starter kits with practical training will make apparent increase in students' education profit.

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Comparison of Different Implementations of BLAS and LAPACK Libraries with Application in Computational Fluid Dynamics

D. Langr, I. Šimeček

langrd@fel.cvut.cz

Department of Computer Science, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

Introduction

The performance of much physical modeling software strongly depends on underlying low level linear algebra libraries being used. For matrix-vector computations, BLAS [4] and LAPACK [1] libraries are well known and frequently used standards. There exist various more or less optimized implementations of these libraries:

1. the original implementation from netlib.org,
2. the implementations provided by computer processors vendors,
3. the third-party implementations.

The aim of this paper is to compare few implementations of BLAS and LAPACK libraries in combination with different compilers.

BLAS and LAPACK implementations

The original implementation from netlib.org is deployed in the form of the Fortran source codes. These have to be compiled and final performance of such library depends on optimization capabilities of the compiler.

Processors vendors usually develop their implementations of BLAS and LAPACK libraries. These libraries are designed and optimized for particular processor type and are deployed in the static or dynamic binary form. Intel Math Kernel Library (MKL) for Intel Pentium and Intel Itanium processors and AMD Core Math Library (ACML) for AMD Opteron processors are examples of such implementations.

There are also some third party open source implementations of BLAS and LAPACK libraries as GotoBLAS or ATLAS. Usually, source codes are provided and need to be compiled. The dependency of performance on compiler optimization capabilities is eliminated by coding the performance-critical parts of source codes in the assembler language.

The application in Computational fluid dynamics

The aim of our research was to compare few implementations of BLAS and LAPACK libraries in the combination with different compilers with application in computational fluid dynamics (CFD). For this purpose, we have used a fluid flow problem computed with finite element based CFD solver Femfluid written by Petr Sváček. This solver is based on non-stationary uncompressible Navier-Stokes equations (see, e.g. Johnson [3]). Within every time step a non-linear problem is solved by an iterative process and within every such iteration an unsymmetric sparse system of linear algebraic equations is solved by the UMFPACK library.

The UMFPACK library is an open source library for solving unsymmetric sparse systems of linear algebraic equations by sparse direct LU factorization with the partial pivoting strategy (see Davis [2]). The low level matrix-vector operations are performed with BLAS and LAPACK routines. The UMFPACK library is deployed in the form of source codes and it has to be compiled and linked with the particular implementation of BLAS and LAPACK libraries.

Testing configurations

We were interested in several test configurations defined by:

1. the particular type of CPU,
2. the particular implementation of BLAS and LAPACK libraries,
3. the type and version of the used compiler.

The whole process of the measuring for one test configuration is described as follows. On a computer with particular processor type the particular implementation of BLAS and LAPACK libraries was installed, or compiled with particular compiler if needed. Then the UMFPACK library was compiled and linked with them. Finally, with this UMFPACK library the test program for solving sparse unsymmetric system of linear algebraic equation was compiled and linked. The matrix and the right hand side vector describing this system were extracted from Femfluid software within the given fluid flow problem. The time of solving the system was measured.

Test configurations we measured are described here:

- Two computer processors were used – single-core Intel Itanium 2 1,5 GHz processor and dual-core AMD Opteron 8820 SE (Second Edition) 2,8 GHz processor.
- The Fortran compilers GNU *g77* version 3.2.3, GNU *gfortran* version 4.2.1 and Intel *ifort* version 9.0 were used.
- The C compilers GNU *gcc* version 3.2.3 and Intel *icc* version 9.0 were used.
- The original BLAS and LAPACK implementation was taken from netlib.org source.
- The MKL version 7.2 and ACML version 3.6.0 implementations were used from Intel and AMD processor vendors.
- The third-party GotoBLAS version 1.16 library was used.

Conclusions

- The original BLAS and LAPACK implementations compiled from source codes give very poor performance compared to optimized implementations.
- There is only small or none difference between performance of vendor made and third-party optimized implementations of the libraries.
- For Intel Itanium 2 processor, the optimization capabilities of GNU compilers are much worse than these of Intel compilers.
- For AMD Opteron processor, there is no significant difference between using GNU and Intel compilers.

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Parametrization of Airfoil Geometry with B-spline Curves in Polynomial Form

Daniel Langr

langrd@fel.cvut.cz

Department of Computer Science, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

Introduction

An airfoil geometry is usually defined by a set of points in the x-y plane. For many standard airfoils these points may be found in various databases (see, e.g. [3]) and are frequently perturbed within the task of aerodynamic optimization of the profile under given constraints. For aerodynamic computations a computational grid has to be generated first around the airfoil. Grid generators are usually based on partial differential equations of hyperbolic or elliptic type. The solution of these equations needs the initial or boundary conditions and these represents some number of points (further called nodes) placed along the airfoil in a specific way. To place the nodes along the airfoil we first need to parametrize the airfoil with a parametric curve. B-spline parametric curve (see, e.g. [1, 2]) is one of the possibilities.

The b-spline curves are parametric piecewise polynomial curves. Mathematically they are defined by recursive b-spline basis functions. A common way to work with b-spline curves is to use the recursive definition but this can be too time-consuming. It is also not easy to get some characteristics of the curve such the tangential vector or the value of the curvature, which are defined by the derivatives of the curve of some degree.

The aim of my research was to transform the curve to its piecewise polynomial definition. Piecewise polynomial means that there is some set of intervals along the curve such that on each interval the curve is defined by a simple polynomial function. Unfortunately, it is not possible to find the coefficients of the polynomials straight from the recursive definition of the curve. However, we can find them by solving small systems of linear algebraic equations for each particular interval. After obtaining the polynomial coefficients it is easy to work with the curve such as find the derivatives of any order.

The application in equidistant nodes generation

To compare the recursive and the polynomial definition of the b-spline curve the following problem was taken. We want to place the desired number of nodes along the curve in an equidistant way. It means that the space between the two adjacent nodes is constant all along the curve. Computationally, this is not an easy task. The space between two nodes is equivalent to the length of the curve segment between these nodes. The length of a segment of a parametric curve is defined as the integral of the square root of the sum of the squares of the first derivatives of the curve. Within the scope of the polynomial definition of the curve, it represents the integral of the square root of the polynomial. Such integral cannot be solved analytically and the numerical solution has to be implemented. I chose the adaptive five-point Gauss-Legendre numerical quadrature. Omitting the details, it is important to note that this is a numerical iterative process controlled by a desired precision and a maximum allowed number of iterations.

To find the particular node on the curve we need to solve the non-linear equation by another iterative process. Inside each such iteration the integral described above is computed.

Inside the outer iterative process, which solves the non-linear equation, is then nested the inner iterative process, which computes the value of the integral.

Testing case

A test computational case of the problem described above was established and measured. As a reference airfoil the NACA 64A410 was used, obtained from [3]. The degree of the polynomials was set to the value 4, which ensures smooth curvature along the whole curve. The program was written in C++ programming language and all measurements were performed on the same machine with Linux operating system and GNU C++ compiler.

Results

Using the recursive definition of the curve, the measured time took several minutes while using the polynomial definition of the curve the measured time took only several seconds. The latter measurement includes the curve transformation from recursive to polynomial definition by the solution of linear systems.

Vandermonde matrices

It should be noted that the matrices of the mentioned linear systems are of a very special form – so called Vandermonde matrices. It is known that these systems have unfavorable properties for methods of their solving. My observation is that this issue does not have any effect on the shape of the resulting curve, compared visually. Such visual control is, however, not always possible; for instance in the case of aerodynamic optimization there could be hundreds or thousands of generated airfoils. Hence the deeper mathematical analysis of this problem would be useful complement of this research.

Conclusions

The transformation of the b-spline curve from the recursive to the polynomial form was performed and both cases were compared. The polynomial form turned out to be much more efficient to work with. No difficulties were observed comparing both result curves.

Further research

The equidistant nodes generation would not lead to a good quality computational grid. It is necessary to control the density of the nodes in particular parts of the curve. There are two such major needs. First, for the purpose of accurate computation we need to place the nodes more closely in the curve segment, which corresponds with the leading edge of the airfoil. Second, the methods for solving partial differential equations, which use the grid generators, need the nodes to be placed more closely near the trailing edge or the airfoil; this is due to the unstable behavior of the solution around the corners of the trailing edge. These needs could be relatively simply implemented but the resulting algorithm could be too time-consuming. It is the subject of further research to investigate if such process could be useful for practical applications.

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Effects of Anticipation Behavior in Artificial Life

P. Nahodil, A. Elmahalawy

nahodil@fel.cvut.cz

Dept. of Cybernetics, Faculty of Electrical Engineering, Czech Technical University, Karlovo námestí 13, 121 35 Praha 2, Czech Republic

Over the past century, studies of human behavior have been profiting from the finding that our ***behavior is goal oriented***. In our daily life, anticipation, the prediction of future events, influences our behavior. This influence manifests itself in the setting of long-term goals and also in short-term decision-making. For example, pursuing a long-term goal such as a diploma degree, we anticipate a higher income in the future. As for the short term decision-making example, the anticipation of satisfying hunger makes us eat; the anticipation of a better place to rest makes us choose to lie down in the bed rather than on the floor. Short term decision-making influences the very behavior; for example, the (not necessarily conscious) anticipation of tumbling makes us walk more carefully on a slippery surface. To sum up, anticipation is an important part of human behavior. (Dictionary of the English Language for the verb "anticipate": To think, speak, or write about a matter in advance, more than expect only. To feel or realize beforehand; To look forward to, especially with pleasure; To deal with beforehand; To cause to happen in advance; accelerate.) Robert Rosen defined the anticipatory system as *"... a system, containing a predictive model of itself and/or its environment, which allows it to change something at an instant in accord with the model's predictions pertaining to a later instant."* [1]

Previously, we have introduced the importance of ***Anticipatory Module (AM)*** in different systems and simulators. Also, we evaluated the performance of *Multi Agent Systems* ***(MAS)*** with ***AM*** using two different machine learning algorithms (***Markov Chains and Genetic Algorithm***). From this previous research, a question is appeared, what are things that affect to the ***AM***, the ***MAS*** architecture, or the machine learning algorithm? This work is aimed at answering this question by suggested *New Multi Agent Systems* ***(NMAS)*** *Architecture* with ***AM*** and with a *Modification of Markov Chains* (***MMC***) that is used in an *Anticipatory Module* ***AM***.

Anticipation allows a system to be adapted to conditions that have not yet come, either externally to the system or internally. Autonomous systems actively control their own conditions so as to increase their functionality (they are self-regulated). Living systems self-regulate in order to increase their own viability (theory of evolution). These increasingly stronger conditions, anticipation, autonomy and viability, can give an insight into progressively stronger classes of models of autonomy. [2]

Several successful experiments have been made by us, aimed at integration of anticipatory mechanisms (AM) into the artificial learning systems in the framework of ***Artificial Life (ALife)***. In our simulator were implemented reinforcement learning, learning classifier systems and related ALife systems, as well as neural networks. So far, research in AI has included anticipatory mechanisms wrapped in model learning systems such as the model-based reinforcement learning approach. Anticipatory processes were never analyzed on their own. [3]

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We are engaged in research of two already designed and implemented anticipatory systems with different approaches to their describing and implementation.

1. ***Anticipatory Agent System (AAS)*** used anticipatory module internally for each agent and gave the results for effectors to perform the action. We could consider this as *distribution of anticipation.*
2. ***New Multi Agent Systems (NMAS)*** used anticipatory module externally for all agent where all agent give their input to it and then it gave the output to effectors to perform the action. We could consider this as *central anticipation.*

Also, we suggested a new modification of a well known machine learning algorithm (***Markov Chains - MC***). This algorithm is used in an Anticipatory Module ***(AM)*** of the both previous systems. In evaluation, we have realized and presented many experiments (using the simplified input data) due to make the objective comparison between the previous systems both with ***MC*** and the Modified Markov Chains (***MMC).***

According to the structure of both systems and the performance's evaluation, we concluded that the performance of ***NMAS*** was much better than the performance of ***AAS***. So it seems to us that the central anticipation is better than distributed anticipation. The central anticipation takes all inputs from an agent and then does *anticipation in a global view*. But the distributed anticipation does *anticipation in a local view* for each agent separately.

In the case of the performances comparison of two algorithms (***MC*** and ***MMC***), we could say that the performance of ***MMC*** was better than ***MC*** algorithm in the all surveyed different cases. In ***MC***, it calculated the transition probability from one state to another state only one time and it didn't change during the running time. But in ***MMC***, it calculated this probability at the beginning and changed its value during the running time to good final results. This algorithm was based on the principals of adjusting the weight in Neural Network. The only drawback of this algorithm was that it took more running time than MC to be adjusted the transition probability to a good value.

The anticipation behavior is the most important in ALife domain. In our research, we study the conditions that affect the anticipation as the structure of the modeling system and a machine learning algorithm. The main goal of our future work is to verify the usefulness of the new modifications described here in a real life application.

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Hierarchical Reinforcement Learning in Artificial Life Agents

D. Kadleček

david.kadlecek@cz.ibm.com

Department of Cybernetics, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

This research designs architecture for intelligent autonomous agents intended to behave in complex Artificial Life like environments. The designed control architecture gives the resulting agent ability to be reactive with respect to local disturbances and uncertainties and adapt to more persistent changes in environmental conditions and task requirements. This adaptation occurs in such a way that the agent optimizes its behavior so as to minimize required effort and maximize its profit (i.e. gather maximum environment resources while consume minimum energy). Learning and adaptation occurs without outside intervention – unsupervised learning, which means that the agent itself must decide what is "good" and what is not.

The primary motivation behind this research was to integrate more rigorous methods of reinforcement learning and control engineering into behavioral and ethology approach to agent technology. Designed agent architecture, called HARM, uses concepts from intelligent agent architectures, ethology/biology, hierarchical reinforcement learning and control engineering. Essential component is the dynamic state system that represents agent's properties and its dynamics. The dynamic state system corresponds to physiological state space of animals that through environment feedback provides means for agent's self-regulation and self-motivation. Self-regulation means that the agent itself evaluates its internal conditions and chooses behaviors leading towards optimal state. The agent acts fully autonomously because of its self-motivation capabilities. Neither apriory defined motivations nor online external stimulation is required. Besides motivating functionality, the physiological state space provides basis for assessment of action (or composite behavior) utilities. Second important component is the controller. The controller learns individual behaviours using Q-learning or other online, model free, reinforcement learning method. Learning and control is performed simultaneously in a hierarchically decomposed Semi Markov Decision Space (SMDP). Hierarchical decomposition of the root SMDP is performed automatically based on reinforcement types encountered by the agent. The controller uses motivations provided by the physiological state space to choose the most appropriate behaviour at the given time and state. Agent's behaviour is continuously optimized and adapted according to criteria function. The criteria function is constructed as fulfillment of agent's internal needs.

One of the most important topics of this work is automatic creation of SMDP hierarchies. The decomposition process happens in iterations where a set of patterns is applied in the defined order to SMDPs. Major determination factor for hierarchy creation are reinforcements received by the agent. Reinforcement types can be used for

- horizontal diversification:
    - complementary reinforcements - reinforcements obtained in two behaviors that cannot be used in place of one another in at least some of their possible instances => used to split decision space horizontally

  - compatible reinforcements - reinforcements obtained in two different behaviors that are both necessary to complete some composite (higher level) behavior => used to create composite behaviors
  - substitute reinforcements - reinforcements obtained in two different behaviors that can be used in place of one another in at least some of their possible instances => behaviors that contain substitute reinforcements are contained in the same SMDP
- vertical diversification => behaviors on different vertical level are placed at different level in the tree in the hierarchy

The individual patterns that are applied during the hierarchy creation process are:

- Splitting: SMDP is split to different SMDPs
- Variable promoting: variable is generalizes and moved to parent SMDP
- Variable removing: unused variables are removed from SMDP
- Behavior Associating: SMDP is associated with variables in physiological state space

Resulting agents have been realized using Java software platform and tested in a simulation environment. This work presents several new concepts and its main contribution to agent research is perceived in:

- Integrating principles of ethology/biology, agent technology, reinforcement learning, and control engineering in one architecture
- Automatic creation of Reinforcement Learning hierarchies as opposed to the existing known methods that require a priory decomposition done by the designer
- Rewards used for Reinforcement Learning are inferred by the agent, not by the designer
- Integrating behavioral (bottom up) and deliberative (top down) approaches in a single parallel controller
- Presenting new method for evaluating optimality of agent behavior that is particularly useful in Artificial Life domain

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Laboratory Model "Air levitation" Innovated for Courses in Automatic Control

J. Fišer*, P. Trnka**

Jaromir.Fiser@fs.cvut.cz

* Centre for Applied Cybernetics, Czech Technical University in Prague, Technická 4, 166 07 Prague 6, Czech Republic

** Department of Instrumentation and Control Engineering, Faculty of Mechanical Engineering, Czech Technical University in Prague, Technická 4, 166 07 Prague 6, Czech Republic

In this paper an interface concept of "Air levitation" task is created for the purpose of labs in Automatic Control Courses (ACC). This interface has to be developed so as to be its concept consistent with the concept of Multilingual Virtual Control Laboratory (MVCL) presented recently [1]. This MVCL is available in the Internet, see [2].

The "Air levitation" task is only one of the other suggested tasks, namely "Air Jet" and "Bathyscaphes", for the sake of interface design in the program MATLAB® of The MathWorks, Inc.. The entire interface will be based on GUI (Graphical User Interface) library of MATLAB. The GUI interfaces should relieve operating the tasks by students as from Czech republic as from other countries. These operations are also proposed to be able via Internet, as presented in [3].

Now, let be given the specification of the laboratory model "Air levitation". A ventilator sucks air and pumps it into the air channel. The air stream, coming out of the air channel, lifts up the ball. This amount of air is controlled by the signal *u*, which controls the power of the ventilator. The position of the ball *y* is measured by the sensor and controlled by the chosen type of controller or manually, by manual setting of the signal *u*.

The "Air levitation" task involves PID control of position *y* with anti-windup solution considered as the chief aim for students' work. This control is based on control equation as follows

$$u(t) = r_0 e(t) + \frac{r_0}{T_i}\int_0^t e(\tau)d\tau + r_0 T_d \frac{de(t)}{dt}$$

where a control error results in

$$e(t) = w(t) - y(t) - K\big(u(t) - sat(u)\big)$$

with a reference variable *w*. Constants r_0, T_i, T_d are proportional gain, integration time constant and derivative time constant, respectively, while *K* is a weighting gain of windup compensation, known as the conditioning of PID controller [4]. Not only this aim but also other subtasks, reported in [2], are planned to be made accessible by GUI interface. The subtasks can be summarized into following points.

a) Attach PID controller to the system and set its parameters (r_0, T_i, T_d) using the Ziegler-Nichols method of critical setting. Thus

1. eliminate I a D component of PID controller by setting $T_i \to \infty$, $T_d \to 0$.

2. Slightly increase gain r_0 of proportional component of PID controller.

3. Increase the value of r_0 , until sustained oscillations are reached.

4. Now, the value r_0 corresponds to critical gain r_{0k} and time period of oscillations determines critical period T_k .

5. Based on found values of r_{0k} and T_k compute values of r_0, T_i, T_d with formulae $r_0 = 0.6 r_{0k}$, $T_i = 0.5 T_k$ and $T_d = 0.12 T_k$.

b.) Perform the unit-step responses on the reference variable *w* when applying PID controller with parameters critical setting. Find the settling time T_r, overshoot and steady state control error e_∞.

c) Compare control responses when following controllers (P, PI, PD, PID) are considered, attached to the system, then analyze the stability of oscillations of the feedback control loop for each type of controller and its various parameters.

d) Connect a two-position controller to the system and show how the period of the limit cycle depends on the hysteresis *H*.

e.) Perform the unit-step response of the system, describing the dependency of the output *y* on the signal *u* (unit-step of *u*) in a chosen operating point, and then identify the system from output response.

f.) With the help of the unit-step response in e.) analyze whether the system is static or astatic and estimate the sensitivity S_u of the output *y* on the actuating signal *u*.

Finally, these subtasks are gradually developing. Moreover, colour, shape and topology design of the interface is being unified to be the operations user-friendly.

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Effects of Anticipation Behavior in Artificial Life

P. Nahodil, A. Elmahalawy

nahodil@fel.cvut.cz

Dept. of Cybernetics, Faculty of Electrical Engineering, Czech Technical University, Karlovo náměstí 13, 121 35 Praha 2, Czech Republic

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The database structure design for management and presentation of the spatial vector data containing the folk architecture metrical documentation

L. Tláskal

lubomir.tlaskal@fsv.cvut.cz

Department of Mapping and Cartography, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Praha 6, Czech Republic

Preface

Conventional architectural drawing still remains to be the most demanded metrical documentation output. Nonetheless, the digital processing and designs set up in increasing rate even in conservative field like folk architecture documentation.

The geodetic survey data serve as groundwork for architectural drawing. The application of total stations, easier and more effective application of photogrammetrical methods has changed the character of surveyed (measure) data. The data used to contain only measured sizes. Today, the output data are mainly 3D coordinates of individual points, which allow us to do detailed treatment of vector model and successfully use it to automatically create technical documentation.

The existing model has various uses [1]. The topic of this article is the use of spatial data together with non-graphical data stored in an external database. What are the reasons to use the database interface? The database interface offers many capabilities otherwise unavailable to a regular CAD user. This spans from a simple application tracking part numbers in assembly process to sophisticated facility management systems responsible for the operation and maintenance of a large organization, and everything in between.

For each element of database, a concrete documentation application could comprise used material, level of damage, age, architectural style and functional specifications.

It's a base for simple information system where there are linked spatial and non-graphical data.

Used software and technology

The CAD system Microstation V8 has been chosen for this project. There are decisive reasons in favor of this choice. About 95 percent of the world's infrastructure is designed, constructed and maintained using DGN and DWG files and Microstation provides native support for DNG and DWG file format. DWG files from Microstation have a high level of compatibility with AutoCad, which uses DWG as its native file format. Both Microstation and AutoCad support many popular relational database software product families.

To select the "right one" could be somewhat difficult since these databases differ in a broad range of sophistication, performance and costs. One can implement anything from a single-user database on PC to full featured corporate network system with database servers and distinct vendor databases interacting with the common design files.

There are many factors influencing the choice of database. In our case, simplicity of implementation, low hardware and software requirements, low acquisition costs and high level compatibility, the possibility to create, edit and report data independently of CAD program is required.

Under these conditions is the most convenient solution based on single-user local database accessed with Open Database Connectivity (ODBC) interface. ODBC interface allows applications, via database drivers, to access data from variety of database management systems.

The database Access, Excel and MSSQL 2005 Express were chosen for their availability and wide popularity. Database Excel and Access are included in Microsoft Office package. SQL Server 2005 Express Edition is a free, easy-to-use, lightweight, and embeddable version of SQL Server 2005.

Principle of data association

The database interface is a set of tools and settings that lets user to associate (or link) a row in a relational database to an element in the design. This is done by storing information about the linkage on the element in the DGN file. In order to link a table to a graphical element, the table must have a numeric MSLINK column. This column acts as a unique row identifier (essentially a row ID) for MicroStation. The second requirement is that the database contains a table called MSCATALOG, which MicroStation creates upon connecting to a database if one has not already been created. The attribute table name is entered and assigned a unique entity number.

There are two pieces of information used to retrieve the correct row from the correct table. The first one is the entity number, a unique value assigned to the table in the MSCATALOG. The second one is called MSLINK number, a unique value assigned to the row of data in the table. If a database row is linked to a graphical element, attribute data, in the form of a USER DATA Linkage containing the MSLINK and entity number, is written to the element.

Once this linkage is established one can manipulate and review the database information from inside MicroStation.

Application

Used solution was implemented and applied by the author to create metrical documentation of the farmers house no. 97 in the village Čistá in year 2006. Attachment of a non-graphical information together with detailed model of a historical wooden house (model comprises individual beams, detail of carpenter's treatment) represents unique base for investigation and potential reconstruction of this historically valuable house.

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Frequency Analysis Based Quality Control Indicator Autotuning

S. Vrána

stanislav.vrana@fs.cvut.cz

Department of Instrumentation and Control Engineering, Faculty of Mechanical Engineering, Czech Technical University, Technická 4, 166 07 Prague 6, Czech Republic

There exists a lot of modern control algorithms, but in practise the most used control alorithm is still the PI/PID algorithm. The greatest advantage of PI/PID controllers is its relative simplicity allowing users to understand its function without necessity of deep control theory knowledge when it is implemented. Using PI/PID controllers, it is possible to carry out in situ controller parameter tuning. This is what industrial practise prefers because in experimental tuning any control circuit modelling is unavoidable. This is why the most frequently used controller tuning procedure represent still Ziegler and Nichols rules (disregarding they were published in 1942). In some last years, Åström and Hägglund method has become popular. Both two mentioned methods have a significant disadvantage – control function of the control circuit is interrupted during search of a new (better) controller parameter setting. It means that disturbances are not eliminated during this period. This is the reason why new PI/PID controller autotuning methods are constantly developed. The method which is presented in the paper is based on achieving control quality via indicators of optimal controller setting. Optimal controller parameters are searched without loosing control function of the controller.

Although control quality indicators were introduced by the linear theory, they can be used in non-linear control circuits, especially in such where the controlled plant does not show many signs of linear behaviour. The indicators are connected with well-known Nyquist plot. The best-known indicators are Maximum Sensitivity (M_S), Gain Margin (m_A), Phase Margin (γ), and Crossover Frequency (ω). As additional indicators can be used Maximum Sensitivity Frequency (ω_S) and Phase Margin Crossover Frequency (ω_π). It is also possible to define another control quality indicator which descripts the optimality for any concrete case of plant. There is only one limitation that the desired values of chosen indicators can be reached together. The basic idea of the control quality indicator use is mentioned in [3]. The principle of the method is based on adding small harmonic oscillation to the control error and evaluating a steady state frequency response to this excitation. Their properties and relation between added harmonic oscillation and its response (amplitude gain, time shift, and phase) are evaluated. Then the verification if control quality indicator can be computed is made. If no control quality indicator, then the added harmonic oscillation frequency is changed and the evaluation is made again. If the control quality indicator can be computed, it is computed and its value is compared to their desired value (desired interval of values). If the computed control quality indicator value differs from its desired value, the new PID controller parameter setting is computed. This procedure is repeated as long as all chosen control quality indicators reach their desired values. The added harmonic oscillation should be very small to avoid that the controlled variable leave its operation zone. It is also important to realize that most of the introduced indicators are characterized by a specific attribute, e.g., the value of the magnitude in the indicator Phase Margin is always equal to one, and the phase angle in the indicator Gain Margin is always equal to -180°. These values can be used as conditions under which it is possible to evaluate from the frequency response for a set frequency the specific value of the

searched indicators. This permits two ways of control quality indicator evaluation. The first way is to fix the condition and to change the added harmonic signal frequency so that the control quality indicator achieves its desired value, the second way is to fix the control quality indicator value and to change the added harmonic signal frequency so that condition when the indicator is observable should be found. The same mechanism can be use on evaluation of actual PID controller parameters optimality. The mechanism is described in detail in [1] and [2]. The own evaluation of added harmonic oscillation and its response is based on simple peak detection. It is possible to use zero crossing detection also but it is not appropriate in the case when an offset of controlled variable or control error can occur or if the noise is significant. If the noise is significant it is suitable to use a filter. The filter should be applied both to added harmonic oscillation and to its response to prevent wrong evaluation of relation of both signals because the filter causes additional time delay. Both of used filters should be the same. The amplitude of added harmonic oscillation should be controlled in that way that the controlled variable does not leave its operation zone and the response of the added harmonic oscillation stays detectable. It is also suitable to change amplitude of the added harmonic oscillation not so often because every made change causes additional time consumption. The situation at the beginning of the autotuning process when amplitude gain is not known can be solved in two ways. The process can start with very small amplitude of added harmonic oscillation which continually increases so that its response is detectable or the initial amplitude can be set manually.

The advantages of this method are its relative simplicity, unneeded knowledge of model of plant, no interruption in the control process, purely software implementation, utilization of more than one control quality indicator simultaneously, and the use of the same mechanism both to find new optimal PID controller parameter values and to evaluate if the actual PID controller parameters values are optimal. Because this method does not use any model of controlled plant, it has a good chance to be used in industrial praxis. Expected disadvantage are speed of the tuning process, usability in circuits with significant noisy signals and the solution of situation when the desired values of chosen indicators cannot be reached together. The speed is not so significant when we take into account that the most used tuning method today is Ziegler and Nichols method.

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Optimization of Compression Algorithms for Stereoscopic Video Signal

J. Svítek

svitej1@fel.cvut.cz

Department of Telecommunication Engineering, Faculty of Electrical Engineering, Czech Technical Univerzity, Technická 2, 166 27 Prague 6, Czech Republic

Human perceives three-dimensional (3D) objects in various ways. However, the most effective factor is binocular disparity that is the dissimilarity in views related to the relative location of human eyes and is the best way to provide perception of depth in a scene. A stereoscopic imaging system may be used to artificially simulate the three-dimensional vision ability by presenting slightly different views of the same scene to each eye. The stereoscopic imaging systems have many potential applications, e.g.:

- Minimum invasive surgery (3D endoscopy)
- Aerial 3D mapping
- 3D videoconferencing
- Education and training applications (3D visualizations)
- 3D movies entertainment

According to advances in 3D display and acquisition system, the need of suitable processing and transmission techniques came out. One of the questions is how to reduce double information rate (compared with single video coding) needed to transport the stereoscopic image.

This research was focused on finding the best stereoscopic video coding method to achieve the lowest possible encoder latency and the highest possible compression ratio while still preserving the original depth cue of stereo image pair. Low latency is very important in most of the real-time applications mentioned above (mainly in videoconferencing and surgery) so it was a key parameter of a potential encoder.

Stereoscopic image acquisition

To acquire the stereoscopic image pair two horizontally displaced cameras with the exact same parameters has to be used. There are two possible camera setups:

- Toed-in cameras
- Parallel axes cameras

In toed-in arrangement are the cameras slightly rotated so their lens axes are crossed in the point of convergence of both images. Unfortunately this setup has an undesired effect called keystone distortion. It causes vertical misalignment of corresponding left and right image points called vertical parallax. To eliminate this distortion additional image processing algorithms has to be used. To avoid this need the parallel axes camera setup is used much more often. In the parallel axes configuration is the convergence of the images achieved by shifting the sensors of cameras or by horizontal image translation and clipping of the resulting image. This camera setup gives no undesired vertical parallax.

In both arrangements should be the cameras vertically aligned and the inter-axial separation should be approximately 65 mm (it refers to distance of human eyes) to achieve the realistic stereoscopic cue. However, it could be different in some special applications like stereo endoscopy or aerial mapping.

Stereoscopic display techniques

There has been developed many stereoscopic display techniques since Charles Wheatstone constructed first simple stereoscope. The best known are listed below:

With passive glasses - Anaglyphic technique, Polarizing technique, Chroma-depth technique.
With active glasses - Time division multiplex of images with synchronized shutter glasses, Head-mounted displays.
Without any glasses - Parallax barrier displays, Lenticular sheet displays.

Stereoscopic video coding techniques

Main goal of this research was to find the best stereoscopic video coding techniques (or combination of them) to achieve low encoder latency and high compression ratio while preserving the original depth cue of stereo image pair. Proposed techniques are based on two facts: 1. Human visual system is less sensitive in perceiving chrominance than luminance information. 2. Both stereoscopic images are highly correlated.

Method 1: *Shared chrominance*

Human eye is more sensitive to brightness than color so we could avoid compression of full stereo pair of images if we will let both images to share the same color information. What this means is that if we use YC_RC_B 4:2:0 encoding for the image, then we can compress a stereo image pair by compressing one of the images as a mono-scopic color image and the other image as a monochrome image. Upon reconstruction, the color components are shared between both images in stereo pair meaning that two color images can be reconstructed.

Method 2: *Disparity-motion compensation*

During the stereoscopic image acquisition process we will get two sequences of highly correlated images. To significantly reduce the data rate, disparity prediction (DP) could be used to exploit the high correlation between this two image views. There are two proposed coding schemes. In case of the first encoding scheme is primary image sequence coded using motion prediciton (MP) and the complementary sequence is created just by disparity prediction (DP). In this case the correlation between image pair is exploited but the coding efficiency is still low because of unused temporal correlation. The second encoding scheme is more efficient. It takes advantage of both inter-view and temporal correlations while using the combination of both prediction methods (DP and MP). For the right view is each frame encoded with MP within the right channel sequence and with DP within both views. This scheme have the highest encoding efficiency but for a price of high encoder complexity and inconsiderable computational cost that could be the reason of higher encoder's latency.

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Object Tracking with Background Model

Lukáš Cerman, Václav Hlaváč

cermall@fel.cvut.cz

Department of Cybernetics, Faculty of Electrical Engineering, Czech Technical University, Karlovo námestí 13, 121 35 Prague 2, Czech Republic

Three are at least two important sources of information that can be used to find and track object in a video sequence. The first one is *appearance of the object*. Usually the object differs from the background and its appearance can be modeled and predicted. In such a case the object position can be inferred from the image using the maintained model. The second source of information is *appearance of the background*. The moving object always occludes some part of the background. If the background appearance can be modeled, the occluded parts of background can be detected by their dissimilarity from the background.

Approaches to tracking can be divided into several groups in the way they use those information sources. There is a big group of approaches called appearance template trackers [1]. In such approaches, only the information about the object appearance is used. The appearance model (template) can be learned off-line from the training data or can be estimated on-line from the already processed video frames. Tracking with appearance template is reasonable when the object does not change much between individual video frames. If the object changes rapidly, so it no longer matches the template, the tracking might get lost.

Other approaches rely solely on the information about the appearance of the background [2]. Usually, the image regions different from the background model are detected in the first step and then assigned to objects. Such approaches can be successful when the background changes slowly so it always matches the maintained model. If the background changes rapidly, everything appears as a foreground given the wrong background model and the tracking might get lost.

There are not many approaches combining both sources of information. One group of them are methods based on layered image representation [3]. The involved model is composed from independently moving image layers. Each layer is represented by its appearance model, segmentation prior and a motion model. One of the layers is assigned to the background, while the others are assigned to objects. The position of all layers (thus objects) is estimated simultaneously in each video frame as a maximization of the likelihood of the observed image in an expectation maximization framework.

Different group of tracking methods combining background and foreground information form methods based on classifiers trained to distinguish objects from background [4]. The object position is obtained by scoring different image regions with the classifier and choosing one of them which appears most likely to be the object. The information about background and foreground is included in the discriminative function of the classifier. Classifier-based approaches exhibit a very good performance. They are robust to slow changes of background or foreground appearance. We believe this is mainly due to simultaneous use of information about background and foreground appearance. However, there is space to go even further this

performance. Since classifiers do not model appearance of the background at each place in the image but treat the background image patches from all distinct positions as one class. The information about the exact appearance of background at each image position is not used.

We have created a novel tracking method combining both background and foreground information. Similar to the appearance template trackers we formulate the problem of tracking as a minimization of a cost function. However, in contrast to the traditional appearance template trackers, our cost function includes information about the occluded background in addition to the information about the foreground appearance.

We conducted several experiments to verify our method is robust to variations of its parameters and to compare performance of the new method to the traditional appearance template tracker. Despite a very little tuning, and many simplifications, the proposed method performs surprisingly well. It can successfully deal with changes of the object appearance. The inclusion of background information to the cost function stabilizes the tracking in cases where there is not a good match of the foreground object appearance and its template.

There has been done lot of simplifications in the current implementation. We see many ways to further improve the performance of the proposed tracker in terms of robustness. More, the current Matlab implementation needs just one ore two second to process a single video frame. We believe that rewriting the current experimental implementation from Matlab to C/C++ makes this method capable of real-time tracking. The further improvements and investigations may be a part of the PhD thesis of the first author.

The proposed tracker may be used as it is or may be a part of the more the complex model consisting of a collection of parts arranged in a flexible configuration. In such a model, the proposed tracker may be used to model the probability of observing a particular part of the complex model at a particular position in the image. Implementing the proposed tracker to more complex model might be a part of further investigations.

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City Modeling from Omnidirectional Video

M. Havlena

havlem1@cmp.felk.cvut.cz

Center for Machine Perception, Department of Cybernetics, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

Three-dimensional models of urban environments are useful in a variety of applications such as urban planning, air quality checking, virtual reality, architecture and monument preservation, and propagation simulation of radio waves for the cell phone and Wi-Fi industry. Computer technology, computer graphics, and computer-aided design (CAD) offer powerful tools for creating and visualizing digital models of cities.

Early city reconstruction used aerial imaging which allowed reconstructing large areas from a small number of images. The resulting models, however, often lacked visual realism when viewed from the ground level since it was impossible to texture the facades of the buildings. These modeling systems were often semi-automatic and were used as supporting tools for a human operator. Ground level imaging techniques are complementary to the aerial ones: they allow very good reconstruction of the facades of the buildings but the acquisition of such data for the whole city is very time consuming. That is why the first systems working purely with terrestrial images were not able to reconstruct more than single buildings. As the desired models are becoming larger and larger, human interaction is becoming a bottleneck of the whole modeling process and fully automated approaches are preferred.

Recently, a fully automated framework for city modeling from terrestrial image sequences working in real-time has been developed in [1]. It uses structure from motion (SfM) to reconstruct camera trajectories and 3D key points in the scene, fast dense image matching, assuming that there is a single gravity vector in the scene and all the building facades are ruled surfaces parallel to it, and real-time texture mapping to generate visually correct models from a very large number of images. The system gives good results but two major problems have been reported. First, cars parked along streets were not correctly reconstructed since they did not lie in the ruled surfaces representing either the ground or the buildings on the side. This problem has been solved by recognizing car locations and replacing them by corresponding computer generated models [2]. Secondly, 3D reconstruction could not survive sharp camera turns when a large part of the scene moved away from the limited view field of cameras.

Our contribution lies in solving the second problem by using “omnidirectional” cameras with larger field of view. Catadioptric cameras with views optimized to see the complete surroundings in a limited resolution do not provide images of photographic quality needed for city modeling. We therefore use 180° fish-eye lenses which are compact and provide better image quality [3]. Omnidirectional vision was previously used also for city modeling to capture images with very large resolution when panoramic mosaicing was preferred to using a fish-eye lens. This approach provides very detailed but large images and is not suitable for real-time processing. We use two compact 4 Mpixel omnidirectional cameras. Images of such size can be processed in real-time. On the other hand, our images are extremely radially distorted and a special projection model is needed to process them.

During the adaptation of the original SfM [1] into an omnidirectional one, we first adapted the projection model and used a single omnidirectional camera [4]. The SfM worked fine when using additional GPS/INS data but failed when these data were not used, because the positions of world 3D points were not estimated well as the scale of the reconstruction was gradually lost.

In our further work we extended the framework for using an omnidirectional stereo rig. Using two omnidirectional cameras bound into a stereo rig prevents the undesirable loss of the scale of the reconstruction because the length of the baseline remains fixed. This extension involved an adaptation of several parts of the original SfM, mainly the establishment of the tentative 3D-to-2D matches, the camera pose hypothesis computation from these matches inside the RANSAC loop finding the best hypothesis, and the bundle adjustment routine running in parallel with the camera pose estimation.

For our experiments, we have constructed a two-camera rig mounted on a survey vehicle. Each camera of the rig is a combination of Nikon FC-E9 mounted via a mechanical adaptor onto a Kyocera Finecam M410R digital camera. Kyocera Finecam M410R delivers 2272x1704 images at 3 frames per second. Since the FC-E9 lens is originally designed for a different optical system, we used a custom made mechanical to fit it on top of the Kyocera lens. The resulting combination yielded a circular view of diameter 1600 pixels in the image. Kyocera cameras do not have external synchronization but we were able to connect an external signal to start the acquisition at the same moment. The two cameras with large fish-eye lenses form our stereo rig with 0.95 m base line.

Our test sequence was 870 frames long. It showed up that reconstructing straight street segments is quite easy while it is much more difficult to correctly reconstruct the segments with sharp turns. We hypothesize that this is caused mostly by inaccurate camera and/or stereo rig calibration because the world 3D points come closer to cameras and start rotating, which causes the errors in the estimations of their depths to become much more important than when these 3D points are distant and the movement is rotation-free. On the other hand, the error accumulated along the 420 meters long loop is still less than 4.5 meters.

The original SfM framework is able to work in real-time and it would be exciting to achieve the same speed even with fish-eye cameras. Until now, we were interested more in functionality than in performance and the actual speed of our C++ implementation on a standard 2GHz Intel Pentium 4 computer is about 1.3 frames per second. This is primarily caused by the size of the input images which is 800x800 compared to 360x288 used with perspective cameras. Working with smaller images makes it more difficult to detect and to correctly describe enough feature points and making the images much smaller will be possible only if an extension to feature extraction would be proposed and implemented.

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A Simple Visual Navigation System for a Mobile Robot

T. Krajník and Libor Přeučil

tkrajnik@labe.felk.cvut.cz

The Gerstner Laboratory for Intelligent Decision Making and Control, Department of Cybernetics, Faculty of Electrical Engineering, Czech Technical University in Prague, Karlovo náměstí 13, 121 35 Prague 2, Czech republic

In recent years, as the computational power of common systems increased and image processing became possible in real-time, the means of using vision to navigate mobile robots have been investigated. We have developed a simple Map-building based [1] system, which utilizes a single camera. Similar to [2],[3] our system has to learn the environment during a teleoperated drive. Unlike other visual navigation systems, which are based on direction assessment and recognition of significant places in the environment, we use camera sensing only to correct small-scale errors in movement direction. Positions of significant locations, i.e. places where the robot changes its movement direction significantly, are estimated by odometric measurements. We explore properties of such landmark navigation and state that for some trajectories, the camera readings can correct odometry imprecision without explicitly localizing the robot. A formal mathematical proof of our statement is presented. Both simulation and real-world experiments also confirm validity of the proposition.

Our navigation system recognizes objects in the image taken by forward looking camera and corrects direction of robot movement. Data from compass and odometry are processed as well. The system works in two phases: learning and navigation. We have decided to use Speeded Up Robust Features [4] to identify landmarks in the image. Algorithm provides image coordinates of salient features together with their descriptor. To speed up computation time, the image is horizontally divided and both its parts can be processed paralelly by a multiprocessor machine. Typically, image recognition duration is 300 ms while 250 features are detected.

In the learning phase, the robot is guided through the environment on a polyline shaped trajectory. At the beginning of each segment, the robot resets its odometry counter, reads compass data and takes a serie of images. Positions and descriptors of stored objects, which are considered to be stable, are saved. As the robot moves forwards, it obtains and processes images and records odometric data. When an object is detected for the first time, the algorithm stores its descriptor, image coordinates and robot distance from segment start. Stored objects are tracked over several pictures and their positions in image are assigned to current robot position within a segment. When tracking of an object is terminated, because it is not visible any more, its descriptor, image coordinates and odometric data in moments of the first and the last successful recognition are inserted into the dataset describing the traversed segment. Segment learning is terminated by an operator, which stops the robot (segment length is saved) and turns it in the direction of next movement. After that, the learning algorithm either runs for next segment or quits.

When the navigation mode is started, the robot loads description of relevant segment and turns itself to the indicated direction. After that, the odometry counter is reset, forward movement and picture scanning are initiated. Objects, which are expected to occur in the image, are selected from learned set. Expected image coordinates in current camera image are calculated by linear interpolation using aforementioned distances. Selected objects are rated by

a number of frames which they have been detected in and 50 best-rated objects are chosen as suitable for navigation. For each candidate, the most similar object is searched in the set of actually detected ones. A difference in horizontal image coordinates is computed for each such couple. A modus estimate of those differences is then converted to a correction value of movement direction. After the robot travels distance greater or equal to the length of given segment, the next segment description is loaded and the algorithm is repeated.

Two mathematical models, (nonlinear and linear) describing robot movement along one segment were formulated. Both assume, that the robot moves towards landmarks slightly behind the end point of the current segment. Both also show that position uncertainty during segment traversing increases in direction parallel to the current segment and decreases in the perpendicular orientation. The linear model is then used to formulate a proof stating, that for regular polygonal trajectories and bounded odometric error, the norm of covariance matrix representing the position uncertainty converges to a bounded value.

Experimental evaluations were performed both by simulation and real world experiments. Simulations compared linear and nonlinear mathematical models of the navigation systems to check, whether linear model is not too crude. Real world experiments were conducted to verify whether the theoretical assumptions correspond to real world properties. Real world experiments were performed by Pioneer 3AT robotic platform with TCM2 compass and Fire i-400 digital camera. The robot was learnt a closed trajectory first. Then it was placed on the trajectory start point and switched to navigate the learned path five times. Every time it completed a loop and started the next one, its position relative to the trajectory start point was measured. The robot was then placed 1 m away from the start point in direction perpendicular to the first segment and navigated the loop five more times while measurements were taken. The same position set was collected for another initial position, which was 1 m away from learned trajectory trailhead in direction parallel to the first path segment. These measurements were taken for two trajectories, one being a straight line and second of triangular shape. Both indoor and outdoor experiments were at CTU FEE campus at Charles square in Prague. The sequence of taken measurements conformed well with the mathematical model of the navigation system.

Future work will focus on modifying the proposed system in order be able to follow a wider set of trajectories. We will try to extend presented proof to trajectories different from regular polygon. A framework to combine this navigation system with existing visual-based collision avoidance algorithms will be implemented.

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Relational Data-Mining of Genome Data

R. Letko
F. Železný

radek.letko@coex.cz
zelezny@fel.cvut.cz

Katedra kybenetiky
ČVUT FEL v Praze
Technická 6
Praha 6

The aim of the project was to create computing models of gene interactions and functions in biological processes. The intended contribution of the project was mine knowledge patterns in complex representations combining gene ontology, regulation pathways and other sources of background knowledge.

During the project we elected several gene expression datasets as the primary source of measurement data, from which novel patterns were to be mined in conjunction with background knowledge sourced from public bioinformatics databases (mainly NCBI Entrez/Gene). The technology producing the required gene expression data is known as gene expression microarrays. Microarrays [4,2] are at the center of a revolution in biotechnology, allowing researchers to simultaneously monitor the expression of tens of thousands of genes. Independent of the platform and the analysis methods used, the result of a microarray experiment is, in most cases, a list of genes found to be differentially expressed in different types of tissue. A common challenge faced by the researchers is to translate such gene lists into a better understanding of the underlying biological phenomena. Manual or semi-automated analysis of large-scale biological datasets typically requires biological experts with vast knowledge of many genes, to decipher the known biology accounting for genes with correlated experimental patterns. The goal is to identify the relevant "functions", or the global cellular activities, at work in the experiment. For example, experts routinely scan gene expression clusters to see if any of the clusters are explained by a known biological function. Efficient interpretation of this data is challenging because the number and diversity of genes exceed the ability of any single researcher to track the complex relationships hidden in the data sets. However, much of the information relevant to the data is contained in the publicly available gene ontologies and annotations. Including this additional data as a direct knowledge source for any algorithmic strategy may greatly facilitate the analysis.

In the project we have developed a method to identify groups of differentially expressed genes that have functional similarity in the background knowledge formally represented with gene annotation terms from the gene ontology. Precisely, we present an algorithm that for a given multi-dimensional numerical data set, representing the expression of the genes under different conditions (that define the classes of examples), and an ontology used for producing background knowledge about these genes, is able to identify groups of genes, described by conjunctions of first order features, whose expression is significantly different for one class compared to the other classes. Another application of this algorithm is to describe groups of genes already selected as features for some classification problem. Medical experts are usually not satisfied with having a separate description of every important gene, but want to know the processes that are controlled by these genes. With our algorithm we are able to find these

processes and the cellular components where they are ``executed'', indicating the genes from the preselected list of differentially expressed genes which are included in these processes.
These goals were achieved by enhancing the methodology of Relational Subgroup Discovery (RSD) developed previously at the Department of cybernetics at CVUT FEL [1, 3]. With a new version of RSD we were able to induce sets of rules discriminating between the differentially and not-differentially expressed genes in terms of functional knowledge extracted from the gene ontology, information about gene interactions and their inclusions in gene regulatory pathways.
The project thus helped design and implement an algorithm that uses gene ontologies, together with the paradigm of relational subgroup discovery, to help find patterns of expression for genes with a common biological function that correlate with the underlying biology responsible for class differentiation. Our methodology proposes to first select a set of important differentially expressed genes for all classes and then find compact, relational descriptions of subgroups among these genes. It is noteworthy that the latter descriptive "post-processing" step is a machine learning task, in which the curse of dimensionality usually ascribed to microarray data classification, actually turns into an advantage. This is because, in traditional microarray data mining configurations, the high number of genes results in a high number of attributes usually confronted with a relatively small number of expression samples, thus forming grounds for overfitting. In our approach, on the contrary, genes correspond to examples and thus their abundance is beneficial. Furthermore, the dimensionality of the secondary attributes (relational features of genes extracted from gene annotations) can be conveniently controlled via suitable constraints of the language grammar used for the automatic construction of the gene features. A further remark concerns the fact that genes are frequently associated to multiple functions, i.e. they may under some conditions exhibit an behavior of genes with one function while in other conditions a different aspect of their function may be important. Here the subgroup discovery methodology is effective at selecting a specific function important for the classification. Indeed, one given gene can be included in multiple subgroup descriptions (this was e.g. the case of genes with over-expression in the breast cancer class), each emphasizing the different biological process critical to the explanation of the underlying biology responsible for observed experimental results.
Thanks to the support provided by the internal project, the above described work essentially contributed to long-term research plans of the investigator's research group in bioinformatics.

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Advanced Methods of Visual Object Recognition and Categorisation

M. Perďoch, J. Matas

perdom1@fel.cvut.cz

Department of Cybernetics, Faculty of Electrical Engineering,
Czech Technical University in Prague, Karlovo náměstí 13, Praha 2, 121 35

The main achievement of the project is a new affine-covariant feature, the Stable Affine Frame (SAF). SAFs lie on the boundary of extremal regions [1], i.e. on isophotes. Instead of requiring the whole isophote to be stable with respect to intensity perturbation, as in maximally stable extremal regions (MSERs), stability is required only locally, for the primitives constituting the three-point frames. The primitives are extracted by an affine invariant process that exploits properties of bitangents and algebraic moments. Thus, instead of using closed stable isophotes, i.e. MSERs, and detecting affine frames on them, stable affine frames are attempted, on all, even unstable, extremal regions.

Set of isophotes is a complete representation of the image, i.e. any image can be fully reconstructed from its set of isophotes. In our work we have attempted to recover all affine-covariant structures contained in the sets of nested isophotes. The computational cost of the process is not unacceptable; isophotes can be enumerated in real-time on current CPUs using an efficient union-find algorithm. Analysis of the isophotes takes seconds in our implementation, which is not prohibitive in most applications.

The idea of finding covariant frames - structures covariant with affine or perspective transformation on digital curves - is not new. Lamdan et al. proposed construction of affine covariant frame on a contour. A fully perspective canonical frame construction was proposed by Rothwell et al. [4]. However, all early approaches required a contour to be extracted a priori, e.g. by an edge detector or by thresholding, with all the associated problems like parameter setting and linking errors. In our approach, we check all isophotes as an integral part of the process and output any stable feature. The need for prior segmentation is obviated. The hard detection decision is based on geometric stability w.r.t. photometric changes, a quantity that has direct relevance in many matching applications.

In real valued world, an isophote is a level set of intensity. We found, that a suitable discrete alternative is a boundary of extremal region - a maximal 4-connected component of sublevel set. The partial ordering of nested extremal regions by intensity defines an adjacency relation between isophotes that allows us to define photometric stability. First, given a set of isophotes, we want to find point-to-point correspondences between adjacent isophotes using an affine covariant process. LAFs [3] were used to construct affine covariant triplets of points on isophotes. Then a photometric and positional stability of these constructions is evaluated. In our definition, affine frames are stable if their location does not change significantly along a sufficiently long sequence of intensity adjacent isophotes. To identify the stable frames, frames on intensity-adjacent isophotes are first grouped (tracked) according to a similarity measure. From a feature matching perspective, the natural choice for a similarity measure would be a function of descriptors computed in the normalized frame coordinates, such as correlation of normalized patches or distance of SIFT descriptors. However, evaluation of such a function would be time consuming. Hence, we adopted a “geometric” similarity i.e.

two frames are matching if distances of endpoints after projection of one LAF into another's LAF canonical coordinate system are under certain threshold. Using geometric similarity, we form sequences of matching frames across adjacent isophotes. Then, we employ greedy selection of most stable frame in a sequence i.e. of longest subsequence that satisfies positional stability criterion. Stable frames in all subsequences that achieve sufficient photometric stability (measured in number of intensity levels in the subsequence) are considered as Stable Affine Frames.

We shown experimentally on standard datasets that SAFs have repeatability comparable to the best affine covariant detectors tested in the state-of-the-art report [2] and consistently produce a significantly higher number of features per image. Moreover, the features cover images more evenly than MSERs, which facilitates robustness to occlusion. Latest results showed improvement over previous MSER+LAFs method [3] in a large scale recognition experiment. Without significant computational effort, it is possible to modify the detector to construct stable homography-covariant frames, or simplify it to similarity covariant frames.

In the other part of the project, we have presented an efficient method for detecting planar bilateral symmetries under perspective projection. Grouping of detected elements (LAFs, SAFs, etc.) in the bilateral symmetry similarly as any other repeatedly constructed grouping of elements improves the indexing performance in a large datasets. Our method uses local affine frames (LAFs) constructed on maximally stable extremal region or other affine covariant regions detected in the image to dramatically improve the process of detecting symmetric objects under perspective distortion. In contrast to the previous work, no Hough transform is used. Instead, each symmetric pair of LAFs votes for a single axis of symmetry. Hypotheses are generated from each corresponding symmetric pair of local affine frames and verified using the rest of the corresponding pairs. The time complexity of the method is n log (n), where n is the number of LAFs, allowing a near real-time performance. The proposed method is robust to background clutter and partial occlusion and is capable of detecting an arbitrary number of symmetries in the image in near real-time.

In the future work we plan to extend evaluation of the SAF detector in object recognition experiments, compare it thoroughly to the MSER+LAF method and finally publish journal paper and the source codes. In the further work on the detector of bilateral symmetries, we plan to add detection of repeated structures and other kinds of symmetric configurations under perspective projection.

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Combination of Stochastic and AdaBoost Approach for Object Tracking and Recognition in Video

P. Vlček, T. Svoboda

vlc@fel.cvut.cz

Center for Machine Perception, Department of Cybernetics,
Faculty of Electrical Engineering, Czech Technical University,
Karlovo nám. 13, 121 35 Prague 2, Czech Republic

The digital video processing becomes more and more important area of the computer vision. Because of the relatively bad image quality, high volume of the video data and the real-time processing requirement, it is important to develop methods which are very robust and effective at the same time. This is especially true in the area of object detection, tracking and recognition. These tasks have many practical applications, such as human-computer interaction, surveillance systems, data compression, or video indexing.

In this work we focus on the task of video indexing, a textual or database like description of feature-length movies, which would encompass information about presence of specific persons in action. We decided to solve the indexing problems by detection, modeling and tracking of the human heads. The aim is to sequentially provide the current 3D position of a head moving in front of the camera. What is typically requested is to keep the individual track and re-detect it in case of re-appearance. Some of the main challenges are rapid and dynamic motion of a human head, complex background, possible occlusions, and unstable appearance of the head. Model-based approaches to monocular 3D object tracking use a manually defined or automatically learned generative model of the tracked object. Many of these algorithms formulate the 3D tracking as an optimization problem, where the criteria function is a similarity function of the model projection and the actual image. The profile and back of the human head are more difficult to model than the face, since they do not contain enough discriminative visual features. Therefore, one of the most essential problems in 3D head tracking/position estimation is to keep tracking in the situation, when the tracked individual does not look into the camera. We propose the following procedure. First, we detect faces with a standard face detector [3]. The detection initializes a tracking process which provides information for modeling of the particular human head. A rich model of the human head allows for detection and tracking in cases where the efficient face detector fails.

The successful *Viola-Jones face detector* [3] uses a clever combination of the AdaBoost learning algorithm with a very quick computation of the visual features based on the so called “Integral Image” image representation. Another contribution of this approach is a sequential processing of the classified image regions, which allows quickly discarding the uninteresting background image regions and spending more computation on the promising object-like regions. This approach and its modifications are capable of robust real-time detection of any objects with reasonable visual appearance. The main drawbacks are the need of many labeled training images and the high computational complexity of the learning stage. The *WaldBoost* algorithm [3] extends the original Viola-Jones approach by an optimal strategy with the shortest average time to decision. One of the most successful real-time tracking algorithms is the *CONDENSATION* algorithm [4], also known as *particle filtering*. It is a model-based approach, which uses stochastic sequential estimation of the state probability distribution, based on weighted samples. The measurement function used for weighting of samples is based on the given object model and it is stationary in time. Also an object motion model, if available, can be easily incorporated to help the tracking. The approach is very similar to the well known Kalman filter, but it is more flexible and can handle also

nongaussian densities and nonlinear object motion. In the original paper, the algorithm was used for 2D deformable contour tracking using the image gradient, but many modifications in different scenarios with various object/motion models were proposed later. The main drawback of this approach is the *curse of dimensionality,* i.e. the number of samples and therefore the computational complexity of the algorithm increases exponentially with the dimension of the pose space to be covered.

Our work [1] combines the state-of-the-art *WaldBoost*-based face detector with a *CONDENSATION*-based 3D head tracker. It is adaptive in terms of the appearance part of the generative model. In every frame, where the face is detectable by the detector, the 3D head position relative to the camera is estimated and the tracker is initialized. We approximate the head shape by an ellipsoid. As the head moves in front of the camera, new parts of the head surface, not visible in the camera before, appear. We add this new texture to our model. Therefore no precomputed head model is needed - the head appearance model is built online. After the full angle rotation, the full textured ellipsoid is yielded, which can be used as the person specific generative appearance model of the head to render head appearances from arbitrary poses. We estimate the translational and rotational components of the rigid 3D motion separately. Only the global motion, i.e. the translational component is robustly tracked by the *CONDENSATION*-based approach; the head occluding contour is approximated by an ellipse and the measurement function is based on the image gradient. After eliminating the global motion, we estimate the resulting local motion, i.e. the rotational component. We track selected internal points of the head projection area by standard Kanade-Lucas tracker and estimate the rotation matrix by a known SVD technique. A standard *RANSAC* is applied to make the algorithm robust. To prevent the well known error accumulation problem standard bundle adjustment is applied, using the point correspondences from the point tracker.

The experiments have shown, that it is possible to successfully track the full angle head turnaround, assuming relatively slow head motion and high image resolution. Tracking the back of the head under more difficult imaging conditions and higher motion dynamics and re-detection after the loss of the track remain still open problems. However, estimating the motion only from point tracks without the boundary contour tracking leads to far more error accumulation and sooner loss of the track. In [2] we experimentally evaluated this approach and compared it with other model-based algorithms with slightly different criteria functions and search strategies on labeled ground truth data. We compared their relative performance in terms of accuracy, robustness and speed. The proposed method showed slightly better robustness in comparison to the simple point-based tracking without the occluding contour.

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Theoretical study and scalability tests of the developed air traffic control algorithms

P. Volf

volf@labe.felk.cvut.cz

Department of Cybernetics, Faculty of Electrical Engineering, Czech Technical University, Karlovo namesti 13, 121 35 Prague 2, Czech republic

In the future warfare and humanitarian relief operations (especially in the surveillance and monitoring domains) there will be a strong potential for integration of the technologies and mechanisms supporting the coordinated flight among the collective of autonomous manned and unmanned aerial assets (UAAs). This requires the See & Avoid capability. It is ability to monitor local environment (using on board radars, information from the headquarter, other UAAs etc.), detect possible collision situations and take actions to avoid them. The See \& Avoid capabilities distributed among several autonomous airplanes allow to utilize the benefits of the free flight concept.

The goal of free flight is to allow each airplane the freedom to fly a continuously changing optimal trajectory with respect to a separation. Such approach allows efficient operation of dynamically tasked UAAs. Each airplane plans its own flight trajectory to fulfill its mission and checks for possible future collision situations during the flight. Local collision avoidance mechanisms are applied if such collision situation is detected. This concept allows more efficient usage of the airspace taking separation in account.

The collision avoidance problem is difficult, because the domain is very complex. In general, each part of the solution has to be planned in 3D space with time factor. This is mainly problem of the planning of the flight trajectory. The flight plan is created by the set of mission objectives given as 3D points with possible time restriction. The planner has to create trajectory fulfilling these mission way-points with respect to the physical model of the simulated airplane, shape of the ground surface and no-flight zones (predefined static or dynamically created and changing 3D objects representing areas, where airplane can't fly, e.g. nuclear powerplants, storms, icing areas, SAM sites, etc.)

It is not possible to solve the collision avoidance by centralized algorithms, because there is only limited connection with nearby airplanes. Collision avoidance algorithms have to work in a distributed manner within several nearby airplanes or pairwise. It is not possible to use well-know techniques for collision avoidance (e.g. potential fields) in the UAA domain, because it differs from robotics domain which is almost 2D and often with the ability of communication among all robots.

We introduce distributed agent-based iterative peer-to-peer collision avoidance algorithm (IPPCA) [2]. It is a domain independent algorithm, while the manoeuvre implementation is domain dependent. The IPPCA algorithm is utility-based avoidance mechanism providing solution for a pair of airplanes. First, the participating airplanes select the master and the slave entities for the detected collision. Each agent generates a set of parameterized plans using defined manoeuvres. The result after applying the manoeuvre is changed flight plan including utility value for this new flight plan.

The utility function is used to include the aircraft's intention to the proposed solutions of the conflict. The utility value is evaluated as weighted sum of the utility function parts considering total length of the flight plan, time deviations for mission waypoints, altitude changes, fuel status etc. Lower value of the utility function suggests more preferred deconfliction maneuver.

The best possible deconfliction manoeuvres is identified by a variation of the monotonic concession protocol (MCP). The monotonic concession protocol is a simple protocol developed by Zlotkin and Resenschein for automated agent to agent negotiations. When the master entity generates its own plans and receives plans from the slave entity, it tries to combine all plans together. The collision solution is then selected from cartesian product of the generated plans from both participants. These candidates for solution are ordered in increasing manner by product of utility quotients of flight plan pair. The slave entity is notified about selected flight plan.

If there is no collision-free pair in the cartesian product, it is necessary to generate more wide flight plans. This new plans are added to flight plans from previous round of generating and the master will repeat to select solution among all flight plans.

We show properties of the IPPCA algorithm using both theoretical proof and empirical experiments [1]. We prove convergence of the IPPCA algorithm at the selected high-density landing scenario. The landing scenario contains n airplanes forced to fly from their starting positions through the single landing point and follow straight part common to all airplanes simulating landing on an aircraft carrier. All airplanes fly at the same altitude and they cannot avoid collisions by changing their altitude. The airplanes have to arrange their times of arrival in such a way, that no more than one airplane flies through the landing point at a time.

We formalize scenario properties into a formal model. We theoretically prove the convergence of the distributed algorithm and provide the worst case estimate of the convergence in any possible case.

The provided theoretical estimation has been experimentally evaluated on the described scenario. All experiments have been carried out using the multi-agent framework for airspace domain simulations AGENTFLY. Experimental results of a number of iterations fulfill polynomial tendency although the implementation is quite more complicated than the simplified formal model. The goal of the future work is to prove theoretically polynomial estimation of these results.

We also run a numerous different huge scenarios including sphere scenario (tens of airplanes starting on the sphere and flying across centre in one time), flows scenario (two perpendicular flows of airplanes crossing at same altitude), random scenario (random flights over specified area testing density of the air traffic) etc.

We've developed, proved and tested the iterative peer-to-peer algorithm which can work in full 3D domain with heading, altitude and speed changes on the very complicated scenarios.

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Real-Time Data Flow Routing in Multi-Hop Sensor Networks.

Jiří Trdlička, Zdeněk Hanzálek

trdlij1@fel.cvut.cz, hanzalek@control.felk.cvut.cz

CTU Faculty of Electrical Engineering
Department of Control Engineering
Karlovo náměstí 13, Prague 2,
Czech Republic

Wireless sensor network (WSN) is a wireless network consisting of spatially distributed autonomous devices using sensors to cooperatively monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants, at different locations. The development of wireless sensor networks was originally motivated by military applications such as battlefield surveillance. However, wireless sensor networks are now used in many civilian application areas, including environment and habitat monitoring, healthcare applications, home automation, and traffic control.

In addition to one or more sensors, each node in a sensor network is typically equipped with a radio transceiver or other wireless communications device, a small microcontroller, and an energy source, usually a battery. The size of a single sensor node can vary from shoebox-sized nodes down to devices the size of grain of dust. The cost of sensor nodes is similarly variable, ranging from hundreds of dollars to a few cents, depending on the size of the sensor network and the complexity required of individual sensor nodes. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and bandwidth.

The most critical resource constraint in WSN is usually the energy consumption of the devices. Due to the energy consumption of the wireless communication increases with the communication distance, the communication in WSN is done through multi-hop. To avoid the communication to long distances, the devices send the data to its near neighbors, which resend it to its near neighbors and so on to the destination.

With usage of the WSN in the industrial environment, the real-time behavior and communication has to be ensured. However, due to strict energy constraint of the WSN, the usual communication protocols from networks area cannot be used and new protocols has to be developed. [4]

Our work [2, 3] is focused on data flow routing through the multi-hop static network, where all data has to be delivered to the destinations in time. An example of a target application could be a network for periodic sensing and control of some commodity consumption (like electrical energy consumption, gas consumption, water consumption, etc.) in large objects, like airports, supermarkets, etc. Then each sensing device produces a data flow of a particular volume, which is supposed to be routed through the network. We optimize the energy consumption for data transfer and we assume the following constraints: link capacities, node capacities and different deadlines for each sensed value. The solution where not all data is delivered before the deadlines is not feasible. We assume a TDMA-like medium access protocol (e.g. GTS allocation in IEEE 802.15.4 which ensures collision-free communication and causes communication delay.

Due to the TDMA mechanism assumed, the worst-case delay from the source node to the destination node is a sum of the particular delays for each of the hops, assumed to be an integer (derived from the parameters like TDMA period, worst-case execution time of the communication stack...). In a particular setting, we may assume a unit delay common for all hops (the same TDMA period, negligible influence of the transmission delay on physical layer...). Therefore, we assume the unit hop delay (the deadlines are expressed as the number of communication hops between devices).

The optimal routing of data flow depends on the link capacities and on the communication prices (e.g. energy consumption). We take the value of the data flow as a continuous quantity and we allow the flow fragmentation go to more routing paths. Thanks to the flow continuity, the problem is solvable in polynomial time by Linear Programming. The network topology is represented by a directed graph where the nodes represent the devices and the oriented edges represent the oriented communication links between the devices.

The TDMA-like medium access protocol is needed to implement and test the routing algorithm, as was mentioned above. To ensure the TDMA behavior, we have implemented a communication module (ITEM), which follows an adaptive TDMA slot assignment protocol (E-ASAP) [3]. The module ITEM is implemented in operation system TinyOs 1.1.x and the logical structure of the module is designed to be easy modifiable. The module ensures a unique slot assignment for all nodes, which communication can interfere, including the hidden node problem. There are no data collisions during the communication due to the ITEM module and the maximum one-hop communication delay is limited by the TDMA period.

The combination of both the ITEM module and routing protocol, which we have developed, constitutes the Link and the Network layers of our communication protocol. The communication protocol ensures the end-to-end real-time communication in multi-hop sensor networks and it optimizes the energy consumption during the communication. The protocol holds the link and the node communication capacities too. There is no other communication protocol, which ensures the real-time communication, holds the capacity constraints and optimizes the energy consumption.

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A General Model for Personalized Web Design

M. Balík, I. Jelínek

balikm1@fel.cvut.cz

Department of Computer Science and Engineering,
Faculty of Electrical Engineering, Czech Technical University,
Karlovo náměstí 13, 121 35 Praha 2, Czech Republic

Adaptation is often a discussed topic in the field of web technologies. There is a need to personalize the information presented to the user. Most of the current approaches use ad-hoc solutions and there is a need of a general formal model to simplify development of adaptive systems and enable data interchange among them. In our work we aim to propose such a model and develop an experimental system based on this model. In this paper we present partial results of the project.

Several models have been proposed for the description of adaptive hypermedia architecture. However, there is still lack of generality in the architecture, which makes collaboration and content reusability difficult, even impossible. In our previous publications we have proposed a general adaptivity model [1]. We have analyzed the requirements of universal adaptive systems and extended the GAM model [2] to satisfy all the needs.
Adaptive systems perform an adaptation of content and an adaptation of links. However, recent research noticed the need to select the type of adaptation itself. This leads to meta-adaptive systems. In adaptive systems we need to model users as individuals and even as groups with similar interests. Frequent property used in the adaptation process is the amount of user knowledge of some topic. The limited capacity of the human memory causes forgetting, which needs to be integrated into the system. We also need to deal with the problem of ensuring user privacy and data security.
Having all these features in mind, we have extended the GAM model. To enable interchange of data among systems, our model is based on semantic representation. It is necessary to represent information content in a form where content can carry machine-understandable meaning and use intelligent techniques to take advantage of these content representations. Proposed representation is in the form of multidimensional matrix, where each plane contains the ontological representation of a specific domain. The ontologies on the planes are application independent, modular and layered.
The system needs to be capable of achieving the optimum balance between configurability and automation. The highest degree of efficiency can be achieved by applying heuristics upon previous results in the system. User feedback is necessary, because some preference of the use could be changed over time or some of them could be incorrectly determined.

The most popular application fields of adaptation are e-learning, community websites or e-commerce. We have focused on the field of e-learning [3], because e-learning environments are more and more used for the education support, and it allows us to perform experiments with real users of the system at the university. Later the verified results will be generalized and tested in other application environments.
We have developed ontology for university e-learning environment [4]. The ontology consists of two main parts. The first is the ontology of course materials, and it includes lecture slides, learning objects used to compose the personalized webpage and tasks for students. The second, the ontology of the progress of students in the course, includes test scores, homework

scores, evidence of course attendance, etc. In addition to the ontology, we are developing a web-based tool which will be used to present data to the user. We are implementing this system in Java language and we use the Jena semantic framework to access the data repository.

In our future work we will focus more on the means of data integration. We want to achieve an effective ontology-driven metadata extraction and annotation. The data needs to be machine-understandable. This includes the description of user characteristics and also the selection of adaptation techniques to enable meta-adaptation. The description of this data structure and processes will be formalized as theoretical foundations of our model. We will also continue with the development of our web-based adaptive system and perform further experiments.

The results of our research are part of the work of a special research group WEBING (http://webing.felk.cvut.cz).

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Continual Evolution Algorithm and its Application to the Artificial Neural Networks Adaptation

Z. Buk, M. Šnorek

bukz1@fel.cvut.cz, snorek@fel.cvut.cz

Department of Computer Science and Engineering, Faculty of Electrical Engineering, Czech Technical University in Prague. Karlovo náměstí 13, 121 35 Prague 2, Czech Republic

The Continual Evolution Algorithm (CEA) for building of models has been presented in our works [1-4]. We chose an artificial neural networks (ANN) based models in our applications to show properties of CEA algorithm. During CEA evolution process a continual (in time) gradient learning algorithm is combined with a classical genetic (evolutionary) approach. Thus in this application a structure of models is constructed separately from particular parameters optimization in such models (e.g. weights in neural networks). These two optimizations are running at the same time but using different methods. As a platform for our experiments the universal neural network topology implementation based on the fully recurrent neural network has been chosen. This implementation allows the evolution algorithm to create any network structure with no limitations for a usage of gradient real time recurrent learning algorithm. An advantage of using evolutionary algorithms for neural network construction is in finding its optimal structure (number of neurons and connections among them). Splitting the construction process into structure finding part and the particular weight values setting (finding) has an advantage in reduction of the problem dimension. Number of reproduction operation calls is reduced and a part of optimization process is done separately. Results of these two parts are then combined before the next reproduction operation is needed. Individuals in our algorithm contain an age parameter, so the CEA allows for the number of gradient based algorithm steps for the individual quality assignment. The CEA is a universal optimization algorithm with no limitations for neural network construction and evolution. Neural networks created using this algorithm can be used for example in classification, prediction, etc.

As well as standard genetic algorithm (SGA) also the CEA is fundamentally inspired by nature and it is a part of group of evolutionary algorithms. It combines genetic operators (representing the evolutionary part of the algorithm) with a gradient optimization method. Evolution in the CEA runs in two relatively independent processes - genetic based process and time-dependent gradient-based process. The main idea of this approach is to separate the evolution of a structure and behavior (parameters) of individuals. When applied to a neural network construction we can imagine the structure as a topology of network and behavior as a particular weight values setting in such network.

The main core of CEA is the SGA extended by new parameters and techniques. Genetic algorithms in general work with some encoding of individuals – each individual represents one solution. In CEA the floating point vector is used for encoding of individuals. This encoding vector is additionally divided into logical parts, representing the structure and behavior of individual – topology and weights setting of neural network represented by the individual. An individual in CEA the individual is represented by vector contaning four main parts – the age of individual, the initialization parametric vector (called instinct), the structural parameter and behavioral vector of i-th individual, which contains actual set of working parameters of the individual (at the beginning of evolution it is created as a copy of the parametrical vector).

The CEA is controlled by several auxiliary parameters that are computed for each individual in population. These parameters are used in the reproduction cycle. The first parameter is the reproduction probability (RP) which describes the probability, that the i-th

individual of age 'ai' and quality 'F' given by the fitness function, will be used for reproduction operation and that they will produce some new individual (offspring) to the next generation. Parameter death probability (DP) represents the property that each individual has some maximal age that they can live for. The probability of survival of each individual depends on the quality and actual age of this individual. The final values DP and RP, which the CEA works with, are computed from the raw values using the balancing functions . These functions represent the influence of the size of the population to this size itself – the bigger population will grow slowly (to some limit value, where no new individual will be born) and the smaller population will grow faster (for smaller populations the death probability is reduced and goes to zero).

We chose a neural network based models construction problem as an application for our CEA evolution algorithm. Using this algorithm the structure of the model is being evolved with the goal of finding some optimal neural network topology for given problem. At the same time there is running a process of optimization of parameters of the model. As a platform for our application we chose the implementation of fully recurrent neural network (FRNN) as a most universal neural network structure. For gradient learning part of CEA we chose a real time recurrent learning algorithm. All experiments has been performed in Wolfram *Mathematica* programming language and environment. We have chosen the simple experiment "learn to oscillate" to check our implementation and for comparison with other optimization algorithm. The neural network is trained to generate some defined periodical sequence. We have tried pure gradient method (real time recurrent learning), differential evolution algorithm and CEA algorithm. We have tried many parameters setting of used algorithms to get an appropriate results. Performed experiments confirmed the theoretical properties of our CEA algorithm.

On the experiments we have successfully tested some theoretically expected properties of CEA algorithm and we have shown that it can be used for ANN based models creation/evolution. Comparison to other methods (real time recurrent learning and differential evolution algorithm) has been shown [3].

We have presented the ability of CEA to produce smaller (simpler) models (networks) than RTRL and DE (used for weight matrix adaptation) [3].

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GAME Subsystem for Data Preprocessing

Čepek Miroslav, Šnorek Miroslav, Kordík Pavel

cepekm1@fel.cvut.cz

Departement of Computer Science and Engineering

Missing data is a big problem in simulation for data mining and data analysis. Real world applications often contains missing data. Many data-mining methods is unable to create models from data which contains missing values. Traditional approach is to delete vectors with missing data.
Unfortunately, this approach may lead to decreased accuracy of the models and in the worst case all data in dataset may be deleted. For this reason many different imputation techniques were developed and some are widely used. In this paper, we present a comparison of several well-known techniques for missing data imputation. Presented techniques includes imputation of mean value, zero, value from nearest input vector and few others. In this paper we show which techniques are the best in estimation of missing values. To test imputation methods we used several different datasets. We compare the imputation methods in two ways. The first is to compare imputed data with original data. The measure of similarity is RMS. The second test was to compare the accuracy of inductive models generated from datasets with missing values replaced by different imputation techniques. Results shows that no method can be chosen as the best because the performance of each method depends on characteristics of the data.
As may be seen there are many different imputation methods but we did not found any comparative study which compares influence of the imputation method to the modelling methods. In this work we are interested only in one particular modeling method called Group of Adaptive Model Evolution (GAME) which is developed in our department. The GAME creates models from complete training data. Here we test the ability of the GAME method to create successful model even when some values from the learning set are missing and are treated with several different imputation methods. For our experiment we use several different datasets. From each dataset we remove some values and replace missing data with several imputation techniques. The performance of imputation techniques will be compared in two different ways. At first the Root Mean Square (RMS) over all inputs will be computed and used as measure of quality. The RMS will be computed as root square of difference between original dataset and result of each imputation technique.
The second criterion is the accuracy of the GAME models. For classification problems the classification accuracy of created models for original and imputed data is compared. For regression we compare RMS of model outputs for original and imputed data. The general goal of our work is to explore behavior of GAME neural network with missing data and to find if suitable imputing method for specified type of data can be found. The results will be used for extending the automated FAKE GAME data mining tool.
Case Deletion (DELETE) – This is probably the oldest and probably the most popular method among missing data threating methods. As name says we just drop the vector which contains missing data.
Replace by zeros (ZERO) – All missing values were replaced by zero.
Replace by mean value (MEAN) – For each input we calculated average value for all non-missing data and all missing values in input is replaced by this average.
Replace by value from random vector (RANDOM) – as name says for each missing value we randomly select non missing value from corresponding input.
Replace by value from nearest neighbor (NEARESTN) – For each input vector we determined the nearest vector and impute its value(s) at the place of the missing values.

Replace by average from values of five nearest neighbors (AVGNEAR) – In this method we extended the previous method and we calculated average value for five nearest vectors.
We compared several methods for imputing missing data. We tested imputation methods in two ways. In the first experiment we tested the data distortion introduced by imputation method. This we compared using RMS error computed between original and imputed data. The method with the lowest data distortion we identified as the AVGNEAR method. This method imputes average of values of five nearest vectors. The AVGNEAR method is followed by MEAN and NEARESTN methods which achieve slightly higher errors. The worst method we identified as the ZERO method. This is because imputing still the same value, which is not the mean value, always produce high RMS error.
The reason why the AVGNEAR method is superior to NEARESTN is because among irrelevant vectors also truly near vectors are selected and the average of several values will push the result to correct value. In the second experiment we tested influence of imputation method to performance of the GAME modeling method. During this experiment we created 20 GAME models for each imputation method and we compared performance of these models. For regression and prediction problems we compared only RMS errors of the models. RMS error in this case is difference between value predicted by GAME model and value observed. Typical results are presented of Figures 7 and 6. The main conclusion about GAME modeling method and imputation methods is that if there is low number of missing data (less then 10%) the performance of created GAME models do not depend on imputation method. In addition, their performance is not statistically distinguishable from performance of the GAME models with original data.
When there is more than 10% of missing data the performance of the GAME models degenerates and depends on imputation method. The worst results achieves DELETE imputation method. The reason is that it removes vectors from training set and the GAME model can not be created properly. In the worst case all vectors are removed from the training set and the model can not be created.
The MEAN and ZERO methods for some data work very well but sometimes they works quite bad. In addition, sometimes the MEAN method achieves lower error than ZERO method, but sometimes vice versa. The reason is not clear now and will be subject of further analysis. For this reason we cannot recommend these methods to be used with the GAME modeling method.

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Algorithm for Distance-Based Visualization of Data in Computational Intelligence

J. Drchal, M. Šnorek

drchaj1@fel.cvut.cz

Department of Computer Science and Engineering, Czech Technical University,
Karlovo náměstí 13, 121 35, Prague, Czech Republic

The visualization of multi-dimensional data is a very important task in computational intelligence methods. This article describes a new algorithm which was originally designed to visualize diversity of population in Evolutionary Algorithms (EAs). Later, we realized its abilities for visualization of any general data sets which makes it suitable for data mining purposes.

Our approach visualizes distances (Euclidean or any other user-given measure) between data samples. More precisely, our algorithm projects high-dimensional data samples to the 2D (or 3D) while keeping the new 2D (3D) distances as close as possible to the original distances. Such visualization is very helpful when taking picture of data clustering. In classification tasks it can be used to select outlier for removal. The results of our algorithm were compared to the well known Sammon's projection [1]. Sammon's projection does a similar job – it minimizes the square of the error (the difference between original and projected distance) for all data samples simultaneously.

The solution we propose is based on modeling of a physical phenomenon. It is inspired by intermolecular forces. Atoms in molecules are exposed to attractive and repulsive forces. Attractive forces prevail for long distances while repulsive forces for short. We used the above scheme, associating data samples with atoms, and modified it to

1. the shorter the original distance (the original distance in the high-dimensional space) is, the stronger the attractive force is,
2. the shorter the projected 2-D (3-D) distance is, the stronger the repulsive force is.

This system can be described by energy and force equations. The total energy of such system should be minimized. The force contribution of each data sample can be evaluated as a gradient of its energy contribution taken with minus sign.

We have developed two different sets of energy and force equations (A and B). The difference between these sets is in the influence of the original distance (in A the influence for longer original distance is stronger). Both A and B were found empirically, however, they are very similar to the real-world equations. Detailed description of our algorithm can be found in [2].

The first experiments were done on artificial datasets. We have generated multiple high-dimensional data sets with different clustering. It was shown that equation set A, while giving similar results, can be optimized much faster than Sammon's projection. We have found that both Sammon's projection and equation set A often fail when there are both large and small clusters together in the dataset (the small clusters are disrupted in the final projection). The equation set B is much more resistive to this problem, giving the best visualization results of all. Unfortunately it is slower than equation set A and Sammon's projection.

Later, we have experimented with population data taken from NEAT (NeuroEvolution of Augmenting Topologies). NEAT is a system which evolves neural network parameters and topology simultaneously. It is based on a niching EA. Niching algorithms divide population to multiple sub-populations (called niche) in which solutions are found separately. We have shown that niche emerged during evolution as expected – niche were visualized as different clusters of variable sizes.

The main part of our algorithm is the minimization of the simulated system energy. It can be done using known numerical optimization methods. We have extensively tested Steepest Descent, Conjugated Gradient and Quasi-Newton methods. The detailed comparison can be found in [2]. Conjugated Gradient seems to be the best choice as it was fastest and most reliable for dataset of any size [2]. However, attention should be paid to the choice of the proper line-search method.

The next experiments we have performed were the visualizations of the well-known datasets Iris and Ecoli in 2D and 3D. We have found that it is useful to alter the original distances: to make small distances even smaller and large distances even larger. For this purpose we have used a slightly modified squashing function known from the area of neural networks. The use of squashing made the clusters in the data even more evident [3].
Our algorithm was also included to the GAME - the data mining software developed on CTU, Department of Computer Science and Engineering [4]. Here, it is used both for visualization of data sets and visualization of diversity (as GAME internally uses niching EA).

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Model For Automatic Ontology Linking

R. Jun, I. Jelínek

junr1@fel.cvut.cz, jelinek@fel.cvut.cz

Department of Computer Science and Engeneering, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

Nowadays, we are facing to growing amount of documents, publication freedom (no authority control), searching engines, electronic catalogues, web applications, need of simple data format (better then the HTML, but stil text based), need of cooperation (such as Yahoo pipes, not only linking of multmedia documents). The use of ontology seems to be good solution to these problems. An ontology provides way how to classify data and way how to store data itself. In order to use ontologies as default web technology we need auxiliar tools.

Existing ontology tools enable making and managing, merging and integrating, partially automatic [1]. This integration process mainly suppose that each input ontology describes own specific domain. If we look at an ontology as interesting data source, then we also need to merge two (or more) ontologies describing the same domain. If we talk about an ontology then we mean OWL (Web Ontology Language). The OWL extends RDF(S) language and it is also based on triples (subject, predicate, object). Ontology is consists of classes and properties. Both is organized in hierarchical structures based on “is-a” relationship.

Problems appear when we want to join or integrate ontologies. Each author can makes own hierarchical structure and uses different names or different meanings. We need tool [2 , 3] which helps to solve this problem. We focused on a special situation where each ontology describes the same domain. But each ontology can be described in a little different way or describes another part of the domain. Our goal is to make a fully automatic tool for simple ontology linking. To reach this goal we have to put some restrictions on an input ontology.

At this moment, we suppose only one restriction. Each ontology is based on a common model. If the model is a full graph, then an ontology structure is a sub-graph of the model. This precondition simplify matching function to looking for sub-graphs. As we mentioned above, an ontology structure is consist of classes and properties. Now, we reduce ontology structure only to a class hierarchy. So the model should describes relationship between all possible classes (or class names).

It would be nice to have an ultimate model, which is behind all designed ontologies. In searching for that model, we can suppose that ontologies are designed by man. The man use language and own experiences to build ontology hierarchical structure. It is why we choose the lexical database of English words WordNet [6] as a model.

The WordNet describes relationship between nouns, verbs, adjectives and adverbs. Ontology class names are typically based on nouns, adjectives and prepositions. We are focused at nouns and relationships between them. The most important of them are hypernyms and hyponyms. The word “family” is hypernym of the word “group”, because “family” is a special case of “group”. The hypernym relationship is equal to “is-a” relationship, which is used in ontology design structures. The hyponym relationship is opposite to the hypernym relationship.

The WordNet organizes nouns in sets of synonyms called “synsets”. All nouns in a synset have the same meaning. If a word has more than one meaning, then we can found it in more than one synset. It is important to choose the right synset. To find the right synset WordNet offer a gloss and an example sentence for each synset.

An ontology *O* fit to a model *M*, if for each class of ontology *O* is true, that are in the right relationship relates to the model *M*. It means that if an ontology has class names "group" and "family", then the class "group" have to be superclass for the class "family". It is obvious that for ontologies which fit to a one model is simple to make mapping.

To check if an ontology to a model (as we mentioned above, we use WordNet as a model) we made tool [3], which compute distance between two words (precisely between two nouns). This tool is based on API for latest WordNet 3.1 [5] and has command line and a graphical user interface. Graphical interface offers visualization of distance and relationship. The input of the tool are two words (nouns) with a context. A word context is another set of nouns and is applied on a synset nouns, gloss and example sentence. And the output is a distance and a relationship.

Possible relationships are hypernym, hyponym and other. The last mentioned type describes situation when a path between two nouns is not straight. In that path is a break in relationship type, which makes shift in meaning (and also in semantic distance). We prepared and tried two distance algorithms. The first of them computes only a distance as number of nouns between input nouns and does not prevent this meaning shift. We improved this algorithm by sum of sub-tree values, which respects this meaning shift.

In future work, we would like to use the tool for measuring an ontology distance from WordNet model. And verify this method on real ontologies, which were made without any respect to the WordNet. We would like to compare our distance algorithm to other existing algorithms and choose optimal variant for automatic mapping. Next, we want to enlarge a model with ontology properties hierarchy. The final result may be the set of restrictions on ontology design which allow fully automatic mapping.

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Probabilistic load-balancing for mining of frequent itemsets

Robert Kessl

kesslr@fel.cvut.cz

Department of Computer Science, Faculty of Electrical Engineering, Czech Technical University,
Karlovo nám?stí 13, 121 35 Prague 2, Czech Republic

Today's world is producing and collecting a tremendous amount of data. Analyzing the collected data is often a challenging task. Data mining (DM) is a collection of techniques for analyzing the collected data. One of the important DM techniques is *finding of co-occurrences* of events, bought items, etc. These co-occurrences provide basic overview of the data. Searching of these co-occurrences is called a *basket market analysis or association rule mining [1]*. The mining of association rules has wide variety of applications such as text mining, medical data analysis, etc.

Mining of association rules is a two stage process. In the first stage all *frequent itemsets* (FIMs) are mined from the dataset, and in the second stage *association rules* are produced from FIMs.

In our work we have focused on the *mining of frequent itemsets*, because it is the most time-consuming stage of the process. Since the FIM is an NP-complete task that also consumes huge amount of memory we have focused on parallel algorithms for the FIM problem. Currently, there is no efficient parallel algorithm for FIM.

The problem of mining of frequent itemsets is the following. Imagine a store where the people buy some items. At the cashier we record all items in one consumers basket and store them in a database. Given a parameter *min_support* we want to compute all set of itemset (itemsets) that occurs in at least *min_support%* of records(transactions) of the database. The produced itemsets are called frequent itemsets.

In [1] we have designed the Parallel-FIMI method for mining of frequent itemsets. The algorithm is a four phase process.

In the phase 1 each processor loads its database partition into local memory and the first processor collects database samples from all processors and computes an approximation to the *maximal frequent itemsets* (MFIs). The MFIs are maximal frequent itemsets whose all supersets are not frequent. The approximation of MFIs gives a sense of the size of the space of frequent itemsets (the search space) and therefore allow us to estimate size of every subspace.

In the second phase processor one partitions the search space of all frequent itemsets into partitions of approximately equivalent size and schedule the partitions to processors using statical ordering of items and the LPT-Makespan algorithm. This is an important phase because it determines the load-balance of the whole algorithm.

In the third phase the first processor redistributes the partition scheduling to the other processors. Now the processors are able to redistribute the database x, so every processor has the partition of the database needed by the processor for further computation in local memory. In the fourth phase the processors runs an arbitrary sequential algorithm for mining of frequent itemsets.

The Parallel-FIMI method has two big drawbacks: 1) MFIs are computed only on the first processor; 2) in the phase two, the scheduling algorithm uses only statical ordering of items while scheduling.

Computation of MFIs is a very time consuming when the database is very large. In our experiments we have discovered that the computation of MFIs can slow down the parallel algorithm. To speed-up the computation of MFIs we can use all the processors and compute the MFIs in parallel. This approach has one big drawback: the parallel algorithm produces not only MFIs, but also some non-MFIs. These non-MFIs are always subsets of MFIs. Because the amount of MFIs computed by one processor can be huge each processor must take samples from its computed search space and send it to processor one. Processor one then schedule the subspaces.

Statical ordering of items used by the scheduling algorithm in the Parallel-FIMI method has big impact on the speedup of the phase 4. The statical ordering of items used in the scheduling algorithm is not optimal and slows down every sequential algorithm used in the phase 4. The dynamical ordering of items is estimated by the processor 1 from the database sample.

Based on our experience with the parallel-FIMI algorithm we have proposed two new improvements in [3]. These improvements resulted in two new algorithms: Parallel-FIMI-DYN that uses a dynamic ordering of items and Parallel-FIMI-PAR that uses a parallel algorithm for mining of MFIs and dynamic ordering of items while scheduling the subspaces.

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Hardware Accelerated Computational Intelligence

R. Marek, M. Skrbek

marekr2@fel.cvut.cz
skrbek@fel.cvut.cz

Department of Computer Science and Engineering, Faculty of Electrical Engineering, Czech Technical University in Prague. Karlovo náměstí 13, 121 25 Prague 2, Czech Republic

This contribution focuses on implementation of the Radial Basis Function (RBF) neural network by using linearly approximated functions. The presented approach is suitable for hardware implementations on FPGA that may accelerate the simulation of neural networks of this type. Linearly approximated functions are based on shift and addition operations without the need for multipliers and look-up tables for implementing activation functions . Further, we present the results of our pilot implementation on FPGA consisting of arithmetic blocks for neural calculations, memory blocks for prototype storage, and controllers. We provide a number of parameters such as maximum clock frequency and the number of function blocks that characterize the resulting synthesized FPGA design

This contribution is based on our previous research presented in [1], where we introduced a set of linearly approximated functions suitable for the implementation of neural networks. The approach of linearly approximated functions goes beyond the complexity of multipliers and large look-up tables and replaces them with simpler logic circuits based on adders and shifters. We show how linearly approximated functions can be used for the effective implementation of RBF neural networks.

Recent years have seen rapid growth in the importance of neural networks and other computational intelligence paradigms in many applications. Radial Basis Function (RBF) can learn much faster than other comparable neural paradigms, therefore, they are suitable for real-time data processing and real time control. Neural networks used for this kind of application require fast simulation platforms to achieve short input-to-output latencies and fast responses to outer events. One solution is hardware acceleration of the simulation process by implementing the neural networks completely or partially in hardware [1] using FPGA as a rapid prototyping platform.

We propose a new functional unit, which merges and significantly simplifies the implementation of an approximated function chain. In this contribution [2][3] we present fully parallel FPGA synthesizable VHDL implementation of the RBF network using linearly approximated functions. We show that the combination of activation function and logarithm function results in a very simple operation (negation), which significantly simplifies the hardware implementation of the whole RBF neural network. The proposed RBF neural network consists of adders and multiplexers, no multiplier or large look-up tables are necessary. Bus interconnections among neurons and command based control of neurons provide very good scalability of the proposed architecture. It allows increasing the number of RBF neurons as well as increasing the dimension of the input vector. The pipelining technique used for RBF neurons allows full utilization of the hardware.

We present in [2][3]the synthesis results as well as the usage of RTL blocks obtained from the Xilinx ISE 8.2. The results show that more than 32 RBF neurons at a minimum can be implemented in 4vlx25sf363-12 FPGA. For a base unit containing 16 RBF neurons, we can achieve a processing rate equal to 1,5GCPS at 96MHz clock frequency. The architecture was simulated by the ModelSim VHDL simulator and validated against the model written in Java.

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Additive Interference in Real Ad-Hoc Networks

In-depth ZigBee / XBee Case Report

Alexandru Moucha

moucha1@fel.cvut.cz

Computer Science Departement, Czech Technical University, Karlovo namesti 13, 121 35 Prague 2, Czech Republic

Many papers have been written concerning the interference values in ad-hoc radio networks some providing solutions to improve the network in order to have as few collisions as possible. Due to the fact that interference itself is defined in multiple ways (some of which have geometric bases and not electromagnetic), it is kind of difficult to compare the given methods and algorithms because one method could be optimal for one given metric and very poor when analysed through another metric perspective. This work has been oriented to establish a proper objective model, based more on wave propagation laws and interference between electromagnetic waves, than on geometry and graph theory, and finally to measure the parameters on the field with a real and certified ad-hoc network.

Geometric interference models suppose that an antenna belonging to an ad-hoc communication node emits perfectly circular patterns and, based on this fact, it is possible to choose exactly the emitting power required to reach another neighbouring node, to exactly count the number of nodes found in the coverage area of an emitting node and to exactly measure the distance between two nodes based on the RSSI (Received Signal Strength Indicator) only. Some of the early models of interference take into account only the quantitative side of interference (two nodes interfere or not) and not the qualitative side (how strong the noise signal level becomes if there is more than one emitter and how the noise signal level decreases with distance from the noise sources), thus the additive and attenuated characteristics of interfering signals. Even though more recent models have incorporated the quantitative and qualitative approaches, they fail at providing good localised approaches for improving the overall network: in order to achieve good overall results, global knowledge about the topology is required, fact which is very difficult to achieve in a dynamic environment, where communication nodes are switched on and off and where links are formed and torn appart.

This work has been divided into five constituent parts and it uses the first certified ZigBee network: XBee Series 1 and 2 from MaxStream. The first paragraph studies the emitting stage of the communication nodes: radiation powers and patterns for the antennas. The research was conducted in the anechoic antenna chamber of the Department of Electromagnetic Fields and the results are the radiation patterns for the five communication node types. One of the results actually corrects one mistake that the manufacturer has in the documentation papers, where one antenna was wrongly measured in the cross polarisation mode.

The second part of this work was to determine the distance to RSSI characteristics for all the antenna types, all the node types and all the power levels and in a shielded environment (as close to the ideal case as possible). The experiments were conducted in the anechoic antenna room and cover the near field (0 m – 5 m) of the antennas, due to the confined space of the antenna chamber. The third paragraph covers the far field of the antennas (0 m – 0,5 km) for all node types and power levels. These experiments were conducted on the Kolin Airport runway, at least 5 km away from any emitter in the 2.4 GHz

band. The results from these two paragraphs provide a practical proof that measuring the approximate distance between the emitter and the receiver is possible, although a precise measurement is impossible to achieve, even in the anechoic chamber.

The fourth part contains the simple interference experiments, based on the additive characteristic of noise signals. Practically, three XBee nodes were programmed to establish the simplest ad-hoc ZigBee network (coordinator, transmitter and receiver) and a fourth XBee node was programmed to simulate another communication, by sending each millisecond a 802.15.4 frame containing just a single numerical value, at -39dBm power level (measured at the receiver). The average packet loss of the simple network was measured at 85.5%. Next step consisted in having two noise generators that give the same combined measured power level at the receiver (-42.6 dBm and -47.5 dBm) and measuring the packet loss rate, which in this case achieved only 2.18%. The main cause for this huge difference is the low probability value that over the same time slot both emitters are actually using their maximal radio power.

The fifth and final part of this work contains the complex interference experiments, based on the additive characteristic of noise signals. Five XBee nodes will be programmed to act as different quasi-simultaneous communications, all of them sending 802.15.4 frames at a rate of one per millisecond and the packet loss rate of the main network will be recorded. Due to the time consuming experiments (data rate of XBee is 115200 bps only), the results will be ready until the end of the week, just in time for the Workshop 2008.

The partial conclusions supported by this research are: 1. Ad-hoc networks strongly depend on their topology, location and environment (just a small change in the environment, such as a person walking, induces dramatic changes in the measured results); 2. Although distance can be measured on the RSSI only, on ZigBee it is possible to obtain the magnitude and not the precise value; 3. Although noise signals are additive and this is measurable on the Agilent and WiSpy spectral analysers and on the XBee nodes themselves, thank to the time slot separation, the effects are much less dramatic than theoretically predicted. This aspect has to be included in the interference metric. 4. Although studies of interference between ZigBee and Wifi have been done, none of them takes into account multiple noise sources with precisely determined radiation parameters.

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Quality aspects in digital and analog cinema technology

M. Tourek, M. Bernas

tourekm@fel.cvut.cz, bernas@fel.cvut.cz

CTU in Prague, FEE, Departmemt of Radioelectronics, Czech Republic,
Technická 2, 16627 Praha, Czech Republic

Cinematography is one of the latest fields, where digital technology isn´t widely spread. Nowadays the digital technology is mostly used in postproduction processing of films, especially for animation and implementation of effects. But in last years was happend of reality to project movies in really digital cinema's especially in USA and West Europe. In rest of the World we can see the first attempts of replacement of film projectors by digital ones too.

Comparison of film and digital projection shows important differences. It is related especially to color reproduction, precision of gray scale interpretation, reproduction of luminance and color contrast and image resolution. The big advantage of digital technology is the full reciprocity and no aging.

This paper deals with the discussion of problems and advantages of digital projections in cinematography. First part is devoted to the description of present state in this field. Next the recommendations DCSS (Digital Cinema System Specification) supported by most of film production companies are described. Further part deals with the discussion of parameters of modern digital cinema projectors and comparation of used technologies. The main part is devoted to the discussion and comparison of digital and film projection.

Despite its undeniable strengths which have helped it survive more than a whole century, 35mm film stock does have intrinsic technical limits. Firstly, despite the accomplished efforts of film manufacturers, it is impossible for the basic silver grains of film stock to become any smaller than their current size (around 6 microns). The fineness of the silver-based image is close to its asymptote, or its optimum. Secondly, the luminosity of projectors cannot increase indefinitely. The most powerful lamps available today, with their 7000 Watts, already pose major cooling problems. At levels beyond 10000 Watts, the heat would simply melt the film stock! And despite all possible precautions, 35mm prints attract dust and are prone to mechanical wear, both of which are detrimental to projection quality. Furthermore, prints run off in large numbers in a short space of time are often of relatively poor quality.

In digital projection, the images are completely free of dust and scratches. Audiences will see no mechanical wear, whether this is the film's very first or its 200th screening. There are no variations in luminosity and the image is absolutely stable as there are no noviny parts in play. Digital projection allows images to be shown on screens wider than 15 metres at resolutions and contrast levels equivalent to, if not superior to 35mm. Three technical advances have made projection on such large screens possible.

For comparison with 35mm projectors, digital projectors are graded according to four essential imaging parameters: luminosity, colorimetric space, resolution and contrast.

The most powerful lamps installed in 35mm projectors today are 7000 Watts. The quantity of light reaching the screen must be at least similar. The effective power of digital projectors is measured in lumens on the screen. Smaller projectors for home cinema systéme can make do with 1000 lumens; cinema projectors have to reach at least 10000 lumens.

Colorimetric space defines the actual palette of colours that can be represented on the screen. The colorimetric space of 35mm film is delineated by the combination of the three

different coloured layers. Digital projection uses red, green and blue filters of differing values and has a different colorimetric space. Put simply, colours are formed not by the chemical agents in the strip of film, but by differing combinations of three coloured beams of light. In practical terms, this results in a much larger palette of colours that can appear on the screen. Colorimetric space also depends on the quality of the digital processing of the image that occurs before the filters come into play. Today's digital projectors can have colorimetric spaces far betone those of 35mm prints; indeed, film falls well short of displaying the full spectrum of colours that the human eye can register. Thus, with digital projection, cinema-goers can for the first time see colours that to date were beyond representation.

It is difficult to compare the resolution of a digital image against that of a silver-based film image. In theory, the resolution of 35mm negative film is equivalent to, if not higher than that of a digital image. In practice, however, audiences do not see a camera negative, but a positive print made from an interpositive, which is in turn another copy. With each generation, the film grain increases and the subjective impression of sharpness decreases. This effect is often further heightened by the mechanical imprecision of some 35mm projectors. In digital projection, the minimum resolution called for is some 2000 pixels per line.

The contrast level of an image is measured by gauging the proportion of light in a totally white area to that in a totally black area. Such figures can only be guidelines, as they can vary enormously according to the way this proportion is measured. Suffice to say that a contrast ratio of 1000:1 is generally considered very respectable. Multiple factors can affect this ratio. Cinemas are never completely dark – at the very least, there must be illumination from signs showing the emergency exits. DLP Cinema projectors have been specially designed to avoid contamination of the projector beam by light from external sources. Such precautions are vital to ensure that dark areas of the image do not become grey.

The DCI parameters: The tolerance of white calibration is selected so that even by maximal brightness and deviations of white (in cinema) the color deviation according to CIEDE2000 is 1,18. This value is very close to the 1, which was define as just visible difference. One of the most important parameters is the definition of gamma on value 2,6. A lot of subjective test shown, that this value best match human sensitivity to brightness under the observation condition valid in cinema. Very important is also the decision, that in the digital cinema the color space XYZ is used for color coding instead of RGB space. This will allow fully exploit the color space of new displays. Application of color transformation

As was possible to see in this paper, the advantages of digital cinema are persuasive and in short term the digital cinema will be prevailing type of cinema in industry countries.

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Intelligent web technologies

Ivan Jelínek

jelinek@fel.cvut.cz

Department of Computer Science and Engineering, FEE CTU in Prague
Karlovo nám. 13, Praha 2, 121 35

Present-day web is at the crossroads of development – on one hand the amount of information on the web astronomically grows, on the other hand the number of common web users grows enormously and so the present technologies of data representation and information retrieval angles at their limits. The solution of this situation is not to "educate" more advanced web users but, on the contrary, the solution is: from one side to adapt the communication with web to natural human thinking and human behavior and from the other side to transfer "the thought what the web user searches on the web, indeed" to computer platform. That means the solution is to design such data representation (and access to it) which should respect the semantic of the information in such way that make possible simple semantic processing and that make possible in accordance to abilities and needs of particular user correct information interpretation. And the proposed project deals with these challenges. Expected assets in the frame of information technology are and among investigated areas belong especially:

- research on intelligent and heuristic technique to *support information searching* in web environment,
- research on searching methods on the web with consideration to *the semantics the information* sought,
- investigation on *adaptability of access to information* on web according to the user requirements, types and possibility,
- formulation and implementation of *integrated access to heterogeneous type of information* on the web.

Research team: Ivan Jelínek, head of the team, associate professor; Lukaš Bařinka, secretarial assistant, assistant professor; Miroslav Bureš, head of sub-team, former PhD student + assistant professor; Martin Švihla, head of sub-team, PhD student; Martin Ota, head of sub-team, PhD student + assistant; Martin Balík, member, PhD student; Lenka Lhotská, member, PhD student; Tomáš Havryluk, member, PhD student; Radek Jun, member, PhD student; Karel Richta, associate professor; Ladislav Čmolík, member, PhD student; Martin Klíma, member, PhD student + assistant professor; Michael Valenta, member, assistant professor

The target of the grant project 201/06/0648 is to suggest new intelligent solutions in the web technologies area, which would qualitatively improve the user access to information on the web. By the formulation of the main aspects of proposed solution of the project we put emphasis to structure the main goal to sub-goals not only in the topics but also in the time. *Research covers three basic areas of the web intelligence and eight of its sub-domains*:
Task A. Intelligent methods of information searching on the web
Task B. Adaptation of information of hypertext documents
Task C. Unification of access to information on the web

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Practical courses innovation in subject "Data Networks"

P. Bezpalec

bezpalec@fel.cvut.cz

Department of Telecommunication Engineering, Czech Technical University in Prague, Faculty of Electrical Engineering, Technicka 2, 166 27 Praha 6, Czech Republic

For a graduate in our profession it is important to gain not only theoretical foundation through education, but also an adequate practical proficiency. The main aim of the project was to innovate educational process in subject "Data Networks" mainly in practical courses but in theoretical level as well.

Innovation of practical courses

Main work has been done in innovation of practical courses. Refreshed practical courses syllabus contains six practical tasks.

Task 1 Universal cabling measurement
Task 2 Physical level of Ethernet type 10 BASE-T
Task 3 Protocol PPP – basic analysis
Task 4 B- and D-channel Data Transmission Analysis
Task 5 FrameRelay – basic analysis
Task 6 ADSL – configuration and analysis

Innovation of theoretical workshops

Three theoretical workshops consist of segment of theory and segment of simulation presentation. Simulation should enrich educational process with demonstration of behavior theoretically known methods and principles.

Simulations are mainly in a manner of

- Primitives exchange in multilayer reference model.
- Signal propagation within Ethernet media.
- Call flow in PPP protocol.
- Data communication principle in ISDN D-channel.
- FrameRelay operations.

All simulations are done by multimedia presentation.

Innovation of practical tasks

All input study materials for practical tasks have been innovated and transformed into Internet—ready form and then published to server that belongs to our department (www.comtel.cz → Předměty → X32DAS → Materiály pro výuku) and therefore are anytime easily accessible by students.

Innovation of Task 1 – new data terminal endpoint as well as material and tools to successful task realization (cables, connectors …) has been bought, repaired and re-measured.

Innovation of Task 2 – new laboratory oscilloscope has been bought.

Innovation of Task 5 and 6 – new multiprotocol routers has been bought, till now routers had to be commercially loaned out.

Innovation of theoretical lectures

The revised basic of telco knowledge that has been deeply studied has extended a spectrum of lectures. Mainly English written literature has been translated into new lecture base that is in form of MS PowerPoint presentation. This chosen format is able to show new concepts with animated explanation. This is more didactical. An electronic form of new lectures has been placed on Internet (www.comtel.cz → Předměty → X32DAS → Materiály pro výuku) and therefore is easily accessible by students.

Conclusion

Main goals of subject innovation are:

- New knowledge implementation.
- New simulation implementation in theoretical workshops.
- Workplace innovation for practical tasks.
- Practical tasks optimization and material, tools and device complementation.
- New study material creation for theoretical parts of course.
- All study material is now in electronic form of presentation.
- Motivation of students to study modern telco technologies.

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Utilization of Modern Information Technologies for Knowledge Evaluation

P. Mach, D. Krčmařík

machp2@fel.cvut.cz

Department of Telecommunication Engineering, Faculty of Electrical Engineering,
Czech Technical Univerzity in Prague, Technická 2, 166 27, Praha 6, Czech Republic

Nowadays, many educational institutes try to increase the number of graduated students. In order to accomplish this need, an e-learning concept has been developed. The main idea is to let student study without direct interaction with teachers and professors. However, the problem in e-learning is how to score the students after an online course is realized. Although, several commercial products already exist, e.g. Class Server by Microsoft [1], they have many drawbacks such as too expansive license cost and lack of functionalities necessary for this purpose.

In order to overcome the limitations stated previously, new system known as Knowledge Evaluation system (KES) [2] had been developed. The main objective of KES was creating of complex software product with assistance of PHP [3] language and MySQL [4] database system which increase efficiency and speed up the whole process of students testing. Besides PHP and MySQL, another internet technologies were used, i.e. HTTP protocol for data transferring between the server and client computer, HTML language, Apache server to provide the means for system functionality and finally Cascading Style Sheet (CSS) language together with JavaScript were implemented. The KES strength lies in virtues such as:

- ease of use both for teachers and for students thanks to user friendly interface
- test results are transparent for students which allows to student find out where the mistakes were done in the test
- no special demands on system operation and maintenance
- small complexity of the whole system with possibility of modifying the source code for special purposes

After analysis of the KES functionalities and requirements was decided to divide the existing users into three individual groups with distinct characteristic:

- Administrator – The main task of administrator is to change status of users from student to teacher and also the whole system supervising. He has the rights to delete any existing user together with its data. Furthermore, administrator can modify the system functionality and design on the assumption that he has access to the source codes of the system.
- Student – The user with status student is registered through link label located in the main menu. After that, student can anytime access the system. The system offers many functions to students such as: i) changing its personal data (e.g. username, password, etc.), ii) choosing among available subjects, iii) listing of accessible tests within each subject, iv) performing the test and most importantly v) viewing of test results with displaying of wrongly answered questions.
- Teacher – To become user with status teacher, two steps has to be performed. In the first place, user registers in the same fashion as student. To change status of student into teacher, he has to contact the administrator who has the rights to do

that task. The system gives to teacher some additional functions in comparison with students like: i) inserting of new subjects, ii) changing information about individual subjects, iii) inserting of new tests and specification their conditions (time duration, number of attempts, etc.).

All inserted tests in the system have the form of a quiz. This implies that there are questions which have several answers stated below the questions. Either only one question is corrects (radio button type) or several questions are correct (type of multiple choices). For the sake of simplicity, the tests are written as ordinary text files with txt suffix so there is no need of programming skills (the text syntax is shown in [2]). The very convenient function of the system is that during the test initializing, the questions are organized randomly. Besides that, also the answers are sorted randomly. These two features prevent to individual students in copying of others results. Consequently, knowledge evaluation by means of KES is much more objective in comparison with other existing systems (e.g. Class Server).

For adequate system security, the password is protected by MD5 (more detail can be found in [3]) so it cannot be taken out of MySQL database. Furthermore, the session concept was used that enables to discover whether an attempt of unauthorized access, also known as sessionhijeck, was made. During the time when individual user is logged in the system a session number is assigned to him. In case that someone wanted to enter the system as the user currently in the system, he would need to have at the same time the session number of the user, the session variable $_SESSION[loginusername] initialized and the same IP address as the user.

The system offers not only Czech version, but also English version can be used. It is assumed that in the first phase, the application will be used in Optical Communication System (subject code X32OKS), Communications in Data Networks (32KDS) and Transmission Systems (X32PSY) within the scope of educational program at Department of Telecommunication of the Faculty of Electrical Engineering. In the second phase, after system validation, it is supposed its expansion into other subjects both at the same department and other educational institutions.

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Course modernization - X32IBU - Information Security and Secretion of Messages

T.Vaněk

vanekt1@fel.cvut.cz

Department of Telecommunication Engineering, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

For graduates in telco domain it is important to have at least general information about network security, basic cryptographic algorithms and protocols. The main goal of the project was to innovate who educational process in subject "Information Security and Secretions of Messages" in theoretical lectures as well as in practical courses. New lectures made students familiar with principles, architecture and applications of modern symmetric-key and asymmetric-key algorithms, hash function and widely used cryptographic protocols.

Innovation of the lectures

Main improvements in the course have been done in innovation of the theoretical lectures. A lot of actual English written literature has been studied and transformed into new lectures. Every new lecture comes with presentation in PowerPoint. These presentations illustratively show main ideas of the topics. An electronic form of new lectures is available for the students at www.comtel.cz (section Předměty → X32IBU → Materiály pro výuku).

Lecture 1 - Security mechanisms in wireless networks - IEEE 802.11 (WiFi), 802.15 (Bluetooth) and 802.16 (WiMAX).
Lecture 2 - Protocols for securing VoIP protocols (H.323, SIP, IAX, MGCP, SCCP, Skype)
Lecture 3 - Steganography, Digital Watermarks and Digital Rights Management
Lecture 4 - IDS (Intrusion Detection and Prevention) and IPS (Intrusion Prevention Systems)

Innovation of theoretical excercises

In the field of theoretical exercises only minor changes were done. New scripts for cryptanalysis were prepared in JavaScript and Java. During these exercises the students try to decrypt historical ciphers. These exercises cover

- Monoalphabetic substitution ciphers
- Polylalphabetic substitution ciphers
- Transposition ciphers

Innovation of practical tasks

The X32IBU course was transformed from the former 32ODI and 32UDP courses. The main disadvantages of these courses were absence of practical laboratory tasks. Three

completely new tasks were created to demonstrate practical aspects of network security and usage of cryptographic algorithms.

Laboratory 1 – WiFi networks localization and secure analysis. In this exercise the students will search for wireless networks in designated location. The have to localize the APs (using GPS) and gain as much information as possible about security of found networks by opensource programs (Cain&Abel, NetStumbler,…)

Laboratory 2 – Authentication protocol analysis. In this exercise the student will analyze existing authentication protocol using BAN logic and/or Color Petri Nets. A visual model of broadcast authentication protocol TESLA was created using a tool called "CPN tools" and the student try to search for security holes that were injected into this protocol.

Conclusion

Main goals of subject innovation are:

- Four new theoretical lectures.
- Creation of the new study material for theoretical lectures.
- Two new practical laboratory exercises.
- Crypto portal improvements.
- All study materials are available for students in electronic form.
- Motivation of the students to study modern telecommunication technologies.

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Multilingual Virtual Control Laboratory

M. Hofreiter, R. Petrová, D. Urbánek

Milan.Hofreiter@fs.cvut.cz

Department of Instrumentation and Control Engineering, Faculty of Mechanical Engineering, Czech Technical University, Technická 4, 166 07 Prague 6, Czech Republic

Automatic control is one of today's most significant areas of science and technology. This can be attributed to the fact that automation is linked to the development of almost every form of technology. Automatic control is an indispensable branch of all engineering specializations. These days, all engineers and technicians need to know about control engineering. The increasing use and sophistication of automation in modern engineering systems has created the need for students of all engineering specialization and academic levels to have more than just appreciation of the theoretical principles involved in control engineering. It is also important for them to have practical skills and abilities, usually only gained through experience, if they are to be successful in their chosen careers.

In Czech Technical University in Prague, Faculty of Mechanical Engineering there is a common course Automatic Control for all students in the third school year. Practical training as a component part of the course is realised in the laboratory of Automatic Control that is one of the laboratories of Department of Instrumentation and Control Engineering. To get more interest in control theory the old laboratory models were removed and substitute by new ones, which are more attractive for students.

With the development of new computer technologies, JAVA - an interactive multimedia programming language, and the World Wide Web, it is now possible to simulate and animate engineering and science laboratory projects on a computer. With Internet access, it can be offered students "virtual laboratories" via the WWW or CD-ROM. Therefore the Virtual Control Laboratory is gradually being developed in Czech Technical University in Prague, Faculty of Mechanical Engineering. The website of the Virtual Laboratory (http://vlab.fsid.cvut.cz) can be visited and opened via Internet from all over the world in common web browser and therefore enables not just to students, but to everyone, to improve the theoretical knowledge in this subject field.

Most of the real laboratory apparatuses are simulated in the Multilingual Virtual Control Laboratory. It means that nowadays the Multilingual Virtual Control Laboratory contains the following virtual models: "Air Jet", "Ball and Beam", "Water reservoir", "Bathyscaph", "Water Levitation", "Ball and Elliptic Rail", "Air Levitation", "Vehicle Position Control".

The Multilingual Virtual Control Laboratory is an interactive environment where it is possible to find out static and dynamic characteristic of processes and closed-loop systems, to select controller (P,I,PI,PD,PID, on-off controller, three positional controller), to design controller settings, to view time courses of the manipulated variable, the controlled variable, the load disturbances and the set point and to design time courses of the disturbances, the set point and the manipulated variable (in the manual control). All virtual models are described and governed in the same manner.

Each experimental apparatus contains the following items: the title, the schematic diagram, the colour photography, the videorecording, the tasks, the visual simulation, the literature. The layout of graphs, animations, text fields, check boxes, radio buttons, drop-down lists, push buttons etc. is the same for all windows of the visual simulations.

WWW pages were built up in the Hypertext Preprocessor (PHP) with the help of JavaScript and SQL. The applets for visual simulation were developed in Java code. Netscape Navigator version 4.6 or Microsoft Internet Explorer version 4.0 and higher may be used to display and execute all actions of the user.

Animation and visualization make it easy to observe and record the reaction of the real laboratory model on the defined courses of input signals. Several videos, photos and specifications of the real models and introduction to a number of exercises are also parts of the Virtual Laboratory.

Nothing can replace the real, hands-on experience of lab work but with the Virtual Control Laboratory all students can now do every control experiment in their own time, virtual experiments can be carried out either as a teaching aid before actual physical lab experiments, or for comparison after these experiments, if some aspect of the process or system is not understood properly then simulations can be used for clarification and it is possible to obtain results more rapidly than in a physical laboratory and so more examples can be tried.

The Multilingual Virtual Control Laboratory is gradually being developed in English, French, German and Czech in order to correspond to the real control laboratory of Department of Instrumentation and Control Engineering.

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New practice excercises with VoIP technology

Z. Becvar, J. Zelenka, P. Bezpalec

becvaz1@fel.cvut.cz

Czech Technical University
Department of Telecommunication Engineering
Technicka 2 , Praha 6, 166 27, Czech Republic

The main goal of this project was innovation of the subject "Integrated Service Digital Networks" at Czech Technical University in Prague. There were implemented four practice exercises focused on VoIP technology. Two of them deal with VoIP network configuration and the others concern with VoIP protocols analysis. The workplaces are equipped with IP telephones, video IP telephones and VoIP gateways. The changes were introduced into the education in winter semester 2007.

The goal of subject "Integrated Service Digital Networks" is to acquaint the students in Master study program with an overview of principles and current state of switching techniques and technology in systems characterized by digital switching and transport of a signal. The subject is mainly focused on the detailed identification of students with the principles of ISDN (Integrated Service Digital Network) networks. The protocols and signaling systems (including SS7) used in ISDN are presented. The practice exercises give a chance to meet the practical training with configuration and maintenance of ISDN networks, including practical training with protocol analyzer that allow an analysis of signaling messages.

The semester was separated into the two parts according to old syllabus. The first part was theoretical and its target was to provide information that prepares the students for the second part. The second part is consisting of three practice labour exercises. All labours are targeted to the ISDN. The syllabus was following:

1. Introduction.
2. ISDN reference model, functions, protocols. Control and user plane, Basic type of connections in ISDN, Services.
3. Synchronization of digital network.
4. Physical layer of BRI, PRI, power supply, frame structure, link codes.
5. Link layer, Activation, TEI negotiation, access control.
6. Network layer, Packet format, setting up and canceling of connection, controlling of additional services.
7. TA adapters, Access of terminals according to X.21, X.25, V.110, V.120,...
8. Test
9. Introduction to practice exercises
10. *Practice exercise 1.* : Services on ISDN
11. *Practice exercise 2. :* Analysis of signalization in reference point S/T
12. *Practice exercise 3. :* Data transfer in B and D channel.
13. Substitute exercises
14. Credit

Four new practice exercises were integrated to the syllabus. These exercises take place instead of theoretical part of old syllabus.

The first of new practice exercises is focused on SIP protocol analysis. The second and the third are aimed on analysis of H.323 signalization, once for Peer-to-Peer communication and once on cooperation with gatekeeper. The last new practice exercise is focused on the numbering in VoIP networks. All new practice exercises are highlighted by bold text in syllabus.

1. Introduction.
2. Introduction to practice exercises
3. Introduction to practice exercises
4. Introduction to practice exercises.
5. Excursion to TO2
6. *Practice exercise 1. :* Analysis of signalization in reference point S/T
7. ***Practice exercise 2. : VoIP switch Asterisk*.**
8. ***Practice exercise 3. :*** **Analysis of SIP signalization**
9. ***Practice exercise 4. :*** **VoIP gateway configuration**
10. ***Practice exercise 5. :*** **Analysis of H.323 signalization –Gatekeeper**
11. *Practice exercise 6. :* VoIP telephony quality, QoS
12. Test
13. Substitute exercises
14. Credit

Four new practice exercises will be introduced into education in summer semester 2008. These exercises allow getting new practice experiences with VoIP technology to students. The labours are created to cover the most important and more interesting parts of VoIP communications such as analysis of protocols and configuration of VoIP networks.

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Website for teaching Physical Education

V.Botlíková, *J. Kortánek

vladana.botlikova@utvs.cvut.cz

Institute of Physical Education and Sport, Czech Technical University, Pod Juliskou 4, 160 00 Praha 6, Czech Republic

*Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

The students and the teachers at ČVUT spend quite a lot of time in front of their computers. Some of the students and many teachers or employees suffer from various health problems as a consequence of their sedentary lifestyle. These problems are mostly connected with their bad posture while sitting and/or standing. The longer the inconvenient condition lasts, the worth and more long-term the consequences are, it mostly ends as a chronic low-back or neck pain.

At the Institute of Physical Education and Sport at Czech Technical University in Prague, we offer all the students as well as the employees among many other options also Corrective physical education. During these lessons, we teach the clients primarily the proper and effective exercises that release strained posture, relax the neck and raised shoulders etc., but also how to arrange their working place properly to avoid straining and stress of their back.

We have noticed that some students are not able to remember the exercises they have not only seen but also practiced and repeated many times during the lesson of Physical Education. Even though they are very motivated to learn some exercises (because they need help to get rid of pain in certain parts of the body), they forget what to do. There might be a simple explanation: it is known that there are several types of memory – not only visual, but also audio and motoric memory. There are people who are able to remember a long text from a book, can replay several songs heard for the first time without a single mistake and yet cannot remember a motion they have seen several minutes ago. We created this new website not only for those but primarily for people wishing to recall the useful exercises also when peacefully relaxing back home. It is meant as an electronic support for the lessons of Corrective physical education, Fitness lessons for beginners and Frisbee lessons. All the important exercises which are taught during these lessons are presented as animated pictures. This way, the motion can be looked over once more at home and the client can easily repeat the exercise according to the motion model on the computer.

In the first period in spring 2007, the team of students - graphic designers - had to choose the proper device for creating the moving exercises. They considered two ways of creating it: first - recording a person on a digital camera or using a motion capture, second - using one of the programs for computer animation.

The first method was soon rejected: recording people does not allow future correctors to change the performer and surroundings. Furthermore, adjusting the size of the video to the need of fast appearance on the computer would make it a low-quality video. High price is a major disadvantage of the motion capture method. The second way was more real: having rejected two professional but very expensive programs Maya and 3D Max studio, the students have finally chosen the program Poser, version 7.

The advantages of this program are its reasonable price including quality premade models and a relatively easy way of using the tool for animating the exercises. The motion of the model is very precise and can be done in detail. The final animation combined with the graphical quality of the models looks very real. The main advantage but also the main disadvantage of this program is the approximation of the motion: if one needs to create an easy motion, he can adjust only the initial and final state and the program approximates very precisely the motion between these two points.

Unfortunately, when the motion is more complicated, or when one has to synchronize the motion of two or more parts of the body in one time, the tool creates more trouble than help - it approximates the motion usually differently than one needs to. Then the animator has to make the motion in single sequences, one after another. Animating is quite time-consuming, an experienced animator can create easy exercises in one to two hours, but more complicated motion can take even much more time. The final video was rendered to .avi format using MPEG4 and therefore is of quite a small size, approximately 200 - 500 kB. The video is subsequently converted to the Flash format suitable for direct presentation on the internet.

The main project solver has chosen the following number of exercises for animating: 114 exercises from Corrective physical education, 28 exercises from Fitness for beginners and 6 basic motions from Frisbee. The continuous correction of precise details of every motion in each exercise created by the animators was the time consuming part of the work. This part contains also a short text describing every chosen exercise and all the instructions how to use the exercises properly. The main outcome from this part is the original animation of 148 exercises from the three subjects of Physical Education.

The other part of the website content concerns arranging a workplace when sitting in front of a computer and a photo - documentation of correct and wrong sitting on a chair, using various models of chairs and various monitors and computers. This way, the client can learn how to arrange the workplace properly. This part contains a text commenting the correct arrangement of the workplace and some positions and exercises soothing a possible back pain. The main outcome from this part is 38 photos of students – volunteers, showing these various situations.

The last part of the website content is a questionnaire enabling to find out how people use tools (such as mouse, keyboard, laptop…) when working with the computer, what are their sitting habits, if they have some health problems from their work with the computer. Filling in the questionnaire takes just a few minutes.

The website is user-friendly, with intuitive, easy control. The address of the website is www.utvs.cvut.cz/telocvik. The animated exercises are available anywhere on the internet, not only within the school network.

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Practically Oriented Innovation in Subjects "Design and Programming of Database" and "Creation of Interactive Web Applications" at CTU FTS

J. Krčál, M. Jeřábek

krcal@fd.cvut.cz, jerabek@fd.cvut.cz

Department of Informatics and Telecommunications,
Faculty of Transportation Sciences, Czech Technical University,
Konviktská 20, 110 00 Prague 1, Czech Republic

The aim of this contribution is to report on the results of the project Practically Oriented Innovation in Subjects "Design and Programming of Database" and "Creation of Interactive Web Applications" at the Faculty of Transportation Sciences of the CTU, supported by the Universities Development Fund of the Czech Republic in 2007.

The main problem of technical subjects specialized in informatics is a constant and fast development of used technologies. The specialized technical subjects therefore have to adapt to this tendency to provide students with current and valid information which enables them to compete in the employment market.

The aim of the project was innovation of the subjects "Design and Programming of Database" (K614Y1ND) and "Creation of Interactive Web Applications" (K614Y1TI) which are a part of the Bachelor degree studies of the Faculty of Transportation Sciences of the CTU in Praque. The innovation involved creation of an interactive web learning text which reflects the contemporary state and level of technological development taught in both subjects. This contains the practical usage of well-known and highly evaluated database system Oracle and the newest version of PHP scripting language, version five. Both subjects are closely connected to each other, because knowledge in one subject is easily utilizable in the other. Any applications in relation to other subjects of course may be also discussed in terms of the two subjects mentioned above.

The instructional text for each class consists of three parts:

- theoretical explanation of the taught material
- practical exercise focused on the discussed material
- test in which students check whether they fully understand the discussed material

Students may gather required theoretical basis of the material thanks to the instructional text, but the practical exercise and verification of new knowledge are also part of the process. Studying of this instructional text is enabled from everywhere and at any time only with the web browser, no installation of extra software is needed. This fact would primarily improve the teaching and make it more effective, but it would also make studying more pleasant for the students.

The creation of interactive network instructional text was associated with:

- purchase and installation of a server with software equipment required for the teaching (OS Linux, Oracle Database XE, Apache, PHP 5, MySQL)
- creation of an application to construct automatically user's account for the students signed up to the subject
- creating a list of either Czech and foreign literature which is available, together with links to internet pages focused on issues discussed in the subjects.

The subject "Design and Programming of Database" does not focus on database systems using another model than the relational data model, considering the mass expansion of relational database systems and limited teaching capacity.
The material of the subject is divided into three parts:

- students focus on the problem of designing database in the first part, which includes the ability to depict the extent of problem by ER diagram, conversion of the diagram to the relational scheme and correction by decomposition and standards forms
- the second part includes introducing the SQL language and its procedural extension for communication with database system. Even though the standard of SQL language exists, database systems of various producers do not fully follow the standard and they also offer their own extensions. Database system Oracle is used for the instructional purpose, because it is practically used in applications with requests of high security.
- the third part focuses on a developmental instrument which enables easy creation of web application working with data from database.

The aim of the subject "Creation of Interactive Web Applications" is to introduce the PHP scripting language to the students. PHP enables creating dynamic web pages and is widely used in various web projects nowadays.

Students continually proceed from understanding of basic issues to working with database system MySQL or coding a text. The whole instructional text is based on analysing short sequences of code, which leads students to understanding of practical effects of used code recording and its functions. A list of assignments follows after each lesson. These exercises are supposed to prove students´ comprehension of learned material. The web browser is enough to solve these exercises, because the page enables to insert the PHP code directly. Every student may return to particular exercises and continue with the work due to the fact that each student has its own account.

We will continually update and upgrade this interactive web instructional text to keep it up to date and we will also try to cooperate with remarks of students to make it as quality as possible.

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Solving Approximate Values of Outer Orientation Parameters for Projective Transformation

B. Koska*, J. Řezníček**

bronislav.koska@fsv.cvut.cz

*Department of Special Geodesy, **Department of Mapping and Cartography, Faculty of Civil Engineering, Czech Technical University in Prague, Technická 2, 166 27 Prague 6, Czech Republic

In the recent years it is possible to notice quite outstanding introduction of photogrammetric methods for obtaining space information. The main reason of this phenomenon is especially improvement of quality of digital technologies in the area of acquisition and processing an image. As for data collection it is especially increase in resolution, speed, sensitivity and sensor size.

Wider use of digital photogrammetry is also connected with need of more thorough theoretical comprehension of the used mathematical apparatus. The basic relation for description of the central projection is projective transformation. Almost all other relations used in photogrammetry are based on this transformation. A disadvantage of this transformation is its non-linearity. The biggest problem of its applications is therefore inexpensive obtaining the approximate values of their parameters.

This article describes a simple procedure of calculating approximate values of outer orientation parameters for projective transformation.

There are several approaches of how to obtain these approximate values. One possibility is their direct measuring, which is used for example for aerial photogrammetry, but its application for terrestrial photogrammetry is not advantageous. Other possibility is their calculation by some approximate linear method, for example direct linear transformation, so-called DLT. Disadvantage of the DLT is that input points must not lie in a plane or near a plane, whereas creation and maintenance of a plane field of check points is simpler. A minimum number of points is also lower for a plane field when the suggested procedure is used.

A procedure based on homogenous coordinates and application of numerical methods for calculation of eigen-values, singular decomposition and QR decomposition is used in the community of computer vision. A disadvantage of this procedure is its excessive complexity, which complicates detailed comprehension of space geometric relations.

The procedure we suggest is developed from basic photogrammetric equations describing projective transformation and is in accordance with the approach in the photogrammetric community (see [1]). The procedure is original, simple from mathematical point of view and enables detailed geometric understanding of its single steps.

The principle of the method is based on modification of the basic relation between space coordinates of points and their image coordinates. Basic photogrammetric equations are also derived from this relation. In original relations there appears a scale number for each point. The adjusted relations represent linear homogenous equation system. It is necessary to choose a scale number of one point as an invariable for need of its unambiguous solution. In this way we obtain a linear inhomogeneous equation system, which can be simply solved by the least squares method. After calculating the adjusted parameters it is necessary to "normalize" them by multiplication by average norms of rotation matrix vectors. Values adjusted in this way can be used as approximate values for an exact calculation. The minimum number of points necessary for calculating approximate outer orientation parameters is six.

If all control points are situated in a plane or near the plane, a modification of the stated procedure is necessary. Firstly it is necessary to process an identity transformation of all control points into the coordinate system, where their "*z*" coordinate is zero (or almost zero). In the next solution it is possible to leave out the column of unknowns (vector of rotation matrix), which corresponded to the "*z*" coordinates. There are three unknowns less and the number of equations is kept in modified solution. Number of points in a plane necessary for calculating approximate values is four. The missing rotation matrix vector is calculated by the vector product and will therefore complete the right-handed system of coordinates. Other procedures are identical to the solutions with points not lying in the plane.

Use of the suggested procedure is wide. It is for example a solution of one- or more-image calibration of digital cameras with using a plane calibration field, a calculation of space coordinates in some scanning systems that are being developed (see [2]), a calculation of image coordinates for mapping textures onto a triangular mesh in the GUI (Graphic User Interface) PointClouder (see [3]) and adding quality information about colour of the measured points of the Leica HDS3000 scanning system.

Problem of the existing commercial solution in the last two stated applications is an unknown calculation algorithm, its low stability, an unknown method of removing distortions of an image (provided that some method is applied) and low level of user comfort. Therefore it is suitable to introduce the projective transformation including the stated approximate solution and a function based on it into the GUI PointClouder.

The stated solution of approximate values calculation of outer orientation parameters and also an exact solution of all projective transformation parameters in accordance with the least squares method was incorporated into the Alltran library [4].

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EasyControl - Universal Control System for People with Limited Mobility

P. Novák, M. Fejtová

novakpe@labe.felk.cvut.cz

Department of Cybernetics, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

During the recent years there has appeared great number of technical devices one needs or wants to utilize. Personal computers are one of the best examples. Usually, people access and control these devices through various peripheries, e.g. PC mouse, computer keyboard, remote control device with buttons. Construction of these peripheries assumes that the user can hold them in his/her hand and press their buttons or keys by fingers. We are concerned with the situation when this is not the case, namely when the user is lacking fine motorics necessary for that purpose. Our team has designed and developed several peripheries, which are ready to provide assistance in establishing man-machine communication even under such demanding conditions. In the first two following peripheries eye movements take over the role of the driving force:

- The I4Control® system uses a tiny camera attached to the rim of glasses its user is wearing. This camera monitors position of his/her iris. Different types of iris deviation from its stable position are interpreted as specific types of control signals, e.g. for a computer. It is a robust solution for clients lacking all motoric functions.
- BlinkSwitch is a maximally simplified version of I4Control®. It distinguishes between 2 states only: in the first one the observed eye is open while in the second state it is closed. It is intended for control of very simple applications where „closing the eye," indicates the user's choice.
- FingerSwitch does not rely on eye movements but it takes advantage of its user's capacity to ensure some change of position (remaining motorics) and press the switch - this act can be given interpretation chosen from a limited set of signals. The applied switches can be located on the place, which suits best the needs of the specific client (e.g. in the head-support of his/her wheel-chair).

These peripheries can be used to ensure communication between their user and a personal computer or other technical means. To make this connection as simple as possible we are developing a universal control system EasyControl.

The proper choice of assistive technology for the specific user depends on the capabilities and limitations of the considered client as well as on his/her preferences and wishes. The construction of the person-specific solution could be significantly simplified if there is applied a uniform protocol for communication between various peripheries and the output devices. This is the goal of the *universal control system EasyControl*, which provides uniform means for communication between the user (taking into account the *user's profile* describing his/her capabilities and constraints wrt. the selected input device) and various output devices or SW applications.

EasyControl has been constructed to prove the suggested concept. It supports all the input devices designed by our team, namely I4Control®, FingerSwitch or BlinkSwitch. There are implemented 4 modes of control corresponding to various types of output devices. The

first mode is intended for direct control of a PC: it emulates a PC mouse and it provides direct interface between the input device and numerous PC-mouse controlled SW tools. The second mode takes care of direct control of technical devices, e.g. our educational toys: robot Gertie (a model of a caterpillar robotic vehicle) and Robie (a model of the robotic manipulator). The third mode suits both for control of technical systems and for control of appliances: it is a variant of control provided by a limited set of keyboard keys (e.g. cursor positioning by directional arrows). The fourth mode has been implemented most recently. It offers direct connection to the goal application (e.g. TCP/IP protocol, MessageQueue etc.). One can characterize it as a communication channel attached to the considered application. This mode is used in the special software keyboard, where the continuous control provided by a PC mouse is replaced by a discrete control mode (the cursor "jumps" between the neighbouring keys in the selected direction).

The EasyControl provides efficient means for interconnecting various input peripheries with the requested output device. Sometimes, the target application offers the user a possibility to open a new output devices or SW application, which set their own requirements for the mapping between the user's actions and the corresponding commands (e.g. the discrete movement of the cursor in some games). Our next goal is to provide EasyControl with an ability to pick out automatically requirements of such a new output device. This can be achieved by creating automatically a new version of the current user's profile, which is stacked over the former one. This version is erased when the considered SW application is closed.

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Perception Based Conversion of Color Images to Grayscale

M. Čadík

cadikm@fel.cvut.cz

Department of Computer Science and Engineering, Faculty of Electrical Engineering,
Czech Technical University in Prague, Karlovo náměstí 13, 121 35 Prague 2, Czech Republic

Although today's digital cameras take color images, many laser printers still use one color of toner, and most of the pictures in the world's newspapers are in black and white. Conversion from color to grayscale therefore remains an important piece of the digital imaging puzzle. Color-to-grayscale conversion is in fact a mapping of three-dimensional set with strong spatial coherence to a one-dimensional space, and necessarily involves some loss of information. We believe that global transformation approaches [3] cannot be a full answer to the problem, although they have been shown to offer some fast and acceptable results. Adaptive local methods [1,2] hold the promise of a much better solution, because they are better at preserving details than global methods such as simply selecting the luminance channel, although they suffer from theoretical problems in perceptual modeling, as well as computational difficulties.

We present [2] two new local color-to-grayscale conversion techniques (i.e. solutions to both analytical and experimental approaches). The analytical solution is a generalization of the CIELab formula, which introduces a signed power function to give a signum to the weighted Lab components. The experimental solution aims to obtain the best perceptual gray gradient equivalence by exploiting the Coloroid color system and its extensive experimental background. As opposed to the use of either luminance or chrominance to compute gray gradients [1], our two new approaches take into account both quantities, giving (signed) chrominance between 2 and 3 times less weight than luminance. The main contributions of our work are: (1) the two gray-gradient formulas; (2) a new and efficient way of converting an inconsistent gradient field into a consistent one, which can be directly converted into an image by a simple 2D integration; (3) pleasing grayscale images that preserve high-frequency details and contrast effects without artifacts; (4) an absence of any tuning parameters, much faster operation than previous local approaches, and easier implementation.

Before turning to the Coloroid formula, we studied the possibility of extending the Color2Gray method [1], eliminating the artifacts and to reducing the computational cost. Using the CIELab values, Color2Gray computes a warm-cold hue transient value, which is then multiplied by the chroma, and finally modified by a stretched tanh function to obtain the chrominance. The signed gray difference that is used is either the chrominance or the luminance, depending on which has the largest absolute value. However, this approach can result in a strongly inconsistent gradient field, e.g. a large negative value can appear immediately after a large positive one. To `blur' this kind of artifact requires a large neighborhood, and increases the effective complexity to $O(N^4)$. To overcome these shortcomings, we abandoned the use of a simple maximum, and formulated a continuous function using the CIELab space. In contrast to Gooch et al.'s method [1], ours takes just a fraction of a second to process an image, and the results preserve more details.

While luminance obviously plays a role within the human visual system, color-to-grayscale conversion contains additional elements, because local luminance and chrominance changes are not transformed to luminance gradients in the brain [4]. However, some perceptually justifiable values can be determined through observations using an appropriate arrangement of color and gray samples, and the Coloroid system appears to be a very

appropriate tool for this purpose. The Coloroid system is based on a uniquely large number of observations, by 80 thousand observers who made 26 million elementary choices. The basic perceptual quantities measured (i.e. hue, saturation and lightness) have a very good correlation with the Coloroid model parameters. The perceptually-based Coloroid gray-gradient formula is central to our method. Unfortunately, it cannot be given in a closed form, since it consists of tables of observations and appropriate interpolation rules. The structure of the formula and the meanings of the terms involved are described in the paper [2].

Our adaptive color-to-grayscale conversion consists of three steps. In the first step, we regard the color and luminance contrasts as a gradient field which we construct using the formulas described in previous paragraphs. Then, instead of using a Poisson solver or conjugate gradient method, which work with density values, we correct the gradient field using a fast and effective gradient inconsistency correction method, which uses an orthogonal projection technique to find the nearest consistent gradient field. Finally, we integrate the corrected gradient field and transform the values to the display range, which yields the grayscale image. Gradient domain imaging methods generally change the original gradient field of an image, or generate an artificial gradient field from a set of images. The key issue in that approach is the backward transformation, which is the search for an image with a prescribed gradient field. In general, there is no exact solution to this problem and furthermore, the set of manipulated artificial gradient vectors is not a consistent gradient field, we cannot obtain the unknown image by two-dimensional integration.

We approach the problem of an inconsistent gradient field with a new question: what is the nearest consistent gradient field to an existing inconsistent one? Consistency has a simple pictorial meaning: along a loop that starts and at ends any given pixel, the total gradient changes must be zero. We introduce a new gradient correction method [2] for solving the gradient field inconsistency problem. This method differs from all existing techniques (Poisson, conjugate gradient, FFT, etc.), which work with luminance values. Our technique works with unknown gradients to obtain a consistent gradient field. Given an inconsistent gradient field, it can find the nearest consistent field in the linear subspace of consistent gradient fields. Having obtained a consistent gradient field, the final image can then be produced by two-dimensional integration requiring only one addition per pixel. The complexity of this method is linear in the number of pixels, making it suitable for high-resolution images; the results are pleasing and perceptually plausible.

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Sparse Matrix Computations with Quadtrees

Ivan Šimeček

xsimecek@fel.cvut.cz

Department of Computer Science , Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

Sparse computations are used in the wide range of science projects. But suitable formats for storing sparse matrices are still under development, because widely-used formats (like XY or CSR, see [2]) are slow and specialized formats have a large transformation overhead (for example see [1]).
In this paper, we compare performance during the execution of some basic routines from LA using widely-used formats and the quad-tree data structure.

Introduction
The main motivation for the quad-trees is that the recursive style of programming ("Divide and conquer" approach) leads to codes with surprising performance. In the beginning, this format was used for picture compression (for monochrome pictures). It can be also used for the sparse matrix storage. Quad-tree (for details see [3]) is the recursive data structure (4-ary tree, see Figure 1). This tree represents a partition of the matrix into submatrices (regions). One type is assigned to each node of the tree. Inner nodes can be M(Mixed), E(Empty). Leafs be can F(Full), E(Empty).
Great advantages of quad-tree are the following:

- Easy (and fast) conversion from standard sparse matrix storage formats (CSR and XY).
- The modification of the quad-tree is relatively easy (in comparison to standard formats. The exact complexity depends on the type of modified node.

The big drawback of quad-tree structures is that they have larger control overhead than the standard formats. Standard quad-tree implementation leads to space (and execution) inefficiency. So, we used the additional type of leafs: region-based version of the XY format.

Evaluation of the results
All results was measured at Pentium Celeron M420 at 1.6 GHz, 1GB@ 266 MHz, running OS Windows XP Professional with the following cache parameters:
L1 cache is data cache with BS=64, CS=32K, s=8, h=64, and LRU replacement strategy. L2 cache is data cache with BS=64, CS=1MB, s=8, h=2048, and LRU strategy.
Microsoft Visual Studio 2003
Intel compiler version 9.0 with switches:
/O3 /Og /Oa /Oy /Ot /Qpc64 /QxB /Qipo /Qsfalign16 /Zp16
Intel MKL library 8.1

We have implemented two very basic routines from the LA: the multiplication of sparse matrix by a dense vector and the multiplication of sparse matrix by a sparse matrix.
We have used 10 real matrices from various technical areas from MatrixMarket and Harwell sparse matrix test collection.

Experimental results
For the XY format, both tested multiplications are relatively slow due to indirect addressing.

For the CSR format, both tested multiplications are faster than in the XY format due to the lower ratio between memory and arithmetic operations.
For the quad-tree format, the multiplication of sparse matrix by a dense vector is slower due to the large control and storage overhead. But for the multiplication of sparse matrix by a sparse matrix, this format is about 2 - 10 times faster than the CSR format, because it reduces indirect addressing and increasing the cache utilization.

Conclusions
We have implemented some very basic routines from the LA using unusual data structure called quad-tree. Codes with this data format show impressive speedups mainly for more complex matrix operations (like the multiplication of sparse matrix by a sparse matrix).

Future works
The study of efficient implementations using quad-trees leads us to following important questions:

- We should compare standard formats, the standard implementation of quad-tree, and our implementation of quad-tree. We should evaluate the impact of using a node with the CSR format inside.
- We should analyze cache behavior mainly with the respect to different ordering of regions inside each node.
- We should optimize code execution with respect to the region (tile) size and the choosing the optimal fill-in ratio.
- We should implement other routines from the LA using quad-tree.

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An Overview of Factorization of Large Integers Using the GMP Library

Ivan Šimeček, Peter Kováč

xsimecek,kovacp4@fel.cvut.cz

Department of Computer Science , Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

Abstract

Many security mechanisms rely on the fact, that factorizing large integers is a very difficult problem[1, 2, 3, 4] and it takes a lot of time to solve it. In this thesis, we analyzed algorithms for factorizing large integers. Our goal was to find optimizations which could improve their performance significantly.

Introduction

We have chosen the implementation of four existing different algorithms for our research: the Trial Division method, the Fermat's Factorization method, the Dixon's Factorization method, and finally Quadratic Sieve method. As we expected, the performance of the Quadratic Sieve was far better than any of the previous three algorithms. That's why the study of the Quadratic Sieve is the fundamental part of our thesis.

We tried to gather as many information as possible about the principle and properties of this algorithm. Afterwards, it was clear that the performance of Quadratic Sieve is strongly affected by the choice of some parameters. More specifically, the most important choice was the limit B for smooth numbers. For the Dixon's method, there was a good way of choosing the value of the limit B based on the number N which we wanted to factorize. However applying the same method on the Quadratic Sieve did not give us the satisfying results. The Quadratic Sieve was still faster than the Dixon's algorithm, but the speed up was not as big as we expected. We couldn't find any relevant information about this problem, so we had to solve it ourselves.

Experiments

First, we experimented with the size of B and estimated its effect on the performance. After some measurements, it was clear that the size of limit B (computed in the same manner as for Dixon's algorithm) was too small – with bigger values we obtained much better results. There was the question was why did this happen. For the answer, we had to look at the size of the factor base. For Dixon's algorithm, there was a clear dependency between the limit B and the actual size of the factor base. But for the Quadratic Sieve not all primes lower than B can be used for the factor base, so its size varies for different numbers even if limit B is the same. Therefore, instead of choosing the size of B, we decided to choose the size of the factor base. The choice is made by using a small trick. First, we compute the ideal limit B for our number N using the method for Dixon's algorithm. Then we compute the size of the factor base (or more specifically, the amount of primes lower than B). This way we get the ideal size of the factor base. Now we keep adding primes to the Quadratic Sieve factor base until there are enough of them. Measurements proved that when creating the factor base this way, the performance of Quadratic Sieve is far better than with the old method (used in the Dixon's algorithm).

Conclusions

We have developed the new approach for choosing the limit *B* for smooth numbers in the the Quadratic Sieve method. We tested this new approach for numbers up to 40 digits with very good results. Another advantage resulting from this approach is that the factor base often includes a few „large“ primes, which normally wouldn't be in the factor base. Using a few large primes is a key idea for one of the already known optimizations of the Quadratic Sieve method. For further research, we plan to test this approach with bigger numbers.

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CPU or GPU: that is the question

Ivan Šimeček

xsimecek@fel.cvut.cz

Department of Computer Science, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

Plenty of numerical algebra libraries have been developed in recent years. These libraries are tuned for the given CPU and its memory architecture, fully utilize its memory hierarchy and inner pipelines and achieve impressive computation power. There is a new trend in the high-performance computing: GPU computing. This trend is caused by the surprising fact that the most powerful part of modern Intel PCs is not the CPU, but the GPU. Modern graphic cards (shortly GCs) overcome modern CPUs in the memory bandwidth, the number of computational units and possibilities of the vector execution. It results in their surprising floating point performance. In this paper, we have compared advantages of CPU and GPU computation. We will discussed possibilities of the GPU computation and demonstrate them on some programs from the area of numerical scientific computations.

First papers about this GPU computation phenomena were published in the year 2000, when GPUs (more exactly said: their shader units) became programmable. And many papers were published in last four years[1, 2, 3], because the newest GPUs have ability for floating-point computation. One possible motivation for GPU computation is that ordinary quad-core Intel CPU at 2,4 GHz, has got peak performance about 40 GFlops in comparison to ordinary graphics cards that has peak performance about 300 GFlops, but prices for both components are comparable!

GPUs are designed for the fast computation of complex 3D frames. The ability of the floating-point computation is only the "side-effect" and it implies many disadvantages:

- There are very limited possibilities of GPUs to control the instruction flow. All conditional branches are costly. There is a simple but expensive solution for iterative methods: the GPU computes all required operands, sends them to the CPU by AGP bus and the CPU makes only the decision about the convergence.
- Some FPU operations have no support in GPU's instruction set (i.e. EXP operation).
- All computation should be vectorized to maximize the utilization of inner GPU pipelines.
- To achieve the good performance, minimal data transfers between the main memory and the GC are required. The most often way is to transfer all data on the beginning of the computation to GC's memory and after the computation, to transfer all data in the reversal way. It is not problematic, modern GCs have sufficient amount of the memory (512 MB or more and this size quickly grows), so all required data can be stored in the GC's memory.
- The compilation process is little confusing, 2-staged. Firstly, the C code is analyzed by the company (ATI or nVidia) compiler and the inter-code for given GC is generated. Afterward, from the inter-code is generated the final executable code. The reason for this complicated process is that instructions for AGP bus transfers, whose differ among GPUs, must be generated.
- The optimization process is very complicated, only for experts with the deep knowledge of the GPU architecture. For example, GPUs differ in the numbers of general purpose

registers and the program for GPU must be explicitly modified in that way. There is a lack of GPU profilers.

- Only nowadays newest GPUs support the type double for the floating-point computation. Older GPUs support only type float. Supported datatypes do not fulfill standards for non-ordinary values.
- There are great possibilities, but the peak performance is almost unreachable. But this is valid same for the CPU and the GPU computing.
- All nowadays GCs are designed for single user mode, so all addresses are physical. Due to this fact, the multitasking in GC is very complicated.
- There is no support for virtual memory, so the execution of task with memory requirements which exceeds GC memory is also very complicated.
- Both major GPU vendors have developed independently SW tools for the general purpose GPU computing. It leads to the confusing incompatibility.

We have successfully implemented various operations for the GPU computation:

- few basic routines from the BLAS library,
- advanced numeric applications: the fast Fourier transformation and bitonic sort,
- the visualization of particles in force fields,
- an adaptive solver for fluid dynamics on the GPU.

In this paper, we have compared advantages of the CPU and the GPU computing and discussed the main differences. We have demonstrated possibilities of the GPU computing on subroutines from the linear algebra package. The GPU implementation shows great abilities but we can conclude that the effective implementation of the linear algebra package designed for the GPU is a still great challenge.

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INDECS: PSD Acquisition Path

M. Dráb, L. Kalvoda, S. Vratislav, M. Dlouhá

martin.drab@fjfi.cvut.cz

Department of Solid State Engineering, Faculty of Nuclear Science and Physical Engineering, Czech Technical University, Trojanova 13, 120 00 Prague 2, Czech Republic

The specific initial and main aim of the project INDECS was to drive the neutron diffractometer KSN-2 in its upgraded form equipped with the position sensitive detectors (PSD). For the purpose of collecting data from these detectors a special complex structure called PSD Acquisition Path (PSDAP) was created and it will be integrated into the concept of project INDECS as one of its External Execution Modules (EEM).

The entire PSDAP is implemented as just one complex External Execution Module from project INDECS' system, which however is consisting of submodules, each doing one step along the path. The path has to be configured by assembling appropriate submodules of the PSDAP together before it can be used. For some modules there are more possibilities to choose from different modules doing slightly different work.

The PSDAP has several processing steps to do. First the raw sampled signal has to be obtained. Then it can possibly be split into multiple neutron events, which may be detected by one signal trigger event. After that a position of the event on the detector has to be determined. And finally the event's position has to be written to the adequate bin in the resulting histogram. As these are the steps that are done sequentially one by one with each signal pulse, we call this processing tool a "path", because each signal pulse has to walk this processing path step by step from the source into the histogram.

The Data Source is the first module at the entry of the path. Its purpose is to acquire the raw sampled signal from the signal source, decode them and send them further along the path. Currently there exist two types of the Data Source module. So far there are two types of Data Source modules, the PCI9812 and the SDCF module, first of which is used to acquire data directly from the PSD hardware, the second one is used to replay the data previously stored by the Data Storage modules and, thus, in fact repeating the same measurement with the possibility to adjust the data processing algorithms or parameters.

Signal Storage module is a module that is used to store the signal data somewhere, possibly into a file of some kind. Otherwise it is transparent, in a way that it sends out the same data as it receives. This also means, that there can possibly be more of these modules chained at the specific point of the PSDAP, though it is strongly discouraged, as storage itself may be quite a delaying work at these data rates and if the computer and its relevant peripheries aren't fast enough, the whole processing can possibly be delayed so much, that it may miss some neutron events that would normally be detected and thereby the effectivity of the whole system can go down. The signal storage modules can be placed both after the Data Source module and after the Multi Event Separator module as there is the same type of data flow. Currently there are three alternatives for this position.

The SDCF Signal Storage module is used to store the sampled event (meaning a signal on two channels and a time stamp) into a SDCF file. It is using the SDCF library for that and it is a reversed process to that of the SDCF Data Source module. Each data channel is stored in a separate SDCF data substream and before each event a global header with a synchronization time stamp is forced. This is (so far) the most effective way to store the acquired signal, in the means of redundancy.

The RAW Signal Storage module is an analogy of the SDCF Signal Storage module, but instead of storing the event signals into the SDCF file, it stores them into a raw text file, one event per file. The format is simple, just two columns of signal data and commented

header containing information like time stamp and sampling frequency. This is not the most effective way of storing the event data, but it comes handy when you want to do an eye inspection of the data or manual processing of the signal by other programs like GNU Plot or MatLab, which can easily read data from raw text files.

This is a little different kind of module. It is a communication module, that can generate a special kind of data transfer virtual instructions and send them to the predefined target of the EE that the EEM containing this module is attached to. Instead of passing the event signal data through and further along the PSDAP, the data are actually diverted from this PSDAP and sent via these data transfer virtual instructions for further processing to another PSDAP, possibly in another computer.

The Multi Event Separator is another step in the PSDAP path. Its purpose is to separate possible multiple events sampled at one shot on one trigger. So if during the original signal acquisition we sample a signal of some length, where more than one neutron event occurs. This signal can be split into multiple events and sent further along the PSDAP as separate events.

The Peak Analyzer module is the part that does the main processing along the PSDAP. It takes the sampled signal from the two ends of the PSD on the input. And calculates the position of the event along the PSD where it occurred. Each particular detector should be calibrated by covering it with shielding and opening just on several channels (positions) of the PSD. This module can construct a compensation curve, which is then used as a transformation function for calculating the exact position. Peak Analyzer module can construct this compensation curve when run under a special mode.

Histogrammer is the final point of the PSDAP. It is a module which maintains a histogram with a preset number of bins (that generally represents the number of channels of the PSD given by its resolution). And the events, that come in the form of the position, are sorted into the appropriate bins and counted there. Resulting histogram can be sent upon request to the specified target of the attached EE and then used for further processing outside of the PSDAP. The histogram can also be reset by a virtual instruction.

The PSDAP EEM can send and receive virtual commands, some of which have been mentioned above. Another of these commands are start and stop commands, which determine when to start and when to stop acquiring data. You can set various parameters of the PSDAP by sending it virtual commands, including its configuration and compensation curve. You can make it start and/or stop by an external event coming from the INDECS system, namely it can be a timer for a measurement over a specific period of time, or it can be a threshold on the monitor detector counter, so that the measurement stops after a certain number of neutrons entering the measured sample, and so on. And finally you can let the PSDAP send you some status information about the processing.

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Section 4

ELECTRICAL ENGINEERING & INSTRUMENTATION

Design of Pressure Sensor based on Silicon-on-Insulator Technology

P.Kulha*, M. Husák*, A. Kromka**

kulhap@fel.cvut.cz

*Department of Physics, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

**Institute of Physics, AS CR, Cukrovarnická 10, 162 53 Prague , Czech Republic

Electronics for instrumentation and control systems are required to operate at ever increasing temperatures. Device operation at temperatures greater than 200 °C is required for a variety of present and next-generation control applications including e.g. turbine engine control and other industrial applications. SOI technology is suitable technology for fabrication of hi-temperature devices as well as devices for RF applications. The following paper introduces the CoventorWare design environment for SOI based piezoresistive sensor design. It uses a hybrid approach that is a unique combination of diaphragm FEM analysis using Analyzer and piezoresistive sensor modelling using Architect's circuit simulation environment. The FEM results characterizing the mechanical stress and deformations of a 3-D structure are imported directly into Architect, enabling the optimization of the sensor circuit output by varying the position, size, and shape of the PZR device. This approach takes advantage of Architect capabilities, such as vary, sensitivity and other analyses.

Strain related measurement is a key part of many commercial and industrial systems. Silicon has proven to be an excellent material for building small pressure, force and acceleration sensors. Presently, strain related sensors constitute the largest market segment of mechanical MEMS devices. The most commonly used technique for measuring pressure involves applying pressure to one side of a deformable diaphragm, a reference pressure to the other side, and determining how much the diaphragm deforms. There are several ways of sensing the deformation of a diaphragm across which a differential pressure has been applied. The most common is using of piezoresistive devices fabricated directly on silicon diaphragm. The other technique is using cantilevers as transformation element. Piezoresistors can be also implemented to a device package for stress monitoring which is induced from temperature gradients. The effect of piezoresistivity in silicon can be largely enhanced by using ion implantation. This technique is used to implant piezoresistive strain gauges in the diaphragm. The performance of a PZR pressure sensor, such as sensitivity, temperature dependency, and size of the output signal, depends largely on the position and shape of the implanted piezoresistors. Therefore, the optimization of the resistor arrangements in the diaphragm is a key part of the PZR pressure sensor design.

Structure of SOI (Silicon-ON-Insulator) based membrane pressure sensor is presented. Meshed model for FEM simulation was created in CoventorWare. In the next steps is required to set up the FEM boundary conditions and simulate the diaphragm deformation under a series of different pressures. Then we can input those results into an Architect schematic. The schematic components represent the Wheatstone bridge configuration. One of the biggest strengths of Architect is its ability to run many different design variations in a matter of seconds, e.g. simulation of the dependency of the sensor resistivity on the piezoresistor positions on the membrane. Then, resistance peaks indicates areas with highest stress.

The Wheatstone bridge is used to measure small changes in resistance. The relationship between the voltage and the resistance is given by the following equation:

$$\frac{V_o}{V_s} = \frac{R_1R_3 - R_2R_4}{(R_1 + R_2)(R_3 + R_4)}$$

where *Vo* is the output voltage, and *Vs* is the input voltage. R1, R2, R3, and R4 are represented by the four Straight Piezoresistor components.

The output voltage of the Wheatstone bridge is input to the operational amplifier, ideal 3-pin component, which amplifies the voltage difference using the following equation:

$$V_o = V_s\left(1 + \frac{R_1}{R_2}\right)$$

where *Vo* is the final output of the operational amplifier , *Vs* is the output voltage of the Wheatstone bridge, and R1 and R2 are the resistors connected directly to the operational amplifier.

The layout of test structures prepared for fabrication on SOI wafer was designed. Test structure contains several topologies: test structures for TLM method (determination of contact resistance), membrane and cantilever structures for deformation measurements.

Design methodology of deformation sensors with piezoresistive sensing was discussed. Test structures were designed using Coventor software tools. Mechanical and electrical modelling were performed, especially optimalisation of the sensor position at membrane and cantilever and sensitivity analysis.

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Disturbance Currents of Inverters

P. Vrána

vranap1@fel.cvut.cz

*Department of Electric Drive and Traction, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

New trends in the electric drives are implemented into many branches of industries, in railways as well. The drive of a modern locomotive consists of a brushless machine supplied by an inverter. Such an engine behaves as a current harmonic source. The current harmonics are switched in the same way as supply current, it means substation, trolley wire, locomotive, rails and a substation again. Unfortunately a part of this circuit is shared with another system which performs detection of train's position, semaphore settings, automatic control of crossing-gates, switch blocking etc. The function of this railway safety appliance system may not be affected by any other equipment.

This paper discusses the introduced theme and presents the research which takes place at the Czech Technical University in Prague in co-operation with Skoda Electric a.s. Skoda Electric a.s. develops a new tri-system locomotive 109 E with four asynchronous traction motors which provide nominal output 6400 kW. The locomotive disturbance currents are crucial for the railway traffic safety and every supplier of locomotives must satisfy hard conditions given by standards, it applies for Skoda Electric as well. The goal of this research is finding effects which are adherent to disturbance currents and on the basis of this to implement the changes of the power circuit, the control algorithm and the modulation. There are two possible procedures how to find out the way of disturbance currents inception. The first is making a mathematical model and a simulation of generating of the disturbance currents (research on UWB Plzen). The other way (described in this paper) is measuring on the real circuits and monitoring the disturbance currents in DC-link which are produced in different states of inverter and load (CTU Prague).

The workplace consists of controllable source for supplying DC-link , 3μF capacitor and a discharge resistor. The resistor protects the static inverter against mismanagement effects. Inverter supplies tree-phase load. The load can be represented by tree phase resistor or motor. If we supply the DC-link with by another inverter, the measurement will be influenced because the inverter itself is the source of disturbance currents. That is why the special controllable source is used. The drawback of this source is a small performance (1,6 kW).

The purpose of this measurement is to monitor the disturbance currents (by Czech Railways 50±5, 75±6, 275±6 Hz) in DC-link which are produced in different states of inverter and load as well. Measurements are taken with current probe which makes use of Hall phenomenon or with conditioned Rogowski current probe. The Harmonic components 75Hz, 275 Hz are received by filtering. The Chebyshev analog filter was designed for this purpose. At the same time the signal is processed by sounding system which consists of a NI PXI 24 bit digitizer and PC. The digitizer communicates with PC by express card. Sampling rate is 100 kHz, each data block has 5000 samples. A program written in LABView 8.2 performs each 200 ms (50ms) FFT of measured signal and finds maxima in selected frequency band (tone detection). This way it is possible to rate an exact value of harmonic which occurs for more than 100 ms. The minimal operating period of disturbance currents 100 ms is determined by the standard and relate to a response time of track circuits receivers.

For a first measurement the resistor as a load was used. The motor confuses the measured system and brings into other phenomena. It would be impossible to recognize which effect is caused by inverter behavior and what is caused by the change of R,Z engine data. We consider to make measurement of AC/AC converter in the future. In the case of the AC tracks the input rectifier, DC-link and output inverter will be used. It would be difficult to determine which phenomenon is responsible for appearance of the current component 75Hz, 275 Hz in AC mains in the case of interaction between rectifier and inverter. That is why the first measurement was made with "clear" source, just one converter and resistance load.

The first measurement was taken while using the regulator D8218N1 and software which is implemented in a suburban Units 471 (under operation July 2000). The old type of laboratory inverter which consists of IGBT modules FF200R12KL Eupec was used. The basic parameters of the inverter are $U_{(BR)}$= 1,2 kV, I_C=200A, $t_{(on\ delay)}$= 400 ns, $t_{(off)}$=1μs. A program Monitor performs user interface. The modulator works with switching frequency 760 Hz.

The inverter control passed over the "hand" mode in the Monitor. This mode allows setting the inverter opening (from 0 to 255 computer units [c.u.]), frequency setting (from 0 to 200 Hz output frequency with stepping 1/128 Hz) and setting of modulation switch-over position. The biggest disturbance appeared in the state IO 200 c.u. and OF 11,3-13,7 Hz. The value I_{P-P}= 100A corresponds to I_{ef}= 35.4 mA which seems to be really cruel at DC link current 5A. The input locomotive filter consists of reactor L = 10mH and capacitor C = 10 mF has damping 25 dB in the frequency 75 Hz.

It seems the disturbance current is proportional to DC link current (at a constant inverter opening, output frequency , a load parameters, DC link current is changed just by supplied voltage). In the case of using mentioned input locomotive filter the limiting value of disturbance current would be achieved at DC link current 250 A. It would be correct, if the DC link source went on ideal voltage source and inverter on ideal disturbance current source, but it is not. The real state is just approaching the mentioned situation and therefore DC link current can by higher than 250 A without using the special equipment for the disturbance suppression.

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The Hybrid Photonics Integrated Circuits with the Polymer Optical Waveguides

K. Bušek, V. Jeřábek, J. Armas, V. Prajzler

jerabek@fel.cvut.cz

Department of Microelectronics, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

The paper report about design process and experiments, which lead to construction of the optoelectronic receiver hybrid optoelectronic integrated circuit planar lightwave circuits (PLC) for receive of optoelectronic information. The planar lightwave circuit (PLC) hybrid integration technology enables us to construct component by combining PLC with passive function (fiber and planar optical waveguides) and active optoelectronics devices (laser diodes, optical amplifiers and photodiodes) hybridized on a PLC. In the article are described fundamental characteristics separate sections of a PLC (input section-planar optical wavequide with a FD in SMD package and a electrical microwave section) and make optimal of their parameters. The PLC includes input part with an organic planar optical waveguide, a receive part with a PIN photodiode in SMD package (FD) and an output electric microwave part. The realized project was founded on experience with implementation polymer waveguides in Czech Technical University and Chemical Technology Institute in Prague.

The first part of our project was concentrated on design of the PLC and coupling of the radiation from the optical fiber to the channel waveguide. For this purpose the semiconductor laser sources was used operating at 650 nm and 1550 nm wavelength. The laser sources were coupled into the single mode optical fiber (SMF butt-coupling method) which had parameters 3.5/125 μm core/cladding layers and numerical aperture NA = 0.14 for refractive index difference of 0.36 %. This fiber was matched to the channel waveguide by a piezoelectric driven micromanipulator to acquire sufficient position accuracy in the alignment process. For desired alignment the optical power meter (Anritsu ML910B) was used, which measures the transmitted optical power from the waveguide. The optical fiber alignment to a channel waveguide facet (e.g. butt-coupling) without any interface is useful when the beam diameter from the optical fiber is equal or less than the waveguide thickness. This condition ensures the relatively good match between the Gaussian beam profile of the optical fiber source and the TE_0 waveguide mode shape in the waveguide. If the area mismatch of the fiber core and the waveguide are closely matched, high efficiency coupling can be achieved [2]. The attenuation on to the waveguide can be determined from the relation: $n = 10\log(P_2 / P_1)/(Z_2 - Z_1)[dB/cm]$.

The project design is based on the experiences with the implementation of the polymer waveguides in the workplaces of Czech Technical University and the Chemical Technology Institute in Prague. We aspire to build the polymer material technological solution (PMMA, SU-8 2000) and the diagnostics of optical waveguide structures for the PLC integrated circuit project and we want to develop of the active photonic integrated structures design process further. The channel waveguides in lithium niobat and glass BK7 was fabricate classical technology by the diffusion Ti and ion exchange Ag+ and K+ for ion Na+. The optical losses are the most important parameter of the optical waveguides. The optical losses source in optical waveguides is especially scatter and absorption processes. The optical loss of the

polymer Su-8, glasses and lithium niobat waveguides was measured by method of butt-coupling optical radiation from a fiber into facet of the waveguide. The measurement was repeated for a group of the ten samples. The optical losses were 4.47dB for the channel waveguides and 2.7dB for the stripped waveguide from polymer SU-8 at λ =650nm. The measured samples had parameters: width d= 200μm, height h=2μm and sample length l=78mm. For channel waveguide from glass BK7 there are optical losses 0.499dB at λ=650nm. The measured samples had parameters: width= 6.8μm, height = 7μm.

The second part of our research will be the design and fabrication of the platform technology for hybrid PLC to match the optical waveguides and microwave optoelectronic receiver circuits. The PLC hybrid integrated circuits have the three parts: optical part (planar optical waveguide), optoelectronic part (FD-PIN detector in SMD package) and output microwave part (planar hybrid microwave circuits). The optical part is realized by polymer layers deposited by using spin coating method silica on silicon. As polymer we choose NANOTM SU-8 2000 (SU-8) polymer from MicroChem Corp. The optoelectronic part was created by the PIN InGaAs photodetector on the alumina submount. The photodetector was placed in the groove for elimination height offset. The electronic part is made by a planar microwave electrical circuit producted on the composite submount. The computer model of the PLC was simulated in the BeamProp program. The models was created for the optical channel planar waveguide for make optimal distance between photodetector (with active area 100x100μm) and output facet of the optical waveguide at λ=1550nm. The waveguide had facet dimension: 10μm in width and 1μm in height. The basic parameters of the Y branch waveguide-photodetector position were computed in the BeamProp program and make optimal (angle, width, height). For the polymer SU-8, at λ=1310nm. The results from simulation of the Y branch it is seen below.

The method and the results measurement of the optical attenuation were presented in this paper for the polymer SU-8, lithium niobate and glass optical waveguides. The average attenuation of SU-8 was 4.47 dB/cm for 650nm radiation and 2.71dB for 1550nm, which is slightly higher than the dielectric samples. In the compute results was make optimal distance 950μm between FD (with active area 80x80μm) and the facet of the waveguide with λ=1550nm. The make optimal angle Y branch was 75 degree for multilayer structure-waveguide 4μm width, 1μm height, refraction index n=1.596 (SU-8), substrate refraction index n=3.4, buffer layer 2μm with refraction index n=1.46. Following the simulation at program Beam Prop was the Y branch divided symmetrically.

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Post production heat treatment of P3HT-Fullerene Bulk Heterojunction solar cells

A. Sharf, V. Bouda

sharfa1@feld.cvut.cz

Department of Mechanics and Materials Science, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

Though common materials used for photovoltaics (i.e., the conversion of sunlight into electrical energy) are inorganic, there has been a tremendous effort to develop organic solar cells within the last three decades. The fields started by the application of small organic molecules (pigments) [1] and since the development of semiconducting polymers, these materials were incorporated into organic solar cells resulting in remarkable improvements within the past years. Organic semiconductors have relatively strong absorption coefficients (usually> 10^5 cm^{-1}), which partly balances low motilities, giving high absorption in even <100 nm thin devices. The important difference to crystalline, inorganic semiconductors is the relatively small diffusion length of primary photoexcitations (called excitons) in these rather amorphous and disordered organic materials. These excitons are an important intermediate in the solar energy conversion process, and usually strong electric fields are required to dissociate them into free charge carriers, which are the desired final products for photovoltaic conversion.

The chemical flexibility for modifications on organic semiconductors via chemical synthesis methods as well as the perspective of low cost, large-scale production drives the research in this field in academia and industry .The first generation of organic photovoltaic solar cells was based on single organic layers sandwiched between two metal electrodes of different work functions. Organic thin film photovoltaic devices are fabricated in a sandwich structure. As substrates, glass sheets covered with indium tin oxide ITO. The ITO is cleaned in an ultrasonic bath with acetone and finally in isopropanole as cleaning solvents. On the ITO substrate, a layer of Poly (3, 4 ethylenedioxythiophene) :(polysstyrenesulfonated) PEDOT:PSS is an aqueous dispersion with a mean particle size of 80 nm. (0.5 w%, PEDOT: PSS 2:3)is covered as collecting holes .The active layers are consisting of the conjugated polymer poly(3-hexylthiophened) P3HT-(3-methoxycarbonyl)-propyl-1-phenyl-(6,6)C_{61} PCBM is coated. An excess of fullerene is favorable for the percolated transport of the negative charges. So, an optimized polymer to fullerene ratio of 1:1 w/w has been reported for P3HT: PCBM in chlorobenzene. The system shows power conversion efficiencies 0.8 % for P3HT. The top electrode is a layer deposition of Al as collecting electrons. The average thickness of the Al layer is 0.6 nm. The evaporation is done through a shadow mask in order to define the device area. Polythiophenes are among the best and most investigated conjugated polymers. The possibility of synthesis of polymers with regioregular-ordered side chains leads to high mobility polymers. These polymers show high charge carrier mobilities[2-3]. Post production treatement reported by Padinger et al [4]. The device is annealed at a temperature of 80° and simultaneously a voltage of 2.7 V is applied for 4 min. This leads to an improvement in the power conversion efficiency from around 0.5 % to 3.5%. We found that without treatment the efficiency was 0.7% after we used thermal treatment the efficiency was 2.8% .When we used post production treatment the efficiency is 3.5%.

P3HT: PCBM blend devices allow generally higher thicknesses compared to others blends. This observation might be assigned to the higher charge carrier mobility in the P3HT phase. The increased thickness lead to increased absorption and consequently to higher external quantum efficiencies. In contrast, P3HT: PCBM device show a lower Voc after the post production treatment in the range of 600 mV.

We studied the electric field effect on the photoinduced charge carrier recombination in conjugated polymer/ fullerene bulk heterojunction solar cells by means of photoinduced modulation spectroscopy. The magnitude of the photoinduced spectra is increasing by a factor of two to three upon applying an electric field . We assign this increase to the accelerated recombination of persistent charge carriers.

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Switched-Current Circuit Optimization

L. Dolívka, J. Hospodka

dolivl1@fel.cvut.cz

Department of Circuit Theory, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

Thanks to the increasing power of computer technology in recent years, the usage of numerical methods is more spread in various branches. These methods enable solving even the tasks that could not be solved by analytical methods, or if so, it would be very complicated. Among many others, also evolutionary algorithms belong in numerical methods. Evolutionary algorithms [1] are robust and powerful optimization techniques, whose utilization is widespread today, not only in electronics, e.g., [2], but in other branches as well. Evolutionary algorithms are used on solving optimization tasks. The quality of the achieved solution is expressed by the value of an objective function. Depending on the task, evolutionary algorithms try to achieve either the maximum or the minimum value of the objective function. This extreme is reached by finding suitable values of the objective function variables.

The switched-current (SI) technique [3] is used for the realization of analogue discrete-working circuits. In SI circuits, there are a few nonidealities related to the used transistors and switches. The switches have these nonideal features: nonzero on-state resistance, finite off-state resistance, and parasitic capacitances. The transistors in SI circuits operate as controlled current sources and their main nonideal features are finite output resistance and parasitic capacitances. From these nonideal features, two ones were chosen for the SI circuit applied in this paper. The nonidealities are the nonzero on-state resistance of the switches and the finite output resistance of the transistors working as current sources. The choice of these nonidealities was done since they can be considered as the most important in SI circuits.

This paper presents the use of evolutionary algorithms for the optimization of a circuit employing the SI technique. From all evolutionary algorithms, the differential evolution (DE) [1], [4] was chosen for the elimination of the effect of the mentioned nonideal features on the magnitude frequency response of the SI circuit. The used SI circuit in this paper was a biquadratic filter (a biquad). It implements a band-pass filter with certain given parameters.

At first, all the transconductances g_m of the transistors in the SI filter were calculated for the case of an ideal circuit according to a usual method so that the required parameters are satisfied – the filter has the required shape of its magnitude frequency response, denoted M_I.

The used value of the output resistance of the transistors working as current sources was 20 kΩ. The chosen value of the switch on-state resistance was 1 kΩ. These values are common in real SI circuits. When the nonideal features with these values are applied in the SI filter with the transconductances calculated for an ideal circuit, its magnitude frequency response, denoted M_N, is considerably different from the one for the ideal circuit. Thus, the nonidealities affect the transfer function of the biquad markedly.

To remove the undesirable effect of the nonidealities on the filter transfer function, new values of transconductances had to be found. This was made by optimization whose aim was to achieve the shape of the magnitude frequency response M_N of the SI biquad with the nonideal components as similar as possible to the magnitude frequency response M_I of the ideal biquad. Most probably, there is not any analytical method capable of accomplishing it.

For purposes of the optimization, a magnitude filter specification was defined. It consists of ranges $\langle B_L(f_i), B_U(f_i)\rangle$ for several frequencies f_i. When the magnitude frequency response M_N is optimized, its value at every frequency f_i should be in the range assigned to this frequency.

The values of the ranges were derived from the magnitude frequency response M_I because of the aim of the optimization. Addition of a number to $M_I(f_i)$ was carried out to obtain the value of the upper bound $B_U(f_i)$. The value of the lower bound $B_L(f_i)$ was obtained by a similar way – by subtraction of a number from $M_I(f_i)$. Outside of the vicinity of the center frequency of the filter, the values of the bounds were determined so that the deviation of the magnitude frequency response M_N from M_I can be at most ±1 dB. In the vicinity, the ranges are narrower. At the center frequency, both of the bounds have the same value. The number of frequencies f_i is 27. This number was determined after several tests and is sufficient for the optimization.

As mentioned above, the DE was employed for the optimization of the SI filter transfer function. In this optimization, the objective function value was minimized and the objective function variables are the transistor transconductances. Several forms of the objective function can be usually used for a given optimization task.

If the requirements for the result of the optimization are met, the value of the applied objective function is 0. Transconductance values for the optimization could be within a range of ⟨5 μS, 20 mS⟩. One generation consisted of 240 members and the values of optimization parameters F (mutation constant) and CR (crossover constant) were 0.5 and 0.9, respectively.

The optimization reached the objective function value of $5.02 \cdot 10^{-3}$ during 564 generations. The magnitude frequency response M_N with the transconductance values arisen from the optimization is very similar to the magnitude frequency response M_I, which was the aim of the optimization.

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Development of system for creating 3D polygonal human head model of videotelephony customer by camering devices system

M. Nemčík

nemcim1@fel.cvut.cz

Departent of Telecommunication Engineering, Faculty of Electrical Engineering, Czech Technical Univerzity, Technická 2, 166 27, Prague 6, Czech Republic

Almost all video compression algorithms operate by removing the redundancy in the temporal, spatial and/or frequency domains. Greater efficiency may be achieved by the video scene object's modeling. That means the relevant objects in the video scene (i.e. the human head) are first identified and then analyzed.
The paper deals with the model-based videophone coding and new idea of using the 3D bust models database to achieve very low bit rate and to adding new dimension in to the videophone calls. We are analyzing the possibility of using this database for simplifying the complex system for 3D model-based video compression and likewise the benefits of its implementation.

The model-based method for estimating the shape and motion of 3D objects appearing in a video is described. This technique is used for the model-based video coding (the video compression). This method is based on a new variant of optical flow and uses the 3D computer graphics to represent and display an object. Although the algorithm is general, this work focuses on videos depicting the human head and face due to its relevance to the video telephony and teleconferencing. The rigid body motion of a head and facial expressions (i.e. opening the mouth) are accommodated. Results obtained from videos of a moving person are described. We may achieve very low bit rate through this algorithm because we eliminate the redundancy and irrelevancy in typical videophone scenes. This idea is design with the respect for using in the MPEG-4 stream.

Our modification of model-based coding consist in use of a database with customers head 3D model and texture. The frames of input signal are analyzed with utilizing a database to get the parameters of the 3D model of the human bust. We can find for example the information about the shape, size of human head in a visual scene as well as the parameters of its global and the local 3D motion among the parameters. Before first establishment of the customer videophone call in our modification of the model-based algorithm it is necessary to interchange the information about the bust shape and real texture of customers by both sides.

Real video coding scene

The coding process of the typical videophone scene is the base application of model-based video coding without database. Algorithm that we designed is implemented in this application and in addition makes this complex system simpler.

Speech-driven head animation

Our system is suggested by support of the speech recognition algorithm. An algorithm of speech recognition serves to enhance the lips synchronization and to simplify the lips animation parameter estimation.

It is possible to use this mod of our algorithm in the synthetic videophone call without the camera, where animation of the synthetic customer's head is synchronized with his voice.
The most important parameters for lip-synching are:

- Voice intensity (by VAD algorithm)
- Voice detection (voice or background sound)
- Vowels detection (voiced or voiceless)

In this application it is necessary to transmit only the speech signal by the common phone call.

Text-driven head animation

This application is designed for "videophone call" without the camera or voice.

3D video visualization

Electro-stereoscopic displays provide parallax information to the eye by using a method related to that used in the stereoscope. The 3D display systems normally use one of the following methods:

- Separate display for each eye
- Shutter glasses (most common method)
- Colour filter glasses (used in some old 3D movies)
- Polarizing glasses (used in some modern 3D movies)

Stereoscopic 3D displays provide different perspective views to the left and right eye. As in the natural vision, differences in perspective are immediately used by the visual system to create a vivid, compelling and efficient sensation of depth in natural and computer-generated scenes. This technology and our algorithm enable using additional dimension for more real videophone call. A customer is scanned by the "common" (2D) camera device and on the other side he is reconstructed in three dimensions.

Change identity

The possibility of changing customer's identity is the next feature. This feature serves pure for entertainment and it is possible to change identity to e.g. Mr. Bush or Mickey Mouse etc.

The result may be useful in shifting form the classical 2D video communication to the more realistic 3D video communication that uses the 3D mesh model able to simulate the natural human mime. Furthermore, using the model-oriented video compression, to reach the transmission rate at the several kbps level maintaining a very good video quality.

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Direct Path MISO method: Identification of Nonlinear Electro-acoustic Systems

A. Novák *, F. Kadlec *, L. Simon **, P. Lotton **

novaka4@fel.cvut.cz

*Department of Radioelectronics, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

**Laboratoire d'Acoustique de L'Université du Maine, UMR CNRS 6613, Avenue Olivier Messiaen, Le Mans, 720 85, France

Identification of nonlinear systems is a current problem in many domains of acoustics and electro-acoustics, such as loudspeakers nonlinearities, nonlinearities of electronic circuits of multimedia devices, nonlinear propagation and more. Almost all the systems we can find in the domain of acoustics and electro-acoustics behave more or less nonlinearly. There is a different behavior at low and high amplitudes of input signals that is accompanied by a presence of additional spectral components in output signal which are not in the input signal. The nonlinearity in such an audio system may cause either a distortion of the sound quality, which has a disagreeable effect on its perception, or a change in timbre of sound, that is positively used in musical instruments. From that point of view, we can divide nonlinear electro-acoustic systems into two categories. First, where the nonlinear behavior is not desired and a system is supposed to be linear, such as loudspeaker, amplifier, etc. In that case the nonlinearities are often considered to be negligible, but they may cause errors whilst measuring such a system [1]. The second category consists of nonlinear systems where the nonlinear behavior is made on purpose to change the timbre of sound, such as a limiter for an electric guitar.

A lot of identification methods have been developed, such as the Volterra Series, higher-order spectra, Hilbert transform techniques, neural networks, NARMAX models, Multiple Input Single Output (MISO) and many others. The Volterra Series model is one of the most known nonlinear models. The Volterra theory states that any time-invariant, nonlinear system can be modeled as an infinite sum of multidimensional convolution integrals of increasing order. These convolution integrals can be represented by multidimensional kernels. As a Volterra kernel is a function of more variables depending on the order, the model representing the nonlinear system contains a lot of coefficients needed to determinate the system. The total number of coefficients required for a Volterra series representation of a nonlinear system increase exponentially with the model order. For that reason, the other methods are trying to replace the Volterra model by a less complicated model.

The aim of our work is to obtain a nonlinear model of the measured system that would allow a simulation of the identified nonlinear system. The MISO model consists of a parallel combination of nonlinear branches containing linear filters and memory-less nonlinearities. The general use of the MISO method is for the nonlinear systems, where the nonlinear contribution is approximately known and the aim is to find linear the filters of the model. In our work, we consider the measured nonlinear system as a black box, with no idea about the nonlinear input output characteristics. Thus, the method is linked to blind identification of the nonlinear system using a power series expansion. If the memory-less nonlinearities of the MISO model are represented by the power-law distortion functions the model corresponds to the Volterra

subclass. The main reason of using of the power-law MISO nonlinear model instead of Volterra model is to provide a simpler model than the Volterra's one. The total number of coefficients required for a MISO model representation of a nonlinear system increase linearly with the model order. According to Bendat, a nonlinear system based on a nonlinear differential or integrodifferential equation can also be modeled in a MISO framework. In some physical cases, the nonlinear system may be moreover modeled as a memory linear part occurring after the nonlinear memory-less operation [2,3]. This hypothesis is considered in our work.

The excitation signal used for our method is the white noise with zero mean value and defined standard deviation. The advantage of such a signal is that it is broad-band and thus the results can be obtained in one step. Once the measurement is done and the output signal is known, the calculation of the measured system's model can be processed. First of all the decorrelation of the MISO inputs has to be solved. Since the model based on power series is used, the powers of the input signals, which correspond to the inputs of the MISO model, are mutually correlated and they have to be decorrelated in order to find the filters of the model. Then, the power spectral densities and cross spectral densities between the inputs and the output are calculated and the filters of the model are estimated. The given MISO model, which represents the measured nonlinear system, is able of reconstruction of any input signal with amplitude less then three times the standard deviation of the excitation signal.

The method has been verified first of all theoretically on nonlinear models, such as limiter, dead zone system, and many others and then on real nonlinear devices such as a diode circuit, an audio limiter and audio amplifier. The method has given the nonlinear models of the analyzed objects. To verify the functionality of the model, the same input signal has been put into the real system and its nonlinear model and the both outputs has been observed and compared. The outputs matched in all the cases. The method has been also tested on loudspeaker nonlinearities identification, but with not correct results due to the undesirable noise, that might have been correlated with the excitation white noise. The method has been also compared with the sweep-sine method [4]. Based on the results of the comparison, the MISO power series method is nowadays tested with the sweep-sine excitation signal in stead of the white noise. The firs measurements have given very hopeful results.

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Shift Variant Optical Systems in Imaging Algorithms

M. Řeřábek

rerabem@fel.cvut.cz

Czech Technical University in Prague, Faculty of Electrical Engineering,
Department of Radioelectronics,
Technická 2, 166 27 Praha 6

This paper deals with the problems of processing of scientific image data which are obtained from UWFC (Ultra Wide Field Camera) optical systems. Images obtained in UWFC systems are distorted by many various optical aberrations. The influences of aberrations prove at most on the frontiers of the FOV (Field of View). Precision of image data evaluation, post-processing and analyzing, which is very important for these systems, decreases because of a lot of different kinds of these optical aberrations and distortions. This paper is focused to optical systems for acquiring of the astronomical image data. UWFC systems frequently have so called SV (Spatially Variant) properties. It means that the transfer characteristics of these optical systems vary in dependence on object position. This fact along with specific visual data in astronomical images contributes to complicated evaluation of acquired image data.

It is very important to understand the ways how the astrometry measurements depend on optical aberrations and moreover how the optical aberrations affect the transfer characteristics of all optical system. If we know the dependences mentioned above it is possible to define the PSF (Point Spread Function) of optical system. Then we can use some suitable methods (e.g. myopic deconvolution) for restoration of original image. How to define the point spread function of LSI (Linear Spatially Invariant) and LSV (Linear Spatially Variant) systems [2] is one of the most challenging questions of this paper. Astrometry measurements are often limited by variations in PSF shape and size over the image. These variations in PSF structure occur especially in UWFC systems because of the number of aberrations. Optical aberrations increase towards margins as mentioned above. The principal difficulty in spatially variant (SV) systems is that Fourier approaches can no longer be used for restorations (deconvolutions) of original image.

Three deconvolution algorithms have been implemented [3, 4]: Wiener, Lucy-Richardson and maximum likelihood method. We consider a particular invariant system in our experiments. This system is splitted into the parts so called isoplatanic patches, so the transfer characteristics of each part are described by unique PSF. Such a system has parametric PSF – for each value of parameter (in our case it is the coordinate of object at the object plane) the PSF takes the different size and shape according to contained aberrations. The wavefront aberration function [1] for LSV optical system can be described as

$$W(\rho,\theta,\delta,\varphi)=\sum_{n}^{k}\sum_{m=-n}^{n} W_n^m(\delta,\varphi)\, Z_n^m(\rho,\varphi-\theta), \tag{1}$$

where $W_n^m(\delta,\varphi)$ is the RMS wavefront error for aberration mode m,n and for object polar coordinate (δ,φ).

Use of the partially space invariant system allows describing the transfer characteristics in individual patches by Fourier approaches. PSF of this system can be then described as

$$PSF(u,v,\delta,\varphi) = \left| FT\left\{ p(x,y)\exp\left(-i\frac{2\pi}{\lambda} W(\rho,\theta,\delta,\varphi) \right) \right\} \right|^2 , \quad (2)$$

where (δ,φ) is the polar coordinate at the object plane.

So we obtain a quantity of PSFs, one for each part. Amount of PSFs depends on the number of isoplanatic patches. Now, we can use the Fourier approach for image deconvolution as well.

Properties of spatially invariant and spatially variant imaging have been described. The problems related to UWFC imagery have been addressed, especially restoration method using deconvolution in the presence of spatially variant point spread function. The model of partially space variant optical system has been implemented. The "brute force" method has been used for restoration of testing images. The results of different deconvolution algorithms have been demonstrated. The goal of future work is to find the PSF model of high order optical aberrations for real SV (spatially invariant system) and aberrations removal from the image. The model of PSF can be determined empirically from real image data acquired from BOOTES or double station video observation of the meteors. The second approach inheres in the finding of spatially variant point spread function analytical expression. It will be also necessary to find the sufficient splitting of spatial variant system and the proper deconvolution method for removing the aberrations. This approach will help to improve the precision of astronomy measurements around the optical axis and on the edges of FOV (far from the optical axis) as well.

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System for Measurement and Testing of Contactless Current Sensors

P. Mlejnek, P. Kašpar

mlejnp1@fel.cvut.cz

Department of Measurement, Faculty of Electrical Engineering, Czech Technical University in Prague, Technická 2, 166 27 Prague 6, Czech Republic

The measurement of consumed electric energy belongs to most widespread measurements in the world. All households, industrial and other buildings depend on this measurement. Therefore the devices measuring the energy have to be precise and very cheap of producing. Modern electricity meters comprises of three parts: current and voltage sensors, analog to digital converters and microcontroller that computes the product of current and voltage, which returns the absorbed energy.

Nowadays it is no problem to produce low-cost and high-resolution analog to digital converters as well as cheap and fast microprocessors. However there are still problems about the current sensors. They have to be cheap, precise and resistant against intentional disturbance from electricity consumers. These opposite requirements can be fulfilled to the prejudice of one of them.

The manufacturers of solid-state energy meters use mostly DC tolerant current transformers (DC-CT) that are relatively cheap, precise and capable to properly work even if subjected to DC magnetic field as high as the typical intentional disturbance fields.

The difference between classical current transformer and DC tolerant current transformer is the used ferromagnetic core. The core of DC-CT is made of material with low permeability (from hundreds to units of thousands) that brings the intensity of saturating magnetic field to be high: this is an important feature to achieve DC immunity. On the other hand, using low permeability ferromagnetic core causes increasing of phase displacement and ratio error. Fortunately, the increment of ratio error is low and the phase displacement is almost constant and therefore can be compensated by the microcontroller.

In spite of their high saturating magnetic field, DC-CTs can be influenced by modern strong permanent magnets (NdFeB), causing giant errors in the measurement of current. There are two possible methods to apply the DC magnetic field to the ferromagnetic core: either by DC component of measured current or by permanent magnet near the DC-CT. The worst case occurs when both methods are used. It can cause high financial losses of distributors of electric energy.

Therefore many manufacturers of energy meters search for new methods how to measure current. A very interesting and applicable one is air coil (Rogowski coil). Unfortunately its output is rather low and it has to be integrated: this disadvantage inhibits the mass production of these sensors.

Rogowski coils are coils wound on non-magnetic and non-conducting ring. The winding should be uniform with very high number of turns and in best case in one layer. Rogowski coil works according to Ampere's law: the output voltage is proportional to the mutual induction and time derivative of measured current.

The mutual induction M depends on number of turns and dimensions of the core. The dimensions are limited by space available in the energy meter, and they determine the number of turns. That is why the output voltage is very low. Due to this limitation the manufacturing of Rogowski coil is very complicated and it inhibits a wide usage of the coil.

This work was initiated by measuring some parameters of current sensors (as can be seen in our previous works [1,2]). On the basis of these measurements the current sensor was recommended or rejected to be used in the electricity meters.

The measurements on current transformers consist mainly of measuring permeability, B-H loop, DC tolerance, ratio error and phase displacement. All of them involve many repeating routines that require long time to be executed. Therefore an automatic system has been set-up.

The whole automatic system is composed of a few instruments that communicate with master PC via standard IEEE 488.2 and RS 232. The main instrument is the lock-in amplifier SR830 that is used for generating of testing signal and for measurement of vector of input current and output voltage (for measurement of ratio error and phase displacement). The testing signal is sinusoidal voltage with variable amplitude and frequency 50 Hz, synchronized with power distribution network.

The amplifier Krohn-hite 7500, with matching transformer MT-56R, is used to amplify the testing signal from lock-in amplifier and to convert it to measured current. The multimeter HP 34401A is used for measurement of voltage on normal resistor that is proportional to testing current. Switching on the power relays, that connect the diodes, can half rectify the current (which is necessary for measurement of DC tolerance of current transformer according to EN standards [3,4]).

Multimeter Keithley 2001 measures the output voltage of current sensor or output of integrator Lake Shore 480. The integrator is necessary during the measurement of B-H loop and when the Rogowski coil is used as a tested sensor.

The power analyser NORMA D5135 is used for measurement of DC tolerance, defined by the error of power measurement. The signals on primary and secondary side of sensor can be displayed on the HP scope.

Last important instrument is the 24-way programmable switch Time Electronics 5012. It controls all the signal paths and enables switching of the input and the probes for lock-in amplifier, switching of the input for the power analyser, turn on/off the integrator, turn on/off the load for the sensor and the input for the multimeter and the scope on secondary side of the sensor.

The automatic measurement and testing system has been assembled and its functionality has been tested with some current sensors. The results correspond to previous results that have been done by the standard manual process. This system will help us to choose and test new sensors that can be used in energy meters.

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Lab Station for Video Signal Processing

M. Nemčík, J. Svítek

nemcim1@fel.cvut.cz

Departent of Telecommunication Engineering, Faculty of Electrical Engineering, Czech Technical Univerzity, Technická 2, 166 27, Prague 6, Czech Republic

This work deals with the innovation of the Digital signal processing subject. The main goal of this innovation is the preparation of three lab stations for video signal processing. These lab stations are realized in form of the DSP development kits TMDXDSK6455-TE [1] based on TMS320C6455 (Texas Instruments) with the Video Daughter Board for C6000 EVM/DSK [2] used for video signal processing. Changes will be introduced to education starting on winter semester of 2007.

A lot of communication over large distances has today the need of video signal transmission. Therefore, students should be prepared for video signal processing. Until now, practical training in the digital signal processing (DSP) within the education of the telecommunication engineering at the Czech Technical University in Prague, was mainly based on Matlab experiments. In order to cope with the progress in the DSP technology, new laboratory exercises were made for students. Students can become familiar with new types of processors and extended equipment for video processing. This practical training is based on the Very Long Instruction Word (VLIW) DSPs, both with the fix point (320C6455) arithmetic in form of commercial DSP Starter Kits (DSK) TMDXDSK6455-TE. In order to make training more efficient, special daughter cards for video processing were purchased.

The combination of a video daughterboard with DSK makes very strong utility for the development of video signal processing applications such as:

Video surveillance system
Security cameras
Video monitoring system
Personal video recorder (Set-Top Box)
Digital video recorder (Security Systems)
Video phones and video conferencing application
Networked video application
Video base station
Imaging application
3-D graphics application

The Video Daughterboard (vDB) presents a modular approach and provides functions to meet the requirements of standard video interfaces compliant to TMS320 cross-platform daughterboard specifications V1.0.

In order to extend the variability of solved exercises we have acquired three semiconductor image sensors. We have used three contact modules equipped with PX8-32 microprocessor in order to connect image sensors with prepared exercises. This combination is particularly convenient to use for exercises aimed at the video's real time motion detection.

Old Seminar Syllabus

Program tools for the analysis and synthesis of discrete systems:

Matlab basics,
Integral transforms (DFT, FFT, DCT),
Analysis and synthesis of digital IIR filters,
Analysis and synthesis of digital FIR filters,
Decimation and interpolation filters, signal re-sampling,
Development tools for the realization of digital systems using digital signal processors,
Instruction sets of digital signal processors,
Design and simulation of discrete systems,
Discrete system realization,
Speech compression,
Test,
Evaluation of the properties of discrete Systems.

New Seminar Syllabus

Program tools for the analysis and synthesis of discrete systems:

Matlab basics,
Integral transforms, decimation, interpolation, resampling
Analysis and synthesis of digital IIR and FIR filters,
DSP VLIW TMS320C6x,
Development tools for DSP, Code composer studio,
Implementation of convolution and correlation on TMS320C6455,
Implementation of FFT, DFT, DCT on TMS320C6455,
Implementation of echo on TMS320C6455,
Implementation of echo cancelling on TMS320C6455,
Implementation of DTMF on TMS320C6455,
Implementation of motion detection and video compression on TMS320C6455,
Implementation of video filtering on DSK TMS320C6455,
Presentation of semester projects.

The main benefits of the subject's innovation are:

1. Familiarization of students with the new trends in the field of signals processing and introducing the new pieces of knowledge about the digital signal processors.
2. Enabling students to gain a practical experience by using modern software application and multimedia objects.
3. Creation of three science workspaces with the TMS320C6455 digital signal processor and seven exercises for the "Digital Signal Processing in Telecommunications" subject.
4. Motivating students to study current developments in signal processing using the innovative methods joining theory and practical exercises.

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Innovation of the Subject Microprocessor Technology in Telecommunication

Boris Šimák

simak@fel.cvut.cz

Department of Telecommunication, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

The paper deals with the innovation of the subject "Microprocessor technology in the telecommunication engineering" at the Dept. of Telecommunication Engineering, Czech Technical University in Prague. The education of the microprocessor technology was updated. New syllabus of the subject is presented. New practical laboratory activities based on the communication microprocessors Ubicom IP3k and IP5k are presented.

The education of the microprocessor technology in the telecommunication engineering at the Czech Technical University in Prague was based mainly on the simple communication processor Ubicom IP2k in the last years. Because of the advance in the communication processors, the setup and the syllabus of the subject was updated in order to cope with the latest development both in hardware and software. For the educational purposes the advanced communication processors Ubicom IP3k and IP5k [1] were chosen.

The lectures are voluntary. They make students familiar with principles, architecture, programming and applications of microprocessors in telecommunication applications. Both the general and particular features of modern microprocessors are shown on the communication processors Ubicom IP2k, IP3k and IP5k. Our new syllabus of the lectures reads as follows :

1. Microprocessors in telecommunication, basic terms, families, overview
2. IP2k, architecture, functional blocks, signals, system integration
3. IP3k, architecture, functional blocks, signals, system integration
4. IP5k, architecture, functional blocks, signals, system integration
5. IP2k, IP3k, IPk instruction set, differences
6. IP2k, IP3k, IPk instruction set, differences
7. I/O ports, timers, RTC, watchdog, brown-out, ADC
8. Communication blocks for 10Base-T, UART, SPI, I2C, GPSI, USB, BT, WiFi
9. LFSR blocks for CRC, data scrambling, data en/decryption, whitening, hashing
10. Power management, system expansions
11. Support for the SW and HW development, ISD, ISP, remote managing
12. iPModule software concept, stacks for TCP/IP, UDP, HTTP, POP3, Bluetooth, powerline, WiFi, ZigBee.
13. Multithreaded architecture for software I/O , packet processing
14. True random generator, SerDes units, additional features

The seminars are based on the programming of the microprocessors IP2k, IP3k, IP5k with special emphasis on the particular functional blocks. The students have the choice either to pass the particular tasks in the seminars during the semester or to deal with individual supervized semester-long projects. The semester project can be proposed by the student itself, too. In both cases the functional solution of the problem is required. The syllabus of the seminars reads as follows :

1. IPxxxx, features, architecture
2. Integrated development environment
3. Programming in C, introduction, libraries, preconfigured stacks
4. Programming in C, ports, timers, RTC
5. Programming in C, SerDes units
6. Programming in assembler, introduction
7. Programming in assembler, tight loops, SW generation of VGA signal
8. Programming in assembler and C, ADC, DTMF decoding
9. Programming in C, LFSR blocks, data en/decryption
10. Programming, LCD display control
11. Programming in assembler and C, Bluetooth stack, data transmission over Bluetooth
12. Programming in assembler and C, TCP/IP stack, simple web server
13. Programming in assembler and C, web camera steering
14. Programming in assembler and C, sensors, monitoring andremote reporting over internet and WiFi

The semester-long projects include but are not limited to this sample topics on the IPxxxx processors :
Data transfer from sensors via Bluetooth
Programming of a game for mobile phone on the LCD display
Phone answering machine using flash memory
Intrusion registration and reporting via internet and wireless
Web camera realization using CMOS array sensor
Communication via infrared
Powerline communication
DTMF decoding
DTMF generation
Sensor interfacing via USB
Bridge internet-wireless
Internet voice communication

For the practical training, there is laboratory equipped with the Ubicom IP2k, IP3k and IP5k networking and wireless development kits available. On each development kit work no more than two students at the same time. The basic framework based on the development kits are completed by the additional particular hardware in order to increase the variety of the practical tasks.

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Innovation of the Subject Implementation of the DSP Algorithms in Telecommunication

M. Brada

bradam2@fel.cvut.cz

Department of Telecommunication Engineering, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

The paper deals with the innovation of the subject Implementation of the DSP algorithms in Telecommunication. The changes will be introduced in the education starting the summer period 2008. The improvement is defined by utilizing the digital signal processor Texas Instruments TMS320C6x in cooperation with the extending image sensor Neuricam Pupilla NC1802.

The education in the subject Implementation of the DSP algorithms in Telecommunication is aimed at the post gradual students. The knowledge of implementation of the DSP algorithms is for these students crucial. The benefit lies in the creation of fundamental prerequisites for educational and publication activities. The second advantage brings the opportunity to use these modern modules to solve the tasks joined with the diploma thesis and dissertations.

The microprocessors TMS320C6x [1] belongs to the VLIW family. Theirs potential rest in the embedded devices market, especially voice and video transcoding and telecommunications infrastructure.

The NC1802 - PUPILLA [2] is a monolithic VGA active-pixel gray level camera-on-a-chip sensor. It integrates the pixel array, video amplifiers, a 10-bit ADC, microprocessor interface, and several other support blocks. It is fabricated using 0.35 µm CMOS technology.

Its features make the sensor particularly attractive for automotive and outdoor applications, and in general for use in environments with uncontrolled lighting. Many applications can take advantage of the individual pixel addressing of the sensor to increase speed.

Features of the image sensor:

- High dynamic range (120 dB) with logarithmic response and non-integrating continuous readout
- 640x480-pixel resolution, 8-µm pitch square pixels, array size 5.120 x 3.840 mm2
- Random pixel addressing
- Integrated video amplifiers and pipelined analog-to-digital converter with 10-bit resolution
- Addressing optimization circuitry for maximum efficiency when scanned with a TV raster
- Typical sensitivity: less than 1 mW/m2
- Sampling rate up to 16 Mpixels/s, corresponding to 52 frames per second
- Lower cost and fewer support components compared to CCD-based solutions

- Single 3.3-V operating voltage, 200 mW operating power dissipation, 20 mW power-down mode
- Differential analog output
- Evaluation kit based on high-performance CameraLink standard interface available

New syllabus of the seminars:

- Programmatic methods of analysis and synthesis of the discrete systems
- Integral transformation, decimation, interpolation and resampling of the signal
- Analysis and synthesis of the digital filters with finite and infinite impulse response.
- Digital signal processors VLIW TMS320C6x series.
- Development tools DSP, Code Composer Studio for TMS320C6x.
- Implementation of the convolution and correlation algorithms on the TMS320C6x DSP processors.
- Implementation of the FIR and IIR filters on the TMS320C6x DSP processors.
- Implementation of the FFT, DFT, DCT algorithms on the TMS320C6x DSP processors.
- Implementation of the echo generation and echo cancellation algorithms on the TMS320C6x DSP processors.
- Implementation of the various digital modulation algorithms on the TMS320C6x DSP processors.
- Implementation of the DTMF detection and generation algorithms on the TMS320C6x DSP processors.
- Implementation of the movement detection and compression algorithms on the TMS320C6x DSP processors.
- Implementation of the image filtration algorithms on the TMS320C6x DSP processors.
- Presentation of individual projects

According to the specifications the new laboratory exercises were prepared and the syllabus was modified. The new seminars cover these topics:

- Movement detection utilizing the DSP TMS320C6455
- Image compression utilizing the DSP TMS320C6455
- Image filtration utilizing the DSP TMS320C6455

The main innovation lies in introducing the new pieces of knowledge into to the education. The students can learn about the practical applications of modern digital signal processors.

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The Innovation of the Technical Measurements Course: Fiber Optics Measurements

Š. Němcová

sarka.nemcova@fs.cvut.cz

Department of Instrumentation and Control Engineering, Faculty of Mechanical Engineering, Czech Technical University, Technická 4, 166 07 Prague 6, Czech Republic

The course Technical measurements is designed for students of all study programs (bachelor and master study program) independently on the chosen specialization. The mission of this course is to show to students how the various physical properties and values can be measured. Hereafter students learn to process the measured data and sum up it properly. The integral part of proceeding measured data is a calculation of uncertainty of measured data.

Till now this course was composed of measuring of static and dynamic characteristics of temperature transducers, measurement of DC and AC bridges, position measurement using inductance and potentiometer transducer, dimensional measurement with resolver, measuring tube wall thickness using ultrasonic measurement device, measurements of a pressure, a humidity and a force, liquid level elevation measurement, flow measurement, rotameter calibration. An optical part of the course contained image processing, measuring on microscope and rightness measuring using an autocollimator.

We formed a resolution to extend a number of measuring tasks by a new field: fiber optics. Fiber optics is an important and a widely developing field of engineering. Optical fibers are widely used in fiber-optic communication, which permits transmission over longer distances and at higher data rates than other forms of communications. Fibers are used instead of metal wires because signals travel along them with less loss, and they are immune to electromagnetic interference. Optical fibers are also used to form sensors, and in a variety of other applications, such as illumination applications, light guides in medical and other applications and they are also used in imaging optics.

To form a new measuring task for the course Technical measurements, we bought an education set-up Optel Profi of Mikrokom company. This set-up allows to measure ten different basic tasks using telecommunication optical fibers. The set-up consists of a laser radiation source radiating on wavelengths of 850nm, 1300nm, 1310nm and 1550nm, a detector allowing to select the detected wavelength, further one type of a single mode fiber and two types of multi mode fibers. There is an optical line of 1km included, too, and four attenuators.

After getting acquainted with the Optel Profi, following four measuring tasks were chosen for using in the course: 1) Measuring of optical power, 2) Measuring of attenuation by the method of an inserted loss 3) The sensitivity of a fiber to bendings 4) The effect of an actuation to a fiber attenuation. These four tasks was assembled and tried out. The set-up was found capable for measurements in the course.

Instructions to the tasks were created in two versions. The student version consists of theoretical introduction, measurement instructions and proposition of measuring technique. There is an example of typical measured out data with their proceeding output in addition in the version for a teacher

Students even used this Optel Profi set-up during the witer term of the year 2007/2008 in the frame of the lecture Laboratory measurements. Starting in the next winter term, the educating set-up will be used in the Technical Measurements course. For the needs of the course Laboratory measurements, additional tasks will be created.

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Enhanced formation of shallow donors in FZ and CZ silicon irradiated by MeV protons and alpha-particles

V. Komarnitskyy, P. Hazdra

komarv1@fel.cvut.cz

Department of Microelectronics, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

Irradiation of silicon with high-energy light ions is a progressive tool for lifetime control in modern silicon power devices. Increased concentration of recombination centers in defect layers created by the irradiation offers desirable control over electron-hole plasma in the devices [1]. Nowadays a considerable attention is paid to irradiation with both protons and alpha-particles. Compared to alphas, protons bring longer projection ranges, lower leakage and also open possibility of low temperature doping of silicon by hydrogen related donors (HDs) [2]. However, using alpha-particles for lifetime killing is more desirable since it is free from HDs that deteriorate blocking characteristics of power devices. In both cases, problems with parasitic doping given by appearing of shallow thermal donors (TDs) arise after annealing at 350°C. This annealing temperature corresponds to standard soldering process when devices are soldered into modules. The excessive formation of shallow donors is connected with annealing of radiation defects and introduction of new defect centers.

In this work, we investigate the effect of proton and alpha-particles irradiation with subsequent isochronal annealing on formation of shallow donors in different type of silicon substrates. Firstly, the low-doped <100> oriented FZ n-type silicon forming the n-base of the planar p^+nn^+ diodes was used. The diodes have a relatively high concentration of oxygen since their deep p^+ and n^+ emitters were produced by long thermal diffusion. The diodes were implanted by 1.8 MeV protons at fluences ranging from 7×10^9 to 5×10^{12} cm^{-2} and by 7 MeV alpha-particles at fluences ranging from 8×10^8 to 1×10^{12} cm^{-2}. Another test structures were p^+nn^+ diodes based on low-doped <111> FZ silicon with shallow p^+ and n^+ emitters that guaranteed low oxygen concentration in the n-base. The same structures based on Czochralski <111> n-type silicon (CZ) were also prepared. The diodes with shallow anode emitter were implanted by 700 keV protons with fluences from 1×10^{10} to 5×10^{13} cm^{-2} and 2.4 MeV alphas with fluences form 1×10^9 to 1×10^{11} cm^{-2}. Post implantation isochronal annealing in temperature range 100-500°C was applied. Deep levels resulted from implantation and the isochronal annealing were monitored by deep level transient spectroscopy (DLTS). Profiles of shallow levels were characterized using C-V technique.

Results of DLTS measurement performed on FZ and CZ samples irradiated with alphas revealed three major peaks attributed to different deep levels in silicon band gap: the vacancy- oxygen pair $VO^{(-/0)}$ at E_C-0.163eV, the double charge state of divacancy $V_2^{(-/=)}$ at E_C-0.252eV and the single negative state of divacancy $V_2^{(-/0)}$ with a contribution the acceptor level of vacancy-phosphorous pair (E-center, $VP^{(-/0)}$) at E_C-0.436eV. Except of the three levels, two more levels were detected in both FZ and CZ substrates after proton irradiation: vacancy-oxygen pair VO-H at E_C-0.312eV, and defect at E_C-0.463eV which is sometimes connected with hydrogenated divacancy V_2H. Isochronal annealing stimulates annealing out of radiation defects and lead to transformation of new ones. For example, at approximately 220ºC divacancy related centers transform into $V_2O^{(=/-)}$ and $V_2O^{(-/0)}$ centers in all materials [3]. At temperatures higher than 400ºC several new levels appeared. One of them at E_C-0.211eV was detected for both irradiations and showed high thermal stability up to 500ºC.

The results of C-V measurement showed that radiation damages introduced by alphas into FZ material with high oxygen concentration strongly affect formation of TDs if the annealing temperatures exceed 375°C. It was shown that profile of TDs coincides well with profile of divacances received form DLTS for irradiation fluence below 10^{11} cm^{-2}. In case of higher fluences, the TDs distribution does not coincide with radiation defects. It starts from irradiation surface and further extends up to projected range of alphas showing significant spread-out. Saturation of maximum TDs concentration was observed for all fluences. It was explained by limited oxygen content in silicon target. In case of irradiation of FZ diodes with low oxygen content, no generation of TDs was detected in all annealing range. This confirmed necessity of oxygen to its formation. Evolution of TDs in CZ silicon during isochronal annealing showed similar behaviour as for case of oxygen-rich FZ material.

Irradiation with hydrogen leads to formation of shallow hydrogen donors (HDs) in both FZ materials with low and high oxygen concentration as well as in CZ material. The distribution of HDs coincides well with distribution of implanted hydrogen. It was shown that HDs concentration reaches its maximum just after irradiation. HDs anneal out at 250 °C probably due to transformation to other defects containing hydrogen. Confirmation of this was given by DLTS measurement that showed increasing of VOH concentration in this temperature range. Shallow hydrogen donors (SHD) and hydrogen double donors (HDD) appear during annealing at temperature above 250°C [4]. They showed maximum concentration between 250 and 350°C. Most of radiation defects were shown to anneal out in this temperature range. At higher temperatures HDD and SHD anneal out and thermal donors (TDs) start to appear close end-of-range. In case of material with high oxygen concentration and CZ material TDs spread into the whole bulk of irradiated structure which is free from radiation damages. TDs achieved maximal concentration at 475°C and start to anneal at 500°C. For the case of sample with shallow emitters i.e. with low oxygen content material TDs form only close to end-of-range of protons. They demonstrate the maximum concentration at 400 °C and moderate radiation damages towards to the irradiated surface. At temperatures higher than 400 °C, these TDs gradually anneal out. It was also shown that HDs concentration is linearly proportional to the proton fluence in wide flunece range for both FZ and Czochralski materials. Higher introduction rate of HD in Czochralski silicon was determined by the excess of intrinsic impurities.

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Practical Optoelectronic Receiver with a Monolithically Integrated Photoreceiver

J. Armas, V. Jeřábek

jerabek@fel.cvut.cz

Department of Microelectronics, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

The progress on optical telecommunications networks has led to the need for compact, high – speed and cost-effective optical modules. One of the most desirable pieces of hardware is an optical receiver that consists of a photodiode and amplifier in monolithic technology [1].

This article presents an microwave optoelectronic receiver composed of p-i-n photodiode and an amplifier in monolithic form with a bandwidth of 5 GHz. The optoelectronic transmitter used in this work has a wavelength of 1.3 μm. and am ideal bandwidth of 10 GHz. To get the optimal work point, the intensity modulation of the transmitter and receiver are set many values Vss, for some values of P_{in} from the network analyzer [2].

Our first measurement is when the transmitter is set to V_{ss} = 5.8 [V], Iss = 14 [mA] and I_{fd}= 340 [μA], the receiver has been set to Vss = 4.2 [V], Iss = 27 [mA] and the network analyzer will send the modulated signal to many P_{in}: -8 dBm, -2 dBm and 2 dBm e.g. The network analyzer check the dynamic characteristics in the system Tx – Rx, and sends the modulation signal through the measuring E/O transmitter with P_{in}= -8dBm, -2dBm and +2dBm, then the light go across the single fiber and impinges into the photodiode and changes the optical - electrical signal. The network analyzer shows the scattering parameters in the system when is connected the network analyzer in the frequency range 0.01 – 10 GHz. And for every P_{in} we see the behavior of the scattering parameter S_{21}. The best performance in this case is when P_{in} = 2 dBm. Because the shape is smooth at the range 0.1 – 5 GHz.

When we change the values of voltage and current in the transmitter and receiver, the bandwidth has the same behavior in the range 0.1 – 5 GHz.

Our work is complemented with the characterization and simulation in the program named Mide, where the photodiode and amplifier are characterized by theirs equivalent circuit model. It was necessary to approximate the microstrip line generated for the metal conductor strip of the photodiode to distributed elements like inductors, capacitors and resistors[3].

As result, we obtain a receiver with a -3 dB bandwidth of 5 GHz where the scattering parameter S_{21} real and simulated are quite similar. A important element to be analyzed is the capacitance of the photodiode and amplifier, depending of this value and the resistance of the amplifier, the bandwidth can be can be bigger or smaller, with a suitable inductance we get the named peaking effect to balance the limitation of frequency response due to the *RC* time constant [4].

The Microwave OE receiver model is used to optimize and improve the bandwidth on the device. The simulation and analyze reveal that in this kind of microwave circuit the bandwidth is not limited only by the capacity depletion layer C_D on the photodiode and the input impedance of the circuit, the inductance and capacitance distributed generated along the microstrip line limits the bandwidth of the receiver. High-performance of the bandwidth we obtain with photodiodes which have low depletion layer capacity C_D and choosing a suitable value of the filter *DC* component [4].

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Characterisation and Simulation of Electronic States in MOVPE Grown InAs/GaAs Quantum Dots

P. Hazdra, M. Atef, V. Komarnitskyy, J. Oswald*, K. Kuldová*, A. Hospodková*, E. Hulicius*, J. Pangrác*

hazdra@fel.cvut.cz

Department of Microelectronics, Faculty of Electrical Engineering, Czech Technical University in Prague, Technická 2, 166 27 Prague 6, Czech Republic

*Institute of Physics, Academy of Sciences, Cukrovarnická 10, 162 53 Prague 6, Czech Republic

Semiconductor quantum dots (QDs) – nanoinclusions of semiconductor material with lower bandgap inside another one – provide charge carrier confinement in all three dimensions and behave as artificial atoms. This provides novel properties, advantageous for device application: QDs can open way to production of lasers with lower threshold current density, high characteristic temperature and narrower spectral line. QD growth conditions and their accurate control are crucial for development of QD based devices since the main parameters of QDs, the emission wavelength, are strongly dependent on changing their size and composition. Control of the growth and further optimization of advanced QD structures therefore necessitates application of adequate diagnostic techniques capable to characterize them quickly and accurately. Besides the transmission electron microscopy and atomic force microscopy (AFM), optical methods like photoluminecsence (PL) are frequently used. However, optical methods are indirect and extensive simulations capable to calculate electronic states in complex 3D QD structures are necessary to interpret measured data.

In this phase of the project, we used extensive simulations of electronic states in InAs QDs structures to analyze PL data received on different QD structures grown by low-pressure metalorganic vapor phase epitaxy (LP-MOVPE). Structures were prepared by LP-MOVPE in a RAS LayTec equipped AIXTRON 200 machine, using Stranski–Krastanow growth mode on semi-insulating GaAs (100) substrates. TMGa, TMIn, and AsH_3 were used as precursors for the growth of GaAs, InAs, and $In_xGa_{1-x}As$ layers. The structures were grown at 70 hPa total pressure and at a total flow rate through the reactor of 8 slpm. The first GaAs buffer layer was grown at 650°C then the temperature was decreased to 500 °C for the growth of the rest of the structure. All InAs layers were grown under the same conditions: a growth rate of 0.2 ML/s, a V/III ratio of 83 and a growth time of 9 s. The growth interruption after the InAs layer growth for QD formation was 30 s. Samples prepared for PL measurement were provided with 15 nm thick GaAs capping layer (CL). In some structures, we used 5 nm thick $In_xGa_{1-x}As$ (the In content was changed from 0% to 29%) strain reducing layer (SRL) above QDs to modify their emission wavelength. The structures were first characterised by AFM using NTEGRA Prima system from NT-MTD equipped with the universal SPM scanning head SMENA. Semi-contact technique was applied using the high resolution cantilevers of NSG20 series with a typical tip curvature radius of 10 nm. PL of the QDs was measured at 300 K: samples were excited by semiconductor lasers (808 nm and 980 nm) with excitation density of about 5 Wcm^{-2} and a standard lock-in technique with Ge detector was used for detection. Then the simulation model of QD structures for Nextnano^3 simulator was developed and further used for analysis of the effect of QD dimensions on electronic

transitions in QDs. The results were subsequently compared with PL measurement to accurately identify QD dimensions and the influence of capping and strain reducing layers.

AFM results showed that uncovered LP-MOVPE grown QD structures are formed by elliptical lens shaped QDs which exhibit a good uniformity and relatively high average density of $1x10^{10}$ cm^{-2}. QDs have an elongated basis in the [-110] direction 24.4±8.8 nm while their width along [110] axis is 9.5±3.5 nm and height scatters around 4.1 ±0.5 nm. To be embedded into devices, QDs must be overgrown by a GaAs/InGaAs cap. This unfortunately modifies not only the QDs band structure, but also their size and uniformity. For the GaAs capping layers, high difference of the lattice constants between InAs and GaAs causes that InAs QDs are not covered in the initial stage of GaAs overgrowth. As a result, the size uniformity degrades due to compositional mixing or segregation. Moreover, when the QDs are covered with a capping layer, one can hardly obtain information about the QD shape from AFM measurement. To interpret AFM and optical data, a 3D model of a lens shaped QD embedded in GaAs was proposed. First, we supposed a structure consisting of a pure InAs QD lying on 0.3 nm thick InAs WL covered only by 15 nm thick GaAs cap. Then we simulated electronic states in these lens shaped QDs using different dimensions (QD base diameters and height) and compared them with experimental data from PL measurements (energy levels of the ground and excited states transitions). We achieved the best fit for QD height of 4 nm and base dimensions 20.5x15 nm which was is in good agreement with AFM data measured on uncovered structures. Then we used this calibrated model to analyze the effect of increasing CL thickness which causes blue shift of the emitted wavelength from QDs. Simulation showed that this is due to the strain in the QD which grows with increasing CL thickness. Increasing hydrostatic strain in the QD modifies its band structure and compresses electron and light-hole wave functions into the volume of the dot (especially in the direction of the growth). As a result, the quantum states in the dot lift up. The magnitude of the blue shift given by the GaAs covering can reach up to 136 meV what was in a good agreement with results of PL measurement.

We also analyzed the effect of increasing In content in the SRL which causes a red shift of the PL maximum up to 1.46 μm. Simulations showed that electron and light-hole wave functions significantly spread into the SRL from the QD if the In content in SRL grows. This results in the shift of transitions between both the ground and the first excited states towards lower energies. However, comparison of the measured and simulated data showed that this cannot be the only effect, which is responsible for this strong shift. Since increasing In content in the SRL suppresses compositional mixing and In segregation, we also included dependence of the QD height on the In content into our model. We have chosen a linear increase of the QD height (4 to 7 nm) with In content in SRL (0 to 30%). Under these conditions, we got a best fit between experiment and simulation. This confirmed that the red shift of the PL maxima is caused both by the change of band structure and the height of QDs.

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Implementation of Consolidated Prediction Format at Satellite Laser Ranging Station Helwan

J. Blažej, I. Procházka, A. Novotný, P. Matlas,
Makram Ibrahim*, Khalil Ibrahim*

blazej@fjfi.cvut.cz

Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague,
Brehova 7, 115 19 Prague, Czech Republic
* Space Research Laboratory, National Research Institute of Astronomy and Geophysics,
El-Marsad Street, P.O. Box 11421 Helwan, Cairo, Egypt

Satellite laser ranging (SLR) station close Helwan, a suburb of Egyptian capital city Cairo, is the cooperative lab of the astronomical department of National Research Institute of Astronomy and Geophysics (NRIAG), Egypt and the department of physical electronics of Czech Technical University, FNSPE, Czech Republic [1]. The aim of station, alike as many other similar stations around Earth, is the accurate and precise measurement of distance between station reference point and some artificial satellites. The measurement is based on an optical radar principle. To obtain scientifically valuable results the operation of SLR must be internationally coordinate. The coordinator is International Laser Ranging Service (ILRS). Technical improvement and new types of targets, not only on satellites, forces using of new type of calculated predictions called Consolidated Prediction Format (CPF) [2] instead of inter-range vectors (IRV) used so far.

Measurements from the Helwan Station help strengthen the reference frame for defining tectonic motion and enhancing the basic models which are used to define crustal deformation at the boundaries of the African plate with European and Arabian plates. This helps in monitoring of deformation at the boundaries of the Adriatic, Aegean, Anatolian and Red Sea regions, and we hope with the development of earthquake hazard assessment risk models in Southern European and North African countries. Measurement of internal deformation of the African plate will also be facilitated in combination with observations from the satellite laser ranging stations at South Africa with other geodetic techniques such as GPS in the region. This deformation would help identify areas of potential earthquake hazard within the African continent.

The software package has been designed, written and debugged for implementation of the CPF in the satellite laser ranging station in Helwan, Egypt. The package is designed is such a way, that the codes and files should be direct added to the existing prediction and data analysis package based on IRV type of prediction. The main functions of the software package are:

- input ephemeris data file manipulation
- satellite position prediction, tracking data for SLR station on-line control, generation of standard tracking data file
- interactive procedure for computation of satellite position and range for given epoch
- post pass data analysis by means of orbital data fitting

The software package consists of six programs, which are described below. All the programs have been written in Fortran, the conventions of very conservative language implementation have been followed. The names of programs are analogical to original package one with '`_cpf`' endnote.

Program package consists of six programs: `eph_cpf`, `con_cpf`, `one_cpf`, `topo_cpf`, `int_cpf`, and `ofp_cpf`. The '`eph`' program converts ephemeris file to internal file `cpf.dat` with reduced headers. The '`con`' program converts predictions to geocentric coordinates and call '`one`' program internally. Finally '`topo`' program is generating predictions in topocentric coordinates simultaneously in several formats needed by a consequent parts of original software package. The '`int`' program is only interactive equivalent of '`topo`' and the '`ofp`' program is the interactive analytical tool for on-site analysis. For package running several static data files are needed: `slrcor.dat` (station coordinates), `gem10n.dat` (simplified tabulated model of Earth gravity field), `satcat.dat` (catalog of known satellites), and `mtmdl.map` (tabulated map of mount correction). Entire prediction is encapsulated in batch '`precpf.bat`'.

To simplify used algorithm structure several limitation remains in implemented programs. The passes going through midnight are not treated, in other words all the predictions and analysis is for one day only. And the additional time of 3 minutes is needed on start and stop of the pass. The satellite position prediction is computed for 47 minutes maximum. The standard astronomical refraction is applied to the pre-computed elevations.

The new algorithms have been tested during several months during 2007 year. The founded and solved problems and results are summarized in references [3, 4]. Generally, the new software package is completed and it allow full station operation with new prediction format. Since January 1 2008 SLR station Helwan use described new software package.

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Medipix in an extremely hostile environment

M. Platkevič, C. Granja, J. Jakubek, Z. Vykydal

michal.platkevic@utef.cvut.cz

Institute of Experimental and Applied Physics, Czech Technical University in Prague, Horska 3a/22, CZ 12800 Prague 2, Czech Republic

Significant technological progress in the last years in electronics opens up new possibilities in particle detection and imaging. Nowadays promising digital detector systems such as Medipix2 (MEDical Imaging PIXel detector 2nd generation [1]) enable real time μ–imaging with high sensitivity and broad dynamic range. Uses range from biomedical applications (digital mammography, dental X-ray diagnostics, DNA studies, small animal imaging.) up to non destructive material studies [2].

Semiconductor hybrid pixel detectors

The hybrid semiconductor pixel detector Medipix2 consists of a semiconductor sensor chip with 256 x 256 square pixels of 55 μm size and a bump bonded ASIC read-out chip containing a preamplifier, two discriminators (high and low threshold) and 13-bit counter for each pixel. This hybrid configuration offers to optimize the read-out electronics and sensor separately. This brings flexibility in the choice of the read-out chip design technology. In addition, suitable sensor material and thickness can be chosen with respect to the specific application. This device operates as a single quantum counting device for various types of radiation (X–rays, light and heavy charged particles, neutrons) at varying energy and flux. In combination with a fully integrated USB–based readout interface, the Medipix2/USB serves as a portable versatile radiation camera for real-time measurement in various modes: imaging, spectroscopy and/or tracking (visualization).

Operation in high radiation and high noise environment

For expanding the range of applicability of Medipix detectors, such as plasma induced nuclear excitation [3], we decide to implement and test its operation in the extremely hostile environment of high power laser induced plasma which is characterized by (*i*) high vacuum, (*ii*) very high radiation and (*iii*) extremely high electromagnetic noise (with large induced gradients in very short times). This ambitious task implies many and large engineering challenges for the operation of this real-time active digital chip device consisting of highly integrated state-of-the-art microelectronics of over 65.000 individual pixels acting as individual detectors.

Tests were carried out at the PALS facility (Prague Asterix Laser System). The high-power iodine laser system delivers up to 1 kJ of energy in one pulse of about 350 ps with resulting instant power on target of about 3 TW.

The controlling and DAQ of the Medipix detector can be currently realized via devoted interface MUROS2 or USB1.0 interface device [4]. In case of the MUROS2 interface the number of wires needed to conduct through the vacuum chamber are 64 in addition to the wires for power supply and detector bias. On this account we decided to use USB1.0 interface which requires only five wires (two for data, two for power supply and one for external trigger which we exploit to drive the detector shutter). Disadvantage of this solution is that the USB1.0 interface has to be also inside the vacuum chamber.

These studies were carried out with laser flash pulses directed at a tantalum target (where a 6 keV gamma ray depopulating an induced excited level is emitted after several μs [3]). Initial tests were carried out with the detector placed outside of the target vacuum

separated by a thin Beryllium foil. Shielding of the detector (made of 5 mm Pb and Al plates) ensured functionality of operation namely at low energy laser pulses.

In a second stage we placed the detector inside the interaction chamber for vacuum tests. First of all we implemented the cooling for both the detector and read-out electronics. For this purpose we glued the bottom side of both, the detector and read-out electronics, to an aluminum panel by thermo conductive polymer (silicone elastomer Sylgard 160). These successful tests demonstrated the operation of the Medipix detector with the USB1.0 read-out interface in high vacuum environment without any problems.

As next step, we made several tests with laser shots fired at the tantalum target with the detector placed inside the vacuum chamber in the vicinity of the interaction point. In view of the expected high radiation and high electromagnetic noise the detector system was double shielded. The first shield consisted of an aluminum casing, with a cylindrical tube against the active sensor chip of the detector, connected to the signal ground. The second shield, isolated from the first, consisted of lead coated plate grounded to the chamber. Also the communication and power supply cables were double shielded.

In spite of the shielding, the laser pulse still affected the power supply and reset the CPU of the interface. We resolved this problem by usage of a DC-DC converter (20V to 5V) and filtering capacitor close to the device. This solution was functional with energy of the laser shots up to about 10 J. In case of more powerful flashes the USB communication failed. We fixed this problem by disconnecting of data wires during the measurement by relay. The corresponding modification of the software was implemented as well. The measurement procedure was the following: preprogram the device to wait for trigger, disconnect USB data wires (by relay), laser shot, connect USB data wires, and read-out the data. This solution was functional with laser shots up to about 50 J (cca 150 GW).

Further tests, investigation and shielding of electromagnetic noise influence, namely of the extremely large electromagnetic gradients generated by such high power laser induced plasmas, are underway.

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Photon Counting Module for Laser Time Transfer between Station and Earth Orbiting Satellite

I. Procházka, J. Blažej, Fumin Yang*, Peicheng Huang*

prochazk@cesnet.cz

Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, Brehova 7, 115 19 Prague, Czech Republic
* Shanghai Observatory, Nandan Road 80, Shanghai, People Republic of China

For the joint project Laser Time Transfer (LTT) with the Shanghai Observatory, Chinese Academy of Sciences we have developed the photon counting detector package dedicated for the synchronizing the space clocks by laser pulses. The device flying modules have been constructed at the Shanghai Observatory, China, and they have been tested for operation in space environment in 2006. Numerous indoor tests of time synchronization of Rubidium clock have been performed. The device has been launched on board of the Chinese experimental navigation satellite Compass-M1. The first space clock synchronization by means of laser pulses has been carried out from the satellite laser station Changchun, Jilin, China, August 1, 2007.

The LTT instrumentation has been launched on board of the Chinese experimental navigation satellite Compass-M1 to a high altitude orbit of 21500 kilometers, launch, April 14 2007, 4:11 Chinese central time, (April 13, 20:11, Universal Time), launch site Xichang, carrier CZ-3A.

LTT project is a part of building a new positioning system Beidou-2. Beidou (Chinese name of starts generating our constellation Ursa Major) was a project to develop an independent satellite navigation system. Its successor is called Beidou-2 or Compass.

The solid state photon counting module for space project LTT has been successfully designed, tested and launched to space. The excellent ruggedness and optical overload tolerance was demonstrated in space. All the measurements are carried out shortly after the detector is exposed to long lasting direct exposure to the Sun light. No degradation of parameters has been noticed within 4 months of operation. The world first Laser Time Transfer ground to space has been carried out with the clock comparison accuracy of the order of 100 picoseconds.

The principle of laser time transfer, synchronization of clock in space by means of laser pulses and laser ranging is based on consequent detection of range epoch on board and standard laser ranging providing by one laser pulse.

The first “ground to space” clock comparison using laser pulses was completed with results obtained August 1, 2007 at the satellite laser station Changchun. The observed quantity was the difference of the time scale in space (Rubidium clock) versus station local one (Hydrogen maser) as a function of time. The measured frequency drift of the space clock was 1.12×10^{-10}. Individual readings precision was 250 picoseconds rms, the clock comparison accuracy of the order of 100 picoseconds. The number of results was impaired by extremely high optical

background exceeding 10 Megacounts per second on one hand and by limited downlink data transfer capacity, which is limited to 40 bits per second on the other hand.

The main parameters of the flying unit are:

- quantum efficiency > 10 % at 532 nm
- active area diameter 25 μm
- timing resolution < 100 ps
- overload (unlimited time) 10^{16} times (direct Sunshine)
- lifetime in space > 10 years
- field of view 30 degrees
- optical band-pass filter with center 532 nm, width 10 nm
- dimensions 105 × 70 × 50 mm
- mass 300 g

The overall timing resolution and stability tests of the flying version of the detector package along with the satellite laser ranging system has been completed in connection to the Shanghai satellite laser ranging observatory. Tests confirmed the timing resolution better than 130 picoseconds and the timing stability better than 10 picoseconds within one hour of an entire measurement chain under high background count rate conditions.

The series of an indoor Laser Time Transfer experiment has been completed. The frequency difference has been determined with the uncertainty of 1.2×10^{-13} within 3000 seconds in indoor conditions.

The advanced clock comparison experiments using laser pulses are conducted at the satellite laser station Changchun now.

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New Development Boards for DSP Education

L. Novák

novakl5@fel.cvut.cz

Department of Telecommunication, Faculty of Electrical Engineering,
Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

1. Introduction

In the past, the education of the subject digital signal processing in telecommunication at the department of telecommunication engineering of the Czech Technical University in Prague was based mainly on theoretical training and partly on practical training. The practical part of the subject was focused on implementation of chosen algorithms in MATLAB program environment. Only few seminars were concerned the old generation of digital signal processors TMS320C50. In order to cope with the advances in the DSP technology, we have designed and used new DSP development boards with new DSP which supported the change of syllabus of the subject. Therefore, the practical training is now based on these in-house designed and produced DSP development boards (DSK) with fix point DSP TMS320C6455 and floating point DSP TMS320C6713 [1]. The first DSP was chosen because it is the member of this time highest-performance fixed-point DSP generation in the TMS320C6000™ DSP platform. These development boards allow students to gain practical skills of hardware implementation of DSP algorithms. In order to make the training more efficient, several special daughter cards were designed and realized. We have designed special daughter card for data visualization and also daughter card for data communication. Now, students may design their own special purpose DSP algorithms within the scope of individual projects, they implement it on DSK and they have the possibility to test and verify it.

2. Old Syllabus of the Lectures

Analog and digital signals, sampling, quantization, analog-to-digital and digital-to-analog conversion
Mathematical methods for description of discrete systems
Finite impulse response filters
Infinite impulse response filters
Integral transforms (DFT, FFT, DCT)
Decimation and interpolation filters, oversampling and undersampling
Stability of discrete systems
Parametric coding, linear predictive coding, speech codecs
Architectures of digital signal processors
Realization of discrete systems using digital signal processors
Image signals
Digitalization of video signals

3. New Syllabus of the Lectures

Analog and digital signals, sampling, quantization, analog-to-digital and digital-to-analog conversion
Mathematical methods for description of discrete systems
Finite impulse response filters
Infinite impulse response filters
Integral transforms (DFT, FFT, DCT)

Decimation and interpolation filters, oversampling and undersampling
Stability of discrete systems
Parametric coding, linear predictive coding, speech codecs
Architectures of digital signal processors, DSP TMS320C6455, instruction set, architecture, description of starter kit DSK
Realization of discrete systems using digital signal processors
Image filtering, image compression

4. Old Syllabus of the Seminars

Program tools for analysis and synthesis of discrete systems
MATLAB basics
Integral transforms (DFT, FFT, DCT)
Analysis and synthesis of the finite impulse response filters (FIR)
Analysis and synthesis of the infinite impulse response filters (IIR)
Decimation and interpolation filters, oversampling and undersampling
Development tools for realization of discrete systems using digital signal processors
DSP instruction set
Design and simulation of discrete systems
Video and speech signal compression
Test
Evaluation of properties of discrete systems

5. New Syllabus of the Seminars

Program tools for analysis and synthesis of discrete systems
MATLAB basics
Integral transforms (DFT, FFT, DCT)
Analysis and synthesis of the finite impulse response filters
Analysis and synthesis of the infinite impulse response filters
Decimation and interpolation filters, oversampling and undersampling
Starter Kit with DSP TMS320C6455, description, instruction set, Code Composer development Studio (CCS)
Implementation of quantization, convolution and correlation on DSK TMS320C6455
Implementation of DFT, FFT, DCT on DSK TMS320C6455
Implementation of FIR filters on DSK TMS320C6455
Implementation of IIR filters on DSK TMS320C6455
Implementation of DTMF decoding on DSK TMS320C6455
Implementation of image filtering on DSK TMS320C6455
Presentation of individual projects

6. Conclusion

The use of new development boards and special daughter cards for practical training led to innovation and improvement of the subject. The education of the subject is now much more effective and students can work on their individual projects focused on the implementation of DSP on these development boards.

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Timing Unit for Lunar Reconnaissance Orbiter

One Way Ranging

J. Kodet, I. Prochazka

kodet@fjfi.cvut.cz

Department of Physical Eletronic, Faculty of Nuclear Sciences and Physical Engineering,
Czech Technical University in Prague, Brehova 7, 115 19 Prague 1, Czech Republic

We are presenting the design construction and performance of the timing unit for Lunar Reconnaissance Orbiter (LRO) one way ranging [1]. The main design goals were to construct event timing module with resolution 200 ps and dead time less than 100 μs. The unit is controlled by 10 MHz oscillator which must have stability better than 10^{-7} and is calibrated with 1 PPS time signal. Such signals can be derived from commercially available GPS timing receivers. The unit will be a part of Satellite laser Ranging stations dedicated for one way ranging and which should provide one way range measurements between Earth based station and LRO to better than 10 cm precision.

Event timing is technique of time measurement, which is mainly used in satellites laser ranging, spectroscopy and other scientific applications. This module works as a black box which is calibrated with accurate one second signal, frequency reference and clocks. The module (black box) provides the epoch – time of arrival of an external pulse to its input with respect to the Universal Time scale represented by one second pulses and frequency reference. Time interval between two consequent pulses may be evaluated as a difference of two epochs.

The entire timing unit consists of three main blocks. The 10 MHz counter is based on programmable logic device form Lattice company with name ispLSI1032 [2]. It gives the resolution of measurements 100 nanoseconds. The heart of the unit is time to digital converter (TDC-GP1), which can accurately measure time intervals. It is produced by Acam Company [3]. The measurement principle of TDC-GP1 is based on propagation delays of simple logical gates. Due to a modern CMOS technology it has become possible to measure time intervals with high precision in picoseconds range. The resolution of TDC-GP1 is 125 ps of single bin, which satisfied the requirements. The control circuit of the timing unit is microcontroller from Microchip (PIC18F4620). It is powerful 8 bit RISC microcontroller, which includes a lot of communications peripherals as SPI, parallel slave port, UART and others. One of the main advantages of the PIC18F4620 is support of C language programming, which enables to use floating point arithmetic and low power consumption [4].

Computer communicates with the timing unit thought standard serial line RS232 or 16 bit parallel port, which can be use for fast data read out, when it is needed.

The event pulses are received with input comparator, which can be optionally switchover to works with TTL, NIM or ECL voltage levels. The input comparator drivers the pulse shapes circuit, which produces nanoseconds edges of the event pulse. The nanosecond edges of event pulse are required for low jitter of time measurement.

The timing unit offers option to run it in event timing mode, when the ispLSI1032 counts time periods of 10 MHz and the Time to Digital Converter (TDC) chip TDC-GP1 measures time intervals from coming even to first rising edge of clock signal. When event comes microcontroller reads the output bits of the Lattice counter and TDC-GP1 chip. Then the microcontroller sends the data to the computer for further elaboration. The second mode of time measurement is to measure time intervals between start and stop signals of maximum

7.6 µs long. In such configuration only TDC-GP1 measures these time intervals and microcontroller collect date and send them to the computer.

The entire timing unit is designed using the SMD technology. That enabled to create the device very compact 100 x 80 mm in size and two sided PCB is used. The circuit is powered with external stabilized supply providing +5 volts, the input signals are connected via SMA connectors.

The timing unit has been tested in our lab. The linearity test has been done. The timing unit was connected to the GPS timing receiver, which generates pulses at a repetition rate of 100 Hz synchronously to a 10MHz frequency reference. As a source of 10 MHz clock was used different oscillator from GPS, which had slightly different frequency. The 100 Hz events source and 10 MHz meets in phase every 70 seconds. This setup enabled to test the event timing linearity within the entire range with picoseconds reproducibility. The data spread is approximately 250 picoseconds what corresponds quite well to the device timing resolution of 125 picoseconds and to the TDC-GP1 chip performance.

The timing unit has wide range of application. The foreseen application is lunar reconnaissance orbiter, one way ranging, but due to a variety of options and easy programming, it is possible to use it in spectroscopy, LIDAR and other applications, where accurate time measurement is required.

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Sub picosecond event timing system

Petr Panek
Ivan Prochazka*, P. Jirousek*, M. Kropik*
Peter Sperber, Joseph Kolbl****

prochazk@cesnet.cz

Institute of Radio Engineering and Electronics , Academy of Sciences of the Czech Republic,
Chaberská 57, 182 51 Praha 8

*Czech Technical University in Prague
Brehova 7, 115 19 Prague 1, Czech Republic

**University of Applied Sciences, Edlmaierstr. 6 + 8
94469 Deggendorf, Germany

We do report on a design and construction of a world unique time interval measurement device based on Surface Acoustic Wave (SAW) filter interpolator providing sub-picosecond precision and accuracy.

All the existing high-resolution time interval meters are based on some principle of time interpolation. Commonly used methods usually utilize interval to voltage increment conversion, different variants of vernier principle or on pulse propagation through tapped delay lines. A novel time interval measurement method that makes use of a transversal SAW filter as a time interpolator has been introduced by Petr Panek in 2005 [1]. The method is based on the fact that a transversal SAW filter excited by a short pulse can generate a finite signal with highly suppressed spectra outside a narrow frequency band. It results from the sampling theorem that if the responses to two excitations are sampled at clock ticks, they can be precisely reconstructed from a finite number of samples and then compared so as to determine the interval between the two excitations.

The ultimate goal of our project was to construct, for the first time, the time interval measurement device providing the picosecond timing performance, simple and rugged design, low mass and low power and last but not least, not requiring any adjustment and recalibration in the field operation. According to the theoretical analysis and numerical simulations the SAW filter technique should provide all the performance required.

The interval measurement device has been designed in a two-channel configuration. This enables to determine the times of arrival of two independent pulses in a local time scale. The time interval between these two pulses may be computed as a difference of these two events. This set up permits to measure both positive and negative time intervals without any dead time. The device consists of two exciter modules, two SAW filter modules and one control, sampling, and communication module, which is common for both channels.

The device has been constructed using commercially available components only. The input and clock distribution circuits use the fast SiGe components to ensure low jitter and good delay stability. The other logical circuits use common CMOS components. Most of the device control, data collection, and communication functions are concentrated into a field programmable gate array (FPGA). The raw data from the device are collected via USB interface to a host computer where the time events and the length of time interval are

computed. As the reference clock source we have used a frequency module built at the University of Applied Sciences, Deggendorf, Germany. This module provides 200 MHz LVECL clock signal with jitter far below 1 ps rms.

We have developed and constructed the time interval measurement device, which is based on a SAW filter as a time interpolator. The first results proved the concept of a time interpolator based on surface acoustic wave filter. We have assessed the single-shot interval measurement precision of 1.3 ps rms which corresponds to the time of arrival precision of 0.9 ps rms in each channel. The error distribution is close to normal. The results are in good agreement with the error budget based on the theoretical analysis. We have identified the noise of the excitation as the source of the dominant contribution in the overall error budget. We suppose that, after redesign of the excitation circuits, the level of this noise can be reduced and the precision further improved. The temperature drift of the measured time interval on temperature is lower than 0.5 ps/K, the long term stability is better than +/- 0.1 ps per hour [2]. The interpolator non-linearity was measured to be below 0.4 picosecond over an entire interval range.

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This work has been carried out at the Czech Technical University in Prague. Recently, the research and development of high accuracy timing systems and their applications is supported by the Grant MSM6840770015 The authors are grateful to Jiri Plasil for design of the measurement software..

R/O Device based on USB1.0 for Spectroscopy DAQ

P. Mašek*, V. Linhart, T. Slavíček****

Petr.Masek@utef.cvut.cz

*Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

**Institute of Experimental and Applied Physics, Czech Technical University, Horská 3a/22, 128 00 Praha 2, Czech Republic

The main goal of this work is to develop a simple R/O (read-out) device for spectroscopy. This device should communicate with an analog-to-digital converter (type of Canberra, model 8715) to provide an inexpensive, easy to operate, and versatile instrument for data acquisition. The device should transmit data to computer for data acquisition (DAQ), data storage and further processing. On-line control and monitoring of real-time measurement should allow control and set-up setting modification capability.

It is desired to connect the device to computer through a bus which is universally accessible, sufficiently fast and if possible easy to use. These demands are fully fulfilled by the USB standard. An additional advantage is that USB provides also power so no auxiliary hardware – e.g. external supply, is needed. The reliability of USB consists in the protocol. Signals are transmitted on a twisted pair data cable. These collectively use half-duplex low voltage differential signaling (LVDS) to combat the effects of electromagnetic noise on longer lines. Both lines usually operate together; they are not separate simplex connections. Transfer of data is not based on the voltage levels but on the direction of current. All the communication of the device and a computer is ensured by the FTDI (Future Technology Devices International Ltd.) product, FT245BL concretely [1], that is commonly accessible. Its function is to transform LVDS to first-in-first-out (FIFO) parallel 8-bit data transfer.

In the past, previous version of the device was designed. In the first generation, more simple construction was used. Two integrated circuits FT245BL were employed to take advantage of the full 13-bit range of the converter. This solution was tested and brought first successful results. All the implementation was thoroughly described and presented on Topical Workshop on Electronics for Particle Physics 2007.

Although the first device proved useful and satisfactory, next development headed towards eliminating the main disadvantage – using two USB ports. So it was necessary to divide 13-bit data string into two shorter parts by using a fast multiplex 74HC157.

For spectroscopy measurements, the pulse height analysis (PHA) mode of converter is used. Each particle noticed the by detector invokes a corresponding pulse whose maximum height is converted. After the conversion, the result is notified. When data are read out, the converter starts a new cycle. These flags are brought to the next part of the device – a microcontroller unit (MCU), type PIC16F84A. The MCU drives all inner processes and assures data transfer as fast as possible. Firmware written in assembler can be simply modified thanks to the in-system programming (ISP) property. This fact enables to mount the component before programming or debug the firmware during primary tests.

A basic control application was created to transfer measured data to host computer. The application is based on freeware D2XX direct drivers. FT245BL is commanded via included dynamic linked library (DLL). The main task of the application is to figure out the measured spectrum and enable data storage. Some features were added, e.g. time count, stats, discriminations etc.

Presented device was successfully tested as prototype. Two particular tests were performed to confirm the right operation of the device under real conditions. The first test focused on the fine structure of gained signals. The measured signal was induced by radionuclide emitter of a mixed alpha source in vacuum creating a well defined line spectrum. The second test verified the correctness of data transfer. This was realized by a mixed alpha source tilted to detector in air where the energy of particles is absorbed. This set-up creates a very wide spectrum similar to white noise. Both results correspond with those by a commercial product (Multiport Multichannel Analyzer by Canberra).

Furthermore, it was verified the possibility to read up to 250k events per second at the highest 13-bit resolution. The device is usable with any computer equipped with USB port, is supported by both versions USB 1.1 and USB 2.0. The application should be freely portable among platforms. This was tested only on Windows.

The presented device is usable at universities as well as institutes interested in nuclear research. It is appropriate equipment of laboratories because it is inexpensive undemanding and can be subsequently customized to work with older models of converters when no modern interface exists.

In the future, next steps will lead to improved device in terms of hardware as well as software. The design of printed circuit board will be revised and extended by dead time counter with the control software correspondingly adapted. It is planned to realize the simultaneous operation of two or more converters to measure a multi-parametric spectrum. This task will use a complex programmable logic device (CPLD) to simplify the design of PCB and allow for the next modification of the devices.

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Section 5

MATERIALS ENGINEERING

Influence of Spot Welds on Mechanical Performance of High Strength Steel Sheets

R. Mušálek, P. Haušild, J. Siegl

radek.musalek@fjfi.cvut.cz

Department of Materials, Faculty of Nuclear Sciences and Physical Engineering,
Czech Technical University, Trojanova 13, 120 00 Prague 2, Czech Republic

High strength steel (HSS) sheets are used in the car industry for the construction of reinforcement parts due to their high strength and ability to absorb extensive plastic deformation. These characteristics lead to the better crashworthiness of the car and safety level of the crew.

Unique mechanical properties of HSSs are given by their fine microstructure. Nevertheless, it is necessary to join individual parts of the car body construction. For this purpose spot welding technology is very often used. Disadvantage of this technology is a fact that materials of the welded parts can be affected in the zone of the spot welds by introduced thermal field. For example grain growth, recrystallization, shrinkage cavities formation, or oxidation can occur. Such defects can deteriorate mechanical properties of the whole structure. It is important to be sure that spot welds do not influence the materials performance beyond a tolerable limit.

This research succeeds our previous studies in which fracture and impact toughness of several grades of HSS sheets were evaluated [1]. In this research impact toughness of 4 different HSS sheets from different manufacturers was measured by means of modified Charpy impact test carried out on specimens provided with "V" notch and a typical spot weld. Four sets of specimens with different distances of notch root from the spot weld (e = 0, 4, 6, 8 mm) were prepared for each material.

Typical mode of crack propagation was described for each set of specimens and fractographic analysis was carried out on broken specimens in scanning electron microscope JEOL JSM 840A. Gradient of Vickers microhardness was evaluated on polished specimens using O.P.L. microhardness tester with 500 g load. Modification of the microstructure in the spot weld area was observed after etching with 5 % Nital by means of light microscopy. Three different areas were observed – area of spot weld (where the welding electrode was in contact with the material), thermally affected area and thermally unaffected material.

From the obtained results some general conclusions about mechanical performance of welded HSS sheets can be stated. Mechanical behavior of all 4 tested steels was rather the same. Dependencies of impact toughness on the notch-weld distance e were practically identical. The impact toughness values were lowest for e = 0 mm, i. e., when the roots of the notches were situated directly in the spot welds area. Cracks were therefore constrained to propagate directly through the spot weld area.

This conclusion was supported also by fractographic analysis. Features of cleavage fracture as well as intercrystalline decohesion were observed on the fracture surfaces of cracks propagating directly through the spot weld area. Lower values of impact toughness can also be due to the fact that the cross-sections adjacent to the spot welds were weakened by presence of shrinkage cavities. Scanning electron microscope observation showed that the walls of the

cavities were formed by the dendritic growth. This supports the assumption that these defects appeared as a result of solidification of the molten material during welding process.

Different behavior was observed for the cases when the root of the notch was not situated directly in the spot weld area. Fracture surfaces were covered only by the ductile dimples and the values of impact toughness was significantly higher.

Metallographic observation and microhardness gradient evaluation support the conclusion that the spot welding process has the same effect on all four tested steels. Inside the spot weld the microhardness is roughly the same as for the material unaffected by the welding process. At the heat affected zone was with increasing distance from the spot weld observed a sharp decrease in microhardness value followed by an increase up to the values typical for thermally unaffected material. Radius of the thermally affected area was approximately 6 to 7 mm from the center of spot weld. Therefore crack propagation for all cases of $e = 4, 6, 8$ mm took place within the heat affected area. In all such cases cracks tended to propagate along the boundary between spot weld and heat affected area.

Similar crack propagation tendencies were observed on tensile specimens provided with spot weld [2].

It was found that the presence of the spot weld influences toughness of the material [2, 3, 4]. Nevertheless, the spot weld becomes a crack initiation site only if the weld contains considerable technological defects such as shrinkage cavities.

For further evaluation of influence of spot welding process on mechanical behavior of HSSs would be useful to perform tests on specimens with more complex geometry, e. g., real parts of the car body with technological spot welds.

Conclusions of our work are provided in more details in research report [2]. One of the results is a set of scanning electron microscope images of features observed on fracture surfaces of broken specimens. This set can be an useful source of information for future failure analysis of spot welded parts manufactured from high strength steel sheets.

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Corrosion Testing of High Alloyed Structural Materials Used in Power Industry

K. Dalíková*, P. Linhardt **, V. Číhal*, J. Kunz***

dalikova@svuom.cz

*SVÚOM Ltd., V Šáreckém údolí 2329, 160 00 Prague 6, Czech Republic

** Institute for Testing and Research in Materials Technology (TU Wien TVFA), Vienna University of Technology, Karlsplatz 13, A 1040 Vienna, Austria

***Department of Materials, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, Trojanova 13, 120 00 Prague 2, Czech Republic

The investigation of corrosion behaviour of high alloyed structural materials was focused on six corrosion resistant materials: austenitic stainless steels Uranus SB8 and Uranus B26, duplex stainless steels Uranus 45N and Uranus 52N+, nickel alloys Nicrofer 3127 hMo and Nicrofer 5923 hMo. These alloys are often used in the power or chemical and food-processing industry due to their high resistivity against the degradation effects of mechanical stress and the activity of aggressive ions. This experimental program was dealing partly with the study of the materials resistivity against high aggressive media and the accompanying degradation of the structural and mechanical properties, partly with the monitoring of chemical influence of these media on the mechanism of corrosion-mechanical failure. The aim of research is to provide data serving as basis for the optimized choice of structural material for the corresponding applications and to identify the practical limitations. This paper shortly describes the test at slow strain rate, the test at constant load and the electrochemical measurements (potentiodynamic method, measurement of electrochemical noise and electrochemical impedance spectroscopy).

All materials under study are characterized by very low content of carbon (0.007÷0.026%), trace amount of nitrogen (0.172÷0.248%, except Nicrofer 5923 hMo) relatively high content of chromium (20.4÷26.65%), nickel (24.75÷60.9% for austenitic steels and nickel alloys, 5.07÷6.02% for duplex steels) and molybdenum (3.13÷15.5%). These alloying elements ensure high corrosion resistivity and satisfying mechanical properties. The yield limit $R_p0.2$ and ultimate strength R_m of all investigated alloys are in the range (300÷560) MPa and (600÷800) MPa respectively.

The resistivity against mechanical stress and aggressive media was investigated by slow strain rate test (SSRT). Cylindrical test specimens with diameter 2 mm and working part length 10 mm were used. The corrosion media used in the experiments ($CaCl_2$, $CaCl_2$+$FeCl_3$, ASTM G28B etc.) were selected with the respect to application of the alloys under study in practice. For the comparison, the same tests were carried out in an inert medium (glycerol). Overall 32 specimens were loaded at strain rate 2.56 x 10^{-6} s^{-1} and temperature T = (105÷120) °C depending on the corrosion medium. Time and load to the failure were the main output parameters for the evaluation. The test results were presented in the relative form as the ratio between the corresponding values obtained in aggressive (x1) and inert medium (x0), i.e. $x1/x0 \leq 1$. Moreover, fractographic analysis of fracture surfaces was carried out by scanning electron microscopy [1].

In addition to the corrosion experiments, fatigue tests of CT-specimens (width W = 38 mm, and thickness B = 4 mm) were carried out at constant stress range. Crack length vs. the number of applied cycles was monitored during testing by both, optical and potential method.

The tests were terminated in the moment when crack of length about $a = 21.5$ mm was created. These pre-cracked specimens will be subsequently used in the next part of experimental programme – tests of stress corrosion cracking at the constant load. The same corrosion media and elevated temperature as for the SSRT will be suggested with the aim to assess conditions and kinetics of the crack growth in specific environments. By the test at constant load it can be well simulated the stress corrosion cracking under various load in practice.

Potentiodynamic measurements belong to electrochemical methods which are widely used in the laboratory. The current response versus continuous potential changing is monitored. The potentiodynamic curves for all materials under study were measured (e.g., in 1M HCl + 0.01M KSCN, 1M HCl + 1M NaCl, 0.5M H_2SO_4 + 0.01M KSCN). All measurements were carried out at room temperature in the potential range -450÷1200 mV (E_{SCE}) by anodic and subsequent cathodic scans. All materials investigated remained fully passive in all electrolytes under these test conditions. Consequently, testing at elevated temperatures is foreseen and should bring more information about important corrosion characteristics.

The real metal surface with all its structural defects and chemical inhomogenities does not establish a true stationary state under a constant value of potential or corrosion current. By using of the sensitive electrochemical noise (EN) measuring technique, it is possible to evaluate the fluctuations that are a result of instantaneous flow of charge between cathodic and anodic reaction sites. For classification of the character and intensity of running corrosion processes, the frequency and amplitude of the developed EN is analysed. The aim of this experiment is to register the occurrence of localized corrosion attacks (pitting or crevice corrosion, stress corrosion cracking). EN measurements were carried out in 6% $FeCl_3$ (according to ASTM-G48 - 76 [3]) at 85 °C for three of the studied materials [2, 3].

The electrochemical impedance spectroscopy (EIS) is a powerful tool for examining many chemical and physical processes in solutions as well as solids. For solution phase electrochemistry a complex sequence of coupled processes such as, electron transfer, mass transport and chemical reaction can all control or influence the output from an electrochemical measurement. The EIS instrument records the real (resistance) and imaginary (capacitance) components of the impedance response of the system for a wide range of frequencies. Depending upon the shape of the EIS spectrum, a circuit model or circuit description code and initial circuit parameters are assumed and input by the operator. By means of EIS, the stability of passive layers of mentioned materials were studied [4].

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Influence of Powder Injection on Mechanical Properties of Plasma Sprayed Copper and Tungsten Coatings

R. Mušálek, J. Matějíček*

radek.musalek@fjfi.cvut.cz

Department of Materials, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Trojanova 13, 120 00 Prague 2, Czech Republic

*Institute of Plasma Physics AS CR, v. v. i., Za Slovankou 3, 182 00 Prague 8, Czech Republic

Nuclear fusion is considered to be a promising energy source for the future. Nevertheless one of the biggest problems which has to be solved is the development of inner wall material of the fusion reactor which must withstand extreme loading. For the inner parts which will be exposed to high levels of heat and particle flux, a combination of tungsten layer on copper parts was proposed. Tungsten is refractory material resistant to high heat and particle flux, while copper can efficiently remove heat due to its high thermal conductivity. But high stress concentration on the materials interface can occur due to the thermal expansion coefficient (CTE) mismatch of both materials when exposed to high temperatures.

One of the possible solutions for plasma-facing components is the application of plasma sprayed coatings [1,2]. This technology is suitable for preparation of protective layers on extensive surfaces with complex geometry and thicker coatings can be formed, compared to the CVD and PVD process. Functionally graded materials (FGM) can be prepared by changing the composition of powder injected into the plasma gun, so that a layer with gradual change of composition from pure copper to pure tungsten can be obtained. The level of stress concentration can be thus significantly decreased but the plasma spraying process must be carefully optimized. One of the critical spraying parameters is the carrier gas flow which has to be optimized to ensure proper particle trajectory along the centerline of the plasma flame.

Prior to the spraying of FGM coating, plasma spraying process of each material should be adjusted separately. Plasma spraying of tungsten and copper was previously optimized at the Institute of Plasma Physics AS CR (IPP) with respect to the thermal properties. Feed rate and injection geometry were varied. The goal of this research was to verify sensitivity of mechanical performance of the sprayed coatings to the adjustment of carrier gas flow. Samples of Cu and W coatings were prepared with plasma torch WSP® PAL 160 (IPP, Czech Republic) with 3 different settings (expected optimal and two adjacent values) of relative carrier gas flow.

For each combination of coating material and carrier gas flow, two specimens of coating on steel substrate (ČSN 11 378, dimensions 2,5 x 2 x 100 mm) were prepared. Mechanical performance of the coatings was evaluated by the measurement of in-plane Young's modulus of the coating E_c using 4 point bending (4PB) procedure [3,4] carried out on Instron 1362 universal testing machine (Canton, MA). Specimens were exposed to the load of 300 N up to which Young's modulus is supposed to be independent of loading for the given specimen geometry. Loading was repeated 5 times. First loading cycle was neglected to avoid errors coming from the mounting of the specimen in the test rig. Average values of Young's modulus obtained from the last 4 loading cycles are listed in the table below.

Table: Measured values of E_c.

Coating material	Carrier Gas Flow [relative units]	Coating thickness t [mm]	E_c [GPa]
Cu	60	1,36	35,0
		1,34	34,0
	80	1,28	32,8
		1,27	33,8
	110	1,06	29,8
		1,13	31,3
W	50	1,07	43,3
		1,00	48,0
	70	1,22	58,8
		1,27	52,5
	90	0,98	47,5
		1,05	42,3

According to the obtained results, Young's modulus of copper coatings appears to be relatively independent of the carrier gas flow setting in the tested range. This supports the assumption based on the observation from in-flight particle sensor Tecnar DPV-2000 (St-Bruno, Canada) that due to the relatively low melting temperature of copper (~1085 °C), particles of molten powder can deposit effectively regardless to their injection velocity (which is influenced by the carrier gas flow).

Measurement of Young's modulus of tungsten coatings revealed that coatings sprayed with expected optimal carrier gas flow showed the best mechanical performance. Measurement also revealed that tungsten seems to be quite sensitive to the carrier gas flow settings. This can be due to the high melting temperature (~ 3400 °C) and tungsten sensitivity to temperature fluctuations caused by tungsten oxidation at high temperatures.

Obtained results are currently being used for the development of FGM coatings at IPP.

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Dispersion Methods and Equipment for Carbon Nanoparticles Composite

D. Čuprová*, M. Černý*, T. Jirout **

cuprova@klok.cvut.cz

*Department of Mechanics, Klokner Institute, Czech Technical University, Šolínova 7, 166 08 Prague 6, Czech Republic

**Department of Process Engineering, Faculty of Mechanical Engineering, Czech Technical University in Prague, Technická 4, 166 07 Prague 6, Czech Republic

It is very important to have a lot of information about composite composition, particles distribution in epoxy resin and particles size and finally the mechanical properties of nanocomposites for design and dimension of mechanical and other parts made from nanocomposite materials. Nanoparticles type, size and their distribution in matrix have a great influence on mechanical properties of nanocomposite materials. The size of particles used in nanocomposites is about few nanometers. When dry nanoparticles are first added into a liquid, clusters as large as hundreds of microns can be formed. It is caused by mechanical forces and physical-chemical forces. Nanocomposite materials require break down of these clusters in the liquid, followed by the de-agglomeration and dispersion, ideally down to the primary nanoparticle size. The aim of this paper is uses and adjusts three roll mill and high shear impeller for this case.

Dispersion of nanoparticles into a liquid involves three parallel processing operations:

- stabilization using surfactants and thickeners and thereby the formation of a stable micro-structure,
- wetting and incorporation of the dry nanoparticles, which form large agglomerates,
- de-agglomeration to meet the product specifications in terms of the particle size distribution.

Choice of suitable dispersion method depends on physical-chemical properties of liquid and solid phase and it also depends on final fineness of suspension. Quite a number of processes and methods used for particle dispersion into liquid are described in literature e.g. [1 - 3]. One of the simplest methods is dispersion of particles into liquids by means of high shear stress impeller. This method is used for dispersion of high concentrated particles into liquids or can be used ahead of other dispersion phase in order to get the best solid particle distribution in liquid. Another dispersion method available for high viscosity suspensions uses three roll mills. For high viscosity suspension we can also use colloid mill. This mill contains glass discs which we can load with adjustable forces. Ball mill and vibrating mill is use for dispersion of low viscosity and middle viscosity liquid which allows the movement of dispersions balls. At the present, ultrasound for break down of particle clusters is commonly used. Whereas in the ultrasonic equipment the high impact energy works only locally and the small part of shear forces are created here, the equipment can be used only for low viscosity suspension with small concentration of particles.

For industrial production of nanocomposite materials high shear mixing and three roll mill is simplest technology from above mentioned dispersion method. Both have high productivity with low investment and operating costs. From this reason we are designing pilot plant equipment for more detailed study of these dispersion methods.

High shear mixing technology used for dispersion of nanoparticles into matrix generates high shear stress in a small working volume close to impeller. It is cause by high impeller tip velocity up to 20 m/s (e.g. sawtooth high shear stress impeller) or by special design of agitator (e.g. stator-rotor agitator). This agitator type was used e.g. for dispersion of clay [4].

Other design equipment consists of three roll mills. High shear stress required for break down of clusters occurs in small clearance between rolls in this equipment. Our design enables change the clearance between rolls and their speed for controls of shear stress. Design parameters of this equipment are:

- roll gear ratio 1:2:3
- speed range of driven roll 30 ÷ 100 rpm
- range of clearance between rolls 5 ÷ 200 μm

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Properties of Modified Calcium Sulfate Hemihydrates

P. Tesárek, R. Černý

tesarek@fsv.cvut.cz

Department of Materials Engineering and Chemistry, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

Complete sets of thermal, hygric and mechanical parameters of practically any type of non-modified and modified gypsum are not available and without their knowledge it is impossible to perform any serious mechanical or hygrothermal analysis of building elements based on these materials. Determination of a complete set of these parameters is a very actual problem.

Modifications of gypsum are usually performed using polymer materials. Bijen and van der Plas [1] reinforced gypsum by E-glass fibers, and modified the binder by using acrylic dispersion in a mixture with melamine. The results showed that this material had higher flexural strength and higher toughness than glass fiber reinforced concrete after 28 days. A disadvantage of polymers based on carbon chain is a decrease of fire resistance of calcined gypsum elements. Application of hydrophobization admixtures is another way of possible and perspective gypsum modification because the resistance of hardened gypsum against water is still considered a serious problem. In the literature, only applications of lime and artificial resins (polyvinylacetate, urea formaldehyde and melamine formaldehyde) were studied, some inorganic substances such as fluorosilicates, sulfates and silicates were found to increase hardness and impermeability of the surface, see Schulze et al. [2]. Colak [3] impregnated the gypsum surface by various epoxy resins and studied the effect of impregnation on mechanical properties and water sorption. While the flexural strength was not changed due to the impregnation, some resins were found to protect gypsum completely from water penetration. However, generally it can be stated that the resistance of hardened gypsum against water is not yet resolved in a satisfactory way.

The primary aim of our research work is the adjustment of basic technologies for the production of modified gypsum, particularly from the points of view of hydrophobization and improvement of mechanical and thermal properties. In this paper, results of measurements of basic thermal, mechanical and hygric parameters of calcined gypsum modified by the addition of a commercial hydrophobization substance and a plasticizer are carried out. Bulk density, matrix density, open porosity, thermal conductivity, volumetric heat capacity, water absorption coefficient, apparent moisture diffusivity, bending and compressive strength are determined and compared to the properties of hardened gypsum without any admixtures.

The material, which was used for reference measurements, was commercially produced gypsum plaster from Gypstrend Inc. – Kobeřice. This plaster is β-form of calcined gypsum with purity 80-95 % and consists of natural gypsum and chemo-gypsum. The commercial name of this material is “Grey gypsum plaster.” The classification of the analyzed gypsum was performed according to the Czech standard ČSN 72 2301. According to our results the “grey gypsum” can be classified as G 2 B II.

The water/gypsum ratio was 0.81 for the reference gypsum material, which was denoted as A1. It was determined according to the Czech standard ČSN 72 2301. The test is based on the achievement of so called normal consistence. Water and gypsum blend is full to

the brim of the metal cylinder with the diameter 50 mm and length 100 mm. Then the cylinder is elevated up and the spillage is measured (in two perpendicular directions and averaged out). The standard spillage is 180 mm ± 5 mm. For the gypsum material A2 the water gypsum ratio was chosen 0.71 as consistence, which was ideal from the view point on technological properties, this consistence was arranged with Gypstrend Inc. – Kobeřice laboratory and corresponded with the spillage 140 mm. The water/gypsum ratio which was used for the modified materials A3 (w/g = 0.67) and A4 (w/g = 0.61) was set using the same criterion as for the reference material. The materials A3 and A4 were modified using commercial products Polyfor and Oil MH 15. Polyfor is liquid plasticizer and aeration admixture for plasters without lime. Oil MH 15 is a liquid hydrophobization admixture. Amount of these admixtures for the modified materials A3 and A4 were for Polyfor 1 % by mass and for Oil MH 15 0.3 % by mass. The samples were mixed according to the Czech standard ČSN 72 2301.

The measurements of basic properties of gypsum modified by Polyfor and Oil MH 15 admixtures have shown that there admixtures can be used in further applications. Obtained experimental results of basic physical properties showed that the values of bulk density and open porosity for non modified material and modified materials were very similar. The thermal properties were also quite comparable. Summarizing the results of measurements of water transport properties, we can state that the hydrophobization of the materials A3 and A4 was successful from the view point on transport of liquid water. The admixtures decreased the apparent moisture diffusivity of reference gypsum by about two orders of magnitude, which is a very good result. Another goal, which was the improvement of mechanical properties, was also achieved. The values of mechanical properties after 28 days were for the modified material A4 higher than for the non-modified material A2 (materials with the lower water gypsum ratio) - by about 19% for bending strength and about 20% for compressive strength. For the modified material A3 as compared with A1 were these values higher by about 32% for bending strength and 39% for compressive strength.

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Creep Properties of Base Material and Weldments of P23 Steel

M.Talík*, T.Vlasák, J.Cejp***

talik@svum.cz

*CTU,Faculty of Mechanical Engineering,Dept. of Materials Engineering
Karlovo nám.13,121035 Praha 2
** SVÚM a.s.,Podnikatelská 565,190 11 Praha-Běchovice

In present days there is an extensive research of new USC power plant that can be mainly characterised by increasing of live steam working parameters. Increasing of steam parameters is associated with higher demands on materials applied in power plant. The most critical parts of power plant, from material point of view, like waterwalls, superheaters/reheaters or steam tubes work in circumstances of creep and their construction can not be imaginable without welding. This operation brings many problems either with short time mechanical properties or with long term creep properties. By optimalisation of welding process can be negative effect on short time mechanical properties make acceptable. Nevertheless weldments are weak location in case of long term creep.

For construction of waterwalls are used low alloy 2,25Cr steel because of absence of necessarity of post weld heat treatement. Steels such as T12 or T22 can not be used more for their low creep strength. Up to 560-580°C is able to use new low-alloy steels like T23 and T24. Their benefits are better fabrication, allowing welding without PWHT and lower price in comparison to modified 9-12% Cr steels. Characteristics of T23 steel used for thin tubes are known. However, thick section can not be welded without PWHT. Properties of P23 and their weldments, that are used for thick pipes, are discussed in this article.

Experimental material P23 was produced by Vallourec and Mannesmann Tubes and delivered in the form of seamless tube ⊘ 219x30mm after a heat treatment 1060°C/water + 760°C/2h [2]. Chemical composition of this pipe together with nominal composition of P23 is in table 1. Preparation of weldment joint is discussed in [2].

Table 1. Chemical composition of P23 steel and experimental pipes [3].

Element	C	Mn	P	S	Si	Cr	Mo	V	W	Nb	B	N	Al
P23	0,04-0,1	0,1-0,6	max. 0,03	max. 0,01	max. 0,5	1,9-2,6	0,05-0,3	0,2-0,3	1,45-1,75	0,02-0,08	0,0005-0,006	max. 0,03	max. 0,03
	0,07	0,54	0,008	0,004	0,28	2,08	0,08	0,22	1,65	0,03	0,002	0,011	0,018

Three post weld heat treatments were tried: 750-760°C/2h, 740-750°C/2h and 730-740°C/1h [2]. The last one gives the best creep strength and specimens with this PWHT are evaluated in this paper.

Creep results of base material and welded specimens are given in table2.

Table 2. Results of heat resistance tests.

SVUM CODE	Temperature [℃]	Stress [MPa]	Time to rupture [h]	Note
VV2	500	245	6994	Base material
VV1	500	290	903,25	Base material
VV6	550	150	15199,75	Base material
VV8	550	165	12233,25	Base material
VV5	550	180	11601,25	Base material
VV4	550	200	3296	Base material
VV3	550	220	951,25	Base material
VV10	600	105	13503,75	Base material
VV9	600	125	6764	Base material
VV11	600	145	2021,75	Base material
VV7	600	160	829,5	Base material
VV53	500	235	3224	Welded specimen
VV60	500	270	354,75	Welded specimen
VV55	550	170	5157,5	Welded specimen
VV54	550	190	2004,5	Welded specimen
VV52	550	210	766	Welded specimen
VV59	600	90	7439,25	Welded specimen
VV58	600	110	3667	Welded specimen
VV57	600	130	2287,5	Welded specimen

Macrostructure of weldment in initial is fully bainitic. All analysed welded specimens fractured in HAZ. VV60 (500°C/270 MPa/354 h) ruptured with high deformation (70%). By VV55 (550°C/170 MPa/5157 h) deformation is not distinct. Cavities have not been detected in any analysed specimen. In VV3 (550°C/220 MPa/951 h) and VV9 (600°C/125 MPa/6764 h) base material specimens transgranular cracks made by falling of grain boundaries cohesive strength were detected.

Performed works can be concluded as follows:

- all analysed welded specimen fractured in HAZ even VV60 whose time to rupture was just 354.75 hours
- no cavity has not been detected
- transgranular cracks whose initialized major crack has been detected in some specimens of base material

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Effect of Sc and Zr Additions on Microstructure and Mechanical Properties of Conventional Cast and P/M Aluminium

M. Kolář*, V.Očenášek, J.Cejp***

kolar.mic@seznam.cz

*CTU,Faculty of Mechanical Engineering,Dept. of Materials Engineering
Karlovo nám.13,121035 Praha 2

**VÚK Panenské Břežany, Ltd., Panenské Břežany 50, 250 70 Odolena Voda

The influence of plastic deformation and heat-treatment on the precipitation of Al3(Sc,Zr) particles and the effect of these precipitates on hardening and softening processes of dilute ternary Al-0.2wt.%Sc-0.1wt.%Zr alloy was investigated. Behaviour of two differently prepared alloys (mold cast and prepared by powder metallurgy – PM) was investigated in as-prepared and in cold rolled state. Both alloys exhibit the same peak age hardening, PM one reaches it already during extrusion at 350°C. Both cold rolled alloys are highly resistant against recovery, which proceeds without rapid hardness decrease at high temperatures. Evolution of hardness agrees well with that of resistivity and with TEM observation.

Low additions of Sc and Zr to aluminium and its alloys can significantly improve their mechanical and technological properties [1-3]. It is due to the precipitation of coherent spherical particles of the Al3(ScxZr(1-x)) phase, which contribute substantially to the strengthening [4]. The size of these particles is stable at high temperatures up to the eutectic temperature and has therefore significant anti-recrystallization effect [5]. The aim of the present contribution is to compare the properties and structure development of two dilute ternary Al-Sc-Zr alloys, one prepared by mold cast and the other by PM method, during isochronal and isothermal heat treatment.

Aluminium (99.9 wt. % purity, all composition data are further in wt.%) was alloyed with about 0.2 Sc and 0.1 Zr. The first alloy with composition Al-0.22Sc-0.13Sc (AlScZr-MC) was mold cast. The second alloy with composition Al-0.32Sc-0.19Zr (AlScZr-PM) was squeeze cast, gas atomized by argon (mean powder particle size ~ 30 μm) and consolidated by extrusion at 350°C. Both MC and PM alloys were investigated in as-prepared state and after cold rolling. The MC alloy was rolled to the thickness of 1.9 mm (reduction 86 %), the PM one to the 1.2 mm (66 % reduction). Structure and properties development was investigated during isochronal (30°C/30 min) annealing procedure in the temperature range 90-630°C and during isothermal heat treatment at 300, 400, 500 and 550°C. After each heat treatment step the specimens were water or liquid N_2 quenched. Mechanical properties were evaluated by Vickers hardness (HV10 and HV3) measurements at room temperature. Precipitation was monitored by the resistivity measurements in liquid N_2. Structure was studied by light microscopy. Preferred crystal orientations present in the softened material were investigated

using electron back-scatter diffraction (EBSD) in the SEM. Microstructure after selected thermal-mechanical treatment was analysed using TEM.

Results of the investigation of the phase and properties development in the mold cast and PM prepared dilute Al-Sc-Zr alloys can be summarized as follows:

1) In the PM prepared AlScZr alloy fine coherent particles of the $Al_3(Sc_xZr_{(1-x)})$ phase precipitated during extrusion at 350°C, which resulted in the pronounced precipitation hardening. This hardening does not increase either by isochronal or by isothermal annealing.
2) In the mold cast AlScZr alloy similar precipitation structure developed during isochronal annealing above 270°C which resulted in the similar precipitation hardening as in PM alloy.
3) Both MC and PM alloys exhibit high recovery resistance after cold rolling. At high temperatures the softening proceeds slowly without rapid decrease of the hardness.
4) Mold cast alloy exhibits mostly recovered structure with small ratio of fine recrystallized grains after annealing for 16 h at 550°C. According to light metallography, the structure of the PM alloy is fibre–like one after the same isothermal treatment. Recovered grains are elongated in the fibre direction.

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Multilevel approach of studying deformation processes in Fe-3%Si single crystals

Jakub Prahl*´, Anna Machova**, Michal Landa**, Maxmilien Libert***, Colette Rey***, Petr Hausild*, Miroslav Karlik***

Jakub.Prahl@fjfi.cvut.cz

*Department of Materials, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, Trojanova 13, 120 00 Prague 2, Czech Republic

**Institute of Thermomechanics of Academy of Sciences of The Czech Republic, Dolejskova 5, 182 00, Prague 8, Czech Republic

***Ecole Centrale Paris, Grande Voie de Vignes, 92 295, Châtenay-Malabry Cedex, France

The phenomenon of ductile to brittle transition ranks to one of the most studied topics in material science ever. Till now many experiments as well as theoretical studies have been performed on ferritic steels, but there are still unanswered questions (e.g. which fundamental factors determine the temperature and shape of ductile to brittle transition curve [1]). A model bcc alloy Fe-3wt%Si, which allows reaching transition temperatures closer to room temperature, is sometimes used. There have been also attempts to study the related processes by methods of computational simulations (e.g. [2]). These simulations use very often many simplifications too and that is why they describe the problematic from the simplified angles of view, from certain levels of physical reality. In this paper two approaches – molecular dynamics and finite element crystalline plasticity model – have been used to be compared to experimental results.

Oriented single crystals Fe-3wt%Si prepared by the method of zonal melting, were used. The main axis of the single crystals was oriented into the crystallographic directions <110> and <100>. The test samples SEN (rectangular single edge notched) used in experiments had the following dimensions: length 52 mm, width 10 mm, and thickness of 2 mm. The active length was 28 mm and the initial central notch was 3 mm long and 0.2 mm wide. The crack propagated in the <1 1 0> direction on the plane {1 0 0} and {1 1 0}. Tensile tests were carried out at room temperature on the deformation machine INSTRON 1195 in the Institute of Thermomechanics AS CR. Four crosshead velocities (0.25 to 2 $mm.min^{-1}$) were used.

In the case of test samples of orientation (110)[001] (crack plane/crack front) the fracture occurred on {100} planes caused by crack deflections from the axis [-110] of the potential crack extension of approximately 45^{o} independently on the loading rate. During the experiments, small plastic zones were observed only in 2 of 4 cases and the test samples ruptured rather by cleavage. Subsequent fractographic analysis has confirmed that the fractures were accompanied with slip processes on {011} planes and by twinning on {112} planes.

These test samples have been modeled by the method of 3D molecular dynamics using the semi-empirical interatomic potential for α-Fe. The model of 420 000 atoms having the same crystallographic orientations and similar geometry as the experimental one was treated under the same boundary conditions as experimental at the temperature of 300 K. The results have showed that the crack itself at loaded specimen could cause these processes: twinning on

oblique {112} planes, which hindered growth of the original crack, and emission of dislocations on oblique {011} and {123} planes, which led to separation of the {100} planes and might cause decohesion and subsequent cleavage fracture along mentioned planes. The macroscopic shape of plastic zone was also found to be strongly dependent on boundary conditions. By the block like shear method (BLS), the stress barrier for activation of dislocation slip on planes {123}, which has been found to take role during the simulations, has been also identified. The results of experiments and simulations relevant to the other mentioned orientations have been described in [3].

The mesoscopic approach of simulation of plastic processes in Fe-3%Si was based on a finite element model of the test samples (in ABAQUS 6.6) using user subroutine UMAT allowing to treat the modelized specimen as an oriented single crystal with preexisting dislocations. This approach lies on three laws of theory of plasticity: the flow rule, hardening law, and the law of evolution of dislocations. The plastic behavior has been characterized by 22 parameters determining the elastic moduli, crystallographic orientations, plastic properties, etc., and by boundary conditions corresponding to those from experiments. The model was able to describe evolution of dislocation on 24 slip systems (either {110}<111>, or {112}<111>).

After identifying all the relevant parameters of the model using experimental results also from perfect (unnotched) test samples [4], and test samples SEN of different orientations, the model was supposed to simulate the plastic behavior of the test samples of orientation (110)[001] (crack plane/crack front). But with respect to the fact that the crystalline plasticity model did not involve the twinning processes and the fact that all test samples treated experimentally have ruptured rather in a brittle manner, the mentioned model could not be used to describe it. On the other hand, this model is appropriate for the orientation (-110)[110] (crack plane/crack front) which exhibits plastic deformation and ductile fracture. In this case, the results of computations corresponded well to the experimental results. The model also confirmed strong dependence of small deviations of crystallographic orientations and boundary conditions on the shape of stress-strain curve (number of activated slip systems as well as their activity).

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DESIGN OF DAMAGE-PLASTIC MODEL FOR QUASI-BRITTLE MATERIALS

J. Sýkora, J. Vorel

jan.sykora.1@fsv.cvut.cz, jan.vorel@fsv.cvut.cz

Czech Technical University in Prague (CTU)
Faculty of Civil engineering
Department of Mechanics
Thákurova 7, 166 29 Praha 6, Czech Republic

Masonry structures are widely used for a long time, but a complex analysis of these and similar massive structures that takes into account all geometrical details is still not computationally feasible. Instead, either coupled or uncoupled multi-scale homogenization analysis is often performed whereas the latter one in particular has proved its potential when searching for a reliable estimate of the response of large, generally three-dimensional, structures. In such a case the macroscopic analysis is carried out independently such that the driving material parameters demanded for the macroscopic constitutive model are determined from a sufficient by detailed numerical analysis on the mesoscale. This step constitutes the most important part of the uncoupled multi-scale approach and its success is highly influenced by the proper representation of the material response on the level of individual phases, bricks and mortar. Therefore, a robust constitutive model is on demand. Particular attention is paid to the synthesis of an orthotropic damage model for the description of tensile failure with a modified constitutive model capable of representing the material failure in shear and confining pressure. For such material model some ways of deriving material parameters are briefly presented.

Masonry as well as concrete are typical representatives of materials which are classified as quasi-brittle materials characterized by complex failure mechanisms. Such mechanisms are usually promoted by evolution of nonhomogeneous local stress and strain fields. This unpleasant situation arises when dealing with historical masonry constructions with irregular arrangement of individual phases (stone blocks and mortar), e.g. Charles Bridge in Prague [1]. Successful prediction of the macroscopic response of such structures is highly influenced by the proper representation of the material response on the level of individual phases. A reliable material model with the ability of representing most of the crucial failure mechanism, at least on the micro level (the level of individual phases), is therefore of paramount importance for an adequate prediction of the homogenized structural response. This subject is addressed in this contribution on the bases of thermodynamically consistent combination of damage and plasticity material models employing the concept of effective stresses.

The proposed plastic-damage material model is based on existing models already implemented in a commercial computational code ATENA [2] successfully used for the predictions of the response of historical constructions [1]. In particular, the extended Menetrey-Willam yield function is used to describe the irreversible changes in material. The yield function with a smooth cap in a compression is defined for purposes to grasp a material response during hydrostatic loading and to reduce a computational effort [4]. The material

softening caused by crushing is driving by means of the elastic strain depended damage function [3].

Two simple examples are presented for illustration. The first one shows the ability of the model to represent rather well the classical hydrostatic compression test when employing the hardening law of the cap model. The other one displays the qualitative behaviour of the plastic damage model when running the uniaxial tension test. Clearly, since the evolution of damage parameter (here the response is driven by the volumetric damage parameter *d*) is based on the elastic strains, it is inevitable to include softening in the evolution of plastic yield surfaces to arrive at meaningful results. As evident, neither softening plasticity nor plastic damage model without softening provides acceptable results.

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Comparison of Direct and Inverse Material Parameters Identification for Nanoindentation Model

Z. Vitingerová

zuzana.vitingerova@fsv.cvut.cz

CTU in Prague, Faculty of Civil Engineering, Department of Mechanics,
Thákurova 7, 166 29 Prague 6, Czech Republic

Introduction

Comparison of two ways for identification of material parameters of a finite element nanoindentation model is discussed in this paper. Nanoindentation is an experimental method, which permits testing physical properties of materials in the level of their microstructure. Because real tests are very expensive it is practical to use numerical models instead. Then, the problem is to determine material parameters for the model to achieve the same response from the experiment and from the numerical model.

The specimens of cement paste are characterised by a 30 mm diameter and a 4 mm height. For indentation, Berkovich's indenter with pyramidal shape is used. The loading is cyclic (5 cycles) and is driven by a force in a short period of time (only several minutes). The numerical model is implemented using the ADINA software. The three-dimensional problem is simplified to a plane problem by using axisymmetry. To properly describe cement paste non-linear behavior, a combined visco-plastic model was chosen.

Three of five input parameters determinate creep. The forth parameter is Young's modulus E and the last one is yield stress σ. The inverse and the direct way of identification of these parameters are presented further.

Inverse identification

The methodology of the inverse mode consists of finding an inverse relationship among outputs (load-deflection curves) and inputs of a model (material parameters). To approximate this relationship, the self-organized neural network GMDH is used [1]. The main advantage of this approach is that in case of successful training of a neural network we obtain a general identification tool for this model. The success of training is determined by the choice of appropriate inputs for the neural network training, i.e. enough predicative characteristics of load-deflection curves. Therefore, a stochastic sensitivity analysis was applied to analyze the correlation among particular geometrical characteristics of load-deflection curves and material parameters.

The results obtained by this way were not satisfactory. The unsuccessful training of the neural network was caused by a low correlation for tested geometrical characteristics.

Direct identification

In the direct way of identification the error function between an experiment and results from the numerical model is minimized. The numerical model of nanoindentation is very time consuming, hence it is useful to use its approximation instead of the real model. As one of the today's most promising algorithms, the radial basis function network (RBFN) is used. RBFN is based on artificial neural networks, but has some specific properties: the neural net is created only with one layer of neurons, it has a specific type of a transfer function and the training of this net leads to the solution of a linear system of equations. Our particular implementation is based on the variant introduced in [2]. As an optimization algorithm, the

evolutionary algorithm GRADE with its extension called CERAF is used [3]. This extension allows solving the multi-modal problems.

The leading principle of the methodology is the replacement of an objective function by a neural network approximation and its subsequent optimization by an evolutionary algorithm. The approximation is constructed on a basis of interpolation of several points, where the values of the objective function are calculated exactly. The approximation is adaptively improved by new neurons (points), provided e.g. by optima located on the previous approximation. The main advantage of this methodology is an inexpensive evaluation of the approximation, which is repeatedly used during a stochastic optimization process. The computationally expensive objective function is evaluated only when new neurons are added to the neural network. At this point, the RBFN approximation of the objective function is created and the above-mentioned evolutionary algorithm GRADE is used to locate the "approximate" global optima.

Firstly, the direct identification algorithm with two single objective functions was used. The first objective function was a least square error between the experimental and model curves. The second tested function was a difference between slopes of stress-strain curves. But none of these single functions provided sufficient results.

Therefore, the multi-objective optimization was used with both proposed objective functions. Moreover, differences between these curves in significant points were tested for higher precision. All objectives were to be minimized. As an optimization algorithm the evolutionary algorithm mentioned previously together with the Pareto Archived Evolution Strategy [4] was used.

Conclusions

The proposed methodologies were examined on a set of illustrative problems using both experimental as well as computer-generated data. From the point of view of efficiently and accuracy, the multi-objective identification provides a promising alternative to the existing approaches.

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NUMERICAL IDENTIFICATION OF MATERIAL PROPERTIES OF MASONRY

J. Vorel, J. Sýkora

jan.vorel@fsv.cvut.cz, jan.sykora.1@fsv.cvut.cz

Czech Technical University in Prague (CTU),
Faculty of Civil engineering,
Department of Mechanics,
Thákurova 7, 166 29 Praha 6, Czech Republic

The masonry constructions have been widely used for a long time. Nowadays, new masonry structures are on demand owing to its variety and appealing mechanical properties. Both basic components, i.e. the bricks and mortar joints, are viewed as quasi-brittle materials with inherent strain softening response, which (in dependence on fracture toughness of both components) manifests itself by the localization of inelastic strains mainly into the mortar beds between bricks. With reference to their topology it appears useful, at least for computational purposes, to treat these material systems in the framework of multi-scale modeling based on homogenization techniques for the determination of material parameters on the mesoscopic level. The PUC serves as a suitable tool to determine the effective thermo-mechanical properties (namely the effective fracture energy) of the masonry and macroscopic loading paths that become the input data for the modeling on macroscopic level.

This paper deals with determination of effective fracture energy. The material properties derived in the laboratory are used as a stepping stone for numerical simulations and the compression tests of the masonry serve as comparative data. The examinations were executed on the specimens of mortar and bricks as well as on the macroscopic specimens of the regular masonry. Input data are generated by means of standard simulation techniques, such as the Monte Carlo or Latin Hypercube Sampling methods.

Calibration of the model is a very important task from both the theoretical and practical point of view. An experimentally tested regular masonry sample serves as a suitable source for optimizing the material data, especially for contact elements in the ITZ [1-2]. Loading in compression was selected because in this particular case the satisfactory correspondence of the computationally obtained results with experimental outputs is rather difficult to achieve. There is a variety of techniques how to optimize the input data. Our approach is very simple and starts from a set of input parameters based on a „trial and error“ procedure [3]. The calculated loading path is compared with that obtained experimentally. The least square method applied to the difference between the calculated and measured loading force (if the test is controlled by the displacement) then yields the optimized model data.

In the numerical model mortar and bricks are discretized by finite elements but moreover the contact elements (the Mohr-Coulomb material law) cover the brick boundaries to include the impaired material properties of the Interfacial Transition Zone between the mortar and bricks.

The numerical simulations were performed under the displacement control regime using the finite element code ATENA 2D [4]. The program allows for the representation of quasi-brittle behavior of both masonry constituents trough the plastic-fracturing

NonLinearCementitious model exploiting the mesh-adjusted softening modulus in the smeared crack concept to avoid the mesh dependent results. Subsequently, the effective fracture energy is given by

$$G_F^x = L \cdot \int \Sigma_{xx} \, \mathrm{d}E_{xx}, \tag{1}$$

where E_{xx} is the assumed macroscopic uniform strain, Σ_{xx} is the corresponding macroscopic stress and L the dimension of the PUC normal to the crack orientation.

	μ	σ
G_F^x [N/m]	43,83	5,54

Table 1: Mean and standard deviation of the effective fracture energy

The presented numerical results demonstrate both the ability of the finite element based standard commercial code to capture the mechanical behavior of a regular masonry, and the necessity to consider the Interfacial Transition Zone (ITZ). The lower values of cohesion and tensile strength in the ITZ are mainly affected by two phenomena: First, the suction in pores of dry blocks causes the water content in mortar to become insufficient to reach the complete hydration of the bonding agent comprised in mortar. The second detrimental source of impaired contact properties are the air bubbles in pores of dry bricks.

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Electrically conductive adhesive joints with nanoparticles

D. Bušek

busekd1@fel.cvut.cz

Department of Electrotechnology, Faculty of Electrical Engineering,
Czech Technical University
Technická 2, 166 27 Prague 6, Czech Republic

Introduction

Even though most electronic devices can resist high temperature shock caused by soldering in lead-free solders (according to RoHS effective since 2006), many applications can only be realized using low temperature methods like using electrically conductive adhesives (ECA's). Mechanical stress is also very often presented for the completed device and therefore the quality and stability of such realized joint must be achieved.
This research deals with electrically conductive adhesives (ECA's) with isotropic properties (ICA's) and describes the way of improving the quality parameters of such electrically conductive joint. This paper discusses the advantages and disadvantages of nanoparticle addition into commonly fabricated electrically conductive adhesive. Electrical parameters of ICA joints before and after mechanical, humid and humid-heat stress is applied, are observed.
In this research, two different types of silver nanoparticles were added. One had smaller particle size (cca 6 nm in diameter), the other had cca 100 nm in diameter. The difference is shown in the graphs and in the conclusion. Mechanical straining was conducted by bending of the testing boards with attached resistors. The deflection was chosen according to previous research in order to interpret the results from wider perspective in the future.
Standard controlling and evaluating principles for ECAs are based on resistance measurement of a joint. According to our measurement, nonlinearity evaluation is more sensitive. For some applications, linearity might have crucial importance and an absolute size of resistance might not be so crucial. Our previous work proves that nonlinearity might not just be more sensitive but that it also does not have to progress in the same way as the resistivity [1].

Electrically Conductive Adhesives:

ECA's have many un-substitutable properties. Their main advantage is low curing temperature that can even be 20 ºC. Mainly 150 ºC is used to speed up the curing process. When this temperature is compared to the soldering lead-free techniques where the needed temperature varies around 250 ºC or more, this advantage is obvious. Thermally sensitive devices can be attached without any harm. LCD's for example can only be attached using low temperature technologies.

Project summary

Described project reveals the influence of nanoparticle addition into commonly fabricated adhesive. Altogether, five different adhesives were compared concerning their electrical parameters before and after mechanical stress (dynamic bending of assembled testing boards). All of these adhesives were based on Amepox "Eco Solder AX 20"
Significant positive influence of the 80-100nm sized nanoparticles is clearly visible. While the original ECA changes the resistance after mechanical stress to 400% of the starting value, modified samples show in comparison only a little change (only 45% increase). The double

amount of nanoparticles did not show any further difference, so only a little amount of properly chosen sized particles that are added to an isotropically conductive adhesive can significantly improve resistance against mechanical stress. Measuring nonlinearity instead of ohmic resistance brings higher sensitivity, but if the resistance already has high values, then the nonlinearity stagnates and keeps already high level. The change is then minimal)

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Solar Cell Diagnostics Using LBIC and LBIV Methods

J. Salinger*, V. Benda and Z. Machacek

***salinj1@fel.cvut.cz**

Czech Technical University in Prague, Dept. Electrical Technology, benda@fel.cvut.cz
Technicka 2, 166 27 Praha 6, Czech Republic, phone: +420 224352163, fax: +420224353949

As the solar cell market is one of the most quickly developing one between the renewable sources of energy, the demands on quantity and quality of these cells grows rapidly. For diagnostics of cell homogeneity, LBIC and LBIV methods are widely used. This paper deals with comparing two solar cell diagnostic methods via both the qualitative and quantitative analyses.

Both LBIV and LBIC methods are based on measuring either short circuit current I_{SC} or open circuit voltage V_{OC} under conditions of local illumination by monochromatic light of a proper wavelength (usually realised by laser or LED diodes). Assuming the characteristic of a solar cell with series resistance R_s and parallel resistance R_p [1] under conditions of illuminated spot of area A, it is possible to find out for short circuit current (V = 0)

$$I_{SC} = AJ_{FV} - I_{01}\left[\exp\left(e\frac{R_s I}{kT}\right)-1\right] - I_{02}\left[\exp\left(e\frac{R_s I}{2kT}\right)-1\right] - \frac{R_s I}{R_p}, \tag{2}$$

and for open circuit voltage it can be derived (supposing a high parallel resistance R_p)

$$V_{0C} = \frac{2kT}{e}\ln\left(\frac{-I_{02}+\sqrt{I_{02}{}^2+4I_{01}(I_{02}+I_{01}+AJ_{FV})}}{2I_{01}}\right). \tag{3}$$

I_{01} represents the diffusion component of the p-n junction reverse current, and I_{02} is the generation-recombination component of the p-n junction reverse current. J_{FV} is the density of current generated within the cell structure of thickness H by incident light. Non-uniformity in either the generation or the recombination rate over the area of the solar cell results in a non-uniform distribution of J_{FV} and consequently, in non-uniform distribution of both V_{OC} and I_{SC} under conditions of local illumination [2]. The use of different wavelengths of incident light allows obtaining different types of important information about non-uniformity in recombination rate in different depth below the solar cell surface [3].

Matching the maps obtained by the LBIV method with those obtained by the LBIC method is subject of this paper. Even the LBIC method is relatively simple; its results are not always easy to interpret. The main reason arise from the position of measuring point on the I-V curve that can differ from short circuit conditions due to non-zero internal resistance of measuring device. As follows form (2), the short circuit current is very sensitive to the series resistance value that may depend on the distance between the light spot and the contact grid. On the other hand, this method can be used for detecting microscopic ruptures in the material, because these ruptures act as short circuit (reducing the shunt resistance value ~ 0), thus influencing the measured value of the short circuit current radically. From the equivalent circuit model of the solar cell follows, that the method LBIV operates in a well defined point of I-V characteristic, but it is insensitive to changes in shunt resistance value.

Differences between maps obtained using LBIC and LBIV methods were studies experimentally. They were measured by both methods and with 6 different light wavelengths. Results obtained by using wavelength 670 nm laser diode were compared – apparently a

residuum appears, that may have an origin in the wafer-fabrication process when the surface damaged layer after cutting the rod was probably not fully etched off. Results of the LBIV method are more pronounced than those of the LBIC method under conditions stated above.

Other measurement shows results of application of the methods LBIV and LBIC method on the polycrystalline solar cell. Similar strips as in the monocrystalline solar cell have been observed with the wavelength of 670 nm indicating some variations in the wafer structure, which was, again, most probably brought in during etching the damaged layer after the wafer cutting. Looking at the scale of these maps, it can be found, that the LBIV and LBIC maps are comparable in the resolution of the map as well as in the contrast of observed inhomogeneities.

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Electro-Osmotic Flow in Building Materials - pH influence

T. Mejdr, L. Balík

tadeas.mejdr@centrum.cz

Department of Experimental and Measurement Methods, Klokner Institute, Czech Technical University in Prague

When electrodes are placed across clay mass and direct current is applied, water in the clay pore space is transported to the cathodically charged electrode by electro-osmosis. Electro-osmosis transport of water through clay is a result of diffuse double layer cations in the clay pores being attracted to a negatively charged electrode or cathode. As these cations move toward the cathode, they bring with them water molecules that clump around the cations as a consequence of their dipolar nature. In addition, the frictional drag of these molecules as they move through the clay pores help transport additional water to the cathode. The macroscopic effect is a reduction of water content at the anode and an increase in water content of the clay at the cathode. In particular, free water appears at the interface between the clay and cathode surface.

Influence of pH in electro-osmotic flow was tested on three sets of samples with three samples in each group. Samples were composed of solid phase which was brick cylinder 240mm long and 50mm in diameter. Samples were moistened with salt water solution of well-known pH scale. Samples were equipped with graphite electrodes on both ends and then the whole sample was sealed with tape and shrinkable tube. Samples were embedded between positive and negative electrodes and the current voltage of 6 V was applied. Comparable initial values were moisture of solid phases, applied voltage, arrangements and material base of samples. Dissimilar initial values were pH scale of embedded solutions into samples. Three type of saltwater (marked 1, 2, 3) were used for experiment. Saltwater were solution of salt ions in distilled water. The pH for type 1 was 6,07 and salt ions were KH_2PO_4 and NaOH, for type 2 pH was 9,02 and salt ions were H_3BO_3, KCl and NaOH and for type 3 pH was 11,18 and salt ions were Na_2HPO_4 and NaOH. Samples 19, 20 and 21 were moistened by solution 1, samples 22, 40 and 41 by solution 2 and samples 42, 43 and 44 by solution 3. The capital evaluative criteria were moisture decrease of solid phases and moisture decrease of solid particle which is in contact with anode.

Data evaluation did not approved explicit dependence between pH value and transported water content. Moisture decrease of solid phases near anode, refer to possibility of increasing electro-osmotic flow with lower pH value. The maximum volume of transported saltwater was in test 1 – 1,01g (it means 4,03 % of inlayed moisture), in test 2 – 0,61 g (it means 2,05 % of inlayed moisture) and in test 3 – 0,82 g (it means 3,08 % of inlayed moisture). Test with solutions 1 and 3 confirm theory that increasing pH is restraining electric flow and efficiency of electro-osmosis. In test with solution number 2 did not show monotone decrease in dependence on higher pH. This irregularity may have been caused by different kind of salt ions used in this test. The reason for using different kinds of salt ions is that it is impossible to produce solutions with same ions and such a wide scale of pH. Another thing that can cause non-uniform results is that the solution might change pH value in time especially in time period longer then two months like it was in this test. The great irregularity was noted in case of sample 41 during electro-osmotic action. This sample was disabled from all the valuation.

For more accurate results it would be necessary to have more then three samples in each set.

Biggest issue from last tests was evaporating which was successfully eliminated. Evaporation of samples was less then 0,5 grams in two months period.

Results of tests which were carried out till now and which belong into more extensive project dealing with electro-osmotic effects in building materials can be compiled into next sentences.
Capacity of electro-osmotic flow rises with value of applied voltage and current density.
Capacity of electro-osmotic flow isn´t influenced by initial moisture of sample in the range of 4,87 to 8,6 %.
It wasn´t explicitly approved dependence of capacity of electro-osmotic flow on pH value in the range of solutions 1, 2, 3 described above.

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Reconstruction of 3D Microstructure of Cement Based Composites

K. Forstová, J. Němeček

katerina.forstova@fsv.cvut.cz

Department of Mechanics, Faculty of Civil Engineering, Czech Technical University in Prague, Thákurova 7, 166 29 Prague 6, Czech Republic

Presented work deals with the reconstruction of cement paste microstructure for the purpose of simulation of its micromechanical behavior. Two-dimensional real images of cement paste captured by environmental scanning electron microscope (ESEM) were employed for this reconstruction in three dimensions. Thresholded images were converted to binary representation that allowed using statistical descriptor (autocorrelation function). Computed examples proved good efficiency of the reconstruction algorithms.

Hydrated cement paste is a heterogeneous material at microscale which consists of three main phases- hydration products, unhydrated clinkers and pores. There are several known models for the reconstruction of its microstructure. For example, the Power's model can describe newly formed phases in the quantitative way. In order to reconstruct the cement microstructure also spatially, more sophisticated model has to be used. Such model, based on voxel structure, was developed by Bentz (CEMHYD3D, [2]). In this model, the primary microstructure is generated using statistical descriptor in the form of autocorrelation function. Primary microstructure is generated with the knowledge of cement type and other parameters like grading size curve, water to cement ratio, etc. The resolution of the microstructure is given by the size of voxels that is typically 1 μm. After the iteration process that includes dissolution, diffusion, transport of chemicals and phase percolation the three-dimensional microstucture of hydration products is generated.

The final goal of the presented work is to elaborate an efficient numerical algorithm for the simplified (two-phase) microstructure reconstruction of a particular cement paste sample using real ESEM images. For this purpose images captured by the back-scattered electron (BSE) detector of ESEM were used. Contrast in BSE images is produced by the variation of atomic number within the scanned area of the specimen surface. This variation corresponds to the different material phases. The resulting image displays phases in the grey scale. Typical image of the cement paste contains black color that represents empty pores (they have zero reflectivity), white color of unhydrated clinker minerals (they contain calcium and silica and they have high reflectivity) and grey levels that can be assigned to various hydration products (C-S-H gels, calcium hydroxide, ettringite etc.). So far, there has not been found a way how to distinguish between the hydrated phases just according to the grey level. For the purpose of the simplified model, the complex microstructure was treated like a two-phase medium. Pores were selected from the image using thresholding levels. Since the tresholding was done manually (according to the chemical composition from ESEM), the results are necessarily dependent on this intentional choice.

The proposed reconstruction algorithm is based on the binary representation of the real microstructure. To provide a general statistical descriptor of such a system it is useful to characterize each member of an ensemble by a random stochastic function – characteristic function $\chi_r(x, \alpha)$, which is equal to one when a point x lies in the material phase r in the sample α and equal to zero otherwise [1]. Then, the one-point probability S_r function gives the probability that a point x will be found in a given phase r and the two-point probability

function S_{rs} stands for the probability that the points x and y will be located in phases r and s, respectively:

$$S_r(x) = P(\chi_r(x) = 1) \quad (1)$$

$$S_{rs}(x, y) = P(\chi_r(x)\,\chi_s(y) = 1) \quad (2)$$

For the case of statistically homogeneous and ergodic media, information contained in the one-point probability function reduces to the volume fraction of a given phase. In addition, the two-point probability function then depends on $x-y$ distances and it can be obtained from the relation

$$S_{rs}(x,y) = \frac{1}{WH} IDFT\left\{DFT\left\{\chi_r(x,y)\right\}\overline{DFT\left\{\chi_s(x,y)\right\}}\right\} \quad (3)$$

where W is the width of image, H is the height of image, $\chi_r(x, y)$ is the characteristic function of phase r, $\chi_s(x,y)$ is the characteristic function of phase s, DFT and $IDFT$ stand for the direct and inverse Fourier transform and overline denotes the complex conjugate [1].

$S_{rs}(x,y)$ is computed from 2-D binary image. However, for 3-D reconstruction it has to be converted to $S(d)$ format since for an isotropic media the autocorrelation function should only be a function of the distance $d = \|x - y\|$ [2]. In this case, the autocorrelation function forms a two-column matrix. The first column contains the distance between two points in the same phase and the second column expresses the average probability that two points in certain distance are in the same phase.

In our algorithm an initial 3-D microstructure is created using a Gaussian noise (which was taken from CEMHYD3D algorithm). It has a probability density function of the normal distribution as the Gaussian noise. Then, the convolution mask of two images is computed. It involves the multiplication of a group of pixels in the input image (created with the Gaussian noise) with an array of pixels in a convolution mask (specified by the autocorrelation function). The output value produced in a spatial convolution operation is a weighted average of each input pixel and its neighboring pixels in the convolution mask. Initial 3-D microstructure is also filtered by a convolution mask maintaining periodic boundaries. The newly created microstructure is thresholded in order to convert each pixel into black or white. The resulting 3-D microstructure is produced so that it has very similar autocorrelation function as the input 2-D image.

To summarize, algorithm 3-D reconstruction of random microstructure of cement paste using image analysis and two-point probability function was presented. However, it is clear that even if the correlation function of the reference and reconstructed images are in good agreement, it is not ensured that both images will match each other. An extension to higher-order correlation functions and applying various boundary conditions to the resulting system that will match better is possible. It is planned to use the result of this work as an input for finite element analysis of the micromechanical properties of cement paste.

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Properties of Cement Composites with Hybrid Fiber Reinforcement

E. Vejmelková[*], P. Padevět, P. Konvalinka[**], R. Černý[*]

cernyr@fsv.cvut.cz

*Czech Technical University in Prague, Faculty of Civil Engineering, Department of Materials Engineering and Chemistry, Thákurova 7, 166 29 Praha 6, Czech Republic

Czech Technical University in Prague, Faculty of Civil Engineering, Department of Mechanics, Thákurova 7, 166 29 Praha 6, Czech Republic

**Czech Technical University in Prague, Faculty of Civil Engineering, Experimental Center, Thákurova 7, 166 29 Praha 6, Czech Republic

Fiber reinforcement is a traditional and effective method how to improve the toughness and durability of cement based products [1]. The steel rod reinforcement became very popular during the whole last century. However, in the second half of the 20th century, an application of uniformly dispersed short fibers strengthening the brittle cementitious matrices appeared with an increasing frequency. In the current practice, steel, glass, carbon and various polymeric fibers such as polyethylene, polypropylene, nylon, polyester, polyurethane, cellulose, etc., are commonly used in cement-based materials.

Cement based composites with hybrid fiber reinforcement present a perspective way of development of this type of materials because they can combine positive effects of fibers of different type and length. However, the structure and properties of this type of fiber composites are not well known yet. The effect of simultaneous application of glass, cellulose, carbon, polypropylene and other fibers or by their combination in the conditions of variable relative humidity, permanent elevated temperatures or in the extreme conditions of a fire was not studied in a systematic way, until now. Only particular results were published (e.g. [2]). In this paper, basic mechanical and water-vapor- and water transport parameters of hybrid glass-polypropylene fiber reinforced cement composite are studied.

Table 1 Mechanical properties of the studied fiber reinforced cement composite

Material	Tensile strength [MPa]	Bending strength [MPa]
SC-ref	3.98	15.08
SC-600	1.86	3.78
SC-800	0.40	2.42
SC-1000	0.14	1.93

The specimens of the hybrid glass-polypropylene fiber reinforced cement composite were produced in the laboratories of VUSTAH Brno. The composition of the material was as follows (calculated among the dry substances only): Portland cement CEM I 52.5 54%, sand 0-1 mm 40%, microsilica 3%, alkali-proof glass fiber 12 mm long 2.7%, polypropylene fiber 30 mm long 0.3%. Water in the amount corresponding to the w/c ratio of 0.33 was added to the mixture. Samples for measurements were prepared using vacuum technology. First, cement, sand and microsilica were homogenized in the mixing device, then water and glass fibers were added and the wet mixture mixed again. Finally, the polypropylene fibers were

stirred into the mixture. The liquid mixture was cast into the forms and de-aerated during 1 hour. After the time period of 28 days after mixing, the samples were dried and four various sample pre-treatment conditions were induced. Reference specimens were not exposed to any thermal load (they are denoted as SC-ref), other specimens were exposed to a gradual temperature increase up to 600, 800 and 1000°C (SC-600, SC-800, SC-1000) during two hours, then left for another 2 hours at the final temperature and slowly cooled.

Table 2 Water vapor transport properties of the studied fiber reinforced cement composite

Material	97/25-30%			5/25-30%		
	Water vapor permeability [s]	Water vapor diffusion coefficient [m^2s^{-1}]	Water vapor diffusion resistance factor [–]	Water vapor permeability [s]	Water vapor diffusion coefficient [m^2s^{-1}]	Water vapor diffusion resistance factor [–]
SC-ref	4.37E-12	6.00E-07	38.42	2.16E-12	2.97E-07	77.32
SC-600	1.10E-11	1.51E-06	15.22	6.97E-12	9.58E-07	24.05
SC-800	1.99E-11	2.73E-06	8.42	8.70E-12	1.20E-06	19.23
SC-1000	3.73E-11	5.12E-06	4.49	8.62E-12	1.18E-06	19.48

Table 3 Water transport properties of the studied fiber reinforced cement composite

Material	Water absorption coefficient [kg $m^{-2}s^{-1/2}$]	Apparent moisture diffusivity [m^2s^{-1}]
SC-ref	0.0096	1.65E-09
SC-600	0.0465	2.13E-08
SC-800	0.0718	4.20E-08
SC-1000	0.2750	6.91E-07

Tables 1-3 present the mechanical and water-vapor- and water transport properties of the studied composite material. The major changes in all the studied parameters were observed between the reference state and the pre-heating temperature of 600°C. This indicates the importance of the effect of portlandite decomposition taking place at 460-480°C.

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Optical Materials Doped with Rare Earth Ions

V. Prajzler, I. Hüttel*, J. Špirková*,
O. Lyutakov*, J. Oswald, V. Peřina***, Z. Burian, V. Jeřábek**

Vasek.Prajzler@email.cz

Department of Microelectronics, Faculty of Electrical Engineering,
Czech Technical University,
Technická 2, 166 27 Prague 6, Czech Republic

* Institute of Chemical Technology,
Technická 5, 166 28, Prague 6, Czech Republic

** Institute of Physics, Academy of Sciences,
Cukrovarnická 10, Prague 6, Czech Republic

*** Academy of Sciences, Nuclear Physics Institute
250 68 Řež

Optical materials play very important role in photonics, optoelectronics and integrated optics. Up to now many different optical materials have been used for photonics and optoelectronics applications. The most often used materials are optical glasses (phosphate glasses, germinate glasses, tellurite glasses, fluorophosphate glasses etc.), optical crystals (lithium niobate, sapphire, lithium tantalite), semiconductors (silicon, gallium arsenide, gallium phosphate, gallium nitride, indium phosphate). Nowadays are also investigated new types of materials such as polymers.

Rare earth (RE) doped optical materials can be used for many applications [1]. The most used RE ions is erbium (Er^{3+}). Er^{3+} doped materials can emit at wavelength 1530 nm. This nature of materials are used for fabrication of optical amplifiers or optical sources at telecommunication systems because the fact that 1530 nm corresponds to a low loss window of silica based on optical fibers. For better optical properties of Er^{3+} doped optical amplifiers are often co-doped with ytterbium (Yb^{3+}) ions. Thulium (Tm^{3+}) ions are new candidates for optical amplifiers operating in the 1450 nm – 1530 nm region, but the disadvantage of these materials is a double pumping (800 nm + 1400 nm or 980 nm + 1510 nm). Next very often investigated RE ions are neodymium (Nd^{3+}) and praseodymium (Pr^{3+}). Nd^{3+} and Pr^{3+} ions can be used for fabrication optical amplifiers operating at 1300 nm. This signal at this wavelength is applied because silica fibers have no chromatic dispersion.

In the last decade are studied optical properties materials doped with erbium (Er^{3+}), europium (Eu^{3+}) and thulium (Tm^{3+}) ions. These materials are used for fabrication of full color flat panel displays. Er^{3+} is used as source of green light (537/558 nm), Eu^{3+} is source of red light (621 nm) and Tm^{3+} as source of blue light (477 nm). Nowadays are also studied optical materials doped with thulium (Tm^{3+}), holmium (Ho^{3+}), dysprosium (Dy^{3+}) and so on. These RE ions are used for fabrication optical sources with operating wavelength higher than 1600 nm. In the case of Tm^{3+} and Ho^{3+} ions are used for fabrication optical sources operating at 2010 nm and Dy^{3+} ions is used for operation at 3.4 μm or 4.34 μm. These materials can be used for eye-safe remote sensing systems, medical applications, coherent Doppler LIDAR wind sensing, and wind shear detection.

The researches of optical properties of RE doped optical materials have long tradition in Laboratory of the Integrated Optics at Department of Microelectronics at Czech technical University. At the beginning in co-operation with Institute of Chemical Technology the researches were focused on investigation of optical properties of glasses doped with Er^{3+} ions. Next researches were focused on doping $LiNbO_3$ with Er^{3+} and Yb^{3+} ions. After that we fabricated by PACVD and by sputtering carbon layers doped with Er^{3+} ions. In the last few years were our researches concern to investigate properties of GaN layers doped with Er^{3+} and Yb^{3+} ions. Nowadays our researches are focused on fabrication and investigation properties of polymer layers doped with rare earth ions. For our researches we choose Polymethylmethacrylate (PMMA) and Epoxy Novolak Resin (ENR) polymers due to its excellent mechanical and optical properties (PMMA - refractive indices 1.490 at 632.8 nm, 1.481 at 1550 nm and optical losses 0.08 dB/cm at 632.8 nm, 0.4 dB/cm at 1330 nm, ENR - refractive indices 1.596 at 632.8 nm, 1.575 at 1550 nm and optical losses ranging from 0.08 to max. 1.5 dB/cm in the region of 632.8 to 1550 nm).

Our researches are mainly focused on studying photoluminescence spectra of Er^{3+} doped materials at wavelength 1530 nm. We also investigated properties of Er^{3+} doped materials co-doped with Yb^{3+} ions. In the future we would also like to study photoluminescence spectra of other RE ions. For photoluminescence measurement we used four types of optical sources: 1. Ar laser ILA-120 at λ_{ex}= 488 nm, E_{ex}= 100 mW; 2. Ar lasers operating at λ_{ex}= 514.5 nm, E_{ex}= 300 mW; 3. He-Ne lasers operating at λ_{ex}= 632.8 nm, E_{ex}= 150 mW; 4. Semiconductor laser P4300 at wavelength of λ_{ex}= 980 nm, E_{ex}= 500 mW.

We observed typical photoluminescence bands that attributed to the erbium transition $^4I_{13/2} \rightarrow {}^4I_{15/2}$ at 1530 nm at glass and $LiNbO_3$ samples doped with Er^{3+} ions. Doping with ytterbium ions increased the intensity of the luminescence as well. It was mention above that our researches were also focused on fabrication of carbon and GaN layers with Er^{3+} ions. In this case the most successful method for the fabrication of erbium doped carbon layers was magnetron sputtering. Under the optical pumping at 514.5 nm (4 K) the typical photoluminescence emission at 1530 nm was observed. GaN samples were fabricated by magnetron sputtering and for Er and Yb doping the erbium and ytterbium powder was placed onto the top of the target or by MOCVD and doping were done by ion implantation. We observed luminescence at 1530 nm at optical pumping at 980 nm under room temperature. The more details about our research you can find at [2, 3, 4].

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Epoxy Novlak Resin Optical Waveguides

V. Prajzler, I. Hüttel*, J. Špirková*, M. Myslík,
O. Lyutakov* Z. Burian, V. Jeřábek

Vasek.Prajzler@email.cz

Department of Microelectronics, Faculty of Electrical Engineering,
Czech Technical University,
Technická 2, 166 27 Prague 6, Czech Republic

* Institute of Chemical Technology,*
Technická 5, 166 28, Prague 6, Czech Republic

In recent years, passive and active optoelectronics and photonics waveguides are widely used for production of optical components such as optical couplers, switches, multiplexers, modulators, polarization converters, wavelength filters, attenuators, sensors, optical amplifiers, optical sources and displays [1].

There are many optical materials used for optoelectronics and photonics devices such as semiconductor materials, dielectric materials and glasses. In the last decade are studied new materials such as polymers [2]. Optical components based on polymers are specially attractive due to simple fabrication process and low cost. Polymer materials have also been investigated due to their advantages such as, e.g. low dielectric constants and there is also flexibility in the sense that polymers are used as spun-on layers that are compatible with many substrates like glass, silicon and so on.

Polymers have been investigated in many laboratories and some are available commercially it is due to its increasing role in optoelectronics and photonics applications. Different kinds of polymers have been demonstrated as suitable materials for optical waveguides and different fabrication technologies. Most often reported polymers waveguides were fabricated using spin-coating, reactive ion beam etching, UV lithography, photo-bleaching, ion-implantation, laser/electron beam writing. Up to now lot of polymer materials were used for fabrication optical waveguides for example Polymethylmethacrylate (PMMA), Polysthyrene (PS), Polyfluoromethacrylate (PFMA), Polydimethylsiloxane (PDMS), Epoxy Novolak Resin (ENR, formally named as NANO^{TM} SU8 2000), Ultradel 9000, Chloro-fluorinated, Deuterated polysiloxane and etc. [2], [3].

For our research we chose Epoxy Novolak Resin (ENR) polymer due to it excellent optical properties (refractive indices 1.596 at 632.8 nm, 1.575 at 1550 nm and optical losses ranging from 0.08 to max. 1.5 dB/cm in the region of 632.8 to 1550 nm), easy fabrication process and low coast.

The first optical waveguides were theoretically designed by using mathematical modification of the dispersion equation [4]. We determined the number of guided modes and critical thickness of the waveguides.

Before the deposition the substrates were cleaned by standard cleaning procedure and optical waveguides were fabricated by spin coating on silicon or silica-on silica substrates and channel waveguides were fabricated by single optical lithography. Fabrication procedure was as follows: a drop of the ENR polymer was trickled down onto the substrate from a pipette, then the substrate was let to spin round, the ENR drop covered the substrate surface and

partially evaporated out. Rotation rate was 700 – 1 000 rev./min and deposition time was 3 min.

The properties of the fabricated layers were analyzed by various methods. Refractometer AvaSpec-2048-2 was used to measure refractive indices in the range from 350 to 750 nm. The measured values were evaluated by a computer programme Avantes. Waveguides properties of the samples were determined by mode spectroscopy (prism coupling method) by using He-Ne laser (632.8 nm). For optical coupling was used SF4 prism. The specially designed software (Planproof) was used for evaluation of the data obtained from the mode spectroscopy measurement. The thickness was measured by a profilmeter Talystep (Hommer Tester T1000).

We found out that the samples had waveguiding properties and the number of propagating modes varied from 1 to 10 depending on the thickness of the deposited layers. The refractive index was about 1.602 for TE mode and 1.606 for TM mode respectively. We fabricated rib waveguides based on Si/SiO_2/ENR structures by standard optical lithography. The next research will be focused on investigation of properties of fabricated rib waveguides.

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Computational Modeling of Coupled Heat and Moisture Transport with Hysteretic Transport and Storage Parameters

J. Maděra, R. Černý

madera@fsv.cvut.cz

Department of Materials Engineering and Chemistry, Faculty of Civil Engineering, Czech Technical University in Prague, Thákurova 7, 166 29 Praha 6, Czech Republic

Computational modeling of coupled heat and moisture transport in porous building materials with hysteretic transport and storage parameters in the conditions of difference climate is presented in the paper. As the mathematical model for the coupled heat and moisture transport we have chosen a diffusion-type model. The diffusion theory of moisture transfer in porous materials is based on the assumption that moisture in liquid or gaseous phase penetrates through the porous system by a diffusion mechanism in a similar way as for instance in a system of two gases.

The modeling of coupled heat and moisture transport leads to a system of non-linear partial differential equations. The construction of the computer code is based on the application of the general finite element computer simulation tool SIFEL (SImple Finite ELements) developed in the Department of Mechanics, FCE CTU. The basic state variables (moisture content, relative humidity, temperature) can be obtained as functions of space and time. The diffusion model used in the computational modeling of the problem of coupled heat and moisture transport was the model by Künzel [1]. The moisture and heat balance equations were formulated as

$$\frac{d\rho_v}{d\varphi}\frac{\partial\varphi}{\partial t} = div\left[D_\varphi grad\varphi + \delta_p grad(\varphi p_s)\right]$$

$$\frac{dH}{dT}\frac{\partial T}{\partial t} = div\left(\lambda grad T\right) + L_v div\left[\delta_p grad(\varphi p_s)\right],$$

where ρ_v is the partial moisture density, φ the relative humidity, δ_p the water vapor permeability, p_s the partial pressure of saturated water vapor in the air, H the enthalpy density, L_v the latent heat of evaporation of water, λ the thermal conductivity, and T is the temperature.

An empirical procedure was chosen to describe the path between the transport- or storage parameters functions corresponding to wetting and drying. As the transport parameter we have chosen moisture diffusivity, as the storage parameter water retention curve. The hysteresis model by Pedersen [2] was used in the computational modeling. It can be formulated as (slope of the hysteretic parameter)

$$\xi = \frac{a_d\left(u-u_a\right)^2\xi_d + a_a\left(u-u_d\right)^2\xi_a}{\left(u_d-u_a\right)^2}$$

where u is actual value of surveyed unknown, u_a and u_d are unknown values for adsorption and desorption cycles, ξ_a a ξ_d are values for tangent adsorption and desorption in the points u_a a u_d, a_a and a_d are the correction coefficients.

In the computer simulations of the practical use of hysteresis problem in the coupled heat and moisture transport in porous building materials we have solved two variants of sandstone wall, with and without hysteretic problem. The thickness of sandstone wall was 450 mm. Basic material characteristics are summarized in Table 1. These properties were obtained from TRANSMAT material database. Hysteretic transport and storage parameters were calculated using inverse simulation.

Table 1: Basic materials characteristics of sandstone

	ρ [kg/m^3]	θ_{sat} [m^3/m^3]	λ_{dry} [W/mK]	c [J/kgK]	μ [-]
Sandstone	1890	0.32	0.48	550	6

For sandstone wall, there were taken initial values of field variables corresponding to the values outside (temperature equal to 5°C and relative humidity equal to 95%). As for the boundary conditions, the analyzed building envelope was exposed from inside to constant conditions (temperature equal to 21°C and relative humidity equal to 55 %) and from outside to the climatic conditions corresponding to the test reference year for Prague. The 1st of January was chosen as the starting point in the calculations. The time of simulation was one year. Hourly data of temperature and relative humidity in the sandstone wall were calculated.

The computational modeling in this paper revealed that the application of hysteretic water transport and storage parameters can be considered as quite important in durability analyses of building materials. The results showed very significant differences in relative humidity profiles calculated for model with hysteretic parameters and without hysteretic parameters.

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Moisture and Salt Transport and Storage Parameters of Renovation Plasters

M. Pavlíková, Z. Pavlík, R. Pernicová, R. Černý

milena.pavlikova@fsv.cvut.cz

Department of Materials Engineering and Chemistry, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6

The durability of new surface layers is mostly estimated on the basis of experience because too few parameters are known for a reliable durability estimate. The choice of a material for reconstruction is then often less suitable regarding to the moisture and salt content in the masonry which leads to low durability and short service life of surface layers. The current practice of the solution of the problem of historical buildings surface layers damage is based more or less on the method of analogy. At a reconstruction, usually such material and method of its application is used which is according to the meaning of supervisory authorities compatible with the original treatments and which already was found to be suitable at an application on some other building before. Plaster can play its function, it means architectural and protective against negative environmental conditions, only if it creates a compact cover with surface treatment. Contemporary plasters meet these requirements due to their proper raw materials, technological processing, suitable storing and final application. Historical facades restoration brings not just new plaster creation but also protection of existing one. It is difficult and mainly unsuitable to produce plasters with the same composition and behaviour as historical plasters. The current solution of the problem of surface layers damage of historical building is based more or less on the improvement of technology and properties of each input raw material with preservation of visual and physico-chemical compatibility to original plaster. The main reasons of construction materials deterioration are salt crystallization, water and salt solutions movement through the walls by capillarity and worse environmental conditions.

Therefore, in this paper, we are focused on the basic material characteristics and water vapour, liquid water and salt transport and storage parameters of lime based renovation plasters modified with metakaolin addition. Comparative measurements with common lime plaster are done as well.

At first, basic material properties of all tested plasters were determined. As fundamental physical material characteristics, bulk density, matrix density, and open porosity were measured. Bulk density was determined using gravimetric method. Matrix density was obtained with Pycnomatic ATC device, automatic helium pycnometer with fully integrated temperature control with precision of ± 0.01 °C and real multi volume density analyzer. Investigation of mechanical parameters was carried out according to the norm ČSN EN 196-1, 2005. The compressive and flexural strengths were determined as the most important mechanical parameters for lime-based plasters. For each measurement standard prisms 40 x 40 x 160 mm were tested with DSM 2500 hydraulic testing device, Inova Praha. The flexural strength was measured using standard three-point bending test. The compressive strength was determined using the same test device on the remainders of the specimens after bending test. Water transport was characterized in quite common way using the sorptivity and apparent moisture diffusivity [1]. The wet cup method, dry cup method and wet-dry combined method

were employed in the measurements of the water vapor diffusion coefficient. For description of water storage parameters, the sorption isotherm and water retention curve were measured. The sorption isotherms were measured employing desiccators with different salt solutions for simulation of specific relative humidities. The water retention curve was determined using an ordinary pressure plate device. In the determination of ion binding isotherm as of the main salt storage parameter, a modified Tang and Nilsson adsorption method [2] was applied. Using the Bear and Bachmat diffusion-advection model [3] taking into account (in addition to salt dispersion in the liquid phase) the influence of moisture flow on salt transport and also the effect of bound salt on pore walls, the moisture diffusivity and the salt dispersion coefficient appear as the main salt solution transport parameters. In this way, system of two parabolic differential equations, solved by an extension of the Boltzmann-Matano treatment, is used for description of water and salt mass balance [4].

The modified plasters showed significant improvement of mechanical properties. Another good point with the studied lime-metakaolin plasters was that the hygric and thermal properties were basically unaffected by the metakaolin addition. All studied materials have proved high porosity, what is very positive factor from the point of view of their presumed application on historical buildings. The high porosity of plasters guarantees fast water vapour transport, and so its fast removal from the load bearing structures of reconstructed historical buildings. Lime-metakaolin plasters had higher water vapor diffusion resistance factor than the reference lime plaster but the differences were not very significant. From the quantitative point of view, the obtained values of water vapour diffusion parameters of renovation plasters are very promising for application in restoration of historical buildings and renewal of the old materials. The values of liquid water transport parameters were in case of lime-metakaolin plasters similar or slightly higher than for pure lime plaster. This may be considered as a negative finding in general because the rain water could be transported either the same fast or even faster into the load bearing structure. However, from the quantitative point of view the differences were not very high so that this is only a minor flaw on otherwise significantly improved material. Measured salt transport and storage parameters give clear evidence about the high salt binding capacity of the studied materials.

The measurements of water and salt transport and storage parameters of renovation plasters determined in this paper can be utilized in the practice in computational predictions of combined water and salt movement in envelope parts of historical buildings. On the basis of the experiments performed, it can be concluded that the analyzed lime-metakaolin plasters are suitable for an application in reconstruction of historical buildings.

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Evaluation of Bituminous Materials by Non-destructive Testing

E. Kartakova, L. Kubincanova, J. Smid, O. Vacin

vacin@fsv.cvut.cz

Department of Road Structures, Faculty of Civil Engineering, Czech Technical University, Thakurova 7, 166 27 Prague 6, Czech Republic

Rapid road deterioration is caused by increase in traffic, especially truck traffic. The goal is to find basic characteristic for hot mix asphalt, which could effectively lead to the better pavement maintenance and enhance life time of pavements. The objective is to obtain data in the laboratory with the same input as gathered during the field experiments. Hot mix asphalt (HMA) material testing and evaluation is still based on empirical evaluation mostly. The state of the art in new European specifications will be a measurement of HMA at different temperatures and loading frequencies in near future. The goal is to develop a set of procedures based on performance testing e.g. Complex modulus, fatigue, triaxial testing, low temperature characteristic. This should lead to better understanding of basic behavior and new design of pavement materials. It involves laboratory specimen preparation, equipment and testing procedure. In this paper, procedure of complex modulus in cyclic loading is evaluated. Recommendations, based on findings, are discussed.

Flexible pavements are consisting of several HMA layers, which is in new European terminology called Asphalt Concrete (AC). Nevertheless bitumen as a binder constitute a small portion of the total mass of each AC layer, it substantially influence overall properties of the whole mix. Material behaves as elastic at low temperatures, visco-elastic at intermediate temperatures and visco-elasto-plastic at high service temperatures. It can be concluded that AC properties are predominately influenced by asphalt at low and intermediate temperatures, while the mix rheology at high temperatures is predominately influenced by aggregate. Because of the complexity of the material behavior, it was easier to introduce empirical tests which are still in use for more than a half century for AC, binder characterization and pavement designs. Together with empirical procedures, rational tests with good scientific approach were developed from the late 60´s [1,2]. However, these were either too time consuming or too expensive to carry it out routinely.

European Union countries decide to accept new testing methodologies for AC based on performance. Nevertheless these tests procedures are known for some time, their usage is still limited and it is restricted to research centres mostly. On the other hand, Simple Performance Test (SPT) was developed and spread in North America as a simplified procedure and it is used as one of the inputs in Mechanistic-Empirical Pavement Design Guide in the United States.

In accordance to the definition, complex modulus (E*) expresses relationship between stress and strain for a linear visco-elastic material when is subjected to sinusoidal loading. This is well suited for AC where elastic and viscous part can be expressed in the forms of storage (E´) and loss (E´´) moduli, using the phase angle shift ϕ as a ratio between E´´ and E´. Higher phase angle value means that material tents to be more viscous and material is potentially less rut resistant. It occurs at higher temperatures and/or longer loading rate (frequency). Current European specification, EN 12697-26 Stiffness [3], is taking into consideration different types of specimen's geometry, which may create differences in results values of complex modulus. In this paper, cylindrical specimens were evaluated in accordance to the AASHTO TP-62 [4] procedure.

This research describes importance of rational specification for AC which will ultimately lead to better understanding of material behaviour, address premature failures and extend

pavement life time. European Union countries decide to accept new testing methodologies for AC based on performance. It is believed that evaluated methodology will be used in AC thickness design in the near future. In this paper, evaluation of complex modulus test is discussed. It involves laboratory specimen preparation, equipment and testing procedure.

Cylindrical specimens of different asphalt binder types and aggregate distributions were use for procedure evaluation. It was decided to keep ratio height to diameter as 1,5 to 1. It means that specimens of uniform dimensions of 150 mm (height) and 100 mm (diameter) had to be drilled from compacted slabs. Asphalt concrete slabs were prepared in the laboratory by different compaction techniques using the French and the segment compactor. Slabs requires substantial amount of material, the amount was determined from the Marshall design and from dimensions of French and segment compactors (500x150x150 mm and 350x150x15 mm). Commercial equipment made by Cooper Technology, was found suitable for AC testing. It consist of hydraulic 25 kN frame, environmental chamber and data acquisition system. The methodology is based on sinusoidal loading by axial compressive stress at given frequencies (0,1; 0,5; 1; 5; 10; 25 Hz) and temperatures (0; 20; 40 °C). Resultant axial strain was recorded and used to calculate dynamic modulus and phase angle.

It is believed that evaluated methodology will be used in AC thickness design in the near future in EU. It involves laboratory specimen preparation, equipment and testing procedure. Recommendations can be described as follows: i) test is suitable for determination of rutting potential of AC mixes; ii) special attention has to be given to sample preparation; iii) proper placement and check of LVDTs should be done prior the testing; iv) it can be concluded that dynamic modulus data can be easily determined on cylindrical specimens. Precision regarding to the transfer of the strain readings is a key factor influencing results. It requires good bond between sample and the steel pin and good connection between the pin and LVDT. This can be achieved by magnetic clips and/or special LVDTs mounting device.

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Fracture Toughness of Fe-40Al Based Intermetallic Alloys

P. Haušild, M. Karlík, P. Kudrna, T. Skiba

Petr.Hausild@ fjfi.cvut.cz

Department of Materials, Faculty of Nuclear Sciences and Physical Engineering,
Czech Technical University, Trojanova 13, 120 00 Praha 2

Iron aluminides based on FeAl exhibit superior corrosion resistance to high-temperature oxidation and sulfidation, good wear resistance, low density (~5.6 $g.cm^{-3}$), ease of fabrication and relatively low cost reducing the amount of Ni and Cr indispensable in common high-temperature stainless steels or nickel superalloys. These properties offer a potential for several uses such as heating elements, furnace fixtures, heat-exchanger piping, sintered porous gas-metal filters, automobile and other industrial valve components, catalytic converter substrates and components for molten salt applications [1].

The potential applications of iron aluminides were limited for a long time by their poor room temperature (RT) ductility resulting mainly from environmental hydrogen embrittlement. Although the influence of the environment and alloying elements on tensile properties of iron aluminides such as strength and ductility is widely reported, very little work has been published on the fracture toughness.

Two alloys with addition of carbon (Fe-40Al-1C at.%) and titanium (Fe-40Al-1Ti at.%) were prepared by vacuum induction melting and casting. The ingots were hot rolled to plates 12,5 mm thick at 1200°C and subsequently quenched into mineral oil. The Fe-40Al-1C alloy showed microstructure with coarse grains elongated in the direction of rolling. Grain boundaries were decorated by second phase particles. The Fe-40Al-1Ti alloy exhibited two times smaller grain size than Fe-40Al-1C alloy.

The fracture toughness tests were performed on a computer–controlled servohydraulic loading machine INOVA ZUZ 50 equipped with a resistance-heated furnace. The tests were performed at the constant crosshead speed of 0.25 mm/min according to the norm ASTM E 1820. Half inch Compact Tension (CT) specimens of thickness B=12.5 mm and width W=25 mm were machined in perpendicular to the rolling direction. The experiments were performed at 20, and 400°C. Since the material is coarse grained and it is very difficult to distinct the boundary between fatigue crack propagation and final static rupture (fracture morphology of final static failure is very similar to the morphology of fatigue fracture), the specimens were not precracked using cyclic loading but using electroerosion by a wire of diameter 0.3 mm. The crack length-specimen width ratio a/W was about 0.55. The crack growth during the fracture toughness test was monitored by temperature independent potential method using TECHLAB SRT-2K device controlled by Fatigue Crack Growth Monitor software. The methodology of fracture toughness testing of iron aluminides based intermetallic alloys has been developed in Ref. [2,3].

The fracture toughness K_Q has been measured from the load *vs.* load-line displacement. The values of fracture toughness are given in table 1. The fracture toughness of Fe-40Al-1C alloy increases from about 20 $MPa.m^{1/2}$ at RT to about 45 $MPa.m^{1/2}$ at 400°C. The Fe-40Al-1Ti alloy exhibited at both temperatures lower fracture toughness (decreased of about 40 % comparing with fracture toughness of Fe-40Al-1C alloy).

The specimen dimensions did not allow to fulfill the plane strain conditions during the tests. However, previous studies [2,3] have shown RT the specimen thickness has only very low effect on the fracture toughness values.

Table 1 Values of fracture toughness K_Q measured at 20, 200, 400, and 600°C

Alloy	*T* (°C)	K_Q (MPam$^{-1/2}$)	K_{Ic} (MPam$^{-1/2}$)
Fe40Al1C	20	20	-
	20	21	-
	400	44	-
	400	45	-
Fe40Al1Ti	20	14	14
	20	13	13
	400	34	-
	400	34	-

The fractographic analysis showed that the fracture surfaces of specimens from Fe-40Al-1C alloy fractured at 20, and 400°C exhibit transgranular cleavage facets, while on the fracture surfaces of specimens from Fe-40Al-1Ti alloy fractured at 20, and 400°C the intergranular decohesion predominates.

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Aramid-Fiber Reinforced Cement Composite Loaded by High Temperatures

E. Vejmelková*, P. Konvalinka, R. Černý***

petr.konvalinka@fsv.cvut.cz

* Czech Technical University in Prague, Faculty of Civil Engineering, Department of Materials Engineering and Chemistry, Thákurova 7, 166 29 Praha 6, Czech Republic
** Czech Technical University in Prague, Faculty of Civil Engineering, Experimental Centre, Thákurova 7, 166 29 Praha 6, Czech Republic

In this paper, water sorptivity A, apparent moisture diffusivity κ [1], open porosity ψ, bulk density ρ, matrix density ρ_{mat} [2], water vapor diffusion permeability δ, water vapor diffusion coefficient D and water vapor diffusion resistance factor μ [3] of aramid fiber reinforced cement composites produced by vacuum technology using the OMNI MIXER 10 EV mixing device were studied as functions of thermal load, the elevated loading temperatures being 600 ºC, 800 ºC and 1000 ºC .

The samples of the aramid fiber reinforced cement composite were produced in the laboratories of VUSTAH Brno. The composition of the material is shown in Table 1. Water in the amount corresponding to the w/c ratio of 0.9 was added to the mixture.

Table 1 The composition of the studied cement composite material in mass-%

Component	Quantity
Cement CEM I 52.5	36.0
Silicate aggregates	17.0
Microsilica	4.0
Wollastonite	39.0
Aramid fiber 1.5 mm	2.0
Aramid fiber 6 mm	2.0

Samples for measurements were prepared using vacuum technology of the OMNI MIXER 10 EV mixing device. First, cement, silicate aggregates, microsilica and wollastonite were homogenized in the mixing device, then water, plasticizer and shorter aramid fibers were added and the wet mixture mixed again. Then, the longer aramid fibers were added and the mixture shortly mixed again. The liquid mixture was cast into the forms and de-aerated during one hour. Finally, the prepared mixture was autoclaved in order to achieve better high-temperature resistance of the matrix. After the time period of 28 days after mixing, the samples were dried and prepared for testing.

Table 2 Basic properties of aramid fiber reinforced cement composite

Material	ρ	ρ_{mat}	ψ
	[kg m^{-3}]	[kg m^{-3}]	[%]
T-ref	1405	2414	41.8
T-600	1309	2802	53.3
T-800	1366	2814	51.3
T-1000	1387	2797	50.4

Table 3 Water vapor transport parameters of aramid fiber reinforced cement composite

Material	5/25-30%			97/25-30%		
	δ	D	μ	δ	D	μ
	[s]	[m^2s^{-1}]	[-]	[s]	[m^2s^{-1}]	[-]
T-ref	6.59E-13	9.06E-08	179.78	7.53E-12	1.03E-06	23.59
T-600	4.94E-12	6.79E-07	33.89	1.45E-11	2.00E-06	11.53
T-800	8.65E-12	1.19E-06	19.34	2.12E-11	2.91E-06	7.90
T-1000	8.36E-12	1.15E-06	20.02	3.84E-11	5.27E-06	4.36

Table 4 Water transport parameters of aramid fiber reinforced cement composite

Material	A [kg $m^{-2}s^{-1/2}$]	κ [$m^2 s^{-1}$]
T-ref	0.032	5.82E-09
T-600	0.110	4.27E-08
T-800	0.298	3.42E-07
T-1000	0.505	8.07E-07

Tables 2-4 show that the effect of elevated temperatures up to 1000 °C on the analyzed properties of the investigated aramid fiber reinforced cement composite varied for different parameters. In the most significant way it appeared for the liquid water transport parameters where the differences in moisture diffusivity between the reference specimens and specimens pre-heated to 1000 °C were as high as two orders of magnitude. The water vapor diffusion resistance factor decreased four to seven times after 1000 °C pre-heating which was also a convincing indicator of extensive structural damage of the porous structure.

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Effect of Alternative Silicate Binders on Hygric and Thermal Properties of High-Performance Concrete

E. Vejmelková, R. Černý

eva.vejmelkova@fsv.cvut.cz

Czech Technical University in Prague, Fakulty of Civil Engineering, Department of Materials Engineering and Chemistry, Thákurova 7, 166 29 Praha 6, Czech Republic

Nowadays, concrete belongs to the most extensively used materials in construction industry. Requirements on increasing load or on reduction of the construction thickness become highly actual. Main durability properties, namely moisture and heat transport and storage parameters, of high performance concrete belong to the most critical parameters in designing and using complex reliability based models for service life prediction of concrete structures. Alternative silicate binders such as metakaolin, fly ash and ground granulated blast furnace slag have a high potential to replace a part of Portland cement in concrete due to the generally recognized necessity to decrease the amount of carbon dioxide in atmosphere. Fly ash and ground granulated blast furnace slag are waste materials. Metakaolin is produced by thermal decomposition of kaolin without production of CO_2.

In this paper, mechanical and durability properties of high performance concrete containing three selected alternative silicate binders, namely metakaolin (BM), ground granulated blast furnace slag (BS), and fly ash (BP), are studied. Compressive and bending strengths are measured using common methods. Moisture diffusivity is determined by a method utilizing the results of water sorptivity measurement [1], water vapor diffusion permeability is measured by the cup method [2]. The experimental results indicate that the chosen composition of the three studied concrete mixtures and one mixture in reference state (BR) can ensure both sufficiently high compressive strength and reasonable resistance against water transport which makes good prerequisites for the achievement of high durability.

Table 1 Basic properties of the studied concrete mixtures

Material	Bulk density [kg m^{-3}]	Matrix density [kg m^{-3}]	Open porosity [%]
BM	2366	2691	13.0
BS	2334	2602	9.7
BP	2356	2717	12.5
BR	2380	2715	12.3

Table 2 Mechanical properties of the studied concrete mixtures

Material	Compressive strength [MPa]	Bending strength [MPa]
BM	86.95	11.925
BS	85.30	11.095
BP	80.52	10.64
BR	87.31	11.63

Table 3 Water vapor transport properties of the studied concrete mixtures

Material	97/25-30%			5/25-30%		
	Water vapor permeability [s]	Water vapor diffusion coefficient [m^2s^{-1}]	Water vapor diffusion resistance factor [–]	Water vapor permeability [s]	Water vapor diffusion coefficient [m^2s^{-1}]	Water vapor diffusion resistance factor [–]
BM	8.01E-12	1.10E-06	20.99	5.16E-12	7.09E-07	32.44
BS	1.90E-11	2.61E-06	8.99	9.52E-12	1.31E-06	17.70
BP	9.76E-12	1.34E-06	17.18	3.81E-12	5.23E-07	44.63
BR	2.64E-11	3.63E-06	6.60	1.09E-11	1.50E-06	15.80

Table 4 Water transport properties of the studied concrete mixtures

Material	Water absorption coefficient [kg $m^{-2}s^{-1/2}$]	Apparent moisture diffusivity [m^2s^{-1}]
BM	0.0070	4.09E-09
BS	0.0057	3.77E-09
BP	0.0105	6.49E-09
BR	0.0099	7.15E-09

The results of the experimental work presented in the paper indicated that metakaolin, ground granulated blast furnace slag and fly ash were materials having good perspectives as partial cement replacement in future use. The compressive strength of HPCs with either metakaolin, fly ash or ground granulated blast furnace slag in the amount of only 10 % of the mass of cement in the mixture was after 28 days higher than 80 MPa which with the CEM I 42.5 type of cement was a very good result. The water transport properties of three studied concretes were found to meet reasonably the basic requirements necessary to achieve such a durability which is expected for HPC.

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Comparison of Properties of Lime-Metakaolin Plasters Prepared Using Lime of Different Producers

E. Vejmelková, R. Pernicová, R. Černý

eva.vejmelkova@fsv.cvut.cz

Czech Technical University in Prague, Faculty of Civil Engineering, Department of Materials Engineering and Chemistry, Thákurova 7, 166 29 Praha 6, Czech Republic

From the point of view of a historian, it is not acceptable to use lime-cement plasters in Romanesque, Gothic, Renaissance and Baroque buildings. The requirements of conservators who take care of historical monuments are that the materials for repair or innovation of plasters must have the most similar composition as the historical materials and they have to be applicable by the original methods [1]. This concerns especially the number and the structure of coated layers, the way of plaster surface treatment by striking, indentation or making it smooth. So, the demand for the substitution materials in the restoration and renewal of historical buildings appeared due to the necessity to imitate the appearance and the quality of the original materials. The methods for the application of these materials followed at first from empirical experience, which had the tradition of thousands of years. However, often an unsuitable material and an uncorrect application was proposed, as a result of the fact, that some processes taking place during the formation of solid structure were not known exactly.

For an assessment of the hygrothermal performance of renewed plasters in reconstructed historical buildings, it is necessary to determine their basic thermal and hygric properties. In this paper, apparent moisture diffusivity and water vapor diffusion coefficient of several lime-metakaolin plasters are measured.

The composition of lime-metakaolin plasters is shown in Table 1. They differ in the lime used for their preparation, which is chosen in such a way that all major lime producers in Czech Republic are present, and are denoted as S1 - S7. Metakaolin MEFISTO produced by České lupkové závody Inc., Nové Strašecí, was used as the pozzolanic admixture.

Table 1 The composition of lime-metakaolin plasters

Material	Lime [kg]	Natural quartz and basalt sand with continuous granulometry 0 to 4 mm [kg]	Metakaolin [kg]	w/b [-]
S1 - Mokrá	2.08	7.5	0.48	0.278
S2 - Štramberk	2.08	7.5	0.48	0.258
S3 - Vitošov	2.08	7.5	0.48	0.263
S4 - Čertovy schody	2.08	7.5	0.48	0.223
S5 - Mokrá	2.08	7.5	-	0.266
S6 - VAPO - 3,33 kg	6.66			0.413
S7- Schwenk TKP - hrubá - 10 kg				0.216

Table 2 Basic properties of studied lime-metakaolin plasters

Material	ρ	ρ_{mat}	ψ
	[kg m^{-3}]	[kg m^{-3}]	[%]
S1	1637	2478	33.9
S2	1716	2669	35.7
S3	1756	2582	35.4
S4	1767	2638	33.2
S5	1745	2663	34.5
S6	1296	2603	50.2
S7	1384	2609	47.3

Table 3 Water transport parameters of studied lime-metakaolin plasters

Material	A	κ
	[kg $m^{-2}s^{-1/2}$]	[m^2 s^{-1}]
S1	0.1610	1.85E-07
S2	0.1588	2.02E-07
S3	0.1391	1.97E-07
S4	0.1510	2.02E-07
S5	0.1919	4.20E-07
S6	0.3248	5.95E-07
S7	0.0728	2.41E-08

The experimental results presented in this paper have shown that the addition of metakaolin in the amount of about 25 % of mass of lime led to an about 20-35% decrease of water and water vapor transport parameters compared to the lime plaster which is a relatively small difference. The type of lime as for the different producers was not found to be a significant factor affecting the hydric transport parameters. The differences were only within the error range of the measuring methods. These are both positive findings because the newly designed plasters preserved the open character of the original lime plaster and all the tested types of limes representing major producers in Czech Republic were found suitable for application in lime-metakaolin plasters.

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Thermal Stability of Modern Structural Steels

M.Svobodová, J. Douda*, J. Kudrman*

M.Svobodova@sh.cvut.cz

Department of Materials, Faculty of Nuclear Sciences and Physical Engineering,
Czech Technical University, Trojanova 13, 120 00 Prague 2, Czech Republic
* UJP PRAHA a.s., Nad Kaminkou 1345, 156 10 Prague - Zbraslav, Czech Republic

A tendency to improve operating parameters of power and chemical plants and the efficiency leads to a building of plants with supercritical steam parameters, i.e., an operation at the temperature of a medium about 600 °C and the pressure of 30 MPa. Recently, in term of these parameters, in common use steels, e.g., ČSN 15 313 and 15 128 kind of steels use for more than 40 years, have no sufficient properties. Otherwise, the progress in low-alloyed modified steels improved of 2,5Cr1Mo kind of steels, as well as corrosion resisting (9 to 12)% Cr steels, presents a possible solution to achieve required materials properties. The modified steels, in addition alloyed by tungsten and vanadium, are commercial produced with a mark T23 and T24. In the present study, these new steels have the excellent heat resistance behaviour and there is a strong tendency to use them in practice.

The main point of our research is focused on a verification of steel properties, especially in term of long-term degradation. Therefore, an experimental programme of a long-term annealing (air atmosphere) in laboratory of T23 and N10 steels, simulating a thermal loading in operation, was designed.

T23 steel represents a modern modification of structural CrMoV steel ČSN 15 313. Due to the percentage of tungsten (1.6 wt.%), the T23 steel in comparison with ČSN 15 313 should have better creep characteristics and be useful at higher operating parameters. Therefore, the T23 could present a suitable material for, e.g., boiling pipeline or super heater components. Opposite to the T23 steel, the older German N10 steel (DIN 21CrVMoW12) has higher volume of a carbon. In the Czech Republic, it is known as ČSN 15 420. Our studied steel was taken from an exposed pipe (450 °C/ over 170 000 h). The initial state was achieved with a recovery heat treatment, i.e., normalizing annealing and tempering on air: 1 100 °C/2 h/air + 720 °C/4 h/air. The metallographic analysis and the long-term exposition programme designed to assessment of the influence on mechanical properties, including the tensile test, impact value, hardness and creep with constant and cycling loading, and the microstructure of both materials were carried out.

The T23 steel after the initial heat treatment has a tempered bainitic microstructure. As result of long-term temperature effect, it is expected a grain growth, a coarsening of already separated carbides, and a nucleation followed with a growth of new carbide particles. The separation of fine carbides from the solid solution is the dominant structure process. Microstructure of N10 steel after the recovery heat treatment is created by a tempered bainite with a large number of separated globular carbides on the grain boundaries of origin austenite and on the lamella boundaries. The long-term operation induces a microstructure with a number of disperse carbides in ferritic matrix.

The value of hardness of the T23 steel has decreased from 184HV10 (steel after the initial treatment) to a value of 150HV10 after the annealing 650 °C/10 000 h/air. In addition, the long-term exposition at the temperature 650 °C has caused a significant decrease in strength characteristics, especially after 10 000 h the values have fallen down to a two-thirds of the initial level. However, this strength decrease is not followed with an appropriate increase in the plasticity. Considering tests of impact value, the elevated temperatures of tests had no remarkable effect on a transition temperature, but they have induced a raise in impact

values. And eventually, the creep test with constant loading carried out on specimens of the steel after the initial heat treatment at five levels of test temperature and after the annealing 650 °C/10 000 h/air at two levels of test temperature has brought unfavourable results. Opposite to the steel in the initial state, the time to fracture of the steel after the annealing has dramatically shortened; the value of fracture elongation and the minimal creep rate (about 2-4 order) has increased. Besides, the creep lifetime has differed about 2 orders. By contrast, the creep test with cycling loading has proved any effect of the cycling neither on the creep resistance nor lifetime.

The hardness behaviour of the N10 steel during the degradation process is decreasing, too (from 240HV10 to 210HV10). According to the strength characteristics, the long-term operation at elevated temperature has caused a significant hardening of the steel. Corresponding, the high temperature of tensile test has increased in a value of the yield strength closed to a tensile strength. On the other hand, the strength ratio Rp02/Rm has stayed independent of the long-term annealing. Furthermore, the higher values of strength of the steel after the annealing have induced a decrease in the toughness as well as contraction. Similarly to the T23 steel, the annealing at the temperature 650 °C has deteriorated strength properties of the N10 steel followed by hardening with a negative influence on the plastic behaviour. Thus, the steel has got numb. Opposite to the T23 steel, the results of the impact value tests have shown a remarkable difference between the both states of the N10 steel. Comparing the steel after the recovery heat treatment, the impact value of the steel after long-term exposition has dropped down to a half level and the transition temperature has raised about 100 °C. Eventually, the creep tests of the N10 steel after the recovery heat treatment as well as after the long-term exposition carried out on two levels of temperature have resulted in the higher creep resistance of the steel after the exposition probable caused by a precipitation of very fine carbide particles.

Obtained results of the microstructure and mechanical testing have shown a very high level of the heat resistance of the T23 steel after an annealing treatment. Nevertheless, the long-term effect of the high temperature rapidly decreases in this resistance. A possible reason could be a precipitation of the secondary carbide particles and their gradual coarsening. In opposite, the N10 steel after long-term operation has a significantly higher level of the heat resistance probably caused by a precipitation of very fine carbides. However, similarly to the T23 steel, the annealing at the temperature 650 °C deteriorates strength properties of the N10 steel followed by hardening that has a negative influence on the plastic behaviour.

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Quantitative Fractographic Analysis of Impact Fracture Surfaces of Steel R73

Hynek Lauschmann, Linda Mrázková

lausch@kmat.fjfi.cvut.cz

Czech Technical University, Faculty of Nuclear Sciences and Physical Engineering, Department of Materials. Trojanova 13, Praha 2, 120 00, Czech Republic

Textural fractography as a part of quantitative fractography investigates fracture surfaces as image texture. Many types of textural elements can be replaced by simple binary objects which are representative for the given type of fracture. In this research, macroscopic images of fracture surfaces got from Charpy test were analyzed. Bright spots were chosen as typical textural elements of these fracture images. Statistical characteristics of counts and areas of them will be discussed.

Within the scope of research thesis [1], the Charpy impact tests of 20 Charpy V-notch (CVN) specimens were performed. Experimental material was low-alloy steel R73. Microstructure of R73 steel is mixture of ferrite-pearlite. Yield strength $R_{p0,2}$ = 394 MPa, ultimate tensile strength R_m =732 MPa and elongation A_5 = 22,8 %.

Impact energy was measured on instrumented impact pendulum device Roell Amsler RKP 450. The nominal energy of the machine was 300 J, angle of the fall 150° and striking velocity at point of impression 5,23 ms^{-1}. Temperatures of the specimen ranged -70 ºC and 230 ºC. Measured values of notch toughness (impact energy divided by the area of specimen cross section under V-notch) cover the interval from 6 Jcm^{-2} to 75 Jcm^{-2}. Transition temperature determined as the inflection point of transition curve is 44ºC.

From the point of view of application, the upper bound of transition area is especially important. It is located at about 90˚C. From this temperature higher the material possesses its full notch toughness of about 70 Jcm^{-2}.

Fracture surfaces of all specimens contain transgranular cleavage facets. Their number decreases, and simultaneously the area of ductile fracture increases with increasing impact energy [1].

Macroscopic images of the fracture surfaces were provided by means of digital camera. All images were done under the same light conditions. The images were cropped for demand of image analysis – only the fracture surfaces were analyzed.

Images of fracture surfaces contain bright spots reflecting especially cleavage facets [2], but also some of ductile dimples, both in certain ranges of orientation, so that they reflect light into the camera lens. The area ratio of bright spots decreases with increasing temperature of specimen. Consequently, analysis was focused on these bright spots which can be considered as textural elements. Segmentation (selection of bright elements) was accomplished by binarization by means of the same threshold value for all images. Binary images is data source for further statistical analysis.

Two basic quantities of bright spots were measured: their number and their areas. Various statistical characteristics of these quantities were estimated. Strong dependence on notch toughness as well as temperature has the area ratio of bright spots (total area of bright spots / area of image). These relations were fitted with a parametric function generalized at the basis of hyperbolic tangent. Matlab function fminsearch was used to estimate regression parameters by means of minimization of variation.

The area ratio of bright spots does not follow the transition curve in the whole range. The width of transition area is smaller - lowering starts at about 30˚C. On the contrary, indicating full toughness at about 90˚C shows a tight agreement with the transition curve.

Other characteristics with even better resolution of this limit are average and standard deviation of bright spot areas.

Values of the mean and standard deviation of bright spots area are divided into two groups, representing fracture surfaces with and without cleavage facets, respectively (in other words, in the second case bright spots reflect only ductile dimples in a certain range of orientations). Within individual groups there are only small differences, while each group has significantly different average value. Limiting point determines the temperature of full toughness, 90˚C, with high resolution.

Simple binary representations of textural elements in fractographs may offer valuable quantitative characteristics of fracture surface. Among other cases, also fatigue striations [3], plastic dimples [1,4], mezoscopic ridges in fatigue crack surfaces, and other fractographic features were analyzed and described by means of stochastic geometry and spatial statistics.

From the stochastic geometry, especially point processes and their characteristics may be used to describe the distribution of a given fractographic feature in the image of fracture surface. The best results in characterizing line structures were reached with the joined distribution of lengths and orientations of line segments. In particular case of arc segments, the joined distribution of arc radii and central angles may be used.

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High Temperature Mechanical Properties of Ni-based Superalloy IN792-5A

T. Skiba *, B. Podhorná **

skiba@fjfi.cvut.cz

* Department of Materials, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Trojanova 13, 12000 Prague 2, Czech Republic

** UJP PRAHA Inc., Nad Kamínkou 1345, 15610 Praha – Zbraslav, Czech Republic

Ni-based superalloy Inconel IN792-5A is an alloy strengthened by intermetallic phase γ' Ni_3(Al,Ti) used for hot parts in gas turbines by PBS Velká Bíteš. The alloy is characterized by very high strength at room as well as at elevated temperatures and sufficient high temperature creep resistance. In spite of the fact, that there are several heat treatment procedures recommended [1], a great effort has been spent to prove that these heat treatments have nearly no effect on the microstructure of material which is designed to work at very high temperatures up to 900°C [2]. The idea of omitting heat treatment is based on the fact that the working temperature (900°C) in gas turbines is approximately the same as the temperatures used during heat treatments.

The first set of specimens was in the as-cast condition (without heat treatment), the second set of specimens was subjected to a three-stage heat treatment 1120°C/4h/air + 1080°C/4h/air + 845°C/24h/air. The specimens in both sets were then divided into five separate subgroups which were then exposed to the temperature 900°C for 0, 1000, 2000, 5000 and 10000 hours. Mechanical properties were measured using 30 kg load Vickers hardness test performed at room temperature, and tensile test and Charpy impact test, carried out in the temperature range 20 to 1000°C. The Charpy impact U-notch specimens had dimensions 10mm × 10mm × 70mm, tensile specimens were 5mm in diameter and 25mm in gauge length. Structure of all specimens, etched in oxalic acid, was examined by scanning electron microscope (SEM). The acquired micrographs were processed by LUCIA G software. The quantitative stereologic analysis computations were based on Saltykov's method adapted by Kudrman.

As expected, HT material showed increase in hardness before exposure to operating temperature 900°C. However, after LTE in order of hundreds of hours, the differences in HV30 between as-cast and HT specimens became negligible. After 5000 hours, when the structure can be considered as homogenous, the values of hardness of as-cast and HT materials were practically the same. The results of notch impact strength tests performed at temperatures up to 1000°C showed that only as-cast specimens without HT exhibit a distinct increase in toughness with increasing testing temperature. On the other hand, the as-cast material after LTE of 10000 hours shows relatively uniform values in the whole testing temperatures range. However, due to LTE, the values of KCU were roughly one third lower than those in the as-cast condition. At room testing temperature, the HT material has approximately the same value of notch impact strength as as-cast + 10000h LTE condition. With increasing testing temperature, the KCU values were situated between the curves of as-cast and as-cast + 10000h LTE condition. The 10000h LTE has practically no effect on KCU values of HT material in the whole range of testing temperatures. The yield stress and ultimate tensile strength of as-cast and HT specimens showed only small differences in the whole testing temperature range. During LTE the strength characteristics of both materials decrease, but this decrease is lower for HT specimens [4].

The heat treatment provided globularization and size homogenization of γ' particles and strong casting cell boundaries were dissolved [3]. Subsequent application of LTE led to elimination of the differences between as-cast and HT materials. Globularization is probably finished in exposure considerably shorter than 1000 hours. After LTE 10000 hours, very similar microstructure of as-cast and HT material was observed.

The effect of heat treatment on morphology and distribution of carbides was not observed, because even the temperature of the first stage of heat treatment is lower than their melting point [4].

Two most important results based on quantitative stereologic analysis, change of the mean diameter and mean number of γ' particles in volume of $1\mu m^3$ with long-term exposure, show that in as-cast and HT material the particles were nearly of the same mean diameter. During annealing, particles in as-cast specimens were growing somewhat faster to reach after 10000 hours of LTE the same value as in HT material. From this point of view, it could be stated that there is no effect of heat treatment on particles size. But the standard deviations of data gained from as-cast specimens were nearly twice of that of HT material. This shows that the heat treatment considerably homogenized particle size. A smaller standard deviation in the HT material during LTE was probably caused by a uniform growth of large number of particles of similar diameters.

The mean numbers of γ' particles in volume of $1\mu m^3$ were approximately 50% higher in HT material then in as-cast material. The standard deviations, on the other hand, were nearly two times higher in HT material. Considering errors caused by intentionally neglected particles smaller than 0.1μm in diameter which are present in as-cast material but not in HT material, the curve of the as-cast state would have exceeded the one of heat treated material. With the application of LTE, mean numbers of particles are decreasing for both states of material but even for 10000 hours there is an inconsiderable difference between these samples. Higher standard deviation in numbers of γ' particles for heat treated specimens are illogical at first, because, as mentioned before, the heat treatment homogenizes the distribution of precipitated particles. But due to heat treatment, particles are globularized and easily detected by LUCIA G system even they are small or large. In as-cast alloy, particles are hard to detect (because of their shapes) and it is probable that system counts just with particles of mean diameters.

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Study of various parameters dependency estimated by Lanczos and bicubic interpolation of image fatigue crack surface to crack growth rate by means of multiparametric fractal analysis

Z. Sekerešová

sekeresova@fjfi.cvut.cz

Department of Materials, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Trojanova 13, Praha 2, 120 00

Fatigue crack surface can be seen as fractal surface. We study the morphology of this crack by many methods, [1]. The surface is described by fractal analysis.

Fractal objects by means of self-similar objects are isotropic upon rescaling, whereas rescaling of self-affine objects is direction-dependent. Fractal properties include scale independence, self-similarity, complexity, and so on. Fractal theory gives us methods for describing the inherent irregularity of natural objects. This process is characterized by a constant parameter D known as the fractal dimension. The fractal dimension can be viewed as an index of the scale-dependency of a pattern. The estimated fractal dimension of an object, tells us nothing about the actual size or overall shape, nor can we reproduce a map of the object from the D parameter itself. However, the fractal dimension does tell us a great deal about the relative complexity of the object.

Image of fatigue crack is not self-similar upon rescaling; therefore, we do not use the fractal dimension to describe morphology. We use all the data from the last step of the estimation of fractal dimension, as a feature vector.

At first: the image of a surface is interpolated by Lanczos resampling and by bicubic interpolation two or tree times to increase size of the image and to smooth the surface without losing the information saved in the image and to make image details better to recognize by fractal analysis.

Lanczos resampling is a multivariate interpolation method used to compute new values for any digitally sampled data [2]. The Lanczos filter is defined as a product of normalized sinc functions. The resulting function is used as a convolution kernel to resample the input field. The block uses 36 surrounding pixels to interpolate the pixel value.

Bicubic interpolation uses the information from an original pixel and sixteen of the surrounding pixels (4x4 array) to determine the value of new pixels that are created from the original pixel.

For estimating fractal feature, the box counting method was used, [3]. 2D interpolated image was interpreted as a brightness surface in the third dimension above the projection plane. This surface was covered by boxes of different size r, and the number N(r) of boxes necessary for covering was computed. To obtain a multiparametric characteristic, instead of computing fractal dimension we used all values N(ri) corresponding to a

selected set of ri, i=1,2,...,k, as a feature vector. Components of feature vector [N1, N2, ... Nk] contained valuable information on crack growth rate pertinent to the given location of crack surface.

Experiment: Specimen of the CT type from aluminum alloy AlCu4Mg1 was loaded by a repeating block of different loading cycles in air at the room temperature, [4]. Pairs [number of cycles N, crack length a] were recorded during the test. Crack length was measured by means of an optical microscope fixed to a NC table. Fatigue crack surfaces were documented using SEM with magnification 200x (the real field of view being about 0.6 x 0.45mm). The sequence of images was located in the middle of the crack surface; the images were distanced by 0.6 mm. Digital representation in 1200 x 1600 pixels and 256 brightness levels was used.

Analysis: 45 images were characterized by a multiparametric fractal feature vector estimated by the box counting method. Set of box sizes r = 20, 25,..., 200 pixels was used. The multilinear regression was used to express crack growth rate as a function of components of the feature vector, [3]. Features that do not contribute to the model were excluded by t-test.

We had 5 series of image characterized fractal surfaces. The first group of images had this parameters: bicubic interpolation, size of the final image 2400x 3200 pixels and 256 brightness levels; the second group: bicubic interpolation, size of the final image 3600x 4800 pixels and 256 brightness levels; the third group: Lanczos interpolation, size of the final image 2400x 3200 pixels and 256 brightness levels, the fourth group: Lanczos interpolation, size of the final image 3600x 4800 pixels and 256 brightness levels; and the final fifth group was without interpolation.

Comparison of estimated crack growth rates with input values leads us to a standard deviation and range of confidential belt, [2], the best value is shown on the Lanczos interpolation, then bicubic interpolation and at the end the non-interpolated images, but the difference is not so significant, in extent of 5 percent. It follows a little improve. It is necessary to consider if this improvement is adequate. The fractal characteristics, obtained from the SEM interpolated images, resulted into sensitive dependence on the crack growth rate expressed by multilinear model.

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Investigation of Coincidences between Material Structure and the Morphology of Fracture Surface

Hynek Lauschmann, Jan Siegl, Jan Kober

lausch@kmat.fjfi.cvut.cz

Czech Technical University, Faculty of Nuclear Sciences and Physical Engineering, Department of Materials. Trojanova 13, Praha 2, 120 00, Czech Republic

Austenitic and duplex steels URANUS [1], and low-alloyed Cr-Mo steel N10 [2] in form of CT specimens (dimensions 47.5 x 45.6 x 4 mm and a 19 mm deep V-shaped notch) were tested. Specimens A2 (Uranus SB8), C2 (Uranus 45N) and D2 (Uranus 52N$^+$) were made from a rolled plate so that crack plane was perpendicular to the rolling direction. Specimens KA1-I and LA1-I (material N10) were taken from a tube after long time of service in chemical industry. Specimen LA1-I was regenerated by annealing. The plane of crack propagation corresponds with the cross section of original tube.

Fatigue tests were performed under a constant cycle loading at electrohydraulic testing machine Inova ZUZ 50. Optical and potential measurement of crack length were applied simultaneously. Fracture surfaces were documented by SEM in magnification 300x. Following fractographic findings were obtained:

Specimen A2: Transgranular fatigue fracture contains facets which size corresponds with structural grains. Striations are distinguishable from fractographic crack length $a_f = 2{,}9$ mm. Final rupture is ductile with typical dimples.

Specimens C2 and D2: images of the transgranular fatigue fracture contain bright fibrous objects. Final rupture contains ductile dimples. In specimen C2, within the stage of apparent striations, sporadic objects denoted as "B-type facets" are present. Their micromorphology shows features of cleavage together with features of a ductile process and damage mechanism is unknown.

Specimens KA1-I and LA1-I: The character of fracture surface is predominantly transgranular with apparent striations. Locally ductile non-striation areas and cleavage fracture may be observed. Numerous sulfidic inclusions show their significant influence within the process of crack growth. After crack reached a selected length, specimens were broken by a static final rupture combining cleavage and ductile mechanisms.

After fatigue tests, parts with crack surface were cut off and prepared for metallographic analysis in a plane close to the fatigue fracture surface [3]. Grinding and polishing in standard way was finished with fine polishing by a diamond suspension with grain size 1μm. Specimens A2, C2 a D2 were etched electrolytically in 10% solution of oxalic acid. Specimens KA1 and LA1 were etched chemically by 5% Nital. SEM images in the same magnification 300x were used for metallographic analysis. Significant anisotropy of microstructures A2, C2 and D2 has origin in the technology of rolling.

The microstructure of specimen A2 is composed of austenitic grains with numerous twins.

The microstructure of specimens C2 and D2 is composed of austenitic grains in a ferrite matrix. Great austenitic grains often contain twins creating subgrains in the same orientation. In specimen C2, one to three extraordinary large austenitic grains are present in each image.

The microstructure of specimens KA1-I and LA1-I is bainitic with apparent boundaries of original austenitic grains. Dark prolonged objects are sulfidic inclusions.

The first task for image analysis was a comparison of microstructures of steels Uranus 45N (specimen C2) and Uranus 52N$^+$ (specimen D2). Their microstructures as well as fracture surfaces are visually very similar, while the fatigue crack growth rate is about 2 times greater in specimen C2. Microstructures (one image of each material) were binarized manually (ferrite: black, austenite: white) and analyzed by means of Matlab's Image Processing Toolbox.. The average number of austenitic grains in the area of 0.1 mm^2 is 92 in C2 and 79 in D2.

Following characteristics of austenitic grains were estimated: surface, perimeter, maximum length, maximum width (both with respect to the main directions of structural anisotropy), mean width and elongation (max. length / mean width). Distributions of all parameters are asymmetric with a positive skewness. Histograms of grain areas and perimeters in specimens C2 and D2 are almost the same. Variance of grain dimensions is greater in D2 than in C2. The peak of histogram is higher and located lower, while decreasing from the peak is steeper in C2 than in D2. The rare extra large grains in C2 make the distribution of grain width two-modal.

The second task was intended as starting step of development of a new branch within applications of image textural analysis in fractography [4] - comparison of image textures of quite different objects. The aim consisted in a comparison of material microstructures and the morphology of fatigue fractures of steels URANUS 45N and URANUS 52N$^+$. A visual impression emphasizes bright fibres in images of fracture surfaces, which are oriented predominantly in crack growth direction, identical with length direction of austenitic grains. Correspondence between bright fibres in fractures and austenitic grains was explored. Distance of objects, i.e. the stochastic periodicity in the direction of crack front has been investigated. The frequency of austenitic grains was compared with the spectral density function of images of fracture surface. In both materials, the dominant frequences of both features are very close. So the hypothesis on their mutual correspondence may be regarded to be acceptable.

A significant difference between both materials are B-type facets at fracture surface of specimen C2. They were binarized manually in 12 images. Their origin in ferrite matrix or in typical austenite grains was rejected due to their great width. Widths of extremely large austenitic grains were measured also in 12 images. Distribution functions of sets of widths (of large grains and B-type facets) are almost exactly the same, proving so the coherence of both features.

Results obtained show that a detailed quantitative analysis of coincidences between morphology of fracture surface and microstructure of material may offer a valuable output.

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Laboratory of Materials Texture Characterisation

M. Keppert, R. Černý

keppert@fsv.cvut.cz

Department of Materials Engineering and Chemistry, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6

Properties and behaviour of a building material are related to its texture, i.e. porosity, pore size distribution, specific surface area etc. Especially transport and storage parameters of water and ions in a material are significantly influenced by its pore size distribution. Also the deterioration of building materials due to the salt crystallization depends on the shape and size of the present pores. Consequently the texture of material determines, among other parameters, its lifetime. Thus the knowledge and control of the materials texture is an essential in the engineering of building materials.

A porous material consists of a solid matrix and certain amount of free space – pores and voids. Thus the porous materials exhibit a difference between bulk and matrix (real or apparent) density. This difference is given by its porosity [%]. The pores are classified according to their accessibility for fluids as closed and open. The open pores may be dead-end or interconnected. According to their size, pores are classified [1] as macropores (radius > 25 nm), mesopores (radius from 25 to 1 nm) and micropores (radius < 1 nm).

The texture properties of materials are studied at Department of Materials Engineering and Chemistry by three techniques which provide set of morphological information about both compact and particular matters. The employed techniques are helium pycnometry, nitrogen adsorption porosimetry and mercury intrusion porosimetry (MIP).

Helium pycnometry is a reliable method for determination of matrix density of solid porous materials. It is based on measurement of the real volume of the sample be means of helium which has very small atoms easily penetrating into the pores of the sample. The measurements are performed by Pycnomatic ATC equipment (Porotec, Germany).

The gas adsorption porosimetry is based on nitrogen or krypton physisorption on the whole (external and internal – inside the pores) surface of the studied sample. The gradual increase of the adsorbate relative pressure results into covering of the sample surface by a measurable amount of the adsorbed gas which provides the desired information about the surface area. The raw data are obtained in form of adsorption isotherm – dependence of the adsorbed amount upon the adsorbate relative pressure. The correct experimental methodology is described in [1]. The gas adsorption is widely used for determination of specific surface area of whole range of materials. In general it is applicable on all types of solids (from non-porous to microporous), but when nitrogen is used as adsorbate, the method is reliable when surface area is higher than about 5 $m^2 g^{-1}$. Several calculation methods of the surface area from the gas adsorption data were developed, the Brunauer, Emmett and Teller (BET) 2 or 3 parameters equation [2] is the common way how to determine the specific surface area. Besides the surface area calculation, the nitrogen adsorption may be used as tool for measurement of mesopore volume and their size distribution as function of radius. These data are determined on basis of the nitrogen condensation in the mesopores and its consequent evaporation. The pore size distribution is calculated by means of e.g. Barrett, Joyner and Hallenda method (BJH) [3]. The gas adsorption technique is usable also for characterization of microporous matters, e.g. nanomaterials. Their micropore size distribution might be calculated according to e.g. Horvath and Kawazoe method [4]. The nitrogen adsorption

measurements at our department are performed by Sorptomatic 1990 (Thermo Finnigan, Italy) equipment. The experimental data are processed by ADP (Advanced Data Processing) software (Porotec, Germany).

Mercury intrusion porosimetry is based on the gradual intrusion of mercury into pores of the studied sample. Since mercury does not wet most of the solid materials, it has to be pressurized in order to enter into the pores. As higher is the mercury pressure as smaller pores are penetrated by mercury. The experimental data are obtained in form of dependence of filled pore volume upon the applied pressure. This curve may be converted into pore size (volume or area) distribution histogram; the relation between mercury pressure and pore radius is given by Washburn equation. These experimental data further enable to determine the bulk and matrix density and specific surface area. The shape of volume/pressure curve indicates the dominant geometry of the present pores (cylindrical, conical etc.). The particle size distribution may be determined in case of a powder sample. The MIP in our laboratory is performed by Pascal 140 and Pascal 440 porosimeters (Thermo Electron, Italy). They serve for analysis of macroporous solids, the high pressure station Pascal 440 enables to intrude mercury to pores as small as 2 nm in radius, i.e. also mesoporous solids may be studied by MIP.

Instruments available in laboratory of Department of Materials Engineering and Chemistry, Faculty of Civil Engineering, enable to study texture properties of wide range of solid matters such are building materials, catalysts, natural raw materials or nanomaterials. The matrix density may be determined by helium pycnometry and mercury intrusion porosimetry. The porous materials are studied, with respect to the size of the present pores by nitrogen adsorption (micro and mesoporous solids) or mercury intrusion porosimetry (macro and mesoporous solids). The nitrogen and mercury porosimeters enable to determine the pore size distribution and specific surface area and volume of solid materials. Moreover the MIP can be used for particle size distribution of powders and for estimation of the pore shape.

The utilization of the above reviewed techniques is illustrated by help of analysis of a metakaolin “Mefisto” (České lupkové závody, a.s., Nové Strašecí), having increasing importance as a puzzolanic component in building materials.

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Durability of Concrete with Addition of Metakaolin

K. Kolář, D. Jandeková *, P. Konvalinka, J. Kolář **

karel.kolar@fsv.cvut.cz

Experimental Center, Faculty of Civil Engineering, Czech Technical University,
Thákurova 7, 166 29 Prague 6, Czech Republic
*Department of Mechanics, Faculty of Civil Engineering, Czech Technical University,
Thákurova 7, 166 29 Prague 6, Czech Republic
**Department of Experimental and Measurement Methods, Klokner Institute,
Czech Technical University, Šolínova 7, 166 08 Prague 6, Czech Republic

Durability of Portland concrete is one of the most fundamental parameters which define the ability of material to resist series of freezing – thawing cycles by parallel effect of chemical defrosting resistance. Generally, it is believed that the material is compact without microcraks and opened pores. However, this does not reflect the reality. By adding metakaolin which granulometry is properly designed, it is possible to achieve improvement of compactness of material and decreasing of volume of pores in it. This article deals with experimental determination of surface waste amount for two different types of concrete, which depends on number of freezing–thawing cycles in saline solution.

Metakaolin produced by company KERAMOST a.s. was used for the experimental research. The bond CEM I 42,5 R was during the experiment partly replaced by metakaolin. Influence on reological properties of fresh new concrete and progress of fundamental mechanical parameters (compression strength, static modulus of elasticity) were observed as well as namely resistance of concrete towards effect of chemical defrosting agents in conformity with the standard ČSN 73 1326. This all was conducted on two variations. Variation B1 – reference concrete without metakaolin and variation B2 – concrete, in which metakaolin replaced by 10% of concrete weight, and with superplastificator in the amount of 2% by mass of fine mixture ingredients.

Table 1: Formulas of concrete mixtures

		B1 - reference concrete	B2 - concrete with metakaolin
Concrete ingredients		Amount in the batch [kg/m^3]	Amount in the batch [kg/m^3]
Cement CEM I 42,5 R		440	400
Metakaolin		-	40
Aggregates	sand 0-4 mm	795	795
	granulated gravel 4-8 mm	315	315
	granulated gravel 8-16 mm	670	670
carboxylether-based plastifikator (Stachement 2090)		4,4	8,8
Water H_2O		177	160

The concrete mixture labeled B1 – reference concrete – showed medium soft consistency with cone subsidence S3. For concrete mixture B2 – concrete with metakaolin – was measured spilling consistency in agreement with the standard ČSN EN 206-1. In time 15 and 30 minutes from water addition was spilling consistency 540 mm, in time 60 minutes was spilling consistency 490 mm and in time 90 minutes from water addition was spilling consistency 460 mm.

Further the compression strength was measured from mechanical parameters (in

accordance to ČSN EN 12390-3). The testing specimens were in the shape of cube with dimensions of 150×150×150 mm. The static modulus of elasticity was calculated (according to ČSN ISO 6784) on specimens in the shape of a beam with dimensions of 100×100×400 mm, cured for 28 days in water.

Table 2: Average values of mechanical parameters

Formula	Bulk density [kg/m³]	Compression strength [MPa]	Modulus of elasticity [MPa]
B1 - reference concrete	2 388	63,7	38 500
B2 - concrete with metakaolin	2 428	90,0	43 970

Measurement of the resistance to chemical defrosting agents on concrete was made in accordance to the ČSN 73 1326. Cylindrical specimens with diameter of 150 mm and height of 500 mm were prepared. One loading cycle means watering the surface of testing specimen with saline solution of concentration of 3% NaCl at temperature -18° C for 3 hours and then at +5°C for further 3 hours. Material released from the surface of the concrete testing sample is captured and changes itself into saline solution. After drying the captured material the is quantified in g/m^2 as the waste. The resistance against CHDR, the surface absorption capacity in 15 minutes (in g/m^2), was measured as well.

Table 3: Average surface absorbing capacity and total waste

Formula		B1	B2
Bulk density [kg/m³]		2399	2412
Surface absorbing capacity after 15 minutes [g/m^2]		300,2	127,8
Total waste [g/m^2]	after 25 cycles	539,1	33,4
	after 50 cycles	928,3	83,4
	after 75 cycles	1428,6	155,6
	after 100 cycles	1906,6	266,8

Admixture of metakaolin-based microfilling agent results advantageously shows increase not only in mechanical parameters of Portland concrete, but also proved significantly higher resistance to chemical defrosting agents. If the reference concrete B1 has surface waste about 1000 g/m^2 already at 50 cycles, the concrete B2 with metakaolin has even after 100 of cycles surface waste 266,8 g/m^2, which is nearly four times lower than limit set by the standard.

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Transport of moisture in capillary-porous construction materials

O. Michalko, Z. Bažantová

michalko@fsv.cvut.cz, zdenka.bazantova@fsv.cvut.cz

Department of Materials Engineering and Chemistry, Faculty of Civil Engineering, Czech Technical University in Prague, Thákurova 7, 166 29 Prague 6

Constructional elements made of porous construction materials are very frequently used in housings built in the past and recently as well. Its role is to create the desired inner environment so it is as much as minimally dependent on the outside environmental conditions. It means, that their the most important role is to be excellent heat-insulation and in some cases also acoustic-insulation. Of course, due to the opened and connected pores, the diffusion of the air takes place and in that way water enters the pores. Water in pores deteriorates the heat resistance, increases the mass the building and allows, due to its ability to solve the harmful agents and makes possible the transport of exhalations from outdoors into the construction. It all deteriorates the inner environment of the building, makes possible the fungi growth and the presence of bacteria in the construction.

When studying the moisture transport in the capillary-porous materials we assume that materials are non-compressible. To the certain extent it is true for solid construction materials. In those materials there takes place the mass (moisture) transport, the linear transport and transport of the mobility. Let us pay attention to the linear mass transport only. There is a linear dependence of mass velocity on pressure gradient and the conductivity of material acts as constant. Such phenomena take place when the value of Reynolds numbers is:

$$R_e = \frac{v * d}{\nu} \leq 5 \div 10 \qquad (1)$$

where v is the mass velocity, d is the equivalent of pore diameter and υ is the cinematic viscosity of moisture.

Of course, there is balance of air pressure and moisture pressure. Air stream, which enters or leaves the material and stream of moisture also entering or leaving the material. When drying of material takes place the stream of moisture leaves material and the air stream enters it, in the case of moistening the air stream leaves material and moisture stream enters it.

When drying of material takes place, the moisture leaves the surface of wet material and the air fills the free space. The different situation takes place during moistening of material. In that case the air leaves the material through totally different points (openings) than the moisture enters it. The moisture in liquid phase is transported by the mean of capillary forces.

Mechanisms of moistening capillary-porous materials and mechanisms of water transport of water transport in materials are often shown with help of models. The simplest model is based on behaviour of cylindrical capillary of constant diameter. The capillaries are connected in parallel wax. For example, Krischer used the two dimensional model. German scientists often use such models. The disadvantage of such models is that there is no mutual interaction of pores included. Also the other than the cylindrical models were created. They are also one-two- or three- dimensional. The use of models is often problematic, as they are complicated and they do not include all phenomena and all processes, often they lead wrong way.

For the study of moisture transport in capillary-porous materials, there is also possible to use the theory of mixture. In this theory, liquid moisture and gaseous moisture is understood as one phase. Then one-phase transport takes place.

One- phase transport of moisture in two- phase system is described by the Darcy´s law. It assumes that the liquid of the Newtonian type does flow through the saturated environment. The resistance against the flow is linearly proportional to the velocity

$$\vec{v} = \vec{k}\nabla(p + \phi) \qquad (2)$$

where $\vec{v}$ is vector of the velocity identical to the area density of volume stream, $\vec{k}$ is tensor of permeability, p is pressure and Φ is the potential of outside force fields.
In isotropous materials, the tensor of permeability is of zero order and may be expressed

$$k = \frac{B}{\eta} \qquad (3)$$

where B is the permeability and η in the viscosity of moisture.
The known relation of Carmann and Kozeny for permeability says

$$B = \frac{\pi}{k^x(1-\pi^2)S_v} \qquad (4)$$

where π is porosity, S_v is the area of inner surface of volume unit and k^x is given experimentally.
Then equation (2) is as

$$\vec{v} = \frac{B}{\eta}\nabla(p + \Phi) \qquad (5)$$

Two-phase flow of 1iquid and gas take place in porous material in non-saturated systems. In this case there act simultaneously many types of forces of unknown origin. The solution of two-phase flow has not been found yet.

The practical calculations of moisture transport are mostly based on vapour diffusion calculation. Usually, the diffusion resistance of building construction made of the one of two elements is calculated. With help of the resistance value the balance equations of water vapour diffusion and water condensation in the construction are norm-settled (balance equations are derived from phenomenological theories). Only recently, the attempts to describe transport phenomena in complete way and include into transport media not only water vapour but also liquid water has appeared. The phenomenological procedure has been used and is probably for long period the only possible.

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Influence of Cr and Zr on the structure and mechanical properties of Al-Mn sheets

M. Karlík*, M. Slámová, A. Kubošová*,**, T. Mánik*,C. Grellier*****

Miroslav.Karlik@fjfi.cvut.cz

*Department of Materials, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, Trojanova 13, 120 00 Prague 2, Czech Republic

**Research Institute for Metals, Panenské Břežany 50, 250 70 Odolena Voda

**Université de Technologie de Troyes, 12 rue Marie Curie, 10010 Troyes, France

To suppress the impact of global warming and the lack of fossil energy sources, it is important to reduce the emission of greenhouse gases (CO_2) and the fuel consumption. This is a challenge also in the car industry. One of the ways of reducing fuel consumption is the weight reduction of the car. All its components should be lighter and, if possible, cheaper and more efficient. For more than 50 years now, aluminum is used to solve this problem [1].

Heat exchangers are one of the indispensable car components. Nowadays, the heat exchangers are most frequently composed of aluminum alloy tubes and fins. To reduce the weight of radiators it is necessary to reduce the thickness of the fins and tubes, which are the principal parts of the heat exchanger. However, the reduction of thickness requires a significant improvement of properties of the alloy. The problem comes from the conditions of the joining process of tubes and fins. In many cases brazing at 600°C is applied for joining that usually results in a significant fin softening. In order to prevent the sagging of the exchanger due to the deformation of fins, materials exhibiting sufficiently high yield stress after brazing are applied. Aluminium-manganese alloys are the most frequent choice as materials used for fins in heat exchangers. One of the ways to improve the yield stress of these alloys, even when they are subjected to high temperature annealing, is to add small amounts of other elements (Cr, Zr) in order to refine and stabilize the grain size [2,3,4].

Fin stocks for heat exchangers are frequently manufactured by twin roll casting (TRC). In this laboratory experiment, ingot casting was used. However, since ingot size was very small, the casting conditions were similar to these of TRC. 6 kg ingots of an alloy with Mn content at the upper limit of the standard EN AW-3003 alloy, i.e. 1,5 wt. % were cast and sectioned into 3 pieces of about 2 kg in weight. The pieces were melted again with additions (Cr, Zr) and cast into metallic moulds of size 10 ×120 × 200 mm. The composition of the alloys is in Tab. 1. After pouring of the melt, the mould was cooled by compressed air. Ingot surface layers were scalped by milling and plates of thickness of about 9 mm were prepared. The procedure used thus simulated closely TRC with similar starting thickness for subsequent downstream processing. Sheets of 2 mm thickness were cold rolled from the ingots.

The aim of the experiments was to investigate the mechanical properties and structure of the sheets after 30 min isochronal annealing in the temperature range from 200 to 550°C. The microstructure was observed by light microscopy after etching by HF to reveal second phase particles and by the Barker's reagent to visualize the grains. Line and point analysis by

means of energy dispersive X-ray spectroscopy (EDX) was carried out in scanning electron microscope (SEM) to investigate the segregation of alloying elements.

Tab.1. Chemical composition of studied alloys [wt.%]

Alloy	Designation	Mn	Cr	Zr	Fe	Si	Al
Al-Mn	M	1.43	-	-	0.004	<0.0025	Balance
Al-Mn-Cr	C	1.41	0.07	-	0.004	<0.0025	Balance
Al-Mn-Zr	Z	1.43	-	0.10	0.008	<0.0025	Balance

The results of the present investigation can be summarized as follows.

(i) EDX analysis in SEM indicated that a significant Mn segregation has occurred in the dendrites of the as cast samples (9 mm). The two other alloying elements were distributed homogeneously.

(ii) In all three alloys, the density of second phase particles was higher close to the surface of the sheet than in the interior of the material. After 30 min annealing at 550°C, needle-like precipitates formed in all alloys. The needles were the longest in the Al-Mn-Zr alloy; this alloy also exhibited the highest density of globular precipitates.

(iii) The conductivity of all three alloys increases in the temperature range from 250 to 400°C. Above 400 °C, a decrease as compared to lower temperatures is observed in alloys Al-Mn and Al-Mn-Cr, while the conductivity of Al-Mn-Zr alloy continues to increase. The conductivity decrease is most probably connected with dissolution of Mn and Cr particles in the two former alloys. A TEM analysis is to be carried out to confirm this hypothesis.

(iv) Natural aging for 340h (2 weeks) after isochronal annealing does not affect the mechanical properties and conductivity of all three materials. It means that there is no solid solution decomposition and new particles forming and mechanical properties changes during 2 weeks following the annealing.

(v) For all alloys, the recrystallization has not started yet at 410°C, and at 500°C the whole volume was recrystallized. In the temperature range from 440 to 470°C, residues of the deformation structure were observed close to the surface of the sheets, due to higher density of second phase particles in this region.

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Mechanical Properties of Metastable Austenitic Stainless Steel AISI 301

P. Haušild[*], P. Pilvin[**]

Petr.Hausild@ fjfi.cvut.cz

[*] Department of Materials, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Trojanova 13, 120 00 Praha 2

[**] Laboratoire Génie Mécanique et Matériaux, Université de Bretagne Sud, Rue Saint Maudé, 56321 Lorient, France

Austenitic stainless steels have an excellent corrosion resistance, good mechanical properties and are widely used for cold forming (deep-drawing) at room temperature. Increasing need for conserving the strategic element such as nickel and chromium impel the steel-makers to lower the content of these elements in stainless steels. However, the low nickel content can lead during the forming process to the plastic deformation induced phase transformation of fcc γ austenite to hcp ε and bcc α' martensites. High internal stresses are generated due to an incompatible transformation strain accompanying the martensitic transformation. The residual stresses together with the internal stresses induced by martensitic transformation can lead after deep-drawing to the phenomenon of delayed cracking [1,2]. The good knowledge of kinetics of the martensitic transformation is therefore an essential constituent for a control of the forming process.

The material chosen for this study was austenitic steel corresponding to the AISI301. The low nickel and chromium content situates the steel at the limit of the austenite field in the phase diagram. The material was provided by the ARCELOR as cold rolled sheets of 0.68 mm thickness in the bright annealed state.

Table 1 Chemical composition of AISI301steel (in wt.%).

C	*Cr*	*Ni*	*Si*	*Mn*	*Mo*
Max 0.12	16-18	6,5-9	<1,5	<2	<0,8

The tensile tests were carried out on a INSPEKT 100kN testing machine at room temperature imposing various strain rates ranging from $\dot{\varepsilon}=5.10^{-5}$ s^{-1} to $\dot{\varepsilon}=5.10^{-2}$ s^{-1}. Temperature increase during tests was measured by a thermocouple.

The shape of stress-strain curves is strongly dependent on strain rate. With increasing strain rate yield stress increases, ultimate tensile strength decreases and elongation to fracture has a maximum at $\dot{\varepsilon}=5.10^{-3}$ s^{-1}. During the tests at higher strain rates ($\dot{\varepsilon}=5.10^{-3}$ s^{-1} and $\dot{\varepsilon}=5.10^{-2}$ s^{-1}), the heating of specimens occurred. In both cases of higher strain rates, the measured magnitude of temperature increase ΔT was about 50ºC, which is nearly the same value as obtained using the formula for adiabatic heating:

$$\Delta T = \frac{0.9}{\rho C_p}\int_V \sigma_{eq}\, d\varepsilon_{eq}^{pl} \tag{1}$$

where ρ is the density and C_p the thermal capacity of steel.

For the observing the changes in microstructure caused by martensitic transformation, four specimens were tensile pre-deformed to 5, 10, 15 and 20 % of (logarithmic) plastic deformation and compared with non-deformed state. Strain rate for pre-deformation was chosen $\dot{\varepsilon}=5.10^{-4}$ s^{-1} in order to avoid the heating of specimens. In non-deformed state, the microstructure is composed of equiaxed austenitic grains with typical annealing twins. After 5% of plastic deformation, several martensitic variants can be seen inside the austenitic grains. After 20 % of plastic deformation, the microstructure is mostly martensitic.

The volume fraction of martensite was estimated using EBSD analysis. In the non-deformed state, the microstructure is fully austenitic. After 5% of plastic deformation, to about 10% of α' (bcc) martensite was found. After 10% of plastic deformation, the volume fraction of martensite was about 40%. After 20% of plastic deformation, the volume fraction of martensite increased to about 60% and this value remained more or less stable.

Table 2 Results of tensile tests at room temperature for different applied strain rates.

Strain rate (s^{-1})	0.2% proof stress (MPa)	Ultimate tensile strength (MPa)	Elongation (%)
5.10^{-5}	270	912	20
5.10^{-4}	288	905	24
5.10^{-3}	308	895	34
5.10^{-2}	324	866	31

Fracture surfaces of tensile specimens tested at the strain rates $\dot{\varepsilon}=5.10^{-5}$ s^{-1} and $\dot{\varepsilon}=5.10^{-4}$ s^{-1}, were oriented in perpendicular to the loading axis whereas the fracture surfaces of tensile specimens tested at the strain rates $\dot{\varepsilon}=5.10^{-3}$ s^{-1} and $\dot{\varepsilon}=5.10^{-2}$ s^{-1}, were inclined of about 45º.

Fractographic analysis of specimens broken at the strain rate $\dot{\varepsilon}=5.10^{-5}$ s^{-1} and 5.10^{-4} s^{-1} revealed several transgranular cleavage facets connected by ductile dimpled rupture. Several slip bands can be found on cleavage facets which indicate that the cleavage facets were formed before the final ductile fracture. On the other hand, the fracture surfaces of tensile specimens tested at the strain rates $\dot{\varepsilon}=5.10^{-3}$ s^{-1} and $\dot{\varepsilon}=5.10^{-2}$ s^{-1}, are completely covered by ductile dimples.

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Experimental and Numerical Comparison of Shear Capacity of Two Pre-stressed T-Beams from Smeared Reinforcement and Stirrup Reinforced Concrete

R. Sovják*, P. Konvalinka*, J. Litoš*, J.L. Vítek**

radoslav.sovjak@fsv.cvut.cz

*Experimental Center, Faculty of Civil Engineering, Czech Technical University in Prague, Thákurova 7, 166 29, Praha 6, Czech Republic

**Department of Concrete and Masonry Structures, Czech Technical University in Prague, Thákurova 7, 166 29, Praha 6, Czech Republic

Introduction

Main advantage of using smeared reinforcement is very high performance in the field of micro-cracks initialization. This point results in high strength of the smeared reinforced concrete. When using plain concrete micro cracks are present wherever concrete is use in larger volumes. These micro cracks result in a local weakening that result further on into a visible cracks eventually to the failure. Smeared reinforcement can prevent initialization of these critical cracks by the increase of the cohesion of the young cement pasta.

Aim of the Experiment

The goal of the experiment is to compare and to investigate a behavior of two different types of pre-stressed T beams – from smeared reinforcement and stirrup reinforced concrete in the age of 140 days. Both samples are stressed

Description of the sample

Shape of both beams is the same. T beam is 3,5 m long, span is 3,2 m. High of the beam is 0,36m. Upper flange is 0,3m width and 0,05 m tick. The web is 0,31 m high and 0,08 m tick. Pre-stressed cable is placed 0,05m from the lower fibers of the web. T beam is additionally pre-stressed on circa 1400 MPa.

Assemblage of Experiment

T beam is loaded in a four-point bending test in the way of shear failure. Forces are acting close to the supports. Distance between acting forces is 2,134 m. Loading were carried out additionally in the steps of 30 kN, 15 kN and 9 kN according to the displacement and crack opening. Displacement was recorded at the beginning of the interval, when certain force is reached. Afterwards another value of displacement was recorded after 60-second interval when the force is kept constant. Displacement was recorded with a three sensors placed under both acting forces and in the middle of the beam.

One crack only with a shear character right under the acting force was developed in the case of smeared-reinforced concrete. These crack leaded further on to the failure of the entire element. On the other hand smaller cracks with bending character equally distributed along lower flange of the beam could be observed in the case of stirrups reinforced beam. Failure was reached right after the destruction of the pre-stressing cable than fire off the concrete element.

Associated Experiments

In order to established a real material characteristic an associated experiments are carried out. These tests are done for both plain and fibre reinforced concrete. Concrte cubes were tested in compression. The dimensions of the cubes were 150x150 mm for both plain and fibre reinforced concrete. Significatly higher value of strength were naturally gained on the cube reinforced with a fibers. Moreover the density of both materials remain almost the same.

	Plain Concrete	Fibre Reinforced Concrete
Strength [MPa]	89,10	103,61
Density [kg/m3]	2432	2464

Numerical Model

Numerical model is carried out in order to establish a sophisticated instrument for prediction of behavior of concrete elements with smeared reinforcement. Model is made in ATENA 3D. Macro elements are meshed with 4 nodes tetra elements with a length of 0,1 m. Standard Newton-Raphson Method is used for computer analysis. Dimensions, material properties, loading characteristic are set exactly according to the experiment. Concrete characteristics of plain concrete are generated automatically via default formulas according to the cubic strength of the concrete. These formulas are taken from the CEB-FIP Model Code 90 and another research sources.

It is said that sufficient similarity was reach in between numerical and experimental model. Therefore a sophisticated instrument for prediction of behavior of these special concrete structures was established.

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Experimental and Numerical Analysis of Concrete Beam with Pre-Stressed GFRP Reinforcement

R. Sovják*, P. Konvalinka*, J. Litoš*, J.L. Vítek**

radoslav.sovjak@fsv.cvut.cz

*Experimental Center, Faculty of Civil Engineering, Czech Technical University in Prague, Thákurova 7, 166 29, Praha 6, Czech Republic

**Metrostav a.s., Koželužská 2246, 180 00, Praha 8, Czech Republic

Introduction

Nowadays a considerable attention is paid on new materials with better characteristics and longer lifetime as well. Regarding reinforced concrete, one of the most important thing that come to one's mind is reinforcement itself. Corrosion, electric and thermal conductibility can decrease the material characteristic of the metallic reinforcement and therefore the lifetime of the structure as well. Nevertheless a non-metallic reinforcement offers an excellent behavior in terms of corrosion-proof ability, thermal and electric non-conductivity and other excellent characteristic. Moreover a very good strength of FRP bar can approach the experiment to very interesting results.

Aim of the Experiment

This paper is focused on the pre-stressed GFRP (Glass Fibre Reinforced Polymers) reinforcement that is placed in the concrete element. Goal of the experiment is examination of the behavior of the beam with pre-stressed GFRP reinforcement in the age of 28 days. Basic material characteristic of GFRP reinforcement can be seen in the table bellow.

	Steel Reinforcement	GFRP Reinforcement
Tensile Strength [MPa]	490	650
Modulus of Elasticity [GPa]	210	32

Description of the sample

Dimensions of the concrete beam are mostly given by the laboratory requirements. Cross section is rectangular 0,6 x 0,2 m. Total length of the beam is 4,5 m, span itself is 4 m. Beams are pre-stressed with four GFRP bars with diameter 14mm. Maximal strength of the GFRP bars is 650 MPa, module of Elasticity is 32 000 MPa. Pre-stressed GFRP bars are anchored by cohesion. Four GFRP bars are strained by the force 32 kN in each bar that correspond to the stress of 215 MPa. Concrete class is C30/37 XF, Dmax 22mm.

Assemblage of Experiment

Concrete element is tested in four point bending experiment driven by force. Acting forces are placed 1,4 m from each other. Short-time experiment contains 10 cycles when acting force goes up to the value 25 kN. After 10 cycles displacement is stabilized at the peak of the loading diagram at 28 mm, after unloading, the residual displacement after ten cycles is 12 mm. After that, the concrete beam is loaded up to the failure. Ultimate loading force reaches the value slightly above 50 kN. Maximum displacement is circa 100 mm.

Associated Experiments

To ensure what the real material characteristics are associated experiments of the concrete are carried out. These test deals mainly with a strength of the concrete. These values should correspond to the given concrete class C30/37.

Cylinder Strength [MPa]	29,64
Cubic Strength [MPa]	39,35
Tensile-Bending Strength [MPa]	5,62
Density [kg/m3]	2391

Numerical Model

Numerical model is carried out in order to establish a sophisticated instrument for prediction of behavior of concrete elements with GFRP bars. Model is made in ATENA 3D. Macro elements are meshed with 4 nodes tetra elements with a length of 0,07 m. Standard Newton-Raphson Method is used for computer analysis. Dimensions, material properties and loading characteristic are set exactly according to the experiment. Detail concrete characteristic are generated automatically according to the cubic strength evaluated in the associated experiment. Working diagram of the GFRP reinforcement is set linear according to the experimental evaluated data.

Numerically gained data were sufficiently close to the experimental ones. Therefore it is reported that we have gained a sophisticated instrument for behavior prediction of concrete element with GFRP reinforcement.

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Detection of Gaseous Ammonia Using Evanescent Optical Sensor

J. Aubrecht, L. Kalvoda

aubrechtj1@km1.fjfi.cvut.cz

Department of Solid State Engineering, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, Trojanova 13, 12000 Prague 2, Czech Republic

At present, rapid detection and exact localization of ammonia gas leaks is an important part of security systems at all industrial facilities utilizing ammonia gas as a cooling set. Inhalation of a low concentration of ammonia gas causes serious health problems for human and ecosystems. The lowest limit for human ammonia perception is about 50 ppm but the long-term acceptable concentration is defined as low as 25 ppm.

Our research deals with preparation and development of optical distributed ammonia sensor based on optical fibers, aimed at location of ammonia leaks. The custom-made multimode optical fibers, the organo-metallic complex dyes and the absorption spectroscopy method within VIS-NIR range were used to basic experiments [3]. The optical time domain reflectometry (OTDR) method was then applied for testing longer fibers for localization of ammonia exposition. The suitable reagents for further sensitization of fibers were tested. Particularly in our case, organic ligands 5-(4-dimethylaminophenylimino)-quinolin-8-1, (7-chloro-5(4-diethylamino-2-methylphenylimino)-quinolin-8-1 [2] and Cu^{2+} and Co^{2+} complexes on the basis of prior absorption experiments were chosen.

The detection principle is based on ligand exchange process, accompanied by changes of optical absorption spectrum within the VIS-NIR range and chemical reaction between gaseous ammonia and a reagent - an organo-metallic complex dye within the polymer fibre cladding. Organo-metallic complexes are created from organic ligands after addition of metallic salts. The chemical reaction can be summarized as

$$2L + Me^{2+} + A^{2-} \Rightarrow \{L - Me - L\}^{2+} + A^{2-} \quad (1)$$

Here, L is an organic chromatic ligand, Me is a bivalent metal ion forming complex ion with the L, A is a suitable anion. Ammonia, as a stronger electron donor than the organic ligand, substitutes latter in the metallic complex, giving rise to a new $[(NH_3)_n Me^+]^{2+}$ complex ion. The decomposition of the original chromatic complex then leads to the absorption changes used for the detection. Diffusion of water into polymer cladding can modify the degree of dissociation and contributing to dependence of the sensor signal to the ambient humidity.

OTDR technique relies on interrogation of an attached optical fiber by short monochromatic laser pulse and followed by temporal analysis of the light intensity returning back to the OTDR detector from the known distance along the fiber. The OTDR setup used in experiments consists of Photodyne 5500 XFA OTDR unit ($\lambda = 850$ nm, pulse duration = 20 ns, average pulse power = 30 μW, repeating frequency = 3.1 kHz), testing chamber with optical fiber and digital oscilloscope [1]. Two types of processes have to be considered as the dominant signal sources in the case of the absorption-driven sensing fiber. The first one is the Rayleigh scattering along the entire fiber length and the second one is the Fresnel reflection. Two main peaks corresponding to the Fresnel reflections are the basic features of

OTDR curves. The first reflection comes from the front end of fiber within the OTDR unit and the second main maximum corresponds to the reflection from the free end of the tested fiber. The recorded OTDR curves provide information about the optical properties of the tested fiber along entire its length. OTDR unit launched the pulses into the tested fiber, registered the intensity of the back-coming light using a Si-PIN diode, and logarithmically amplified the intensity of detected signal. The pulse width limited the spatial resolution along the fiber length to circa 4 m. OTDR curves showing complete time slope to digital oscilloscope can be recorded. The total length of fibers tested until recently was about 28 m; the part sensitized by the reagent and placed in the testing chamber did not exceed 8 m in length. The sensitization was performed by a mixture of ethanol and dichlormethan filled in the testing chamber and let to diffuse into the fiber cladding. Then, mixture of dry nitrogen and ammonia with various ammonia contents was used as the probing gas. All experiments were carried out at the room temperature. The obtained OTDR curves showed distinguishable changes of the light intensity back-scattered from sensitized region accompanied by considerable changes of the second Fresnel reflection intensity.

The aim of the reported research was to demonstrate the principal feasibility of the distributed ammonia gas detection system utilizing fiber optic arrangement. Following characteristics of the tested system have been found as the most important ones for the further progress of the research. (a) Changes of the Fresnel reflection coming from the free fiber end can be used as an integral figure of merit sensitive to the presence of an ammonia leak along the full fiber length. (b) The reagent incorporated into the polymer fiber cladding enhances the local fiber attenuation, but also contributes to the growth of the local back-scattered light intensity. (c) Main difficulty of the system is the full reversibility of the complex reformation, which is very complicated to achieve. (d) Selection of a suitable agent ensuring the sufficient solvation of the reagent molecules within the cladding matrix and type of the solvent(s) used for dissolution of the reagent and its soaking into the cladding have been identified as the most critical technological factors.

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New Instrumentation of the KSN-2 Neutron Diffractometer for Texture Research of Metals, Polymers and Rock Materials

S.Vratislav, M.Dlouhá, L.Kalvoda, M. Dráb
vratisla@troja.fjfi.cvut.cz

CTU, Faculty of Nuclear Sciences and Physical Engineering
Břehová 7, 115 19 Praha 1

The neutron has a unique combination of properties that make it indispensable for many problems in solid state physics and materials research. From the industrial point of view the research activities of the Laboratory of Neutron Diffraction (Faculty of Nuclear Sciences and Physical Engineering CTU Prague) are concentrated to the quantitative texture analysis based on the ODF (orientation distribution function). We have developed the experimental and data treatment procedures for this type research. The texture experiments were carried out on the neutron diffractometer KSN-2 using the TG-1 texture goniometr [1]. This diffraction device offers good intensity with wavelengths in the range 0.095 to 0.141 nm and the best resolution value of $\Delta d/d = 0.007$ was reached in the region $d \sim 1.0 \div 0.1$ nm (d is interplanar spacing).

Texture has large influences on mechanical, electrical and magnetic properties of polycrystalline materials. The texture change measurements during metallurgical processes, i. e. annealing or recrystallisation, give important information which can be used to characterize the technological procedures. Therefore, it is often of interest to be able to measure the texture fast and thereby obtain in-situ kinetic information. These requirements can be fulfilled by neutron diffraction method due to the absorption and scattering properties of thermal neutrons. The high penetration the mostly materials make it possible to obtain information from internal layers of the measured specimens and therefore this method belong among nondestructive way. [1, 2, 3].

Conventional instrument with the constant wavelength of the monochromatic beam at steady sources measures diagrams sequentially and multiple detectors are used to increase the data collection rate. The arrangement of a conventional powder diffractometer is optimized when the divergence collimators and the mosaic spread of the monochromator have a suitable choice with respect to the resolution and the luminosity. The evolution of these methods at the instruments connected with medium power reactors was concentrated to double focusing monochromators and PSD detection systems, when the speed of the data registration can be increased. The texture change measurements by the "in-situ" experiments can be then performed.

At present time the KSN-2 diffractometer was upgraded by means of the improvements as they follow below:

- The bent monochromator unit is placed on the rotation table ensuring the setting of the Bragg angle. The reflections are from planes <110 > zone of silicon. The monochromator take-off angles 2θ range are typically from 40º to 80º for (311) reflection. Switching between the (111), (311), (511) and (533) reflections only requires rotating the unit. The silicon strips are tilted so as to give by segmentation an effective curvature that ensures vertical focusing at the sample position for specified distances from source and to sample.

- The PSD system consists the bank of the three linear position tubes with 25.7 mm in the diameter and 670 mm in the active length. The detector can be placed either 1100 mm or 1600 mm from the specimen position to embrace either 30º or 20º of the diffraction pattern.
- New electronic modules perform the most important activities of motor control and neutron counting. The KSN-2 diffractometer is controlled by PCL 9812 computer and the different programs are available for experiment control, data inspection and simple data treatment.
- Methods of computational modelling have became one of the basic tools in processes of designing and simulating diverse artificial structures. The Materials Studio (MS) from Accelrys Inc. is very likely the first software tool incorporating all the approaches (diffraction structural and texture analysis, surface science etc.) [4].
- The quantitative texture analysis of neutronographic pole figures or inversion pole figures recorded is treated by means of these codes: popLA, TODF-N, MAUD and Rietveld analysis method (texture analysis version: GSAS package, FULLPROF).
- This the KSN-2 update improved the resolution to the $\Delta d/d = 0.002$ in the d-region from 1.4 to 0.075 nm, the neutron flux on sample is about 2.5 times higher, the sample volume is 4.5 times smaller and "in-situ" experiments are available.

Quantitative texture analysis by means neutron diffraction data (experiments were performed on the KSN-2) were used on the investigation of the many samples of the technically interesting materials. For example, we have determined the texture parameters on the oriented SI steel sheets [1], the zirconium alloys (tubes for nuclear reactors) [2], polymer materials (PVC foils) [3] and rock materials (CaCO3 test samples) [5].

On the basis of our results we have proved that the KSN-2 diffractometer together with the above mentioned software codes is very important and powerful tool for understanding the texture development with respect to the mechanical and the thermal processes. Simultaneously, these procedures are useful in the new interesting materials. We can conclude that improvements in electronics, data acquisition software and new doubly focusing devices have opened the door to widespread use of high resolution powder diffraction at small and medium flux facilities.

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Investigation of Microstructural Anisotropy of Limestone

L. Kalvoda, M. Dlouhá, A. Grishin, J. Marek, P. Sedlák, S. Vratislav, J. Hladil*

ladislav.kalvoda@fjfi.cvut.cz

Department of Solid State Engineering, Faculty of Nuclear Science and Physical Engineering, Czech Technical University in Prague, Trojanova 13, CZ-120 00 Prague 2, Czech Republic

*Institute of Geology, AS CR, v.v.i., Rozvojová 269, CZ-165 00 Prague 6 - Lysolaje, Czech Republic

The investigated limestone samples were collected near Choteč, Bohemia (Na Škrábku quarry, SE corner; 49°59'19.57" N, 14°16'44.16" E), from a single overturned/recumbent fold. Two selected sampling points (C1, C2) represent two different parts of this fold but belong to one level of one sedimentary bed (i.e. exactly the same sedimentary precursor). The sample C1 was collected from the lowermost of three limbs of this fold, but close to the hinge of the syncline in the lower part, with uninverted but 65 degrees rotated ideal (vertical) sedimentation direction (SD). In case of the sample C2 the latter was situated farther in the inverted middle limb between the syncline and anticline, with inverted SD (up side down), rotated 46 degrees from vertical. Dip of beds – C1, uninverted, 182/65; C2, inverted, 001/46. The distances between these two sampling points were 2 m and 1 m in the axial plane parallel and perpendicular directions, respectively. Specimen for the experiments were then cut and shaped according to needs of the individual method. From petrological point of view, the rock was formerly a particulate sediment in a considerably homogeneous, amalgamated calciturbidite layer which consisted of coarse-silt to fine-sand sized grains of medium regularity (i.e., roundness + sphericity / 2) values of ~0.5-0.6. The still discernible relict structures suggest that grains were small calcitic bioclasts, lithoclasts and crystalloclasts of various degrees of pre-sedimentary alteration and inherited fabrics. First, the pores of this sediment were filled by crystalline calcite cement. Several amalgamating and disassembling recrystallizations originated in early burial diagenetic conditions, being subsequently overprinted during the deformation-related and deep burial stages and bearing also little effects of immediately pre-exhumation and exhumation structural changes. According to regional data, the tectonic stacking and burial reached the maximum likely in Frasnian times (depths of several kilometers, not more), and the ambient temperatures culminated along the late Famennian burial-exhumation path (100-120 °C. Elemental composition of this calcite-dominated material was characterized by instrumental neutron activation analysis (INAA). The measurements were realized at the INP ASCR in Řež. Besides Ca (34.72 mass %), the following elements were found having the mass concentration higher then 0.1 mass %: Mg (4733), Fe (2253), K (1967) and Al (1185) [$mg \cdot kg^{-1}$]. In addition, traces of another 33 elements were identified having concentration higher then 1 $mg \cdot kg^{-1}$. Total organic carbon (TOC) concentrations are only ~0.15 mass %.

Neutron diffraction (ND) experiments were performed with aim to characterize the bulk crystalline structure and crystallographic preferential orientation (texture) of the selected samples [1]. Two types of specimens have been tested: Powders prepared by ball milling and oriented cubes (a = 20 mm). The later were cut to have the edges parallel to the three principal directions forming a Cartesian co-ordination system: the SD, the direction perpendicular to the contour lines of the fold (PD), and the contour direction (CD). Diffraction diagrams were collected on the neutron diffractometer KSN-2 located at the HK-2 horizontal channel of the research reactor LVR-15 at INR in Řež. The following instrumental settings were employed: Monochromatic parallel primary beam with λ = 0.1362 nm and

divergence $\alpha = 22'$, the BF3 detector scanning along the horizontal plane within the 2θ-range $4^o - 75^o$, the scattered rays filtered by Soller collimator ($\alpha = 22'$). The obtained diffraction patterns were evaluated using the Rietveld method implemented in software packages Material Studio (Accelrys) and MAUD. Crystallographic texture of the samples was quantified by orientation distribution function (ODF). Crystalline structure of calcite was refined within the space group R-3c. The following lattice parameters were obtained: a = 0.4915(4) nm, c = 1.6800(14) nm. The obtained ND patterns gave evidence about traces of additional crystalline phases; their identification is under progress. The texture of the samples could be characterized as follows: (i) the sample C1 posses a moderate texture (the calculated ODF sharpness f = 1.149) and the remarkable declination of crystalline c-poles from the SD (ODF maximum occurs within the β-range 50^o - 70^o; β is the polar angle). (ii) Texture of the sample C2 is more pronounced (f = 2.138), and the c-poles orientation is closer to the SD ($\beta \cong 0^o$ - 20^o).

X-ray diffraction (XRD) method provided additional information about the crystallographic texture. Specimen for XRD experiments were cut into shape of thin plates (17x17x3-4 mm). Four pole figures (PF) – (104), (110), (113) and (202) - were recorded for each sample (Siemens texture diffractometer, filtered CoKα radiation, Bragg-Brentano geometry). To remove possible artefacts caused by the cutting process, the samples were etched in dissolved acetic acid (5 %wt) to get 15 % mass reduction. Within the statistic precision of the measurements (ca. 4 %), the obtained PF did not show any well-resolved texture changes, confirming that the crystallographic texture of the calcite phase of the samples is generally very tame, in agreement with the ND results.

Very low positive values of mean magnetic susceptibility (χ) have been obtained (KLY-2 bridge measurement): $\chi = 3.04 \times 10^{-9}$ m^3 kg^{-1} (sample C1), $\chi = 7.64 \times 10^{-9}$ m^3 kg^{-1} (sample C2). It is apparent that the intrinsic diamagnetic contribution of calcite and an extrinsic paramagnetic/ferromagnetic contribution (considering the chemical composition, very likely dominated by iron compounds) are nearly balanced. The low level of magnetic susceptibility resulted in very noisy AMS results obtained on the same specimens that had been examined by ND. Only the direction of the pole to the magnetic foliation (φ, θ) could be identified: (210^o,89^o) and (230^o,46^o), C1 and C2, respectively. (φ = the angular displacement from the contour, θ = the deflection from the SD). For the supreme negative susceptibility value of a calcite single crystal is parallel to the crystallographic c-direction and supposing the positive contribution to the susceptibility remains the same for the both samples, the increasing alignment of c-poles along SD should lead to reduction of the corresponding magnetic susceptibility, the effect being really observed. Considering further the usual preferred orientation of ferromagnetic particles in sedimentary rocks, the observed direction of the magnetic foliation of the sample C1 (being nearly parallel to SD) suggests that the dominant positive contribution to the magnetic susceptibility is the para-, not the ferromagnetic one. The USR measurements were performed on cubic specimens (a = 4 mm). The obtained USR patterns exhibit sharp resonances approving good homogeneity of the material.

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Preparation and Characteristics of TiN Layers from Sputron Device

O.Kopáček, J.Cejp, J.Mířejovský

Kopaceko@seznam.cz

CTU, Faculty of Mechanical Engineering, Dept. of Materials Engineering

Karlovo nám. 13, 121035 Praha 2

Direction of this annotation was optimalization parameters in preparation of thin layers in Sputron device (producer Oerlikon Balzers AG) for purpose of coating hard alloyed axial tools for boring and cutting operations. Enquired layer TiN was generated of PVD method ("Physical Vapour Deposition") – vapour plating.

This work is a result of collaboration between CTU, Faculty of Mechanical Engineering, SOMA Engineering and SHM Šumperk. Preparation of layers was proceed in two stages. Preparation various stoichiometries of Ti_xN_{1-x} layer with a view to predict a suitable composition for following depositions with temperature and preload parameters. Tendency was preparation of substoichiometry layer with x = 0,44 – 0,28, which analyse good usable qualities. Direction of first stage was suitable selection of gas-flow, too. This gas is determinate of rate p_z+p_{N2} (basic vacuum pressure + nitrogen pressure). Reaching characteristic yellow-gold layer's colour was decided for determination of this rate. Just this yellow-gold colour is characteristic for inducted substoichometry. The second stage was preparation of layers with constant p_z+p_{N2} and parameters – substrate temperature T_S and pre-load on substrate U_S.

Layers was preparated, in relation to first stage, with partial pressure $p_z+p_{N2} = 3{,}7.10^{-5}$ Torr (5.10^{-3} Pa) and total pressure $p_{celk} = 7.10^{-5}$ Torr (9.10^{-3} Pa). Total deposition time – 3 hours. In the aggregate has been prepared three sets of specimens with following parametres: substrate temperature $T_S =$ 300 °C, pre-load on substrate U_S = 0, 50 and 100 V.

All specimens were measured layer's thickness, surface and peculiar resistance, univerzal and plastic hardness, modulus of elasticity, adhesion, cohesion and surface resistance. Adopted method for layer's thiskness measurement - "Kalotest". Resultant average value of layer's thiskness (2 um) were calculate from three particular measurements. From results of layer's thiskness and surface resistance were calculated peculiar electric resistance. In dependence on deposition time and total layer's thiskness were calculated deposition velocity. Microhardness were measured on Fischerscope HV 100 equipment with maximum load 30 mN application. Measuring of adhesion were proceed on REVETEST CSEM Instruments scratchtester. Maximum loading 80N, loading speed 10N/mm and loading time 50 seconds. Surface roughness were tested on responsive Taylor Hobson Talysurf device with 8nm resolution.

Results:

1) We are able to prepare hard surface layer with sufficient microhardness for defined conditions (Ts = 300 °C, Us = -100V a $p_z+p_{N2} = 3{,}7x10^{-5}$ Torr). For segregation of residual tension effect on hardness results is necessary to applicate higher loading (70 mN) with layer thickness at least 4 um. Preload on substrate influence fundamentally surface hardness.

2) All layers adhesion wasn't enough for application in cutting operations. It was due to deficiently surface activation before deposition. For increment of adhesion is nesessary to equip deposition device with voltage supply, for possibility to applicate high pre-load 500 – 1000 V on substrate for pre-deposition surface cleanup of Ar^+ "ion bombard".

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INFLUENCE OF HYDRATION ON THE XRD-OBTAINED CHARACTERISTICS OF ZIRCONIUM OXIDE LAYERS

G.Gosmanová, I.Kraus, M.Kolega*,V.Vrtílková**

galina.gosmanova@fjfi.cvut.cz

CTU, Faculty of Nuclear Sciences and Physical Engineering, Dept.of Solid State Engineering, Trojanova 13, 120 00 Prague 2, Czech Republic
*NTC, West Bohemian University, Univerzitní 8, 306 14 Pilzen, Czech Republic
**UJP Praha Inc., Nad Kamínkou 1345, 156 10 Prague – Zbraslav, Czech Republic

The aim of the present study was to find out the influence of hydration on the properties of oxide layers arising on zirconium alloys during high temperature oxidation in VVER water environment. The residual stresses σ, crystallite size D and micro strains ε were examined by means of XRD. It has been shown that the XRD characteristics of hydrated layers are different from those of dehydrated oxide.

Two types of samples were investigated. The so-called "dry" samples were dehydrated on air after corrosion expositions and "wet" samples were permanently kept in water after corrosion exposition. A hydrated layer is formed in the oxide of wet samples. It can be interpreted as a compact system of amorphous gel-like formations and crystalline oxide. Since the amorphous gel cannot be detected by X-rays, the obtained characteristics are related only to the crystalline part of the hydrated layer.

A D8 Discover powder diffractometer with CoKα radiation was used to measure diffraction patterns. In oxide layers of the samples investigated, the measurements were performed on {10-4} planes with $2\theta = 85.2°$ for CoKα radiation. The appropriate effective X-ray penetration depth $T_e^{(10\text{-}4)} = 3.68$ μm. The fitting procedure had to be used to obtain the accurate profile characteristics such as peak position 2θ and .integral breadth W_{int}. The X-ray diffraction method [1] was used to determine the macroscopic residual stresses σ in oxide layers. The method is based on determination of lattice strains ε^{hkl} from which, subsequently, the stresses were calculated by using appropriate macroscopic Young's moduli. The evaluation of the crystallite size and lattice strains was performed by using a „single-line" method with the Pearson VII approximation of the profiles´ shape [2].

The results of the experiment are given in tables 1 and 2.

Table 1
Specification of samples and XRD obtained characteristics σ, D, ε for oxide layers of Zr1Nb alloy. Rσ D-W is the difference between the values of stresses for dry and wet samples

Sample	Alloy	Condition	Exp.days	Tox, μm	σ, MPa	|Δσ|	Rσ D-W	D, nm	ε
1136348	Zr1Nb	dry	7	2,15	-661	110	144	41	0,0077
1136349	Zr1Nb	wet	7	2,15	-805	76		34	0,0075
1136350	Zr1Nb	dry	21	2,13	-895	53	57	18	0,0084
1136351	Zr1Nb	wet	21	2,13	-952	103		14	0,0079
1136198	Zr1Nb	dry	2000	32	138	97	49	23	0,0059
1136197	Zr1Nb	wet	2000	31	88	57		24	0,0061

Table 2
Specification of samples and XRD obtained characteristics σ, D, ε for oxide layers of Zry4-W alloy. Rσ D-W is the difference between the values of stresses for dry and wet samples.

Sample	Alloy	Condition	Exp.days	Tox, μm	σ, MPa	|Δσ|	Rσ D-W	D, nm	ε
3136348	Zry-4 W	dry	7	2,65	-596	100	75	44	0,0068
3136349	Zry-4 W	wet	7	2,65	-671	118		29	0,0065
3136350	Zry-4 W	dry	21	2,57	-989	58	59	19	0,0086
3136351	Zry-4 W	wet	21	2,57	-1048	62		17	0,0081
3136198	Zry-4 W	dry	2000	50	-70	54	54	21	0,0062
3136197	Zry-4 W	wet	2000	50	-124	90		23	0,0066

It follows from the data tabulated that:

- the values of macroscopic stresses σ in the crystalline part of hydrated layers decrease in comparison with those of dry samples. This effect is systematic even if the values R σ D-W often inhere within the error range.
- the values of crystallite size D in the crystalline part of hydrated layers decrease in comparison with those of dry samples. The effect is systematic except for the thick layers of oxide ($T_{ox} \geq 30$ μm).
- the former conclusion is valid for micro strains ε.

It should be noticed that the results obtained for thick layers of oxide can be affected by X-ray penetration when the thickness of hydrated layer is smaller than the effective penetration depth $T_e = 3.68$ μm (or more realistic $T_{0.05} = 10.04$ μm).

It can be concluded from the results of measurements that the characteristics of wet samples observed by means of XRD are affected by the aqueous environment for the alloys under investigation.

This study refers to recent research [3].

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Properties of Water Vapor Retarders for Interior Thermal Insulations

M. Jerman, R. Černý

milos.jerman@fsv.cvut.cz

Department of Materials Engineering and Chemistry, Faculty of Civil Engineering, Czech Technical University in Prague, Thákurova 7, 166 29 Praha 6, Czech Republic

This paper presents results of experimental investigation of fundamental, thermal and hygric properties of two different mortar mixtures which are supposed to serve as water vapor retarders in interior thermal insulation systems of building envelopes.

The studied mortars were developed by MAMUT-THERM s.r.o. The first of them was water proof mixture 4 SM-T-HSF with water/mortar ratio 0.21. The second one was hydraulic congealing mixture 5 SM-T DD1, with water/mortar ratio 0.16.

As fundamental physical material characteristics, bulk density [kgm^{-3}], open porosity [Vol.-%] and matrix density [kg m^{-3}] were determined. For determination of open porosity, gravimetric and vacuum saturation methods were used. Each sample was dried in a drier to remove majority of the physically bound water. After that the samples were placed into the desiccator with distilled water. During eight hours air was evacuated with vacuum pump from the desiccator. Because of a high value of closed porosity there was not possible to determine matrix density by gravimetric method. Therefore, helium pycnometer was used for determination of matrix density.

Table 1: Basic material properties of the water vapor retarders

Material	Bulk density	Open porosity	Matrix density
	[kg/m^3]	[Vol.-%]	[kg/m^3]
4 SM-T-HSF	1424	8.1	1692
5 SM-T-DD1	1445	9.1	1533

The cup method was employed in the measurements of the water vapor diffusion parameters [1]. The specimens were water- and vapor- proof insulated by silicon rubber on all lateral sides, put into the cup and sealed by silicon sealant. In the wet cup method the sealed cup containing water (the equilibrium relative humidity above the solution was 97 %) was placed in an air-conditioned room with 30 % relative humidity and weighed periodically. The measurements were done at 25 ± 1 °C in a period of two weeks. The steady state values of mass loss determined by linear regression for the last five readings were used for the determination of water vapor diffusion parameters. In the dry cup method the sealed cup containing dried silica gel (the equilibrium relative humidity above the desiccant was 5 %) was placed in an air-conditioned room with 30 % relative humidity.

Table 2 shows that the values of water vapor diffusion resistance factors are very high, approximately ten times higher than for lime-cement- or cement mortar [2]. High water vapor diffusion resistance factors can be useful for using the retarders in some specific constructions, for example in granite or sandstone walls.

Table 2: Water vapor diffusion resistance factors of retarders

Material	Water vapor diffusion resistance	
	5/30%	97/30%
	[-]	
4 SM-T-HSF	142	110
5 SM-T-DD1	126	102

Thermal conductivity was measured in laboratory conditions at average temperature 25 °C using the commercial device ISOMET 2104 (Applied Precision, Ltd.). ISOMET 2104 is a multifunctional instrument for measuring thermal conductivity, thermal diffusivity, and volumetric heat capacity. It is equipped with various types of optional probes, needle probes are for porous, fibrous or soft materials, and surface probes are suitable for hard materials. The measurement is based on analysis of the temperature response of the analyzed material to heat flow impulses. The heat flow is induced by electrical heating using a resistor heater having a direct thermal contact with the surface of the sample. The measurements in this paper were done for dried and water saturated samples only because of a small value of open porosity. The results are shown in Table 3.

Table 3: Thermal conductivity of water vapor retarders

	Thermal conductivity [W/mK]	
	Dried	Water saturated
4 SM-T-HSF	0.481	0.612
5 SM-T-DD1	0.733	0.839

Measurements of basic, hygric and thermal properties in this paper have shown that the studied mortars can potentially be used as water vapor retarders for specific interior thermal insulation systems. However, the final decision on the application of every particular retarder in every particular insulation system can only be done after a detailed computational analysis.

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Final Evaluation of Mechanical Tests of a Primary First Wall Panel Attachment System in Tokamak ITER

A. Materna, V. Oliva

Ales.Materna@fjfi.cvut.cz

Department of Materials, Faculty of Nuclear Sciences and Physical Engineering,
Czech Technical University, Trojanova 13, 120 00 Prague 2, Czech Republic

A project of development and building of the International Thermonuclear Experimental Reactor (ITER) is one of the big international research projects of today [1]. Its fulfillment should be an indication of future sources of cheap, clean and inexhaustible energy. The building of a big experimental tokamak should prove that the industrial extraction of the fusion energy is now already principally feasible from the science and technical point of view.

An important part of the reactor vessel is its inner blanket shield system, comprising of a big number of so-called Primary First Wall (PFW) modules. The modules will comprise of foundation massive shield blocks from austenitic stainless steel 316L to which PFW panels, which will be in immediate contact with plasma, will be fixed. The concept of attachment of these protection panels, which will be exposed to intense loads during off-normal plasma operations, to the shield blocks was the subject of many years of expert discussion on an international scale and was changed several times. A joint system accepted is based on key and key way type joint. Poloidal force F_p and radial moment M_r working upon the panel should be caught by two vertical key – key way systems, whereas the poloidal moment M_p, toroidal moment M_t and radial force F_r should be resisted mainly by special high-strength studs with Cu core which will ensure the necessary pressure of the keys in their ways. PFW panels represent a relatively complex system with complicated inner water cooling, sub-surface layer from heat-distributing copper alloy and protective surface layer of beryllium. The reactor must not deform during its long operation and must remain functional, which requests, after all, a long-term rigidity and strength of the panel to shield attachment system.

To verify the characteristics of the proposed attachment system, following steps have been performed:

- proposal of simplified mock-up of the PFW panel and shield block;
- manufacturing of these test objects from stainless steel 316L according to submitted material specification;
- preliminary computer simulations of behavior of the attachment system under prescribed loads;
- proposal of long-term thermal and mechanical tests of the joint (tests No. 1 on blind hole thread, No. 2 on poloidal moment M_p, No. 3 on radial moment M_r and No. 5 on poloidal force F_p) under submitted conditions [2] and results of preliminary simulations;
- execution of these tests;
- computer simulations of real tests;
- computer simulations of behavior of the stud joint under combined loads during Vertical Displacement Events (VDE) and Halo Currents (HC); interpretation of obtained experimental and theoretical results from the perspective of behavior of a real module during operation.

Three participants from the Czech Republic have been involved in performing of described mechanical test programme: Design of both the PFW panel and shield block mock-ups and all FEM computations were realized at the Department of Materials, FNSPE, CTU in Prague. The stainless steel test objects were manufactured by Vitkovice Steel, a.s. and all mechanical tests were performed in a dynamic laboratory of Skoda Research Ltd.

The major results can be summarized as follows [3]:

Experimental study of behaviour of the PFW panel stud joint has showed that the thermal cycling between operation and room temperature leads to the drop of the studs preload. Resulted stud preload after $30\,000$ cycles of thermal cycling was $F = 73$ kN for room temperature and $F = 63$ kN for the heated assembly. However, this preload relaxation is less than the preload decrease in second parts of fatigue tests where the preload of only 54 kN was prescribed.

Tensile strength (in kN) of the Spiralock thread in panel blind hole is higher than tensile force for the brittle fracture of the high-strength assembling stud (151 kN).

Formation of the gap already during the stud preloading process was observed below the panel lateral strips in two fatigue tests. The cyclic loading of the panel opens these gaps.

Both real and FEM experiments have shown that the panel to shield attachment system shows no loss of the assembling studs preload, no loss of a vertical contact between the panel and shield block in the key way and no macro plastic deformation of contact surfaces under prescribed mechanical cycling even with the preload of only 54 kN. A small vertical gap in the key way was observed only under cyclic poloidal moment with the stud preload decreased to the very low value of 45 kN. The stud bending stresses during mechanical cycling are very low.

Combination of the poloidal moment and radial force during VDE represents the most dangerous case under study. A comparison of FEM results with the experimental results of another performed fatigue tests predicts that VDE loads could lead to the loss of the contact between the panel and block in a key way. The real extent of this phenomenon can be found out only experimentally. The additional experimental test on VDE loads is recommended.

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Development and Application of Digital Image Correlation Methodology

Ivan Jandejsek

wega@bukanyr.cz

Department of Mechanics and Materials, Faculty of Transportation
Czech Technical University in Prague
Konviktská 20, 110 00, Prague 1, Czech Republic

AIM AND SCOPE

The presented work devotes to the methodology and related software development for Digital Image Correlation (DIC). DIC is used for experimental mechanics studies. It is the non-contact technique (Optical or X-Ray) that provides full-field and high resolution measurement of displacements and strains within an object subjected to loading. Outstanding advantages of DIC are the robustness, very low demands on specimen preparation and practically unlimited length scale range. The main requirements for the software are robust computation algorithms and graphical user interface for a wide spectrum of applications and especially for the characterization of various engineering materials.

METHODOLOGY

The technique utilizes a sequence of consecutive images that represents the progress of the object deformation. In this sequence DIC observes a movement of individual templates of some texture employing the correlation technique [1], [2]. The template is a cutout of the texture that contains a small but distinguishable part of the texture. In the case of optical measurements the texture is generated by the surface of an object with significant structure (natural or artificial). In the case of X-ray measurements the texture can be generated by the inner structure of the material. In our case the correlation algorithm is based on the direct definition of a correlation function. The region containing a shifted template in the after-image of the sequence is scanned by the template of the original image to get a matrix of correlation coefficients. A maximum value of this matrix gives the new position of the template and consequently the vector of displacement of the template. Sub-pixel accuracy is achieved by interpolating a neighborhood of this value by polynomial surface. Naturally, if it is desired to obtain the full-field displacements across the whole investigated plane, one has to define an entire regular grid of such templates. Subsequently, the strain or possibly stress fields can be evaluated. This procedure is done for the entire sequence so the time behavior of full-field displacements and strains is obtained.

RESULTS

The DIC analysis software implementing the above mentioned correlation algorithm with graphical user interface was developed. The software is written in MATLAB using its Image Processing Toolbox and Guide (the MATLAB Graphical User Interface development environment). Inputs consist of a sequence of images, DIC parameters such as grid size (size of the investigated area), grid density (number of templates) and the dimension of the scanning template. The choice of these parameters depends on the required results and data type. The solution also provides essential image adjustments such as dynamic range scaling or filtering which are necessary for correct and accuracy computation. These adjustments are applied mainly in view of texture enhancement and noise reduction. The results of displacements and strain fields in every recorded load case are presented in 2-D graphs. So far the software was employed in two real experiments. The first experiment was based on a radiographic measurement [3]. An Al-alloy flat specimen with pre-crack was loaded in tension by a portable loading device. The radiographic sequence of crack propagation was

obtained using a micro-focus X-Ray tube and X-Ray imager Medipix-2. The visible structure of copper distribution served as the necessary texture for correlation. The displacements and strain fields in the area of the crack tip were successfully evaluated. The second experiment was an optical measurement of cubic lime-mortar specimen in a compression test [4]. An image sequence was obtained by digital camera. Significant grainy structure of the surface served as the correlated texture in this case. The time behavior of full-field displacements and strains of an entire specimen face area during compression were evaluated. Results also proved that DIC has the ability to detect some measurement abnormalities and faults such as crack or material non-homogeneities. Moreover DIC reveals crack detections earlier than they are visible by naked eye in photographs. The modulus of elasticity in compression was evaluated as well.

INDUSTRIAL APPLICATION

The software is mainly intended for experimental and fracture mechanics. Thus it stands useful for evaluation of material properties, such as material strengths, modulus of elasticity or fracture parameters. It can be used in many cases where the standard methods using strain gages and/or extensometers are hardly realizable or do not provide enough data. In industry can be also used for evaluation and testing of product behavior. Both images X-Ray and optical can be used as data source.

FUTURE PLANS

In the future, other correlation algorithms will be implemented including their validation and comparison in accuracy and computation speed. The manual settings of the DIC parameters, which depend on data type, will become semi or fully automated.

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Moisture Content Study in Biological Agricultural Materials Using TDR Method

Z. Pavlík

pavlikz@fsv.cvut.cz

Department of Materials Engineering and Chemistry, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

Complete knowledge of physical properties of agricultural materials has a decisive importance for the realization of many technological processes, especially for monitoring their quality and health harmlessness during their production and storage. The quality assessment and guarantee of the safety of foodstuff belong to the main priorities in food industry. From the point of view of optimization of a technological procedure the temperature and moisture have the crucial importance. They present the most important parameters having clear relation to the character of physical, chemical and physiological processes in biological agricultural materials.

In this work, the problem of moisture content measurement in plant materials is closely described, and the applicability of TDR method for the moisture assessment in granular agricultural products is tested.

Measurement of moisture represents one of the most important operations in the harvest, storing and processing of agricultural production. The accuracy of this measurement critically depends on several groups of factors. These are, first of all, conditions of measuring, followed by inaccuracies introduced by measuring equipment and especially the errors introduced by investigated material. Physical properties of agricultural plant materials have varied effect on an accuracy of moisture measuring. These properties are in very complicated mutual relationship. Biological materials are macroscopically and microscopically considerably non-homogenous. They have non-homogenous chemical composition, their components are of varied density, they contain admixtures and pollutants. Moreover, many of them exert continuous biological activity. Their properties are dependent on many parameters, among whose are such as chemical composition and structure of material [1].

Since the electrical properties are utilized in many areas of human activities, there are also very often applied at moisture content measurements, and can be used for investigation of plant agricultural products. However, it should be pointed out that in dependence on the type of the applied electrical measuring method, the above given properties may effect resistance in electric moisture meters, resistivity, conductivity, specific conductivity, impedance, and relative permittivity [2].

Many applications of electrical moisture measurement methods for measurement of different types of plant and animal agricultural products can be found in literature. Among them, electrical resistivity measurements, conductivity measurements and capacity measurements, are the most often used methods, although these methods are critically dependent on measurement conditions, applied frequency and structure of the studied materials [3]. On this account, the new approach to the monitoring of moisture content of agricultural products is presented in this paper. The new approach is based on application of TDR methodology of moisture measurement and should bring substantial improvements in food industry, especially in agricultural products processing as well as in control of food quality.

The principle of TDR device consists in launching of electromagnetic pulse (waves) and the amplitude measurement of the reflections of waves together with the time intervals between launching the waves and detecting the reflections. Time/velocity of pulse propagation depends on the apparent relative permittivity of the porous material. Knowing the relative permittivity water content in a medium can be estimated [4].

In the experimental work in this paper, the cable tester LOM/RS/6/mps produced by Easy Test was used which is based on the TDR technology with $\sin^2$-like needle pulse having rise-time of about 200 ps [4]. The measurements were done on spring oat, wheat mixture Axis, barley mixture Expres, corn mixture and soybean Evans samples. The material samples were provided by Slovak University of Agriculture in Nitra, Faculty of Agricultural Engineering, Department of Physics. The dried samples were maintained in the conditions near to 0% of relative humidity and the relative permittivity of dry materials was measured. After that, the measurement of relative permittivity changes in dependence on moisture content was performed. The samples were stored first in refrigerator at 4°C for ten days in plastic weighing bottles to distribute humidity homogeneously. Then, they were conditioned to 25°C for about six hours, moved to the measuring cylinder and measured using the two-rode miniprobe. The measured values of relative permittivity were assigned to the moisture content that was assessed by gravimetric method. The drying temperatures were as the same as was given above.

From the results there was clear that the value of relative permittivity in the dry state was for the all studied materials more or less similar and close to 1. On the other hand, the dependence of relative permittivity on moisture content was completely different for all tested cases. In the range of moisture content up to 20%, the dependence of relative permittivity on moisture changes was negligible whereas in higher moisture content the effect of moisture content was significant. The highest relative permittivity values were observed for wheat mixture Axis while the lowest effect of moisture content on relative permittivity was found for soybean Evans.

The results presented in this paper have proved the capability of TDR method for measurement of moisture content in granular agricultural materials. The applied measuring technique is applicable for the all studied materials except soybean Evans that has shown only slight dependence of relative permittivity on moisture content.

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The aim of the seminar is to present and discuss the latest results obtained by researchers especially at the Czech Technical University in Prague and at collaborating institutions.

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Section 6

MECHANICS
&
THERMODYNAMICS

Optimization of a diesel engine with the injection system Common Rail in relation to power, fuel consumption and emission

O. Gotfrýd

ondrej.gotfryd@fs.cvut.cz

Department of Automotive, Combustion Engine and Railway Engineering ,
Faculty of Mechanical Engineering, Czech Technical University,
Technická 2, 166 07 Prague 6, Czech Republic

The main goal of the project was to choose an optimization method for the optimization of diesel engine with injection system Common Rail. This method will be later used for online control and evaluation of experimental measurements. The data for method testing were obtained on the test bed at the CTU Prague.All possible variants and combinations of input parameters were measured in selected engine operating points. Different optimization methods were applied on these data with the target to find a method, which needs as few as possible steps to find the optimal combination (or the optimal combinations) with respect to low fuel consumption and minimal emission (above all CO, NO_x and soot).

The efficiency and time demands of the optimization depend mainly on the choice of optimization method, settings of this method, number of input parameters and conditions defining the optimum. Therefore the number of input parameters was tried to be minimized. The most important input parameters, which have main influence on emission and fuel consumption, are: injection pressure, beginning of the main injection and quantity of the pilot injection. Based on experience a lower and upper boundary and a step for each input parameter were determined in every selected operating point. The quantity of the main injection was chosen as necessary to keep the given torque. Output parameters and conditions for optimum finding are the next important factor for the optimization process. On one side there is an effort to optimize the engine with respect to lowest fuel consumption, on the other side there is demand to fulfill the emission limits that means low production of NO_x, CO, CO_2, HC and soot. These demands are often against each other. Therefore it is not enough to find the minimum of one component, but it is necessary to find a compromise between all components. Also the output parameters influence the duration of the optimization, therefore only the most important output parameters were chosen – fuel consumption, production of CO, NO_x and soot. It is very difficult to predict the behavior of individual components. It can be expected that the local minimum also appear during the optimization. For that reason the optimization algorithm should be enough robust to be able to find the global minimum of given component. The problems of emission production are described in [1].

The program modeFrontier (co. ESTECO) was used as a powerful optimizer. This software offers sufficient selection of optimization algorithms and it allows executing of external scripts and programs. Therefore it is suitable for later online control of the experiment. Besides it is also convenient for offline evaluation of big data amount. It can be used only multi objective algorithms (allow defining more output parameters) and discrete algorithms, because the output parameters are known during the offline testing only in the points, which had been measured. Based on these facts were chosen and tested following algorithms: MOSA (Multi Objective Simulated Annealing), MOGA-II (Multi Objective Genetic Algorithm), NSGA-II (Non Dominated Sorting Genetic Algorithm II), MACK

(Multivariate Adaptive Crossvalidating Kriging), MOGT (Multi Objective Game Theory), FMOGA-II (Fast Multi Objective Genetic Algorithm). These methods are described in [2] and [3].

An important step in the optimization process is the initial sampling and number of initial combinations, so called Design of Experiment. The best result was obtained with the sampling Sobol Sequence, which is mainly recommended for MOGA-II. The number of combinations (n) at initialization was computed according to [3]:

n = 2 x number of input parameters x number of output parameters

As it was already mentioned, in most cases it is not possible to determine only one optimal combination. Especially in the cases like e.g. engine calibration of passenger vehicle (must fulfill emission test according to NEDC - New European Driving Cycle) is very difficult to specify the limits for individual engine operating points, because the emission are evaluated after passing of the whole test. For this reasons is better to evaluate more combinations, which can be consider as optimal.

From the testing results that the genetic algorithms need to measure eventually calculate less combinations of input parameters to find combinations, which can be consider as optimal. The algorithms MOGA-II a NSGA-II reached the best results. In addition MOGA-II is easier to use. The most time during the optimization of an online controlled experiment takes the stabilization of measured variables after every change of input parameters. Expected stabilization time is 5 minutes. To measure e.g. 100 combinations (all combinations in one engine operating point) takes 8 hours and 20 minutes. This time increases many times with increasing of number of input parameters. This time can be markedly reduced using selected optimization algorithm (in best cases up to half). A next specification of the optimization method selection will follow within next research on online controlled experiments.

The second goal of this project was to adjust the test bed for application of the selected optimization method. The test bed is equipped with two computers. One PC is for acquisition of the measured data; second PC acquires data from ECU (Engine Control Unit) and allows changing of injection parameters (e.g. injection pressure, beginning of the main injection, quantity of the main injection, quantity of the pilot injection, etc.). Thus the test bed was equipped with an automatic control of data acquisition, automatic settings of input parameters, communication between computers to shared data and control of the dynamometer from the computer. For this purpose was used programming software LabView 7.1 and Visual Basic .NET. It was necessary to make a hardware upgrade on the computers – extending of the operating memory and hard disk for saving of larger data amount.

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Heat Balance of Internal Combustion Engine

V. Klír

Vojtech.Klir@fs.cvut.cz

Department of Automobiles, Internal Combustion Engines and Railway Vehicles, Faculty of Mechanical Engineering, Czech Technical University, Technická 4, Prague 6 166 07, Czech Republic

The purpose of internal combustion engines is a production of mechanical power from the chemical energy contained in the fuel. The solving engine heat transfer problems are obviously a major design task. Heat transfer affects engine performance, efficiency, and emissions [1], [2]. The main goal of this project is to extend knowledge about heat balance of internal combustion engine mainly by experimental work. The knowledge about heat balance of internal combustion engine could help us with improving the quality and quantity of experimental data. These data can be used as a calibration data for a comparison with the results from the mathematics models.

Before this project was started the system for measuring temperature (needed for heat balance measurement) as a part of the data acquisition system had been built. This system is nowadays commonly used in laboratories where internal combustion engines are tested. However measurement of the coolant flow is not so usual. These data are not used very often for next calculation. Simultaneously, there were known some basic algorithms for determination equivalent temperature difference between outlet and inlet engine coolant temperature. It is a very difficult task. The low final value of engine coolant temperature difference originated from the difference between two high values. It is possible to make only relative heat balance when the flow of engine coolant is not known. So firstly the appropriate flow meter was chosen.

Many methods can be used for measuring flow but there are some special conditions for the engine coolant flow measuring [3]. Firstly, demand on endurance of a measuring instrument against dirty water must be taken in to the account. This demand results from lay-out of the test bed in the laboratories. So the cooling water can be contaminated by rust parts. Secondly there is demand on thermo stability, because the temperature of the coolant is about 80 degrees of Celsius. On the basis these two demands paddle system for measuring the engine coolant flow was chosen. The operating principle is following. The flowing medium presses against a baffle plate that is fastened to a spring loaded fulcrum. The paddle movement causes displacement of the fulcrum. The position of a magnet attached to the fulcrum changes and is sensed by a Hall-effect sensor inside the meter head, isolated from the liquid. This signal is processed and evaluated by a microchip.

The measurements of engine coolant flow were made on turbocharged 4 cylinder diesel engine with bore 105 mm and stroke 120 mm. This engine was modified for using as a powertrain for a mine locomotive. So there were some differences in engine cooling system in comparison with its standard design. Flow meter was mounted (according to installation specifications) on output engine cooling pipe. This place was near to the mixing vessel. The mixing vessel is used instead of a cooler. With the help of the appropriated algorithm thermal conditions in the engine cooling system were regulated for all measurements. According to

other experimental work done about the test engine were done several measurements. As was mentioned at the beginning of this text the test bed was equipped with data acquisition system [4]. With help of this system all needed data were noted.

From these measurements all required courses of relevant temperatures and cooling water flow were obtained. These courses were processed with help of previously developed algorithms. It means that some filters were used for treatment of acquired data. In next step algorithm for determination the equivalent temperature difference between outlet and inlet cooling water temperature was used. Now it is possible to interconnect these heat balance data with other experimental data. These data can be used for evaluating the indicator diagrams by inverse algorithms.

This project has extended markedly quantity and quality of the experimental data. Simultaneously these experimental data can be used as a direct output in projects of author's work place. The second possibility is to use them for quantitative estimation (confrontation) with the results from the mathematics models.

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FE analysis of head injury during a traffic accident

Jiří Kunecký, Ondřej Jiroušek

xkunecky@fd.cvut.cz

Department of Mechanics and Materials, Faculty of Transportation Sciences
Czech Technical University,
Na Florenci 25, Praha 1, 11000, Czech Republic

INTRODUCTION

The number of traffic accidents increases every year proportionally to increasing number of car users. The mortality of traffic accidents is alarming and for the society it has become a serious problem. Among the victims the most often cause of death is head/brain injury. The research in this field has been focused mainly on passive safety, however, for the investigation it is necessary to know the tolerance limits of biological tissues to extreme loading. In the case of human head, the most dangerous injury (not caused by a direct impact) is the Diffuse Axonal Injury (DAI) that follows overloading of the head by extreme acceleration.

For the investigation of head tolerance limits both experimental and numerical approaches have been performed. The easiest way is to collect statistic data from the accidents. Guillaume et al. [1] made experiments using cadaver heads using veins filled by contrast pigment to simulate the normal blood pressure. They described the relationship between the impact velocity and type of injury that appeared. The disadvantage of such an approach was that they used heads embalmed in formalin leading to non-realistic material properties of the tissues. Because experiments on living humans are impossible because of ethic reasons, a good FE model of the human head is needed. FE model is able to describe the behavior of the impacting head in the complexity. Willinger et al. [2] introduced the FE model of human head and validated it against experiments. Up to date it is the only model validated.

METHODS

Our model was based on the CT scanning of human body made in the National Library of Medicine as a part of the Visible Human Project [3]. 16-bit slices of 512x512 in-plane resolution scanned in the z-direction every 0.3 mm were firstly improved using segmentation and several filters including Gauss smoothing, binary thresholding and island removing (of pixels of a given value). This procedure resulted in set of images, where only binary values of the skull were present. Next step was the application of eroding algorithm that makes the skull augmented by Gauss smoothing less thick. After that, the Marching Cubes Algorithm (MCA) was used to obtain the surface of the skull represented by millions of triangles. This number was lowered by simplification of the surface represented (each detail is not needed) and surfaces were smoothed. The second part of the work, the artificial insertion of the brain tissue to the model was made using subtraction of given distance from the inner part of the skull's surface. All the surfaces were meshed and the space between the skull and the brain was assigned to be the CST.

The material properties were set according to the values measured in the experiments in our laboratory and for the brain and CST the values were acquired from the literature. The FE model was used in computer simulation of a traffic accident. The problem was solved in two steps.

First, the kinematics of the body after collision with a car running at 50 km/h was assessed using rigid-body pedestrian model. For this purpose, Madymo design and crash simulation software was chosen. The outer geometry of the pedestrian model was represented

by ellipsoids, which provide a less accurate representation of the geometry but result in shorter computation times than facets. Inertial properties of all segments were incorporated in the rigid bodies of the pedestrian models. In the ellipsoid pedestrian models, structural deformation of flexible components is lumped in kinematic joints in combination with dynamic restraint models. Deformation of soft tissues (flesh and skin) was represented by force-penetration based contact characteristics for the ellipsoids. These characteristics are used to describe contact interactions of the pedestrian model with itself and with its environment.

The model was equipped with sensors located in 16 important places registering position, velocity, acceleration and force in every time instant. For the accelerations, acceleration field model calculating forces at the centers of gravity of bodies due to a homogeneous acceleration field is used. From the rigid body simulation of the pedestrian body impacting the car several important values were determined, especially acceleration of the center of gravity of the head. Resulting acceleration history was used to load the detailed finite element model of the head.

Second, the numerical solution of the problem was done using LS-DYNA solver with explicit time integration scheme intended for the applications where short time impacts occur. Time history of von Mises stress as well as history of strains at important locations in brain, subarachnoidal space and in skull were evaluated. As the most important characteristics, the von Mises stress was chosen due to possibility of using engineering limits , e.g. yield stress of a brain tissue.

RESULTS

The paper shows possibility to use detailed finite element model of human head to predict or describe injuries during mechanical loading as in this case of a traffic accident. The possibility of using combination of rigid body modeling of the whole situation together with detailed FE model of the region of interest is highly advantageous. However, the model should be verified in large number of reconstructions, it should be also verified in reconstruction of accidents with mild injuries sustained, e.g. accidents caused during daily activity (falls, falling objects, school sports). Use of detailed medical records is essential.

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Laboratory equipment for the „Heat and mass transfer“ course

J. Čížek, N. Součková, J. Nožička

jan.cizek@fs.cvut.cz

Department of Fluid Dynamics and Power Engineering, Faculty of Mechanical Engineering, Czech Technical University in Prague, Technická 4, 166 27 Prague 6, Czech Republic

The main objective of this work was to introduce a modern measurement method PLIF (Planer Laser Induced Fluorescence) to the education of courses provided under the Department of Fluid Dynamics and Power Engineering. The PLIF method is developed to measure temperature fields in liquids. In contrast to standard methods is this one very illuminating. It is possible to measure the whole temperature field in one time and then plot it for example on the computer monitor. The supplement of the laboratory equipment by new components originates a fully new practice work for the “Heat and mass transfer” course. This experimental setup will also be instrumental in education of lower university level in subject “Thermodynamics”, students of doctoral study programs will meet it in short time courses.

This project is thematically tied together with the project CTU0605212 ”*Experimental equipment for correction possibility verification of PLIF method on refraction index changes*” which has been introduced here last year. The experimental setup is designed as a rectangular pipe heat exchanger, where the specific heat determination can be based on both, the distribution of heat transfer coefficient which can be calculated from the temperature field distribution, and from the total heat balance of the exchanger.

The exchanger is glued to simple plexiglass parts, because of PLIF method tasks. It consists of cold water channel, hot water channel and aluminum plate as a heat transfer surface. The exchanger’s side is splayed under the angel of 5 degrees, because of upright coming out signal and avoiding refraction on the surface of the exchanger. Because the height of the channel is only 20 mm, it was necessary to design another part of the exchanger on the up side. The side of this part is splayed under the angel of 30 degrees, so there is a possibility to record the area under these two angels. The aluminum plate passes through the exchanger and both stilling boxes and is insulated inside of the boxes in order not to transfer the heat inside of them. The plate contains of 21 thermocouples for the surface temperature measurement. Thermocouples are led through the grooves to the sides of exchanger and out of it. This setup allows measuring the temperature behavior along the surface of the plate. Temperature on the inlet and outlet is also measured, and allows computing heat balance of the exchanger. The heat balance and temperature behavior on the wall is used for counting heat transfer coefficient and whole temperature field.

The experimental setup has been, thanks to the University Development Fund, supplied by monochromatic CCD camera SV5M10 with a PIXCI SI Board made by the EPIX Inc. The advantage of this solution against the planned one (camera SI-SV9M001-7FT with the PIXCI CL2 board from the same company) is mainly in the CCD chip resolution. It is 2592 x 1944 instead the planned 1024x1280. Maximal frequency for the full resolution is 10 frames per second (fps), for the 1024x1280 resolution 30 fps, which is the same as for the SI-SV9M001-7FT camera. In addition to this, the bit depth of this camera is 12 bits, against the 10 bits of the planned one. To be able to capture only the light emitted by the fluorescent dye, a filter which transmits a light of wavelength higher then 570 nm must be placed in front of the CCD chip. A 25A photographic filter from the Hoya company has been bought. Since the thickness of the temperature boundary layer is for given parameters of the test section small,

in the order of millimeters, and the signal is relatively weak, it was necessary to use a lens with high lens speed. The Nikon lens 85/1,4 D IF AF has been selected, for its excellent optical features.

For a better control over the experimental setup a user interface in the MatLab R6 has been developed. The program is draw up as a complex but it is also possible to use separated parts of it. It is useful mainly for the part designed for the PLIF data evaluating. Also the part for the data capturing can be used separately. The data evaluating program contains image processing routines like data filtering, masking and so on. The interpolation of calibration curve can be also chosen, linear and exponential are implemented. Common statistical values can be calculated from the evaluated data and the data can be saved off course. The part for data capturing can be used for CCD parameters settings: exposure time, chip resolution, frame rate and so on. The pictures is possible to save in 16 bits depth in format *.tif. The program is furthermore created by several subroutines for experimental set-up control and data acquisition from the thermocouples. Also the temperatures of hot part of heat exchanger and the relay circuit parameters can be changed.

The practice work operating instructions were written for better understanding. These instructions contains all needed equations for evaluating the heat transfer coefficient and Nusselt number, furthermore the description of the experiment set-up and the basic theoretical principles of PLIF and PIV methods which are used. Fro the course “Heat and mass transfer” in summer half 2007 there weren’t all required components available. Accordingly the practice work was offered to the students as the voluntary one and there was given an opportunity to the students to participate on the project solution. Five students were enrolled to the solution of this work. Their work was first of all created by revision of some parts of experimental set-up and furthermore by temperature measurement with set of thermocouples and flow field measurement by PIV method in several cross-sections in the cold part of the heat exchanger. In this year is the practice work completed and it will be included to the syllabus of the course “Heat and mass transfer” and also it will be also used as the demonstrational experiment in the subject “Thermodynamics”.

Within the project “Laboratory equipment for the Heat and mass transfer course” the modern measurement method PLIF for temperature field measurement was implement to the program of course “Heat and mass transfer”. Students of the fourth year of the study branch „Engineering Mechanics and Mechatronics“ have opportunity to get familiar with this method during its practical application. The objective results together with application of PIV method make this method suitable for explanation of thermodynamical processes in fluid under investigation. This experiment will be also the useful supplement of the syllabus in next years.

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Experimental Investigation of the Flow through Small Diameter Tube

V. Vinš, V. Vacek, V. Syrovátka, R. Marek

vaclav.vins@fs.cvut.cz

Department of Physics, Faculty of Mechanical Engineering, Czech Technical University, Technická 4, 166 07 Prague 6, Czech Republic

Department of Physics at Faculty of Mechanical Engineering at CTU in Prague cooperates with international research centre for nuclear physics CERN already for several years. One of the main contributions of the department within this international cooperation is design of special cooling circuits. A capillary tube, i.e. tube with small inner diameter, is used as an expansion device in the most of these specific applications. Large number of capillary tubes made of different materials with various lengths and inner diameters had to be designed for diverse operating conditions. The most specific feature of the detector cooling systems is that they use special fluorinert refrigerants. These fluids fulfill many additional demands. Just to name few: a good chemical stability, radiation hardness and favorable dielectric properties.

Our research team has tried to solve problem of the capillary tube prediction during last few years. Both the experimental and the theoretical approaches were applied for speeding up the prediction procedure and improving the accuracy of capillary tubes trimming. Optional divided capillary tube allowing measurement of relevant characteristics of the capillary flow was designed, manufactured and experimentally tested during year 2007. The main goal of the project was to get accurate experimental data of the refrigerant R218 flow through the adiabatic capillary tube. Obtained results should also provide detailed information of the capillary tube behavior for effective capillary tubes' prediction.

The average inner diameter of used capillary tube was measured by using six times repeated weighing method prior to manufacturing the divided capillary tube. Its value was found to be 0.95 mm. The copper-nickel capillary tube was then divided in eight uneven sections. A pressure offtake was realized by test hole made by a drill having 0.8 mm in diameter at a distance of approximately 3 cm far away from one end of each capillary tube section. A 2 cm long capillary tube piece was then attached on the drilled hole by utilizing silver soldering technique. The capillary tube sections were joined together using short pieces of copper tube of inner diameter equal to outer diameter of the capillary tube. Thermal and high pressure resistant two-component glue (DP190 from 3M manufacturer) was employed at all connections.

Pressure variation along the capillary tube was monitored by nine precise pressure transducers from Huba Control, JSP and SensorTechnics manufacturers. Temperature was measured by set of forty small temperature sensors. They included the NTC, Pt1000 and Pt100 type. All these sensors were attached on the outer surface of the capillary tube by employing a high conductive thermal paste and a metal tape. The outer surface temperature could be considered being equal to temperature of the flowing refrigerant, since a thickness of the capillary tube wall was very small (0.20 mm). Refrigerant mass flow rate was measured by set of different flow meters: a precise corriolis mass flow meter and a turbine volumetric flow meter placed into the subcooled liquid line and by a thermal flow sensor and a volumetric flow meter both installed into the vapor line.

The optional capillary tube was then initially used for measurement in one-phase flow with different liquids and gases in the laboratory of Department of Physics. The liquid flow was carried out with water and with fluorinert fluids namely C_6F_{14}, C_7F_{16} and C_8F_{18}. Collected data verified our previous conclusion [1] to use the Colebrook's friction factor correlation for the frictional pressure losses prediction inside small diameter tubes. The relative inner wall roughness of the capillary tube under investigation was found to be 0.0023. Flow behavior of the compressible fluids was tested with high pressure air and with nitrogen. The capillary tube behaves similarly to chocked gas nozzle as it was observed in case of pressure after the capillary tube being lower than a critical outlet pressure.

Majority of the experimental measurements performed with the divided capillary tube were realized inside of real vapor cooling circuit working with refrigerant R218. The setup was prepared for our experiment at the CERN laboratory. The refrigerant flow consisting of one-phase liquid and two-phase vapor-liquid mixture was monitored under varying operating conditions, i.e. pressure and temperature at the capillary tube inlet and evaporative pressure after the capillary tube. Thermodynamic metastable flow phenomenon, so typical for superheated liquid phase persisting at the pressure below corresponding saturation pressure, was detected at some measurements.

The experimental data of R218 flow were compared with theoretical predictions obtained from our numerical model [2]. Overall agreement between the model and the experiment was found to be relatively good. Since an effect of the metastable flow phenomenon was not fully implemented in the model, the numerical model slightly underpredicts refrigerant mass flow rate. The simulated temperature profile was below experimentally measured one at a location of the onset of vaporization. The metastable flow is in general defined by the underpressure of vaporization, i.e. a difference of the saturation pressure corresponding to refrigerant temperature and the actual monitored pressure at the onset of vaporization. It is foreseen to interpret our experimental data for evaluation of the underpressure of vaporization correlation applicable for R218. For instance Chen [3] tried to introduce detailed theory of heterogeneous nucleation inside the capillary tube. Unfortunately his underpressure correlation is not universal and it was verified only for R12 flow. Our numerical model is now being extended by adding two mestastable flow regions into the model defined by Chen's correlation and by Feburie's model [4].

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Metastable Water and Steam

J. Hošek, K. Studenovský

Jan.Hosek@fs.cvut.cz

Department of Instrumentation and Control Engineering, Division of Precision Mechanics and Optics, Faculty of Mechanical Engineering, Czech Technical University in Prague, Technická 4, 166 07 Prague 6, Czech Republic

This article presents a contribution of authors of division of Precision Mechanics and Optics of Faculty of Mechanical Engineering CTU for grant project GA ČR No. 101/05/2214 Metastable water and steam. This project is focused on design and performing the experimental measurement to obtain missing engineering data and to answer fundamental problems for the range of metastable state of water and steam. This project is composed of few parts like design and develops a new experimental device for measurement of the surface tension of supercooled water; the experiments should confirm or disprove its anomalous temperature dependency and the hypothesized denser surface layer. Next measurements of nucleation of supercooled and stable droplets using a shock tube and diffusion cloud chamber in an extended temperature range, which will be used to determine the size and formation energy of critical clusters and to deduce the microscopic surface tension or numerical study of water clusters, bulk supercooled liquid and its surface using Monte Carlo simulating method and density functional theory. These partial tasks were performed by collaboration of laboratories of Institute of Thermomechanics of the Czech Academy of Science, Institute of Chemical Process Fundamentals of the Czech Academy of Science, Institute of Physics of the Czech Academy of Science, University of West Bohemia in Pilsen and Czech Technical University in Prague.

Our contribution to the project was to develop and design an optical experimental method for the small volume liquid sample surface tension measurement in the supercooled state. The appropriate experimental method of the minimum volume surface tension measurement seems to be a method devised by Furgeson [1] which uses less then 1 mm^3 of water sample only. This method is based on optical observation of liquid meniscus at the open end of the capillary. Our project goal was to redesign this old forgotten experimental method for nowadays technique possibilities.

We performed theoretical analysis of experimental method to determine the necessary resolution conditions and other condition which influents design of experimental apparatus. We found out the three main conditions which have to be fulfilled for successful measurement. These are enough pressure difference measurement resolution between both sides of sample, constant shape and dimension of capillary profile along the whole length of sample and high precision of meniscus planarity determination at the open end of the capillary. This theoretical analysis is broadly discussed in [2].

The original method of liquid sample meniscus observation proposed by Hacker was changed to autocollimation principle. Sample illumination can be preformed with large diffused light or collimated He-Ne laser beam, which seems to be better. Final experimental apparatus is based on adaptive principle optics, which consists of four connected subsystems – a pressure variator, a glass capillary with a sample placed in a temperature controlled cell, a capillary tip meniscus geometry measurement system and data acquisition and processing systems. Details of the whole experimental set-up can be found in [3]. We had prepared and tested two different experimental approaches for the sample surface tension measurement and

it can be used for successful measurement. Real undercooled measurement was not performed, while temperature controlled cell was not build yet.

A serious technical complication appeared during the apparatus experimental tests. Capillary tip meniscus shape and its planarity determination were significantly affected by the capillary tip inner edge quality. Standard methods of capillary splitting and grinding give poor capillary inner edge quality so the one third of meniscus diameter was not suitable for automatic meniscus planarity determination. To overcome this complication we manufactured a lot of capillaries with different grinding and polishing approaches to optimize capillary inner edge manufacturing technology process. Some of these methods are presented in [4]. Finally we found an appropriate technology approach for capillary tip manufacturing, which is applicable for manufacturing sharp edges on any brittle materials. Review of our outputs of the presented grant project will be prepared for publication in suitable scientific journal during 2008.

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Section 7

MECHANICAL ENGINEERING

Kinematics Errors of geared Belt

J, Machyl

Jan.Machyl@fs.cvut.cz

Czech Technical University in Prague, Faculty of Mechanical Engineering, Department of Production Machines and Mechanisms
Horská 3, 128 00 Praha 2, Czech Republic

Annotation

Problem of influence errors gearing at accuracy regulation of position and speed is not possible separate independently. There is interaction with errors of motor and their regulation. Smooth running of production machines is dependent on quality of production and reliability of machines.

Oscillation implicate stress of component, great noise, worse quality of surface. It tall of durability of production machines. This powers of oscillation we have to find and conspicuous to eliminate.

This report has as a goal to follow of effort errors by motor and to weight. Motor and weight are connected one-stage gearing. The gearing is representid by geared belt Power Grip GP,,,,. With incremental sensor by shaft of weight is possible to read a position of shafts orientation. This different is error of shafts orientation. This value is calculated by FFT (fast fourier transformation) system. The peaks on a graph (FFT) are factual errors of gearing and harmonic components.

Characteristics

z_R = 72 number of teeth belt
z_M = 20 number of teeth big pulley
z_L = 30 number of teeth small pulley
J_M = 0.0019kg.m^2 inertia moment to shaft of small pulley
J_L = 0.0042kg.m^2 inertia moment to shaft of big pulley
SIMENS 1FT5 072 brushless three-phase, synchronous motor to shaft of small pulley
SIMENS 1HU3 074 brush three-phase, synchronous motor to shaft of big pulley

Sensor of motor	IRC 120/2500, IP 54 T23, +5V/200mA
Sensor of weight	ROD 426E.010, D-8255 Heidenhein Traunreut-Germany

Introduction

Particular about theory of errors are introduced in many literature. Here is only a brief statement a basic errors.

Kind of sensor is very important. Signals are coming to entry regressive structure and have influence on quality of regulation. Because they are coming in regulator with big magnified and an error is multiplied. If the position sensor use for evaluation of speed for governer of sped is the carry-over between error of position sensor and position of motor.

$$\frac{\varphi_M(s)}{\Delta\varphi(s)} \approx \frac{1}{K_V} \cdot \frac{s}{\tau_V s + 1}$$

Amplitude characteristic this carry-over has derivate character and break by frequency K_V. By lower frequency (slow rotation of motor) is ipact of error of speed sensor subdued. We follow an errors of gearing of gearwheel or pulley. Difference between theoretical and real gearing, geometry of profil teeth, eccentricity of assembly pulley etc.

The motor has 6 compoles it means 3 compole-pars and speed is 8 revs per second. We can read a multiples of speed on the FFT graph (24, 32, 40, 48,..). We can read very interesting frekvency wich belongs of unsteady pitch of belt. It is possible to read a multiples of this frekvency. It can be a unsteady spreading of belt. There are electric frekvency 50 Hz, teeth frekvency and shafts frekvency etc.

Ending

With growing weight are velues of amplitud major. Positive growing weight and negative growing weight make a big value of aplitud. The most influence to errors have speed n_1 and n_2 and their first and second harmonic component. The number of compole of motor are in second harmonic component.

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Application of High-Pressure Membranes in the Design of Hydraulic Components

M. Jalová, V. Andrlík

Martina.Urbanova@fs.cvut.cz

Department of Production Machines and Mechanisms, Faculty of Mechanical Engineering, Czech Technical University in Prague, Horská 3, 128 00 Prague 2, Czech Republic

The main aim

My project concerns the design of a membrane element with higher strength than is usual in current industry, its theoretical calculation and the possibility of its application in the design of hydraulic components.

Present day situation

These parameters in design of mechanisms are increasing: tolerance and quality of surface, performance and dynamic properties of movable parts of conventional elements (e. g.: slide of valves, joint bolt, etc.). These requirements cause the increase of prices of these elements. Temperature dilatations and impurities in systems influence negatively these parameters.

The concept of membranes and membrane elements has extraordinary advantages in specific types of construction of fluid components, mainly pneumatic. Examples of materials used to make current membranes are rubber, resin, silicone, viton, tantalum, stainless steel, polydimethylsiloxane, polyvinylidene fluoride, polyamide-polyvinyl alcohol etc. The working medium can be air, oil, water, electrolytes and liquids with chemical components. Operating pressure depends on application and ranges to 1 MPa. The limiting factor of these membranes is their low strength, which prevents wider usage in hydraulic systems.

The global research in the field of membranes is oriented to minimization or elimination of component dimensions and ratio of metallic parts. There is no based on increasing the strength of membranes. However, the development of high-pressure membranes enables membranes to be used in the field of hydraulics and robotics.

High-pressure membrane element

Term composite material signifies that two or more materials are combined on a macroscopic scale to form a useful third material. There are two categories of constituent materials: matrix and reinforcement. The matrix material surrounds and supports the reinforcement materials by maintaining their relative positions. The reinforcements impart their special mechanical and physical properties to enhance the matrix. Composite materials have two major advantages, among many others: improved strength, especially when compared with other materials on a unit weight basis.

Therefore a special combination of materials from accessible materials, which eliminates this disadvantage, has been chosen. This material is an aramid fabric reinforcement and an elastic resin and the membrane element is made of a composite material.

Six types of kevlar textile fabrics were used for producing experimental samples (membranes). The kevlar fabrics differ in their weave, their thickness and the areal density of their fibres. Matrix is urethane elastomer resin and its main profit is excellent elastic and sealing properties.

The flat experimental sample consists of two flat plastic resin circular ring frames with a textile fabric membrane fixed between them. Experimental samples were created with one layer and also two layers of textile fabrics. The shape of the textile can also be formed or the fabric can be tubular in shape and formed.

Mathematical model

The strength theory of membrane for the mathematical model used for calculating the strength and the deformation of the basic membrane element is an integral part of this thesis. The membrane element is understood to be a thin circular plate, which is geometrically nonlinear and is made of composite material. Results of the mathematical model are verified by comparison with experimental data. The verified mathematical model has wide possibilities of usage and it is possible to draw generic conclusions for the basic design and calculation of thin plates with high deflection made of aramid, carbon, glass or hybrid fibre alternatively fabric reinforcement.

Hydraulic components

In the engineering section there is a summary of definitions and characteristics of different shape dispositions of high-pressure membrane elements and the possibility of their use in the design of hydraulic components. This use is applicable in the construction of hydraulic linear motors with low and higher stroke, the control of slide-valves and distributors, multipliers, hydraulic pulse motors etc.

The membrane single-acting hydraulic motor has been chosen as a referential variant for the realization and verification of the motor's operation. It consists of a membrane element, a piston rod, a lower flange, an upper flange, a fitting, screws and a spring. When hydraulic oil reaches the membrane in the working area, the membrane is deformed and the piston rod is moved at the same time. This is a stroke of the membrane hydraulic actuator. A spring is used for making a back stroke.

Its basic functions were verified by the use of experimental hydraulic rig with pressure feed back control. It was tested: the sealing of working area by the maximal working pressure, move of piston rod, the maximal force of piston rod and the range of strokes.

Conclusion

Research into membrane principles and present-day membrane elements shows that their strength is very limited. Therefore high-pressure membrane experimental samples and various membrane elements were produced. These elements are made of composite materials and are easily and quickly produced. It is also possible to create various shapes. Their maximal strength, which is determined experimentally and theoretically, can reach as much as 30 MPa. The design, theoretical calculation analysis and manufacture of the high-pressure membrane element opens wide opportunities for its application in hydraulic systems.

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Application of High-Pressure Membranes in the Design of Gripper Elements of Manipulators and Robots

M. Jalový, V. Andrlík

Miroslav.Jalovy@fs.cvut.cz

Department of Production Machines and Mechanisms, Faculty of Mechanical Engineering, Czech Technical University in Prague, Horská 3, 128 00 Prague 2, Czech Republic

The main aim

This project focuses on an analysis of the properties of a high-pressure membrane element with fabric or fibre reinforcement through a theory of the mechanical stress of multiaxial fabrics and experimental research methods.

Membrane elements

Membrane elements are very often used in pneumatic robot grippers but it is not possible to use these elements in hydraulic robot grippers due to the high working pressure. The maximal working pressure of membrane elements in pneumatic systems is approximately 1 MPa and the gripper force is too low. Therefore a high-pressure membrane has been developed whose working pressure can reach as much as 30 MPa.

High-pressure membranes are made of composite material. Kevlar textile fabrics are used as reinforcement for producing membranes (experimental samples). The Kevlar fabrics differ in their weave, their thickness and the density of their fibres. Polyurethane elastomer resin is used as a matrix. The strength of these membranes are determined experimentally.

Experimental rig

A rig for the experimental verification was designed which consists of an experimental chamber and a hydraulic unit. The unit has a maximal value of working pressure 38 MPa and is equipped with numerical control of the relationship between time and pressure, which is established by a control scheme. Using this equipment any static or dynamic tests which lead to the destruction of the tested membrane can be conducted. The strength of the membrane, the vibration fatigue limit and the maximal sag under the load are also measured.

The experimental rig is multipurpose; it is possible to add new components to the hydraulic circuit, to add new sensors or new types of experimental chamber. Wide possibilities are provided by control software Matlab, Simulink and Real Time Toolbox or LabView and by analog-digital cards for modern measuring and control.

Membrane's identification

Testing methods and conditions must be unified and defined exactly so that the properties of composite materials can be reproduced and compared. This is a reason for the detailed experimental identification of properties of composite high-pressure membrane elements with respect to their future application in the design of gripper elements of manipulating devices. The main characteristic properties of membrane elements are the strength, the fatigue limit etc.

For basic identification of useful and characteristic properties and experimental research on membrane elements it was necessary to design and realize experimental and technological devices with wide possibilities with regards to usage in various applications.

The static strength of the membranes, which are made of kevlar fabric with an areal density of fibres up to 110 g/m^2, is maximal 5 MPa. Therefore they are not suitable for this application. The static strength of membranes with higher areal density varies from 10 MPa to 16 MPa. If a better isotropic property is applied, the strength of a membrane with two layer fabric can be increased almost twice. Membranes with two textile fabrics are more isotropic

and reach higher destructive pressure. These membranes demonstrate optimal use of material. The strength of the best membrane can reach as much as 30 MPa which is sufficient for use in hydraulic systems.

The areal density of fibres and thickness of membrane increases and its strength also increases. These results, which were obtained experimentally, were verified by analytical calculation (mechanics of composite materials and theory of thin plates which are geometric nonlinear).

Multiaxial theory

This theory is elaborated in full and it is used for the verification of calculations in experimental results. The main aim is to apply composite material structures to the design of robot grippers. The theory exposes problems in the original description of the behaviour of thin walled composite structures and those conclusions can be drawn for the design of membrane elements. These conclusions are verified experimentally by classical tensile tests of textile fabrics which are used as a support for membrane elements.

Robot grippers

There is a summary of definitions and characteristics of different shape dispositions of high-pressure membrane elements, its main parameters and the advantages for the use in the design of robot grippers. Designed and realized membrane elements can be used in the construction of swinging and linear grippers. Both can be either direct or indirect with the grip object.

The swinging direct and the swinging indirect grippers have been chosen for realization. The main functions: principle of gripping, maximal working pressure, operating during the stroke, gripper force and gripper stroke, were tested and compared with theoretical anticipated values.

Conclusion

The project describes the field of production and manufacturing technology of composite materials, analyzes the possibility of the use of high-pressure membrane elements in the design of robot grippers with a selection of the referential variant and a definition of terminology of the high-pressure membrane element.

The motive for this work is the utilisation of known principles, which have been verified over many years in industrial practice with low level requirements, in the origination of new engineering units, which contribute to development in this field.

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Comparison of heat pump experimental measurement with results from simulation programs

R. Krainer, K. Brož

Robert.Krainer@fs.cvut.cz

Department of Environmental Engineering, Faculty of Mechanical Engineering,
Czech Technical University, Technická 4, 166 07 Prague 6, Czech Republic

This paper describes part of a research project which aims to optimize heat pump systems with borehole heat exchanger in terms of energy consumption. The research is dealing with different configurations of system and different control strategy. In regards to a great number of system configurations, only four basic of them were selected for the first study. The paper presents model calibration of one ordering on a real ground source heat pump heating system at CTU in Prague used for heating of a part of laboratory. Model is compiled in transient systems simulation environment TRNSYS. The objective is to determine the most suitable configuration with a relevant control strategy.

Simulation is performed for the heating season because in this period gradual changes both temperature in the surrounding ground and in building heating demand as well appear. Simulation step is set to 1 minute in order to catch influences of heat storing and rejecting process in the storage tank, as well as of control strategy and borehole local changes in the ground surrounding. System is composed of these main components: Data Reader and Radiation Processor (type 109), the weather files distributed with TRNSYS 16 are organized in directories according to the data sources selected worldwide from Meteonorm stations. This directory includes all weather data files for Czech Republic (Churanov, Hradec Kralove, Kucharovice, Ostrava, and Prague). Water to Water Heat Pump (type 668), this model is based on user-supplied data files containing catalog data for the capacity and power draw, based on the entering load and source temperatures. Vertical U-Tube Ground Heat Exchanger (type 557), this model uses calculation divided on three parts (a global solution, a local solution, and a steady-flux part). The global and the local problem are solved with use of the explicit finite difference method (FDM), whereas the steady-flux part is given by an analytical solution. Multi-Zone Building (type 56), this component models the thermal behavior of a building divided into different thermal zones. In order to use this component, a separate pre-processing program (TRNBUILD) must be executed first. Storage Tank (type 60), this component models a stratified fluid storage tank with fixed inlets. Macro representing the heat pump control uses 3 components, TRNSYS / Excel Coupling (type 62), Quantity Integrator (type 24) and Delayed Output Device (type661). Flowchart describing control of system is programmed in Excel file and with the used component type 62 is coupled to TRNSYS.

Model calibration is carried out with data measured on real system at CTU. System configuration consists of 100m borehole with double U-tube configuration, 10 kW water-to-water heat pump, storage tank 540 l, circulating pumps and involved control. Control of heat pump is operated depending on water temperature in the bottom of the storage tank. If water temperature entering to the heat pump from storage tank is lower than required temperature heat pump is switched on. In this particular case temperature sensor is located at inlet pipe to condenser that is why after a preset time period the circuit pump is switched on for the time needed to deliver required amount of water from the storage tank to the measured point.

In the system described above 6 temperature sensors have been installed in the pipes. Pair sensors resistance thermometer Pt 100 has been installed at primary and secondary side of the heat pump and at feeder and return piping of a heating system. For determination of heating capacity flow meters were installed in each circuit. Storage tank was equipped with 8 resistance thermometers in different layers to be able to measure charging and discharging of heat. Electric meter is used for measuring of power draw. Monitoring of all values needed for calibration is completed with technical room temperature and outside temperature sensors. Measurement is continuous, every 1 minute all measuring values are logged with data acquisition equipment ALMEMO 5590 and consequentially downloaded to the computer.

During calibration is component describing building behavior replaced with real heating capacity measured on the device described above. Meteorological data and technical room temperature are replaced with real measured values. Simplification assumed during model compilation is ideal control of radiators, there is no overheating and heating demands of building are fully covered. Physical variable changes with temperature are not included in the model, as well as transfer phenomenon (like heat inertia, circuit pumps operation delay) and rock inhomogeneity.

At present data from first month are obtained and model calibration is being carried out. Results of simulation will be obtained for simplified building. Weather data will be used from databases of Meteonorm for two different outdoor regional temperatures calculations in Czech Republic. The calibrated model and three other basic configurations based on it will be used to simulate several operating strategies. Factor HSPF (Heating Seasonal Performance Factor) is used for comparison of energy consumption.

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Pressure Actuated Membrane Telescope

J. Hošek, J. Kraus

Jan.Hosek@fs.cvut.cz

Department of Instrumentation and Control Engineering, Division of Precision Mechanics and Optics, Faculty of Mechanical Engineering, Czech Technical University in Prague, Technická 4, 166 07 Prague 6, Czech Republic
Institute of Thermomechanics, v.v.v.i. Academy of Sciences of the Czech Republic Dolejškova 3, 185 00 Prague 8, Czech republic

Mirror telescopes are one of the basic tools for nowadays astronomical and basic physical research. Their design dimension has grown from few centimeters up to many meters within its 400 years history. The telescope mass grows dramatically with dimensions growth what leads to many technical complications of its design. Critical point of classical telescope design was attained with six meter diameter main mirror telescope during the last quarter of the last century. To overcome this critical point, many new kinds of light-weight telescope constructions have been designed since that time. Basic approach to decrease the mirror weight is the mirror segmentation. The new mirror design evolution decrease the thickness down to 8 mm in the case of the Very Large Teleskope on the Mount Cerro Paranal in Chile. In order to attain necessary image optical quality, each segment has to be supported with many actuators, which corrects all the telescope deformations. Optical systems can be based on more thick mirrors like foils too. Small stiffness of so thick mirrors is employed in other optical systems called adaptive optics [1, 2]. Other kinds of adaptive optics systems are systems based on liquid optics actuated with pressure, temperature, electrowetting or another principle [3, 4].

This paper presents theoretical analysis of light-weigh telescope design possibility based on combination of mentioned adaptive optics systems – the transparent or mirror foils actuated with pressure differences across the foils. In the idealized case this telescope could be stored or easily moved in deflate state and it can be set to functional state with gas inflate like balloons.

Deformation characteristics of actuated foil loaded with pressure can be derived from Laplace equation of membrane tightness and Hook law and it gives hyperbolical characteristics. The shape of deformed membrane tends to sphere if the margin part are neglected. Paterson at al. [5] expected parabolic membrane shape, but our experimental result shows much better correlation to spherical shape model then to parabolic one. Spherical shape of pressure loaded foils unfortunately affect the optical system image quality, where the can be expected high influence of spherical aberrations.

We try to search the technical parameters of different mirror telescope design systems based on foils to correct optical aberration caused by foil spherical shape. We found out the best kind of foil telescope design it the Cassegrain telescope design. Cause of technical acceptable pressure differences the telescope design has to be separated at least into four pressure sections separated at least with three foils, which affect the telescope imaginary property.

Beyond the pressure difference the foil telescope imagination can be affect with application of difference gasses into each pressure sections. The range of gas refractive

indexes is from hydrogen N = 1,000132 up to benzene N = 1,001762, what has relatively small influence on the whole optical system aberration correction.

We have presented the first results in the field of pressure actuated membrane telescope and it shows it is theoretically possible to design aberration corrected telescope of this kind. We found out, however, a lot of other technical problems during our experiments, which will affect the design of real telescope like foil transparency, homogeny, pressure stability of foil gripping.

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Section 8

PRODUCTION SYSTEMS, TECHNOLOGY, TECHNOLOGICAL PROCESSES AUTOMATION

Perspective Magnetic Materials for EMC Filters

J. Hájek

hajekj1@fel.cvut.cz

Department of Electrotechnology, Faculty of Electrical Engineering,
Czech Technical University
Technická 2, 166 27 Prague 6, Czech Republic

Introduction

Standards for the EMC that are valid in present describe measurements of conducted interferences in a frequency range from 150 kHz up to 30 MHz. This range was chosen with regard to the most often used appliances with switched power sources (SMPS). Because of increasing the number of electronic equipment using SPMPs and due to the strict rules for EMC, this range seems to be narrow. Its expansion to the higher frequencies can be now clearly seen. In the future, the enlargement to lower frequency than 150 kHz can be expected. Interferences in this band make a significant part of the total undesired energy spreading using conducted ways. Described project solves issues of passive LC filters design considering frequencies about 80 kHz. The main point of view is the question of suitable magnetic material for choke's core. The solver of this project tries to find out manufacturers, that offered unusual materials, not only conventional ferrites, but iron-powder cores or metallic-glasses materials that are useful in current band [1].

EMC Filters

All the newly produced electronic appliances have to pass many different bills, including EMC directives dealing with suppressing undesired conducted signals. Filtering these signals using noise-suppressing EMC low-pass filters is the most often used mitigation technique [2]. EMC filters consist only of passive components: capacitors and inductors. Thanks to a big variety of capacitors, many sorts of goods exist and there are no problems to choose suitable capacitor from the safety class X or Y. When thinking about inductors, another issue occurs. There are many sorts of common-mode chokes that are suitable only for suppressing common-mode (asymmetric) signals. These chokes are not efficient when suppressing differential (symmetric) signals. For this purpose differential chokes must be used and often they must be sized, designed and built on demand. Without knowing magnetic parameters of potential materials, this design cannot be successful and the chokes do not work properly. Even, the chokes' suppressing effect can change into the amplification and the choke starts to reflect the undesired noise back into the protected device.

Materials for inductors

High-powered suppressing inductor must provide (amongst others) following assumptions:

- required value of inductance
- high self resonance frequency (low parasitic)
- lumped character in current frequency range
- other (dimension, weigh, price, e.g.)

Classic ferrite cores, iron powder and new Fe-Al powder cores called "Kool Mμ" were compared. The last mentioned cores are interesting because of their huge maximum flux density (1.1 T) that allows storing a big energy in a small space. Thanks to this feature they are more convenient than classic ferrite cores with an air gap [3]. "Kool Mμ" cores are the same price as ferrite cores and have much lower losses in their magnetic circuit. The next advantage is a higher thermal conductivity that can cause better cooling and heat-transfer.

The ability to keep required inductance when saturation occurs is the main criterion for evaluating choke [4]. Saturation can be caused by AC working current at frequency 50 Hz or 60 Hz, through the suppressing choke can flow also DC current (converters with filtering capacitors or earthing chokes). While the most of offered suppressing chokes are wind up as current compensated, the most efficient chokes are wind up as simple series non-compensated chokes. These chokes suppress both types of disturbance – symmetrical and asymmetrical.

Project summary

Described project solves construction issues of designing noise-suppressing chokes from extraordinary magnetic materials. It compares possibilities of different materials. Samples of chokes from each manufacturer were obtained and measured. After measuring, comparing between advertised and measured parameters was done. Simulation in WinSpice 3 was done too. All the comparisons were done with regard to considered frequency range from 80 kHz up to 150 kHz. The result is that the new Fe-Al cores are more convenient for EMC filters than the classic ferrite cores. This project should be finished during the first quarter of the year 2008.

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Section 9

ENERGETICS
&
POWER ENGINEERING

Design of the Control System of Compact Matrix Converter

M. Bednář
J. Lettl

bednam2@fel.cvut.cz

Department of Electric Drives and Traction,Faculty of Electrical Engineering,
Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

Introduction

This contribution deals with the hardware design for a matrix converter compact version. It is presented a short introduction to the power circuit configuration and control system of the matrix converter. The accent is given on the design of FPGA based switching pattern generation board, which is necessary part of the converter. Further it can be found a description of individual parts of the board, which are needed to meet requirements of the system.

Power Circuit Configuration

Configuration of the enlarged compact matrix converter is typically 3 x 3 switching patterns of 18 IGBTs. The compact Eupec IGBT modules FS150R17KE3 are used. These modules configuration is adapted to be employed in matrix converter system. Each module contains 3 bidirectional switches. All the system parts are dimensioned for the permanent current stress of 30 A and for the voltage level of 400 V. The matrix converter system requires an exact generation of switching pulses. The design of the control system is an object of next paragraphs.

Adjustment of the Control System Hardware

Control system has to work in real time to be able to generate switching pulses with maximum frequency. The system should be as simple as possible through the reliability. The compatibility with the standard industry interfaces is the next basic requirement. Control system comprises the drivers, the FPGA based switching pattern board, and the pilot controller card.

The driver role is to amplify switching signals, to check the state of each transistor, and to indicate the switch current direction. Information about the current direction is useful when setting the proper modulation strategy. Each pair of drivers appertaining to the bidirectional switch has to be galvanic separated from the other pairs. The FPGA based board ensures pulses generation according to the requested voltage amplitude and frequency. The request can be given by RS232, PS/2 interface, or by pilot controller through PC/104 bus. The FPGA board contains 8 analog to digital galvanic separated converters, which are necessary for modulation algorithm execution. Every PC/104 compatible board can be used as a pilot controller. In this time it is used a Kontron PC module equipped with the AMD processor.

Specification of FPGA Based Switching Pattern Board

Each bidirectional switch needs 2 control signals and returns 4 signals to indicate the transistor state and current direction. They represent 54 signals that have to be accepted by the FPGA based switching pattern board in conclusion. On the other side, there must be many signals for communication with the pilot controller.

Requirements on Switching Pattern Board

The switching pattern board works as a modulator ensuring generation of control pulses in real time. The information about at least 2 input voltage levels and 2 output currents is needed for modulation algorithm execution. The voltage is measured with 2 analog to digital converters, in the concrete the voltage to frequency converters are used. For the current measurement 2 sigma-delta modulators are used. Of course, there are others analog-digital converters available on the FPGA based board. It means that the board accepts 8 analog channels. For some regulation algorithm implementation it should be useful to have information about speed of the driven machine. It is possible to get this information due to the circuits for incremental sensor signal evaluation. Both of the most often used type (5 V or 15 V supplied) of incremental sensors could be connected to the board. The board is prepared for connection of PS/2 keyboard, RS232 link, or PC/104 compatible module.

Description of the Solution

According to the specified requirements the standard EBX (Embedded Board Expandable) format was chosen. This format is specified by the PC/104 consortium and its employment ensures proportional compatibility to the PC/104 devices. The dimensions of the board are 8.00 x 5.75 inches.

The basic requirement on the control device is exact generation of the switching patterns. There are 2 types of devices, which can be used for this purpose. At first it is possible to think about microprocessor. Of course, microcontrollers are nowadays equipped with special circuits for signal generation, but it is necessary to have in the mind, that there is the requirement to generate 18 signals at the same time. There is no microcontroller, which would be able to generate such signal amount with jitter minimization. This problem solution is possible by using some type of FPGA (Field Programmable Gate Array) circuit. The function principle will be described further. There is an input signal vector. The FPGA applies logical operation on this vector. Large amount of parallel operations can be applied at the same time. Output vector is an issue of all the operations. The clock frequency of modern FPGAs reaches up to 1000 MHz. This system allows implementation of finite state automats working with current system state and generating switching pattern for the transistors. For this application the Altera Cyclone II circuit has been chosen. Configuration and programming of this device is possible due to the programming device connected to PC. The configuration and program are stored in the Flash on the board memory. In addition there is the debugging interface JTAG on the board.

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Large Area Capillary Mats Heating and Cooling with Air-Water Heat Pump

V.Zmrhal

Vladimir.Zmrhal@fs.cvut.cz

Department of Environmental Engineering, Faculty of Mechanical Engineering, Czech Technical University, Technicka 4, 166 07 Prague 6, Czech Republic

Air-conditioning based on radiant cooling or heating surfaces is a viable option of maintaining optimum thermal conditions without great demands on air distribution in a space. In a space with large area radiant cooling and heating there is no risk of noise and draught.

Capillary mat is relatively new radiant air-conditioned system for heating and cooling, which is used especially in Western Europe, and nowadays also in Central Europe (Czech and Slovak Republic).

The capillary mats are composed from the net of the thin plastic tubes from polypropylene into the heated or cooled water is supplied. There is a very short distance (10 – 30 mm) between the capillary and the water temperature difference is only 2 – 4 K what cause practically uniform distribution of surface temperature. Most often the capillary mats are placed on the ceiling under the plaster, but they can be installed on the walls or on the floor.

Due to small diameter of capillary tubes, the thickness of the plaster is acceptable 10 – 15 mm, what makes it possible rapid thermal reaction of the system to boundary conditioning changes. Capillary mats system can be used practically in any building. The system is advisable for new buildings (low energy buildings, family houses, flat buildings), but also for building reconstruction.

Large heat transfer surface allow heating with low water temperature. In relation to small heat loss of the building (low energy buildings) the temperature of heating water can be close to air temperature in the room. On the contrary the cooling can operate with high water temperature (up 24 °C). Mentioned fact allows applying of low energy or alternative heat sources as air - water heat pump with high coefficient of performance *COP* and efficiency of energy recovery *EER*. The using of capillary systems in relation to low energy heat sources can provide optimal indoor thermal environment without great demands on energy consumption.

For heating and cooling with large heat transfer capillary systems the temperature of heating water can be low (23 – 28 °C) and temperature of cooling water is relatively high (from 18 to 24 °C). Common heat pumps or cooling systems doesn't work in this temperature field (evaporating temperature of the refrigerant is low (from -3 to 5 °C), on the contrary the condensation temperature is high.

The project deals with large radiant heating and cooling system with capillary mats in combination with air – water heat pump. The equipment is designed for higher evaporative temperature (for cooling) and lower condensation temperature (for heating), what caused higher values of *COP* and *EER*. The fact contributes to system energy advantage. Project solution is proceed in following steps:

1) Design of capillary systems for heating and cooling in the particular rooms. Capillary mats are installed on the ceiling, walls and the floor
2) Design and research of the air – water heat pump for heating and cooling with capillary mats
3) Producing of the air – water heat pump.

4) Realization of experimental set-up and testing of heat pump
5) Installation of capillary mats into the rooms including the pipeline and heat exchanger
6) Connection of the heat pump with the cooling and heating system
7) Design and realization of the measuring and monitoring system for measurement of energy balances and indoor thermal conditions
8) Evaluation of the measurement and energy efficiency of realized system with air - water heat pump and capillary mats

The main goal of the project is to develop and test energy efficient system of heating and cooling for domestic, office and other spaces, which make use of heat pump and large capillary mats system advantages. For this purpose the experimental arrangement was carried out. The system with air – water heat pump will be tested in the real house and during the year 2008 the energy balances will be monitored.

Solution mentioned above was not realized in the Czech Republic. It contributes to positive improvement of heat pumps with high coefficient of performance *COP* and efficiency of energy recovery *EER* and also the new energy efficient heating and cooling systems. The solution contributes to more expansion of renewable resources of energy.

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Active Power Filter Inverter Construction

J. Pelán

pelanj@fel.cvut.cz

Deparment of Electrotechnology, Faculty of Electrical Engineering, Czech Technical University, Technická 2, Praha 6, Czech Republic

Power quality becomes more and more often the object of concern. Where it is not possible to reduce emitted disturbance, it is necessary to add some means to reduce disturbance propagated to the electric energy distribution system as well. The range of these means is very broad. From simple passive reactive power compensation and harmonic filters over thyristor based devices to modern IGBT power converters used for active enhancement of power quality. The full active solutions in general are smaller and have the best efficiency in terms of interference compensation compared to passive solutions but they are still less efficient in terms of losses and cost as well. As a matter of compromise, various hybrid topologies are under research.

Line current harmonics cause many problems in the power supply grid as for example line voltage distortion due to the voltage drops caused by current harmonics or lowering the network power transfer capability due to the lowering of power factor. There are two ways to prevent the problems. First, lower the emission of harmonics at the source, and second, add a filtering device to filter out at least the most prominent or preferably all harmonics.

There ale also legal issues connected with this problem. In the EU there are two standards which deal with harmonic distortion of the line current – EN 61000-3-2 for devices with nominal current up to 16 A per phase and the EN 61000-3-12 for devices up to 75 A per phase. Also, due to the European directive 2004/108/EC the EMC has to be considered not only for single devices but also for a fixed installation as a whole. A power filter can take care of one or more harmonic sources.

Power filters are divided into three groups according to their working principle – active, passive and hybrid. Each of these groups contains two subgroups named by the type of connection to the main circuit – series or parallel. Hybrid power filters are usually labeled series or parallel with regard to the active part of the system.

Traditional passive filters based on tuned LC circuits are relatively inexpensive, easy to manufacture and can be also used for reactive power compensation of inductive loads. On the other hand, they take up significant space, they can not be controlled and may cause parasitic resonance in the mains.

Since the 1970s specially controlled semiconductor inverters are being used as active power filters (APF) [1]. Among the advantages of the APF one could mention their flexibility. Their control strategy allows for compensation of changing loads. Due to their flexibility they are able to compensate other negative influences as well, for example reactive power, commutation notches, and flicker. The filtering efficiency is usually better as well. Possible wide use of APF is restricted due to the lack of high power high voltage semiconductor switches for the medium voltage level. This can be overcome by using additional transformers and multilevel or cascaded converters. The greatest disadvantage is their high price compared to passive filters with the second being higher power losses.

Hybrid power filters are often considered a good price-to-performance ratio. The main advantage is that the semiconductor converter does not have to be dimensioned on the full harmonic power, but only for a fraction of it. This leads to lowering the initial cost of the

system. This solution has all advantages of their active counterparts with one exception – due to the passive part, the physical dimensions are higher.

The aim of this project is to support the long term research project by building a scaled-down model of a grid-filter-load system, which would allow for experiments with various all active and hybrid topologies as well.

To build such a system, at least four subsystems are needed. First, it is necessary to have a reliable power supply, which is able to provide clean grid power to the system. Line voltage is under normal conditions distorted, with figures of 5 % THD being not exceptional. Distorted line voltage influences the harmonic spectrum of the load current, so this is unacceptable. Therefore, a three phase switch mode power supply with capacity up to 9 kVA by California instruments is used. This power supply has also variable output impedance which is useful for simulating various line conditions. It also allows for perfect repeatability of the experiments.

The second subsystem is a passive harmonic filter. In this case it consists of four tuned LC circuits per phase. The tuning frequencies are equal to the 5^{th}, 7^{th}, 11^{th} and 13^{th} harmonic. Each stage consists of a capacitor bank of fixed value and an iron core inductor. It is possible to fine tune the stage by changing the air-gap width on each inductor.

The third subsystem is a three-phase three leg semiconductor inverter. It is constructed from intelligent IGBT modules by Toshiba, which contain integrated gate drivers. The inverter allows for up to 900 V DC link voltage which is necessary for some of the intended applications (e.g. a parallel active filter). It is built up on a heat-sink and it further contains all necessary equipment (voltage and current sensors, gate supply sources, etc.). If necessary, this module can be supplemented with a coupling transformer for series power filter applications.

This power module is controlled by a real-time control system CompactRIO by National Instruments. The supplied software LabView allows for easy programming using blocks similar to SIMULINK, which is widely used for simulations in the industry.

The last subsystem is the load. The basic non-linear load is a bridge rectifier with capacitor as a filter at the DC side. This kind of load was chosen because it is a part of a large number of drive systems and it is also usually used in switch-mode power supplies.

Such a system is useful for fine tuning of control algorithms for many applications, mostly for active and hybrid power filters. It was built as a follow-up to the author's previous work – simulation of power filters. Details can be found for example in [3] or [4].

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Analyses of Energy Conservation Posibilities in an Opencast Coal-Mining Conveyor by means of Continuously Controlable Drives

K. Buhr, P. Tušla , J. Janoušek, J. Lettl

buhr@cvut.fel.cz

*Department of Electric Drives and Traction, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

It is the well known fact that in the opencast mining systems the inconsiderable part of the expenses is connected with the material transport. It is significant especialy in case of the coal-mining where the major portion of the transported material is the overburden removal. In the EU condition as the most widespread-mode of the opencast mining transport systems the long distance belt conveyor with high power electric drives are used. The length of the conveyor lines continuously increases. In the present-time their current length is anywhere given in thousands of meters and tens of kilometers of lines are in state of the project.

There are two ways of the energy consumption diminution. The first one consists in the movement resistances reduction, the other one consist in the belt velocity adaptation to the belt transport capability:

$$v = \frac{Q}{O_p} \qquad [\text{ m/s, kg/s, kg/m}]$$

where Q is incoming flow of the material to the belt conveyor

Op is the belt conveyor transport capabily

The second way is simultanously the method how to reduce the passive movement resistances of the belt, i.e. their partition on the total belt conveyor resistance.

On presumption that the load of the conveyor is invariably nominal, its velocity is also nominal and no savings can be achieved by using the controlable drive. On the other hand for the zero load the conveyor can be stopped and full no-load conveyor performance which is usually 25-30 % of the nominal power rating (for the case of horizontal disposition) can be saved. In fact the ratio of a really transported quantity of the material in comparison with the nominal transport capability is usually in range from 35 to 50 %. This relatively poor ratio is caused by the wheel excavator mining technology character. For the reason given above the continuously controlled electric drive is the most suitable solution from the point of view of the energy cost savings.

Calculation of the annual energy consumption is made for the unitary belt conveyor with the length of 1000 m and the width of 1800 mm for various inclination and 25 % capacity utilisation. For the horizontal disposition of the conveyor trajectory (0 % inclination) the energy savings of the continuously regulated drive in comparison with a non regulated drive can reach from 30 % to 40 %. Of course on the presumption that the drive has been regulated economicaly, which is the case of modern drives with the squirrel cage induction motors fed by PWM converters.

If the length of the belt conveyor is long, in a mode of starts or load changes the transient phenomenon occures. The optimal method of investigation of the transient phenomenon is a simulation on models. In this paper a mathematical model of the great conveyor with pull back station respecting antislip protection is described. The start or conversely the stop of the conveyor is for the continuosly controlled drive a current operational mode. Therefore a model like this is very useful for simulation of diverse situation such as the fully loaded start of conveyor, the step change of load e.t.c. Because in time of the excavator wheel manoevre the conveyor is no loaded, it can be extremely significant in the energy savings point of view.

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Progressive Approach to Matrix Converter Voltage Control

J. Lettl, S. Flígl

lettl@fel.cvut.cz

Department of Electric Drives and Traction,
Faculty of Electrical Engineering,
Czech Technical University in Prague,
Technická 2, 166 27 Prague 6, Czech Republic

Much more frequently than in the case of any other converter, the maximum achievable voltage transfer ratio is mentioned in papers concerning matrix converters. This is mainly historical in nature since early methods achieved rather small output voltages and even today the matrix converter is still disadvantageous from this point of view in comparison with indirect frequency converters. It is very important to obtain a voltage of value close to the mains voltage. If the output phase-voltage wave form is deformed in a proper way so that the line-voltage remains sinusoidal, the voltage transfer ratio can be improved to 0.866. This can be done, since the common mode voltage (one third of the phase-voltage sum) ideally does not influence the machine behaviour when the neutral line is disconnected. The ratio of 0.866 is the same ratio, which we obtained implicitly from the indirect space vector modulation. Nowadays, the number $\sqrt{3}/2 \cong 0.866$ has become a more or less obligatory part of any article relating to the matrix converter.

Indirect space vector modulation strives to generate a desired output voltage vector (in a harmonic steady state with a constant amplitude $|\underline{u}_{out}|$ rotating with a constant angular speed ω_{out}) and simultaneously to take from the mains current a space vector that keeps a constant angle φ_{in} towards the rotating filter output voltage space vector at $\omega_{in} = \omega_{mains}$ (i.e. a constant input displacement factor of $\cos \varphi_{in}$). The indirect space vector modulation is based on the idea of the virtual dc-link. The converter can be seen as a combination of a rectifier and inverter part. The space vector theory applied to the rectifier leads to the well known formulas that determine necessary switching times given by $d_{\underline{\alpha}}$, $d_{\underline{\beta}}$, $d_{\underline{\chi}}$, $d_{\underline{\delta}}$. The current modulation index is proposed to be kept constant by most authors. But, the current modulation index influences the virtual DC-link voltage and subsequently the output voltage also. Irrespective from the particular voltage adjustment method, the maximum available voltage transfer ratio seems to be 0,866.

However, it is known from the area of indirect converters that a motor can be fed from a non-sinusoidal voltage source. The decisive parameter to the motor is then the first harmonic component of the delivered voltage. In the next considerations we assume the input displacement factor to be equal to one. Then when indirect space vector modulation is employed, the voltage in the virtual DC-link is constant and can be regulated from zero to 0.866 of the input voltage maximum value. The amplitude of the output line-voltage can be regulated from zero up to the voltage value in the virtual DC-link. In an indirect converter with the included energy storage of huge capacity and with a diode rectifier on the input side, the DC-link voltage can be very close to the input line-voltage amplitude. However, it would be connected with a very deformed input current waveform. In other cases the DC-link will be slightly smaller. So, such a converter can produce a sinusoidal output line voltage with

amplitude nearly equal to the mains voltage. In the worst case if the rectifier diodes should carry the current all the time, the DC-link voltage would be given by the average value of the waveform covering absolute values of the input line-voltages.

From the theory of inverters it is known that the maximum output voltage can be achieved when a square waveform is employed. The amplitude of the first harmonic component can be determined by means of Fourier transformation which from an algebraic point of view is simply scalar multiplication of the analyzed function with the basis component divided by scalar multiplication of the basis component with itself. Such modulation can be easily achieved by a modification of the indirect space vector modulation. If in each step we compare d_{α} with d_{β} and set the larger one to unity and the smaller one to zero, the output voltage vector will move with steps of 60° which correspond to generating a square wave form output voltage. Moreover, in contrast to an indirect converter equipped with a diode rectifier, here the virtual DC-link voltage can be adjusted in any regulation step by means of current modulation ratio and thus a continuous regulation of the output voltage amplitude up to the limit is trouble-free. As far as the indirect converters are concerned, different switching patterns synchronized with the first harmonic component and similar to square wave modulation have been introduced because of this reason and the reason of power loss minimization as well (star modulation, hexagon combination with zero vectors, etc).

For smaller voltages the sinus-wave indirect space vector modulation can be used, while the current modulation index is set to its maximum and the output voltage amplitude is controlled by the virtual inverter part. When the voltage limit is achieved, the output square waveform modulation can be employed. The current index must be immediately decreased so that the output voltage retains its amplitude from the previous modulation. Next, by increasing the current modulation index the output voltage can be enlarged up to the limit 0.955.

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Analysis of voltage source possibilities for Multilevel Inverter

O. Sivkov, J. Pavelka

ollerrg@seznam.cz

Department of Electric Drives and Traction, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

This contribution analyses a possibility for realization of multilevel inverters. After general description of all famous solutions, the focus is paid on Diode Clamped Multilevel Inverters (DCMI) and Flying Capacitor Multilevel Inverters (FCMI). The comparison of topological structure and control strategies is presented. The special focus is paid to balancing of voltage on divider capacitors. Capacitor voltages balance in higher-level DCMI (more than 3) generally is not able. FCMI control strategy is possible for all levels. Values of capacitors for both types of inverters are determined and compared.

Four solutions for multilevel inverters are used. They are:

a) multilevel inverters with magnetic coupling (special multi-winding transformer);
b) independent sources for each level;
c) level voltage stabilization using other auxiliary power circuits;
d) switching control strategy for own multilevel inverter devices

This paper analyses two of the most popular types of three-level inverters with switching control strategy (ref. d)). They are Diode Clamped Multilevel Inverter (DCMI) and Flying Capacitor Multilevel Inverter (FCMI) for three levels.

The simplest diode-clamped three-phase three-level inverter consists of 4 switching devices, 2 clamping diodes for each phase and of and 2 common source capacitors. This topology can ensure three voltage levels. The switching state of inverter is –1 when two lowest switches are ON; +1 when two highest switches are ON and is 0 when two middle switches are ON.

The switching states of three-phase three-level inverter can be represented by a space vector diagram. Triplet number in this diagram defines the switching state of three phases for demanded voltage vector. Some voltage vectors can be obtained by two or three triplets. The number of possible vectors is 19 and number of triplets is 27. That allows to choose triplets according to another condition, for example, stabilization of capacitor voltages.

One-phase of three-phase three-level Flying Capacitor Multilevel Inverter consists of 4 switching devices and 1 capacitor. In comparison to three-level DCMI The flying capacitor is connected as the bypass to middle switches in each phase. The total number of flying capacitors is therefore three. That's allows to stabilize capacitor voltage in each phase separately. The zero level on output is the difference of supply voltage and capacitor voltage. The switching states of switches are ON or OFF and of three-level inverter output voltage are –1, 0 and 1.

Possible switching states of one phase of three-level FCMI are four. The output voltage of the phase is –1 when two lowest switches are ON. The output voltage of the phase is +1 when two highest switches are ON.. The output voltage of the phase is 0 when odd or even switches are ON.

The switching state defines a behaviour of the flying capacitor voltage. If the output voltage is +1 or -1 then the flying capacitor voltage doesn't change. If the output voltage is 0 then the flying capacitor voltage changes depending on a direction of the capacitor current. The present switching state can be only changed to a state that is connected to it by a

bidirectional bond corresponding to a level changing in the output voltage waveform. It is seen that by each change to zero level is possible to choose the capacitor voltage increasing or decreasing.

The control strategy of three-level DCMI determines the required vector position of output voltage. The basic idea of capacitor voltage balancing strategy is to choose better triplet from possible triplets from the criteria of capacitor voltage stability.

Control strategy of FCMI differs from DCMI in that a capacitor voltage is balanced in each phase of inverter independently and therefore it can be considered in one phase. Zero level is ensured in two states when the current flows through the flying capacitor. When the output inverter voltage is equal to zero the capacitor can be charged or discharged depending on the current direction.

Above mentioned control strategies were studied and more details will be presented on the poster.

The comparison of common capacitor values for both inverter connections are studied at present time.

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MATRIX CONVERTER MODULATOR AND COMMUNICATION WITH REGULATOR

P. Pošta, J. Lettl

postap1@fel.cvut.cz

Department of Electric Drives and Traction, Faculty of Electrical Engineering, Czech Technical University in Prague, Technická 2, 166 27 Praha 6, Czech Republic

Introduction:

The matrix converter is a direct frequency changer. This converter consists of an array of n×m bidirectional switches arranged so that any of the output lines of the converter can be connected to any of the input lines.

Modulator:

For the matrix converter, which is being developed on the Department of Electric Drives and Traction at the Czech Technical University in Prague, were chosen modules including 3 bidirectional switches in common emitter configuration. Thus the modulator is realized for these switches [3].

For switching is important to choose an efficient switching algorithm. For this modulator was chosen four-steps switching driven by input voltage. For this method is necessary to know the polarity of voltage between input lines. The advantage of this algorithm is its simplicity and its possibility of driving even by low current values. The disadvantage is larger commutation time [2].

Modulation:

In the matrix converter is used Indirect Space Vector Modulation (ISVM). We can imagine the matrix converter as the indirect frequency converter with virtual DC link. We can imagine the virtual indirect converter in different ways. The most spread is out variant with three two-state switches in the inverter and three three-state switches in rectifier. Thanks to this we can use some processes well known from classical indirect frequency converters.

It is necessary to ensure the right timing for command switching and generate guard delay and then the switching in the right moments. We reached this by adding or subtracting the given times of switching combinations and compare them with values of saw courses.
Thanks to the proper switching combinations it is possible to reduce the necessary number of switching IGBT during one switching period [2].

Communication:

Switching command and times of switching combinations are sending from superset regulator per PC 104 bus. All PC 104 bus signals are identical in definition and function to their ISA counterparts [4]. Signals are assigned in the same order as on the edgecard connectors of ISA, but transformed to the connector pins.

The matrix converter modulator was programmed in VHDL language and consists of several parts. First part ensures the right switching signals for IGBTs and is puts the guard delay between the separate switching steps. Second part ensures the generating of switching commands at their right time. Other parts ensures communication. There are realized several registers in FPGA and each of them has its own address. Some registers are “read only”, some “write only” and some “read and write. In modulator is one state register which is clear after

read. The information about state of modulator and values from A/D converters can be read due to superset regulator. Regulator can write to the modulator switching command and times of switching combination.

Modulator has mode register which change its function. This is necessary for testing of this modulator and possibility of changing HW of superset regulator. Superset regulator is one desk PC with the PC 104 bus from RTD or Kontron. During the test communication we found that the one desk Kontron PC read from PC 104 bus in 16 bit mode in different way that is described in the universal bus specification. When we want read 16 bit from PC 104 bus we have to read only even addresses. Due to the fact that one desk PC from Kontron read first from even address and after that from address + 1 which is odd address, special bus handling has to be implemented for this one desk PC. Setting of this bus handling is enabled thanks to mode register.

Summary:

Inputs of the modulator are data of superset regulator. Outputs of the modulator are error messages for superset regulator and driving signals for IGBT drivers. The matrix converter modulator was programmed in VHDL language. Thanks to this it is possible to realize the whole modulator in FPGA circuit. FPGA circuits are characterized by high speed signal processing and they have a lot of high speed inputs and outputs. We can control the switching element, operate A/D converter, and mediate communication with superset regulator per PC 104 bus by means of this circuit. FPGAs use parallel processing. Because of this it is possible to react to input signals in the time shorter then 10 ns.

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Experimental Results Measured on Matrix Converter Drive System

Jan Bauer - Jiří Lettl

bauerj1@fel.cvut.cz

Department of Electric Drives and Traction, Faculty of Electrical Engineering, Czech Technivcal University, Technická 2, 166 27 Pragu 6, Czech Republic

Introduction

The matrix converter belongs to the category of direct frequency converters. Its beginning goes to the late seventies. The converter is composed from nine bidirectional power switches. Output voltage is constructed from input voltages by means of direct switching of input phases to output phases. This fact means that the converter does not need DC link. The absence of DC link capacitors or inductors is one of the main advantages of the matrix converter, on the other side it means that output voltage amplitude is limited to 86,6 % of the input voltage amplitude. Higher voltage could be achieved with overmodulation only, which causes the input current distortion. Other advantages of the matrix converter against conventional indirect frequency converters are: its high power factor, possibility of broadband frequency and voltage control, ability to work in all four quadrants, high dynamics, sinusoidal currents consumption, almost sinusoidal output voltage waveforms, with low harmonic content, and high efficiency. To the main disadvantages belongs: number of semiconductor devices, limited output voltage amplitude, and complicated control algorithms.

The matrix converter system consists of the four main parts:

- bidirectional switch matrix, formed from IGBT transistors with anti-parallel diodes,
- input filter, that is responsible for EMC interference rejection,
- control system, which drives IGBTs and takes care of the proper matrix converter system function,
- clamp circuit, which is not necessary, but it saves semiconductors from destruction in failure conditions.

Measurements

Measurements were made to find out the operational behavior of matrix converter induction motor drive and to prove the accuracy of matrix converter model, which was made in Matlab-Simulink. The converter was supplied from 3 x 400 V mains. The power analyzers NORMA D500 were joined to the input side of the matrix converter as well as to the output side, where the digital oscilloscope TEKTRONIX with current and voltage probe was employed, too. Power analyzer NORMA D 500 can take measurement of electrical variables and is also able to perform the harmonic analysis of the measured waveforms. An induction motor of 5 kW was coupled on and a DC dynamometer was used as a load.

Important measured values are resumed in Table 1. The values of apparent power, motor power, and efficiency were computed from the measured values. The motor efficiency is lowered with choking coils connected to the motor terminals to protect stator windings from voltage strokes. However, the drive efficiency stays high (about 94 %). Measurements were taken for both motor and generator operation regimes. In table the generator regime of the drive is represented by the negative sign. From the table can be clearly seen that voltage and current on the supply side of the converter are in phase.

The waveforms taken by the oscilloscope were compared with the waveforms that were obtained by simulation using mathematical model created in MatLab - Simulink. The

similarity of these waveforms could be seen brightly. Also the ability to perform harmonics analysis was utilized and analysis of input currents and voltages were taken. Very good harmonic composition of the waveforms was proven.

	Nr.	f (Hz)	U (V)	I (A)	P (kW)	Q (Var)	cos φ	M (Nm)	RPM
Converter output	1	39.97	261.04	5.28	547.78	4101.30	0.13	0.00	1196.00
	2	39.97	256.68	9.66	3839.40	6379.10	0.52	25.00	1150.00
	3	39.95	251.53	19.56	7642.20	12629.00	0.52	47.70	1056.00
	4	39.96	266.97	8.82	-2536.20	6595.80	-0.36	-25.00	1230.00
	5	40.00	267.87	10.91	-3596.20	7997.50	-0.41	-35.00	1242.00
Converter input	1	49.41	230.55	1.18	647.99	-500.13	0.79		
	2	49.81	229.71	5.92	4057.80	-405.27	1.00		
	3	49.97	228.32	12.17	8310.80	618.75	1.00		
	4	49.94	232.08	3.55	-2357.60	-748.02	-0.95		
	5	49.97	232.69	4.95	-3345.20	-859.75	-0.97		

Table 1 - Measured values review

Summary

The matrix converter is very popular topic today. Until now it has attracted mainly academic attention. It has many advantages in comparison with indirect frequency converters. As shown in this paper, the matrix converter works at high efficiency and without harmonic distortion both on the input and on the output side. The only problems are caused by the control system and by real-time control algorithms. However, new control strategies are developed, so we expect solving of these problems in recent time period.

The measured results obtained on the built-up experimental test bed have proved the proper function of the designed conception of the matrix converter control system and implemented PWM strategy.

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Compensation Capacitor Temperature Monitoring

P, Mindl

mindl@fel.cvut.cz

ČVUT-FEL, katedra elektrických pohonů a trakce, Technická 2, 166 27 Praha 6

Operational reliability of electric power network is very important phenomenon. It is based on reliability of each network component. For power transmission efficiency very important role plays compensation capacitors banks, used for inductive loads reactive power compensation. Because compensation capacitor is not ideal, partial active power loses in capacitor are produced. It results capacitor temperature increasing and risk of dielectric breakdown. Therefore capacitor temperature state monitoring is one of diagnostics possibilities. But monitoring, based only on capacitor tank surface temperature measurement is insufficient. Very important in this case is temperature distribution in capacitor volume. Capacitor temperature profile prediction is possible, but practically complicated due to unknown parameters of mathematical model. Therefore basic experiments focused on compensation capacitor bank temperature profile and power loses measurement has been arranged.

For capacitor temperature profile experimental investigation a two special capacitors with temperature measurement probes were made. Each capacitor was equipped by two "K" thermocouple temperature micro-sensors type 5TC-TT-K-36-36 situated across aluminium and polyethylene foil roller. Three PT 1000 micro-sensors were situated on both sides of capacitor cover and in the middle of capacitor. Each micro-sensor was electrically insulated from the aluminium foil and connected to the metering unit.

Measured capacitors were filled by different type of internal insulating media.

The first capacitor was filled by insulating gel, the second one by nitrogen (N_2) gas.

During measurement were capacitors connected to the AC power supply. Roller temperature profile was established in voltage range from 200V up to 500V under external temperature stabilised in range 22 – 50°C.

On the basis of experimental results mathematical model for capacitor internal temperature distribution was evaluated. Mathematical model for heat transfer is based on electrical equivalent circuit with "lather structure" with internal additional sources representing internal power losses. Heat transfer between two points in the capacitor roller is given by formula

$$\Phi = \frac{\upsilon_1 - \vartheta_2}{R_\vartheta}$$

Where: υ_1 ... temperature of point 1
υ_2 ... temperature of point 2
R_υ ... temperature resistance between points 1 and 2

Differential temperature resistances of capacitor elementary volume with length l and cross-section area S is:

$$dR_\vartheta = \frac{1}{\lambda}\frac{dl}{dS}$$

This formula is adapted for cylindrical shape of capacitor roller. Heat flow in radial direction is expressed by formula:

$$R_{\vartheta} = \frac{\ln \frac{r_2}{r_1}}{2\pi \lambda h}$$

Due to different temperature properties of insulating media (gel, N_2) the shape of roller temperature profile is rather different for each measured capacitor.
Determination of the capacitor temperature profile under different external temperature and operational voltage conditions only by means of surface temperature and power loses monitoring seems to be good method for capacitor durability prediction.
For presented experiments especially diagnostic assembly was built. Obtained results are applied in development of the new types of compensation capacitors and are practically used.
Next investigation will be focused on the capacitor temperature profile under different ambient temperatures and investigation of high order harmonics currents influences. Although more sophisticated and automated measuring and diagnostic system is developed. Detailed analysis of power loses under high order harmonics currents load is prepared.

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Section 10

NUCLEAR ENGINEERING

Concept of monitor small amounts of uranium and plutonium in solid materials

M. Košťál *, F. Cvachovec **, B. Ošmera ***

Kostal@troja.fjfi.cvut.cz

* Department of nuclear reactors, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University, V Holesovickach 2, 180 00, Prague 8, Czech Republic

* VF Instruments, Brnenska 68, 679 21 Cerná Hora, Czech Republic

** Military academy, Kounicova 65, 612 00 Brno, Czech Republic

*** Nuclear research institute Rez, 250 68 Rez near Prague, Czech Republic

Neutron and photon flux behind target is proportional to the flux in the front of target and respective cross section of target material used. Knowledge of flux in front of target and behind target can be used to verify cross sections content in nuclear data libraries. In order to obtain the relevant theoretically comparable data, there is a need of adequate physical model. Essential part of this model is a source neutron beam description. The most rigorous approach includes a source described as a reactor, as in a real case. On one hand, this is a realistic approach and geometrically it's the best one. On the other hand, a convergence of this model is so slow, that from computable point of view, this way is useless. This problem arises when the transport through thick target is solved. The acceptable way should be to use neutron beam with well defined energetic distribution, angle distribution and particles divergence.

An experimental reactor AKR-2 is used as a source. It is not a pure neutron source, but a mixed neutron photon source. AKR-2 is a homogenous reactor with reactor core from mixture of polyethylene and uranium enriched to 20% 235-U. This core shape is cylinder 25cm in diameter and 27cm high and is all surrounded by graphite reflector. All is surrounded by paraffin as neutron shielding and concrete as a biological shielding. From the center of reactor core a radial channel going through shielding into free space is ducted. In these experiments, the fluency behind material is measured. The sample is placed to axis of radial channel, 10cm after the end of biological shielding. This means, that good beam definition is necessary at this point (that mean at point at channel axis, 10cm from shielding). As samples are used iron and water plates of different thickness.

Because of big fluency of particles, and small cross sections in adequate energetic regions, we may neglect albedo and elastic scattering from construction material. With this approximation we can describe this neutron beam as a current of particles emitted from point source into defined spatial angle.

Position of this point is an essential parameter. This point is located in geometrical focus. Distance should be the same as distance between focus of the beam and measuring point. This parameter is fixed by shapes and proportions of reactor core and radial channel. This is the geometrical way, with non scattering approximation. The second approach is experimental. It was measured flux intensity in 2 points. First was located 10cm from, second one 1m from end of shielding both located at axis of radial channel. The ratio between fluxes at these points should be the same as ratio between inverse values of distance these point from

focus. Both results were compared, and relative difference between geometrically and counted data was less than 0.6%.

Spatial angle have only small importance. This effect could be adjusting by adequate normalization. The reason is to reduce the variance, and to reduce the computation time.

Energetic distribution may be defined as measured channel leakage spectrum, or may be counted. When counted, reactor as source is used. To obtain relevant results, there are more possible ways. Tally F4 or tally F5. The main difference is in result estimation. Tally F4 uses track length estimation. This tally should be used under all conditions without limitations. There are no restrictions when using tally F4 for scattering matter. By reason that as contributions are proportional to lengths, if only small fluxes are present, the convergence is very slow. Tally F5 uses semi empirical formula, which enables it to count all scatter to value. This ensure fast converge even if a thick target is used. But, as everything else, this approache has not only advantages. The main disadvantage is a bad convergence in scattering matter. In this case, ambient was filled by air. Because of very long neutron diffusion length in order of kilometers for air, non scattering approximation was used. Nevertheless, both approaches were used. As expected the data obtained with different tallies differ only in statistical error counted.

The neutron and photon spectra were measured and counted at the horizontal channel of the Dresden University reactor AK-2. The measurements have been performed with the multiparameter spectrometer [1] with stilbene cylindrical crystal 10 x 10 mm and 45 x 45 mm; the neutron and photon spectra have been measured simultaneously with the 45 x 45 mm crystal. The calculations were performed with the MCNP code and nuclear data libraries ENDF/B VI.2. For this purpose, this library is fully sufficient for calculations [4].

For neutrons above 1MeV, where relevant evaluated interval begins, a good correspondence between calculated and measured data is achieved. In wide groups, the differences are less then 5%. Only in energetic window 3-5MeV the error concurs is about ~10%.

In results of photon fluxes, the situation is different. The correspondence achieved is only rough. The reasons are two. First, in these spectra occurs narrow peaks, and stilbene broaden it. And the second is, that in MCNP are not counted delayed gamma ray production.

It appears, that neutron beam can be described with measured spectra or calculated spectra. Photon beam energetic distribution is suitable to be described with calculated data, supplied with adequate normalization.

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Section 11

CHEMISTRY

Toxic wastewater treatment - Fenton reaction

Š.Tutter, P.Ditl, J.Nápravník

stepan.tutter@fs.cvut.cz

CTU in Prague, Faculty of Mechanical Engineering, Department of Process Engineering, Technická 4, 166 07 Prague 6, Czech Republic

New methods of toxic wastewater purification need to be found in industry as the traditional procedures are ineffective. This water contains mostly toxic, excitable, explosive or environmental unfriendly materials. Most of these substances are either very difficult or not biological degradable at all. To use the AOPs (Advanced Oxidation Processes) is the solution. Most of AOPs generate free hydroxyl radical. These radicals can be generated by chemical reaction, electrochemically or by using UV irradiation.

Fenton process and its various modifications also belong to AOPs technologies. Fenton processes generate free radicals by chemical reaction. This reaction involves the use of one or more oxidizing reagents and metallic cations - catalyst. Degradation of this reagent produce hydroxyl radicals, hydrogen peroxide is usually used. Metallic cations are batched by electrolytic anode dissolving. This process is controlled by Faraday law. The advantage of this application is that the amount of dissolved iron is exactly regulated. Moreover, the pollutants are oxidized at the anodic area.

Fenton processes have many limitations. One of these limitations is an acidic background. In neutral or alkali background the reaction is either much slower or does not work at all. The other limitation is with substances, which can be degraded by these reactions. Some substances are not oxidized by Fenton reaction, e.g. acetone. The other disadvantage is the possibility of water toxicity increasing within the reaction. That is why it is necessary to know all the oxidation levels. Many times these levels are unpredictable mainly when more substances are present.

The aim of all experiments is to obtain all necessary parameters to design the reactor which is based on this technology and which would be able to use in waste water treatment plant in various branches of industry.

All measurements were carried out in transparent cylindrical vessel with flat bottom. The vessel was equipped by four radical plastic baffles. Pitched six blades impeller covered in Polyurex layer was used to homogenize the batch. The pH and redox values were measured by two probes. DC source was used and the temperature was measured by mercurial thermometer. The chemicals were of G.R. purity. Model solution consisted of demineralized water and phenol. The solution volume was 1,5 l. Chemical oxygen demand was used for comparison of all measurement. Electrode pairs were made of dissolved iron anode and a cathode cell made from titanium.

In the paper [2] there was the influence of the surrounding temperature discussed. And the lower temperature at the beginning of the reaction the more convenient is the process. In some cases the purification was even by 50% efficient.

The adding of hydrogen peroxide at the beginning of the process causes the process more effective. pH increases by Fe^{2+} dissolving and that is why the efficiency decreases. The comparison of various electrolytes according to their properties was done in paper [2] as well.

The conductivity of the model wastewater was increased by adding inorganic salts, such as chloride or sulphate [1]. There were used two types of chlorides (potassium chloride and calcium chloride) and four types of sulphates (natrium sulphate, calcium sulphate dihydrate, cupric sulphate pentahydrate and aluminum sulphate hexadekahydrate). And in the paper [1] the costs of above mentioned electrolytes were discussed and compared. The calcium chloride is the most suitable electrolyte according to its properties and even to its costs.

The design of an apparatus for toxic wastewater is the aim of the experiments. Thanks to this apparatus the substances should be partly or fully degraded. After the degradation water could be treated by standard technological processes. The apparatus should not have a big trap circuit, due to apparatus low dimension.

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Study of Contaminants Leaching from the Fucoid Sandstone Samples originated from the Stráž pod Ralskem Site

L. Kraus, P. Franta*, V. Havlová*, B. Drtinová, K. Štamberg, D. Vopálka

lukas.kraus@fjfi.cvut.cz

Department of Nuclear Chemistry, Faculty of Nuclear Sciences anf Physical Engineering, Czech Technical University in Prague, Břehová 7, 115 19 Praha 1

*Nuclear Research Institute Řež plc, Husinec - Řež 130, 250 68 Řež

The in-situ leaching of uranium in the Stráž deposit, Northern Bohemia, was characterized by the injection of technological solutions containing sulfuric acid into underground layers of the Cenomanian age [1]. Since 1990 when the chemical mining was finished, monitoring and remediation of the contaminated area still continue. Aiming to control the spreading of the contamination from the Cenomanian into Turonian aquifer, which serves as the water source for a big populated area, it is necessary to describe also the potential transport of contaminants from the layer of fucoid sandstone. The preliminary study of the state and transport of contaminants present in the layer of fucoid sandstone performed in the year 2006 [2] enabled to prepare a complex research program of study that included various experimental and modeling approaches. The contents of the experimental study of fucoid sandstone samples, which were received from the state enterprise DIAMO, covered in the year 2007 batch and column leaching experiments, squeezing of the pore water from the sandstone material and diffusion of selected radioactive tracers into the compact block of the rock.

Leaching experiments were performed applying the batch technique. Individual samples No. 48541, 48544, 48547, 48550, 48555 and 48567 were taken from a different depth of fucoid core hole VP 8C 7095 (42 - 153 m). The mineral samples of the fucoid sandstone were mixed with cenomanian groundwater and distilled water as well. Solid to liquid ratio was V/m = 5 ml/g. The suspensions were shaken under ambient temperature for 1-5-24-120 hours. The velocity of the leaching kinetics was relatively fast for most of studied contaminants. Significant changes in behavior of all fucoid materials materials were showed after 120 hours of leaching, when pH dropped from initially value of 8.2 to approx. 3. This also indicates increasing concentration of dominant contaminants such as SO_4, Al, and Fe. From the observed results we can discuss the influence of porosity, mineralogical composition of rock samples, rinse of technological solutions from in-situ uranium leaching and other geochemical processes including interface reaction, desorption, dissolution etc. Comparison of the results from all measurements indicates substantial heterogenous environment. For the verification of the amount of minority contaminants (e.g. As, Be, Ni, and U) the set of experiments were carried out. These experiments were realized under the same conditions as previous experiments. The analysis did not show the expected maximum concentration of studied contaminants and it confirmed the heterogeneity of the surroundings. The sequential extraction of six fucoid sandstone samples consisted from three steps (1. step: H_2O, 1 hour; 2. step: 1M $MgCl_2$, pH 7, 1 hour; 3. step: 1M CH_3COONa, pH 4.8, 5 hours). The differences among results corresponding to different samples characterized by the depth of the hole were not significant on the contrary to leaching by cenomanian water, where samples could be divided into two groups with respect to the rate of Al and Fe leaching. The smaller total

amount of leached Al and Fe obtained by sequential leaching in comparison with longer time leaching by cenomanian water indicated the dissolution of some minerals containing Al and Fe.

The dynamic leaching experiment was performed with the sample No. 48471 from the core hole VP 13B7051, which had the permeability 10^{-7} m/s and a lower contamination characterized by the presence of 1.5 g/l of dissolved matter in the pore water. The length and diameter of the cylindrical sandstone block were 20 cm and 13 cm, respectively. The pore volume of the block was about 530 cm^3, corresponding to the total porosity of 20 %. The uncontaminated natural cenomanian water (pH 8.2) was used as a leaching medium, the Darcy velocity used was about 1.5 cm/day. After eight months, during which about 15 pore volumes flowed through the porous rock block, the pH value of the water changed from 1.53 to 5.55. On the curve describing the pH change as the function of flowed liquid, measured by pore volumes (PV) of the sandstone block, can be distinguished several intervals in which the increase of pH value was diminished by some heterogenous reactions. The fast washing out of dominant contaminants, e.g. sulfates, corresponded to the results of batch leaching experiments. According to experimental data obtained (composition of both the pore water and the eluate, silicate analysis, Rtg-diffraction analysis) following likeliest effects and reaction were selected for the model description of the leaching behaviour if the layer of the fucoid sandstone: desorption of H^+ from the solid phase, transformation from HSO_4^- to SO_4^{2-}, transformation of jarosite $KFe_3(SO_4)_2(OH)_6$ into $Fe(OH)_3$, transformation of alunite $KAl_3(SO_4)_2(OH)_6$ to $Al(OH)_3$, dissolution of alunogene $(SO_4)_3.17\ H_2O$, jarosite and gypsum $CaSO_4.2H_2O$, and desorption of NH_4^+ with the subsequent oxidation by the aerial O_2 to NO_3^-.

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RADIATION REMOVAL OF IONIC FORMS OF LEAD AND CADMIUM FROM AQUEOUS SOLUTIONS - SUMMARY

B. Drtinová, M. Pospíšil, V. Čuba*

barbora.drtinova@fjfi.cvut.cz

CTU, Faculty of Nuclear Sciences and Physical Engineering, Břehová 7, 115 19 Prague 1, Czech Republic

*CTU, Centre for Radiochemistry and Radiation Chemistry, Břehová 7, 115 19 Prague 1, Czech Republic

Due to extensive contamination of the environment with heavy toxic metals, more efficient and economically more convenient methods of their removal from wastewater and groundwater are pursued. The utilization of ionizing radiation for radiation removal of heavy metals from aqueous solutions could be a possibility in this case. This application could be ecological, less time-consuming, and requires a rather low number of partial operations, if compared with conventional chemical methods of heavy metal removal [1,2]. The aim of this work is to investigate whether and under what conditions picked heavy metals can be removed from aqueous solutions under irradiation.

The radiation removal of lead (100 mg/L) and cadmium (100 or 27 mg/L) from aqueous solutions in presence of different scavengers has been investigated.

The free, non-complexed lead (100 mg/L) can be completely removed from aqueous solutions (pH ~ 5 – 6) containing OH radical scavengers (1×10^{-2} mol/L of potassium formate HCOOK) already at the dose of 2.5 kGy. The radiation removal of lead is slightly influenced by the presence of some solid modifiers (zeolite, Cu_2O) and enhanced by bubbling with N_2O.

The cadmium requires dose of 15 kGy to be removed from the system containing 1×10^{-2} mol/L of HCOOK.

The experiments show that in acidic solutions, the EDTA complexed lead may be reduced at a dose of 30 kGy up to 92 % without the addition of typical OH radical scavengers such as HCOOK. The addition of OH radical scavengers as 1×10^{-3} mol/L HCOOK, 2×10^{-3} mol/L carbonate or 2×10^{-3} mol/L bicarbonate results in no further improvement but the efficiency is the same in such wide range of pH (3.2 – 9.5). The bubbling of the solution with nitrogen or oxygen also exhibits no positive effect. On the contrary, saturation with nitrous oxide in the presence of scavengers has a modest positive influence, whereas in the system which is scavenger-free, high negative effect (30 %) was observed. The presence of nitrate (e^-_{aq} scavenger) appears to be important for an effective removal of complexed

lead. The behavior of the system with citric acid complexed lead was very similar to the system with $Pb(EDTA)^{2-}$ complex.

The efficient removal of cadmium complexed with EDTA proceeds up to 90 % at dose of 45 kGy with an addition of 5×10^{-3} mol/L of carbonate as the OH radical scavenger and simultaneously pH buffer (pH 10). After irradiation, the cadmium is present in the final form of $CdCO_3$.

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Monitoring of Chloride and Sulfate Influence on Corrosion of Carbon Steel at Various Temperatures - Electrochemical Noise Analysis

D.Dobrev*, R.Silber*,, A.Vokál****

rostislav.silber@fjfi.cvut.cz

*Faculty of Nuclear Science and Physical Engineering, Department of Nuclear Chemistry, Břehová 7, 115 19 Prague 1
**Nuclear Research Institute, Řež plc

Czech Deep Geological Repository concept considers the carbon steel as a reference material for spent fuel disposal canisters. Lifetime prediction of these canisters is necessary for determination of the overall *performance* of HLW repository. The canisters would be deposited in granit and surrounded by a bentonit barrier. Their lifetime will be given by corrosion rate of construction material in depository conditions, such as composition of bentonit water, temperature and absence of oxygen in corrosion system. Corrosion rate will be determined not only by own reaction e.g. $3Fe + 4H_2O = Fe_3O_4 + 4H_2$, but also by transport rates both of depolarizer (H_2O) to steel surface and of corrosion product, mainly H_2, to corrosion medium. Rate of transport processes will be influenced by characters of corrosion products layers formed mainly during initial stages of corrosion process. Canister lifetime may be estimated by extrapolation of short-term corrosion data in modeled repository conditions collected from controlled laboratory tests, to long-term performance.

The corrosion tests developed in our laboratory comprise: direct measurement of corrosion rate at anaerobic condition by determination of hydrogen evolution rate at different temperatures, electrochemical methods like free corrosion potential monitoring, linear polarization resistance measurement and methods derived from electrochemical noise analysis (ENA), which is most notable among used methods [1].

ENA is based on measuring of potential and current fluctuations, generated spontaneously by the corrosion processes. Analysis of these fluctuations after spectral deconvolution provides information not only on corrosion rate (statistical polarization resistance), but also on characteristic of the corrosion process. Absence of external current or voltages sources which may perturb the electrochemical system and relatively simple and easy to be operated measurement system are main advantage of the electrochemical noise method. Measured signals can be mathematically processed. These techniques may contribute to evaluation of the mechanism of corrosion processes.

Previous ENA study [2] was concerned with the behavior of carbon steel in both pure water and aqueous solutions modeling repository conditions at various temperatures.

Aim of this study [3] is monitoring of chloride and sulfate concentration influence on corrosion behavior of carbon steel at various temperatures. Course of corrosion was detected by ENA method.

Deoxygenated synthetic bentonit water (pH=8, ionic strength=0,29, $c(Cl^-)=6{,}18.10^{-2}$M, $c(SO_4^{2-})=9{,}5.10^{-2}$M, ...) was prepared by degassing at boiling point temperature followed up bubbling with nitrogen. Anaerobic experiments were conducted at 40, 50, 60 and 70 ^oC. Corrosion cell comprises glass vessel (volume about 1,7 l) and plastic cover with electrochemical (pH, Pt, reference and steel electrodes) and temperature sensors.

Measurements were performed using two identical carbon steel wires (CSN 11 321) in short-circuit related to the reference electrode.

After some initial period - 6 days - (corrosion products layer formation), simulation of chloride and sulfate concentration influence was performed by injection of defined amount of saturated sulfate or chloride deaerated solutions. After that the electrochemical response of the corrosion system was detected.

For ENA was used PC4/750 Potentiostat/Galvanostat/ZRA analyzer with the evaluation software ESA 400 (Electrochemical Signal Analyzer version 2.01) from Gamry Instruments. TDC 2 (Temperature Controller) with controlling unit Watlow series 988 PID was used for temperature operations.

Surface morphology and surface layer analysis of exposed samples were performed by scanning electron microscopy VEGA TS 5130 XM with X ray analyzer INCA ENERGY 350.

Signals of the potential difference and the short circuit current are sources for time-dependence of free corrosion potential and statistical (noise) polarization resistance. After their transformation into frequency domain by Fast Fourier Transformation method e.g., we may obtain power spectrum densities of potential difference (PSD_P) and the short circuit current (PSD_I).

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Electrochemical Study of UO2 Dissolution in Modelling Repository Conditions

M.Velický*, R.Silber*,, A.Vokál****

rostislav.silber@fjfi.cvut.cz

*Faculty of Nuclear Science and Physical Engineering, Department of Nuclear Chemistry, Břehová 7, 115 19 Prague 1
**Nuclear Research Institute, Řež plc

Possible failure or destruction of long-lived nuclear waste container in deep geological repository will cause underground water leakage, resulting in the contact with spent fuel matrix surface the creation of conditions for UO_2 fuel matrix dissolution. Rate of UO_2 fuel matrix dissolution will be the rate determining step for the release of radionuclides (RN) to environs. Interaction between carbon steel (construction materials for container) corrosion products and UO_2 in repository conditions and potential role of carbon steel corrosion products as a chemical barrier for RN eventually release are investigated.

Rate of UO_2 fuel matrix dissolution will be influenced not only by various parameters (temperature, pH, ground water composition, formation of corrosion products layer) but also by reactive intermediates of water radiolysis. For successful predicting of RN release, it is necessary to understand and evaluate all potential fuel degradation processes[1].

Dissolution of UO_2 occurs via electrochemical mechanisms and therefore anodic oxidation (UO_2 dissolution) in condition modeling repository conditions may be investigated by electrochemical techniques. To simulate the corrosion conditions, to conduct experiment in real time and to work with defined sample surface are the main advantages of electrochemical techniques use.

Previous study [2] was engaged in development of corrosion cell allowing formation of anaerobic condition, redox and corrosion potentials measurement, three electrodes (UO_2-working, reference and Pt-counting electrodes) arrangement for polarization experiments and temperature controlling. The corrosion cell is equipped by working electrode realized by rotating electrode. Top of the electrode is formed by UO_2 disc (5 mm in diameter with surface area about 20 mm^2). Stirring rate using in all experiments was 160 min^{-1}).

UO_2 electrodes were polished using 600-grif SiC paper before each experiments, washed with pure water and polished by electrochemically (reduced at -2,0 V potential vs. SAE for 5 minutes) in the corrosion cell.

Aim of this work [3] is to study a modification of thin surface layer composition under natural or electrochemically induced conditions. Corrosion under natural conditions was characterized by the corrosion potential (E_{cor}). Evaluation of various stages of surface oxidation was performed by suitable electrochemical polarization methods - cyclic voltammetry (CV), chronoamperometry (CA) (dissolution currents measured on UO_2 electrodes as a function of applied potentials are plotted) and cathodic stripping voltametry (CSV).

Electrochemical analyses were performed on PC4/750 Potentiostat/Galvanostat/ZRA analyzer with the evaluation software from Gamry Instruments. TDC 2 Temperature Controller with controlling unit Watlow series 988 PID was used for temperature operations.

Following experiments were carried out:

0,1 mol/l $NaClO_4$ solution (pH = 9,5, 25^oC) vas selected owing to the approach to the groundwater composition. CA curves in the polarization range from -200 to +500 mV were

measured in aerobic and anaerobic conditions. Influence of temperature (25 – 65°C) was tested by CV and influence of ionic strength (0,01 and 0,1 M $NaClO_4$) was tested by CV and CA.

Subsequent CA experiments were performed in demineralized water (pH=7,3) in polarization from -100 to +600 mV. Influence of pH (4,6 – 10,6) and carbonate concentration (0,001M and 0,01M, pH=8,5) were tested by CA and CSV.

Some initial CV experiments were performed with hydrogen peroxide, which is considered to be a stable product of water radiolysis.

Surface analysis – X-ray diffraction, electron microscopy – of selected electrochemically treated samples was carried out.

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Section 12

BIOMEDICAL ENGINEERING

Detection of Autofluorescent Zones in Ophthalmologic Images

Miloš Bělehrad

belehrad@fbmi.cvut.cz

Collective Workplace of Biomedical Engineering and 1st LF (Faculty of Medicine) , Faculty of Biomedical Engineering, Czech Technical University of Prague, Nám. Sítná 3105, 272 01 Kladno, Czech Republic

At present, the appearence of autofluorescent (AF) zones is an important feature in particular fundus oculi photographs. Images obtained by the HRA2 device have the capability of producing information that cannot be provided with conventional devices for fundus imaging. The presence of AF zones is related to macular degenerative diseases, which appear as a side-effect of its progress. These diseases when untreated lead to patient's sight-loss. The virtue of HRA2 device is its ability to register the early stages of the disease in-vivo. One of the most significant diseases is the glaucoma. It is a group of diseases of the optic nerve involving loss of retinal ganglion cells in a characteristic pattern of optic neuropathy. Although raised intraocular pressure is a significant risk factor for developing glaucoma, there is no set threshold for intraocular pressure that causes glaucoma. Worldwide, it is the second leading cause of blindness, affects one in two hundred people aged fifty and younger and one in ten over the age of eighty.

This paper deals with detection of AF zones in retinal images. These zones are associated with higher lipofuscin accumulation. According to [4], lipofuscin is the name given to finely granular yellow brown pigment granules composed of lipid-containing residues of lysosomal digestion. The accumulation of lipofuscin-like material may be the result of an imbalance between formation and disposal mechanisms. The dye produces the autofluorescent phenomenon. While observing images acquired by HRA2 device, we can conclude following results concerning the AF zones characteristics:

- Higher brightness intensity against to background
- Area of appearance can be defined as annulus with inner perimeter (*ip*) corresponding to optic disc border and outer perimeter (*op*) defined experimentally : $op\_radius = 1.5 \cdot ip\_radius$; this area forms the "Region of Interest".
- The actual width of the annulus is 0.5 mm (early stage of disease) up to 2.5 mm (middle stage) with extreme value of 5 mm (late stage).
- Presence of noise. Firstly the cumulative technique was used to increase the signal-to-noise ratio (performed with 9 successive images) [2].
- Spurious-like features (shading, low contrast between AF zones and background, non-uniform procedure in acquiring the images).

A database with 36 images in two series with manually segmented zones was available, all images of size 512 x 512 pixels with 10 μm resolution . Manual segmentation was performed by physicians at Ocular Clinic of Friedrich - Alexander University of Erlangen- Nürnberg, Germany.

The procedure of image processing was divided into three main streams. Firstly, various approaches of preprocessing were examined. One of the most significant step was to select the "Region of Interest". Special algorithmic procedure was used according to [1]. The effort was to select an image area with most valuable information. Next step of preprocessing was filtration, leading to noise reduction in principle. Respective linear and non-linear methods in cartesian and polar coordinates were performed. The most significant feature of AF zone is its higher brightness intensity level against to background. Since there was insufficient contrast between these zones and their background in large number of cases, two different methods of contrast enhancement were examined (gamma correction and experimentally developed "modified mean value"- *msh*).

Secondly, segmentation was a key procedure resulting to content analysis of processed image data [3]. This involved gray-scale to binary conversion, where objects (foreground) were areas, correspond to AF zones. The basic criterion was to find appropriate method for thresholding. Furthermore, number of areas misdefined as objects was diminished.

Finally, post-processing consisted in seed points determining (seed point is an initial pixel for region growing method) of every valid area and to apply a modified region growing method. Ideally, automatically segmented areas are equal in number and size to manually segmented areas. This condition is not possible to reach from several reasons. One of them is that manual segmentation is highly personal matter. Each physician denotes different number and size of AF zone.

The method for detection AF zones was developed in fully-automated mode. Satisfactory results were reached in images without shading and with sufficient contrast. Two different approaches of contrast enhancement were carried out for comparison. *Msh* method was more sensitive than gamma correction and was capable to detect more areas. Its disadvantage was of detecting non-valid areas and this method becomes unstable (region grows outside relevant area). Contrary, approach with using gamma correction was more stable, but not sensitive enough for certain group of images. Seed point was determined as a pixel with highest intensity level in segmented area and region growing method was modified to match chosen criteria.

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Inovation of Existing Laboratory Works and Introduction of New Ones in the Course Unsteady Flow and Hemodynamics

J. Matěcha, J. Adamec, M. Schmirler, H. Netřebská

Jan.Matecha@fs.cvut.cz

Department of Fluid Dynamics and Power Engineering, Faculty of Mechanical Engineering,
Czech Technical University in Prague
Technická 4, 166 07, Prague 6, Czech Republic

The course of Unsteady Flow and Hemodynamics is taught in Division of Fluid Dynamics and Thermodynamics, Faculty of Mechanical Engineering, Czech Technical University in Prague. The students are familiarized with the topic of unsteady flow and liquid flow in human body. This course started to be taught in 1996 as a recommended course and has been included in obligatory-optional courses since 2003. The following laboratory works have been performed in this course so far: "Steady flow in the vessel model with constant pressure drop", "Flow visualization downstream distal bypass anastomosis" and "Flow field measuring downstream distal bypass anastomosis by steady flow".

The aim of presented project was to enlarge existing laboratory works and to build up new laboratory works with the help of modern measurement techniques as Particle Image Velocimetry (PIV), Time Resolved PIV (TR-PIV) and pressure transducers etc. which can be used in the department workplace.

Two new experimental circuits were made. The first one is for measurement by steady flow and the second one for measurement by unsteady flow. Both experimental circuits enable measurement in different parts of cardiovascular system (CVS) like bypass, bifurcation, aneurysm, stenosis, etc. The models of particular parts of CVS are prepared in several realizations with different geometric shape, for example different size of stenosis, different angle of bifurcation etc. Both experimental circuits enable to carry out simple experiments which allow obtaining basic skills connected with performing of experiments in the field of fluid dynamics and students mainly obtain ideas about flow in parts of cardiovascular system. These circuits are designed mainly for flow visualisation and for introduction to PIV method in the course Unsteady Flow and Hemodynamics. Further, the students can obtain basic knowledge about measurement methods and possibilities of collecting and evaluating data. The measurement card for PC is used for collecting data and controlling external devices, the card is controlled by MATLAB program (Data Acquisition Toolbox).

The steady circuit consists of several parts: tank with overflow because of holding constant pressure gradient, measurement space, tubes, flowmeter, valve and pump. The test circuit enables regulating and holding constant flow through the model. All parts of test circuit are fixed to the rigid aluminium construction. The holders for digital camera and source of light sheet are fixed to this construction. The continual light sheet is generated by laser diode and appropriate optics.

The unsteady test circuit comprises the source of periodical unsteady flow, tubes, measurement space and stabilization tank. All parts of test circuit are hold to rigid aluminium construction. The holders for digital camera and source of light sheet are fixed to this construction. Continual light sheet is generated by laser diode and appropriate optics. The peristaltic pump is used as a source of periodical unsteady flow. It is driven by stepping motor. Mechanical connection with the pump is implemented with the help of elastic coupling

which reduces vibration. The control electronics allows setting precise position with precision 1.8 degree. It is possible to increase stepping accuracy (pump rotation) by microstepping with the help of control electronics. It is possible to define flow pulse shape and the shape of synchronization signal (0/5V) in the software which controls the operation of motor stepping. The synchronization signal has rectangular pulse in desired places. The device with optical sensor placed in the shaft between pump and motor which generates synchronization pulses (0/5V) was made for alternative drive.

The universal test circuit used for research in field of hemodynamic was adapted for teaching. This universal test circuit enables to simulate steady flow and periodic unsteady flow with accurate defined conditions. After adaptation it is possible to use this circuit for individual complex students works in courses Experimental fluid mechanics and thermodynamics, Project II, Semester project, Conclusion project and for solving bachelor, master and doctoral theses. This universal test circuit enables to carry out measurements by PIV and TR-PIV systems and with other experimental methods which are accessible in department workplace. The set of models of different parts of cardiovascular system and manuals for test circuit control and experimental equipments were made for this circuit.

The water or glycerine-water solution is used as working fluid. Glycerine-water solution is used because its viscosity is near to the blood viscosity. The seeding particles are added into the working fluid which enables to make visualisation and PIV measurements. The transparent fluid-filled boxes were made because of reducing optical distortions. Distortions can be reduced by refractive index matching or when the model is enclosed in a transparent fluid-filled box with flat faces so that the camera chip plane was parallel to the box wall and thus the transition from one optical environment to the other one is made by flat plane.

The manuals for experimental test circuits control, the manuals for control of experimental equipments (digital cameras, step motor, camera signal amplifier, pressure transducers, etc.) and procedures for evaluating flow characteristics. The assignment tasks, measurement procedures and MATLAB scripts were prepared.

During solving of the project, the students in particular subjects were provided with partial results and their reactions lead to adapting the teaching material.

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Design of the Application to the Analysis and Biofeedback Research of HRV and Development New Algorithms by Using Matlab Environment

T. Funda

funda@fbmi.cvut.cz

Joint Department of Biomedical Engineering of Czech Technical University and Charles University in Prague, Faculty of Biomedical Engineering, Czech Technical University in Prague, Studnickova 7, 120 00 Prague 2 - Albertov, Czech Republic

Heart rate normally has a lot of variability. Heart rate data reflects various physiological states such as biological workload, stress at work and concentration on tasks, drowsiness and autonomic nervous system activity. Loss of this variability is uniformly associated with a negative effect influence on health.

Measures of heart rate variability are reliable reflection of physiological factors quantity, modulating the normal heart rhythm. Heart rate variability can be increased by exercising. In the final form the use of HRV in biofeedback should give the operator easily understandable information of psychic and visceral state and help with therapeutic methods for curing various pathological states and diseases.

Biofeedback is a training technique in which people are taught to improve their health and performance by using signals from their own bodies. Within the frame of project research called „Biofeedback effect of selected human physiological parameters modeling“, we try to solve problems related to heart rate variability (HRV) signal processing. HRV selectively reflects the work of the autonomous nervous system, it's sympathetic and parasympathetic components, their reactions to different emotional states, which are closely tied to the baroreflexes (responsible for the regulation of blood pressure) and breathing. The rhythms of the cardiac and lung systems have a massive effect on all other body systems and their function. They are beginning to be considered as a link between psychic and somatic processes, where both way transfers are in this time beginning to be more palpable with the use of new technologies of applied psychophysiology.

The heart is a very powerful pump that is controlled by the central nervous system. The heart action is not regular, it is a very variable function dependent on breathing, psychic state, physical load, generally stress and by pathologies. The heart can in some situations change rate very quickly and many are very perceptive to any change. Most of these changes or irregularities of our pulse do not indicate a pathological occurrence. Usually it is referred to as the sinus respiration arrhythmia (RSA), which means that the rhythm of the pulse changes according to the breathing phase. During expiration the heart rate decreases and during inspiration the heart rate increases.

Heart rate variability analysis is based on measuring variability in heart rate (variability in intervals between R waves - RR intervals). These RR intervals are then analyzed by statistic and spectral analysis or some other form of mathematical analysis.

a) The method in the time domain: The simplest method, where one heart frequency is given by the time or interval. On the ECG recording we can observe the QRS complex.

Pauses between the QRS so called normal to normal (NN) intervals: $NN = N_{i+1} - N_i$ or immediate heart rate: $HR = 60 \cdot 1000 \cdot \frac{n}{\sum_{i=1}^{n-1} NN_i}$.

b) The static method: Due to this simple method we can calculate a series of immediate heart frequencies in a longer time scale. This method will allow comparing of HRV during a longer time base (24 hours) a series of immediate heart frequencies or pauses in the cycles.

c) Geometric methods: This method can be divided into three subgroups: 1) The basal measuring of the geometric example is changed to the measurement of the HRV. 2) The geometric image is a mathematically defined shape. 3) The geometric shape is sorted to several models given to separate categories, which represent several classes of HRV.

d) The methods of frequency domains: There are many different spectral methods for the analysis of the tachograph. The analysis spectral density (PSD) which gives the basic information, as the strength is distributed as a function of frequency. The methods for the calculation of PSD can be classified as parametric and nonparametric. Both of these give comparable results.

To assure lucidity easy design and modifiability of investigated application, we try to find solutions with Matlab environment by using GUI and interactive form designer. The application was created in Matlab environment, using both default functions and also by functions designed by ourselves. Our functions were created as M-files and were written in MATLAB language.

This designed application serve to HRV signal processing and calculation of many different parameters: heart rate (BPM), many statistical parameters, power spectrum, heart rate variability (HRV), stress index (SI) $SI = \frac{AMo}{2 \cdot Mo \cdot MxDMn}$ and many others. The application displays these results to the lucidity tables and charts. The results are possible to save and used by another application. This application was used to the analysis HRV signals from the clinical research and the laboratory of Faculty of Biomedical Engineering.

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Feature Extraction in EEG Processing

L. Lhotská*, V. Gerla*, V. Djordjevic*, V. Krajča, S. Petránek****

lhotska@fel.cvut.cz

*Gerstner Laboratory, Czech Technical University in Prague, Technicka 2, 166 27 Prague 6, Czech Republic

**University Hospital Bulovka, Budínova 2, 18081 Prague 8, Czech Republic

The electroencephalogram (EEG), describing the electric activity of the brain, contains a lot of information about the state of patient health. It has the advantage of being non-invasive and applicable over longer time span (up to 24 hours if necessary). This is an important feature in case we want to follow disorders that are not permanently present but appear incidentally (e.g. epileptic seizure) or under certain conditions (various sleep disorders). Although the attempts to support EEG evaluation by automatic or semi-automatic processing have been made for a long time, there are still many problems to be solved. We try to contribute by our research to this effort. The main objective of the described work is the identification of the most informative features from sleep EEG records that could be used for automated (or semi-automated) sleep stage classification. Our approach to the analysis of human sleep uses wavelet transform (WT) and statistics for feature extraction and construction. The extracted and computed features are used as inputs for a decision tree that is learned to classify individual sleep stages.

In our previous work we used the Fourier transform for preprocessing and feature extraction. It proved to be suitable for preprocessing of epileptic signal but we did not acquire satisfactory results for sleep recordings. Although in a number of works wavelet transform was also used mainly for epileptic recordings and evoked potentials we decided to design and perform experiments with sleep recordings.

We have applied wavelet transform to sleep EEG signal preprocessing. Mean of the signal is calculated and subtracted from a signal before WT is applied. Discrete Wavelet Transform (DWT) represented by a filter bank is employed for wavelet decomposition. Before the decomposition starts it is necessary to select a mother wavelet used for defining FIR filters and a level of a decomposition tree. For deciding which mother wavelet should be selected we consider the impulse response and amplitude frequency characteristics of the FIR filter specified by the corresponding mother wavelet. After the DWT is done we get approximation and detail coefficients as input data for further processing. Then the segmentation is performed.

Segmentation. In this case the non-adaptive segmentation is employed. Non-adaptive or constant segmentation divides a signal into segments of a constant length. This kind of segmentation is basically the easiest and fastest one. The disadvantage of this method is that the segments are not necessarily stationary. The length of a segment is chosen regarding the character of data.

Feature extraction is the second most important part after wavelet decomposition. It is a process which changes representation of segments by extracting features from them. The aim is to select those features which carry most information about the segment. The statistic parameters are in principle very suitable for this purpose. We use autoregressive features and computed wavelet coefficients as well. We use the following parameters: average absolute amplitude, maximal positive amplitude, maximal negative amplitude, maximal absolute amplitude, frequency-weighted energy, sample mean, sample central moment, sample variance, statistical median, energy, and entropy. The autoregressive features are calculated

from the transfer function of an *autoregressive model*, in which a present value x_n or future values x_{n+1}, i=1,2,… are estimated by using the previous values $\{x_{n-m}, \ldots x_{n-1}\}$. Extracted features are organized in a feature vector $F = \{f_1, f_2, \ldots, f_M\}$. We can extract features from each source (an original signal, its first and second derivation) independently.

Feature normalization. Mean and standard deviation of extracted features are different. That could have a negative influence to the classification process, when a classifier uses distances between points in n-dimensional space. Before we start classification the features must be normalized to have the same mean and standard deviation. The features have normal distribution N(0,1). **Feature reduction**. There are several different ways in which the dimension of a problem can be reduced. In this work Principal Component Analysis (PCA) approach is used which defines new features (principal components or PCs) as mutually-orthogonal linear combinations of the original features. For many datasets, it is sufficient to consider only the first few PCs, thus reducing the dimension. **Feature selection** is considered successful if the dimensionality of the data is reduced and the accuracy of a learning algorithm improves or remains the same. Decision tree algorithms such as C4.5 can sometimes overfit training data, resulting in large trees. In many cases, removing irrelevant and redundant information can result in C4.5 producing smaller trees. The Chi-squared statistic is used for feature selection.

Classification. We have decided to use decision tree algorithms because they are robust, fast, and what is important especially in medical domain their results are very easy to interpret. In particular, the C4.5 algorithm has been applied, namely its J48 variant available in the Weka software tool.

We have performed three basic types of experiments. The aim of experiment 1 has been to find features which contain relevant information about class membership. The experiment 2 has been motivated by the results of the experiment 1, namely lower differentiation between four couples of classes. The aim has been to identify such features that contribute to increase of classification accuracy. The experiment 3 has verified the relevance of features selected in experiment 1. All features extracted for the classification task in the experiment 1 are based on energy, mean absolute amplitude and frequency weighted energy. These features reflect the changes of energy in the given wavelet coefficient which is related to a specific frequency spectrum.

The designed approach has been tested on real sleep EEG recording for which the classification has been known. When we have tested sleep EEG data, we have focused on discovering the most significant features which would be highly correlated with classes of data. We have tried to examine many settings of DWT for this purpose. The decision tree classifier (C4.5) has been used for its easy interpretations and reasonable computational speed. Chi-square statistic method is used for feature selection. Our experiments have been based on the selection of a single feature to separate data belonging to two classes. There have been many other features with good selection results. The most frequent ones have been autoregressive features representing the order of used AR model and error of AR model. We have determined some features and wavelet coefficients which are best suited for classification of sleep EEG data. The future work will be focused on exploitation of other types of mother wavelets, using higher level of wavelet coefficients as source of features, and more sophisticated classifiers.

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Databasing EEG

L. Lhotská*, V. Gerla*, R. Horniak*, M. Kytka*, V. Krajča, S. Petránek****

lhotska@fel.cvut.cz

*Gerstner Laboratory, Czech Technical University in Prague, Technicka 2, 166 27 Prague 6, Czech Republic

**University Hospital Bulovka, Budínova 2, 18081 Prague 8, Czech Republic

Computer assisted processing of long-term EEG recording is gaining a growing importance. The aim is to simplify the work of a physician that must visually evaluate many-hour EEG recordings. At present, EEG is recorded at patients 24 or 48 hours. The automatic systems cannot fully replace a physician but they are to make his/her work more efficient. They identify segments of the signal where there are deviations from standard brain activity and in this way they shorten the time required for visual inspection of the whole recording. However in this automatic evaluation there is negative influence of, for example, movement artifacts that cannot be easily removed from the signal. Therefore we have decided to develop a database system for storing all interesting segments of the signal – both artifacts and graphoelements with the contextual information.

As basic source of information about time course of EEG signals we usually find very comprehensive atlases. However they have several basic disadvantages, namely a) they show only the time course of the signal; b) since they are mostly available only in printed form no computer supported processing can be used to acquire further characteristics of the signal, for example in frequency domain; c) the displayed signal is relatively short which is disadvantageous for deeper analysis in some cases. Although time course of the signal is important for description and understanding signal morphology, the frequency spectrum and power spectrum density, for example, can contribute to more detailed and objective analysis.

These facts and our discussions with neurologists contributed to our motivation and decision to design a database system that would collect in digital form measured EEG signals, and significant segments (graphoelements and artifacts) together with medical interpretation, computed quantitative characteristics and reference to original signal to keep the possibility to view the whole recording again.

Here we describe the design of the database that was developed as the basis for unambiguous overview of the most frequently appearing EEG artifacts and graphoelements. During design phase of the database we considered future addition of new data items into already implemented database.

In the database structure we store the original selected part of the signal (from all leads) together with the information about the file from which the particular signal segment has been extracted. Then we compute all necessary characteristics and store them as additional information to the database record. Finally, the medical doctor adds interpretation from the medical point of view and classification (group membership). Thus the database records can also serve as training sets when developing a new classifier for a certain classification task. Of course, for different classification tasks different subsets of database records would be used. For example, when classifying epileptic EEG recording we use records containing epileptic graphoelements, when identifying artifacts we use records containing artifact samples.

The database was designed in such a way that it is possible to save measured time courses that bear accompanying information about electrodes, description of artifact/graphoelement and information about the class where they belong. It is possible and

in this case necessary to have the possibility to add groups (for example after identifying a new category). The designed database is composed of six tables.

First table that must be created is the table "Login" with a user name and password for access to the database. Login serves for unique identification and also for recording the history of database modifications which can prevent many superfluous complications (e.g. wrong identification of a pattern, unclearness concerning a given record). In addition, different users may have different access rights, e.g. only read, read and modify, store new records with interpretation. Second table "Doctor" contains information about a particular medical doctor – user of the database, including the assigned role defining access rights. Third table "Artifact/graphoelement" is the crucial table of the whole database. This table contains following information: the description, date of measurement, date of last change, group (class) into which the artifact or graphoelement belongs, time course of the part of the signal, number of electrodes, sampling frequency, name of the original file from which the artifact or graphoelement was extracted, and computed characteristics. Fourth table "Group" is a table that serves for description of artifact and graphoelement categories (classes). It contains class description, name of the doctor who created it, and date of creation. Examples of classes are: movement artifacts, triphasic waves, sleep spindles, hypsarrhythmia. Fifth and sixth tables contain information about electrodes. Table "Table_electrode" serves for identification of individual electrodes. Each electrode has its denomination and order based on the placement on the sculp. Last table "El_artif/graphoel" links table of electrodes with the table "Artifact/graphoelement".

The main aim of this particular work has been creation of the basic part of a library of characteristic time courses of artifacts and graphoelements that can serve as a core of a training set for learning classifiers for EEG recording classification. The advantage is that the program enables to complete the time courses with medical interpretation which might help the user when creating a new classifier. An interesting side effect is the possibility to use the database as an interactive atlas for students of medicine or EEG technicians. They can see the time courses and also additional computed characteristics (alternatively in graphical form). Moreover if they are interested they can open the original EEG recording that served as a source file for the particular selected time course.

Computer supported EEG processing brings several substantial advantages. The most important ones are more efficient, faster and more objective evaluation. Visual evaluation is exhausting, time demanding and requires permanent attention. In addition, it is subjective and depends on experience of the evaluator. Therefore it is necessary to ground evaluation in objective basis and use the opportunity that quantification of EEG offers. Development of the above described database system tries to contribute to this aim.

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Decision Support in Cardiology

L. Lhotská, M. Roubíková

lhotska@fel.cvut.cz

Gerstner Laboratory, Czech Technical University in Prague, Technicka 2, 166 27 Prague 6, Czech Republic

The aim of the described work was to design and develop knowledge bases for diagnostics of specified cardiovascular diseases, namely arrhythmias and ischemic heart disease. The knowledge bases were developed for the FEL-EXPERT expert system, version 4.1.

The FEL-EXPERT is a family of diagnostic rule-based shells using a Prospector-like model for uncertainty handling. Basically, three types of knowledge representation elements are used in the knowledge base notation for the basic system versions:

Production rules having the following E → H form: <evidence E> → <hypothesis H>, where both E and H are propositions. The sufficiency and necessity measures are assigned to each rule. The graphical representation of a set of production rules forms the inference net.

Logical functions (enabling logical combinations of propositions).

Context links: by means of a context link the investigation of the given node of the inference net (as well as of all the nodes belonging to the subtree rooting in the given node) may be blocked, if the actual probability/validity value of the context is outside the prespecified probability interval.

The FEL-EXPERT system can be used not only as a diagnostic tool but also as an educational aid. For this purpose, it is advantageous that it is equipped with an extended explanation mechanism that enables to explain which symptoms support or reject the final diagnosis. In a certain way it may replace specialised libraries because accessibility of this information is surely higher. The possibility to execute external programs is another feature of this system and it is ideal for parallel interaction, for example, with a bibliographical database.

Cardiovascular disease refers to the class of diseases that involve the heart or blood vessels (arteries and veins). Most Western countries face high and increasing rates of cardiovascular disease. Diseases of the heart alone caused 30% of all deaths, with other diseases of the cardiovascular system causing substantial further death and disability. Up until the year 2005, it was the number 1 cause of death and disability in the United States and most European countries. By the time that heart problems are detected, the underlying cause (atherosclerosis) is usually quite advanced, having progressed for decades. Thus correct and timely diagnostics is very important. In addition, there is increased emphasis on preventing atherosclerosis by modifying risk factors, such as healthy eating, exercise and avoidance of smoking.

Cardiac arrhythmia is any of a group of conditions in which the electrical activity of the heart is irregular or is faster or slower than normal. Some arrhythmias are life-threatening medical emergencies that can cause cardiac arrest and sudden death. Others cause aggravating symptoms, such as an awareness of a different heart beat, or palpitation, which can be annoying. Here there is the list of the most common arrhythmias: atrial (premature atrial contractions, wandering atrial pacemaker, multifocal atrial tachycardia, supraventricular tachycardia, atrial flutter, atrial fibrillation), ventricular (premature ventricular contractions, accelerated idioventricular rhythm, ventricular tachycardia, ventricular fibrillation, polymorphic ventricular tachycardia, ventricular extra beats), atrial ventricular (AV nodal

reentrant tachycardia, AV reentrant tachycardia), junctional arrhythmias (junctional rhytm, junctional tachycardia, premature junctional complex), heart blocks (first degree heart block – PR prolongation, second degree heart block, third degree heart block), other less common arrhythmias (e.g. trigeminal rhythm).

Ischemic heart disease (IHD), or **myocardial ischemia**, is a disease characterized by reduced blood supply to the heart muscle, usually due to coronary artery disease (atherosclerosis of the coronary arteries). Its risk increases with age, smoking, hypercholesterolemia (high cholesterol levels), diabetes, hypertension (high blood pressure) and is more common in men and those who have close relatives with ischemic heart disease.

Based on the analysis of the problem we decided to develop two separate knowledge bases. The development process was divided into three phases. In the first phase two knowledge bases ARYT (for diagnosing arrhythmias) and ISCH (for diagnosing ischemic problems) were designed. The ARYT knowledge base contained 85 nodes, out of which 57 were questions and 19 hypotheses, 98 rules, and 61 context links. The ISCH knowledge base contained 29 nodes, out of which 25 were questions and 3 hypotheses, 33 rules, and 11 context links. The second phase represent very intensive communication with an expert (medical doctor) who recommended changes in question ordering, addition or modification of questions and rules, and in several cases removal of questions that were not important for the problem solving. The main changes were made in the so-called quantitative nodes where the input information is a number. For example: “What is the heart rate?” Further, nodes representing risk factors were added. The last phase of the development was testing on real data. The expert supplied examples for each diagnosis included in the knowledge bases. Based on the testing new logical nodes were added. Further new rules were added and rule weights were modified. Finally the ARYT knowledge base contains 75 nodes, out of which 48 are questions and 19 hypotheses, 87 rules, and 51 context links. The hypotheses are the types of arrhythmias listed above. The ISCH knowledge base contains 44 nodes, out of which 32 are questions and 5 hypotheses, 55 rules, and 80 context links. The hypotheses are the following diagnoses: acute myocardial infarction (heart attack), unstable angina pectoris, stable angina pectoris, atherosclerosis, and other diagnosis (not originating from heart).

In the future we plan to continue development of the knowledge bases. It will be necessary to extend them by, for example, adding nodes for entering additional information about patient state. Further the ARYT knowledge base must be tested on more patient data because there might be more unclear cases that will result in additional knowledge base tuning.

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Software for synchronous electrophysiological and image recordings and high level mathematical analysis

E. Krajčovičová*, M. Martinková*, R. Konopková, M. Fejtová*, J. Otáhal****

fejtovam@k333.felk.cvut.cz

*Department of Cybernetics, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

**Institute of Physiology, The Academy of Sciences of the Czech Republic, Vídeňská 1083, 142 20 Prague 4, Czech Republic

Electrophysiology is more than 200 years old, and in the last half-century electrical recording techniques have advanced to a level where observing the flickering activity of a single ion channel has become a routine, everyday occurrence. When it comes to the central nervous system, however, focal electrical recording leaves us with the proverbial dilemma of seeing the forest or the trees. We must choose between a detailed electrical accounting of the responses of one or at most a few individual elements out of a population of billions or a blurred recording of the average behaviours of the system as a whole that ignores the variable response of individual units.

A number of new imaging techniques are available to scientists to visualize the functioning brain directly, revealing unprecedented details. These imaging techniques have provided a new level of understanding of the principles underlying cortical development, organization and function. The first technique is based on intrinsic signals. The second technique is based on voltage-sensitive dyes. Currently, these two optical imaging techniques offer the best spatial and temporal resolution, but also have inherent limitations.

In neuroscience it is increasingly important to provide synchronous detection and analysis of optical and electrophysiological signals. The systems that are available nowadays are tools specialized for either imaging or electrophysiology without possibility to both in one environment. Moreover, high level mathematical analysis of acquired data is usually done separately in home based scripts written in Matlab.

The aim of present study was to develop free software for broadly used windows based computer systems. Whole system consists of National Instruments (NI) data acquisition cards series M and standard set of cameras. This system provides simple user interface for both types of recordings, triggering external devices like stimulator and powerful Matlab interoperability.

The software was programmed using Microsoft .NET Framework 2.0 library and C# programming language and thus it is suitable for any MS Windows based computer. System consists of three main components: graphic user interface, video acquisition component and signal acquisition component. User interface controls both acquisition components using user events. User interface also cooperates with settings object that contains initial settings for all above said components.

Video acquisition component is able to cooperate with several camera devices, such as standard web cams, DV cams and with selected high sensitive cameras for microscopy use (UI, Q-Imaging, etc.), and capture image data. Recordings are afterwards saved in AVI or

BVG file. AVI is file type commonly used for video storage having unfortunately lots of limitations, e.g. image type, image bit depth, impossibility of saving camera settings, etc.

Hence we designed our own file type called BVG (Brain Vision Graphics), which allows saving various image types and bit depths, changing frame rate during capturing and saving camera settings. File includes three parts; main header, where image parameters and camera settings are stored, image header, where period between frames is stored, and its own image data. Format is designed so that it is possible to modify it in future.

Signal acquisition component cooperates with any multifunction card M series produced by National Instruments, which communicates through the PCI bus (PCI 62xx) with personal computer. Cards of this type have up to 80 analog inputs and 4 analog outputs at 16 bits and 48 digital I/O lines.

Measuring data are stored in our binary file called BVD (Brain Vision Data), which has its own designed structure. BVD file consists of primary header, secondary header and signal data. There are saved information about size of headers, device settings such as resolution A/D converter, sample rate, etc. In primary header and settings of each analog and digital input in secondary header.

High-level mathematical analysis is realized using Matlab and .Net interoperability. There are two different approaches of communication between Matlab and .Net. The first one uses .NET builder for compilation of user matlab scripts into .NET dll libraries, which allow later data processing in the software. The second one transfers data using COM Automation server form .NET to Matlab for further processing or displaying it in its own environment.

The software was successfully tested with PCI-6221 (National Instruments, The Czech Republic) data acquisition board (16bit, 250kS/s, 16 AI, 2AO, 24DIO channels) with homemade EEG for channel amplifiers for signal preconditioning. For video recording we tested simultaneous image acquisition with high resolution web cam (Philips 900NC) providing 12 or 16bit color images, industrial cameras UI-2230C and UI-2230M (Imaging development System, Germany) providing 8 bit grayscale and 24 bit RGB images and high sensitive cooled camera Retiga 2000R (Q-Imaging, Canada) providing 12 bit grayscale images.

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Legal Metrology in Health Service, a Current Situation, Avaibillity of Services, Possibilities of Outsourcing

M. Dobiáš

dobiam1@fel.cvut.cz

Department of Economics, Management and Humanities, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic

The project is focused on the metrology in health service in Czech Republic. The main task of metrology is securing of uniformity and accuracy of measurement in the country. In general, metrology has three categories of devices (stated gauges, etalons, and reference materials) and two types of services (calibrations, verifications of stated gauges). The classification is very extensive and it describes all of processes in metrology. Executed research was oriented only to stated medical gauges and relevant services - verifications.

The stated gauges are such devices, which are regularly verified with a consideration to their purpose. The devices are usually used for a business contact, a health protection and an environmental protection. It is possible to find the list of the stated gauges in law regulations. The verification means a consumer protection, where the state protects people against "trickster". The appropriate technical status of the important gauges is secured by a regular metrological verification in Czech Republic. The stated gauges can be verified by an Accredited Metrological Centre (AMS) and a Czech Metrological Institute (CMI). The verification is check, which has only two results – yes, inspected gauge is all right; or no, gauge gives wrong results and it must be stopped used immediately.

The Stated Gauges in the Health Service in Czech Republic by the Law

The list of the stated gauges with interval of verification validity in the health service in Czech Republic is shown in the next table.

ID	Measurement Device	Interval of Verification
1	Blood pressure meters	2 years
2	Medical Scales	2 years
3	Medical Thermometers	2 years
4	Ocular Sphygmomanometers – electronic (non contact)	2 years
5	Ocular Sphygmomanometers – mechanical (contact)	1 year
6	Audiometers	2 years

Companies with a Checking Device Authorization in the Health Service in Czech Republic

Next table shows companies with an authorization for checking certain gauges (last column). There are also information represented about the company (public/private) and places of activity. The company like the CMI has very much places of activity and it could verify all the types of stated gauges, but every subsidiary did not verify each type of gauges. Private companies are more efficient in the legal metrology, than public. There is only public sector for majority of the stated gauges in the health service in the Czech Republic.

Company name	Type of company	Place of activity	Type of device
CMI	Public (CMI)	Prague, České Budějovice, Plzeň,	1,2,3,5,6

		Liberec, Most, Pardubice, Brno, Jihlava, Kroměříž, Opava, Olomouc	
HNS mechanix, s.r.o.	Private (AMS)	Kroměříž	5
CHIRONAX Estra, s.r.o.	Private (AMS)	Praha	1
Gabriela Tejkalová	Private (AMS)	Býšť (Hradec Králové)	1
Hospital – Homolka	Private (AMS)	Prague	1
VDI metros	Private (AMS)	Ostrava	1
Medicton Group,s.r.o.	Private (AMS)	Prague, Polička	1,3

The Institution in the Health Service in Czech Republic

The next table shows a majority of types and a number of organizations in Czech Republic. A last column depicts type of the gauges which are used by institutions. The brackets mean that the types of devices are used only in a few workplaces.

Type of institution	**Number of institution in Czech Republic**	**Type of device used in institution**
Hospital	201	1,2,3,4,5,6
LDN	76	1,2,3
Policlinic	189	1,2,3,(4,6)
Rest Home	95	1,3
Bathouse	81	1,2,3
General Practitioner (private)	6564	1,2,3
Proprietary Medicine Doctor	6048	1,2,3,(4,5,6)
Gynekologist	1152	1,2,3
….	….	….

The results of the research summarize current situation in this area, show good accessibility of services for every medical organization and convenient prices for it. The public organizations has a very long waiting time for realization service, this is not good for a customer. Every user feels the importance of the metrology in the heath service. Moreover, there are more medical devices, which could be verified the same as the stated gauges. There are also other devices, which are regularly checked for safety, but a correct functionality is important too. For example, SPO_2 meters, ultrasonic diagnostic devices, ECG, EEG etc. The metrology checking is necessary for securing of correct functionality. The opportunity for the metrology in the health service is to increase number of gauges for verifying and to open more services to the private sector.

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Heart signal processing using artificial intelligence methods

M. Burša*, L. Lhotská*

bursam@fel.cvut.cz

*BioDat Research Group, Gerstner Laboratory, Department of Cybernetics,
Faculty of Electrical Engineering, Czech Technical University,
Technická 2, 166 27 Prague 6, Czech Republic

Holter recording is a long-term electrocardiogram (ECG) recording used as a non-invasive diagnostic aid in coronary disease diagnostics and also in heart disease prevention. By long-term monitoring, a huge amount of data is presented to the cardiologist. The speed of record evaluation and automated analysis is crucial. An expert-based analysis of the long-term electrocardiogram recording (Holter ECG) is time consuming. Together with the need to process huge amount of data, it can lead to misinterpretation or overlooking of important patterns in the signal. Therefore a computer system can be an important aid in facilitating the work of cardiologist. Such system also helps to eliminate the human-error in Holter ECG classification process.

Heart-beat clustering can effectively reduce the amount of data presented to the cardiologist: cardiac arrhythmias and significant morphology changes in the ECG can be visually emphasized in a reasonable time. The exhaustive clustering methods are resource demanding (in terms of computational time and memory), therefore appropriate heuristics should be considered.

This work evaluates the use of ant-colony inspired metaheuristics for data clustering. The method is compared with well known clustering techniques (both classical and nature-inspired), first testing on the known dataset and finally applying them to the real ECG data records from the MIT-BIH database. The final evaluation of the ECG recording must still be made by an expert.

The research in nature inspired methods nowadays concentrates on improving performance, stability, convergence, speed, robustness, stopping criteria and other key features that would allow deploying these methods in real and industry applications. The main research on the nature inspired methods does not focus on the strict modeling of the natural processes; it merely focuses on extracting and using the best ideas to improve the convergence and accuracy of the methods.

The objective of clustering algorithm is to discover similar classes in spatially distributed data. There are no efficient solutions known to clustering problem and some formulations of the problem are even NP-hard [1].

M. Dorigo presented in [2] an Ant System and Ant Colony Optimization which is a meta heuristic approach based on the foraging behavior (a positive motivation) of real ants. It is based on the parameterized probabilistic model – the pheromone model. Deneubourg et al. [3] proposed the basic approach for Ant Clustering approach.

For basic parameter estimation and implementation testing the well-known iris-dataset has been used (freely available). Real ECG signals are taken from widely used MIT-BIH database [4], which contains annotated records. For the sake of simplicity, only two major

distinct classes have been used: normal cardiac action and abnormal cardiac action (mainly premature ventricular contraction beats or left or right bundle branch block beats). The classification into more classes is nearly impossible due to lack of the data (abnormal heart action signal) in some signals. By omitting minor abnormal heart actions, more records from the MIT-BIH database can be processed.

All the algorithms have been implemented in Java 1.6.0 and run on the Intel Pentium PC with Linux operating system. Ant Colony clustering used a toroidal world of 150×150 elements together with 120 ant-agents (experimentally determined values). The stopping criterion has been reaching the number of 500000 iterations. In the case of SOM, the stopping criterion has been reaching the number of 5000 iterations. The learning parameter α has been set to the value of 0.005. In both cases the stopping values have been overestimated, allowing the algorithms to stabilize.

All results have been first clustered into four classes (the data contained four natural classes); classification of each class has been determined by the major class representation in the cluster. Only measures with best results are presented in the table.

The best results (SE/SP [%]: 96/74) have been achieved by the hierarchical agglomerative method, which is the only method not using centroid approach. The nature inspired methods (SE/SP [%]: 79/69), however, outperforms the basic k-means algorithm (SE/SP [%]: 77/65) both in specificity and sensitivity and achieves more stable results (in term of standard deviation). Final results using with comparison to the Dynamic Time Warping over the test runs improved sensitivity about 0.7 % and Specificity about 0.9 % when compared to classical feature extraction.

The results have shown that the performance of the nature inspired method is comparable and in some cases outperforms the classical methods, but it depends on the type of clustering method. The centroid methods can get stuck in the local minima.

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Proccesing of body surface ECG potencial

M. Huptych, L. Lhotská

huptycm@fel.cvut.cz

Department of Cybernetics, Faculty of Electrical Engineering, Czech Technical University, Technická 2, 166 27, Prague 6, Czech Republic

The standard 12-lead ECG is still the only universally accepted practical method in heart disease diagnosis. However, as many research and clinical studies show this method is not optimal and has its limitations. The Body Surface Potential Mapping (BSPM) leads system was introduced in 1963 [1]. The BSPM is record of surface manifestation of heart activity. The BSPM systems uses from tens to hundreds electrodes, that are placed on the thorax of a human body [2]. After the years the BSPM was used on experimental field the number of data seems to be large enough to enable us new knowledge about the way how the heart works [3]. The aim of this work focuses on feature extraction from the body surface potential maps that should allow us by using the means of artificial intelligence to find possibly useful knowledge, so far not routinely analysed, for description of interesting events on the human heart. We have used Cardiag 112.2 system (Czech-made BSPM device) witch allows recording of 12 standard ECG leads, 3 vector-cardiograph leads and 80 mapping leads (BSPM leads).

All 95 signals are filtered with 50Hz notch filter to remove power-line frequency, and with set of adaptive filters for removing of breathing and MEG artefacts. Very important step is correction of signal electrical isoline. However this step is practicable only after analysis of signal, because the isoline interval of signal is between P and Q point of ECG beat. After the filtering of the signal, simple analysis was performed to find the erroneous signal – such as those with bad contact or signals too small for further consideration. Such signals were replaced with linear combination of it's four neighbors. Further step in the processing phase was signal analysis. We used wavelet-based signal detector that uses signal decomposition that uses discrete wavelet transformation to detect characteristics points of ECG [4]. There are defined eleven characteristic points on one ECG period (maximum amplitude of R wave, beginning and maximum amplitude of Q wave, maximum amplitude and end of S wave, and beginning, maximum amplitude and end of P and T waves). It is important to mention, that the analysis was performed on all signals separately – thus set of 95 independent results was acquired for each parameter of the analysis searched.

Results of body surface potential measurement can be defined as four types of maps. First type is the immediate potential map, which is created from current potential distribution on single electrodes at the given moment. It is defined as $P_i = U_i(t)$, $t = \text{const.}$, $i = 1,2,\ldots n$. Second type is the integral map defined as integral of amplitude in given time interval. This map is generated as sum in the chosen time interval $<t_1,t_2>$. User can choose the interval for mapping arbitrarily. However, five intervals in praxis are often used – P wave integral map, Q zone integral map, QRS integral map, ST-T interval integral map, and QRST interval integral map. Third type is the isochronic map, in which time of detection of some characteristic points on each signal or length of some defined interval is mapped. It is defined as $T_i = f(U_i(t))$. Last type of map is differential map. It is created as subtraction of two maps. Again the user can choose interval for mapping and also has five integral intervals from automatic analysis, which is described above. Differential maps are defined as $D_i = U_{i2} - U_{i1}$ resp. $P_{i2} - P_{i1}$. Mapping on one period of signal, based on lead signal, turned out to be fundamental for

the best display of immediate potential maps and integral maps. The mapped interval for generation of maps is defined unambiguously for all electrodes. Thus, it allows better variability of creating maps by user's choice from different periods.

We have decided to obtain basic features from standard ECG and mapped leads, local features of the BSPM and global features of the BSPM. We have analysed a number of parameters that can be computed from the measured signals. Based on our previous experience with ECG signal pre-processing and classification, and a number of experiments we have identified several parameters that may contain the significant information. Features that were selected for further consideration are described in the following sections followed by the way of their computation.

Basic features from the standard ECG is based on segmentation of signal to characteristics of the wave and points. These attributes are maximum P wave amplitude, interval from P wave onset to P wave offset, interval from P wave onset to R wave maximum amplitude, QRS complex interval, interval from S wave offset to S wave offset, interval from S wave offset to T wave onset, maximum of T wave amplitude, maximum of R wave amplitude, interval from T wave onset to T wave offset and interval from Q wave onset to T wave offset.

For local feature extraction map has been divided into 60 squares. In each square we compute distribution of positive, negative and neutral amplitudes. Local features of the BSPM maps consist of distribution of positive, negative and neutral amplitudes in each of 40 squares from anterior part of thorax. Global features of the BSPM maps consist of position of global maximum and minimum of integral map, position of local maxima and minima of integral map and zero-line of the map. For this extraction have been used integral maps from QRS and QRST interval and immediate potential maps for computation of maxima and minima of the maps movement. Important for further use is also zero-line, which is described by array of squares containing all three (positive, negative, neutral) polarity of given square from local features. The results of feature extraction can be used as inputs of known methods of machine learning (classification and clustering) such as support vector machine (SVM), artificial neural network (ANN), self-organization maps (SOM) and etc.

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Measurement of Bioelectrical Signals in Environment With Strong Electromagnetic Noise

L. Vojtíšek, P. Smrčka, K.Hána, J. Kašpar, J. Brada

vojtisek@fbmi.cvut.cz

Joint Department of Biomedical Engineering, Faculty of Biomedical Engineering, Czech Technical University, Nám. Sítná 3105, 272 01 Kladno, Czech Republic

Introduction

The manner of central nervous system in man is considerably complicated and learning all the underlining processes is a natural mankind's desire. Each process is in fact a system of more physical procedures that result in more or less measurable quantities. Monitoring of such quantities helps us to detect physiological or pathological principles. Many physical approaches could be used in general but the combination of functional MRI and monitoring of the electrical brain activity by EEG seems to be very promising.

Materials and Methods

Functional magnetic resonance (fMRI) enables the mapping of active brain areas with fine spatial resolution based on so called BOLD effect. The increase of the local blood flow in given area result in the change of T1,T2 and T2* constants which is manifested by changes in the shades of gray in final image. By comparing and further processing prior to and after the activation, the areas can be later highlighted in 2D or 3D model for easier diagnostics.

The electrical activity of a brain is viewed by EEG. This method monitors brain with very fine time resolution of incoming signals and is ideal complement to the spatial information generated by fMRI. Problematic issue in this combination seems to be low level of EEG signals that are in addition under fMRI deformed and produce specific artifacts. These are caused by a strong magnetic field, radiofrequency pulses (RF) and also by alternation of gradient fields. The EEG apparatus destined for operation in magnetic resonance environment should therefore be specifically adapted. Elimination of the disturbing factors should be distinguished in two levels. Firstly at the level of the very signal acquisition, e.g. of measuring hardware (HW) and secondly at the level of the registration program and digitalized data processing.

Results

Development and construction of such EEG device adapted for an operation in the high noise environment is planned in Institute for Biomedical Engineering at Czech Technical University in Prague. Our team is focused on the development and construction of such acquisition hardware and control programs with incorporated numerical filters.

The protection from RF pulses is ensured by shielding and a special construction of the scanning electrodes. Further protection from the disturbance at the level of HW is replacing the classical metallic data transfer system by optical fibers or alternatively using wireless system that does not interfere with the RF of MRI. However, a substantial deal of the artefacts

yet remains on the side of processing the signal by the measuring program. Precisely defined pulse sequence in MRI allows us to set the adaptive filtration of signals very effectively and eliminate thus the influence of RF and gradient fields. By further numerical filters and processing we should eliminate the influence of balistic-cardiographical artefacts (such as synchronization with ECG) and effects of movements of scanning electrodes and cables within the MRI chamber.

Conclusions

Scanning the EEG signals in the course of fMRI proves to be a beneficial combination for monitoring of time-spatial processes in human brain and it is a subject of further research, what are the diagnostic scopes of the correlation between these two methods. There are some results obtained especially in epileptic patients but it is quite possible that this approach will become very valued in the health care of the future.

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Analysis of hip joint hemiarthoplasty influence to stress field changes in bone tissue

D. Kytýř*, M. Micka**

xkytyr@fd.cvut.cz

* Department of Mechanics and Materials, Faculty of Transportation Sciences CTU, Prague, Czech Republic

** Department of Biomechanics, Institute of Theoretical and Applied Mechanics AS CR, v.v.i, Prague, Czech Republic

Introduction

Hip joint replacement is the only way for millions of patients to recover their mobility. Although new designs of replacements are developing every year, manufacturing technologies are advancing, new materials are emerging and surgical methods are improving as well, the optimal hip joint replacement has not been designed. There are two basic surgical methods for hip joint replacement: total hip joint replacement which consists of femoral component and acetabular cup and hemiarthroplasty (femoral component only) which article deals with. Hemiarthroplasty is usually used in case of femoral neck fracture of senior patients. In context of global population aging this problem is becoming world-wide important.

The most common problem that may happen soon after hip hemiarthroplasty surgery is migration of the head of the replacement. In the operation records of the Orthopaedic Clinic of the 3rd Faculty of Medicine of the Charles University in Prague, the implants that migrated in different ways in the course of several months were retrieved and evaluated, see Bartonicek [1]. There are two dominant directions of the replacement head migration: median migration into pelvis minor or migration in acetabular labrum direction. The aim of this research work is to analyse the migration of the replacement head in pelvic bone under various types of loading and shapes of acetabulum.

FE Models

The geometry of the skeletal elements is based on series of CT scans of resolution 512x512 pixels taken in 1 mm slices. For construction of the organs geometry a standard procedure including semi-automatic tissue segmentation is used. Identification of some physical properties of the tissue of interest is the aim of image segmentation. Before the specified tissue can be reconstructed its boundaries must be identified. For the segmentation purposes we use traditional intensity based segmentation relying on the fact, that pixels representing the same tissue are clustered around a mean characteristic value. A tresholding procedure combined with repetitive application of Gaussian filter is used combined with removal of islands (removal of non-connected regions of tissue with area smaller than specified value) and semi-automated removal of misclassified tissue. This procedure is fully automatic, but for segmentation of such a geometrically complex object as a skeletal element a manual correction of several slices must be applied.

The factors, which could have influence to migration are considered as parametric inputs. The main geometrical factors, which may influence the migration of the implant are the CE angle and the direction of loading force. Boundary conditions were represented by fixation of all surface within the area close to acetabulum. The loading of the acetabulum is modeled by assigning acceleration to the mass steel replacement head. Loading resultant intersects the center of the replacement head. The frontal plane inclination from the plane of interest of the model was set to 19°. Model was solved in various loading directions with

loading direction from -45° to 10°. This loading range is a little bit lager than the range of physiological loading.

Materials

The bone material for the experiments was obtained from cadavers. We had several samples of cancellous bone from the femur of relatively old patients. Tensile tests in combination with optical identification method were used to gain material properties of cancellous bone. Drilled out testing samples with diameter three to five millimeters and length minimally eighteen millimeters, sized and glued in wood holders were tested using Instron 3382 loading machine. It is required to use the holders to avoid the crack of the sample in jaws. Second testing device was Nicon high resolution camera. Optical identification method is based on spot centers detection. Strain was measured from the position of spot centers during the test. From the measured data we were able to obtain stress-strain curve and modulus of elasticity. There are two materials in this simplified model. Steel implant head was defined using rigid material, pelvic bone using nonlinear foam material model with crushable elements. Stress-strain curve, which was used to define material properties of the cancellous bone were taken from literature [4] and validated by our experiments.

Conclusion

The total displacements and values of the first and the third principal stresses were used as reference magnitudes. Results showed importance of well-developed acetabulum reducing extreme values of cancellous bone stresses. The way of artificial femoral implant fitting influences the direction of loading force. When the prosthesis is fitted higher in comparison with intact head the muscles on lateral side is prestressed and the resultant force is deflected from vertical direction laterally. On the other hand when the replacement head is fitted lower the result is opposite. The head of the hip joint replacement is fitted correctly, when its centre is 1-3 mm under the greater trochanter. Also coxa vara and coxa valga positions have the significant influence on loading of the hip joint.

The stresses and displacements fields showed that primary migration of the replacement head followed the direction of loading. Decreasing of the CE angle and increasing of the loading direction angle concentrate the stress to the acetabular labrum area. This very unfavourable situation probably initiates the migration; therefore the natal predispositions of acetabular CE angle and higher fitted prostheses have significant influence on the lateral migration.

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Contact Stress Analysis of Pelvic Bone and Cemented Acetabular Component with Imperfections of Cemented Layer

J. Vyčichl*, O. Jiroušek, J. Jírová****

xvycichl@fd.cvut.cz

* Department of Mechanics and Materials, Faculty of Transportation Sciences CTU, Prague, Czech Republic

** Department of Biomechanics, Institute of Theoretical and Applied Mechanics AS CR, v.v.i, Prague, Czech Republic

The important role in the process of the acetabular cup loosening is remodeling of bone tissue as a result of the change of stress field after implantation. Living bone tissue is continuously in the process of growing, strengthening and resorption, a process called "bone remodeling". Initial cancellous bone adapts its internal structure by trabecular surface remodeling to accomplish its mechanical function as a load bearing structure. In the case of cemented acetabular implants the remaining cartilage is removed from the acetabulum and the shape is adapted to the original one by means of a spherical milling machine. By this procedure a roughly spherical bed is obtained. The size and character of the contact stress distribution in subchondral bone depends on the type of imperfections in cement layer. These imperfections are created during the implantation process, when polyethylen cup is not placed exactly in the centre of the acetabulum so that the cup forces out the bone cement and creates direct contact between polyethylene cup and pelvic bone [3].

The three-dimensional geometrical model of the left pelvic bone is generated from the sequence of 240 CT slices using segmentation procedures [2]. Tissue segmentation is followed by for surface reconstruction and geometric model development using either volume-based or voxel-based methods. All procedures for these methods are programmed using the Tool Command Language (Tcl), ToolKit (Tk) libraries and a set of libraries from Visualization ToolKit (VTK). As an input data we use data from the Visible Human Project VHP (both CT & MRI sequences) and data obtained from 1st Medical Faculty in Prague, Charles University. Geometric model of the acetabular component, polymethylmethacrylate bone cement and polyethylene cup with ceramic head is inserted into the pelvic bone by means of Boolean operations.

Two FE models are studied. The endoprosthesis is inserted with 47.5° inclination and 19.7° anteversion with the ceramic head being positioned out of centre of the acetabular cavity for first model and at the centre of the acetabular cavity for second model. The whole high resolution finite element models are composed of the above mentioned geometrical models. Modelling and all simulations are carried out using ANSYS FE package. Elements representing trabecular bone are created using quadratic tetrahedral elements. The same element type was used for meshing of all the other parts of the cemented acetabular component model. The surface of the pelvic bone is covered by the layer of cortical bone modeled with quadratic shell elements of 0.9mm constant thickness and the surface of acetabulum is covered by the layer of subchondral bone modeled with quadratic shell elements of 0.7mm constant thickness.

Boundary conditions are specified at the sacro-illiac joint, where the nodes are fixed in all directions and at the contralateral side of the pubic symphysis, where the nodes are fixed in x and y directions.

Three contacts are defined in the first FE model and two contacts in the second FE model. The first contact is defined between the pelvic bone and the external surface of the cemented layer, the second contact is defined on the internal surface between the cemented layer and the polyethylene cup and the third contact is defined between the pelvic bone and the polyethylene cup. The friction value used f=0.5 represents an intermediate value determined for the wet femoral bone and the titanium implant, but could vary according to surface roughness of the cement layer and the bone tissue or even the presence of an affective lubricant (e.g. blood). By this information are defined friction values in this manner. The friction value f=0.6 is used for the first contact. The friction value f=0.8 is used for the second contact and f=0.3 is used for the third contact. FE model without imperfection in the cement layer haven't the third contact between the pelvic bone and the polyethylene cup.

In our computational models quasistatic joint contact forces, representative of the stance phase of gait, were applied to the model (body weight BW=84 kg) during normal walking 4 km/per hour [1]. The loading was applied to the centre of the ceramic head. Interaction of the cemented acetabular component with the underlying subchondral bone is studied as a contact analysis.

Stress distribution in subchondral bone tissue depends on the imperfection in the cement layer. If the imperfection is in the cement layer then the local stress concentration is in the pelvic bone on the border of the imperfection. On the other hand if the cement layer has no imperfection then the stresses are distributed on the border of the cement layer. Computational modeling has showed that the subchondral bone at the contact with the cement layer is even unphysiologically loaded by tension stresses during the routine activities of the man. The FE model is appropriate for the solving contact stress analysis of the interaction between the pelvic bone and the cemented acetabular component and will be used in the next analysis.

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Recognition and automated classification of significant areas in EEG signal

V. Gerla*, L. Lhotska*, V. Krajca, K. Paul*****

gerlav@fel.cvut.cz

* Department of Cybernetics, FEE, CTU, Technicka 2, 166 27 Prague 6, Czech Republic
** University Hospital Bulovka, Budinova 2, 180 81 Prague 8, Czech Republic
*** Institute for Care of Mother and Child, Podoli, 147 00 Prague 4, Czech Republic

In this paper we present results of the development for EEG record analysis. These results have been presented in [1-4]. The main aim of our study was to design and develop a combination of feature extraction and classification methods for automatic recognition of behavioral states using polygraphic recording. Such method would speed up and objectify identification of described states and may be used for online classification. Till now the identification has been performed manually through visual analysis of the recordings. In our study, first the feature characteristics for individual states were extracted from polygraphic recordings. Then the behavioral states were identified from extracted features using several classification methods. Data have been provided by the Institute for Care of Mother and Child in Prague (12 infants, recorded 5-10 days after childbirth).

All recordings used in this work contain eight EEG channels (these are FP1, FP2, T3, T4, C3, C4, O1, O2), Electrooculogram (EOG), Electromyogram (EMG), Respiratory channel (PNG) and Electrocardiogram (ECG). All the data have been annotated by an expert into four classes (wake, quiet sleep, active sleep, movement artifact). For accurate classification it is necessary to determine and/or calculate the most informative features. First, we focused on computing features derived from the EEG signal. We computed Power spectral density (PSD) for common frequency ranges (delta, theta, alpha, beta, and gamma). One of the criteria for determining newborn behavioral states is regularity of respiration. We have used use the autocorrelation function in this case. Next we detected eye movements using the modified method developed by Värri et al.. This approach is based on applying a weighted FIR-median-hybrid (FIR-MH) filter. For detecting the heart rate we used modified version of Pan and Tompkins algorithm. In newborns, there is a major problem with movement artifacts. A large majority of these artifacts is present in the EMG channel. It was sufficient to use the standard deviation feature for this signal.

We apply *Principal Component Analysis* (PCA) for all described features. We use PCA for data compression (reducing the number of dimensions, without significant loss of information). After PCA we use for classification Hidden Markov models, Ant-colony approach (ACO-DTree algorithm), the GAME (Group of Adaptive Models Evolution) inductive models, nearest neighbour and decision rules. In the process of the classical pattern recognition we classify each segment on the basis of the features obtained from this segment. *Hidden Markov Models* (HMMs) are widely used for this problem. HMMs are a special class of stochastic processes that uniquely determine the future behaviour of the process by its present state. We use the EM algorithm for finding the maximum-likelihood estimate of the parameters of HMMs given a set of observed feature vectors. *The ACO-DTree method* [1] uses an evolutionary approach combined with ant colony optimization approach: Evolutionary methods work on the population basis, where the individuals (candidate solutions) are evolved in Darwinian style. Ant colony optimization is based on the real ant

colony behavior in nature: ants deposit a chemical substance (pheromone) through time. The pheromone concentrates in areas frequently visited by the ants, leading to the discovery of the shortest path. In addition, as the pheromone evaporates, the ants are able to cope with dynamically changing environment. *The GAME* [2] is an inductive model that means it is automatically generated from a data set. It grows from a minimal form during the learning phase, until the optimal complexity is reached. The GAME model consists of interconnected elements – units or neurons. Units and connections are evolved by means of special genetic algorithm. We compare results with a method based on *the nearest neighbour classifier*. This very simple model depends on the quality of the training set. It is possible to achieve good results on the known data (the training data set corresponds to the testing data set), but it has no ability of generalization. This classifier does not work correctly on the unknown data. The classifier based on *decision rules* has not only been good classifier, but it has also described important trends in data. The accuracy and the ability of generalization have influenced number of used rules (great number of rules means high accuracy but low ability of generalization).

Computer-assisted methods can extend our abilities to examine physiologic relationships between cerebral and non-cerebral measures, and explore associations with representative outcome variables. All neonatal states have been recognized by combination of EEG, EMG, EOG, PNG and ECG features. The approach has been tested on real sleep EEG recording for which the classification has been known. The most important part of the work was identification of the most informative features in all PSG signals and their successive extraction. The applicability of these features was verified. They were utilized for classification and we reached very good results. The final mean accuracy of classification is 82% for HMMs, 75% for GAME classifier, 68% for ACO-Dtree approach, 66% for RandomTree method and 65% for nearest neighbour classifier. During automated classification we have problem with clear separation of stages of wake and active sleep. Now we try to find hidden information enabling this separation. We are developing methods for rapid eye movements detection from EOG signals and try to detect specific graphoelements in EEG signals. The accuracy of results obtained is comparable with manual classification accuracy and the characteristics can be used as a hint to neurologists for neonatal sleep stages evaluation.

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System for Interactive EEG Analysis

J. Mužík*, K. Hána, J. Kašpar****

muzikj@gmail.com

*Department of Radioelectronics, Faculty of Eletrical Engineering, Czech Technical University in Prague, Technicka 2, Prague 6, 166 27, Czech Republic

**Faculty of Biomedical Engineering, Czech Technical University in Prague, Náměstí Sítná 3105, 272 01 Kladno, Czech Republic

We describe novel original software which allows EEG to be processed and visualized interactively in real-time using 2D or model-covering maps. Although real-time observation of EEG maps can provide new information and ideas, offline processing is definitely indispensible. So the standard offline processing as well as export to other software is also possible.

Most systems for EEG processing and visualization are based on offline processing. Offline processing stands for recording, storing and later processing of EEG, possibly recorded simultaneously with other biological signals, stimuli, video or even fMRI. Such additional information greatly improve extraction of information from EEG data but the delay between recording and processing causes lost of interactivity in EEG processing.

Software is fully modular and therefore enables easy extensibility by custom modules. Main application framework and some modules were developed in Borland Delphi under component object model (COM). Currently most of the input and visualization modules are implemented in C#. This is possible thanks to interoperability feature of .NET framework. Standard dataflow mechanism is: an input module hands over data to a signal preprocessing module. Than follows chain of data processing modules and post-processing modules and finally signal vectors are sent to interpolation and visualization modules.

Input modules are in fact device drivers for obtaining EEG data vectors from EEG machines. Usually for each EEG machine extra input module has to be developed. Input modules provide universal interface between EEG machine and main application. Input modules are responsible for all configuration and communication with device. They also do montage recalculation, if necessary.

Preprocessing modules are responsible for noise and artifact removal. Preprocessing modules, unlike signal processing, are supposed to be simple synchronous modules without possibility of real-time adjustment of parameters. Basic preprocessing modules are band limiting filters with suppression of power line noise. More sophisticated artifact removal methods like PCA are difficult to implement to work in real-time.

Signal processing (DSP) modules are intended for in-depth signal analysis and extraction of parameters which are used for visualization. They can be implemented either as synchronous or asynchronous. DSP modules can have its own graphical interface, which is embedded into main application window, so their parameters can be adjusted in real-time. Currently

implemented modules include mapping of amplitude, band power spectrum, coherence and others. DSP modules receive input vectors one by one but are expected to process data in overlapping block where the degree of overlap can be set.

Post-processing modules are useful when actual signal maps should be compared with any reference map. Reference maps can be entered in form of vector of numbers or can be captured during processing of real-time signal. Reference map can be than added subtracted or multiplied by actual map. Another function of post-processing module is to hold maximal or minimal values in maps or average maps during given period. It cans also capture-and-hold maps in synchronization with another non-mapable signal.

Visualizations modules are most complex components. They are required to interpolate and visualize maps of many EEG channels in real-time. Calculate EEG maps one by one pixel is impossible on standard personal computer, since at least 25 frames per second (FPS) are needed to achieve smooth perception. It is necessary to make use of advanced interpolation methods such as Delaunay electrode mesh triangulation and recursive mesh refinement, where finally triangle set is rendered by hardware graphics subsystem. Another module implements method for parallel calculation of Shepard interpolation using multiple shader processors on graphics cards. Using two processor allow to easily reach 45 FPS for maps as large as 300 by 300 pixels at 80 mapping channels.

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Scoliosis Treatment with Force Prescibed Brace

J. Čulík

culik@fbmi.cvut.cz

Faculty of Biomedical Engineering, Czech Technical University of Prague
Sítná 3105, 272 01 Kladno

The children scoliosis is conservative treated by corrective braces. The brace is made individually for each patient. The first is made the negative and then the positive form of children trunk. The final plastic brace is made according to the positive form. The brace type Cheneau or Černý are used at Czech Republic. The plaster form is deepened at the place, where the brace have to push on patient trunk and at the appositive side is made a free slot.

The new type of brace with regulated pushing on the patient trunk was developed. The brace can consist of 2 or 3 parts connected by joints and on the appositive sides by telescopes with adjusted forces. This article describes the brace consisting from 2 parts which can be used for spine defects at form letter 'C' (spinal curve has only one extreme). The top of the work was to develop a calculation algorithm of optimal force value at the telescope and to compose program for computer aid brace design.

The brace consists from two plastic parts: a lumbar part length l_1 and a thoracic part length l_2. The bought parts are connected by joint *j* and telescope with adjustable force *F* at appositive side. The brace turns a patient trunk with moment $M = F.r.$ The moment effect is carried to a patient trunk. The patient trunk is loaded partly by continuous parabolic loading. One parabolic loading with maximal value f_2 is under the brace joint. The parabolic loading is unsymmetrical with bright b_1 on lumbar part and b_2 on thoracic part. The parabolic loadings are on lumbar brace end with bright *a* and maximal value f_1 and on thoracic part with bright *c* and maximal value f_3. The spine is solved as a beam stiff at vertebra parts and elastic at the inter-vertebrae parts. The first will be determined values f_1, f_2, f_3 as a function of force *F* according to moment equilibrium conditions the lumbar and thoracic parts to joint *j*. The ratio of dimension l_1, l_2, *a,* b_1, b_2, *c* were estimated according to measurements at applied braces:

$$l_2 = 2l_1,\ a = b_1 = 0.2\ l_1,\ c = b_2 = 0.2\ l_1$$

The loading coefficients are

$$f_1 = 8.878504674 Fr / l_1^2,\ f_2 = 6.54205609 Fr / l_1^2,\ f_3 = 4.205607477 Fr / l_1^2$$

The spinal pathologic curve is measured on X-ray and the parts between extremes are approximated by polynomials. The spine is loaded from brace partly parabolic and the spine between the parabolic loads is unloaded. The spinal curve correction as a brace force effect is solved as beam deformation from differential equations

$$M'' = -f,\ \varphi' = -\frac{M}{EI}(1+\varphi^2)^{\frac{3}{2}},\ w' = \varphi$$

where *f* is load (at unloaded part is $f=0$), *M* is bending moment, *E, I* are module of elasticity and moment of inertia (at vertebra parts $EI \to \infty$), φ and *w* are turning and displacement of spinal curve correction. The parabolic load (see fig. 3) is defined by function (positive direction is down)

$$f = -\frac{p}{l}\eta^2 + p\eta$$

where η is distance from origin of parabolic load, l is length of parabola and parameter p is

$$p = \frac{4 f_i}{l}$$

where f_i is the maximum value at center of parabolic load.

The shear force Q and bending moment M below the parabolic load are

$$Q = Q_1 + \frac{p\eta^3}{3l} - \frac{p\eta^2}{2}$$

$$M = M_1 + Q_1\eta + \frac{p\eta^4}{12l} - \frac{p\eta^3}{6}$$

The M is calculate analytic and φ, w numerical by Runge-Kuta´ method. The differential equations are solved with initial values $Q(0) = M(0) = w(0) = 0$ and estimated value $\varphi(0)$. This value is corrected after numerical solving to be $w(l) = 0$.

The second problem is to determine optimal value of telescope force F. The optimal spine correction is if the quadratic error of correction values w_i and the spine curve points y_i measured at X-ray is minimal

$$\varepsilon = \sum_{i=1}^{n} (w_i - y_i)^2$$

The minimum of error can be searched by Newton's iteration method with numerical derivations.

The problem of solving differential equations and minimum of quadratic error is shown in detail at the article Čulík (in print). This article solves the brace with regulated pushing on patient trunk consisting from 3 parts with 2 couples of joints and telescopes.

The new types of brace with regulated pushing on patient trunk is moor effective the previous types. Bought problems were interpreted on computer. The program can be used for computer aid design and it calculates optimal telescope forces for measured patient data on X-ray and dimensions measured at patient positive plaster form.

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Error Assessment of Volume Reconstruction of Biological Specimens from Confocal Microscopy Images

M. Čapek* **, J. Janáček, L. Kubínová**, P. Smrčka*, K. Hána***

capek@fbmi.cvut.cz

* Faculty of Biomedical Engineering, Czech Technical University,
nám. Sítná 3105, 272 01 Kladno 2, Czech Republic

** Institute of Physiology, Academy of Sciences of the Czech Republic, v.v.i.,
Vídeňská 1083, 142 20 Prague 4 - Krč, Czech Republic

We apply volume reconstruction for visualization and analysis of biological specimens which are greater than field of view and/or thicker than maximal depth of scanning of a used optical instrument. We use a laser scanning confocal microscope capable to focus a laser beam into a layer of an investigated specimen, and by the gradual scanning of this layer it acquires an optical section. By consecutive scanning of all preset layers of the specimen the microscope captures a stack of optical sections, i.e. a 3D digital representation of the specimen [1].

Volume reconstruction consists of the following steps [2]: A) Specimen preparation and cutting into thin physical slices. B) Acquisition of overlapping fields of view (spatial tiles) from all physical slices. C) Horizontal merging (mosaicking) of the spatial tiles into a sub-volume representing a physical slice. D) Vertical merging of sub-volumes of successive physical slices into volume representation of the whole specimen using elastic registration. E) Image enhancement of optical sections in the resulting volume using our own developed algorithms [3].

In Step A) the specimen must be cut into physical slices, so as these can be investigated by the confocal microscope that has limited depth of scanning – approx. 30 μm in case of our specimens which are embedded in paraffin [4]. The physical cutting of specimens introduces spatial discrepancies between successive physical slices. These discrepancies are created mainly by mechanical deformations (e.g., shrinkage, and/or partial rehydration of different sections), and by the off-cut made by the cutting tool resulting in the loss of some information between the successive physical slices.

The reason for applying the elastic registration in Step D) is to compensate for possibly extensive deformations of specimens caused by their cutting and manipulation during preparation. The elastic registration solves efficiently problems regarding deformations of successive physical slices, however, it introduces one difficulty: The alignment is performed step by step using a bottommost mosaic image of one physical slice as a reference (fixed), and a topmost mosaic image of the second physical slice is registered (floating). As a consequence, objects/structures in the floating image are transformed according to objects/structures in the fixed image. If we cut, for example, a “cone-like” object into physical slices, as a result of 3D reconstruction using elastic registration, that covers also scaling and shearing, we obtain a “cylinder-like” one, which is not desired.

A solution to this problem lies in recording the shape of the object prior to its cutting using a digital video camera or a digital still camera. Then the shape of the object could be restored after elastic registration using information in the video stream or the pictures.

Similar approach we applied for assessment of errors during volume reconstruction. We recorded series of pictures of cutting planes of the specimen (17-days-old embryo of a Norway rat) before cutting physical slices by a microtome. For this purpose we used a portable Dino-Lite USB digital microscope having resolution of 1280×1024 pixels. After recording pictures and cutting all physical slices we captured high-resolution images of all physical slices of the specimen by a confocal microscope.

We performed both volume reconstructions using images captured by the USB microscope and images captured by the confocal microscope. We manually marked important corresponding structures in both reconstructed data sets, and computed distances between corresponding structures, assuming that structures in the reconstruction from USB microscope data are without deformations.

According to our expectations, the main errors of high-resolution volume reconstruction (from confocal data) are in the direction of physical cutting (vary in units of millimeters) and in the direction perpendicular to cutting due to off-cut (vary in tenths of millimeters).

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Search for Unrelated Bone Marrow Donors

D. Steiner, L. Lhotská

steind1@fel.cvut.cz

Czech Technical University/Gerstner Laboratory, Technická 2, Praha 6, 160 37, Prague, Czech Republic

Hematopoietic stem cell transplantation (HSCT) [1] or bone marrow transplantation is a medical procedure in the field of hematology and oncology that involves transplantation of hematopoietic stem cells (HSC). It is most often performed for people with diseases of the blood or bone marrow, or certain types of cancer (e.g. leukemia). In principle intravenous infusion of stem cells collected from bone marrow, peripheral blood or umbilical cord blood could reestablish hematopoietic functions of a patient with damaged or defective bone marrow or immune systems. But HSCT is a risky procedure with many life-threatening complications (i.e. Graft-versus-host disease) and has always been reserved for patients with life threatening diseases.

There are three types of stem cell transplantation maneuvers: Autologous, Allogeneic and Syngeneic HSCT.

Autologous HSCT, in which the patient's own cell are used, involves isolation of HSC from a patient, storage of the stem cells in a freezer, high-dose chemotherapy to eradicate the malignant cell population at the cost of also eliminating the patient's bone marrow stem cells, then return of the patient's own stored stem cells to their body. Autologous transplants have the advantage of a lower risk of graft rejection, infection and graft-versus-host disease.

Allogeneic HSCT involves two people, one is the (normal) donor and one is the (patient) recipient. Allogeneic HSC donors must have a tissue (HLA) type that matches the recipient and, in addition, the recipient requires immunosuppressive medications. Allogeneic transplant donors may be related (usually a sibling) or unrelated volunteers. Allogeneic transplants are also performed using umbilical cord blood as the source of stem cells.

Third type of HSCT - Syngeneic HSCT - provides stem cell transplant from one identical twin to the other.

In the most cases of allogeneic HSCT, patients don't find suitable donor in their family, so physicians must search unrelated donors in registries of stem cells donors.

The main goal of this work was to design and implement a new algorithm for searching unrelated bone marrow donors. We also stated additional goals: to describe and categorize existing unrelated donor search strategies (algorithms), classify the new algorithm into system of strategies, design and implement a user-friendly GUI that shows results (outputs) of the algorithm and test the algorithm on real anonymous data.

We have found out reason, why it makes sense to recruit Czech donors - because of genetic relation of Czech and Central European population. We have explained methods and levels of HLA typing and relations between them. We explored differences in estimation of serologic equivalents between two important HLA dictionaries. Results of clinical researches gave us requirements for an unrelated donor search algorithm.

This work is the first one that creates a system of existing unrelated donor search algorithms. We presented system of three types and four generations of algorithms. We also discussed search approaches of the biggest registries in the world and found out differences in their match grade categories.

Our own algorithm was systematically designed. First of all we have defined objectives we want search algorithm to reach. Then we looked at the algorithm as a black-box and we specified inputs, parameters and outputs. Internal data structures were shown by UML class diagrams. We outlined the algorithm itself and then described details.

The core of the algorithm is system of match grade categories and their calculation. Result match list is sorted according to internal match grade, which is in harmony with match grade categories. Quality of donor typing is an additional sorting criterion. We discussed time and space complexity. We found out our algorithm satisfies all defined objectives.

The algorithm uses DNA typing of an individual, if it is available. It does not need the serology typing results, but it can work only with DNA typing results of an individual. The algorithm has native support for multiple patient search and is fast enough for smaller registries (up to 100.000 donors). It can be very well parameterized. User can specify loci, where a mismatch can be placed, number of mismatches on specified locus, the maximal age of the donor, max. number of donors they want to see and if the search result should contain only adult volunteer donors or all donors (including CBU). The maximal number of antigen mismatches can be different for adult volunteer donors and CBU.

Finally we presented sophisticated user interface of results of search algorithm with advanced filtering and sorting, mismatch highlighting and description of multiple allele codes.

The algorithm is used in the Czech Stem Cells Registry (Institute for Clinical and Experimental Medicine in Prague) for searching of unrelated bone marrow donors and in the Institute of Hematology and Blood Transfusion in Prague for selection of unrelated donors of thrombocytes.

In future we would like to continue this work and design software that will calculate advises of donor selection based on allele/haplotype frequencies of Czech population.

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Section 13

CIVIL ENGINEERING

Alexanderheide - Giving Back to Human and Nature

Lucie Nenadálová

lucie.nenadalova@fsv.cvut.cz

Department of Sanitary and Ecological Engineering, Faculty of Civil Engineering, Czech Technical University in Prague, Thákurova 7, Praha 6, 166 29

30 students from different countries participated in an international project called "Alexanderheide – Giving back to Human and Nature", about a former German military airfield. The Fliegerhorst Oldenburg on the Alexanderheide is a no longer used military airfield with two rainwater-retaining basins, a wastewater collection system and a recently shut heating power plant. The ground is possibly polluted. The ground has an area of 309 hectares. Part of its area lies in the city little brooks flowing through. One of them is piped over a distance of 700 m. There are also Oldenburg and the other part lies in the district of Ammerland.

From 9th to 17th of November 2007 took place in Oldenburg (Germany) Project " Oldenburg – Alexanderheide – Giving back to Human and Nature". Faculty of applied science in Oldenburg (FH OOW) allowed me to participate in a German group on this project during my fellowship in Germany.
Project came from NEPTUNE (Network for Environmental Projects in Technology, United in Europe).
Participants were 30 students from five different universities Mikkeli Polytechnic (Finland), Noordelijke Hogeschool Leeuwarden (the Netherlands), Vitus Bering College (Horsens, Denmark), Instituto Superior de Engenharia de Lisboa (Lisbon, Portugal) and the FH OOW (Emden, Oldenburg, Germany).
Together were 8 nationalities. (Portuguese, Finnish, Dutch, Danish, Icelandic, Norwegian, Germany and Czech).

Our task in international teams was developed plans and find solution for a new use of the area with a focus on water management. It included considerations regarding renaturation of the brooks, a plan for a new heating system and for future rainwater management while taking climate change into account. All conceptions had to take a look at the consequences on the economy, people and the environment.

The project started with introduction weekend with team – building activities. The language for the project was English.
On Monday 11th November started official opening and keynote lectures from Haarenwasser-Acht, city Oldenburg, group water local agenda 21, FH OOW dean and vice – president.
We visited Alexanderheide, found out where two little brooks through the airfield. One of them is piped over distance of 700 m. There were also rainwater retaining basins and a wastewater collection system from the airfield buildings. We looked at old military buildings and at obsolete old heating plant that was shut down at the end of June 2007.

During the week six teams made up of students from five different countries. Each team was mixed by discipline as well. Each team had a supervisor. Teams developed plans how to implement it.

On Friday November the 16th teams presented their ideas and plants of a jury of experts. Students presented proposed heating system, water management plants, possible costs, creativity a feasibility of the ideas. The „A-Team“ wanted to transform Alexanderheide into a second Versailles, „Team Tower“ opted for a huge lake in a natural surrounding overcoming the height differences with a pump driven by a wind mill, „Terra Fox“ compared human development with the spreading of cancer and tried to provide some more space for this, including sport and leisure activities into the plant, „Team Water World“ saw the possibility of a small wind park and forest in the area, and „Beiji“ even came up with the idea of creating a motocross/paintball /guad driving field.
At the end were announced two winners. The ideas of the „A-Team“ and „Terra Fox“ interested the most the jury.

The Neptune Project was grateful opportunity to try working with students from different countries, different academic backgrounds and to get to know friendly people in a same branch.

Spatial Requirements of Rural Roads Design in Relation to Design Classifications.

P. Pánek, F. Eichler

petr.panek@fsv.cvut.cz

Czech Technical University in Praque, Faculty of Civil Engineering, Department of Road Structures, Thákurova 7, 166 29 Praha 6, Czech Republic

The focus of this work is on issues of rural roads design in connections to complex land redistributions. These roads are designed within or in close connection to a framework of complex land redistributions. The complex land redistributions organize the plots of land in terms of space and function. In order to provide accessibility and good function the plots of land are merged or divided. The complex land redistributions provide good conditions for environmental improvement, protection and fertilization of land resources and increase ecological stability of the area.

There is a technical regulation number ČSN 73 6109 Design of Rural Roads prescribing fundamental requirements for the design of rural roads including particular features and conditions for their construction. Another technical regulation TP Catalogue of Pavements of Rural is integral part of ČSN 73 6109 serves as a base for design of pavements.

The complex land redistributions result in regeneration of cadastral apparatus. Approved information arising from complex land redistributions are registered in the land register. This process opens new space for construction of rural roads and other facilities.

Cadastral plot of land allocated for construction of rural roads should follow the technical regulation number ČSN 73 6109. This regulation determines project classifications of the rural roads and their features that are necessary for their good functionality. Knowledge of the most often used design classifications of rural roads is necessary for optimal design of complex land redistributions in further phases of the project. Gradient ramps are integral parts of rural roads when this road is designed under or over the level of the terrain. Ramp gradients follow the norms of technical regulations number ČSN 73 6109 and depend on the type of soil used generally 1:2 exceptionally 1:1. Side ditches, lay–by, access roads to neighbouring plots of land etc. are integral parts of the rural roads. The space required for the design of rural roads increases when these features are applied. According to above mentioned it is not possible to design a rural road of the same width as the cadastral plot of land.

Rural roads are used mainly for agricultural machinery operation. The type of the agricultural machinery is considerably diverse and varies according to seasons of the year. There are machines of different width and length which changes with the type of equipment connected to the vehicle. We have to consider enlargement in the directional horizontal curves depending on the diameter of the curve. This is also regulated by the technical regulation number ČSN 73 6109. The rural roads should be designed with respect to surrounding terrain and the type of landscape. Gradient ramps to maximum high of 0,5 metres are not considered as disturbing the surrounding land. The width of usually used types of rural roads are within the span of 3,0-5,0 meters.

The following examples of various road cross-sections show the minimal width of the cadastral plot of land needed for the design of purpose roads.

- Rural road of the classifications width of 5,0 meters with ditches on both sides, gradient ramps 1:2, profile grade in the same level as the surrounding terrain. Suitable width of cadastral plot of land for the rural roads of these specifications is approximately 10,0 meters. If the rural road is to be designed under or over the level of surrounding terrain it is necessary to increase the width of the cadastral plot of land. This needs to be applied also in case of enlargement in the directional horizontal curves.
- Rural road of the classifications width of 5,0 meters without ditches, profile grade 0,5 meters above the level of the surrounding terrain, gradient ramps 1:2. Suitable width of cadastral plot of land for the rural roads of these specifications is approximately 7,5 meters. If the purpose road is to be designed with ditches it is necessary to increase the width of the cadastral plot of land. This needs to be applied also in case of enlargement in the directional horizontal curves.
- Rural road of the classifications width of 5,0 meters with ditches on both sides, profile grade 0,5 meters bellow the level of the surrounding terrain, gradient ramps 1:2. Suitable width of cadastral plot of land for the rural roads of these specifications is approximately 11 meters. If the rural road is to be designed with enlargement in the directional horizontal curves it is necessary to increase the width of the cadastral plot of land.

Conclusions

The above examples of rural road cross-sections arise from practical experience with their design. The plot of lands allocated for the design of rural road arising from complex land redistributions should satisfy conditions make the designing phase easier. Fulfilment of these conditions ensures the compliance with the technical regulations and prevents challenging technical solutions.

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Modelling the Performance of Layers of Cold Recycled Materials in Non-rigid Pavement Constructions

P. Pánek, F. Eichler

petr.panek@fsv.cvut.cz

Czech Technical University in Prague, Faculty of Civil Engineering, Department of Road Structures, Thákurova 7, 166 29 Praha 6 - Dejvice, Czech Republic

Cold recycling

Cold recycling represents a technology often desirable in road repairs, which, however, is still little applied in our country. This technology utilizes the material of the existing road construction (recyclate) with simultaneous addition of binders (cement, asphalt emulsion) for improving technological properties (strength, bearing capacity).

The benefits of selecting this method of road repair are considerable financial savings in construction costs and a short repair period due to efficient use of machinery.

This technology is suitable mainly for secondary and tertiary roads, local roads and traffic surfaces which show defects like overall pavement deformation, edge spalling, local settlement, cracks, irregular bumps, deep corrosion and pot holes.

The advantage of cold recycling is utilization of secondary raw materials in road construction, which represents economic and ecological contributions, a considerable increase in the bearing capacity of pavement base courses and extension of the minimum service life by up to ca 15 years. Road operation during repairs may be only partially limited. In case of need passage along the adjoining lane may be enabled. The advantage of this repair method are lower financial expenses for a unit of implemented work.

Modelling and evaluation of non-rigid pavement construction

The major factor in the modelling and evaluation of the non-rigid pavement construction according to the Czech design method in force described in TP 170 is so-called relative damage of the respective layer or subbase. In order to evaluate the performance of layers of newly designed cold recycled mixes applied in the pavement construction, comparison with the “basic” pavement D1-N-5(IV/PIII) was made with a composition adopted from the catalogue TP170 (AB II 40mm, OK I 70 mm, KSC I 140 mm, MZ 200 mm, Epd 50 MPa).

Individual layers of the basic pavement were replaced with layers of cold recycled materials during modelling. Depending on whether a wearing, ballast or base course was replaced (in keeping with recommendations of TP 162) the modelling always involved several versions of this replaced layer differing by thickness (until roughly identical relative damage was found as that of the original pavement).

The calculation output was always the corresponding relative damage of asphalt layers and subbase. An imperfect interaction of layers and potential classification of recycled mixes as asphalt layers or others (i.e. assessment or non-assessment of recycled mixes) was taken into account in modelling.

The calculated values of relative damage were arranged in synoptic graphs documenting the relative damage dependence on the recycled layer thickness.

Two mixes were used for the calculation with working names AE1 and AE2.

R-material fraction 0/11, 0/22 and 0/32 was used for their production without any other addition of next fine or coarse aggregate or filler. It was necessery (with respect to increasing the parts of elements < 4 mm) to add to the mixture fine aggregate fraction 0/2 (quarry Dobkovice) and waste aggregate 0/2 and 0/4 (fracture Kostalov and Smrci).

By the mixture was used Portland cement fort classes 32,5 R. Like emulsions were used two samples of slowly-fission cationic asphalt emulsion EMULTECH P producer SSŽ, Inc . and Vialit RE60 Austrian producer Vialit Asphalt, GmbH.

The composition of AE1 (or AE2 resp.): R-material : additive aggregates 75:25 (or 60:40 resp.), Asphalt emulsion 3.5% of weight (or 3.0% of weight), Cement 1.5% of weight (or 3.0% of weight), Stone flour 6.0% of weight (or 0.0% of weight).

Individual versions were evaluated under identical input conditions i.e. using the same design level of failure (D1), the same traffic load (TNVk=500 i.e. TDZ IV), subbase type PIII and the required length of service life of 25 years.

Conclusions

The large amount of calculated data and drawn charts make it possible to specify in which pavement layers the above-mentioned recycled mixes are advisable for use. This means that we may find out at which thickness of the new recycled layer the same relative damage may be obtained as in the “basic” pavement.

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MASW tests for detection of buried trestles - experimental and numerical study

Fernando Tallavó*, Giovanni Cascante*, Mahesh Pandey*

gcascant@civmail.uwaterloo.ca

*Civil Engineering Department, University of Waterloo, ON, Canada N2L 3G1

This paper presents results from multi-channel analysis surface waves tests (*MASW*) conducted on an earth embankment to detect the location of rotten buried trestles in two different sections (*A* and *B*). In section A, the locations of the trestles are known as well as the soil properties; thus, this section is used for calibration purposes. In section *B*, the trestle locations are unknown. A seismic array of 24 geophones with a geophone spacing of 0.5 m is used. Different signal processing techniques were used for the analysis of surface waves to compute dispersion curves, power spectral, distance-frequency contour plot, and wavelet transform. Finite element numerical simulations of *MASW* in an elastic half-space with and without buried trestle are performed to confirm the experimental results. The results show that *MASW* tests were able to detect the location of buried trestles.

Wooden trestles were extensively used in the nineteenth century by railway companies in mountainous areas and in areas approaching bridges. Wooden trestles were backfill with soils for the construction of earth embankments. The buried trestles have not produced negative effects for many years. However, vertical settlements on railroad tracks can be caused because of the decomposition of the wood. These settlements may cause unsafe conditions for trains approaching the embankments. To prevent these settlements, it is necessary to locate the trestles. Nondestructive field tests can be conducted for the detection of buried wooden trestles and for the mitigation of settlement potential. This paper presents the results of Multi-channel analysis surface waves tests (MASW) for the detection of buried trestles in two different sections along an embankment (sections A and B). In section A, the timber trestle locations are known as well as the soil profile. It is used as a calibration section to find a characteristic wave pattern from MASW tests that can be used to locate buried trestles from the surface. The testing methodology defined using the results from section A is then used to find the locations of timber trestles in section B, where the locations are unknown. Finally, numerical simulations of surface waves in an elastic layered half-space are conducted to confirm the experimental results. Signal processing techniques such as Fourier analysis, wavelet transform, and dispersion curve were used for the identification of buried trestles. A series of Matlab programs were implemented for the data processing.

In the test sections A and B, 24 geophones were placed at 0.5 m intervals. A sledgehammer was used as a seismic source. The shots were given at 2 m, 4 m, and 6 m from the first geophone on both sides of the geophone array. To improve the energy transmission of the sledgehammer source, a new plate was designed in the shape of a dumbbell. The new plate is partially buried in the ground. It has a rubber sheet between the cap and the top plate to attenuate high frequencies. The rubber sheet reduces also the bouncing of the hammer by which more energy at low frequency is generated. The subsurface stratigraphy is known to consist of fill material (sand and silt) overlaying a native clay. The 2D-Fourier transform [1] shows vibration energy between 50 Hz and 80 Hz. The frequency of 77 Hz has a wave number of $\kappa = 2.42$ (1/m), and a corresponding wave length of 2.6 m. The vertical distance between the geophones and the trestle is approximately 1.1 m (trench depth $\approx$ 1 m). Thus, the

ratio wavelength to depth of the timber trestle is equal to 2.4. Experimental and numerical studies have shown that the optimum wavelength for the detection of underground voids is in the range $5d > \lambda > 3d$ [2]. A closed form solution for wave propagation in an elastic layered half-space is not available; therefore, numerical simulations are conducted to better understand of the detection of buried trestle using surface wave analysis. Finite element numerical simulations of an elastic vertically heterogeneous half-space with and without a buried timber trestle are performed to confirm the experimental results. The shear wave velocity of each layer is determined by solving the inverse problem from the experimental phase velocity curve. Therefore, the numerical dispersion curve is compared with the theoretical one. Figure 23 shows time signals computed at 10 locations on the surface spaced 0.5 m. The first location is at 4 m from the source. The arrival of the P-wave and the surface wave are shown in this plot. The P-wave velocity and group velocity are 450 m/s and 150 m/s, respectively. The numerical, theoretical, and experimental dispersion curves in the frequency range between 10 Hz and 100 Hz are computed. The maximum difference between the experimental phase velocity and the theoretical one is 21%. The normalized power energy for the case without buried trestle shows amplifications of the energy at 2 m and 5 m. It is very likely that these amplifications are produced by reflections coming from the layered soil profile. On the other hand, when a trestle is buried in the ground, the energy is amplified at the location of the trestle, but the energy is more attenuated after the trestle than the case without buried trestle.

The main conclusions from the test sections and from the numerical simulations are: *Section A*. *MASW* tests with a low-energy source (sledgehammer test) clearly show the location of buried trestles in the vicinity of geophones 9-10 and 18-19. Timber trestles can be detected by plotting the normalized power energy and confirmed with the results of dispersion curves, the distance-frequency contour plot, and the Morlet wavelet transform.
Section B. Sledgehammer shots at 4 m on the east side of the arrangement of geophones show that there are timber trestles close to geophones 7 and 16. Not all source locations showed the location of timber trestles, likely because of the stronger effect of the ballast layer in this test due to the shallower trench. *Numerical Simulations*. Numerical simulations confirm the experimental results. The location of the buried trestle from the normalized power energy plot is confirmed with the 2-dimensional Fourier transform. Therefore, both signal processing techniques should be used for the identification of buried trestles.

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Application of 3D FEM models for the analysis of CC slab stress state due to acting wheel load

P. Pánek, L.Vébr

petr.panek@fsv.cvut.cz

Czech Technical University in Prague, Faculty of Civil Engineering, Department of Road Structures, Thákurova 7, 166 29 Praha 6 - Dejvice, Czech Republic

Specification of stress state in CC slabs

Specification of the stress state in cement-concrete road pavement slabs due to the effects of wheel load. By the accurate stress state specification the correct thickness of the CC slab may be determined thus significantly contributing to the optimization of the whole road pavement construction. The research resulted in the creation of a 3D model of the pavement system and its successive analysis using the finite-element method (FEM). The modelling and design were made with the ABAQUS programme. The resulting values of monitored stresses (max. tensile) in the CC slab reached by the 3D FEM analysis were compared with the stresses calculated with the help of currently used calculation methods. All is documented both by numerical values and graphically. The research proved the usability of 3D FEM models for the dimensioning of road pavements.

Design of CC pavements

Correct design of rigid concrete pavements in the Czech Republic, but also in other countries, is to a considerable extent problematic thanks to the number of factors which affect the actual behaviour of the pavement system, above all the stress values in the cement-concrete slab (CC slab). Moreover, unlike non-rigid pavements, the design of rigid pavements must consider some specific features such as e.g. the final slab dimensions, considerable temperature effects on the resulting stress value in the pavement, the interaction not only on the slab-subbase system contact, but also the interaction with the neighbouring slabs (stress transfer via reinforcing pins and anchors) and others.

The majority of designs of new concrete pavements are based on practical experience in using CC slabs of various thicknesses, various types of subbase and protective layers taking into account the significant effect of the subbase bearing capacity. This is so-called empirical design. There also exist other regulations containing procedures for the design and assessment of rigid CC slabs. The classic theory applied in design methods is the calculation of stress according to Westergaard (tensile stress – the greatest value is in most cases calculated on the longitudinal edge).

These equations for the calculation of stress, however, tend to be differently modified in various design methods. The most commonly used programme for the determination of tensile stresses in the CC slab in the Czech Republic is “Laymed“ and various FEM programmes, e.g. “CC Pavements“. The programmes above, however, have their limitations, mainly concerning their development. They are mostly based on the assumption of elastic behaviour of layers, which does not hold true of some (unbonded) materials, and so a more complicated non-linear model must be chosen. This very possibility is offered by 3D

modelling. Among potential factors implementable in the 3D model, therefore, there is the modelling of pins and anchors – determination of the degree of load transfer, modelling of non-linear behaviour of unbonded materials, saturation of layers from unbonded materials, consideration of the effect of primary consolidation of subbase materials, load due to climatic conditions in cooperation with acting load (temperature), definition of material properties (moduli of elasticity, fatigue, time-related growth in strength), load (static x dynamic, position, time, number of repetitions, shape of loaded surfaces (airplanes, loaders….).

Due to the fact that these are highly demanding problems, some of the factors are not included in the current 3D-model, nevertheless further development of the model is presumed.

Input data for 3D - model

A specific pavement composition was selected for the calculations. The 3D-model is composed of four CC slabs (4x4m) so that at least their mutual contact is considered. To shorten the calculation time the remaining structural layers of the pavement are not modelled individually, but were replaced with a single "equivalent" layer with the modulus of elasticity E = 454 MPa and Poisson ratio $\mu = 0.3$. So-called "continuity" elements are selected for both layers with eight integration points for each element. Then mutual interaction on the contact of both layers and boundary conditions are defined to avoid deformation of the results. The load was considered as static – the footprint area of the design loader wheel. The load has the intensity of 1MPa and the loading area radius is 0.2481m. To compare the outputs (max. tensile stresses on the slab edge) from the 3D model programmes Laymed and CC Pavements were selected which helped to specify the tensile stresses on the slab edge for the same pavement construction and identical loading conditions.

Conclusions

The results support potential use of 3D FEM analyses for the accurate determination of tensile stresses in the CC slab. Further model specification would require calculations of a greater number of constructions and, ideally, experimental verification of the results. Modelling the behaviour of CC pavements, mainly on major road projects in the future, would help to save considerable investment resources during their construction. In this perspective, investments into the 3D-model creation seem justified.

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Aggregate in road structures - problems with application of EN

J. Hradil

jan.hradil@fsv.cvut.cz

Department of Road Structures, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

According to some changes, that are rising with transformation of current ČSN(Czech National norm)to new EN(European norm), is current situation slightly complicated. Especially in testing of aggregate appeared some radical changes, that are necessary to realize. In time appeared problems, that nobody expected in the beginning or worse, did not pay attention to them.

Generally can this problems be split in two basic categories. Problems, that were created during the translation (this are less extensive problems, they can be solved with help of additions and repairs) and problems created by application of EN to Czech conditions. Generally speaking, in present is situation still uncertain – as valid were set out new EN, however current ČSN and categorization of aggregate in them can be still used in use. Luckily is part of EN National Addendum(NA), that transforms current categorization to EN categorization and determines, what tests must be used for different categories of aggregate.

However, lets take a closer look on these problems

1) problems created by application of EN to Czech conditions

There are several problems of this type, as the most important can be determined new categorization of aggregate according to its use in road structures. For road structures exist three EN.

Aggregates for concrete (EN 12620)

Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas (EN 13043)

Aggregates for unbound and hydraulically bound materials for use in civil engineering work and road construction (EN 13242)

That means, that compared to situation in past, when only one ČSN (Aggregate for building purpose) existed, we have now three new EN. (and that are taken only road structures). Every norm has some different requirements, every has its own terminology, every can require different types of tests for aggregate. Tests in these norms are divided into three areas: tests for geometrical characteristics, tests for physical characteristics and tests for chemical characteristics.

Tests for geometrical characteristics

As typical example of simple accepted nonsense without seeing consequences is division of aggregate according to its grading. In ČSN was used division to coarse and fine aggregate, whereas the division screen was 4mm. According to current EN every single norm has its own parameters for this type of division. While in EN 13043 is the division screen 2mm, in EN 12620 is definition, that fine aggregate must have top screen (D) ≤ 4 and under screen (d)

= 0, apart from EN 13242, where is no such simple division and the aggregate must be categorized with help of tablet. In addition was added the third category of aggregate (All-in-one), so the categorization is even more complicated. Nevertheless there are other problems – for example tablet of norm screens, that can be used for determination of grading, is not the same in all norms, but the main problem is, that it is not complete. It starts on screen 1mm, but in fact there are smaller sheets, than 1mm.

Tests for physical characteristics

Problem with these tests is fact, that in some tests the technique of testing was changed. The result is, that real implementation of tests is more complicated. As an example can we take test for tolerance of aggregate against temperature. The aggregate is in the water and every 3-4 hours in 10 cycles must be changed temperature. Without automatic device, that changes this temperature, its merely impossible to accomplish this test.

Tests for chemical characteristics.

These tests are not used so often and many of them origins from current test techniques.

2) problems created during the translation

This problem appeared as the effect of two factors – these three EN were not translated by one person and it seems, there were no correction of norms with one another. Same characteristics have in different norms different signification, norms use sometimes different terminology and there are differences for use of tests (the same test is in one EN useable only for verification, but in the other norm is not usable at all). But these problems can be solved in time.

Generally speaking, new EN (at least in testing of aggregate for road structures) have not brought significant progress. On the contrary, categorization of aggregate is even more complicated and have some major problems. This situation can be more difficult, than it looks like. EN is valid for all countries in EU, so enforcement of changes in EN will be much more complicated and circumstantial, then in ČSN.

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Fire Resistance of Timber-Concrete Composite Structures

P. Kuklík, T. Baierle, A. Kuklíková

kuklik@fsv.cvut.cz

Department of Steel and Timber Structures, Faculty of Civil Engineering,
Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

The load-bearing capacity of the timber-concrete cross-section composed of the timber beam and the concrete slab connected by the several types of the shear connectors is particularly defined by ultimate strength of the timber beam and used types of the mechanical connectors. The knowledge of fire behaviour of the timber-concrete composite floor and used mechanical connection is necessary to achieve reliable and economic design of this structure in fire.

Behaviour of timber-concrete composite structures

The temperature inside the timber member depends particularly on the cross-sectional dimensions and shape, on the density and moisture content of wood and on the fire load and temperature development during the fire. Over the design process, the temperature development in the place of the shear connection can be governed by the cross-sectional dimensions, particularly by the width, and by the sort of fire scenario. It is possible to use nominal, parametric or natural fire scenario. The effect of the beam width and fire scenario was founding out by experiments under nominal and natural fire conditions and numerical modelling.

Numerical models

Some problems with numerical models of the heat transfer in wood and charcoal occur, when the simplified models are used, that do not explicitly take into account some physical processes, e.g. the internal convection due to pyrolysis gases and vaporized water, pyrolysis heat, heat convection in porous wood material and fissures formation in the char layer. In such a case of the simplified models, the effective rather than physically correct thermal properties λ [W/mK], c [J/kgK], ρ [kg/m^3] should be used. The physically correct properties are modified on those effective depending on the used numerical model and fire scenario, which means, that the effective thermal properties of wood and charcoal verified for the nominal fire exposure give incorrect results when applied to other then nominal fire scenario such as parametric or natural fires. Therefore, the "nominal fire" effective thermal properties were calibrated for the natural fire by the wood temperatures measured during this fire experiment.

Based on this research, fire experiments and numerical modelling of the timber-concrete composite beam in fire, the undermentioned conclusions can be set to the effect of the width on the temperature development in the place of the mechanical connectors. Under nominal fire condinitions, the mean temperature along the connector axis shows power dependence on the initial timber beam width. The temperature nonuniformity along the connector axis increases with the initial beam width decreasing. This is due to the bottom heat flux, which is cause of the rapid temperature growing in the bottom part of the cross-section and which has more importance with the decreasing of the cross-sectional dimensions $b \times h$. From the temperature measurement was derived the equation for the time t [min], depending on the width b [mm], in which the initial temperature in the middle of the beam width begins to grow during the nominal fire. It is require verifying this equation by another fire

experiments. Further it is necessary to set the effect of the bottom heat flux and the perimeter-to-crossectional area ratio O [m]/A [m^2] of the beam. The influence of the natural fire on the temperatures inside the timber beam is very similar to that during the nominal fire. However the temperature rises earlier, which is caused by the higher thermal conductivity λ [W/mK] calibrated by the temperatures measured in the place of thermocouples influenced by the significant drought crack and the joint between the concrete slab and the timber beam. This implies, that the temperatures solved by the numerical model in the place of the cross-section in the real structure non-affected by the drought cracks and the joints, will be partially overestimate. From the comparison of the test results and the numerical modelling was significant the severe effect of the drought cracks on the higher heat transfer into the cross-section. Another fire tests are needed to say, that the right moisture loss is assumed in this FE-model. This question can be also answered by using the coupled heat and mass transfer numerical model based on the Luikov equations.

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Mechanical Analysis of Timber Structures in Fire

P. Kuklík, A. Kuklíková, J. Vídenský, T. Baierle

kuklik@fsv.cvut.cz

Department of Steel and Timber Structures, Faculty of Civil Engineering,
Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

In recent years, the use of timber as a structural material has considerably increased in Central and Eastern European countries, especially in the construction of prefabricated residential houses, sports, sacral and other long-span structures. However, the requirements for safety and functional use of such structures demand a special knowledge from the structural designers. One of the most important requirement is fire resistance, which, because wood is highly combustible material still presents a high risk for investors and conservative designers.

Mechanical Analysis

The notion of fire resistance is generally related to experimentally obtained fire resistance of structural elements and structural assemblies. Experiments, on one hand, can reliably describe behaviour of structural elements under fire, but on the other hand, they are subjected to numerous limitations. Thus, parallel to the development of numerical methods and computer technics, in fire engineering a considerable effort is given to the development of computer programs for numerical simulation of the thermo-dynamical and thermo-mechanical processes which occur during the fire. Only with efficient numerical models, numerous parametric studies may be performed and thus the influence of various parameters on behaviour of structures under the fire can be studied. However, the importance of experiments is still significant, as experimental results serve for verification and validation of used mathematical models.

Mathematical models

In general, the numerical analysis of timber structures behaviour under fire is composed of three mutually coupled physical phenomena: (1) the determination of fire scenario, which means determination of temperature and moisture of surrounding air during fire, (2) the determination of temperature and moisture distribution in structural elements as a function of time and (3) mechanical behaviour of structure, namely, development of stresses and deformation of structure during the fire as a function of space and time. In the literature there is no numerical procedure for simultaneous analysis of mentioned problems. From the thermo-dynamical point of view the first stage is very complicated and subjected to numerous random influences. Consequently, the attention is focused on the second and the third phase of numerical procedure, and thus, development of computer tools for the analysis of an extensive spectrum of feasible fire scenarios.

Results

Computer program for calculation of simultaneous heat and moisture transfer in glued laminated timber elements during the hypothetical conditions of natural fire in which the charring of wood is taken into account and computer program for non-linear mechanical analysis of timber frame structures, where the results from previous stage serve as input data.

Heat and moisture transfers in porous media are coupled in rather complicated mechanism. Simultaneous transfer of heat and moisture is described with a system of non-

linear partial differential equations (Luikov), for which in general there is no analytical solution. In addition, the influence of charring (model of charring, which is a function of moisture, density, temperature, etc.) of the material must be added. Owing to the non-linear system of governing equations, solution is obtained by the use of numerical procedures, such as, finite element method, finite difference method, boundary element method, etc. Results obtained and numerical model used have been verified by comparison to the analytical solutions in the literature.

The results of coupled transfer of heat and moisture and charring of wood have served as input data for numerical procedure for determining stresses and deformations of structural elements as a function of time under the hypothetical fire. It is geometrically and materially non-linear problem which incorporates the influence of temperature and moisture on development of elastic, plastic, viscous and mechanosorptive, creep and shrinkage deformations. The problem has been solved with the use of finite element method and highly efficient beam element, which has been derived from modified Hu-Washizu functional and Bernoulli hypothesis of plane sections.

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HDM - 4: Strategy Analysis

E. Veselá, O. Ryneš

eva.vesela@fsv.cvut.cz

Czech Technical University in Prague, Faculty of Civil Engineering, Department of Road Structures, Thákurova 7, 166 29 Praha 6

Highway Development and Management (HDM-4) software was developed by University of Birmigham with the aim of analysis and evaluation of the road network. Currently, software version HDM-4 ver. 2 is being evaluated at the Czech Technical University in Prague. It is possible to use HDM-4 for analysis on different levels. Project analysis is the only level were different alternatives are being compared with respect to road maintenance and improvement of network system. Such analysis is being made strictly according to the Czech System of Highway Evaluation (CSHS). Therefore, software workspace was calibrated on specific conditions and parameters in the Czech Republic. This calibration was done by Mott MacDonald in spring 2004, using previous version 1.3, which was used at most of the European countries. New, upgraded HDM-4 ver. 2, will be used in the Czech Republic since January, 2008. It is expected, that all types of roads will can be evaluated; including motorways, primarily, secondary, tertiary and low volume roads.

Strategy analysis is used for long range planning in order to evaluate total cost of the network system. Application can also be used for preparation of the medium to long term forecast for development, maintenance and operation of road network. The goal here is the budget analysis demands for the administrators including government, county, and/or district of the whole road network. It is also possible to simulate and analyze estimates of surface resistance to wear and its deteriorations caused by road usage including traffic increase forecast. HDM -4 strategic tools are being well employed all around the world namely in Canada, United Kingdom, Australia; however, it is not possible evaluate such projects, these have to be analyzed in accordance to CSHS [1].

Concept of medium to long term planning investments requires overall detailed knowledge of the road network system. Function of the strategic analysis should be managed by one organization only eg. Directorate of motorways, counties etc. Network matrix is been created in order to set up road network demands according to HDM-4 for the medium to long term planning for the total network or its parts. Matrix is defined according to several key factors. The most influentional is the pavement load capacity and user cost. Although it is possible to model each road segment, the methodology is mainly used for several thousands kilometers of roads. Road matrix can be defined by the user in such a way, which will reflex the most important factors, influencing traffic cost in given area.

Strategy analysis should be used as an assessment of the road network as a whole, in order to provide medium to long term planning investments; need it for development and maintenance in the scope of different budget options. Estimates are calculated from expense demands in the medium to long term horizon, which means five to forty years [3].

Employment of strategy analysis for the road network administrator would include information such as i) medium and long term forecast of financial demands, for given maintenance plan; ii) long term road network condition forecast and its financing; iii) optimal cost allocation in the frame of each budget chapters (eg. maintenance cost, repairs, development) ; iv) optimal cost allocation in the frame of road type (eg. highway, primary and secondary

roads) and / or administrative areas (eg. counties) ; v) studies – including change in maximal axial load; energy budget; change in maintenance standards; non-motorist facilities provision; cost of sustainable development [2].

Strategy analysis is important tool for funding redistribution by the road network management. Key road network parameters such as surface roughness, distresses, costs, accidents and environmental impacts can be predicted by the analysis.

As a conclusion it can be said that strategy analysis applications are useful tool for long term planning. This is valid especially for agencies which are in charge of parts or the whole road network. Because of the changes in monetary effects in the long term horizon, it is necessary to look at financial market with long perspective and set up an appropriate discount rate for analyzed period.

It would be useful to have strategy analysis of some kind, with the assumption of sufficient maintenance and development funding for the smaller road network. Unfortunately, there is no strategy analysis for critical shortage of funding. All kinds of optimization are based on the assumption that funding is secured.

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Horizontal comparator for system calibration of digital levels

Ing. Zdeněk Vyskočil

zdenek.vyskocil@fsv.cvut.cz

Department of Advanced Geodesy, FSV ČVUT Praha, Thákurova 7, Praha 6

Brand new horizontal comparator for system calibration of digital levels was constructed in laboratory of Institute of advanced geodesy at the Faculty of civil engineering, ČVUT Praha. This device was designed for smart, full-automatic calibration of precise geodetic levels with bar-code staffs. Construction team Z. Vyskočil, A. Roubal and F. Krpata built the only one device of this type in the Czech Republic. Now the comparator works after trial measurement and final debugging without a problem.

Systeme calibration.
Quality control of level instruments consists by optics and digital devices of detection of non-horizontal line of sight. This test is executed in laboratory and also in field, after each device transport. In the case of level staffs, there is controlled the length of staff meter, that means distance between segments of scale. This measurement is maintained in laboratory conditions by using very precise laser interferometer as length standard.

With outcome of digital levels (first instrument by Wild, 1990) was necessary to calibrate also errors emitted by electronics and CCD array. These errors can't be nor detected neither prune with common staff comparation or field level calibration. System calibration is repeated laboratory measurement by digital leveling instrument with continuous change and control of height of the leveling staff. The output of measuring is the scale of the whole system, which means particular staff and particular device. Calibration then uncovers quantization error at the CCD unit of the instrument, which appears during overcame of signal between two pixels of CCD camera by height change. This error disturbs the measurement just in some 'critical' distances between level and staff, when one pixel of CCD unit observes integer of pixels of the staff bar code.

For system calibration is ideal and most used vertical comparator (TU Graz, Stanford University), but good alternative is also horizontal comparator. This needs less vertical space (standard room x 6 meter shaft for vertical comp.) and its construction is generally cheaper and easier. The horizontal comparator hold the leveling staff in horizontal position and it accordingly needs mirror or other reflexive element for erection of the bar code picture.

Comparator in our laboratory has mirror, which is inclined for 45 degrees to the line of sight of the level and simultaneously to the normal of the staff. This system is used also at the University of Bundeswehr, Muenchen and GSI Japan. The comparator consists of these parts:
1) Mirror with holder and accurate screws for precise setting up to the ideal position.
2) Very precise distance meter – here laser interferometer Renishaw ML10 for control of staff position.
3) Carriage, which holds leveling staff and linear reflector of the laser interferometer. With moving of the carriage is changed the 'height' of the staff in level field of sight and this 'uplift' is then measured by interferometer.
4) Motive device – step motor with screw thread stick
5) PC for direction of the system

Main advantage and also of the system calibration is automation of the process. Support software was developed for synchronous operating of digital level (repeated measurement and download of measured heights), step motor (staff movement in calibration step) and laser interferometer (continuous control of cart position resp. of change of its distance from level). By calibration there are all parts online controlled and operator gets running value of height deviation (difference between relative heights of level and interferometer) in real time.

Conclusions

New comparator will be useful calibration device in geodetic metrology. Until now the system calibration doesn't belong to metrological standards, but it's supposed to be. Our laboratory will be prepared for full-automatic calibrations as the first in our country.

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LEnSE - Methodology Development towards a Label for Environmental, Social and Economic Buildings

A. Lupíšek, P. Hájek

antonin.lupisek@fsv.cvut.cz, petr.hajek@fsv.cvut.cz

Department of Building Structures, Faculty of Civil Engineering, Czech Technical University in Prague, Thákurova 7, 166 29 Prague 6, Czech Republic

The EU Sixth Framework Programme project LEnSE - Methodology Development towards a **L**abel for **En**vironmental, **S**ocial and **E**conomic Buildings started in January 2006 and the finalisation of the project is planned for the March 2008. The main objective of the LEnSE project is the development of methodology for complex sustainability assessment of existing buildings and buildings in design phase as well. This methodology should become a basis for future buildings labelling or certification.
To reach the goals following steps are performed within the work packages: i) identification of relevant sustainable criteria that should be used in assessment methodology according to different interests of all participants in process of construction and use of buildings; ii) development of methodology of complex sustainability assessment of existing buildings and buildings in design phase that could be suitably useful for future labelling or certification of buildings within the EU; iii) provide European methodology to all relevant participants of construction and usage process. The methodology will be tested on limited but representative file of key criteria; iv) arrange the European methodology to be generally accepted by different participants of the process of construction and building usage within the EU.

During the first year a complex review of the existing assessment methodologies has been done – in order to extract the sustainability issues implemented in these methods. This analysis covered environmental assessment tools, cost calculation tools, calculation of energy performance, building rating systems, incentives, environmental risks etc. The result of this reviewing exercise was a long list of possible issues to be included in the LEnSE sustainability assessment methodology. This list was further refined to become a sufficiently wide, but practically feasible set of sustainability issues:

Environmental issues
Environmental risks (climate, earthquakes, floods)
Environmental toxicity (through outdoor air, through water, through soil)
Effects on fauna and flora (acid rain, eco-toxicity, biodiversity and local habitat)
Resources (energy, water, materials, land use)
Waste
Environmental management (planning, data)

Economic issues
Financing
External costs (health, risks, damages)
Local economy (local employment)
Adding value (improving productivity – related to comfort conditions, increasing site value)
Building life cycle cost (construction, operation, maintenance, dismantling, land cost)

Social issues
Safety and security (indoor risks, burglary)
Health (indoor air quality, water quality, electro-magnetic fields)
Comfort (thermal, visual, acoustic, odour, micro-climate)
Well being (amenities, transport)
Functionality (services, maintenance, flexibility, mixing living/working)
Social value (equity, accessibility, privacy, working conditions, affordable housing, etc.)
Cultural heritage (architecture, image, history)
Ethical issues (ethical purchasing, probity, prompt payment)

The second year of the research was dedicated to work on the assessment methodology and benchmarks of the sub-issues that have never been developed before. The final proposal of European assessment methodology is based upon a scheme, that assigns maximum 1 000 points in total to the particular sub-issues.
The total maximum possible 1 000 points are divided among eleven sub-issues groups and then within each group among the particular sub-issues. There has been set universal EU pointing scheme based on consensus that assigns 800 of points (i.e. 80 % of weights). The rest 200 points could be assigned by the experts groups in each particular member country in order that the local conditions are taken into consideration.

Based on the weighting scheme and the provided benchmarks, there has been made up a tool for testing and verification of the methodology. With its employment the testing assessments were processed and the real usability and powerfulness of the methodology has been shown.

The main outputs of the research have been published in Stepping Stone 1-3 publications that are available on the web http://www.substance.cz/lense.

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Measurement of the Hygric Parameters of the Concrete Lining of the Panenská Tunnel

J. Matoušek*, V. Kuráž, J. Litoš*, P. Konvalinka*, J.L.Vítek*****

matousek@fsv.cvut.cz

*Experimental Centre, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

**Department of Irrigation, Drainage and Landscape Engineering, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

***Metrostav a.s., Koželužská 2246, 180 00 Prague 8, Czech Republic

The moisture of a concrete tunnel lining is one of major parameters, which affects its behaviour at fire. If the concrete is not specially protected (casing, spray application, etc.), or there is no another precaution designed, e.g. the usage of threads, then at exposition toward high temperatures there happens a conversion of phase of water contained in concrete and the pressure of rising vapour causes shelling of the surface layers. The size of flake off partitions is dependent on the water quantity in concrete poruses (caverns) and, moreover, also on speed of warming the concrete surface.

An improved version of the Dielectric Soil Moisture Meter (DSMM) developed by Kuraz and Matousek [1] was used for field measurement of the distribution of moisture content in concrete lining. The DSMM has been upgraded [3], so that it can be used for current field measurement with manual reading of the measured values on the display of the meter, and also for automated data logging, using a notebook, etc. The basic principle of the meter is the conversion of capacitance to frequency.

The meter consists of two parts: the probe and the evaluation unit. The outside diameter 58 mm cylindrical probe consists of two electrodes placed on the wall of the probe, which form a part of the measured oscillation circuit. A capacitance variation of the capacitor, caused by a change of moisture, results in a deviation of a resonance frequency of the connected oscillating circuit. The output frequency is compared with the constant frequency produced by fixed oscillator, which operates in the frequency range about 60 MHz. The differential frequency is divided and counted in the evaluation unit.

The range of sensitivity of the probe and the influence of another material properties were tested by Kuraz [2]. The centre of sensitivity was chosen as a level where reading of 50% is reached. This value corresponds to a level of 5 cm from the bottom of the probe. The probe starts to respond when it is inserted into measured material to a depth of 2 cm, reading increases until 10 cm.

Another important factor is the radius of measurement. Experimental results show that measurement is mostly affected by the measured porous material within a radius of 1 cm around the access tube, since 75% of a maximum reading was obtained within this volume. At a distance of 2 cm from the access tube, 90% of the electrical field was attenuated. Material (e.g. concrete) at a distance of more than 10 cm does not affect the results of the measurements.

These results were practically invariable within the whole range of moisture content. Based on these results, the volume of the surrounding porous material in which the electrical field is attenuated is formed by an annulus 8 cm in depth, 3 cm in inner radius and 13 cm in outer radius.

For measurement purposes, plastic access tubes should be permanently installed. Due to the relatively small measured volume of porous material, care should be taken in installing the access tubes. In order to facilitate the measurement of moisture in different depth profiles it was necessary to bore access openings for the dielectric probe of 58 mm in diameter and 20 cm in depth into sides of monitored tunnels. Then middle parts of particular layers were in 5, 10 and 15 cm distances from the surface walling of the tunnel tube. Calibration was performed later in laboratory conditions for each access tube and for each horizon.

The withdrawed samples (cores) from performed boreholes were divided on 3 or 4 parts (from different depth layers) and the moisture content by mass has been calculated by using a gravimetric method as soon as possible after taking. Gravimetric method continues to be the most utilizable method for calibration, and the reliability of this method is very high.

After the assignment of appropriate pairs of highest and smallest measured values parameters of linear calibration models were calculated to convert measured data (in impulses per second) to corresponding actual moisture values in all three monitored highway tunnels.

The residual value of moisture after the hydration completion can then negatively affect solidity characteristics of concrete. On the other hand, if there's not sufficient portion of water either from standpoint workability of mixtures or from subsequent hydration of cement, the concrete will also not have optimum firmness [4].

The main aim of the research on the sites was to monitor the moisture parameters of the concrete linings of the Valik, Panenská and Libouchec highway tunnels during the period of several months.

At 1 and 2 month intervals in measuring sites there were performed follow-on moisture measurements with described dielectric meter (again in depths 5, 10 and 15 cm from surface). The obtained results were processed tabularly and graphically with regard on long-time trends of moisture in tunnel linings.

By metering it was ascertained that the moisture (content of free water inside of concrete) oscillates in a small span of values. Although the linings of the mentioned tunnels were different old, content of free water spanned from 4.3 to 6.4 % by mass.

Inside of the Libouchec tunnel there were moisture values slightly higher than in the Valik or the Panenská tunel, because the concrete has been younger there. On monitoring of the successive dehydration on the Panenská tunnel it was realized that changes of moisture within 2 months were relatively small (at range 0.1 – 1 % by mass).

Inside of Libouchec tube greater drops of moisture were observed during the first month of monitoring (1.4 – 1.6 % by mass), which matches to successive dehydration of a younger concrete.

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Modelling of Chlorine Decay

K. Štrausová, *P. Fošumpaur, A. Grünwald,, **J. Jindra

grunwald@fsv.cvut.cz

Department of Sanitary and Ecological Engineering, * Department of Hydrotechnics
Faculty of Civil Engineering, Czech Technical University,
Thákurova 7, 166 27 Prague 6, Czech Republic

** VAK JČ Boženy Němcové 12/2, 370 80 České Budějovice, Czech Republic

Disinfection is used to destroy harmful microorganism contained in drinking water. The most commonly used disinfectant is chlorine. To predict bacterial regrowth the dosing rate must be in the optimal range. If the dosing rate is too low, there may be insufficient residual at the end of the distribution system. On the other hand, the addition of too much chlorine can lead to customers complains about odor or taste. However, chlorine reacts with natural organic matter like humic substances to form disinfection by-products, which are potentially carcinogenic. Trihalomethanes and haloacetic acids are the major disinfection by-products detected in chlorinated water.

In order to achieve a balance between sufficient chlorination to ensure bacteriology quality and, at the same time, providing customers with water which they find pleasant to drink, it is necessary to understand the mechanism of chlorine decay in water distribution systems and factors affecting it. The spread of chlorine within distribution system can be best studied by the use of mathematical models due to the complexities arising out of varying hydraulic conditions and non-applicability of universal chlorine reaction kinetics.

Traditionally used methods describing chlorine decay in natural water are process-based models following first order kinetics [1]. They are based on the underlying physical process. In first order decay models is the chlorine concentration assumed to decay exponentially with given initial concentration during the time period. An alternative modeling approach based on historical data is the use of the artificial neural networks (ANNs). The historical data provide the context in which the past decisions are carried out, as well as the fundamental information on which operator´s behavior is founded. ANNs are used due to their ability to handle nonlinearity and large amounts of data. The multi layer perceptron (MLP) using the back-propagation training algorithm is the most widely used type of network for forecasting and prediction applications.

In practise there exist two models: process and process inverse. Process models use as model inputs process inputs (e.g. raw water quality – temperature, UV_{254}) and process control parameters (e.g. chlorine dose) and as process outputs the outputs of the process that is being modelled (e.g. residual chlorine concentration). By using process inverse model, the inputs include the values of the process inputs, the values of all but one of the process control parameters and the desired values of the process output parameters.

Rodriguez and Serodes [2] presented a methodology called Chlorcast©, which leads to the development of models to forecast residual concentration of chlorine in drinking water systems. They used ANNs to predict the chlorine concentration in water tank as well on the

distribution network of the city of Sainte-Foy (Canada). The key parameters that affect chlorine consumption are chlorine dosage, temperature and flow rate of water.

Gibbs et al. [3] used in their study General Regression Neural Network with network parameters: water temperature, chlorine concentration at various locations in the network, the flow from the water treatment plant, the dissolved organic carbon content and Ultra Violet light absorbance ant the time chlorine measurement.

This paper presents a modeling approach using MLP simulating chlorine consumption in treated water at WTP Plav in southern Bohemia. The pre-processed data-elements were structured into 3 layers: 1 input (5 neurons), 1 hidden (15 neurons) and 1 output layer (1 neuron). The determination coefficient R^2 and RMSE (root mean square error) were used as the characteristics to evaluate model performances.

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Methods of Life Cycle Cost Analysis

V. Beran*, Z. Prostejovska*, P. Dlask*, E. Hromada*, D. Macek*

zita.prostejovska@fsv.cvut.cz

*Department of Economics and Management in Civil Engineering , Czech Technical University, Thákurova 6, 166 29 Prague 6, Czech Republic

Economics of investment (structural work) is basically attestation about balance of limiting effects for investors, where they could find potential priority yields. Technical and economical design could be reviewed from viewpoint of whole life cycle with respect to accessibility of rated impacts. It means accessibility of used input data, rate of running risks, uncertainty and any other impacts. Life cycle costing (LCC) is a mathematical method used to form or support decisions. LCC Is usually employed when deliberating on a selection of organization or structure of construction.

An ability to forecast the consequences of our decisions eliminates uncertainty and forms the basis for ultimate success. Usually, the focus "point the solution that is the cheapest" has had formed the decision-making process. Technique of supporting a financial decision needs to be established to give good reason for such a decision.

The first step consist in collecting the data, determining quality standards of construction elements, their lifetime, investment costs, operating and maintenance costs and at the end of the life cycle it is necessary to add costs for the removal (demolition). It was also necessary to determine all the construction elements that occur in buildings and the life of which does not reach the life limit of the building as a whole.

Then a number of options are available. Traditional methods are all well documented and have been in use from the first half of last century. The most commonly used in the building sector are (see Bull, 1993):

a) **Payback method** (PBM). PBM define pay back period (t_{eco}) taken to repay the investment (I) based on return of the investment (R). $t_{eco} = I/R$

b) **Nett present value** (NPV). NPV define the sum of money that needs to be invested today to meet all future financial requirements throughout investment LC, where $NPV = \sum_0^T C(t)/(1+r)^t$ and C are costs in year t recalculated by discount rate r, T is the period of analysis (in years).

c) **Internal rate of return** (IRR)**.** IRR is defined as the percentage earned on the amount of capital invested in each year of the life of the project after allowing for the repayment of the sum invested. The capital cost is balanced against income to obtain a NPV of zero. The discount rate necessary is the IRR.

d) **Profitability index** (PI) which identifies the relationship between the costs and benefits of a proposed project through the use of a ratio calculated as a ratio of PV of future cash flows to initial investment. A ratio of 1.0 is logically the lowest acceptable measure on the index. Any value which is lower than 1.0 would indicate that the project's NPV is less then the initial investment. As values on the profitability index increase, so does the financial attractiveness of the proposed project.

For every type of investors are the main point of view on Life cycle costing (LCC) focused on a different fundamental part of a decision-making process like:

User, major factors being a) location, b) facilities, c) reputation, d) credits, e) running costs,

Developer, major factors are a) short pay back period t_{eco} , b) max difference of *buy* and *sell*, c) prospect for future yields and market potential,

Institutional investor, a) high yield, b) high retained value of structure, c) low maintenance and management costs, d) secure original use, e) prospect on upwards rent reviews,

Business, a) low input costs, b) prestigious building (construction), c) modern functionality, d) prestigious location,

Public sector, a) building or construction functionality, b) transparent decision making process, c) cost effectiveness.

The methodical approach, presented is based on the *in situ* simulation. The every element of construction, building, and structure has its own scheme of life cycle standards. The important element of simulation is the desirable standard of element in use and type of the element.

Impact of lowered *min* standard permitted for operation decrease substantially number of maintenance cycles. However, the costs of single maintenance increase. The free operation time of the building object increase. The results of simulation are standards profile, expressed in cost.

The result of solution is differentiation of buildings and their functional parts. This differentiation is mainly put together by demand of its standards over using period. From technical and economical reasons are the demands on maintained standard of construction elements differentiated. The reasons why lies in esthetical, hygienic requirements, safety and operating reliability.

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Brownfields – Storage Areas in Prague and its Outskirts

D. Čápová*, Z. Prostějovská*

dana.capova@fsv.cvut.cz

*Department of Economics and Management in Civil Engineering , Czech Technical University, Thákurova 6, 166 29 Prague 6, Czech Republic

In the course of the year of 2007, the real supply of storage areas and logistic centers, already existing or being constructed in the Czech Republic, was analyzed. We conducted a thorough survey and monitored the trend of the supply on the market in the capital of the Czech Republic, Prague during one year. We obtained the data from resources accessible to public, such as internet pages.

According to the information obtained from the internet sites of reality agency, the vacant area was 89.208 m^2 (in October 2007). The rate of vacancy of the storage area makes about 7% of total storage area. This rate is higher than the rate of vacancy which is being published.

Rent for the storage areas

The reality agencies often do not provide the information of the level of rent which is being paid for the large storage areas or those rents are being overestimated owing to so called remission of rent. The examples of advertised storage areas rents range between 4 and 6 EUR per m^2 per month (110 – 170 Kč). Ie. Rudná Logistics Park - 5,25 EUR (149 Kč), Utility Park West 6 EUR (170 Kč). In the database of storage area can be observed a variety of offered storage areas. In contrast to modern logistic parks, the older areas are usually not marked with a class which would evaluate their qualities. They differ in the lay-out as well as in offered services. Comparing prices, there is not a major difference between new modern logistic centers and older storage areas. If a person interested in storage areas requires an area over 500 m^2 and does not care about the location in Prague, he/she will more likely choose a modern logistic area. The clients who are dependent on the location in Prague will take into account the freight costs to the more remote modern logistic areas.

The following data was obtained from the reality server REALITY MIX in December 2006, May 2007 and September 2007. The table summarizes the amount of offers to rent a storage area in different time periods. This amount can be described as stable in contrast with the supply quoted in m^2. The number of offers to rent larger areas increased in the beginning of the year 2007. The reason of the increase could be seen in the fact that some companies did not renew the contracts for the following year. Despite almost unchanged amount of offers, the amount of areas had decreased by September 2007.

The following graph depicts the amount of offers in October 2007 and the structure of the amount of m^2 of vacant areas and the time of being vacant.

Out of 194 offers of rent storage areas in September 2007, 46 offers were older than 4 months and 40 offers older than 9 months. Surprisingly, only 4 owners of storage areas reduced the prices of the rent. The discounts were ranged from 5 to 12 %. The graph depicts the amount of offered storage areas in m^2 in October 2007 and in the structure of the period the storage area is being vacant.

Out of the total amount of supplied storage areas-- 264 755 m^2, 35,4% were older than 4 months and 23,5% older than 9 months.

The results of the survey show that the supply of storage areas smaller than 500 m^2 in Prague and its outskirts makes up around 50% of total storage areas in the long term. In the modern logistic centers, the smallest rented unit is determined. The size of such unit varies from 500 to 5 000 m^2 which implies that logistic areas do not compete with centers of such sizes. The amount of storage areas over 2000 m^2 is very low. In our survey, those areas took up only 15% of offers. Usually, Czech firms seize these storage areas.

We can conclude that most of the storage areas are supplied in Prague 9, followed by Prague 10, 4 and 5. In Prague 9 and 10 larger areas are situated. The smaller areas are located in Prague 4 and 5. The most rents of modern logistic areas are taking place westwards from Prague. In the eastern part of Prague are located older storage centers. In the current supply of storage areas is being emphasized the access to the area with railroad spur. So far there have not been many offers of storage areas with such access.

The conducted survey of storage areas in Prague and its outskirts evaluates the real situation on the market of modern logistic centers and older storage units. Currently, the areas of older units are not being monitored on the whole. The boom in construction of new logistic areas is taking place. A problem with the usage could appear in case of massive runaway of some foreign investors and companies that are using storage services. After the Czech Republic joined the EU, distribution centers from Germany an Austria started to move to cheaper locations, such as our country. Temporarily cheap labor is highly attractive for foreign investors. However, in case of increase of wages, those investors will prefer countries such as Russia, Romania or Hungary. While older storage units up to 500 m^2, which make up to 50% of vacant storage areas, do not have to compete with new logistic areas, for the bigger storage units are the modern logistic centers hard competition.

The level of rent is almost the same. The older storage areas are preferred by Czech companies and by firms which are from some reason dependent on the location of the storage unit.

To sum up, after studying advertised rates of return for storage areas we conclude that data provided by dealers are overestimated and do not correspond with reality. The rate of return will decrease in the future because of the increasing supply, which will also bring about growth of the rate of vacancy and certainly fall in the rent. Older storage units will probably have more vacant area and might even turn into Brownfields.

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Reliability, Estimation and Risk Evaluation of Development Projects

V. Beran, E. Hromada

eduard.hromada@fsv.cvut.cz

Department of Economics and Management in Civil Engineering, Faculty of Civil Engineering, Czech Technical University in Prague, Thákurova 7, 166 29 Prague 6, Czech Republic

Application carries out simulations of the time and cost schedules of the defined development project. The application software is designed for building owners and contractors as a tool for rational comparison of a bid price of construction complying with the proposed time schedule of the building process. On the basis of the statistical evaluation of realized simulations, program algorithm calculates the expected real value of compared bid price and corresponding assumed start and end terms of particular building activities, as well as the assumed end term of entire construction. Thus it is possible to use the application for finding an optimal model variant of development project in terms of minimization of time and costs.

Application simplifies planning and managing of processes associated with the realization of particular development project. The application software is possible to use at many levels of project management and in different project phases.

Within the development of application software the emphasis was placed on the simplicity and expediency of its utilization. Application software was developed by means of spreadsheet program Microsoft Excel 2003 and its integrated programming language Microsoft Visual Basic. Therefore the application uses the spreadsheet program Microsoft Excel as operating program environment.

For easy utilization of the application there was developed so called working module which enables an easy switch between particular application modules.

The application outputs can be used for bid preparation of investment projects. However the application can at the same time carry out interesting simulations of predefined scenarios of development projects. On the basis of the input of minimum and maximum deviations specified by the user the application carries out simulation of the supposed development of the building phase. In such a way it is possible to identify the effects of changes in scope of work and time schedule of particular activities to final structure of costs and construction deadline.

The results of particular simulations of development project are continuously recorded. When a simulation is finished, the recorded data serve as a basis for statistical analysis of construction process. For each simulation and budget item the following data are recorded: scope of work, production speed, speed index, time duration, start deviation, the earliest and the latest start, the earliest and the latest end, total reserve, resources demand in time.

The results of simulations are used for graphic visualization of the assumed progress of the building project. These data can be at the same time saved to the user-defined file with extension CSV. Thus the application makes it possible to observe the detailed progress of any above mentioned parameter of the defined building project from cost and/or time point of view.

The application is also able to calculate the probability levels for total costs and duration of the development project. These results are presented by means of reliability graphs.

Among other interpretive outputs of the application software belongs the compilation of a so called probabilistic Dynamic Flow-chart. This progress chart represents the expected scenario of development of a building project with the mapping of potential time dislocations for particular activities.

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Economic Evaluation of Transport Constructions

V. Beran, E. Hromada

eduard.hromada@fsv.cvut.cz

Department of Economics and Management in Civil Engineering, Faculty of Civil Engineering, Czech Technical University in Prague, Thákurova 7, 166 29 Prague 6, Czech Republic

Software carries out simulations of probable costs of life cycle of transport construction. In terms of simulation there are modeled costs expended on maintenance and renewal of transport construction and costs evoked by occurrence of expected traffic accidents during life of transport construction.

It is possible to use the software for evaluation of economics suitability of variants of constructional and technical design of transport construction in phase of conceptual proposal from sight of project life cycle.

Significant aspects within constructional and technical design of transport construction represent costs of project life cycle. Currently we are unfortunately frequently witness of preferring minimization of budget (capital) costs without further expert evaluation of evoked costs caused by following phases of development project in consequence of selected variant of constructional and technical design of transport construction. Within the scope of preparation of studies and project documentations of transport constructions however cannot be (with regard to large amount of financial requirements and long - term project lifetime) applied this manner in the future. Therefore the software developed the method that it is possible to use as one of methods for evaluation of economics suitability of constructional and technical design of prepared development project from sight of project life cycle.

Software shows on model example of development project of bridge the evaluation of design of its constructional and technical solution with reference to value of potentially achieved capital and operational costs during the life cycle of planned investment.

The substance of the economical assessment is represented as sum of total investment costs N_I^i and total operating costs N_p^i. Parameter N_I^i includes any costs of preparatory and construction phase of project. Constructional and technical solution of *i* variant of project causes differentiation of final costs N_I^i. It is possible to use for assessment of its values readily available valuation software and expert calculations.

Parameter N_p^i includes any costs of operational phase of project. Constructional and technical solution of *i* variant of project also causes differentiation of final costs N_p^i. There are usually calculated in this cost category the costs connected with maintenance and renewal of constructional parts of bridge construction and highway body and costs connected with removing of construction after termination of its lifetime.

Selected constructional and technical solution of transport construction however markedly affects quantity and relevance of traffic accidents on examined sector of transport construction. In consequence of occurrence of traffic accidents it has to be expended another additional costs (e.g. costs on health service, costs on administration - police forces, courts, insurance companies, costs on physical damages, etc.). With regard to high level of these indirect costs on behalf of durability life of transport construction the economics assessment of constructional and technological solution also includes the category of indirect costs caused in consequence of traffic accidents.

Particular phases of life cycle of construction should have been harmonized and from aspects of expended financial and other sources also at least optimized. Traffic constructions generally represent such character of investment, where should have been reviewed also indirect costs evoked by selected constructional and technical solution, because these costs represent significant amount in structure of total costs of life cycle of reviewed construction.

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Historical and contemporary methods of measuring of the position and shape of high voltage line

J. Suchá, M. Štroner

jitka.sucha@fsv.cvut.cz

Department of Special Geodesy, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

The contemporary literature deals relatively little with the issue of measuring position and shape of above-the-ground high voltage transmission line, although many surveyors get in touch with it quite often during their professional life. Older texts (50s – 70s) state several ways of measuring process of electric line. Yet these methods are obsolete. Therefore it was suggested to carry out comparison of methods that are today already historical with methods using the modern instruments within next series of graduation thesis. So that the work is actual, close cooperation with the PRAGOPROJEKT a.s. (Ing. Sobotka) company and also with the Geoline s.r.o. company was established.

Methods of determination of line position and shape can be divided into three main groups. They are measuring, numerical and graphical methods. All three stated groups are based on the measured data, but they differ in their processing.

Measuring methods (i.e. trigonometric method, method of crossing from angles, space polar method etc.) use the measured values directly to calculate the line deflection. One of the most modern measuring methods is also laser scanning.

Numerical methods use mathematical definitions of a curve the form of which the hung conductor takes up or they replace this curve by a simpler curve. The exact process of the hung conductor is characterized a chain track. The chain track is also used most often for calculation of deflection. The chain track can be replaced by a parabola that has almost identical course when specific conditions are met.

In graphical methods, the measured quantities are drawn into a picture and searched values of deflections are measured from the picture.

The goal of the experimental measuring was to evaluate suitability, speed and accuracy of the individual methods.

Experimental measuring was carried out on 11th October 2005 near the municipality Lipence u Zbraslavi. Weather was clear, wind was mild and temperature moved between 8 and 10 °C during the measuring. The Trimble 5605 DR 200+ total station was used for focusing the conductors. Standard deviation of direction measured in both positions of the binoculars σ_φ stated by the manufacturer is 1 mgon, standard deviation of the measured length in one face is σ_d is 3 mm + 3 ppm. Measuring was carried out for three compared methods: method carried out by the Pragoprojekt a.s. Company, space polar method (contemporary methods) and trigonometric method (historical method). The measuring was followed by processing the results and final assessment of methods, the conclusions of which are stated in the following paragraphs of the text.

All tested methods of determination of electric line course do not have any special demands on measuring works in terrain and the measuring itself goes easily and quickly. Only in case of trigonometric methods position of the stand must be kept so that the stand

lies upright to the focused line field. This configuration must be kept, because computing relations are derived from this position of the instrument. The method carried out by the Pragoprojekt a.s. company and trigonometric method do not have any special demands on measuring equipment. A total station without special equipment, e.g. any theodolite with a distance meter, suffices for using these methods. It is also possible for trigonometric method to use a theodolite and a tape, as only one length is measured. Space polar method has higher demands on instrumentation. For this method it is necessary to use a total station with special equipment (with a prismless system of length measuring).

Computing works of all the selected methods are not demanding and they can be carried out in any computing and graphical softwares. Creating own programs for calculation of these methods should not cause inconveniences even to beginning programmers. Resulting values of the current methods are space rectangular coordinates of the focused points with which it is further possible to work in graphical programs. Trigonometric method provides only three height data. Most geodetic orders are handed over in a graphical form, therefore the resulting values of trigonometric method are nowadays a significant drawback.

Accuracy of the current methods (the method carried out by the Pragoprojekt Company and space polar method) is comparable. Resulting values of the height coordinates and flowingly of line heights over the terrain determined by these procedures reach at most 2 mm. Differences of the rectangular space coordinates in a position move at most up to 15 mm. However more important is height determination of line, and its accuracy is sufficient. Trigonometric method is least accurate. Height deviations from both current methods reach up to 50 mm. According to the achieved results it is possible to recommend both current methods for determination of position and shape of the above-the-ground high voltage transmission line.

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The Analysis of the Functional Principle and Reliability of the Crystalline Waterproofing Systems

J. Pazderka

jiri.pazderka@fsv.cvut.cz

Department of Building Structures, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

The crystalline waterproofing systems are the cement based materials which are designed for a concrete structures protection against water and moisture. The crystalline materials application causes a creation of a new crystal structure in concrete by chemical reaction, which results in waterproofing effect. The experience with these materials in practice is good, but a lot of properties of these systems were not adequate described so far (for example the time-effect). The further experiments and analysis are necessary for more efficient use of these materials in building structures.

The crystalline waterproofing technology is generally available in several main versions: (1) Crystalline coat - All crystalline waterproofing coats operate on the same functional principle. The new crystalline formation migrates throughout the pores and capillary tracts of concrete after the coat application. This process fills all capillary pores by crystals in the depth of a concrete which in the consequence create the waterproofing effect. But water in capillary pores is necessary for this additional crystallization. This attribute is a benefit for reconstruction of an old concrete structure with infiltrating water, because this wet structure need not to be drained before application of the crystalline waterproofing technology. (2) Crystalline admixture - The quantity of crystalline admixture, which is added to concrete mix, is very small – usually it is only 2% of cement weight. First the crystalline admixture is mixed with water (separately from sand and cement) and then is mixed with the other components. The crystalline additional crystallization is started late, in order to the cement basic microstructure could be arise first. The waterproofing crystalline admixture in concrete is useful for waterproofing of underground concrete parts of new buildings. (3) Other types of application are: Crystalline fast-setting bonds (can stop flowing water in seconds and it is typically used to seal cracks), Crystalline material for a dry-shake application on a horizontal concrete surfaces, etc.

There is the different information regarding the time effect of the crystalline waterproofing systems from various producers. Each producer presents different data about the time of beginning of waterproofing effect (after this time is concrete with crystalline material already waterproof). For example the Akvatron system needs 21 days for the final waterproofing effect but the Penetron system needs only 5 days. These big differences between each material are not reliable because all crystalline materials operate on the same functional principle. This fact was the motivation for the following experiment. The aim of experiment was carry out the water test in different time intervals after the concrete creation. It was necessary carry out the water test for this analysis. The test was conducted in accordance with the standards for the concrete structures, exactly by the standard [1]. Unfortunately the standard [1] is only a few years in force and all the crystalline coats producers in CR have made the certificates in accordance with invalid old standard. The result of this situation is absence of the correct data. So this was the second reason for this experiment. The experiment was carried out in the CTU Prague, Faculty of civil engineering laboratory. There were created 12 cube-shaped concrete test specimens for the test (the new test specimen is necessary for water test in each time interval). The size of each test cube was

150x150x150 mm and all the cubes were made from C20/25 class concrete with crystalline admixture. The Xypex Admix C-1000 material was chosen as the admixture. The crystalline admixture was added to the concrete mix in the amount 2% of cement weight. The admixture addition was made exactly in accordance with the [3] and the test specimens were created and cured in accordance with the [2]. After the next 3 days was the first test specimen ready for the test. The water test was carried out in the special equipment which is designed for producing of water pressure. Each test cube was loaded by 0.5 MPa water pressure and stayed in the equipment for 72 hours. After this time the cubes were broken up and the seepage was measured. At the end the result graph (see the poster) was created from the test data - seepage depth in each time interval.

The test results have shown that the full waterproofing effect of the crystalline material is available between 11^{th} and 12^{th} day after the concrete with crystalline admixture creation. In that time is the seepage value about 15 mm. In the underground parts of the building structures (lower water pressure) is possible load the concrete by water sooner - about the 7^{th} day. In 7^{th} day was the seepage 21 mm but the test was conducted with the pressure 0.5 MPa (= pressure in the depth 50 m below the water surface) and this value is unrealistic in the building structures. The second result of experiment was discovery that the crystalline admixture fills the new standard [1] requirements (no seepage through the test specimen during the test).

The next experiment examined crystalline coat curing influence on the waterproofing effect. The curing of the crystalline coat during its ageing is important for the consequent waterproofing effect. Probing of coat curing exact influence was the aim of the experiment. Concrete cubes with crystalline coat were made for the experiment. Making procedure of these next six was the same as for the specimens for previous experiment. After the concrete aging (28 days) were the cubes painted by “Penetron” crystalline coat. The coating was made exactly in accordance with the [4]. The coat was applied only on one side of the cube. Then the crystalline coat was curing on first three test cubes and this process took 5 days. But the curing was not applied on the second three test specimens during the coat ageing. The difference in waterproofing between test specimens without curing and cured specimens was evident. During the water pressure test of the specimens without curing the water seeped through the cube sides in a short time after the start of water pressure loading. After the test the cubes were broken up and the seepage was measured. The seepage depth was average only 11 mm for the specimens with curing and 65 mm for the specimens without curing (but this value is not real because water escaped through the cube’s sides during the loading). The experiment has shown that curing of the crystalline coat during its ageing is absolutely necessary for the consequent waterproofing effect. The coat without curing has not chance for waterproofing. This fact is also the risk factor for the using of crystalline coat.

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Moisture Transport in Flat Roofs with Perforated Vapour Barriers

P. Slanina

petr.slanina@fsv.cvut.cz

Department of Building Structures, Faculty of Civil Engineering, CTU,
Thakurova 7, 16629 Prague 6

Introduction

Simple calculation methods are still used at present for the evaluation of the risk of moisture condensation inside building envelope assemblies. These methods are described in the Czech and European standards ČSN 73 05 40-4 and EN ISO 13788, EN 15026. They usually lead to correct designs as far as safety is concerned. These methods consider only one-dimensional transport of the moisture content and the qualities of materials as homogeneous.

In fact, however, the materials built in building structures are non-homogeneous the reason being their structural arrangement (i.e. linking of materials, mechanical fixing) or because of a negligence in a construction.

Under the influence of originating non-homogeneities of materials the moisture transport is in more dimensions in the roof assemblies and thus the moisture content in the roof layers is raised. The calculation with the aid of the standard methods do not answer to the real state of the structures, the resulting roof assembly designs are then not correct. Their function is lost, the life-service of the whole structure is shortened and the result will be expensive reconstruction.

Measurement of Water Vapour Transmission Rate

One of the possibilities how to find out moisture content than can condensate in an envelope assembly with perforated layers is measured diffusion properties of non-homogeneous materials especially with high sd-value (i.e. vapour barriers or roof membranes) where is significantly appeared multidimensional moisture transport. In the past these measurements were done by Civil Engineering Academy in Germany or by Research Institute of Civil Engineering (VUPS) in Zlin, Czech Republic. The results of these measurements are a few with unclear solutions and thus the measurement of diffusion properties of materials with high sd-value has been continuing at the Faculty of Civil Engineering at CTU in Prague.

Many methods for water vapour transmission rate measurement exist in the world. We have chosen Wet-Cut method because the method is simple, exact and correspond to the conditions which occur in a real envelope structure. We have developed a special apparatus which allows to measure materials with very high sd-value. One disadvantage of this measurement is very long time to get the results; it takes 2 to 3 months.

During the measuring we monitored relative humidity and temperature in an environment outside and inside of cups. We also monitored the atmospheric pressure.

Results of Measurement

We have measured five different materials which are used for vapour barriers or for roofing membranes. We measured three or four samples from each material. Three materials were PE foils with very different thickness and sd-value (85 m, 185 m and 575 m) of the material. Two materials were bitumen belts, one without and one with aluminium foil inside the belt. We measured sd-value of this material with different degree of perforation (0%-0.06%).

The results show a great fall of sd-value of PE foils, higher fall was in PE foil with higher sd-value. All three PE foils have almost the same sd-values with degree of perforation more than 0.02%. The decrease of sd-value of the bitumen belt (without aluminium foil) was not such big as PE foils. The reason is that the bitumen belt joins a pinhole after penetration. We were not able to measure sd-value of the bitumen belt with aluminium foil because the sd-value was out of the apparatus measurement or we needed more time that we did not have. More about results you can find in [1].

Discussion of the Results and Conclusion

The results of the measurement show that the apparatus measures exact up to sd-value 500m. Also the results proof that the sd-value of materials with high diffusion resistant factor increases very quickly with a small degree of a perforation.

Conclusion for building envelope designers are in [2,3] or briefly here: 1) From view of the moisture transport through a building envelope is better designed envelop assemblies with inverted order of layers than with classical order of layers. 2) A bitumen belt is better to use as a vapour barrier in a roof with classical order of layer than a foil because the bitumen belt join the pinhole after a perforation. 3) For the stability of roof assembly is better used special weight layers (gravel, substrate, concrete panels) or to join each roof layer to the other than use a mechanical fixing which penetrates vapour barriers.

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Optimization of Photovoltaic Sun Blind Shading

M. Ženka

marek.zenka@fsv.cvut.cz

Department of Building Structures, Faculty of Civil Engineering, Czech Technical University in Prague, Thakurova 7, 166 29, Prague 6, Czech Republic

Photovoltaic Sun Shading Systems

Building Integrated Photovoltaics (BIPV) has recently become a very rapidly developing concept for integration of hi-tech renewable energy sources in building environment. A building itself offers a wide range of possibilities how to utilize a photovoltaic system within its envelope. It can be designed as a façade cladding, as a substitute for roofing, in the form of semitransparent panels etc. Full integration designs search for solutions where the structural, technical, energetic and aesthetical concepts are taken into account. The latest trends aim aside of this for solutions where photovoltaics serves not only as energy producer, but also holds other functions.

One of the many possible ways of integration PV in the building envelope is using it for sun shading devices. An invention of PV sun blind shading system is disclosed that shades a building from solar energy gain while simultaneously channeling intercepted energy in the form of electricity (hybrid systems also make use of heat) for useful purposes. It is mounted optimally on exterior building surfaces having some direct exposure to the sun. The effect is to avoid solar gain to the building especially through windows and to concentrate solar flux onto solar receivers.

Another stationery solution is represented by a semitransparent phovotoltaics placed straight in the building envelope as subsidy for windows. It is important what kind of room is intended to be behind the semitransparent PV installation, since there are various possibilities the light penetrating through can be formed. Using classical crystalline silicon waffles laminated in glass set farther apart will give a sharp border of light and shadow in the interior. A thin film silicon technology may be an alternative for interiors which require a diffuse light source.

A potential problem for all sun shading systems is a level of daylight available in the interior when there is cloudy outside. These questions gave rise of a project where the light and energetic issues should be closer examined.

Experimental Set-up

The project is aimed at searching for optimal geometries of the photovoltaic sun blind shading system with regard to the daylight factor, the heat load from passive solar gains, minimization of the need for cooling the interior and also with regard to the electricity production in the PV system. The goal is to use as much solar energy as possible and decrease the overall energy consumption of the building/room in the course of the whole year. It is supposed to be solved as a part of the whole integrated design of "intelligent buildings" which should be tested and evaluated in the climatic conditions of the Czech Republic.

As part of the project an experimental set-up was created at the Faculty of Civil Engineering in Prague, in the middle of August 2007. The installation is a physical model of a middle-size office room made to scale 1:3 to the real state. The construction is light, wooden-frame insulated in between the structural parts. The exterior finish is made from OSB boards. The case has a large (wall to wall, floor to ceiling) glazed opening in one of the front sides. From both sides of the window there are moveable OSB screens, which can be used for

changing the actual size of the window. An adjustable carrier of photovoltaic sun blind is mounted above the window. The PV model used as the blind is a frameless thin film semitransparent module ASITHRU SG-36 (1000/600 mm). The installation is further equipped with two small ventilators and two bulbs which serve in winter for heating the interior.

The model is provided with an extensive measurement of key physical quantities. There are 10 thermometers, two lightmeters (exterior and interior sensors) and two sensors of heat flux placed within the installation. The small PV system contains a DC/AC changer with MPP (maximum power point) tracking and a stream and voltage converter. All the measured data are collected and stored in a data-logger connected to PC. From a large nearby PV installation [3] some additional data like a global radiation on horizontal surface and an ambient temperature are gained.

Numerical Analyses

In the five-moth of operation, several positions of the PV sun blind, sizes of window and ventilation schemes were tried. The project is in the phase of data collection and theoretical preparation for analytic calculation. There are 3 partial problems to be observed: thermodynamic processes inside the case, electrical output from the PV system and light conditions in the interior. An important input quantity for the first two problems is the incident solar radiation (on the window surface; on the PV panel) which is calculated form radiation on the horizontal surface [1]. The daylight factor on a working plane in various spots in the case is obtained as a ratio of the two (exterior, interior) lightmeter sensor values.

For the main and the most complex task, the indoor environment, thermodynamic simulations will be carried out in ESP-r. The measured data shall serve either as a source for tunning of thermodynamic simulation tools and parameters and thus it shall contribute to a better understanding of the importance of individual processes and as a validation for newly created numerical models. Especially the time period of a potential overheating is of a great interest.

As a result of this project, parametric studies should be issued to demonstrate the influence of various sun shading schemes on the internal climate and energy balance.

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Dates for Building Energy Loads Modelling

R. Musil

roman.musil@fsv.cvut.cz

Department of Building Services Systems, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 169 34 Prague 6, Czech Republic

Two thematic topics were solved within the frame of this grant project called "Dates for Building Energy Loads Modelling". These topics are heterogenous but they are linked by one collective aim – improvement of description building energy performance.

First solved project part is stochastic process modelling and their influence on the total energy need in the building. [1,3,4]

Purpose

This topic deals with assessment of people activity on the object total energy need. Currently are for object energy need calculation used dynamic simulation where given problem is formulated by set of input variables and their each other connected structures. Some input values aren't possible to describe only by one value or by one load profile. Those are random character magnitudes which depend on one variable – time. These magnitudes are called stochastic process and they are linked with user activity and behaviour in the interior. These simulation input values are currently described like static (constant) loads profiles during the time but in the most cases it isn't true. The main aim of this work is to create probability model of presence user in one single office and by the help of energy simulation to determine dispersion of yearly energy need of this office and compare it with simulation results with static presence profile. After probability model of presence in the interior assessment it is possible to continue with assessment next profiles which depend on presence (ventilation by windows, lighting, hot and cold water consumption, intervention into heat or cooling systems etc.)

Methods

User presence probability model in one office room is processed like set of each other connected Matlab scripts. Model works on base of pseudo–random numbers, probability distribution functions and empirical probability functions. The algorithm connect Matlab calculation kernel with excel file where are taken data for own calculations and simultaneously the profile results are saved. Excel makes possible easy access to results and their next processing.

People probability model of presence usage

Result of this work is to create universal model which after setting presence data of typical building and their processing will generate user profiles of presence for one people. In the case of presence more than one person in the interior the algorithm will calculate so many times how much people is in the interior and total presence will sum. Primary algorithm aim is to create input user profile for energy simulation where by help multiple simulations happen to determine dispersion and specification of total yearly energy need in dependence on presence human factor in the office. Next algorithm aim is to create foundation for possible continuation in modelling of more energy performance stochastic process like is hot and cold water consumption, ventilation by windows, etc. As it has already been noted, stochastic processes very much depend on the random factor over time which we can't influence and therefore it isn't accurate this process describe by the help of constant profiles.

The second part of this grant project is hot water measurement of typical buildings. [2]

Purpose

At first, typical buildings were chosen. Benefit to determine hot water consumption curve in warm water reservoir is for these buildings. Currently valid norm ČSN 060320 deals about hot water preparation like that hot water consumption curve is assessed only for flat buildings. We were target on the hotels, hospitals and pensions from that reason. Simultaneously one flat building was chosen and measured in detail and these results will be compared with norm take–off profile. Need and consumption of water is magnitude which isn't initial only for dimension of water supply systems but it shows life style and user consumer habits. This value is evolving and changing with society development. Impact on user behaviour is in relation prices development. The second aspect is technical building facilities development in hot water preparation which enables using flexible facilities reacting on variable water needs. Water need is supposed take–off while consumption is the real take–off water amount for certain time period. Water consumption assessment is input value which is covered with sufficient equipment capacity for water supplying. Problem is when consumption is function of time and we have to observe it in different time scale. Therefore water need assessment isn't possible simplify to one value but time period has to be written by more parameters which are:

Water need during the chosen period (specific water need) and water take–off during time period distribution

Measurement

It was possible to realize practical measurement of hot water consumption in typical buildings thanks to support of this grant project. The measurement was recently impossible because of big prices of measuring appliances in building services systems laboratory realize. From this reason, measurement was realized by help company QZP ltd. which has extensive experiences with project similar type.

Types of measured object

Hot water take–off measurement: hospital (15 objects), hotel (5 objects) pension (7 objects) and hot water take–off measurement in detail of one flat building.

Take–off hot water profile usage

Loads profiles of type buildings used for hot water reservoir design will be determined from performed measurement. It is possible to deduce hot water consumption behaviour over time from measured values more object of one type. It has practical usage in warming–up hot water design for type object.

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System Energy Flows and Variability in Civil Engineering from Aspekt of Sustainable Development

J. Karásek

jiri.karasek@fsv.cvut.cz

Fakulta stavební ČVUT v Praze, Thákurova 7/2077, 166 29 Praha 6

Global Changes Context

In a global changes context resulting from the new international research is necessary reducing of the CO_2 and other industry effects in all of human activities. Risk of the global warming is significant. We must reduce global warming accelerating by the effective policies, technical progress and by energy demand controlling and degreasing. Buildings and generally building industry is the branch with high share of the energy consumption. Energy consumption reducing starts during the designing of the building. CO_2 growing has direct causality with the energy consumption growing. At present exist new instruments for energy demand, CO_2 and other effect monitoring.

Energy Consumption

Systematic growth of the energy consumption and increasing energy demand used in new production technologies creates necessity of the energy demands analysing currently with energy demands degreasing of the now days used technology processes. By analysing of processes, we prevent next growth of the energy consumption. In a Civil Engineering are indicated during the Long-life cycle building different operations in all phases of the building. By comparing of the phases and energy demands in time for new designed and existing structures we get basis for the choosing of the best variant and theirs optimization processes in succession of the structure operating and Long-life cycle building.

Building energy consumption is about 8% of the world energy consumption. Energy related with building industry is about 40% of the world energy consumption

Risk of the Global Warming

Now we have new information about influences of human activities in the world. Concentration of the CO_2 in atmosphere made in last one hundred years brought about 0,5°C warming. In case of the current trends will temperature growth about 2-3°C in the next 50 years.

Energy Demand of the Building Process

In area of the building processes is the most important part primal energy consumption during the building material producing. Value of the energy demand in every technological variant and technical solution helps during the managing process in building designing. Restituted Strategy of the Sustainable Development has like aim systematical supporting of the recycling, included building materials, principle of the minimizing material and energy demands and reducing of the CO_2.

Example of the New Possibilities during Long-life Cycle Building Modeling

Long-life cycle building modeling is often from the cost aspect, time aspect and partly from building material aspect. Created are timetables of the building, harmonograms, net graphs and cyclograms. By the next work are created resources charts, workers, machines and

materials charts. These charts are only for preparing and building phases of the structure. Models are not so exactly created for other phases.

Simple House Analyzing

A simple example possibility of the modeling is construction of the family house. From the bill of quantities we know amount of the material, from the project we know energy and technical parameters, energy consumption and water consumption. By integration of the project, energy database and Long-life cycle building durability we can make model of the structure.

Conclusions

Possibilities of the building structures modeling from the Sustainable development aspect offers many of information for future decision making of developers, information for planning engineers and architects and for the state support of the energy and ecological suitable buildings. Comparing of the gained data from different construction variant, or comparing of habitation ways from different periods we can estimate, which ecological impacts and impacts for material recycling we will solve in next years.

Like an example ware solved real structure of the building, with complete data for energy flows modeling and Ecological modeling.

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Processes Identification of Changes of Mechanical Properties of Soils Due to Groundwater Flow

M. Brouček, P. Kuklík

miroslav.broucek@fsv.cvut.cz

Department of Mechanics, Faculty of Civil Engineering, Czech Technical University in Prague, Thákurova 7, 166 29 Prague 6, Czech Republic

For the successful analysis of the behaviour of the structure, the best possible description of all processes involved is the necessary precondition. This fact is valid also for back-analysis of the structure failure. The description of the processes in the subsoil could be crucial when the groundwater flow is involved. Groundwater can significantly change the estimated behaviour of the subsoil and consequently the behaviour of foundations. Understanding of the processes which affect the soils can lead to recommendations for the design strategies on soils that are potentially vulnerable to groundwater flow and also to proposals for mitigation of negative effects to potentially endangered structures.

The aim of this work is to introduce experimental results on the selected soils, mostly with great part of sand fraction, from the Veselí nad Lužnicí district. Three natural streams and one artificial channel are situated in the area of interest. The area also contains many dead branches which were filled up in past. Major part of the city built-up area is situated exactly at the lately filled up sewer, canals and river branches. The demolition of 38 housing structures was needed to be ordered and many others are monitored as a result of two flood events [1].

The presented work also offers some conclusions that strikes generally accepted views on the soil behaviour under the groundwater flow influence. However the number of tests carried out is insufficient for the general theories for sandy soils can be the results quite convincing due to lack of any other experimental data for such particular type of groundwater flow influence.

Laboratory experiments and tested soils

The major or leading processes which affect the soils and change their parameters, either permanently or temporarily can be divided into two classes. First class involves all changes in the pore pressure. A unique position has the process of suction cancellation. In particular cases this process can decrease the shear strength six times [2].The second class covers all possible ways of loosing particles. As in the first class one process has special position. It is the piping process sometimes called wash out process.

The final affection of the soil behaviour is usually a combination of all acting processes from both classes. However for different types of soils the potion of these effects can be evaluated. This evaluation is based on the granular composition of the soil type. The possibility to join the hydraulic conductivity with changes in porosity and the pore pressure has been a part of the tests.

Considering the facts mentioned above five types of experiments were carried out in order to monitor each process separately and also their combination. The long term effect of repetitious influence is still under consideration.

Numerical modelling

The critical state models involving the porosity are widely used for description of the soil behaviour. As an example the modified Cam-clay model can be appointed. The structural strength, overconsolidation ratio and porosity dependence was described by [3].

Unfortunately these models are not very suitable for the subsoil influenced by the groundwater flow. The soil increases its porosity due to piping but at the same time the effective stress is not decreasing. On the contrary it can be assumed that the effective stress increases because with piping the additional deformation grows.

Last development made on critical state models in order to follow the change in grading problem was shifting the critical state surface with respect to grading change. As the results of this new theory are based on discrete element modelling which can not cover all possible forces acting on all affected particles this critical surface shifting can be used for solving the problems in time steps.

Another possibility for modelling the soil influenced by piping is usage of the porosity diffusion model [4] or the general Einstein-Sakthivadiveli erosion model.

Conclusions

Experimental results proved the substantial changes in soil structure. These changes have the influence on the mechanic (settlement) and hydraulic (flow rate) properties of the soil.

Based on the measured values the correlation between the size of the washed particles and the hydraulic gradient can be considered. The influence of the amount of fine particles to the piping stability can be also impugned.

The numerical analysis of the samples can be run on any critical state model as long as it allows change of mechanical parameters between the calculation steps. The evaluation of influence of groundwater flow needs to be done for more type of soils as some of them prove much higher stability and the effect of groundwater on mechanical parameters can be for this soil classes neglected.

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Assessment of the Limit Load Capability of the Masonry Arch Bridges.

M. Posch

marek.posch@fsv.cvut.cz

Czech Technical University in Prague-Faculty of Civil engineering Thákurova 7, Praha 6, 16629, Department of Mechanics.

The maintenance and load capacity assessment of masonry arch bridges have a considerable economic impact owing to large numbers of these structures in all developed countries. Numerous assessment methods have been developed ranging from empirical formulas to 2-D and 3-D numerical models non-linear finite element analyses with potential contact separation. Most effort has been directed toward accurate simulation of the ultimate limit load states (ULS) and collapse of the bridge. The load rating, i.e. the load capacity for service conditions, then is derived as a fraction of the limit load. Probably the most advanced and cited british design manuals recommend the reduction factor whereas, when the standard structural reliability factors of Eurocodes are combined. The core issue of the project reported herein is a simple assessment method applicable on mass scale in the order of thousands of instances. This admits exclusively empirical or semiempirical formulas. Objection can be raised that contemporary software and hardware makes even non-linear finite element solutions available and cheap. Semiempirical formula by Pippard is the basis of the MEXE load rating method, devised in 50s in a british military experimental establishment, which in turn has been adapted to several guides and is widely used today. Failure criteria play important part in the development of semiempirical formulas. Middle half rule is accommodated in the Pippard's formula; whereas relative thrust line excentricity 0.35 is allowed in [1]. Common deficiency of the approximate methods and formulas is that the interaction of the barrel, fill, abutments and roadway is not properly accounted for. The existing empirical formulas do not provide a uniform safety margin. The reason is obvious - they are not flexible enough to account for all important factors like span, rise, barrel thickness, fill thickness, material properties etc. In order to develop more flexible formulas, some systematic, possibly mathematically formalized approach is indispensable. Closed form solutions of the arch bridges with fill and roadway do not exist even in the linear elastic domain, not to speak about nonlinear analysis. The approach thus is based on numerical nonlinear solutions of a set of individual instances (bridge configurations) and their best fit approximation by the target semiempiric formulas. The prospective users of the formulas need not know about the subtleties of the nonlinear numerical solutions. Semiempiric formulas should have bounds on their parameters. These parameter ranges govern the selection of bridge instances to be included in the set and analysed. The selection should represent the country's masonry arch bridge population and is referred to the representation forthwith. Two assessment methods are developed, a direct semiempiric formula and an elaborate numerical analysis. They are hierarchic in that the latter one is more accurate and demanding, the former is a reduced version of the latter. Their use is hierarchic, too. Routinely, the direct formula is used. When the load rating obtained is not sufficient and importance of the bridge outweighs the costs of the numeric analysis, the elaborate method is applied.

A straightforward paradigm of the numerical analysis might be simple: The Guide specifies the admissible relative crack depth $c_{0,lim}$, safety factor γ for the ULS and instructions for the structural analysis. The user has to perform a nonlinear analysis for the two limit states. This

is not acceptable for mass use, however. In order to avoid nonlinear analyses on the part of the user, a modified paradigm is adopted. A correlation is assumed between c_0 in a nonlinear analysis and the relative thrust force eccentricity e in a linear analysis in the same bridge instance at the same load level. The correlation is assumed in the form of a function $e(c_0, l, h, d, s)$. Actually, table functions $e_j(f)$ and $c_{0,j}(f)$ are recorded from the linear and nonlinear analyses of each instance j and $e_j(c_0)$ are obtained by elimination of f. Substituting $c_{0,lim}$ for c_0 yields function $e_{lim}(l, h, d, s)$. It provides an admissible relative eccentricity of the thrust force for every bridge from within the valid ranges. Owing to the correlation to $c_{0,lim}$, it may be assumed that c_0 would remain below $c_{0,lim}$ in a nonlinear solution as long as $e < e_{lim}$ in the linear solution. The RLLS criterion can thus be honoured indirectly through e, approximately at least. Explicit dependence on c_0 in could be abandoned if $c_{0,lim}$ were known.

Linear solution of the bridge structure is the most demanding step of the numerical analysis. In order to arrive at the direct formula, this step is carried out for the representation in a simplified manner. Namely, the same 2D structure model is used by which functions $e_j(f)$. The inverse functions $f_j(e)$ are employed to obtain $F_{RLLS,j}$ loads for the representation. Most bridge instances fail when mechanism builds up with four virtual hinges in the barrel. Some fail in a combined bending/shear mode with three hinges, some by plastic instability in the fill. The two latter modes occur in low rise arches with deep fill layers. Crack grow functions $c_{0,j}(f)$ were extracted mostly manually from the standard output of the nonlinear FEM solutions in a table form. The relative thrust eccentricity at a section is a simple rational function of f in the linear solutions owing to superposition. Functions $e_j(f)$should record the history of the largest eccentricity anywhere in the barrel. The location of it may change in the loading process. Consequently, these functions are not simple rational functions available by superposition. A concession to simplicity is made in this respect and rational eccentricity functions for a section where the maximum eccentricity occurs at the ultimate load level are taken for $e_j(f)$. Further details of the representation solutions are beyond the scope of the paper. A load rating method is developed for masonry arch bridges, suitable for mass scale application. Two hierarchic procedures are proposed, linear elastic numerical analysis and semiempiric formula. Both are based on two limit states, the ultimate load state and the repeated load limit state. The actual calibrated values of the limit crack depth and ultimate load safety factor yield load ratings better than the present czech standard or the MEXE.

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Influence of fibre reinforcement on behaviour of concrete in D-region of concrete structures.

R. Grebík*, A. Kohoutková**

robin.grebik@fsv.cvut.cz, akohout@fsv.cvut.cz

*Department of Concrete and Masonry Structures, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

**Department of Concrete and Masonry Structures, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

In selecting the appropriate design approach for structural concrete, it is useful to classify portions of the structure as either B- (Beam or Bernoulli) regions or D- (disturbed or discontinuity) regions. B-regions are parts of a structure in which Bernoulli's hypothesis of straight-line strain profiles applies. D-regions, on the other hand, are parts of a structure with a complex variation in strain. D-regions include portions near abrupt changes in geometry (geometrical discontinuities) or concentrated forces (statical discontinuities). Based on St. Venant's principle, the extent of a D-region spans about one section depth of the region on either side of the discontinuity. Most design practices for B-regions are based on a model for behavior. As examples, design for flexure is based on conventional beam theory while the design for shear is based on the well-known parallel chord truss analogy. By contrast, the most familiar types of D-regions, such as deep beams, corbels, beam-column joints, and pile caps, are currently still designed by empirical approaches or by using common detailing practices. For most other types of D-regions, code provisions provide little guidance to designers. The Strut-and-Tie Method is emerging as a code-worthy methodology for the design of all types of D-regions in structural concrete. Concrete is excellent in transferring compressive forces, for use of concrete for bended structures steel rebars were imbedded into concrete element in 19th century. Concrete with rebar reinforcement – reinforced concrete still doesn't utilize positives of concrete in full scale; the compressed area in bended section is very small and the tensile part of the section is not exploited. In structures fibre concrete is preferably used in idustrial floors and pavements. The full advantage of structural fiber concrete can only be achieved in new construction, where design solutions are not limited to the geometry of an existing building. Present utilisation of fibres signify, that fibres could substitute stirrups, using of fibres in a mixture benefits in higher load bearing capacity, higher ductility, enhance triaxial acting of a structural element, inhibit looses of stiffness at loading, enhance interaction of classical steel bar reinforcement and concrete. Significance of enhancement in fibre reinforced elements leads to possible reduction of transverse reinforcement in earthquake regions.

With proper design of a mixture a fibre reinforced structural element has favourable behaviour comparing to a classical reinforced concrete element both in service life and in ultimate loading. High residual strength increases resistance and behaviour in failure. Also in analysis of serviceability limit state fiber concrete has opportunities comparing to "normal" concrete.

Among main positives of fibre concrete is mentioned tensile behaviour. However also in compression fibre reinforced element has better loadbearing capacity for combination of compression and flexure thanks to better triaxial behaviour.

Present codes forbid designing of members without stirrups. Experiments show, that in fiber concretes with volume content of steel fibres 0,5 ÷ 2% fibres act as sufficient shear reinforcement. Members with fibres have more ductile and thus more safe failure. To enable

design of beams without classical links (or to decrease amount of links – increase spacing of links), proper quantification of contribution of particular fibres of different materials, shapes, types interaction of fibres and concrete and content in a mixture to shear resistance is necessary.

Experiments and some practical applications proved that fiber concrete elements have bigger loadbearing capacity and ductile fail mode comparing to comparable concrete element. Realisations of flooring systems are exceptional they exist as a unique effort to introduce advanced technology and material.

Lately an accent is put on sustainable development and limited growth. One of important points in sustainable building is sufficient durability of structures. Durability is influenced by permeability that is affected by cracking and porosity. Thus for better permeability of structures cracking must be avoided. Thanks to favourable spacing of cracks and smaller crack width, which has been proved by experiments permeability of fiber concrete structures, is preferable. Even now demands on durability and satisfying of serviceability limit state were solved successfully by using high performance fiber concrete.

In fire design polymer fibre are profitable. At high temperatures these fibres escape and created cavities enables expanse of gas and avoid spalling. Thereby the fire resistance is increased and repair after eventual fire is easier and cheaper.

There is a broad range of fiber concretes nevertheless research of fiber concretes still advances. There are developed new fiber concretes with new fibres and cocktails of fibres that are used at present. A new term is hybrid fiber concrete – it is a fibre-reinforced cementitious composite where combination of more types of fibres in a mixture shall take advantage of both (all) fibres. To prevent cracking in different stages of loading fibre of different types, length and modulus of elasticity are used.

Description of materials with so differing properties is impracticable. Lately a new classification of fiber concretes occurred – according to behavior of material in tension there are two basic types: materials with tensile hardening and tensile softening; the second category has two subcategories according to behavior in bending - materials that exhibits softening and materials with hardening in bending.

Aim of this paper was to present a simple general routine of determining material properties for a fibre concrete with which could be used in a further analysis of a structural element with D-regions. It was an intention to offer a simple low-cost method because depending on content of fibres the resultant properties of fibre concrete may be very different. If these new materials shall be used in a structure, engineers must have an elementary tool to verify load bearing capacity and service behaviour of the fibre concrete structural element. Utilization of fiber concrete instead of classical reinforcement saves labour cost and ensures better stress distribution in D –regions.

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Experimental Vertification of Influence of Fiber Reinforcement on Splitting of Fiber Concrete

O.Klečka

ondrej.klecka @ fsv.cvut.cz

Fakulta stavební ČVUT v Praze
Thákurova 7
166 29 Praha 6

Annotation
Previous research confirmed influence of fibers on increasing ductility and splitting tensile strength. Smeared reinforcement caught up splitting tensile from load. This influence is necessary to take into account at experimental tests and calculations.
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Aim
The aim of the research is to propose useful methodic for numerical conversion of the fiber reinforced concrete cross-section to the transformed section.

Procedure of Solution
The procedure of solution has two parts. The first one is theoretical the second one is practical that is useful for confirmation or specification the first one.

a) Practical part
Three sets of samples were made.. Each set contained nine specimens – concrete cubes of 150x150x150mm. All of the cubes were made with the same technology (the same amount of cement, aggregate, water and plasticizers). The first set was unreinforced concrete. The last two sets were fiber reinforced concrete cubes each of them reinforced by different kind of fiber in amount 1% per volume.
Three of each set were used to determine the compressive strength and the elastic modulus. The rest of specimens were test for tensile strength in which the cubes were loaded to failure in diametral compression applied along the entire length. The value of load causing the failure of specimen was written down. This value is used for assessment of the splitting tensile strength. The value to express splitting tensile strength *Fct,sp* for unreinforced concrete is known as

$$Fct,sp = (2\ P) / (\pi\ Ac), \qquad (1.1)$$

where *P* is the maximum load at failure, and *Ac* is the area of cross-section of the cubical specimen.

b) Theoretical part
In this part it is proposed to modify value above for fiber reinforced concrete. It is assumed that at stress-strain diagram exist quasi-linear relation between ultimate strength of the fiber reinforced concrete and the unreinforced concrete. Amount of fibers at fiber reinforced concrete is usualy defined in percents. It is supposed that if it is 1 percent of fiber in the volume of cube also 1 percent is at cross-section. The problem is that the fibers are orientated in 3 dimensions. We can say that the fibers in the plane of failure do not have the influence to splitting tensile strength. It is necessary to take it into account. To get the transformed section

it is added area of 1 percent of cross-section multipled by the ratio of elastic modulus of steel and concrete. In our case the ratio is 6.
It is looking for the behavior between splitting tensile strength of fiber reinforced concrete and unreinforced concrete.

$$F_{ct,sp,1} = \kappa * F_{ct,sp,2} * \alpha, \quad (1.2)$$

where $F_{ct,sp,1}$ is splitting tensile strength of fiber reinforced concrete, $F_{ct,sp,2}$ is splitting tensile strength of unreinforced concrete, α is the coefficient ratio of transformed section and cross-section of concrete specimen, κ is coefficient of influence of difference between elastic behaviour and quasi-linear behaviour.
Coefficient α is called the influence of transormed section and can be directly calculated from these equation: $\alpha = A_i / A$, where A is area of cross-section, A_i is transformed section area.
$A_i = A + \eta A_f$ where η is ratio of elastic modulus of steel and concrete $\eta = E_s / E_c$ and A_f is an area of fibers in cross-section.

Conclusion
The influence of coefficient α only doesn't come up to results of experimental tests. It would come up to experimental results only in elastic region of stress-strain diagram that respond upto 40% of ultimate load. Experimental tests aren't able to cover only this part of stress-strain diagram. Hence the coefficient κ is introduced which is also influenced by amount and kind of fibers. By taking into account the presumption and experimental test the κ is designed to take the value from 1.3 to 1.5.

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Timber-Concrete Composite Floors in Fire

T. Baierle*, A. Kuklíková*

tomas.baierle@fsv.cvut.cz

*Department of Steel and Timber Structures, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

Compared to the traditional timber floors one of the main advantages of this type of the composite structure is improved fire resistance, which is achieved due to the improved load-carrying capacity of the timber-concrete composite cross-section at the room temperature as well as in fire (stability criteria "R") and due to more favourable fire behaviour of the concrete slab in comparison with the traditional subflooring (improved integrity criteria "E" and insulation criteria "I").

The load-bearing capacity of the timber-concrete cross-section composed of the timber beam and the concrete slab connected by the several types of the shear connectors is particularly defined by ultimate strength of the timber beam and used types of the mechanical connectors. The knowledge of fire behaviour of the timber-concrete composite floor and used mechanical connection is necessary to achieve reliable and economic design of this structure in fire.

The fire research carried out by Fontana and Frangi [2] shows that the timber-concrete composite beam can be designed according to γ-method with charring of the timber parts of the composite structure specified by the charring rate β [mm/min] and the stiffness reduction of the shear connection k [N/mm^2] by the temperature, which governs the stress distribution in the composite cross-section. It means, that important for fire behaviour of the timber-concrete composite beam is the type of the mechanical connector and his mechanical properties affected by the temperature. This influence is different for each connector type and it is possible to specify that through the shear tests at the room temperature and under fire conditions. In general can be assumed that shear resistance decreases with the increasing temperature by each connector type and the stiffness at the service load level is reduced by the temperature only at some types. Therefore, the considerable input parameter for shear resistance and stiffness of the shear connection between the timber beam and the concrete slab in fire becomes the temperature in the place of the mechanical connector. Thus, in the first step was built the FE-numerical model of burning of wood calibrated on the basis of fire experiments. In the other steps will be the structural model of the timber-concrete composite floor built that will be coupled subsequently with the heat transfer model to carry out the coupled thermal-stress analysis of the timber-concrete composite floor in fire. This complex numerical model will be calibrated and verified by the bending fire test of the complete composite floor structure.

The temperature inside the timber member depends particularly on the cross-sectional dimensions and shape, on the density and moisture content of wood and on the fire load and temperature development during the fire. Over the design process, the temperature development in the place of the shear connection can be governed by the cross-sectional dimensions, particularly by the width, and by the sort of fire scenario. It is possible to use nominal, parametric or natural fire scenario. The effect of the beam width and fire scenario was founding out by experiments under nominal and natural fire conditions and numerical modelling.

Some problems with numerical models of the heat transfer in wood and charcoal occur, when the simplified models are used, that do not explicitly take into account some

physical processes, e.g. the internal convection due to pyrolysis gases and vaporized water, pyrolysis heat, heat convection in porous wood material and fissures formation in the char layer. In such a case of the simplified models, the effective rather than physically correct thermal properties λ [W/mK], c [J/kgK], ρ [kg/m^3] should be used. The physically correct properties are modified on those effective depending on the used numerical model and fire scenario, which means, that the effective thermal properties of wood and charcoal verified for the nominal fire exposure give incorrect results when applied to other then nominal fire scenario such as parametric or natural fires [3]. Therefore, the "nominal fire" effective thermal properties were calibrated for the natural fire by the wood temperatures measured during this fire experiment.

Based on this research, fire experiments and numerical modelling of the timber-concrete composite beam in fire, the undermentioned conclusions can be set to the effect of the width on the temperature development in the place of the mechanical connectors. Under nominal fire conditions, the mean temperature along the connector axis shows power dependence on the initial timber beam width. The temperature nonuniformity along the connector axis increases with the initial beam width decreasing. This is due to the bottom heat flux, which is cause of the rapid temperature growing in the bottom part of the cross-section and which has more importance with the decreasing of the cross-sectional dimensions $b \times h$. From the temperature measurement was derived the equation for the time t [min], depending on the width b [mm], in which the initial temperature in the middle of the beam width begins to grow during the nominal fire. It is require verifying this equation by another fire experiments. Further it is necessary to set the effect of the bottom heat flux and the perimeter-to-crossectional area ratio O [m]/A [m^2] of the beam. The influence of the natural fire on the temperatures inside the timber beam is very similar to that during the nominal fire. However the temperature rises earlier, which is caused by the higher thermal conductivity λ [W/mK] calibrated by the temperatures measured in the place of thermocouples influenced by the significant drought crack and the joint between the concrete slab and the timber beam. This implies, that the temperatures solved by the numerical model in the place of the cross-section in the real structure non-affected by the drought cracks and the joints, will be partially overestimate. From the comparison of the test results and the numerical modelling was significant the severe effect of the drought cracks on the higher heat transfer into the cross-section. Another fire tests are needed to say, that the right moisture loss is assumed in this FE-model. This question can be also answered by using the coupled heat and mass transfer numerical model based on the Luikov equations.

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Long Bolted Joint of High Strength Steel Members

V.Hatlman

vaclav.hatlman@fsv.cvut.cz

Department of Steel and Timber Structures, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

High strength steel is a new progressive material in structural engineering. Its mechanic proprieties as well as lower secondary costs increase competiveness of steel structures. High strength steel can be understood by grade S500 and higher. Number of steel producers provides such materials capable to be used in many industrial branches. Civil engineers use steels only to grade S460 nowadays, because we have still lack of normative prescription for high strength steels. Research in high strength steel sphere is at the beginning. Joints of high strength steel members are in priority of many researches facilities and teams.

This paper is focused on high strength steel connections. Experiments are based on conclusions of research carried out at the University of Ljublana. It contained an experiment with a single and double bolted joints of high strength steel plates. Their experiments are focused on bearing capacity of end part of high strength steel members joint. The objective is the study of bearing failure mechanism. Bolt shear failure, net section failure and gross section failure have to be avoided. The following design resistance rules are given in clause 3.6.1 in EC 3, Part 1.8 and they were used in the design of the test specimens.

$$F_{b,R} = \frac{k_1 \cdot \alpha_b \cdot f_u^h \cdot d \cdot t}{\gamma_{M2}}$$

where: $\alpha_b = \min\{\frac{e_1}{3d_0}; \frac{f_{ub}}{f_u}; \frac{p_1}{3d_0} - \frac{1}{4}; 1{,}0\}$, $k_1 = \min\{2{,}8 \cdot \frac{e_2}{d_0} - 1{,}7;\ 2{,}5\}$

Eurocode 3 applies also for minimum spacing between the joints - clause 3.5 of EC3 Part 1.8:

- Minimum end distance: $e_1 \leq 1.2$ d
- Minimum edge distance: $e_2 \leq 1.2$ d

The higher value for the ultimate tensile strength of the plates was taken to obtain the maximum value of the bearing resistance. All the others failure mechanisms can be avoided:

$$F_{b,R} << \{F_{s,R}\,; N_{u,R}\,; N_{pl,R}\}$$

where $F_{s,R}$ is shear resistance, $N_{u,R}$ is net cross section resistance and $N_{pl,R}$ is gross section resistance.

Experiments described in this paper are focused on long bolted joint of high strength steel members. Steel grade S960 is used in first step of this project. Fisher equation for long

joint for high strength steels, influence of load bearing capacity and lower ductility as well as bolt forces distribution are discussed in this paper. EUROCODE 3 1.8 uses for long bolted joints equation:

$$F_{v,Rd} = \frac{a_v \cdot f_{ub} \cdot A}{\gamma_{M2}} \cdot \beta_{Lf}$$

where: $\beta_{Lf} = 1 - \frac{L_j - 15d}{200d}$, L_j is dimension between centers of outer bolts, a_v is 0,5 for bolt M 12 10.9 and $0{,}75 \le \beta_{Lf} \le 1{,}0$

Research is focused on β_{Lf} , which is given for normal strength steels (S235 to S460) and for those steels is used in Eurocode. Normal strength steels have ductility around 20%, so distribution of stress between bolts is different than in high strength steel. That distribution will be observed with many strain gauges around holes for bolts. From measured values will deduce how stress and forces are distributed in long joints.

This year was prepared experimental plates in common structural steel work that experiment will be next to reality of steel constructions. Steel plates haven't any surface customization. Friction between plates has an influence on experiment that is why plates will be greased. Plates are made of steel S960 and dimensions are 70x70x600mm. Plates are connected with the 10 single-shear bolts.

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Header Plate Connection with Higher Fire Safety

J. Chlouba, F. Wald

jiri.chlouba@fsv.cvut.cz

Department of Steel and Timber Structures, Faculty of Civil Engineering, Czech Technical University, Technická 7, 166 29 Prague 6, Czech Republic

Reliability of structures during fire situation was considerably improved in the last decade. This was achieved by elaborating of prediction models of structural element behaviour, which are based on tests of beams and columns in furnace. The findings were used for creation of guidelines and standards for designing of structures, which take into account both strength and stability problems including lateral torsion buckling and design of thin-walled structures. Full scale fire tests on an eight-storied structure in Cardington and observing carried out during real fires proved that the structure as a whole behaves diametrically different in comparison to individual members [1]. During the heating the members are subjected to compression forces, which are caused by restraining the thermal expansion. This results in plastic deformations that cause tensile forces during cooling. These forces lead to failure of the connection. For designing of connections in steel structures in room temperature the component method is commonly used. The connection is decomposed into components and the behaviour of the whole connection is deduced from the behaviour of the components. For the utilisation of the component method for the design during the fire situation the description of components and proper methodology of assembling when subjected to fire are needed.

In June 2006 a full scale fire test was carried out [2]. The tested object was a three-storied steel structure with composite slabs, steel beams of hot rolled sections, beam-to-beam and beam-to-column header plate connections and diagonal wind bracings. Internal size of the fire compartment was designed 3.80 x 5.95 m with height of 2.78 m. The mechanical load on the floor above the fire compartment was composed of the dead and life load. The life load was simulated by about 1m of water. From this experiment the temperature distribution over the connection was acquired [3]. This distribution is intended to be used for comparison with the temperature distribution gained from an experiment with a connection with higher fire safety. The connection chosen from this experiment for the comparison was a beam-to-column connection. A beam of hot rolled I 300 section was connected by a header plate connection with 6 M20 bolts to a column of I 340 section. The fire load and the fire compartment characteristics were adapted to make a fire curve similar to the fire curve measured by the Cardington experiment.

The experiment with a connection with higher fire safety was carried out in November 2007 in PAVUS laboratory in Veselí nad Lužnicí. It was not a full scale fire test; the tested member was a steel concrete beam over a 3m span composed of a hot rolled I 160 section. The concrete slab of thickness 100 mm was created by use of thin-walled trapezoidal sheet of 50 mm height. This sheet acted only as a permanent shuttering the same way as in standard practice. The concrete slab was 800 mm wide because of requirements of the laboratory equipment. The supporting structure was composed of an insulated frame from HEB 200 profiles. The frame was stiff enough to give support to the beam even during the fire. The hot rolled beam was connected to a supporting structure by header plate connections with four bolts. The specialty of this connection is that the upper row of bolts is above the upper flange of the beam and thus embedded in the concrete slab. By that the two bolts are protected from the direct contact with the fire providing extra resistance during the fire situation. Moreover, there is a stiffener between the upper bolts giving good shear resistance during both room and

higher temperatures from the same reasons. The specimen was loaded during the whole experiment by a constant load which was induced by a hydraulic jack. Two local loads of 25 kN were placed in the forth of the span from both sides of the tested beam. The temperatures were measured in both connections in both bolt rows. From these measurements the temperature profiles of the connections can be derived. The specimen was tested at a gas furnace and the fire loading corresponded to the fire curve measured in Cardington.

To make the comparison of the two obtained temperature profiles possible the temperature development of the fire must be approximately the same or the relation between those two different developments must be known. The temperature during the full scale experiment was not completely the same as in Cardington because of the complexity of fire development. Therefore, the comparison is made based on finite element models by the use of computational methods. Suitable instrument for this is program SAFIR which combines thermal and structural behaviour of a structure. For creation of the mesh pre-processing software GiD was used. The models are almost finished, but the results are not available yet.

An approximate idea of what is the difference between the two connections can be made based on the measured temperature developments in the connections. From the temperature profiles it is obvious that the connection with supposed higher fire safety is more resistant during the fire situation. The temperatures reached in the lower bolts are about the same as in the case of all bolts in the standard connection whereas the upper bolts of the latter connection have reached considerably lower temperatures. This has crucial impact on the connection resistance. The reached temperature is directly affecting the resistance of a part of a connection as it is described in EN 1993-1-2:2005. According to Annex D the difference in resistance of the upper and lower bolts is 70% when the temperatures reached 280°C and 690°C respectively. The difference in resistance of the upper bolts of the standard connection and of the altered connection is more or less the same; the temperature in the upper bolts of the standard connection reached over 730°C in comparison to 280°C on the altered connection. The temperature reduction of the connection parts embedded by concrete applies also for the temperature of the stiffener. By that the connection is capable of transferring relatively large shear stresses even in the case of fire.

These results obtained during this research work prove the positive influence of the embedding of a part of a connection by concrete on the fire resistance of the connection. More precise results of the thermal behaviour and the mechanical behaviour of the connection will be the aim of further research. For the following research the above mentioned finite element software will be used.

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Behavior of Small Steel Bridge with Overthickness Deck

Jiří Jirák*

jiri.jirak@fsv.cvut.cz

*Department od Steel and Timber Strucutres, Faculty of Civil Engineering, Czech Technical universityin Prague, Czech Republic

The lifetime of bridge structures is supposed to be 100 years. In the recent decades, rapid deterioration of assembled bridge structures has become a serious technical and economical problem. The technical improvement in bridge rehabilitation is one of the most important tasks of civil engineering nowadays. The serious defect appearance on load-carrying member causes the necessity of bridge reconstruction well before expected service time. An increase in the durability of existing bridges should be achieved by periodic bridge inspections and just in time maintenance. In the first instance the inspections are performed in a visual way. The second stage follows in more advanced methods as diagnostic investigation of visually defective parts.

To improve the field inspection and design of new structures, the Ministry of Transport launched research projects on failure, durability and load capacity of bridge structures in Czech Republic, for steel, steel-concrete and concrete bridges respectively. The research project on steel bridges is still under progress. The main goal of this research is to determine the general condition of road bridges in Czech Republic, to investigate frequent defects and failure causes and to prepare recommendations how to design new bridges without inherent failures and with higher durability. In horizon of the government research, there have been performed the initial inspections of almost 100 steel bridges. The examined bridges were in various stages of service life and of different structural systems. All failures as well as structural condition were described in details. The particular attention was aimed to load-carrying members as the most important part of evaluation. The CTU project extended the amount of inspected bridges on next 10 and the results of investigation were described in similar way. The detected failure causes were determined.

The whole number of examined bridges provides a statistically sufficient sample for analysis, as it includes bridges in all stages of service life and various structural systems. It has been find that the usual maintenance and repair practice of the pavement, particularly on the short span bridges in the Czech Republic is to lay up a new layer assembling without the old coat removal. This practice leads to un-proportionally thick deck (overthickness deck). The effort in CTU research project has been aimed to study this problem as follows.

The bridge at village Tample was selected for diagnostic inspection as the typical example. The reinforced concrete deck slab was placed without any shear connections on the top flanges of the 8 hot-rolled main girders connected by cross beams in every quarter of span. Total thickness 51 cm of the pavement crust and the deck slab was measured in the field. The standard load capacity of bridge is declared as one truck with weight of 22 t. Any serious defect of the bridge structure was not found during the initial inspection before and after diagnostic load test as well.

The assessment of the superstructure appropriate to codes provides merely the increasing dead loads of additional coatings. The ordinary used theoretical calculation presumes no composite action between steel and other elements. The whole load is supposed for main girders only. The measured deflection in midspan was equal to approximately one quarter of theoretically calculated deflection. It confirms that the bending resistance of dead load layer provides strong composite action with main girders and so ordinary used calculation model does not correspond with the real behaviour. Considering the diagnostic

inspection results, the effective behaviour of overthickness deck is very different and therefore the more sophisticated numerical study is planned for future.

The diagnostic inspection results are considered during the numerical model calibration to reach the best approximation between the results of numerical model and the inspection results. The numerical model is prepared in advanced FEM software. Simultaneously the a little simpler model is prepared. Both models are consequently calibrated according to the experimental diagnostic inspection data. The main aim is to prepare the model which will be able to predict actual load capacity of bridge with very thick deck for use in practice. The advanced numerical model is provided in Ansys.

Generally, the structural stage of the steel bridges in the Czech Republic is sufficient enough and for each bridge deeply depends on provided maintenance. The main aim of the research is to improve the design, assembling and methods in practice to decrease the rehabilitations costs.

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Fracture Toughness of Steel S355 NL

A. Jůza

ales.juza@fsv.cvut.cz

Department of Steel and Timber Structures, Faculty of Civil Engineering, Czech Technical University in Prague, Thákurova 7, 166 29 Prague 6, Czech Republic

Steel structures and bridges are designed to suit both the ultimate and serviceability limit state. The purpose of respecting the ultimate limit state is to design steel structures so that a brittle fracture is avoided. There are two possible ways of evaluating the brittle fracture. The first one is a process closely specified in European standards. It is based on selecting a suitable steel grade by the recommended values of impact toughness at transition temperature; and at the same time, it sets up a limit for designed plate thickness in table 2.1 "Maximum permissible values of element thickness" specified by the standard ČSN EN 1993-1-10 [1]. This method can be used only for purpose of designing a new structure and is derived from values of notch toughness. The other approach applies methods of fracture mechanics to analyze solid bodies with a crack. It is also suitable for cases where the first way may not be used for obvious reasons, e.g. existing constructions with already cracked parts or calculating the remaining life of such structures. This procedure of design or other evaluations is more accurate, but it is necessary to know the values of fracture toughness of the designed material.

The value of fracture toughness depends on many parameters. The basic parameter is micro-structure of the material, which depends on chemical composition, melting procedure, rolling technology and further manufacturing of steel structure. Very important parameter is operating temperature as the fracture toughness of constructional steels decreases with lower temperature. It is also dependent on thickness of the used element. As the thickness of the elements increases, more of its volume is getting into the state of plain strain and the fracture toughness decreases. It is important also to consider loading speed. With higher loading speed, fracture toughness decreases. Usually loading speed divides fracture toughness up to static fracture toughness and dynamic fracture toughness. The last very important parameter is welding, which is thermal process of connecting individual parts of the steel structure together. In the vicinity to the weld is created heat affected zone. Very high temperature from the welding and following cooling brings changes into microstructure of this heat affected zone in dependency on the welding procedure specification. In the very near of the weld there is a risk of creating coarse grains with low fracture toughness susceptible to brittle fracture.

Obtaining the fracture toughness value is possible only by experimental testing, which is a highly time and resource consuming procedure. Static fracture toughness, determined by ISO 12135 [2], is measured on specimens of the real thickness with a fatigue pre-crack in bending. Dynamic fracture toughness, determined by ČSN EN ISO 14556 [3], is measured on small specimens with fatigue pre-crack with instrumented pendulum.

Considering civil engineering praxis, there is many different materials, structure types and environmental conditions, including temperature. Any dynamically loaded structure may be in the risk of brittle fracture which is the final stage of fatigue. Methods of fracture mechanics can estimate rate of fatigue crack growth and the critical crack length, meaning remaining life of the structure, with known value of fracture toughness. For existing structures, it might be difficult or nearly impossible to obtain relevant specimens, therefore correlation techniques may help.

It is possible to estimate value of fracture toughness from values of notch toughness, even if the fracture initiation is slightly different. Notch toughness is measured on small specimens with common Charpy pendulum, which is very well known test determined by ČSN EN ISO 10045-1 [4]. This correlation technique should bring an easy tool for using methods of fracture mechanics into practical design of new structures and more precisely estimating remaining life of existing structures with cracks.

Research of commonly used constructional steels for bridge building is continued at Department of Steel and Timber Structures, Faculty of Civil Engineering, Czech Technical University in Prague. Investigated steel grades are S355 J2G3, S355 NL and S460 NL. Main parameter taken into consideration is temperature and micro-structural changes caused by welding. This project is aimed at steel S355 NL.

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Bolted Connections of Corrugated Sheet at Elevated Temperature

P. Kallerová, Z. Sokol

petra.kallerova@fsv.cvut.cz

Department of Steel and Timber Structures, Faculty of Civil Engeneering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic.

The corrugated sheets are used for various structural elements. Design models of thin-walled elements at ambient temperature exist for both ultimate states (load carrying capacity, serviceability). The most typical application is the roof structure of single storey buildings. The behaviour at fire situation is influenced by the temperature. High temperature of the steel elements is the cause of decrease of the mechanical properties (yield strength and the modulus of elasticity) and has influence on local buckling of the cross-section. The increase of the temperature results in thermal expansion which induces axial force in the sheet and must be resisted by screwed connections of the sheets at the supports. At later stages of the fire the bending resistance is reduced and large deflection is observed. Membrane effect occurs as a consequence of the large deflection. This effect leads to increase of the load carrying capacity and the fire resistance of the roof structure. The influence of the connection is significant for the behaviour of the sheet at fire. The connection must provide the support for the membrane effect at later stage of the fire. It should resist the force induced by thermal expansion at the beginning of the fire and the force from thermal contraction at the cooling phase of the fire. To obtain reliable model for the trapezoidal sheet at fire, the stiffness and resistance of the connection must be taken into account. However, design models for the connection at elevated temperatures are not available. To develop design model of the connection at fire a group of tests is necessary.

The behaviour of the connection is temperature dependent. Testing at high temperatures is more difficult than testing at ambient temperature as it requires the use of furnace and large number of tests to cover the full temperature range. Two types of testing procedure can be used for the tests: steady state test method or transient state test method. With the first method the specimen is heated to the required temperature before loading, with the other method the loaded specimen is heated according the specific time-temperature curve.

The experiments with screwed connection at high temperatures were carried out at the laboratory of Faculty of Civil Engineering, Czech Technical University in Prague in 2007. The experiments were focused on stiffness, resistance, deformation capacity and collapse mode of the connections at fire. The specimens were tested at temperatures 20°C, 200°C, 300°C, 400°C, 500°C, 600°C and 700°C. Two specimens were tested for each temperature. The tested specimens were taken from the trapezoidal sheet with nominal thickness 0.75 mm. The measured thickness of the specimen in the first set was 0.75 mm, measured size 75×500 mm, measured yield stress 338 MPa and measured ultimate strength 428 MPa. The properties of specimens in the second set are: thickness 0.80 mm, size 50×350 mm, yield stress 327 MPa and ultimate strength 426 MPa. The material properties were tested only at ambient temperature. The lower part of the specimen was situated in the furnace and the thin plate was attached to steel plate of thickness 10 mm representing a beam flange. One self-drilling screw SD8-H15-5.5×25 (ø5.5 mm, length 25 mm, bolt head diameter 14.5 mm) was used.

The specimens tested in the first set of tests were heated in an electric furnace with internal diameter 150 mm and height 300 mm. The temperature of the connection was measured by a

thermocouple which was attached to the steel sheet close to the bolt. Observation of the behaviour during the test was not possible as the furnace didn't have a window. The second set was tested in a furnace with internal dimensions 50×130×125 mm. The temperature was measured by two thermocouples; one was used for measuring the air temperature, the other for temperature of the screwed connection. This thermocouple was located in a small hole in the bolt head. The furnace was equipped with a window allowing observation of the connection behaviour during the test. The deformation of the connection was recorded by a camera located in front of the window. The photographs were taken in 5 seconds interval during the whole experiment. The edge of the specimen was marked at spacing 5 mm for displacement measurement. These photographs will be instrumental for further evaluation.

The tests give information about the connection behaviour at high temperatures. The resistance of the connection is limited by bearing resistance of the steel sheet. Shear failure of the bolt was observed at temperature 700°C (at specimen thickness of 0.80 mm). The resistance is reduced at high temperatures. Comparing to the resistance at 20°C, it is reduced to approximately 50% at the temperature 500°C and to approximately 20% at 700°C. The temperature does not have a significant influence on the initial stiffness of the connection at temperatures lower than 500°C.

These results were used in preparation of experiment which was focused on the behaviour of the trapezoidal sheet at a roof exposed to fire. The aim of this test was to reach the membrane effect and to use the obtained data for preparing the analytical model of the structure. This experiment was carried out in the fire test laboratory Pavus in Veselí nad Lužnicí. The trapezoidal sheet 800×3500 mm was connected to a steel frame. The sheet was loaded by uniformly distributed load 2.4 kN/m^2. The same bolted connection as before was used. The temperature in the furnace followed the natural fire in an office building. The temperature was predicted by a parametric curve, maximum temperature 1108°C was reached in 55 minute. The test also included the cooling phase, duration of the test was 2 hours. The vertical deformation and the temperature of the sheet in the middle of the span ware measured. The behaviour of the connection was observed, therefore the temperature and the deformation in the bolted connection during the test was recorded. Maximum deformation of the sheet 228.5 mm was measured but no collapse of the structure or the connection was observed. The experiment proved very high fire resistance and reliability of this type of structure.

These experiments will be used for development of a design model of the connections at high temperatures. Preparation of the model is in progress.

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Analysis of Timber Space Structures Joints

J. Skopalík

jiri.skopalik@fsv.cvut.cz

Department of Steel and Timber Structures, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 27 Prague 6, Czech Republic

At one time regarded as nontraditional and outlandish, space structures are now all-round accepted as economical and aesthetically attractive. Within the past decade advances in computerization have resulted in important changes in space structure design, and in the analysis of their plastic behavior and stability. Whereas space structures were often referred as interesting but nontraditional structures, today these structures are now accepted all over the world.

The advantages of tree dimensional structures have been known for many years. Engineers always appreciated the primary rigidity of three dimensional structures and their ability to cover large spans with very small weight. But the difficulty of the complicated stress analysis of such structures originally contributed to their limited use. Steel is the unique structural material for such construction. One has to remember the renowned timber laminated dome, till now the biggest timber dome in USA, completed in 1983 in Tacoma, Washington. The dome has a clear span of 162 m and elevation of 48 m. Another equally convincing example of a laminated timber dome is the Round Valley Ensphere, completed in 1991, of clear span of 132 m. According the engineers and designers the cost of these timber structures prove to be about less by half cheaper than in steel.

The project is focused on research glue laminated timber dome structures, especially using the very quick and simple friction joint. The construction of designed timber dome is composed from two layers. The single beams are made from the glue lam timber in dimensions of 60 by 60 mm. The square profile is composed from the six pine lamellas. Single layers are against each others turned about 90 degrees. Intersections of the beams are jointed by a special friction joints and form such rigidity grid. Upper layer has a clean span of 4,075 m, elevation of 1,030 m and radius of curve is 2,530 m. Lower layer has a clean span of 3,925 m, elevation of 0,097 m and radius of curve is 2,470 m. The beams are compressed among three sheet metals and each other bolted together by four bolts of diameter 8 mm.

The experiments are being recently evaluated. The section of the dome construction with designed friction joint is investigated in detail at the laboratory. It's expected that the bending rigidity and the strength have a large effect on the buckling of such grid dome. The joint system which has been developed as a semi-rigid connection is investigated in a series of loading tests to find the bending characteristics. It means bending rigidity, twisting rigidity and strength for the springs on the both ends of the member. The specimen consisted of two members with one friction joint between them and one hydraulic jack. The jack is positioned to apply an axial force N_x to the first member and currently bending moment M_y, twisting moment M_x and shear force Q_z to the second member. The second member is grounded on the both ends by a pinned support.

The strength test was also conducted by bending moment M_y, twisting moment M_x and shear force Q_z to the second part. For the connection between the both timber members is very important tightening torque T_x applied to bolts. In the first test was tightening torque T_x = 20.0 Nm. The first results have revealed that the axial force N_x increasing and consequently increasing bending moment M_y, twisting moment M_x and shear force Qz have proved that the global strength of friction joint is higher then that strength the second timber member.

From the strength test undertaken, that the glue lam timber members failed before the internal forces acting on the joints reach its ultimate strength. The data from the experiments will be very useful for numerical modeling and calibration of the preparing numerical model of the friction joint. A test was conducted on the joints to prove that the joints have sufficient rigidity and strength for the domes to function as required in the design.

The main experiments of the frictional joints will be filled in by another test of the whole dome to proved their high rigidity and strength against buckling. Further will be realized material tests of the glue lam timber beam in dimensions of 60 by 60 mm form which afford to a necessary values and characteristics. From the bending strength, average density and elastic modulus is possible to determine other mechanical values.

Performed experiments of the joints and physical domes model will be served for validated numerical models and further will be possible to do some recommendations for applications such systems to the usually forms used in the civil engineering.

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Influence of Moisture on Semirigid Joints of Timber Frames

M. Truhlář

martin.truhlar@fsv.cvut.cz

Department of Steel and Timber Structures, Faculty of Civil Engineering, Czech Technical University, Thakurova 7, 166 29 Prague 6, Czech Republic

Recently has been already worked out and checked [2] the procedure for designing and analyzing the evaluation of the resistance of steel threaded rods glued-in a timber. It was a part of draft rules for bonded-in rods in the code prEN 1995-2 Part 2: Bridges. In the final edition of the code, unfortunately, it hasn't been stated. As the one of the main reason is stated the influence of moister to the wood and its inefficient consideration to resistance and rigidity of glued-in steel rods.

The changing of timber moister during the structure and also during the all time of its usage has the influence to the timber construction components, joints and even the whole structure and the connected parts. The moisture influences the timber in many factors. The one of the important information are the relationships between the moisture and the mechanical characteristic of the timber, which importantly influence the characteristic of glued-in steel rods behaviour loaded by an axial tension force. The first man who occupied himself mind by these problems was Riberholt [4] who did the first experimental analysis on this problem. Follow amount of researchers who continued research this problem analytically or experimentally, for instance Broughton with Hutchinson in [3]. They experimentally tested the influence of changing moisture to resistance of rods glued in the green wood; it means wood with high initial moister content recently taken from the tree. In [2] were tested the specimens subjected to air humidity in the outer environment for a long period (months), but under these conditions the covered wood (not exposed to the rain) can reach maximum about 18% of moisture. But in the the real usage of this type of the connection could moisture become higher than 18% - for instance in the problematic detail with a heat bridge or during accident on water or on a plumbing. Therefore this research has been carried out.

Experiments

Were prepared and done the experiments with specimens consist of timber blocks 100 x 100 x 260 mm with glued-in steel threaded rods with diameter 14 mm. The rods where glued-in by epoxy resin in the hole 250 mm length. After the stiffening of the resin the specimens were exposed to water treatment. In the water bath they spent 4 months. Then they were taken out and the pullout experiments were carried out. The timber part of specimen was leaned against steel plate with the central hole with diameter 65 mm. There were designed two types of specimens. It was type with rods glued-in parallel to the grains (PAG) and perpendicular to the grain (PEG). The depth of the gluing-in has been chosen in order to realize the results transferable and usable for simulation of exposing the joints from work [1] to the higher moister. Thus in the PAG were rod glued-in 250 mm depth and in the PEG were glued-in 180 mm depth. The part of specimens was left in primary atmosphere (20° C and 60% humidity). Their inner moister were stabilized on value 10%. This set of pullout test was used for comparing results with moisturized specimens. All tests were done on jerk machine FZP 100 in CTU Experimental Center. Each specimen was settled by inductive transmitter of path also the force has been recorded. Such a way has been developed plenty of stress-strain diagrams.

Due to need of find out the characteristic of the steel rods the tension test also has been carried out.

Results of experiments

The result of the tension test of the steel rod is stress-strain diagram typical for steel shaped in cold thus without clear an yield point, which was stated to 520 MPa and resistance of 580 MPa.

The results of the pullout test validated assumption of relations between resistance of joint and moisture content in the timber. The moisture content influent all mechanical characteristics of the timber to the level of full water saturation (this level is approximately 30%). The timber as a nature material has a big differences in the characteristics which dramatically increase with increasing of timber moisture. The resistance of glued-in rods in PAG specimens with 10% of moisture was almost the same as resistance of steel rod. In one case the rod has been damaged by yielding. The resistance of moisturized PAG has drop about 21% but had a bigger variability between 27 kN and 47 kN. The resistance of glued-in rods in PEG specimens with 10% was higher than resistance of connection and the rod always has been snapped. Different situation was with moisturized PEG which all had an initial crack which caused a dramatically drop of resistance from 54 kN to aprox. 20 kN. Also appeared a big variability of results from 14 kN to 29 kN all depended on the dimension of the initial crack. Moisturized timber allowed a lower level of deformation which has been dropped from 2.5 mm to 0.85 mm.

Analytical model

The analytical model has been developed. This model can be used for calculation of joints stated in [1] using of usually accessible devices without need of specialized software. The whole connection has been divided in to the elementary parts and their stiffness and resistance has been counted separately. Consequently has been all components connected in to complex, which qualify the real behaviour of the joints. The experimentally discovered values of resistance and stiffness have been used.

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Composite beams made of high strength steel and high performance concrete with partial connection

I. Tunega

ivan.tunega@fsv.cvut.cz

Department of Steel and Timber Structures, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

Composite beam made of high performance concrete in combination with high strength steel represents a progressive structural member. Since new EN 1994 has been issued it is possible to use steel grades up to S460 and concrete grades up to C60/75. Standards also prescribe certain limitations for a usage of high strength materials with partial shear connection. Composite beams are mostly designed according to plastic theory. Specific material properties with respect to ordinary design processes bring many questions.

The most important research program at this area is a work of the research group under leadership of Aachen Institute [1]. Conclusions of [1] describe a wider issue. Following points are the most interesting regarding to this study:

- Strain limitation for high strength concrete in compression is necessary. Further tests have to be performed. Until then it can be recommended to reduce the compression strength to 70% for calculation with concrete C70/85 and C80/95.
- Basically, partial connection concept is suitable. Performed tests show, that the calculation in accordance with ENV 1994 underestimates actual load capacity of studs.
- Studs should be distributed according to elastic shear force line along beam length.
- The rules of EN for calculation of the ultimate loads of shear studs in high strength concrete have to be revised. Further tests are necessary.
- The deformation capability of shear studs in high strength concrete is insufficient. It has to be investigated if there are chances to increase the slip of the connectors in high strength concrete.

Steel products of grade S460 (and higher) are accessible as well as high strength concrete (up to the grade C100/115) in last years. Therefore a research project to study the behaviour of composite beams made of high strength materials has been started at CTU in Prague. The goal of this project is to verify some conclusions of [1]. First experiments have been carried out.

Standardised Push-Out Tests:

The experiments have been performed with the aim to determine the initial stiffness, load bearing capacity and ductility. During the experiments, the steel beam shall be displaced relatively to both concrete slabs such that the shear connectors undergo stress of the pure shearing type. While testing the load, the slip in the shear joint and a possible rotation of the concrete slabs is measured. In order to prevent a divergence between the steel profile and the slab, steel bars will be arranged at the bottom of the specimens without any pre-stressing force. For test evaluation of the tests the load-slip will be evaluated for each specimen.

Beams have been made of steel rolled members (HE260A, S 460) and concrete slabs 150 mm (C 70/85). Shear connection has been provided by means of shear studs with nominal diameter d = 19 mm and nominal tensile strength 340 MPa.

The bearing capacity of composite beams depends on the cross section, material and the stiffness of the shear joint. This stiffness results from the chosen shear connectors, which are transferring the shear forces in the joint.

Shear $$P_{RD} = 0{,}8 * \frac{f_u}{\gamma_v} * \frac{\Pi * d^2}{4}$$

f_u – tensile strength of stud

d – stud diameter

Load-bearing capacity $$P_{RD} = 0{,}29 * \frac{\alpha * d^2}{\gamma_V} * \sqrt{(f_{c,cube} * E_{cm})}$$

$f_{c,cube}$ – mean cube compressive strength on the 150 mm cube

$\alpha = 1{,}0$ while $h/d > 4$

E_{cm} - modulus of elasticity of concrete

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Design Optimization of Directional Layout of Roads Allowing Passage of Oversize Vehicles with PC Support

F. Eichler

filip.eichler@fsv.cvut.cz

Czech Technical University in Praque, Faculty of Civil Engineering, Department of Road Structures, Thákurova 7, 166 29 Praha 6, Czech Republic

The project is focused on the problems of the passage of oversize vehicles on the roads. These problems undoubtedly represent an important factor affecting the design of the directional layout of roads. The optimization of the directional design is given by the necessity of enabling the passage of a vehicle (truck train) which considerably differs by its dimensions from vehicles for which this type of roads is mainly designed.

There presently exists the technical regulation of the Ministry of Transport CR TP 171 "Tow curves for the verification of passage along directional elements of roads", but its application is limited to a set of curves contained in it. These curves represent a certain group of motor vehicles whose dimensions are based on the current and expected composition of the motor pool. The simulation of vehicle movement with the help of these curves is a relatively simple and practical aid for the design of selected geometrical elements of roads. The drawback of using tow curves is potential inaccuracy which may be caused by the level of skills and application precision of these curves. The use of a software application which will allow, among other things, the definition of any oversize vehicle will enhance the accuracy of the results and eliminate potential errors. Another advantage of this programme is a possibility of simulations of reverse travel which is indisputably suitable for the design of different types of back - arounds, loading ramps etc. Reversing of vehicle trains is far more than by vehicle geometrical parameters affected by the driver's skills and so these results are considered only as rough guidance.

The software AutoTURN 5.0 for the simulation of tow curves allows determination of the area taken up by a vehicle passing along a directional curve, and it was used in the design of purpose-built roads servicing a set of wind power plants. This programme set up the minimum requirements for the passage of oversize vehicles. The main problem was to design the necessary widening in directional curves. This design was applied together with the calculation taken over from the standard ČSN 73 6109 – Design of Rural Roads. The maximum length of the vehicle ranges around 35 m including the transported sections of wind power plants. This load will not be transported only on roads designed for this purpose, but the vehicle will also travel on existing roads. An undeniable advantage of this software is also a possibility of specifying the envelope curves of the load exceeding the vehicle on one or more sides. Another use of the software brought about the minimization of the dimensions of individual types of back - arounds necessary for turning round oversize vehicles.

The software option of defining any vehicle and specifying the necessary extension in the directional curve proved its advantages in comparison with the application of the necessary extension under ČSN 73 6109 – Design of Rural Roads. Rural roads as purpose-built roads mainly serve for the operation of agricultural machinery. The motor pool of these types of vehicles is quite diverse and depends on the season. It differs not only by its width, but mainly by its length which is variable depending on the type of machinery towed behind the vehicle. The standard ČSN 73 6109 specifies the minimum extension values in the curve which are based on the radius, design speed, design category and axle base. Considering a

unified axle base for all vehicle types may in some situations result in a solution where the minimum extension specified in ČSN 73 6109 will be insufficient. In these cases it is advisable to use the software, which is able to solve such situations and if appropriately applied provides the optimum solution.

The use of the software is not limited to the area of purpose-built roads. Its advantage is potential application for various types of roads such as roads with traffic calming, residential and pedestrian zones, traffic surfaces etc. In solving these design situations, analogically to using tow curves under TP 171, two different results may be obtained. One of them is smooth vehicle turning into a directional curve in forward travel and the other is a possibility of turning the vehicle axle after stopping and successive pulling off. In dimensioning roads the former of the above-mentioned possibilities of travel methods is principally used. The latter method is considered as an exceptional case and should not be used for new structures. It is useful e.g. in the verification of passage along existing roads by new vehicles.

Conclusions

The optimization of geometric dimensions of individual types of back - arounds, traffic surfaces and parking places allows reduction of spatial and investment demands, which are often the major factor in approving an investment project.

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Static Analysis of Impact Test Deformation Modulus for Rail Bed Constructions

P. Brestovsky

petr.brestovsky@fsv.cvut.cz

Department of Railway Structures, Faculty of Civil Engineering, Czech Technical University in Prague, Thakurova 7, 166 27 Prague 6, Czech Republic

To find out the bearing capacity of the rail bed layer the static plate load test is used. During this test the pressure under the load plate is induced and the depth of the deflection of the load plate is monitored. The depth of the insertion is measured for various sizes of the pressure. From the results of the measuring the static modulus of deformation E is calculated. In the regulation CD S4 – Railway Substructure mimimal values of the static modulus of deformation are specified for various component parts of the rail bed. The disadvantage of this test is long time and technical heftiness. The test takes about one hour and the hydraulic press ram plus the counterweight must be used. For a complex picture of the bearing capacity of the rail bed measuring in various measuring profiles must be done.

An alternative of the static load test could be the impact load test with the use of the light-weight deflectometer. Today, it is used for the control of the static compaction level. During this method, the deflection of the load plate of the same diameter as in the static plate load test is used, but due to the impact pulse in this case. The result is the value of the impact modulus of deformation Mvd. The advantage of this test is that it is fast and simple, with an immediate result. It can be done 15 times in one hour.

At the Svetice railway station the measurement of the impact modulus of deformation with the light-weight deflectometer on the layer of lime stabilization, on the antivibration mats and on the layer of sub-ballast and on the layer of ballast was implemented. The results of the impact modulus of deformation Mvd from seven measuring profiles were subjected to the static analysis with the goal to find out the most exact Mvd value for each layer and evaluate the quality of all layers.

The measurement with the use of the light-weight deflectometer is controled by the standard ČSN 736192 "Impact load tests for road surfaces and subsurfaces" [1] The equipment LDD 100 from the ZBA GeoTech s.r.o company was used. It consisted of the load plate with the 300 mm diameter and of the interposer bar with the weight. There is a shield indicator on the load plate that allows the measurement of the insertion of the plate. The weight of the interposer bar is 10 kg and it falls from the height of 76.5 cm on the shock absorber. That allows achieving the impact pulse of 18 ms. From the deflection of the load plate the impact modulus of deformation Mvd is calculated using below mentioned formula:

$$M_{vd} = \frac{F}{d \cdot s} \cdot \left(1 - \mu^2\right) \quad \text{[MPa]} \qquad (1)$$

where: F = size of the maximum impact power (7.07 kN),

μ = Poisson ratio,

d = the diameter of the load plate (300 mm),

s = the size of the flexible deflection under the middle of the load plate in mm.

The electronic part with the evaluating equipment and the printer for immediate printing of the protocol is connected to the machine. The protocol consists of the graph with the courses of three deflections in dependence on the impact pulse, the biggest value of the deflection, their average value and the final result of the impact modulus Mvd [2].

To find out the impact moduli of deformation, the section between 161.200 – 161.400 km on the doubletrack railway n. 221 that connects Prague and Benesov by Prague was chosen. In 2006 and 2007, the renovation of this section was made, the measurement of the impact load test was implemented during this renovation. This track goes through the built-up part of the village Svetice with a nearby station. To reduce the effects of vibrations the antivibration mats from the BohemiaElast Company were used. The tests of the impact modulus of deformation were done on the layer of lime stabilization, on the antivibration mat and on the layer of sub-ballast and ballast.

4 statistic sets with the same number of results were evaluated. The average value and the median were not really different in any of those sets. We can claim then that the average value is a realistic reflection of the middle value. The number of the elements that are higher or lower than the middle value is almost identical. The width of the maximal and minimal value is high in all sets, but the variation coefficient for the values of the impact modulus of deformation on the ballast layer is low reaching values up to 0.1 and it shows the compendiousness of the set. The big span is caused by a very low number of the distant values. In the other sets the variation coefficient is higher than 0.1 and lower than 0.3 which is the acceptability border of the distant values. Especially the values of the sets on the lime stabilization layer and on the subballast layer are very wide apart, which is shown by the sampling standard deviation and 95 % the reliability interval of the mean value. The reason for the variance of the values of the impact modulus of deformation on the lime stabilization could be a variation of the dose of CaO, a change in the natural soil moisture content and the grading curve. The values of the impact modulus of deformation on the subballast layer are affected by laying on the layer of the antivibration mat, which has low rigidity. The satisfactory variance of the resulting values of the impact modulus of deformation on the antivibration mat layer may be attributed to the material homogeneity and placing on the rigid lime stabilization layer. The most satisfying measured data is on the ballast layer.

The method of using the light-weight deflectometer makes the test (compared to the static plate load test) faster and simpler. It allows a bigger amount of measurement at the same time and finding out the rail bed carrying capacity in not such distant profiles. The impact load test provides a much clearer description of the surveyed layer. It can help to make the static plate load test that is usually done in the interval of 200 m more precise. In order to introduce the impact load test with the use of the light-weight deflectometer to the relevant regulations, the correlation coefficient between the impact modulus of deformation Mvd and the static modulus of deformation E must be determined. The measurements using both methods must be done in the same measuring profiles. Then, from the 95 % interval of the reliability for the mean value the minimal required value for each layer of the rail bed could be derived [3].

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Numerical Simulation of Organic Contaminant Transport in Porous Media

L. Gvoždík

libor.gvozdik@fsv.cvut.cz

Department of Irrigation, Drainage and Landscape Engineering, Faculty of Civil Engineering, Czech Technical University in Prague, Thákurova 7, 166 29 Prague 6, Czech Republic

Nonaqueous phase liquids (NAPLs) are one of the most common health-threatening organic chemicals in groundwater. They typically enter the groundwater through leakage, spillage or disposal at manufacturing sites, or at chemical waste disposal facilities. In the subsurface, NAPLs usually occur as pools on top of the water table, or on the underlying bed, and as residual globules in soil pores where serve as long-term sources of pollution due to slight solubility and low remediation concentration limits for drinking water. Understanding the evolution of NAPL contamination in groundwater and subsequent remediation of the aquifer requires a detailed knowledge of the physics of multiphase flow in addition to information on the mass transfer (contaminant partitioning) from the immobile nonaqueous phase into a mobile aqueous-phase field. Hence, an extensive research has been performed in recent years to evaluate the governing mechanisms of entrapped NAPL blobs and ganglia distribution and dissolution (e.g. overview of experimental studies in [1]). Field and laboratory data indicated that the groundwater concentrations of NAPL compounds, usually even lower than their aqueous solubility, can be attributed to irregular NAPL distribution, nonuniform water patterns, sorption effects, but primarily to rate-limited interphase mass transfer (dissolution) and to bypassing of mobile aqueous phase around contaminated regions (dilution) due to reduced relative permeability.

To estimate NAPL dissolution rates, two basic approaches are used – local equilibrium approach based on an equilibrium partitioning relationship related to aqueous phase solubility, and nonequilibrium approach based on a linear driving force model required mass transfer coefficient evaluation. The latter approach gives more accurate results of solute concentrations and source zone life spans. However, numerical modeling indicated [2] that mass transfer coefficients developed from experimental data are typically highly system dependent and predicted dissolved phase concentrations downgradient of a realistic NAPL release are quite sensitive to the chosen mass transfer expression. It was also illustrated that local equilibrium assumption applied at REV can be used to describe the effect of dilution only at higher NAPL saturations. At residual saturations the LEA is not able to predict the decreasing concentrations in the groundwater. In this period, a combination of low NAPL saturations and high aqueous phase velocities contribute to rate-limited mass transfer, even at the local scale. In [3] equilibrium partitioning was incorporated into alternative types of models: two domain model (analogue to the double porosity models) and parallel column model (conceptually similar to capillary bundle models). Numerical modeling of the one-dimensional column experiment showed parallel column models are able to reproduce the concentration drop-off and tailing observed in laboratory study of NAPL dissolution.

In this contribution the results of the numerical modeling of the laboratory experiment published in paper [4] are presented. Simulation model TMVOC was used to simulate two-phase water-NAPL flow in simplified heterogeneous two-dimensional region consisting of well-defined coarse sand lens contaminated by NAPL surrounded by a clean fine sand matrix. Local equilibrium approach was used to estimate NAPL dissolution rates. Various scenarios were modeled, where the influence of model grid dimensions, porous media characteristics

and type of relative permeability function on multi-phase system behavior was explored. Effluent solute concentrations and total dissolution times were evaluated and discussed with those measured and published.

Numerical modeling confirmed significant influence of rectangular model cell dimension on dissolution process simulated. The dilution phenomenon at the material interface is usual and typical for the numerical models. For the presented model with coarse sand lens divided in flow direction into five cells, it was identified that the regular grid (uniform cell sizes) caused decrease in the complete dissolution time to one-half. In realistic subsurface NAPL pollution this effect could have substantial impact on source zone life span and the site remediation duration. More precise results were obtained with the boundary fine sand cell width of 1/10 of the prior value.

Various porous media characteristics scenarios modeling pointed to some limitations of the generally used relative permeability function relationships. Although both the Parker's and Stone's relative permeability functions resulted into similar effluent concentration profile and were developed and linearized for the three-phase air-NAPL-water system, these relationships failed in the dissolution process evaluation. In the coarse sand lens, the entrapped (due to capillary forces) but high saturated NAPL phase contamination ($S_n = 0.68$) caused the coarse-grained porous material had to be simulated as very fine-grained medium with low van Genuchten parameter n (function of Parker) and high pore size distribution index λ (function of Stone). The numerical model also showed that the NAPL is not dissolved evenly through the whole coarse lens as discussed in [4], although the NAPL saturation remained uniform. The dissolution process occurs only in the region where the fresh water enters into the coarse sand lens and the generally uniform NAPL saturation through the contaminated lens in the groundwater flow direction is equilibrated due to capillary pressure gradient and opposite NAPL phase flow direction.

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The Effect of Preferential Flow on the Solute Transport in Soil

M. Sobotková and M. Sněhota

martina.sobotkova.1@fsv.cvut.cz

Department of Irrigation, Drainage and Landscape Engineering, Czech Technical University in Prague, Thákurova 7, 16629 Praha 6, Czech Republic

The detailed knowledge of water flow and solute transport in structured porous media is essential for adequate mathematical modeling of the movement of nutrients or contaminants in the natural soils. Solute transport through highly permeable structures and macropores is substantially faster than transport through the soil matrix. Therefore the presence of preferential flow may affect essentially the transport of contaminant through the soil profile. It is assumed that the preferential flow will notably change the shape of the breakthrough curve of both reacting and non-reacting species comparing to the homogeneous media. A standard infiltration experiment in combination with tracer leaching experiment is suitable for characterization of soil hydraulic and transport properties.

Standard infiltration-outflow experiments were conducted on two undisturbed soil columns and on the reference sample (18.9 cm in diameter and 25 cm high). Undisturbed soil cores were collected in the experimental catchment Liz (Šumava Mts.), where the preferential flow has been detected [1] and the experimental catchment Uhlířská (Jizera Mts.). The reference sample was packed by fine sand.

Infiltration experiments were conducted with constant pressure head at the top and the seepage face at the bottom of the soil cores. Boundary conditions were the same for all infiltration events, while the initial soil water contents were different for each infiltration.

The newly designed experimental set-up [2,3] was tested. Microtensiometers were inserted into the sample in depths 8, 13 and 17 cm from the top of the column sample to measure suction pressure head during the experiments. Microtensiometers were constructed from high-flow ceramic cup (0652X03-B01M3, Soil Moisture, CA, U.S.A.) and pressure transducer (236 PC Honeywell Microswitch, U.S.A.). Constant pressure head was maintained at the upper surface of soil cores during the experiments. The amount of effluent was measured by tipping bucket and weight of the soil column was recorded continuously.

The breakthrough curves (BTC) of nitrate and bromide were determined during the quasi-steady state flow. Nitrate and bromide were applied as a concentration pulse at the top of soil cores (3,38 ml of 0.1 M bromide standard and 50 ml of nitrate solution). The initial concentrations in application time were: 108.9 ppm Br^- and 100 ppm KNO_3^-. The experimental set-up was equipped with in-line electrochemical analysis in the effluent. Nitrate concentration in the effluent was measured continually by ion-selective electrode (Orion 97-07 BNWP, Thermo Electron Corporation, U.S.A.), which was installed in the flow cell. The ion-selective electrode was connected to the ion meter (Orion 4 Star, Thermo Electron Corporation, U.S.A.). The effluent was pumped by peristaltic pump (Mini-S Pumps, Ismatec, UK) into the flow cell and mixed with ISA solution (5M $NaNO_3$) in ratio 1:50. Bromide concentration in the effluent was sampled by fraction collector and measured separately.

Ponded infiltrations and repeated ponded infiltrations were performed for two soil samples and one reference sample. Three sets of BTCs measurements were obtained for reference sand sample, four BTCs of Br^- and NO_3^- were received for soil core from Liz catchment and four BTCs Br^- and NO_3^- for soil core from Uhlirska catchment. The upper

boundary condition was set to 6 to 8 mm of pressure head. The shape of the breakthrough curves of bromide and nitrate ions, which were determined during quasi-steady state flow, shows the presence of preferential flow in undisturbed soil cores. For artificially packed sand the preferential flow was less pronounced. As a next step, the experimental data will be fitted with numerical model based on the dual permeability approach.

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Observation of the Preferential Flow on Cambisols with Fluorescent Tracer

D. Zumr, M. Císlerová

david.zumr@fsv.cvut.cz

Department of Irrigation, Drainage and Landscape Engineering, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

Although the importance of preferential flow on soil water regime is a known fact, it is difficult to quantify the zones where it takes place. One way how to measure the effect of macropores is based on the use of tracers. Comprehensive overview of different types of tracers and their suitability for various environmental problems are discussed in [1].

The goal of the study is to assess the preferential flow impact using simulation models. Connectivity, volumetric ratio and spatial development of preferential pathways are necessary information for simulations performed with dual-permeability models [2]. The proposed method is based on laboratory and field infiltration experiments the application of the fluorescent dye tracers.

Around 60 % of the soils in the Czech Republic are classified as Cambisols formed on weathered crystalline bedrock. These soils are texturally heterogeneous and exhibit fast preferential flow. All experiments and tests were done on Cambisols from experimental sites Uhlířská (hillslope Tomšovka) in the Jizera Mountains and Korkusova Huť in Šumava. Three studies were conducted within the frame of the work:

1. Visualization of preferential pathways with use of fluorescent dye tracer Rhodamine 6G.
2. Evaluation and inverse simulations of laboratory inflow-outflow tracer experiment on undisturbed soil sample.
3. Field tension disc infiltration experiment.

Visualization experiments were done on small packed soil samples containing artificial macropores. Rhodamine 6G, in concentrations ranging from 100 ppb to 100 ppm, was infiltrated into the soil. The setup of the experiment was placed in a darkroom. The progress of the wetting front as well as of the steady saturated state was vertically photographed with digital camera using the 365 nm UV LAMP as a source of light. The photographs were digitally processed. It has been observed, that Rhodamine 6G is highly florescent in concentrations between 10 ppb and 2000 ppm. Beyond this range the tracer loses its fluorescent ability. During the experiments high adsorption of Rhodamine 6G was recognized, which was confirmed by adsorption isotherms tests. The tracer is rapidly attracted to the solid phase where thin films with high concentrations beyond the visible threshold are formed. The only visible areas are the preferential pathways where the mobile water is present. This fact makes Rhodamine useful tracer for preferential pathways observation and tracking and it must be considered during evaluation of breakthrough experiments.

As a next step, the inflow-outflow experiment with fluorescent dye tracer Rhodamine WT (20 $\mu g\ l^{-1}$) was numericaly simulated with dual-permeability code S1D_DUAL [2]. The experiment was performed on an undisturbed core sample from Korkusova Huť, Šumava. The outflow concentrations of Rhodamine WT were continuously measured with 10-AU Fluorometer (Turner Designs). Inflow, outflow, suction pressures in three depths, temperature of outflow water and temperature in laboratory were monitored during experiment. Results were used as an input into the S1D_DUAL dual-permeability numerical model to solve the infiltration-outflow experiment inversely. Breakthrough curves of Rhodamine WT and cumulative outflows served as the calibration data for the model. Dual-permeability model,

coupled with inversely determined transport characteristics, gives a very good picture of the processes within the media. With single Richards equation and single advection-dispersion equation one can't simulate the observed early breakthrough of Rhodamine followed by slow tailing, which clearly indicates preferential flow.

The aim of the field measurements done by means of tension infiltration was the estimation of soil hydraulic properties. The infiltration experiments were carried out in two 27 cm deep pits. Hydraulic conductivities were measured in the field using a tension disc infiltrometer. Infiltrations were performed under the tensions of -6, -3, -1 and 0 cm. 2D axisymetric numerical simulations were conducted to evaluate the results of the experiment. Two different approaches were used: single-domain approach based on Richards' equation and dual-permeability approach based on two water flow domains (matrix and preferential pathways), each governed by own Richards equation [3]. In the first simulation, the input hydraulic parameters were inversely optimized, the objective function consisted of infiltration flux and suction pressure head data. Parameter estimator PEST [4] coupled with the simulation code S2D_DUAL [2] were used. In the second approach a reference set of parameters, which was obtained by standard pressure extractor method, was taken as properties of the soil matrix. The parameters of preferential flow domain were again optimized by inverse modelling. Concerning the existence of preferential flow on investigated soil, the dual-permeability model gives a better picture of the flow character.

The work has proved that fluorescent dye tracers, which are easier to visualize and detect than non-fluorescent dyes, are suitable tool for preferential flow research. Fluorescent tracer experiments give valuable results which were successfully used in dual-permeability simulations. More experiments and simulations will be needed to properly describe the regime of water flow and tracer transport in heterogeneous Cambisols, the used method have appeared to be convenient

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Reconstruction of water supply systems

F. Horký, J. Karásek

filip.horky@fsv.cvut.cz

Department of Sanitary and Ecological Engineering, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6 - Dejvice, Czech Republic

Water is the basis of life, so supplying people with drinking water is one of the topics of our interest. Because of this fact, sustainable development is necessary in order to ensure the quality and reliability of drinking water supply systems. Reliability depends on many factors: from the characteristics of pipe material used and discipline during underground laying to consequential servicing and well-timed and suitable reconstruction. The project was focused on a review of possible pipe materials and reconstruction methods of water supply systems (usage possibilities, positives and negatives). Special attention was devoted to the application of trenchless technologies, which is currently a domain development trend. The project further deal with the methodological process of failure recovery and the methodology of recognition and evaluation of the current state of the system in relation to mathematical distribution networks modeling and failure simulation.

Because pipes are basic element of water supply systems, there is need to use high-quality materials for them. The review and comparison of typical pipe material characteristic (durability, operational safety, price of material and whole construction, allowed operational pressure, chemical resistance and foundation is necessary for choose of optimal kind of pipeline (ductile Iron, polyethylene, polyvinylchlorid, glass-reinforced thermosetting plastic GRP and steel material). Very important matter is material possibility for use in different ways of pipe laying and reconstructions providing. Unfortunetly there is no a simple solution for a choice of a proper material for water supply pipes. Different materials have advantages and disadvantages, but all kind of pipes have to satisfy the standards. Current materials are divided into metalic and non-metalic. The main Advantage of non-metalic materials is corrosion resistance, low pipe weight, fast laying of pipes and good usable for trenchless reconstructions methods. For example in soil with low foundation bearing value only PE pipes can be used because of their flexibility. On the other hand metalic materials are strong and can be used for higher operating pressure and temperature of water. They are Berger in thermal expansion and can be found in a soil without useing any special electric cable. Finding and localizating of water leakages is also better for metalic material.

Leakage reducing procedure is divided on several parts. First part is usually water structure analysis (identification different kind of water loss - network break down, hidden leakages, revenue meter mistakes). Hidden leakages represent for water supply operator the biggest economic loss so he usually do leakage investigation on basis of customer system for reduce the locality of leakages and afterwards he use search team in terrain. Detectors for leakage localization are based on two simple principle. One is electroacoustic and second is correlation. Simple description of electroacoustic principle is that we are using transmitter in pipe and sensor on ground. The signal goes through pipes wall and soil to the sensor. Correlation is based on collection of sound, which is made by leakage current. So we can do it on pipeline under pressure. Ways how to reduce hidden leakages are many more (for example: could be putted down (10 – 13%) by lowering operational pressure in pipe net.

In legislation is set that water supply operator must do renewal plan from economical angle to save money for reconstruction. Simply he has to stay on or lower the leakage rate. From water operator economical angle he needs to proceed removal of leakages on network from largest to smallest to save the most money he can. So it is necessary to know the state of network and systematically update it. Then is usually used multicriterial analysis for evaluation particular nets sections to set the priority for reconstruction. Basic criterions are: diameter, pipe material, age and theoretic service life, leakages, hydrostatic pressure, pipe joining, disorders and their kind in last years, traffic load on surface and many more (depend on water supply operator). When we know which sections have to be reconstructed, selection of way reconstruction is needed (it depends on pipe state and disorders). First step before reconstruction is monitoring and then cleaning. Renovation by coating could be used for the pipe in good static condition (if cementation or epoxidation depend on cleaning and costs). Renovation by relining can be used if we need profile reducing and old pipe could be in bad static condition. For old pipe replacing can be used trenchless technologies or classical methods in open excavation. Trenchless technologies are mostly used in urban area. For relining could be used all kind of material, but for the other methods is usually used polyethylene. Comparison of trenchless methods is not so easy because every have its use so it is about competition fight.

At the end of my work I deal with mathematical pipe network modeling programs to check up its possibilities. Modeling could be very good tools for water supply operator to analyse what is happening in network and for leakage searching, but it depend on calibration and results interpretation. Failure simulation is another problem, because evolution dynamic can´t be described easily and usually is used only statistical economic losses formulation.

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Terms of Application of Rainfall-Runoff Simulation Models in Field of Urban Drainage

L. Novák, D. Stránský

lukas.novak.1@fsv.cvut.cz

Department of Sanitary and Ecological Engineering, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

Rainfall-runoff simulation tools are an important decision support tools for efficient operation of urban drainage, efficient use of capital assets for reconstruction and development of these systems and for mitigation of negative effects on environment. Calibration of these models is an essential part of their application.

The calibration is a process of estimating model parameters and consecutive refinement, as a result of comparing simulated and observed values of interest. Model validation is an extension of the calibration process. Its purpose is to assure that the calibrated model properly assess all the variables and conditions which can affect model results, and demonstrate the ability to predict observations for periods different from the calibration effort.

From point of view of models calibration, Vojinovic and Solomatine (2006) mentioned four concepts. Most commonly used one is trial-and-error method, which is the manual iterative process of selecting an optimal parameter set that satisfies some pre-defined criteria. Automatic calibration can be done through automatic parameter optimisation approaches, e.g. the global optimisation, to identify an optimal parameter set that can be found among many parameters sets. The third concept assumes that an optimal parameter set cannot be identified, but has to be generated by sampling. This approach leads to the acceptance of several models whose outputs have to be combined. Beven and Binley (1992) introduced this concept of equifinality stating that it is impossible to find one optimal parameter set but many such sets are capable of producing model outputs with similar performance statistics. This is the so-called Generalised Likelihood Uncertainty Estimation (GLUE) approach, where the parameter sets are randomly sampled across the specified parameter range, the models with the low likelihood are rejected and the accepted models are run as an ensemble to produce the resulting output. The fourth approach can be called “code of good practice” and means that model parameters are configured on the base of literature/industry experience.

Model performance and calibration/validation are evaluated through qualitative and quantitative measures, involving both graphical comparisons (e.g. timeseries plots, scatter plots, cumulative frequency distributions) and statistical tests (e.g. error statistics – mean error, relative error, root mean square error, correlation tests – linear correlation coefficient, coefficient of model-fit efficiency, or cumulative distribution tests – Kolmogorov-Smirnov test).

The most commonly used key evaluation parameters for comparing simulated and observed values are water level, timing of the peaks and troughs, maximum peak discharge and volume for different conditions, dry weather flow and wet weather flow. Some authors mentioned criteria for these parameters that should be fulfilled during calibration, see table. Approach to evaluation parameters as well as individual criteria all over the world are not comprehensive.

Reliability of model outputs depends on many factors, quality of used data and their schematisation, boundary and initial conditions, description of hydrological and hydraulic processes and method of calibration as well.

criteria	***Pugh, Keeble (2004)***		***James (2003)***		***WaPUG (2003)***	
- author	*DWF*	*WWF*	*DWF*	*WWF*	*DWF*	*WWF*
$T_{Qmin,max}$	-	-	-	-	cca 1 hour	"similar"
WL	±25%	±30%	-	-	-	± 100 mm[1)]
Q_{max}	±10%	±15%	±10%	±15%	±10%	-15% to +25%
V	±10%	±15%	±5%	±10%	±10%	-10% to +20%

[1)] the unsurcharged depth at any key points of the sewer system, e.g. combined sewer overflow, in the case of surcharged depth should be in the range +0,5 m to -0,1 m

In order to explore the difference in model outputs by using different approaches in model calibration and in used schematization of hydrological processes, a separate storm sewer catchment in Prague's district Liboc has been chosen for case study. The catchment has a typical urban residential land use and covers an area of 30 hectares with approximately 44 % of impervious area. For this reason a measurement campaign was carried out from June to November 2007. Campaign consists of 3 tipping bucket rain gauges, 2 water level meters and 1 flow meter in sewer system. Total depth of precipitation during this period, from 16th June to 26th November, was between 317 to 326 mm in individual measurement profiles. Enough different types of rain events from the point of view of total depth of rainfall, time of duration and intensity were recorded as well. The responses measured at monitoring sites were of adequate quality, but as in many campaigns some problems with flow meter had to be solved. The data obtained during this monitoring period will be used for calibration of a model. Second set of measurements, anticipated period May to October 2008, will be used for validation. The delay in the final result of the study is caused by the necessity of resurveying some part of sewer system which was found. A detailed survey for defining real borders of catchment had to be done as well. Consequently, impact on methods of calibration and choice of hydrological model will be analysed.

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Comparison of separation efficiency of new and conventional types of CSO devices

P. Srníček, J. Pollert Jr.

srnicek@fsv.cvut.cz

Department of Sanitary and Ecological Engineering, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6 - Dejvice, Czech Republic

Combined sewer overflows (CSO) are structures in combined sewer systems designed to ensure their hydraulic safety by evacuating excess water during intensive storm events. It is a well known fact that CSOs represent a major source of pollution of urban streams. CSOs are an important source of visual pollution, gross solids, organic matter and heavy metals. Quality of water in combined overflows varies greatly both among locations and storm events. It has been shown that a great part of pollution caused by CSOs is associated to particles. Some studies [1] have shown that as much as 80 % of BOD_5 is associated with suspended solids.

Many different types of CSOs have been designed in the past. Slit overflow, high side weir overflow and frontal weir overflow are some of the most used in the Czech Republic. Modern devices that should have better efficiencies of separation of suspended particles, e.g. vortex separators, are increasingly introduced. Due to scarce occurrence of overflow events, objective determination of real separation efficiency of a specific object is rather complicated. Automatic samplers have to be employed and it is necessary to analyze the water samples in a very short time, because properties of the samples change gradually. Several authors [2] have used computational fluid dynamics (CFD) to determine separation efficiency of various types of particles. CFD models have, however, many drawbacks – high complexity, long computational times and lack of verification for this particular purpose. Some authors [3] suggested that hydraulic retention times, settling curves and hydraulic surface load be used to determine the separation efficiencies. This approach is however not sufficiently verified yet.

This research tries to assess separation efficiencies of three different types of CSO (side weir overflow Sekaninova, vortex separator Čakovice and frontal weir overflow Pod Táborem) in Prague municipal area by combining automatic sampling of water and computational fluid dynamics simulations. It is a part of a wider effort to develop recommendations as to which type of CSO to use in a particular location. All CSOs were equipped with ultrasonic flow meters, water level meters and automatic water samplers. Each object was equipped with two samplers – one for samples of inflowing water and another for overflowing water. Water was sampled in intervals of 1 to 3 minutes during several overflow events. Water samples were collected as soon as possible and taken to laboratory for analysis of suspended solids (SS) concentration and chemical oxygen demand (COD).

Analysis of water samples showed a great variation in values. SS concentrations ranged from 100 to 1000 mg/l and COD concentrations ranged from 100 to 900 mg/l. Some degree of the first flush effect was observed in most overflow events – the beginning of overflows was characterized by high concentrations of pollutants and the concentrations gradually decreased. Concentrations in overflow generally correlated very well with concentrations in inflow. Analysis of water samples proved a significant reduction of SS and some reduction of COD in vortex separator. Reduction of SS is best characterized by a constant value of 70 mg/l regardless of concentration on the inflow. Side weir CSO Sekaninova had equal inflow and overflow concentrations. Frontal weir CSO Pod Táborem

showed a great reduction of both SS and COD concentrations, however, not enough samples were taken in this case.

Computational part of the study consisted of CFD simulations of above mentioned CSOs. Furthermore, a model of side weir overflow chamber Na barikádách was created. (CSO Na barikádách is the original CSO in Čakovice, which was put out of operation after the construction of the vortex separator.) Several flow conditions were simulated for each object using the most appropriate turbulence model. Afterwards, particles of several different sizes and densities were injected uniformly on inlet boundaries and were tracked using Eulerian approach. Separation efficiencies of CSOs were determined by comparing number of injected particles and number of particles in overflow. Obtained results were compared based on Hazen's number (ratio of hydraulic surface load to sedimentation velocity of particles).

CFD simulations show that all sand particles bigger than 0.2 mm are separated well in all assessed CSOs. Particles smaller than 0.01 mm are not separated at all. The interesting range of particle sizes, where efficiencies of the CSOs vary, is 0.01 – 0.2 mm. Side weir CSO Sekaninova has a very high hydraulic surface load and its separation efficiency is low. Simulations of vortex separator Čakovice show transversal currents that help separate floating debris and this effect is also visible on a video captured during one overflow event. The original side weir CSO Na barikádách proved to have even higher efficiencies of separation than the separator, because it has a much larger area and consequently a much lower hydraulic surface load. However, it doesn't separate floating debris (there are no downflow baffles or transversal currents). Simulations of CSO Pod Táborem are still being analyzed.

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The Estimated Annual Velocities of EUREF-EPN Stations Located in Central European Region

Z. Novotný*

zbynek.novotny@fsv.cvut.cz

*Department of Advanced Geodesy, Faculty of Civil Engineering, Czech Technical University, Thakurova 7, 16629 Prague 6, Czech Republic

Abstract:

The EUREF Permanent Network GNSS station observations proceed on European continent for more than eleven years. The movement of Eurasian tectonic plate and local station movements and regional deformations can be determined from the coordinate time series analysis of these stations. The contribution concerns about the horizontal and vertical movement of EUREF Permanent Network (under mentioned EPN) stations in central Europe. The movements are determined by the use of station coordinates from EPN weekly-combined solution. These coordinates are provided by GNSS technique. Since 1996 the station coordinates have been known for the selected stations in week intervals. The stations with the longest time series, which are located in the Central Europe, were selected and their triangulation network was created. The time series analysis was carried out on the principle of coordinate differences between two neighbor stations in one baseline. The network adjustment of determined time changes was performed in baselines in station coordinate differences. The resulting movements of stations are depicted in the local coordinate system (North, East, Up) and the statistical analysis of results is performed.

Motivation and Selected Region:

The EUREF permanent network provides EPN station velocities as the product. The station velocity determination is based on the time series analysis of EPN station coordinates. Our solution to determine station velocities is based on consequent idea. The basic time series analysis was carried out on differences between station coordinates in baselines in local network. The coordinates of station are dependent on change of referential frame and antenna type (effect of change in antenna phase center) etc. All changes, which are common for both stations on baseline, disappear due to coordinate difference. It is because of the same relative changes of coordinates in both stations. When the antenna is changed in both stations in the same time, the relative vector remains the same too. These facts affect the processing of time series of the baselines. This process should simplify the determination of the station velocities. Due to seasonal changes and the relative movement of different geological parts in region, the periodicity is affecting relative vector and its time series.

The specified area of interest is located in Central Europe between 46° and 53° northern latitude and between 11° and 23° eastern longitude. The processed network of stations was chosen to get the greatest amount of the data. The stations with the longest time series in region (since beginning of year 1996 till the end of year 2006) were chosen. We looked at the influence of station stability. It is the example of shorter time series, but very stable station TUBO (GPS station coordinates provided by Technical University in Brno). The last factor, which affected the selection of stations, was the geographical distribution. We chose them to create regular triangles and to locate them into different geological regions. These geological locations are The Alps, Danubian Lowlands, Carpathian Mountains, Bohemian Massif and Central European Lowland.

Computational procedure:

The harmonic analysis as described in [3] and [4] was used for finding linear trend in baseline time series. These linear trends can be interpreted as the annual movement in baselines. All baselines were computed from EPN station weekly-solution coordinates in the first step. The baseline time series were cleaned for outliners as described in [2] and [4]. Several baselines contained the jumps and only linear trend in the time series. This is the example of stations, which were considered as constrained during processing of EPN week coordinates. The baselines containing these stations were divided into separate parts by time corresponding to visible jumps. For all time series the harmonic analysis was carried out to find linear trend and annual movement in baselines. The most of triangulation network baseline time series contained obvious periodicities, which can be interpreted as seasonal changes due to snow coverage, snow melting and other mostly water movement processes in soil. The network of annual baseline movements was adjusted as Gauss-Markoff Model with constraints. This method was used, because all networks are "floating". The EPN station coordinate movements were selected as parameters. The adjustment was performed separately for every coordinate component X_j, where j=1,2,3. The constrained condition was set as $\sum_{m=1}^{18} X_{jm} = 0$, where j=1,2,3. The final station coordinate movements were transformed into local coordinate system with its standard deviations. The transformation from Inertial Terrestrial Referential Frame to local coordinate system was created. The size of horizontal and vertical movements enabled to use spherical instead of ellipsoidal approximation for transformation.

Conclusions:

Estimated horizontal and vertical movements can be depicted in pictures. These pictures and movement values could be used to make conclusions about regional geodynamic. The results were compared with official EUREF EPN solution (Kenyeres A.- http://www.epncb.oma.be/$_$dataproducts/timeseries/index.php). For official EUREF velocities solution reduction was performed to fix these values correctly together with our solution. Resulting horizontal and vertical movements coincide well with official EUREF EPN solution. This comparison verifies the applicability and functionality of "baseline" method in practical applications. It will be necessary to develop some details of this method. The great advantage of this method is, that all coordinate changes, which are common for both stations in baseline, disappear due to creation of coordinate difference.

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Spatial Information System of the Baroque Theatre at the Český Krumlov Castle

R. Balík

radim.balik@seznam.cz

Department of Mapping and Cartography, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 27 Prague 6, Czech Republic

The baroque theatre at Český Krumlov castle is one of two almost completely preserved baroque theatres in Europe; it is therefore a unique monument of its kind. Its most important part consists of a very complex wooden stage machinery controlling the scene, many effect machines, stage lighting etc.; up to 60 people were needed to control all the machinery during performances.

In 1996, a long-time cooperation between the Laboratory of Photogrammetry at CTU Prague, the Administration of the Český Krumlov Castle and the Baroque Theatre Foundation started. The project „Living Theatre" aims to creating a computer model of the baroque theatre that could be later converted to a complex spatial information system of the site accessible via internet. According to its definition (see [1]), the infosystem will consist of three parts:

(a) **3D model** of the building in a format suitable for presentation of virtual models in the internet environment;
(b) **database** containing additional data such as images, text documents, sounds, animations etc.; the database and the 3D model will be linked through hyperlinks;
(c) **control application** serving the user for controlling his or her "walk" through the object, adjusting the environment according to his or her needs such as putting on/off layers, improving the orientation in 3D space or performing deeper study of the object (measuring distances…).

The infosystem will be placed on a web server and it will be possible to visit it using any computer connected to the internet. Simply speaking, the visitor will be able to "walk" through the virtual building and to display more additional data (such as historical pictures, flash animations of the machines' operation, text documents etc.) about the objects given by simply clicking on them.

In 1996-2004, a CAD model of the theare was made within several students' diploma theses. See [2], [3] for more information. The model was created in DXF vector format and later exported to DWG to be worked on in **AutoCAD**.

The CAD model created is static and special CAD software (such as ***Microstation***, ***AutoCAD*** etc.) is needed for displaying it. Displaying the model in such software is not very comfortable and it does not allow the user to „walk through" the building, not speaking about connecting the model to a database – in other words, the DXF model is not usable as an infosystem.

Another task was, therefore, to convert the model from DXF format to a format suitable for constructing virtual models (scenes) accessible via internet. From several formats available, VRML format was chosen. VRML is an open format created by *Web3D Consortium Inc.* Its specification can be found in [4]. VRML scenes can be placed anywhere in the internet. For entering the virtual scene ("world"), a VRML browser is needed.

Companies devoted to VRML usually offer such browsers for free (e. g. ***Cortona VRML Client*** by *Parallel Graphics* or ***Blaxxun Contact*** by *Blaxxun Technologies*) as plug-ins to common internet browsers.

Of course there are applications capable of conversion between formats DXF (or other vector formats) and VRML; there are two types of them: exporters integrated to other applications (mostly CAD software) and stand-alone converters. However, none of tested exporters/converters corresponded with our needs mainly because of too large data volume of the resulting models which, on one hand, guaranteed good visual quality of the model but, on the other hand, would slow down the real-time performance of the model especially when working via internet.

This problem was solved by developing our own converting application between DXF (DWG) and VRML formats. It is a quite simple shell application (macro) for *Autodesk*'s ***AutoCAD 2005*** called ***Virtual Builder***.

With this application, the complex 3D model of the theatre (or any other 3D model) can be easily exported to VRML piece-by-piece, creating one VRML file for every layer in the DXF (DWG) drawing. It performs basic geometric simplification, e. g. approximation of arc-shaped surfaces by planar faces or triangular net (using the feature of optical smoothening provided in VRML).

This "raw" VRML model is now going to undergo other steps in the development of the desired spatial information system, e. g. importing to a newly created browser and creating a database of additional data.

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Creation of Concept of Divisional Metrology Regulation

J. Kratochvíl

jiri.kratochvil@fsv.cvut.cz

CTU, Faculty of Civil Engineering, Dept. of Special Geodesy, Thákurova 7, 166 29 Praha 6

This report apprises of results of the internal grant project, which was focused on creation of concept of divisional metrology regulation.

Metrology is a part of quality management system. Quality management system help the organization to increase the satisfaction of the costumer. The costumer requires the product (or service) with such characteristics, which will satisfy his requirements. Characteristics of the product (or service) from the sphere of surveying are necessary to determinate on the basis of:

uniform procedures - **METHODS**,
using of accurate and precise measuring equipments - **MEASURING INSTRUMENTS**,
using of legal units - **UNITS**,
professional qualification of staff - **SURVEYOR**.

With aforesaid problems deals metrology. Metrology is a theory about measurement. Its major task consists in guarantee of uniformity, precision and accuracy of measurement.

With measurement which affects the environment and product (or service) safety deals **legal metrology**. Reaching the objectives of legal metrology is guaranteed with metrological confirmation.

Metrological confirmation is technical and administrative responsibility for establishing exercitation of measurement management system. One of the instruments of metrological confirmation is metrology regulation.

There are **two reasons for creation of metrology regulation**.

The first one, when is metrology regulation created by reasons of fulfillment of metrological confirmation requirements as a part of quality management system of organization.

And the other one, when the metrology regulation is not created as a part of quality management system of organization, but guarantee of metrological confirmation is required by other subject with quality management system and our organization has a function of subcontractor.

Metrology regulation is usually divided into four parts:

preamble,
organization part,
technical part,
final provisions.

The most important parts are organization part and technical part. Metrology regulation is completed with set of annexes.

Preamble encloses range of metrology in organization and acquaint with reasons that lead to fulfillment of requirements of metrological confirmation. There is stated a list of related

technical and legislative regulations and internal regulations of organization. Preamble is completed with dictionary of terms and definitions.

Organization part includes information about structure of metrological services in organization. Especially deals with specifications of special sections of employees and special formations, which are connected with metrology in organization. In those parts are given sanction for failures of particular establishment of metrological order.

In **technical part** are mentioned the activities, which are carried out at management of particular categories of measuring instruments. Further there is stated a set of legal units and forbidden units. The problematic of determination of precision is solved at this part, too.

Final provisions are fulfilled with set of technical and legislative regulations, which are connected with metrology regulations.

In **set of annexes** is defined the content of measuring instrument metrological card and scheme of integration of organization metrology and national metrology.

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Non-parametrical Methods and their Usage and Application in Engineering Geodesy

J. Neumanová

jana.neumanova@fsv.cvut.cz

Department of Special Geodesy, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

At this time it is necessary to consider of these problems both theoretically with utilize reasonable data and their application in practices. Further it is necessary to consider of these problems as for standard with right terminology, validating law rules and generally mandatory technical standards.
Service area was heigh check of geometrical parameters of line construction. In the particular measuring on the highway D3 – Mezno – Chotoviny construction 0306-I, km 64,000 – 70,800. The measuring was engaged into cross line section every 20m. There was done control the measuration of heigh deviation of roadway covering – levels crusher-run material, MZK (mechanical consolidated aggregates), ABVH (asphaltic concrete highlycrude), AKMS (asphaltic carpet masticic mediumlycrude), etc.. The comparisoning of measured high with the high from project was documented according to TKP [1].

Methods of statistical control and their utilize in practice was developed. Among the methods of statistic inspection belongs to sample inspection (sampling procedures for inspection or measuring) and statistic regulation.

Schedule of test of homogeneity

In the course of process measuring data is supposed that sets of real deviation of geometrical parameters have normal distribution and are homogenous. These are not to fulfilled always. In the standard ČSN 73 0212-6 is mention about verification of normality, there is introduced only the test of symmetry. But this standard is not introduced the mention about testing of homogeneity. Among the most interesting tests of homogeneity belong:

Fisher F-test

In the application of this test is testing the hypothesis about equality variability of two basic sets $H_0 : \sigma_1^2 = \sigma_2^2, H_1 : \sigma_1^2 \neq \sigma_2^2$. For testing is utilized testing criterion $F = \frac{\max\left(s_1^2, s_2^2\right)}{\min\left(s_1^2, s_2^2\right)}$, where $s_{1(2)}^2$ is selective variability of set of real deviation δx_i.

Zero hypothesis of homogenity is refused in case $F > F_{\alpha, n_1', n_2'}$, where $F_{\alpha, n_1', n_2'}$ is critical value corresponding for level of significance α Fisher-Snedecer F-distributions with $n_1' = n_1 - 1$ and $n_2' = n_2 - 1$ degrees of freedom. Tabulation critical value are named in statistical tables [2].

Hartley test

This test is analogic of Fisher F-test and it is application into more sets.

Bartlett test

The advantage of Bartlett test is possibility to verification of homogenity more sets together.
More information about this tests are in [3].

Statistical tolerance interval

Following of testing homogeneity and normality is possible to convert to determination of statistic interval and their comparisoning with interval in standard.

Parametrical tolerance interval

Parametrical tolerance limits suppose that the distribution of real deviations of a geometrical parameter is the normal. In a lot of case was discovered that value of real deviation do not have normal distribution. So it not possible to utilize default model of tolerance. So is necessary to utilize non-parametrical tolerance interval from empirically given data of statistic stability process.

Non-parametrical tolerance interval

In the standard ČSN ISO 3207 is described the determination of statistical tolerance interval for arbitrary distribution. The method mentioned makes use of extreme values in the sample. The statistical tolerance interval could be either one – side limited or two – side limited. For one-sided limited dispersions, the following formula, between sample size *n*, confidence level $(1-\alpha)$ and proportion *p* of the population over x_m (the least value in the sample) or under x_M (the greatest value in the sample), is valid $p^n = \alpha$. The sizes n are tabulated as functions of *p* and $(1-\alpha)$ [4].

Graphical deviation model of geometrical parameters

In this part, the graphical deviation model of geometrical parameters is drawn attention to as a possibility for visualisation of results of geodetic measurements of geometrical parameters coming from the differences of measured and project heights with the help of isolines for separate construction levels.

Basically DMT are used for analysis and visualisation of measurement results for geometrical parameters of line constructions. To build the model, software system Atlas DMT KresCom is used.

Conclusion

For classification of sets which have other than normal distrubution is profitable to utilize statistical non-parametrical methods. Benefit serves to choosed a good test of homogeneity set. Utility of reason is highly actual. These will be serve for innovation, quickening and using a good methods for control of geometrical parameters.

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Application of Alkali-activated Waste Materials for preparing artificial aggregates

V. Petrů

petru@klok.cvut.cz

Klokner Institute, Department of Building Structures, Šolínova 7, 166 08 Praha 6, Czech Republic

In this article will be described the geopolymer binder and the way of his preparation, especially with reefrence to the usage of the secondary raw material, like fly - ash and slag. The geopolymer characteristics will be compared with Portland cement and their advantages and disadvantages will be described below. At the end of the article will be mentioned the experimental programme results.

Waste or natural materials containing silicon and aluminum, such as fly ash, blast-furnace slag, kaolin, silicon light ash and/or natural pozzuolana, are used for their preparation. So called alkaline activator and, in certain cases, relatively small quantity of Portland cement are added to this latently hydraulic substance in order to achieve the binding properties, or the mixture may be completely free of this cement. The most frequently used alkaline activator is water glass, both potassium and sodium. Other activators are also known, such as a mixture of limestone and sodium chloride, sodium hydroxide, or other alkaline substances. The chemical process producing the matured geopolymer differs, due to a different composition, significantly from the hydratation of Portland cement. Geopolymeric reaction takes place in two stages. First activation of a mixture occurs where individual components dissolve and orthosilicic acid forms in the strongly alkaline solution. Subsequently, polycondensation between orthosilicic acid and superficial silanol groups occurs. This process leads to the formation of the polysilicate 3D cross-linked structure of the geopolymer. The structure of matured geopolymers is then either amorphous (hardening at 20-90 °C) or crystalline (hardening at 150-200 °C).

Composition and properties of the fly ash and slag, which are most frequently the main components of geopolymers, are highly variable and depend on their particular production place (technology, which generates these materials). Due to this it is not possible to adopt the results of foreign experiments entirely and the composition of geopolymer needs to be adapted to the particular fly ash or slag used. At the same time it is necessary to monitor not only the mechanical properties achieved, but also temperatures at which the geopolymer may harden.

The application range of geopolymers is very extensive, from ceramic materials and geopolymeric cements through to matrices ensuring stabilization of hazardous waste or fireproof materials.

The aim of experiments was the comparison of the effectiveness different alkaline activators on industrial raw materials as is fly - ash and slag . Sources of informations were gained from the technicall external and ours literature last years and used for the experiments determination progress. Like activators was used potassium and soda waterglass, further sodium hydroxide and mixture milled calcite with NaCl and examined in two different environments for a period of 24 hours, in laboratory conditions at 22°C and in oven at 50°C. Examinational ratio filler/activator was 0,3 further 0,6 and 0,8. Every above - mentioned activator was mixed in single ratios first slag, saved on 24 hours in laboratory conditions, further batch with the same composition in the oven at 50°C. For the better mixtures workability was added water. The same was repeated with ash. After 24 hours the samples of

the proportions 40 x 40 x 35 mm were removed prom the frames. The samples were examined after 24 hours on compressive strength, next was saved in laboratory conditions of other 6 days and then proofed on compressive strength after seven days.
In the first step the samples were examined at the laboratory conditions 22°C and the samples with the same composition in the oven at 50°C. Like activators was used potassium and soda waterglass further sodium hydroxide and mixture milled calcite and NaCl. The samples put in the laboratory conditions showed, excepting several samples taht the compressive strength insignificant as good as zero , the samples break step form and their consistence was as good as liquid . Some samples have had dry its upper layer that was in the contact with air . Insides of these samples was liquid. Then only the sample which containd slag and the hydrated oxide soda solution had the measurable value of the compressive strength that reached in the specific ratio 12MPa.

The compresive strenght of the samples that were saved the first 24 hours in the oven at 50°C were better feature then ones in laboratory conditions. After 24 hours in oven the sampls kept their shape and their compressive strength was able to measure . The sampes made from fly-ash activated by activators were at interval 2-2.5MPa. The highest compesive strenght had the samples made from slag activated by NaOH at interval 2-25 MPa

In the further experiments part were tested samples in laboratory conditions. We focused on the samples from the previous experiments whose compressive strength were one of the highest. It was used the same activator but in the diferent ratio and further combinations of this activator with other activators (water - glass soda lye+NaOH, water - glass potassium+NaOH). Either as other filler was examined the mixture of slag and fly - ash. It was found out that the highest content of NaOH in mixtures does not signify the highest compressive strength like the mixtures with Portland cement. The highest compressive strength have had the slag samples mixed with water glass soda +NaOH, high value reached 50MPa.

In further parts of the experiments was examined cement as the activator. It was created a referential sample only from cement that was weigh against the sampes containing cement and fly - ash in different ratios, its compressive strenght was 47 Mpa. The samples mixtured of fly-ash and cement in diferent ratio have had the compressive strength at interval 0,5 - 5,5 MPa. It was found out that the best values reached the sampes with the highest content of Portland cement.

In the completed experiments was found out a suitable and unsuitable compositions and raitions all components us choiced fillers and activators where we reachd for measurable values of the compressive strngth. In further part of testing will be inquired for next combination activator- filler, checking their feature, search their usage possibilities in industrial production to have been reached the acceptable economical needs for production. The results of this and following experiments will be used for my dissertation.

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Degradation of waterproofing membrane in foundations

V. Husakova*, R. Wasserbauer *

veronika.husakova@fsv.cvut.cz, wasserba@fsv.cvut.cz

*Department of Building Structure, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29, Prague 6, Czech Republic

Applying waterproofing in the foundation parts of buildings, often in permanent contact with moisture, creates ideal conditions for setting off biodegradation. The particular load acting on underground wall structures is the result of numerous factors such as e.g. ground treatment, rock composition etc. Here, spray insulation [1] provides reliable protection of underground wall structures against hydrophysical load. Its aim is to prevent the penetration of subsurface water into structures.

Waterproofing in the substructure must be the subject of special care also due to the fact that, unlike waterproofing applied e.g. in roofs, once embedded, this type of insulation is no longer accessible. For this reason, it should be designed using resistant materials whose durability corresponds to the presumed service life of the completed work [2].

Practical experience shows that asphalt waterproofing membranes in the foundations suffers - most likely due to subsoil moisture, but also due to other unspecified effects - from accelerated ageing despite the significantly limited access of oxygen to these parts, and the oxidizing ageing process itself must be going on very slowly. Therefore, we presume that plastic foils (polyethylene – PE, soften polyvinylchloride – PVC-P) may be degraded through a similar, though still not fully explained process as well. For the infrared spectra of benzene extracts of highly degraded asphalt strips showed massive presence of CO, CHO, COH, COOH and other oxidizing groups [3]. We may, therefore, hypothetically presume that a similar mechanism should also affect the degradation of polyolefins.

The experiments were carried out using the following waterproofing foils: Tenoarm (PE), Flagon (PVC-P), Ecolyte (PE), Radbar (PE), Sarnafil (PVC-P), Sarnafil (FPO), Fatrafol (PVC-P) and Parafib asphalt waterproofing.

The samples were put in a degradation medium. In this medium, the samples were exposed to bacteria and low doses of γ-radiation. The radiation activity of this slag amounted to 5 μGy. Strips of foils were affixed to this radiator (constructed as a bottle which is filled with peaces of the radioactive clinker concrete) modification with adhesive tape and exposed in a carbon-free mineral solution with an addition of 0.2% peptone (which served as a soil microflora starter) together with the radiator. The exposure time was 90 days at a temperature of 25°C. Moreover, Parafib waterproofing was put in the moist soil substrate. This substrate contained soil bacteria which, as we presumed, participate in the degradation of asphalt, and, besides, there was the effect of a low dose of γ-radiation (around 3μGy/h) emitted by the radiator placed in the substrate. The changes occurring in the course of exposure in the degradation media were assessed on the infrared spectrograph.

No visible changes were observed in the Parafib asphalt waterproofing. The infrared spectra of this waterproofing, however, revealed a prominent drop in oxidizing groups, in particular in the degradation medium with soil bacteria. The results of the changes in the infrared spectra range will be compared with the planned mechanical tests.

Mechanical tests of waterproofing foils have already been started. Tensile tests proved, on the one hand, a change in the modulus of elasticity E and, on the other hand, also changes in the ductility A of degraded materials as compared to non-degraded ones.

Based on the knowledge obtained to-date and in accordance with the references we presume that radiation oxidation occurs first with the oxygen, which is dissolved in the polymer. Once it is exhausted, the oxygen diffusing into the polymer during exposure to radiation reacts with it. Due to high dosage velocities, the oxygen contained in the polymer is quickly consumed. The amount of additional oxygen diffusing into the polymer is relatively insignificant as compared to the original concentration, and it is not enough to replace the original volume. Therefore, the effect of oxygen during short-term and massive exposure to radiation is manifested only insignificantly. In contrast, during long-term exposure to low doses of radiation (which was our case), the polymer gets a sufficient amount of oxygen so that the degradation of the polymer is considerably greater than during short-term exposure to radiation using high dosage velocities (at the same integrated radiation dose) [4].

The results of mechanical tests show that individual types of materials react to degradation differently. Sarnafil waterproofing (PVC-P) showed a dramatic drop in the modulus of elasticity (by up to a 1/3 of the original value) and also a prominent drop in ductility. Radbar waterproofing, on the contrary, showed a steep growth in the ductility of the degraded material, and when exposed to the tensile test the material started behaving like "rubber".

The experiments show that most significant degradation process can be achieved with synergetic impact of microflora, low doses of γ-radiation and humidity. On the other side, plastic foils which were tested only by single influence, they were attacked only imperceptibility. The tests performed to-date have confirmed that even at very low doses of γ-radiation, only slightly exceeding the permanent Earth radiation level, due to the interaction of microflora, clearly observable chemical changes occur in PE and PVC plastic foils in a relatively very short period of time, which are, in single cases, manifested even by changes in color. The synergistic effect of microflora, radiation and moisture during the degradation process of polymers is highly probable, and it will be monitored in the course of further experiments, which will be focused mainly on the assessment of the physical properties of the exposed polymers.

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Drafting and Testing of the Methodology of Ecological Assessment of Trenchless Technology Application to the Rehabilitation and Construction of Utilities

Lucie Nenadálová

lucie.nenadalova@fsv.cvut.cz

Department of Sanitary and Ecological Engineering, Faculty of Civil Engineering, Czech Technical University in Prague, Thákurova 7, Praha 6, 166 29

Installations of underground services are unrealizable without the participation of such technologies, which disturb ground to minimal extent and which do not require larger excavation work. These technologies rank into wide group of trenchless technologies.
The trenchless technologies (TT) are friendly to the environment, soil profile and vegetation are disturbed to minimal extent, the noisiness and dustiness on surface decrease, it is not necessary to limit the traffic and commercial and the soil operation in the vicinity of the construction and the repairs of underground lines be often carried out under their full operation.
In the Czech Republic mention can be made e.g. of the breakdown of the DN 200 water supply pipeline (dating from 1881) in Vodičkova Street in Prague in 2005 or the breakdown of the DN 900 feeders in Sokolská Street in Prague of February 2006. The number of other pipeline breakdowns includes e.g. the numerous pipelines in the chemical works in Záluží nr. Most with their unpleasant scope and impact. The risks that such situations may arise on a major scale anywhere and at any time, if adequate preventative measures are not taken in due time, are increasing.
Probably one whole half of all pipelines in Europe is at the end of its service life which causes the increase of costs of not only their operation, but also their classical renovation, particularly in the cities. A system renovation of urban utilities has become an indisputable necessity.
What are the possible reasonable methods of solution of this situation? Emergency situations are usually reacted to operatively, by improvised, but non – systematic methods. However, what system instruments can be applied to their solution? In the situation in which we have – and even cannot have – adequate control of the state of the underground of major or minor cities and during the continuing use of common installation of utilities and the absence of co-ordination of their economic life expectancy the application of combined utility routes appears as a feasible solution of all problems while providing a number of long term advantages.
In the first place it is necessary to increase the application of better methods of utility installation represented by the corresponding types of combined utility routes, thus increasing, in the first place, the possibilities of their continuous operative control. The application of higher- quality utility installation in the form of combined routes is necessary particularly in the centers of big cities and in development areas. However, this application must be consistent

These instruments must be characterized as system instruments. The application of adequate types of combined utility routes represents the target solution. What to do in the meantime? Also a number of types of trenchless technologies represent an instrument for the restoration of the services life and the maintenance of utilities in operation, which makes them effective

instruments, or replacement and emergency assurance of their services. A mobile combined utility route seems to provide a progressive and effective solution.

What is the present state of development of the methodology of ecological assessment of trenchless technologies, the first successful step of which had been made more than three years ago and terminated by the award of ISTT NO-DIG AWARD in the category "Students or young professional paper" in Hamburg in 2004 to (today Ing.) Tomáš Kubát for the graduating thesis of this orientation?

Analogous was the success of the graduation thesis of Ing. Jiří Granilla, oriented on the provably most ecological trenchless technologies represented by the combined routes of utilities of the most varied types (ISTT NO –DIG AWARD 2006, Brisbane, Australia). At present the Faculty of Civil Engineering, Czech Technical University, Prague, has prepared a preliminary research of ecological assessment of trenchless technologies by the methods of value analysis. The process consists in three-stage valuation in which we first ascertain the applicable valuation criteria, subsequently refine them and form their representative group and finally the selected variants of TT will be evaluated by a team of experts (respondents). The results of their assessment will be evaluated subsequently by statistical methods. On this project we intend to work in direct co-operation with experts from engineering practice, i.e. the employees of the firms using TT. That is why we would welcome close co-operation with the members of CzSTT.

There is no doubt that TT are provably ecological. The fact that combined utility routes built by trenchless technologies are most highly ecological has been proved by analyses and studies. Engineering practice will confirm this conclusion without any doubt sooner or later. However, a great deal of work remains to be done in the field of refinement of ecological assessment of individual TT to achieve maximally attainable objectivization of such assessment.

Existing activities to the methodology of ecological assessment of trenchless technologies were crowned by ISTT NO DIG AWARD 2007, Roma, Italy.

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Enhanced reliability of glass structures

M. Eliášová

eliasova@fsv.cvut.cz

Department of Steel and Timber Structures, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

Modern trends as well as new technologies in production and materials are used in civil engineering. Nowadays one of the most progressive materials is glass with its new function. It is not only the filling but also very often the load-carrying element. The glass is used for façade systems, roofs of the atrium, railing of the staircases and next bearing structures, [1]. The structural glass is combined with others materials, mostly with steel. There is a lack of knowledge, design rules and procedures, which may lead to use of this attractive material. Designers have at present limited coherent approach to these problems. Major questions in design of the structures from glass are the connection between the glass components or in the joint with the supporting structures. The knowledge in the glass connection is limited even though it is one of the most important parts in the structure. For the connection of the glass elements to bearing construction or for connection of the glass elements between each other's are used shear or friction bolts. In the same way as for design of the bearing elements for its connection any design rules does not exist.

Glass behaves in a different way in comparison with other more familiar structural materials. Glass does not yield and it is fragile and that is why designers cannot ignore stress concentrations. Plastic material (steel, aluminium) will yield and flow if it is locally overstressed and therefore stress concentrations are not generally a problem. For glass is very important to give attention to the details and way of their design. Limit load depends on the working of the edge, on methods of the drilling, bolt position, type of the bolts. For bolted connections of glass bearing structures it is important to eliminate direct contact between glass and bolt. High local stress cannot be reduced by plasticity because of the brittleness of glass. For this reason, various types of inserts between glass and bolt were used. These inserts are made of different materials, e.g. silicone, polyamide, neoprene, epoxy resin.

Research was focused to one of the many types of connection - connection with the steel cover plates. The main question for this type of connection was to determine the state of stress and the level, to which the forces of individual bolts act together (one or two bolts in line). It was expected to evaluate the mutual interaction for the bolts in the group. With respect to real conditions it was also inevitable to the research behaviour of the glass in the contact with other materials. At the beginning of the project the material experiments were performed to obtain the basic material characteristic for the different type of glass, inserts and cover plates. The experiments of bolted connections were carried out on the simplified model with steel splices. Considering the natural properties of glass (transparency and optical sensitivity) the photoelastic reflecting method was used [2].

The test specimens were made from float glass with nominal dimensions 680 x 300 mm and with thickness 12 mm. Drilling of the hole for bolts was carried out with chamfer (45°) and smooth edge finishing. Between glass and bolt, an insert from hard plastic with external diameter 40 mm and internal diameter 18 mm was used. Bolts M16 of quality 8.8 were loaded by shear. The steel splices were made of steel S235 with dimension of 165 x 100 mm and thickness of 10 mm. The test specimens were held during loading by a machine with special hinge, which was from one side of glass panels due to the use of the photoelastic reflecting

method. The free side of the panel was painted with reflecting coating. The points (sections) to be investigated were marked on the glass specimens. The polariscop was situated in front of the test specimen. The luminous ray was pointed at the area with the holes. The tension force was measured by means of the dynamometer, which was situated above the upper steel hinge. The test specimens were loaded on two loading levels. Firstly, the test specimens were loaded by a tension force to the level of F = 2 kN, where values of isoclinics were measured. Secondly, the test specimens were loaded by a tension force to the level of F = 10 kN, where values of isochromatics were measured. The values of isochromatics were being found out by using the linear compensator. This process was carried out for the 20 test specimens with one or two bolts in the line. The values of the isoklinics and the isochromatics, which were obtained from the photoelastic method, were used for the subsequent evaluation - for the calculation of stress around the hole. The calculations were carried out tabularly.

The software package ANSYS 10.0 was used for the numerical analyses. Glass test specimen was modeled by means of shell elements. Because the failure modes are symmetric, in order to save solving time, only one half of glass test specimen was modeled. Contact between glass and insert from hard plastic was the same as it was considered in the experiments. Full Newton-Raphson geometrically and materially non-linear procedure with large deflection effect was used in the analysis. A number of alternative boundary conditions were tested until the model corresponded to the results, which were verified with results of experiments. The shell element SHELL181 was used for the modeling of glass test specimen and bolts. A contact pair was created between glass and insert from hard plastic and between insert and bolt, to prevent the penetration of material: the CONTA175 element was used for the modeling contact elements and TARGE169 for the target elements. Boundary conditions were defined according to the real test specimen arrangement. The model was verified with results of the experiments.

Experiments improved the knowledge of behaviour of bolts, which are loaded by shear in the joints of bearing glass structures. The results show that the photoelastic method is appropriate for determining the state of stress of glass elements of bearing glass structures. The state of stress of glass specimen depends on the accuracy of drilling, technology of fabrication and the material of inserts between glass and bolts.

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The Non-linear Behaviour of Timber Structures With Glued-in Rods Joints

M. Vašek

vasek@fsv.cvut.cz

*Department of Steel and Timber Structures, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

The subject of the presented research is the investigation of the non-linear behaviour of timber structures connected by the mean of glued-in rods. Two groups of joints were examined during the research. The group of joints for rectangular several stories framework were prepared and measured and analysed. The special joint for the space spherical or barrel vault dome was developed and prepared for experiments 1:1. The number of tests were prepared and tested with respect to the possible statistic evaluation of experimental results. The verification by FEM method with respect to the non-linear behaviour of structure with semi rigid joints was performed. The experimental tests were performed for the separated joints and also for whole semi-rigid frame in the scale 1:1. The component method was also used for the basic models of joints to check the carrying capacity of semi-rigid joint. The final result of the research is the definition of M-φ curve of joints and recommendation of the design method for the structure with semi rigid joints of given stiffness with respect to the increasing deflection during the loading of the structure.

Material for joints was submitted by the manufacturer of laminated wood company TESCO. For the laminated Czech spruce timber the Swedish glue either Cascomin 1242 or Cascomin 1240 produced by AZKO NOBEL was used. The steel threaded rods, zinc coated is made from steel S235, but the threads are cold formed, therefore the yield point is 95% of the ultimate strength. Steel were tested informatively for the tension, modulus of elasticity was used nominal guaranteed by the steel and rods producer.

Threaded rods are glued into the timber by epoxy resin with small viscosity less then 5 Pa.s. to ensure good filling of the glue in about 200 mm deep holes. Epoxy resin 455 was used with the hardener Telalit 0252. Epoxy is low molecular weight resin based on biphenyl A modified by glycidyl type with non-functional reactive solvent and non-reactive diluent. All these materials are available in the market.

The joints were assembled from beam part and column part with glued-in rods. The holes for the rods were drilled by electrical hand drilling machines and the diameter Ø15 mm of holes was used. We realized the offset 1mm to be good for the technology of gluing. The depth of holes was in general about 200 mm that corresponds to recommended values for glued-in rods by today valid code. The properties of laminated timber are varying even in between the lamellas in one cross section. The only strength of the cut out lamella parallel to the grain and perpendicular to the grain was tested for the each set of specimens. This allows us to classify the wood good enough for the design and analysis.

Experiments on **s**everal types of connections were tested. Geometry of joints was T and L.

1) First pilot type of joints used only glued-in rods on both side of the connection (the column and the beam). Two arrangements of glued-in rods were used, that were two rows of bolts of smaller diameter or one row of larger bolts near the upper and lower face of beams. One row of larger bolts was finally used in further developed joints.

2) The another type of joint (called hybrid connection) used glued-in rods in beams and the rods are bolted to the steel column.

3) The final chosen type of joints uses steel rectangular tubular part with rods glued in to the timber and bolted with nuts to the beam and column. These joints allow good assembly of a semi-rigid structure in situ. Rods Ø 14 mm were used in one row at the upper face and the lower face of the beam.

4)The whole one story frame was tested also in the scale 1:1.

5) Set of parts of the spherical dome was tested 1:1 scale and the behavior of special steel joint to which are members connected by glued-in rods was tested and calculated.

FEM at program ANSYS was used for the verification of experiments. The M-φ curves were defined as the important characteristic for the calculation of semi-rigid frame as is recommended by Christopher, Vašek and Bjorhovde for the solution of semi-rigid frames. Comparison of experiments and FEM model gave us finally expression for the M-φ curves of timber frame joints. For the T shape joint we can express $M= -9.0356 \varphi^2 + 37.245 \varphi$ and for the L shape the curve is given by the expression $M= -15.079 \varphi^2 + 45.19 \varphi$.

The joint assembly with steel rectangular tubular part that is bolted to the glued-in rods in the horizontal and vertical members of the frame allows relatively good assembly in situ. Carrying capacity of the semi-rigid frame that is serving as the bracing system of the building can be used for buildings up to about four stories and three bays. There is also possibility to use frame connection at the joint for two perpendicular directions. This allows the structure to work as the semi-rigid frame in both perpendicular directions.

The experimental results and FE solutions are in good correspondence at the range of loads until cracks in the timber occur. Level of this loading is in the range of service loads. Final values of collapse loads of experiments and collapse loads obtained by FE analysis are similar. Because of the very wide variety of material values even in the laminated lamella wood the obtain results allows to apply procedures for the practical design of semi-rigid frames.

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Revised Feedback System for Curing Concrete Specimens under Prescribed Temperature

N. Pokorná, P. Štemberk

nataliya.pokorna@fsv.cvut.cz

Department of Concrete and Masonry Structures, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

The very early age defects in concrete are mostly attributed to the incapability of the hardening concrete to cope with the increasing differences in stress distributions, mainly caused by the non-uniform temperature fields, [1]. This effect becomes of importance in massive concrete structures where the heat generated by the hydrating cement is constrained by the surrounding mass. Since massive concrete structures are usually unique in shape, direct measurements of temperature and other measurable quantities acquired from precedent cases are not available, therefore, it is desired to develop a system for simulating a temperature history at arbitrary position in the concrete structure on a specimen which can provide valuable experimental information on the effects related to the hydration of mass concrete. In an analysis of a massive concrete structure the effect of elevated temperature due to hydration can be taken into account by applying, e.g., the equivalent age concept using the Arrhenius reaction-rate equation whose parameters are available for commonly used cements, [2]. However, in the case of special structures new materials may be used for which relevant experimental data are not at hand, such as time-dependent deformation of solidifying concrete at elevated temperature which come into play with the considerable self weight of the concrete mass. It was attempted to develop and test a revised heating system for curing specimens under prescribed temperature history. For the sake of generality in application, it was decided to employ a decision-making mechanism based on the fuzzy logic, [3], so that no exact information on performance of heaters, heat losses amount of concrete specimens submerged in the heated container is necessary. The controlling units of heating systems in general have to overcome the difficulties with a delay in response to heating which is due to the thermal conduction, convection and radiation characteristics of materials. For the conventional convection-conduction systems an efficient stirring is essential to reduce this effect. The controlling units can be divided into two classes, first, those with simple on/off switches controlling a constant rate of heat supply and, second, those capable of changing the rate of heat supply. Obviously, the second class has a greater potential to ensure a good accuracy. However, the final accuracy and stability of a heating system depend on the decisions when or how much heat should be supplied. The traditional mechanical thermostats using bimetallic strips, which engage and disengage the heat supply source upon reaching a certain temperature value, are replaced with electronic units based on a similar principle, which is a change in properties or shape of a material with varying temperature. Mathematically, the controlling units acting at a certain temperature value are based on the classical set theory with the classical logic decisions giving the true or false ruling. Such controlling units are suitable for heating systems whose parameters are known and which do not change significantly within the range of their application, therefore those heating systems are usually closed systems which were previously well calibrated. For systems whose parameters may vary, such as the heat losses, the amount of supplied heat or the volume of heated medium, those

controlling units in their simple form do not work well, and for ensuring a good accuracy the decision making based on true/false rulings becomes too robust to be applied at all.

The system consisted of a plastic container with a single heater. The water in the container was stirred by two screw propellers. The temperature was measured by temperature sensors available at ordinary electronics shop. Two of sensors were placed in the monitored specimen and other two were placed in opposite corners of the container. The temperature readings were transferred through a A/D card to a PC where the decisions were made upon the temperature information and the target history temperature. The PC then turned on the single submerged heater for decided heating time duration, or it rested while monitoring the temperature development. The interface of the controlling software, which was developed in Control Web 5, allowed easy implementation of fuzzy controlling and very simple controlling of the system. Basically, the objective in development of the heat controlling system is a general controlling unit which can be applied to an arbitrary set of a heat source with a constant rate of heat supply, stirring device, thermocouples, a container and a heated medium. This was achieved by choosing the target temperature history, the temperature of a concrete specimen and the temperature of the medium surrounding the concrete specimens (water in our case) as the ruling quantities and the duration of heating and the duration of waiting for the recognition of an action as the acting quantities. Based on the inaccuracy among the target history temperature, the temperature of concrete and water, and their rates of change, the decision on heating duration and corresponding waiting time are made. The calibration of the above fuzzy quantities is made on separate tests, when the tests focus on the performance of the heater and the response of the system, the heat losses and the interval after which an action can be recognized. It should be noted that no exact information on the parts of the system is necessary, that means the volume of the medium and its thermal properties do not have to be measured, the type and nominal performance of a heat source does not have to be known and the dimensions and material properties of a container also do not have to be considered.

The revised controlling unit of the heating system was again based on the fuzzy logic, which allowed assembling a system of components of unknown thermal properties while a reasonable accuracy was ensured. The fuzzy parameters for controlling the system could be obtained easily from few preliminary tests on the overall performance of the heating system. The only drawback, which was pronounced when running the simulation at high room temperatures, was the absence of any cooling device. This effect could be overcome by pouring cold water, when the controller would heat up the water back to the prescribed temperature. However, it was shown that accuracy of the developed system, once the target temperature exceeds the initial temperature of concrete specimens, is about 0.06°C, which represents an error of 0.1 % to 0.2 % depending on the related temperature.

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Model of Very Early Age Concrete under Uniaxial Short-time and Sustained Loading

P. Štemberk, P. Kalafutová

stemberk@fsv.cvut.cz

Department of Concrete and Masonry Structures, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

Construction of concrete structures using in-situ placement of concrete inherently suffers from the necessity to provide a technological pause for concrete to gain prescribed strength, which eventually slows down the entire construction process. In case of falling behind schedule, construction companies often seek possibilities how to accelerate the construction, which may result in overloading of concrete at extremely early ages. For concrete placed in a well-sealed vertical formwork the overloading can provide perfect compaction, which is a positive result. But, overloading of newly cast concrete slabs can result in permanent deformation in the form of tracks left by vehicle tires, which in the case of a concrete bridge deck eventually reduces durability of the road surface, which is not allowed to deform uniformly with temperature differences due to the shear locks represented by the imprinted tracks in the surface of the bridge deck. Premature loading of concrete can be analyzed using a variety of numerical tools, which were created for investigation of early age defects, e.g. [1]. Such material models need to take into account the rapidly progressing hydration of concrete. This effect is in most models included as a parameter which expresses the age of concrete in the form of e.g. the degree of hydration or equivalent age. The multi-level models, such as the one presented in [2], do not include the evolution of microstructure as a simple formula, but they use another analysis, where the kinetics of hydration reaction is evaluated on a representative volume. As the material models are usually derived theoretically, they need to be calibrated and verified with experimental data. The material models then should be also derived with this fact on mind. Usually, the practicing engineers do not have all necessary experimental data at hand which would make the provided material models reliable for their specific applications. This fact was the objective of this contribution, which provides a simple framework for derivation of a model for expressing mechanical response of concrete subjected to uniaxal short-time and sustained loading at the age of just few hours. The number of material parameters, which can be calibrated with experimental data commonly provided by concrete producing plants, is reduced to minimum with respect to accuracy of the model.

In general, the deformational behavior of concrete at the ages of just few hours resembles that of already hardened concrete with the distinction of the pronounced plastic deformability which is at the ages between the initial and final setting times prominent. With the further increasing age the ratio between the irreversible and the reversible deformations decreases, which means, the deformation can be distinguished according to its nature. For that reason the total strain can be split into four components, namely the elastic or instantaneous strain, ε_e, the reversible viscous strain,ε_v, the irreversible viscous (flow) strain, ε_f, and the stress-independent strain, ε_0, produced by the hydration process such as autogeneous shrinkage, cracking strain and the thermal strain. The difference between the deformational behavior of hardening concrete and the already hardened concrete is in the pronounced variation in magnitudes of the strain components. At the ages ranging from the time of mixing

until about the initial setting time the irreversible viscous strain component, ε_f, prevails. With progressing hydration the elastic component, ε_e and the reversible viscous, ε_v, components are more pronounced while the prevalence of the irreversible viscous strain component, ε_f, recedes. The strain component related to the hydration process and stress-independent influences, ε_0, is of varying importance throughout the solidification process, which is attributed to the increase of tensile strength of concrete.

The instantaneous deformation of hardening concrete comprises the deformation of solid particles of sand and aggregate, the deformation of water and the deformation of the already hardened cement paste and the not yet hydrated cement grains. These particles can be considered to be non-aging constituents of concrete, which is consistent from the physicochemical point of view once the effect of aging is dealt with separately. The aging can be defined as a variation of proportions among the constituents or a ratio between an instant value of a quantity and the value of the quantity when the hydration is completed, which is known as the degree of hydration. The reversible viscous strain represents the strain component which later for the hardened concrete becomes the strain usually described as the viscoelastic. Therefore, an non-ageing compliance function was used and the effect of aging was expressed with the degree of hydration, measured in this case with the evolution of the compressive strength. The instantaneous deformation was expressed with a simple formula based on the evolution of the modulus of elasticity and the time-dependent deformation, in which the effect of shrinkage was not accounted for, firstly, due to its much smaller amount compared with creep deformation and, secondly, it was not investigated independently on a not loaded specimen, was expressed with another simple where the effect of aging was expressed with evolution of the compressive strength.

The formulae for modeling short-time and time-dependent response of hardening concrete at the ages from 3 to 8 hours, which were derived by fitting the proposed formulae to experimentally obtained results, were used in modeling of response of concrete slab subjected to sustained loading by a tire. These formulae were implemented as such to the finite element code SIFEL, which was successfully used for investigation of construction of a bridge [3]. This was done by Dr. Jaroslav Kruis and Dr. Tomáš Krejčí. Then, the numerical and experimental results were compared and discussed. The numerical experiment revealed a considerable effect of friction between the concrete and the base of the steel form.

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Experimental Investigation of Response of Early Age Concrete to Uniaxial Short-time and Sustained Loading

P. Kalafutová, P. Štemberk

stemberk@fsv.cvut.cz

Department of Concrete and Masonry Structures, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

Overloading of concrete at extremely early ages is nowadays considered an integral part of concrete construction technology. While for concrete placed in a well-sealed vertical formwork the overloading may have the positive result in perfect compaction, overloading of newly cast concrete slabs may result in permanent deformation in the form of tracks left by vehicle tires. Such heterogeneity in the surface of, for example, a concrete bridge deck reduces eventually durability of the road surface, which is not allowed to deform uniformly with temperature differences due to the "shear locks" represented by the imprinted tracks in the surface of the bridge deck. A variety of numerical tools has been developed for analysis of early age defects caused by premature loading, e.g. [1][2]. The material models necessary for such analyses need to take into account the rapidly progressing evolution of concrete microstructure. In most models, this is done by including another parameter which expresses the age of concrete, such as the degree of hydration or equivalent age. In multi-level models, e.g. [3], the evolution of microstructure is not expressed by a single formula, but by another analysis of a representative volume, where the kinetics of hydration reaction is evaluated. Nevertheless, either type of the modeling requires experimental data for calibration or verification. Having on mind the example of the Border Bridge, which was presented in [1], it is understandable that there are no exact data for verification of the model proposed in [1] at hand. Generally, it means that the specific experimental data for verification of realistic numerical simulations are very scarce. Therefore, the motivation behind conducting the presented experiment was to simulate the loading condition of a truck tire entering a concrete slab after only few hours after casting of concrete is finished. The experimental work consisted of two phases. Firstly, evolution of compressive strength and evolution of stiffness were investigated on standard cubic specimens under standard compressive test configuration. Then, concrete placed in a form which was designed specifically for simulation of the mentioned loading condition was subjected to loading by a tire. The data obtained are both for the instantaneous and time-dependent deformation of concrete tested on cubic specimens and on slab specimens at the ages ranging from 3 to 8 hours.

The main objective of the experiment is to describe the behavior of the hardening concrete under the truck tire. The force representing the truck tire is 90 kN for one wheel axis. In the presented experimental analysis, the front axis was considered. Then, the pressure on the slab was derived as a force of 45 kN on the contact area under the wheel, whose standard value is circa 20 x 30 cm. In our experiment, a smaller tire was used due to space available in the loading system. The contact area then was circa 15 x 20 cm. The contact area is not defined precisely as it decreased with progressing age, by about 10 %, which however does not affect accuracy of the results considerably. Because it was impossible to place the whole tire into the testing machine, a 10-centimeter slice was cut out of the tire and then filled with concrete in order to stabilize its shape. The tires filled with concrete were prepared 28 days

before the experiment so that the concrete inside the tire was sufficiently stiff. Since the rubber of the tire can be deformed under loading, only the modified tire was placed in the testing machine and loaded to find out the response of the tire to various load levels. The concrete bridge deck slab was represented by a concrete slab cast in a form of the sizes of 40 x 50 x 10 cm. The form was designed and produced for this particular experiment in a series of three pieces. The concrete slab along with the form is quite heavy therefore the form was equipped with two handles and the corner joints of the form were made stiff enough. The main difficulty was that there were only three forms available and it was of interest to investigate the behavior of concrete at ages ranging from 3 to 8 hours. Moreover, it was desirable to repeat the experiment at least three times so that statistical analysis was possible. Therefore, it was necessary to draw a schedule very carefully so that the experimental work was most efficient, as, for example, the opening hours of the school, which were from 6:00 to 22:00, also had to be satisfied.

The concrete used was of the class C35/45 with rapid hardening portland cement I 42.5 R. The mix proportions were: water 180 kg/m^3, cement 430 kg/m^3, sand 780 kg/m^3, fine aggregate 140 kg/m^3, coarse aggregate 965 kg/m^3, and they corresponded with those used for concrete deck of the Border Bridge. Firstly, the short-time response of concrete at the ages from 3 to 8 hours under uniaxial loading was investigated. The specimens were the standard cubic specimens with the dimensions of 150 x 150 x 150 mm. The concrete specimens were cured and tested at room temperature of 20 ± 2°C. There were four series measured and incorrect measurements were excluded. The ultimate result was the averaged the stress-strain curve. From these data, the evolution of compressive strength and the modulus of elasticity could be evaluated. Then, the cubic specimens were subjected to sustained loading at the 30 % load level. The duration of the sustained loading was 20 minutes. From this experiment, the time-dependent deformation was obtained for the ages ranging from 3 to 8 hours. Secondly, the concrete slab in the form was loaded at a constant rate till the desired load level, which corresponded with the load of 45 kN, which provided data on instantaneous deformation of concrete under the tire and then the time-dependent deformation for the 20 minutes of loading.

The provided data can be readily used for verification or calibration of material models for analysis of response of concrete at extremely early ages to uniaxial loading, and along with the data on the Poisson's ratio shown in [4], a multi-dimensional analysis for such early ages is also possible.

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Design optimization of progressive concrete structures

P. Hájek, C. Fiala

petr.hajek@fsv.cvut.cz

Department of Building Structures, Faculty of Civil Engineering, Czech Technical University in Prague, Thákurova 7, 166 29 Prague 6, Czech Republic

Optimization of material consumption is one of the basic approaches applied in the development process of new types of structures and structural elements, respecting requirements of sustainable construction. The optimized lightened shape of structural elements demands less material. All these approaches lead to savings in primary material use and to improvement of environmental parameters of the entire building. Within the scope of the research several new types of RC floor structures were optimized. The possibility of the use of recycled municipal waste has been proved by theoretical, as well as experimental and in situ results. The LCA analysis and comparison with other standard types of RC floor structures have shown that using HPC, recycled materials and the optimized shape of the floor structure, it is possible to reduce environmental impacts such as consumption of non-renewable silicate materials, the resulting level of embodied CO_2, embodied SO_x and embodied energy.

One of the most important criteria in the optimization of load bearing structures is consumption of non-renewable materials and associated consequences during the whole life cycle of the structure (transport and manipulation with material during construction, demolition, recycleability, etc.). Material effective progressive concrete structures (with a reduced amount of structural material) can be based in general on several structural principles and their combinations: (i) optimization of the structural form and shape of structural elements, (ii) use of high performance concrete, (iii) use of recycled waste materials (including municipal waste), (iv) use of renewable materials. The process of optimization of concrete structures is generally based on the following principles: (i) optimization of production technologies of concrete components, (ii) optimization of concrete mix composition, (iii) optimization of the shape and reinforcement of structural elements, (iv) life cycle optimization of the whole concrete structure.

The goal of the optimization of RC cross-section in environmental context is to reduce the environmental impact by decreasing (a) the consumption of non-renewable raw materials and energy sources, (b) the amount of embodied energy, (c) the embodied emissions (CO_2 , SO_x , etc.), and (d) the amount of waste at the end of a structure lifetime. Consequently the improvement of functional characteristics is required.

The solution of multicriterion optimization problem was based on the weighting method. The problem was transformed to single-criterion goal function $F(\{x_j\})$ by the use of weighting coefficients. Final goal function is defined as scalar product of weighting vector and vector of normalized goal function:

$$F(\{x_j\}) = w \,.\, f(\{x_j\}) \ ,$$

where $w = \{w\} = [w_1, w_2, ... w_m]^T$ is weighting vector associated with particular criterions, $f(\{x_j\}) = [F_{1,\ norm}(\{x_j\}), F_{2,\ norm}(\{x_j\}), ... F_{m,\ norm}(\{xj\})]^T$ is vector of normalized goal functions and $\{x_j\}$ is vector of optimization variables. Particular goal functions $F_{i,\ norm}(\{x_j\})$ are normalized by the (utility function) according to

$$F_{i,\ norm}(\{x_j\}) = (F_i(\{x_j\}) - F_{i,\ min})/(F_{i,\ max} - F_{i,\ min}) \ ,$$

where $F_{i,min}$, $F_{i,max}$ are minimal and maximal value of goal function, respectively, $F_i(\{x_j\})$ is value of goal function for actual optimization variables and *i* is an index for optimization

criteria (cost [CZK/m^3], embodied CO_2 [kg $_{CO2,equiv}$/kg], embodied SO_x [g $_{SOx,equiv}$/kg] and embodied energy [MJ/kg]).

The typical outcome of the shape optimization of the concrete slab structure with the objective to reduce structural material consumption (while a high level of reliability is kept) is the ribbed or waffle structure. The basic structural advantages of waffle and ribbed slabs are demonstrated in the layout of the structural material in a cross section. The "T" shape of RC ribs allows a convenient distribution of the structural material, saving material in the tension part of the section. In comparison with the full RC slab, the basic shape of waffle or ribbed slab structures reduces concrete use by 40-55%, and also the corresponding steel use. Consequently, the reduction of the total self weight acting on vertical bearing structures and foundations can decrease their sizes. Due to their shape, the reinforced concrete waffle and ribbed slabs represent the effective types of structures given by the relation between the material consumption and structural characteristics. Several potential environmental results of reduction of the material used in the structure can be recognized: savings in natural resources (especially non-renewable ones), savings in transport and maintenance due to reduction of the total amount (volume and weight) of construction materials, reduction of the volume of waste material at the end of the life cycle of the structure, and others.

The theoretical analysis, optimization and performed case studies have supported preliminary assumptions about the undisputed significance of the selection of materials, including recycled materials and optimization of the shape of the structure. The performed case studies - LCA analyses and comparisons with other standard types of RC floor structures have showed that using recycled waste materials and the optimized shape of the floor structure, it is possible to reduce environmental impacts, such as consumption of non-renewable silicate materials, the resulting level of GHG emissions (embodied CO_2, embodied SO_x, etc.) and embodied primary energy. The evaluated factor of environmental impact reduction in the range 1.2 – 1.8 can be considered insufficient, compared with the range of the needed improvements (factor 4 and more). However, it should be considered that these impact reductions are associated with material savings in a load bearing system where the main criterion is structural reliability and reduction of the use of structural materials is thus limited by safety reasons.

Nevertheless, there is a big potential for the use of high performance silicate materials (UHPC, HPFRC etc.) to form ultra thin shell (ribbed, waffle, etc.) structures with higher reduction of the use of primary raw materials, and correspondent reduction of associated environmental impacts. The studies made by authors support the expectation that it will be possible to reach factor 3 or even more while keeping structural reliability on the needed high level.

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Rehabilitation of sewer systems in undermined areas

J. Pollert

pollert@fsv.cvut.cz

Department of Sanitary and Ecological Engineering. Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech republic

The issues of designing, operation and rehabilitation of sewer systems in localities with mining work or work employing mining technologies have a number of specific features that do not occur in designing of sewer systems in other localities. This includes subsidence related to radical changes in the hydraulic conditions of the sewer systems compared to the original assumptions, changes in static action on sewerage structures, specific requirements for refurbishment methods, etc. The application of standard principles in designing and constructing of sewer systems may cause major problems in these localities, sometimes resulting in destruction of these structures. In relation to this, serious operating problems occur and the operation is limited, and if immediate steps fail to be taken, important elements of the sewer systems may have to be put out of service. This is an issue of utmost importance for the pilot locality as well as a number of other localities where mining work continues or has ceased. This involves the fields of sanitary engineering, hydraulics, geotechnics related to the development of regions, having broader impacts on the localities with a number of risks entailing significant social effects. At present, legislative background with administrative effects on the refurbishment and operation of sewerage structures is missing.

The ongoing as well as terminated mining work very often results in ground movements, above all subsidence, causing changes in the sewer system slopes and local structural faults (fissures, dislocations, destruction of structures). This entails reduced hydraulic capacity, i.e. the reliability of the sewer system. In the sewer network of North Moravan Water and Sewerage Copany (SMVAK, a.s,) were selected an experimental locality where the effects of sewer system undermining were studied. Within the project, were developed selected methods of conceptual solutions to rehabilitation of sewerage structures in undermined areas with possible conceptual procedures and recommended applications. Main focus was on specific requirements for sewerage structures (sewer systems and structures). Thus was searched and analysed available methods of rehabilitation specifying the applicability of their employing in undermined areas in terms of geometric changes of the individua sewerage structures. In doing so, the chosen methods were applied which are capable of fulfilling the required functions even after further potential subsoil movement.

In a specific locality Horní Suchá the survey was carried out in sewer and determine the actual condition of the sewer structural state including deviations of the as-built state from the design. Failures were classified in various groups, based on whether these are local bursts, general breakdowns, whether they affect the tightness, stability of the pipes or both. Furthermore, the failures were classified on whether they occurred as a result of standard wear or otherwise. For the purposes of simulating rainfall-runoff processes in experimental catchments, were first developed a digital model of the existing sewer system and related sub-catchments. In order to do so, design documentation updated by detailed height surveying of gradients was used. Mid-term monitoring of rain intensities and discharges (i.e. water levels and velocities) in selected points of the sewer system was made for the calibration and verification of the model. The calibration and verification of the rainfall-runoff model was performed generally irrespective of the occurrence of structural faults in the sewer system. In standard cases, this does not introduce any major uncertainties into the solution; however, in areas affected by mining work this can lead to incorrect calibration and verification and resulting incorrect assessing of the sewer system behaviour. In relation to a camera survey of the sewer system critical points, the individual structural faults were grouped according to the European

standards. The effects of the individual types of faults will then was quantified by means of 3-D flow simulation. The head loss caused by the specific type of fault was quantified for various levels and types of disruption. This resulted in expressing of the dependence of the head loss coefficient on the type and magnitude of the fault. For the purposes of verification, the total hydraulic roughness of selected sections of the sewer system were determined by longitudinal dispersion of dosed tracers. Identification of the hydraulic roughness parameter was made using a hydrodynamic mathematical model of the relevant section and measured data. The effect of identified structural faults was reflected in increased hydraulic roughness in the section, where the fault occurs. The calibrated and verified rainfall-runoff model was loaded by selected rain events from a historic rain series so as to enable assessing of the sewer system hydraulic reliability. This showed the frequency of overloading of the individual sections of the system and the overall reliability of the sewer system, expressed as the level of the system overloading MPS and the time-space factor TSF.

What is decisive for the design and operation of a sewer system in terms of its hydraulic reliability is the volume of infiltrated water having a negative impact on the hydraulic capacity of the system, on the frequency of discharges from the combined sewer overflows (CSO) into the receiving waters during rain events and on the performance of WWTPs. As regards the environmental effects, both elements of filtration, i.e. into and out of the sewer system, are important. Wastewater exfiltration deteriorates the quality of groundwater. On the other hand, infiltration influences the quality of surface water by increased frequency of wastewater overflown from CSOs. Furthermore, the groundwater in industrial and undermined areas is often contaminated by specific pollutants having an adverse impact on the quality of wastewater due to the treatment technologies. Sewer system leakage identification, along with quantification of infiltrated/exfiltrated water, was carrfied out using balance of mass flow of natural (occurring in the relevant locality) and artificial tracers. The sensitivity analysis of affecting factors were performed in order to identify key effects of undermining resulting in reduced hydraulic reliability of sewer systems in undermined areas. This analysis form the basis for the definition of criteria of design and rehabilitation of sewer systems in undermined areas.

The outcome of project is the possibility of predicting changes in the sewer system capacity in dependence on the mining work. This should be used in decision-making on the rehabilitation and reconstruction of sewer systems. A methodology concerning design and rehabilitation of sewer systems in undermined areas focusing on hydraulic, civil and potential environmental impacts will be developed. The results of the projects will be employed by the operators and owners of the sewer systems in relation to minimising of operating costs, improving of the environment and enhancing of the quality of services provided to the consumers.

The existing technical recommendations (ČSN), also due to the time of their issuing, do not sufficiently cover and fail to contain the up-to-date knowledge and materials suitable for the construction of water-related structures at the current level of technical potential. This situation is partly caused by the incomprehensive solution to the relations between the mining work and the effects of mining on other economic activities in the previous period. The project result is possible to use for elaboration of methodology of designing of sewerage structures in undermined areas, including recommendations of the types of materials, method of pipe laying, types of linear structure joining, and principles of non-linear structures foundations. This should be carried out taking into account mainly the level of undermining, geological conditions, ground sloping, water level and chemical composition of groundwater and a potential effect of the receiving body of water (possible endangering of civil structures by surface water during land subsidence). The methodology as a result of project determines comprehensive specifications of conditions and decisive criteria of designing, construction and rehabilitation of sewerage structures and conditions and criteria reliable and ecologically harmless drainage and treatment of wastewater in undermined areas.

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Long-Term Effects of Temperature and Moisture Fields on the Service Life of Damp Proofing Systems of Bridges

Jaroslav Římal, Vladimír Jelínek, Kamil Maleček, Renáta Hoďánková, Jan Kouba, Anna Kovářová, Petr Kouba, Jana Zaoralová, Simona Rohrböcková, Jaroslav Listoň, Daniel Šindler, Hana Horká*, Vít Sopko, Bruno Sopko, Ladislav Samek, Marta Kořenská*****

rimal@fsv.cvut.cz

*Czech Technical University in Praque, Faculty of Civil Engineering, Thákurova 7, Praha 6,
**Czech Technical University in Prague, Faculty of Mechanical Engineering, Technická 4, 166 67, Praha 6,
***Brno University of Technology, Faculty of Civil Engineering, Veveří 331/95, Brno

Introduction

The experimental structure selected for the verification of new bridge deck damp proofing technologies was structure No. 2000, Prague 4-Spořilov, a fly-over crossing on Hlavní Street. The experiment also included the measurement of temperature and moisture fields in the damp proofing and pavement system.

The structure is composed of two individual, inclined bridge structures of identical geometry separated from each other by a free strip 8.5 m in width. The surface levelling of the load-bearing structure composed of prefabricated girders is made using concrete leveling topping 60 mm thick with a welded mesh and uniform 1.5% cross fall. Each bridge structure is fitted with a one-directional pavement 8.5 m in width, and on the outer side there is a pedestrian pavement 3.05 m wide.

The multi-layer pavement structure and NAIP damp proofing on the right bridge structure (direction to Lešanská Street) has the following composition:

50 mm ABS I	wearing course
40 mm ABJ	protective course
2 x 4 mm	modified NAIP strips
2 mm	modified asphalt adhesive coat, expansion insert – EXPA strip, bonding primer

The multi-layer pavement structure with gravel insulation of cold produced and laid epoxyasphalt material on the left bridge structure (direction to Senohrabská Street) has the following composition:

50 mm ABS I	wearing course
25-33 mm	poured epoxyasphalt
5-8 mm	insulation mastic epoxyasphalt roughened with gravel
1-2 mm	expansion reinforcing insert – EXPA strip, adhesive bonding primer

Measurement methodology and measuring system

Measuring sensors for temperature measurements and measuring probes for moisture fields measurements were used. They were mounted on the side of the road by the pedestrian pavement (ca 50 cm). The measurement methodology and the operating staff requirements made it necessary to construct working spaces in the pedestrian pavement of the bridge structure. Three working spaces were built there. The mounting of temperature sensors was performed in two phases:

- while laying individual layers temperature sensors were replaced with steel models of the same dimensions so that they would not be bonded with asphalt in the multi-layer pavement structure,
- after the completion of works on the pavement the models were replaced with real sensors.

The mounting of probes for the measurement of moisture fields was performed continuously while laying individual pavement layers.

Measuring system

The measuring apparatus for remote temperature measurement with digital data recording is able to measure temperature even in places with difficult access, with simultaneous reading of all measured values and their objective recording. Special temperature sensors resistant to mechanical strain based on platinum thermometers were developed.

Also, the method of 4-wire measurement using Pt 100 Ω was used, and internal connection of the measuring point feeds was modified to fit this. The basic part of the measuring system was the apparatus by ULTRAKUST Company.

Conclusion

The obtained results confirm that the measurement methodologies applied for temperature fields and the monitoring method of moisture fields allow sufficient precision of the evaluation of the temperature and moisture fields not only of the damp proofing system, but the whole multilayer pavement and that they may also be successfully applied on other projects.

The monitoring of the moisture fields is more complicated as compared to the temperature field measurement as it depends not only on the multilayer pavement type, but also on the temperature and climatic conditions allowing ice formation and water vapour condensation, including their potential discharge. The results of this monitoring allow the assessment of the damp proofing system functionality, its connection with the bridge deck or the levelling layer and the efficiency of reinforcing expansion inserts, layers. In this case unsuitability of the levelling layers execution was clearly proved as they still contain a high percentage of moisture, are maximally saturated even under the impermeable insulation.

The applicability and precision of the results are fully sufficient as background material for the design of road pavements, insulating systems and technologies of their implementation on bridge structures.

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The Effect of Moisture Fields on Bridge Structures

Jaroslav Římal, Vladimír Jelínek, Kamil Maleček, Renáta Hoďánková, Jan Kouba, Anna Kovářová, Petr Kouba, Jana Zaoralová, Simona Rohrböcková, Jaroslav Listoň, Daniel Šindler, Hana Horká*, Vít Sopko, Bruno Sopko, Ladislav Samek, Marta Kořenská*****

rimal@fsv.cvut.cz

*Czech Technical University in Praque, Faculty of Civil Engineering, Thákurova 7, 166 29 Praha 6,
**Czech Technical University in Prague, Faculty of Mechanical Engineering, Technická 4, 166 67 Praha 6,
***Brno University of Technology, Faculty of Civil Engineering, Veveří 331/95, 602 00 Brno

The research team composed of experts from various fields has been continuously working on problems related to moisture content, moisture transport in different structures, mainly bridge structures. With a view to the starting reconstruction of Charles Bridge in Prague, research on this historical monument is very important.

The moisture content in building materials and structures is a highly changeable variable. It depends on external climate conditions, but also on internal conditions existing in specific building constructions. External climate conditions are independent, while internal conditions may be affected by selecting suitable structural systems and materials. Moisture distribution within building materials follows a non-uniform pattern and depends on the pressure, temperature and texture of used materials and the type of structure. Moisture penetration into building materials and structures is mainly affected by the following:

- climate conditions
- water-vapour diffusion and capillary moisture conductivity due to temperature and moisture gradients
- capillarity and capillary absorption capacity
- sorption and de-sorption.

Charles Bridge over the Vltava River is one of the historical dominants of Prague and one of the oldest stone bridges in Central Europe. It is over half a kilometer long, ten metres wide and it is not perfectly straight. It rests on 16 bridge piers. Except for some repairs the bridge looks just the same as when it was completed by architect Peter Parler, who started working on it in 1357.

Charles Bridge is exposed to climate effects in the form of rain and snowfall, air flow and water vapour arising above the water surface, which does not freeze over in winter, and in the form of solar radiation. Rain water and water from melting snow affect the surface of the bridge sandstone blocks, partially dripping down its walls, partially soaking in and leaking through the cracks in the joint between individual blocks. Due to the wetting of the breast and spandrel walls by water, sandstone blocks get soaked.

During winter, the structure freezes through, but the freezing process occurs slowly at the crown of the arch and moves towards the piers. In the hand-placed arenaceous marl close to the piers, the core remains unfrozen. There it can only freeze under extremely long-lasting

low temperatures. This phenomenon probably affects the moisture transfer and brings about changes in the moisture field of the structures.

The moisture field in the bridge structure is also influenced by the air flow from the wind and the impact of the free water level of the river which continuously releases water vapour thus maintaining permanently high air moisture content. This moisture affects the soffit of the bridge arch and accumulates at the extrados. High summer temperatures and solar radiation which are one-sided coming from the south side also affect the moisture field in the bridge structure. Finally there are some chemical effects due to acid rain and earlier bridge pavement salting.

At places where damp proofing is not applied correctly and does not perform well, particularly at the ends and connections to the spandrel walls, massive leakage into the bridge occurs. The layers of the pavement and the hand-placed arenaceous marl become saturated with water to a large extent. The damage of the damp proofing system of Charles Bridge was confirmed by the results of experimental measurements.

Long-term experimental measurements have been performed on Charles Bridge (from its major repair of 1966-1976 to the present time). Moisture field measurements of the structure of Charles Bridge were conducted with a digital system using devices like the Ultrakust (FRG), Multimetre (UK) and Sanwa Electric (Japan) systems. For the placement of sensors core boreholes were drilled in the bridge structure. The moisture sensors were developed and calibrated. The cable line from the moisture sensors is led along the external side of the protective tube of the temperature sensor line. All cables lead to the central measuring unit. The results of moisture field measurement are displayed in a graphic and numerical form.

The goal of the experimental project is to measure moisture gradients and temperature fields inside the Charles Bridge structure. The numerical results of the moisture field have proven that the field is almost stable and constant in time during the year. It does not vary very much during the year, not does it vary due to the influence of temperature gradients of the bridge structure. The temperature fields are variable during a one-year cycle, but these changes do not affect the moisture fields in a substantial way.

For the future restoration of the damp proofing system, it is important to continue the experimental measurement in the laboratory, and choose and explore new materials which will satisfy the demands laid on the new damp proofing system of Charles Bridge.

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3D Scanning system with virtual binary targets

R. Urban, M. Štroner

rudolf.urban@fsv.cvut.cz

ČVUT in Prague, Faculty of Civil Engineering, Department of Special Geodesy, Thákurova 7, 166 29 Praha 6

A functional prototype of a fotogrammetric scanning system using virtual targets with a binary code was created. The system is designed for laboratory scanning of small objects as e.g. archaeological objects with point accuracy in a position up to 1 mm. An advantage of the system is especially its low purchase price and its modularity.

The whole system is based on using a data projector with which virtual targets on the scanned object are realized and on the digital camera serving as a data collecting unit. Virtual targets on the objects are interconnected with a starting system of coordinates by means of photogrammetric points. In terms of measuring it is therefore possible to divide the scanning process into two parts. The first part is determination of the coordinates of the photogrammetric points by means of classical geodetic methods. The second part of measuring results from photogrammetry principle where it concerns finding out snapshot coordinates of virtual targets and photogrammetric points. Measuring snapshot coordinates is here converted only to finding out a position of the relevant pixel in the raster, which is a digital photograph. In each photograph there must be at least seven photogrammetric points suitable
for evaluation. A frame with photogrammetric points enabling measuring in different places without necessity to redetermine coordinates of the photogrammetric points is part of the prototype.

A key part of the scanner is generation and then identification of codes contained in targets. With respect to the fact that the scanned object is a generally irregular form, a unique numeric code is created for each point; this numeric code converted to binary system creates a sequence of ones and zeros. If a certain colour is assigned to one and another colour is assigned to zero, it is possible to create a sequence of pictures definitely identifying selected points in the figure screened from the data projector. Decoding goes in the following way: values one and zero are assigned to each pixel in sequence of pictures according to the accomplished calibration; these values are then converted to a number in decimal system. The same sequence of pictures is taken from different standpoints, identical points focused from different standpoints have the identical code for evaluation carried out in the same way. Under the condition that elements of inner and outer orientation determined by calculation by means of control points are known, it is further possible to determine space coordinates of points signalized by virtual targets on surface of the scanned object.

Program equipment was created especially for this system (M. Štroner, R. Urban) and covers the whole measuring process and measuring evaluation up to calculation of space coordinates of points.

The Lumenera Lu125C digital camera with distinction of 1,3 megapixels is available for realization of the scanning system. This camera is connected to any PC through USB 2.0 port. The efficient Umax Lumens LM136 data projector, luminous intensity 3600 ANSI lumens with contrast ratio 400:1 is used as well. The set is used with notebook.

An experiment for testing prototype accuracy was conducted. There were selected thirty virtual binary targets, which were screened on the back wall of the calibration frame and focused by the Topcon GPT-2006 instrument. Virtual targets created a square picture (4×4 pixels), the proportions of which were in fact approximately 5×5 mm. Scanning by the system was carried out afterwards from six various standpoints.

Coordinates of virtual points were calculated from two, three, four, five and six pictures (always from the selected most suitable combination) so as to determine efficiency of number of pictures of the scanning system. Conclusion of the efficiency test is that increasing number of pictures is almost irrelevant for accuracy of the whole system. It is therefore possible to judge that the system moves on the frontier of achievable accuracy that the used set of instruments and aids can offer.

Deviations in coordinate axes can be reduced by the average values of deviations for purposes of evaluation of relative accuracy of the scanning object. Reduction theoretically suppresses effect of systematic errors that is the same for the whole scanned object.

The system achieved the following accuracy parameters in the experiment:

Standard deviation of the scanner	0,61 mm.
Standard deviation of the scanner after reduction	0,15 mm.

It is planned for further development mainly to increase measuring accuracy by using system components of higher quality to realization of virtual targets and mainly to improve distinction of the digital camera and of the used objective for example by a quality digital camera with a replaceable objective (so-called reflex camera) that is already available today and the price of which (about 20 000 CZK) would be compensated by distinction up to 10 Megapixels. The expected standard deviation (without reduction) should be reduced according to the preliminary tests by one half up to one third of values that were found out here.

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Radar Data for Rainfall-Runoff Models

JL. Halounová*, J. Horák, M. Hanzlová**, J. Unucka****

ena.halounová@fsv.cvut.cz

*Department of Mapping and Cartography, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic
**Institute of Geoinformatics, TU Ostrava, 17. listopadu15, 70833 Ostrava-Poruba, Czech Republic

Small river water catchments rainfall-runoff is analyzed in the framework of the Czech Grant Agency project No 205/06/1037 called "Application of Geoinformation Technologies for Improvement of Rainfall-Runoff Relationships". The project combines information about rainfall, surface runoff, ground water runoff and water stream runoff in one system. The surface runoff is derived from precipitation, land cover, soil type, soil moisture, and slope. Basic model are extended and combined with other models representing behaviour of individual parts of water balance. More concretely, kvasi 2D hydrological model HELP, snow melting model (degree/day) and locally hydrogeological model are used.

The remote sensing part was focused on evaluation of land cover and soil moisture. Two remote sensing data types were used for - optical data for the land cover and radar data for the soil moisture. There are two catchment for the analysis – the Bělá River catchment and the Olše River catchment – both in Moravia.

Land cover data were used in fact from two data types. One data type are CORINE data. These are classified areas in the form of shape files processed according to European Union methodology used for the whole Europe. There are two temporal levels of them; the first one is from 90-ies and the second one from 2000. The last update was performed in 2000 from remote sensing data – from the Thematic Mapper on board of Landsat satellite. The data are processed in 1:100 000 scale. The second data source were classifications performed directly for the purpose of the project from the same data type – two temporal levels of the Thematic Mapper imagery. Analyzing the catchments´ situation, only small changes in land cover were found in two level CORINE data. However, comparing of two levels Thematic Mapper data showed far larger areas with changed land cover type important for the rainfall runoff.

The found changes are from urban areas to agriculture, forest, water body, from agriculture areas to urban area, forest, and water body, from forest to urban area, agriculture, and water body, from water surfaces to urban areas, agriculture ones, and forest. 24 per cent of the Bělá River catchment land cover have changed – in prevailing part from agricultural areas to urban ones and forests according to classifications and only 0,1 per cent according to CORINE data.

The radar data were used for the analysis of relation between soil moisture and changes in digital values of the radar data. Previous flood situations were described by the Czech Hydrometeorological Institute data measurements of precipitation, temperature, and open channel discharge. Four flood events were processed regarding meteorological and hydrological data, land cover data at the moment of the events and radar (ERS-2) imagery before and after the flood events. The radar data changes were used for the land water storage capacity for the rainfall-runoff model. Future flood events will be used for the model calibration (1).

The radar data choice was performed to cover the analyzed flood events measured and selected by the Czech Hydrometeorological Institute. Choice condition were based on time gap to be shorter than 1,5 month. ERS data were chosen for. ERS is European Radar Satellite with the revist equal to 34 days. Therefore the selection is quite narrow. That is why some flood events were covered by one scene before and one by one scene after the event. Some of them were covered by two scenes only after the flood describing only the drying period.

To analyze change between radar measurements was transformed to the task to analyze changes between homogenous areas. These areas were calculated by subtraction of two images: the older is subtracted from the younger. That was in fact a calculation of new channels. The subtracted channel was filtered by low pass filters – median, mean and Lee one.

The homogenous areas were determined from Thematic Mapper data – from previously land cover classes. Individual classes formed homogenous areas. The classification was performed by eCognition software using segmentation and standard nearest neighbor classifier. Polygons of resulting classes used for their temporal change detection

It was proved that the SAR data can be used for detection of soil moisture changes:

These changes can be caused either by land cover or moisture and in case of temporally homogenous land cover it is only the soil moisture change causing it.

To evaluate the changes the following workflow was proposed: In the first step to calculate of two SAR image by image data subtraction. The second step is to filter the subtraction channel. The third step represents land cover classification from optical images and subtraction of optical channels. The fourth step should be determination of boundaries of individual classes for the change detection evaluation. In the fifth step, homogenous areas of land cover classes should be determined with all individual land cover classes. The last step means to calculate mean value of digital value of homogenous parts of land cover classes for the future modeling of the soil moisture.

Future work will be focused on testing of filters for evaluation of moisture changes of the surface layer in rainfall-runoff models.

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Design Optimization of Foamed Asphalt Mixes

J. Valentin, Fr. Luxemburk

jan.valentin@fsv.cvut.cz

Department of Road Structurec, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 20 Praha 6

The technology of foamed (expanded) asphalt mixes has not been used widely yet in Czech Republic even if the technology has a long-term tradition in many countries worldwide [6, 7]. The technology has been introduced to the Czech market the last couple of years and the most popular technique, how it has been since used, is the in-place technique. There were also several sites where in-plant production was introduced by using mobile plants. However in general using cold recycling as a modern, cost effective, natural resources protecting and time less demanding pavement rehabilitation technique has still not been standardized enough among public road administration bodies. The key issues are limited practical experience by the public bodies and in case of mobile plants only small number of sites in one location to make such technology economically efficient and interesting

The cold recycling technologies are specified in four miscellaneous technical specification approved by the Ministry of Transport (TP112, TP126, TP134, TP162). These specifications describe different testing and evaluation procedures and present various values for similar or same technical parameters. The use of these specifications is therefore not simply and their complicated or in some cases inconsistent facts and information could be interpreted as one reason for limited utilization of foamed asphalt technology. The technical specifications TP112 and TP126 define foamed asphalt mix as well as key parameters necessary for suitable use. The mixes can be designed for sub-base of all types of pavements according to Czech pavement categorization, in case of binder or wearing course the use is limited only to pavements with low bearing capacities. Both specifications expect utilization of only 25-75% by mass of reclaimed material in the final foamed asphalt mix. The preferred test method is the Modified Marshall Test, when specimens are prepared at temperature 20±5°C and tested at temperature 22±1°C.

During the experimental testing of about ten different mixes has been tested and analyzed, where two types of reclaimed material have been used. Graded reclaimed (milled) asphalt materials 0-22 and 0-11 have been used for the foamed asphalt mixes. At first the recycled material was always analyzed to gain information about grading, amount of bitumen, attendance of environmentally problematic substances (especially tar), specific gravity and optimum moisture content. None of the analyzed reclaimed material contained tar. The bitumen content laid between 4.0-5.0% by mass

In the mix design different binder combination has been used – foam bitumen, foam bitumen with cement and foam bitumen with lime hydrated. The foam bitumen content was always 3.0% by mass. To content of hydraulic binders was between 1.5-3.0% by mass. According to the previous analysis of the reclaimed material it was not necessary to add extra fine particle material because the requirement of minimum amount of filler 5% by mass fulfilled both materials. Therefore the function of cement and lime was to improve Marshall stability as well as stiffness and reaching better cohesion between the binder and the reclaimed material. The void content of tested mixes was between 8.0-13.5% by mass and fulfilled the requirements given in technical specifications.

The Marshall test has been carried out at 22°C or 60°C, and the specimens were conditioned in a water bath at the testing temperature for 30 minutes. The results of latter testing conditions cannot be compared with any boundary values set in the specifications, because they specify requirements only for the temperature of 22°C. However Marshall stabilities and deformation gained at 60°C validate our expectation and international experience that hydraulic binders improve significantly the strength of a foamed asphalt mix [7]. This fact is underlined by the results gained at the temperature of 22°C. For mixes where same reclaimed material has been used the Marshall stability raised by more than 100% if cement has been added and by more than 70% if lime has been added. It was also possible to fulfill the required boundary values of technical specifications if cement or lime has been added. All mixes have met the requirement of loss in stability.

Important and in the Czech Republic so far new characteristic we focused on in our experimental testing has been the assessment of dynamic stiffness modulus at different temperatures as used for hot asphalt mixes. Stiffness modulus seems to be a suitable performance characteristic for proper mix design as well as a comparator between hot asphalt mixes and foamed asphalt. Other research results [6] speak about a possibility of setting equivalence coefficient, which could be a criterion for the capability of vertical forces distribution in a pavement structure, where also foamed asphalt has been used. Values of 2400 – 5000 MPa for foamed asphalt mix with 50% reclaimed asphalt stabilized with cement could be found in the literature. The stiffness modules were tested in Nottingham Asphalt Tester (NAT) at 5°C for winter conditions, at 15°C for medium conditions and at 27°C for summer conditions. Because this characteristic has not been tested and assessed yet in Czech Republic, the only possible comparison where similar technologies used for pavement sub-base. Achieved results show for foamed asphalt mix with 3% cement very good comparison with experience which could be found in the literature as well as with the boundary values set in TP170 for dense bituminous macadam. Results gained for foamed asphalt with 2% hydrated lime correspond to the previous results of Marshall stability if compared with cement stabilized foamed asphalt. The absolute difference between both mixes was a surprise.

Results of our research have so far confirmed positive effect of hydraulic binders use for foamed asphalt mix optimization as well as its main characteristics improvement. Adding hydraulic binders it was possible to meet the boundary values set in the specifications. On other hand these binders of course limit considerably storing of foamed asphalt for longer time if produced in-plant.

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Monitoring Biofilm Formation in Drinking Water Network

A. Grünwald, B. Šťastný, K. Slavíčková, M. Slavíček,
*** M. Křížová *J. Jindra**

grunwald@fsv.cvut.cz

Departement of Sanitary and Ecological Engineering, Faculty of Civil Engineering,
Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

*VAK JČ Boženy Němcové 12/2, 370 80 České Budějovice, Czech Republic

Biofilms on pipe walls in water distribution systems are composed of bacteria in a polymeric matrix which can lead to higher chlorine demand, coliform growth, pipe corrosion and water taste and odor problems.

In water distribution systems, excessive biofilm formation leads to a deterioration of quality of drinking water. Major disadvantages include regrowth of coliforms, multiplication of opportunistic pathogens such as *Mycobacterium* sp., *Legionella* sp., *Aeromonas* sp. and *Pseudomonas* sp. Other problems include increased heterotrophic plate counts HPC, complaints about invertebrates, taste, color, odor and microbially induced corrosion [1, 2].

Most of the microbial biomass in drinking water distribution system is located within biofilm. There are several factors which can influence the formation of biofilm, e.g. microbial nutrients, pipe materials, disinfectants, bacteria from water and the hydraulic regime.

The traditional method for controlling bacterial growth in distribution systems is the application of disinfectants. Chlorine and monochloramine are used extensively. Chlorine reacts readily with organic carbon and pipe materials thus creating difficulties in maintaining chlorine residuals through distribution systems. Monochloramine does not react with organic matter to the same extent as chlorine but has a greater penetration of biofilms [3].

This paper considers the changes in water quality and formation of biofilms occurring in a real water distribution system.

The study was undertaken on the WTP Plav. Samples were taken from three sampling places, situated on the influent to the WTP, after coagulation/filtration and on the effluent from the WTP. Glass-coupons were incubated for one and two month and then collected after colonization in order to perform microscopic study on the biofilm. Presence of Flagellates, Ciliates, Rotifers, Crustaceans, Green algae in crude water, treated water after filtration and treated water after chloramination were compared.

During the sampling campaign, water samples were also analyzed. Active chlorine, DOC, BDOC, P and other chemical parameters were determined as well as the bacterial abundance. BDOC concentration in water was estimated as the difference of DOC concentrations measured before and after 30 day incubation at 20^{o}C with indigenous bacteria.

Occurrence of living microorganisms in all biofilm samples was negative. The results of chemical analysis indicate that the material accumulated in biofilm was derived predominantly from iron corrosion processes rather than from the sedimentation of particles introduced into the water during the water treatment.

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DBPs Formation from Deposits in Drinking Water Distribution System

A. Grünwald, B. Šťastný, K. Slavíčková, M. Slavíček, *J. Jindra

grunwald@fsv.cvut.cz

Departement of Sanitary and Ecological Engineering, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

*VAK JČ Boženy Němcové 12/2, 370 80 České Budějovice, Czech Republic

Use of chemical oxidants such as chlorine, chloramines, chlorine dioxide, and ozone as drinking water disinfectants is a well-established and successful treatment practice to combat waterborn disease. While the addition of chemical oxidants to drinking water yields a measurable benefit in public health protection, it may also result in the introduction of other potential risks. The chemical oxidants react with naturally occurring organic and inorganic compounds in water to form by-products.

Among all the chlorinated by-products, trihalomethanes, which exhibit a potentially carcinogenic activity, are certainly the class of compounds that has been investigated most thoroughly during the last 30 years. Classical THM consist of chloroform ($CHCl_3$), bromodichloromethane ($CHCl_2Br$), chlorodibromomethane ($CHBr_2Cl$) and bromoform ($CHBr_3$). They are formed through the reactions of hypochlorous acid (HOCl) with natural organic matter (NOM) in water in presence or absence of bromide [1]. DBPs group include also halo acetic acids (HAA), haloacetonitriles (HAN), haloketones (HK) and chloropicrin (CP).

The measurable operational parameters which influence the occurrence of trihalomethane in the distribution systems are chlorine dose, water temperature, pH and travel time of water within the system (residence time) [2].

Distributed drinking water contains invisible particles, transparent or smaller than 50 μm which can reveal a deterioration of the water quality. The presence of particulate matter in distributed water is detected from the coloration and clogging of domestic filters and from the accumulation of loose deposits in drinking water reservoirs and pipes systems. Loose deposits are also responsible for serious drinking water quality problems when they are resuspended: increase in turbidity and color, bacterial recontamination, decrease of disinfectant concentration etc. Resuspended particles contain a variable, but minority fraction of organic matter which can affect the DBPs formation in distributed water [3].

A possible formation of disinfection by-products by reaction with chlorine were studied in the laboratory experiments under defined conditions (temperature 20^0C, residence time 72 hours, chlorine doses 0,5 – 4,0 mg.l^{-1}, by chloramination constant addition of NH_4^+ 0,5 mg.l^{-1}). Deposits from the shaft before WR Sv. Anna were used. Their characteristic was as follows: suspended solids content 346 mg.l^{-1}, TOC 7,46 mg.l^{-1}, pH 7,6.

It was shown, that the concentration of chloroform increased with the increasing doses of chlorine from 15,4 $\mu g.l^{-1}$ (at Cl_2 dose 0,5 $mg.l^{-1}$) to 77,7 $\mu g.l^{-1}$ (at Cl_2 dose 4,0 $mg.l^{-1}$) whereas during the chloramination with the same chlorine doses ranged the THM content from 11,5 $\mu g.l^{-1}$ to 14,1 $\mu g.l^{-1}$. That means that the increase of THM concentration was negligible.

The results of this study confirm the possible formation of THM from deposits resuspended into the bulk flow during changes in hydraulic conditions in the distribution system. Formation of these compounds depends mainly on the concentration of resuspended particles in water, doses of chlorine and the reaction time.

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Study of Corrosion Rate in Water Treatment System

A. Grünwald, B. Šťastný, K. Slavíčková, M. Slavíček,
***J. Jindra**

grunwald@fsv.cvut.cz

Departement of Sanitary and Ecological Engineering, Faculty of Civil Engineering,
Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

*VAK JČ Boženy Němcové 12/2, 370 80 České Budějovice, Czech Republic

The internal corrosion of potable water pipes causes considerable investment for the municipalities world-wide. The consequences are pipe breaks, overflows, clogging of pipes with corrosion products and, the major effect for the consumers, water quality deterioration. Corrosion of iron is also the primary factor controlling biofilm growth.

In past decades, numerous studies have been conducted to investigate iron corrosion to elucidate fundamental mechanisms responsible for iron release, which often causes red water. It is known, that corrosion processes consists of a series of electrochemical reaction occurring at the metal surface in contact with water and its constituents.

Corrosivity of a particular water depends on its chemical properties (e.g. pH, alkalinity, dissolved oxygen content, dissolved solids etc) and physical characteristics (temperature, flow, velocity), as well as the nature of the pipe material. In addition to general corrosion, localized pitting corrosion may also occur if there are imperfections in the metal, oxide film or scale. Pitting is localized corrosion which results in pits in the metal surface. This type of corrosion generally takes place in corrosion cells with clearly separated anode and cathode surface.

Pitting is accelerated by high levels of chloride and sulfate. Microorganisms can also promote corrosion by creating areas with different concentrations in oxygen, minerals and metals. Some microorganisms also catalyze reactions associated with corrosion process. Corrosion products of iron pipe provide habitats for microbial growth and react with disinfectant residuals, preventing the disinfectant from penetrating the biofilm [1, 2].

The formation of passive layers on iron pipes has been subject of many investigations and the saturation or Langelier index has been widely used since it was introduced in 1936. This index indicates whether the water is supersaturated or under saturated with respect to calcium carbonate. However, later investigations showed that the saturation index is insufficient to predict iron corrosion. The buffer capacity is referred to as the most important factor for the formation of good protective layers because an increased buffer capacity leads to slower precipitation of the corrosion products and the formation of more protective scales. The buffer capacity is related to the alkalinity of the distributed water and this is why an increased alkalinity is regarded as favorable [3, 4].

What sets uniform corrosion apart is that it proceeds at about the same rate over the whole surface of the metal exposed to the corrosive environment. The extent can be given as a mass loss per unit area or by the average penetration, which is the average of the corrosion depth. This can be determined by direct measurement or by calculation from the mass loss per unit area, when the density of the material is known.

The goal of our work was to define the new method of corrosion rate calculation and differentiation between two types of corrosion: uniform and pitting corrosion. The investigation was performed in the WTP Plav which provides potable water to many municipalities in South Bohemia. Three places were chosen as locations for corrosion monitoring and taken samples for the analysis of the main characteristics of the treated water from WTP Plav in South Bohemia.

Temperature, pH, alkalinity levels, iron, manganese, calcium and magnesium concentration, disinfectant residual were measured at the inlet of WTP, in water after coagulation and filtration and at the outlet of WTP.

Corrosion rates were measured using removable steel coupons. The coupons were removed from the cradles after a 35 and 70 days incubation period. After this period the coupons were analyzed using mass loss and a new scanner method as well. A software simulation study was carried out using Matlab program.

Corrosion rate measured in crude water from Římov reservoir after 35 resp. 70 days exposition was between 32,6 and 243,3 $\mu m.year^{-1}$(∅ 83,1 $\mu m.year^{-1}$) resp. 51 and 212,4 $\mu m.year^{-1}$ (∅ 89,0 $\mu m.year^{-1}$) and in final drinking water after 35 resp. 70 days exposition was between 45,9 and 135,8 $\mu m.year^{-1}$(∅ 73,9 $\mu m.year^{-1}$) resp. 26,6 and 102,3 $\mu m.year^{-1}$(∅ 51,3 $\mu m.year^{-1}$).

Corrosion rate showed a typical seasonal pattern with the maximum value in summer and a minimum in winter.

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Deposits in Drinking Water Distribution System

A. Grünwald, B. Šťastný, K. Slavíčková, M. Slavíček,
***J. Jindra**

grunwald@fsv.cvut.cz

Departement of Sanitary and Ecological Engineering, Faculty of Civil Engineering,
Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

*VAK JČ Boženy Němcové 12/2, 370 80 České Budějovice, Czech Republic

Deterioration in drinking water quality represents serious problems in distribution networks. These can be an elevated concentration of iron, increased turbidity, colour, odour, and taste in the drinking water and also an increase in microbial numbers. Water leaving from waterworks usually meets the standards for chemical and microbiological quality. However, there are often chemical and microbiological changes which deteriorate the water quality within the distribution networks. Discolored water resulting from suspended iron particles is a relatively common drinking water consumer complaint. Deposited particles are also suspected to accumulate organic matters (pesticides, polycyclic aromatic hydrocarbons), especially the ones with a low solubility. Resuspension of deposits may be accompanied by high micro-pollutant concentrations in water and result in a rapid decay of the disinfectant residual. Suspended particles in normal flow conditions in distribution systems are also suspected of transporting, throughout distribution systems, attached bacteria and bacterial aggregates which are thus protected from residual disinfectants. Soft deposits inside the pipeline were occasionally released to bulk water, increasing the concentrations of iron, bacteria, microbial available organic carbon and phosphorus in drinking water.

Particles in the distribution systems may have several origins. First of all, treated water produced from surface water contains particles since the efficiency of coagulation and filtration is never 100%. Moreover, filter materials (sand, GAC); include particles which can be released in water during the treatment. In pipes, dissolved material can be flocculated or precipitated following changes in environmental conditions. Water dissolved organic matter also results in particle production. Corrosion of iron pipes or erosion of cement-lined pipes results in the accumulation of soft deposits in the pipe works. Transport processes within the distribution network, including exchanges between deposits and the water phase, are dynamic processes. Accumulation of particles is a very slow process dealing with very small quantities.

Some particles may be generated by precipitation or flocculation processes, from biological growth or by corrosion phenomena, while others may disappear following dissolution, deposition or the lyses/predation of bioparticles.

Soft deposits and biofilms in drinking water pipelines have been found to consist mostly of bacteria, including pathogenic microbes, which can also be present in drinking water distribution system.

In distributed water, the number of suspended particles is usually quite low. Brazos et al [2] counted between 293 and 1116 particles larger than 3 μm per ml which is in a range comparable with corresponding treated water concentrations (186 – 1229 particles per ml).

This study concentrates on changes of water quality in the pipeline that take their drinking water from the WTP Plav to the city of Tábor and to the cities and the villages which lies on route during its transport (El-Shafy et al. 2000). The length of the pipelines is about 80 km. The material of the pipelines is steal without any type of coating. They carry about 285 $l.s^{-1}$ from WTP Plav. There are six reservoirs along the pipelines, at various intervals, with a total capacity of about 48000 m^3.

Previous research on the south Bohemia transport pipeline has shown that deposits formed from particles of different origin and size can deteriorate under specific conditions the quality of distributed drinking water. As a consequence of the resuspension of these deposits rise the consumption of active chlorine and disinfection by-products formation in the bulk flow [3].

In our research few deposits were sampled from different sampling points along the transport pipeline.

The content of suspended solids varied between 33 and 911 $mg.l^{-1}$, the content of volatile solids was rather low (1,2 – 17,8 % of suspended solids). Prevailing part of suspended solids was constituted by iron. Its content (Fe_2O_3) ranged between 442 and 933,4 $mg.g^{-1}$ (44,2 – 93,3 %). The content of other metals like manganese (0,28 – 0,67%), nickel (0,01 – 0,04%) and zinc (0,05 – 0,007%) was much lower.

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Optimizing Chloramine Disinfection of Drinking Water Using Neural Network

A. Grünwald, *P. Fošumpaur, K. Štrausová, **J. Jindra

grunwald@fsv.cvut.cz

Departement of Sanitary and Ecological Engineering, *Departement of Hydrotechnics, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

**VAK JČ Boženy Němcové 12/2, 370 80 České Budějovice, Czech Republic

Disinfection is one of the most important processes for producing safe drinking water. Disinfection of drinking water by chlorine has been a strategy commonly applied for consumer protection against waterborn disease. However, chlorine reacts with natural organic matter (NOM) like humus substances to form disinfection by-products (DBPs). Trihalomethanes (THMs) and halo acetic acids (HAAs) are the major DBPs detected in chlorinated water. All DBPs are regulated because they are considered as potentially carcinogenic and recently associated with reproductive problems. The use of alternative disinfectants that produce little chlorinated DBPs is an interesting option. Alternative disinfectants are chloramines, chlorine dioxide, ozone and UV.

Chloramines have been generally used in distributions systems where it is difficult to maintain free chlorine residual or when excessive disinfection by-products are formed. While less reactive than free chlorine, monochloramine is inherently unstable and undergoes a series of reactions known as auto decomposition, which is the oxidation of the nitrogen present as N (-III) to nitrogen gas (N_2). Monochloramine also oxidizes several commonly occurring aquatic constituents such as natural organic matter (NOM), bromide and nitrite. NOM oxidation by monochloramine is particularly important because it results in DBPs formation [1].

Monochloramine penetrates better into biofilm than free chlorine and is more able to kill sessile biofilm bacteria such as some *Pseudomonas* spp.

A properly designed chloramine disinfection system provides a kill of harmful bacteria and viruses and a protective residual throughout the water distribution system, thereby preventing recontamination. Dosing too much chloramine has a number of negative effects, as it increases water treatment costs and has a deleterious effect on the taste and odor properties of the water. High chloramine levels are frequently related to consumer complaints and are commonly the largest source of customer concern for water utilities. Therefore it is important to achieve a balance between the objectives of ensuring an adequate chlorine residual for microbiological quality and preventing high chlorine residuals that impact on the aesthetic qualities of the drinking water and may also pose health problems.

At the water treatment plant, it is common practice for operators to control the chlorine dose by using information about the raw water quality and the chlorine residuals at strategic points in the distribution system. However, this information is often received too late for the operator's response to be effective. An understanding of this problem has led to an increase in the number of attempts to model chlorine residuals in potable distribution system [2, 3]. A

large number of process-based models have been proposed, however the performance of these models depends on good estimation of a number of chlorine decay parameters. More recently, data-driven methods, such as artificial neural networks (ANNs), have shown their utility in forecasting chlorine residuals within distribution systems.

Many papers have been published on the application of artificial neural networks to water treatment and also wastewater treatment systems. The use of neural network models has been suggested e.g. for the simulation the treatment of surface water by coagulation, the estimation of water quality for a rapid-gravity sand filtration, for the simulation of ammonium N concentration by the industrial wastewater treatment, control of the hydrogen peroxide and ferrous-chloride dosage in treating synthetic wastewater etc.

The objective of this study is to develop an ANN model that is capable of predicting Cl_2 and $(NH_4)_2SO_4$ doses to maintain a disinfectant residual in the water distribution network. Historical data from WTP Plav (southern Bohemia) and strategic points in the distribution system were collected on the chlorine residual and on any variables that are likely to influence chlorine decay. ANN model was calibrated using the back propagation algorithm, as it has already been used for the prediction of coagulant doses. In the input layer of the neural network following parameters were used: flow, water temperature, COD_{Mn}, Cl_2 dose, $(NH_4)_2SO_4$ dose. Concentration of free chlorine in the influent to the water reservoir vas chosen for the output layer.

The findings of this research suggested that the factors, important for the prediction of chlorine concentrations for the case study considered are the chlorine and ammonium sulfate doses at the inlet to the reservoir of treated water, flow and the chlorine concentration at the sampling points of the distribution system.

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Specific Methodology Application to Structures of Various Characters

D. Macek

daniel.macek@fsv.cvut.cz

Department of Economics and Management in Civil Engineering, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

The paper is related to the project presented in [1-2]. Theoretical results will be supplemented with data originated from model application to practical tasks decision. Created relations are useful for practical application, but at the same time further requirements to the models of structure renovation and maintenance were recovered. The stage of elaboration denotes directions for the theoretical part development. The aim is to create application software which will meet the determined needs of users. After checking the basic principles it is possible to support other areas for development of models and instruments, which were not evident at the beginning or which seemed to be unimportant.

The objective is to apply the model of structure renovation and maintenance from the point of view of the owner (administrator) of the structure. The matter concerns the creation of the system which enables qualified management of costs and incomes of the object and defines the way of its utilization with maximal possible efficiency. Target group are the public administrators, for example, municipalities or local government. These entities manage a large part of real estate including objects of completely different sort, which vary in structure types, structure age and manner of use.

The model of technical-economical analysis (further referred to as T-E analysis) is based on the principle of robust algorithm for input data processing by means of referential databases of constructional production. The model enables optimization of administration financing with basic or incomplete information about the object. This information can have a different level of accuracy and reliability. Processing is possible for one object or group of objects without regard to their type, age and structure maintenance quality. The renovation time schedule, with percentage range of costs, for example in five-year cycles, is generated on the base of total expected lifetime of the object, budget costs and their percentage share in construction elements and craft branches. Clearly defined form and extent of input data are needed for practical and full-value usage of T-E analysis model. The input data are subsequently summarized. To the compulsory data specified by the user of application, the rest of data needed for the analysis is automatically added. The source of additional data is two internal databases: database of typical representatives of constructional production and database of typical construction elements database.

Processed and developed results in the sphere of the theory of costs planning for the building renovation and maintenance were continuously consulted with experts and target users. In this way it was possible to obtain a feedback which allows correcting and adjusting the project during its development according to practical suggestions and to point of view of target users. Users' responses and requirements are various and there was a necessity to unite them. On the base of most frequent questions and notes was made a questionnaire which includes summary of questions relating to the problems in the area of construction renovation, maintenance and possible ways for project continuation and development.

The questionnaire contains the following questions:

•1. Do you have an interest in the listing of elements, i.e. separate constructional parts of the object? (partition walls, paintings, roofs, roofing, windows, drips etc.)

•2. Do you have a notion about construction elements used in your structures?
•3. Are you able to insert new construction elements into the system?
•4. Are you interested in detailed course of these cycles (i.e. internal structure of the solution)?
•5. Are you able to describe the intervals of construction elements maintenance?
•6. Should also the software calculate the distribution of maintenance costs in time, at present and in the future (5, 10 or more years ahead)?
•7. Do you calculate the net present value of structure – NPV or the internal rate of return?
•8. Do you wish to know the nearest term of construction elements maintenance?
•9. Are you able to define dimensions of the structure?
•10. Are you able to define purchase costs of the structure?
•11. Was purchase cost actualized according to price level?
•12. Do you have the documentation of the last construction elements renovation?
•13. Are you able to determine residual lifetime of single construction elements?
•14. Would you like to follow operative costs of housing unites and non-housing units at the same time?
•15. Would be the database of typical (standard) contracts useful for you?
•16. Would be the database of contract patterns (suggestions) helpful for you?
•17. Would be the database of equipment for housing units helpful for you?
•18. What kind of operating costs (energy consumption in housing and non housing units, cleaning, revisions etc.) do you monitor and how often?
•19. How many types of contracts do you use in administration of the object?

Results of the survey illustrate that users are interested in the structure analysis of particular construction elements. Moreover, users can easily define construction elements of their structures. Half of the respondents are able to define their own construction elements. In the same way users are able to describe the interval of constructional elements renovation and residue lifetime of elements. The most of users have an interest in the course of lifetime cycle of construction elements including the internal structure of calculation. As for the monitoring of costs in time, the most of users do not calculate net present value NPV and internal rate of return IRR. Everybody could easily describe the specific units of structure by the input of data to the model scheme. Users' ability to define the object's purchase cost is lower. A problem also arises in connection with purchase cost actualization to the price level. In most cases user is able to find the last date of renovation of particular construction elements. Otherwise, it is possible to obtain equivalent results by means of determination of residual lifetime of constructional elements. The question 14 wasn't formulated clearly enough and led to further questions about its essence. The support in the area of contract types and patterns was welcomed by the respondents.

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Simple Design Guidelines for Stair Slabs Supported at Landing Level

J.Skala, J. Procházka

josef.skala@fsv.cvut.cz

Department of Concrete and Masonry Structures, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

This paper reports the development of a new design guideline for the stair slab, supported on the structural member spanning at right angle to the direction of the flight. The study is based on finite-element analyses of two common types of stairs, dog-legged and open-well stairs. The stair slabs, usually supported on walls or beams at landing levels, derive significant rigidity from such supporting arrangement. This results in an efficient distribution of moment along the length of the flight. This distinctive feature of stair slab is not recognized by the leading codes of practice. In order to establish the characteristic behaviour of stairs of the aforenamed types, a sensitivity study for the geometric parameters of the stair slab has been carried out.

Owing to their inherent supporting arrangements, the stair slab with supports on three sides at landing level have a very efficient way of transferring load. The leading codes of practice do not provide proper appreciation to the actual behaviour of stair slab of this type. Regarding the design of stairs, the European standard EN 1992-1-1 does not provide any recommendation for the restraining effect on the stair slab owing to its support conditions. The British Code (BS 8110-1:1997) on the other hand, provides some reduction in the effective span of a stair slab. Reduction in the effective span as suggested by the British Code, obviously results in some saving in the design.

Finite-element investigations of stair slabs, built monolithically with structural members spanning at right angle to the direction of the flight have been carried out. The behaviours of both dog-legged and open-well type of stair have been studied. The influences of the various geometric parameters on the design forces have also been studied. Based on the findings of this study, a guideline for the estimation of design forces is proposed. For this purpose, the FE mesh has been used with thin shell linear element SHELL63 of ANSYS. This element has four nodes with six degrees of freedom per node. Shear deformation is neglected in this thin shell element. The mesh comprised of 161 nodes in 128 elements was chosen as an optimum choice.

The study was carried out with the following assumptions:

1. For the purpose of analysis, three consecutive flights have been considered. Symmetry conditions were applied at both the terminal landings. The results of the intermediate flight is considered for discussion in the subsequent sections, since it was contemplated that this particular flight would be free from any undue effect of the boundary conditions imposed at the terminating landings.
2. Waist slab and landing slab were assumed to have the same thickness.
3. The material was assumed to be linearly elastic, homogeneous and isotropic

The effects of varying the geometrical parameters on the overall behaviour of stair have also been studied. The parameters considered are: length of the landing slab- a, horizontal projection of the waist slab – b, height of the flight – h, width of the flight – w, opening – c of an open-well stair. Each of the parameters was varied independently keeping the remaining parameters constant. Effective span values were computed on the basic that $f_d.b_e^2/8$ should be

equal to the maximum positive moment at mid span, where b_e is the effective span (distance between the points of contraflexure).

Results of Parametric Study:

The moments at the waist slab are quite insensitive to the variation in the inclination of the stair slab. Study indicates that the effective span for the stair slab is about 70% of the going. For an open-well stair, the lateral moment at landing does vary to a great extent depending on the well opening - *c.* The moment at the free edge of the landing increases as the distance "*c*" between the forward and the backward flights decreases.

Behaviour of the stair slab with two more supporting arrangements were also studied.

1. A stair slab simply supported on walls at the end of both landings.
2. A stair slab completely fixed at the end of both the landings.

The behaviour of these two cases very closely resembles that of simple and fixed beams, respectively. This implies that the stair slab does not require any special treatment because of is folded nature. Parameter *c* a *w* appears to be the most important parameters influencing the behaviour of the open-well stair under consideration. It is interesting to note that the flexural behaviour at outer edge is insensitive of these parameters. In fact, the outer edge behaves somewhat like a restrained beam. The effect of a restrained outer edge travels towards the inner edge. Some relaxation of this restraining effect (at the inner edge) takes place for higher values of dimension *c* and *w*. For *c=w*, the effective span at inner edge is of the order of 80% of the going.

Proposal for Design Guideline:

The critical locations for moment are identified as:

1. Midspan of the flight for a positive moment in the longitudinal direction.
2. Kink location for a negative moment in the longitudinal direction.
3. Landing slab – kink line of half the width of the landing for moment in lateral direction.

Dog-legged stair ($a \leq 2w$, $b_{eff} = (0{,}8 \div 0{,}9) b_0$):

$$M_{rameno,pole} = \frac{1}{10} f_d b_{eff}^2, \quad M_{rameno,pole} = -\frac{1}{10} f_d b_{eff}^2, \quad M_{podesta,lom} = -\frac{1}{12} f_d (2w)^2$$

Open-well stair ($c=w$, $b_{eff}=b_0$):

$$M_{rameno,pole} = \frac{1}{10} f_d b_{eff}^2, \quad M_{rameno,pole} = -\frac{1}{10} f_d b_{eff}^2, \quad M_{podesta,lom} = -\frac{1}{18} f_d (2w+c)^2$$

The codes of practice do not give proper appreciation to the distinctive feature of the stair slabs where the landings are supported by walls in three sides. In absence of specific guidelines, the practicing engineers have a tendency to follow the design rules specified for a more general type of stair. This results in a gross overestimation of the design forces. On the basic of a finite-element investigation, supported by experimental evidence, guidelines have been developed for simple and straightforward design of stair slabs.

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Revitalization of Landscape and Urban Areas Water Systems

J. Pollert, A. Havlík, L. Satrapa, K. Vrána, D. Jarušková

pollert@fsv.cvut.cz

Czech Technical University, Faculty of Civil Engineering, Thakurova 7, 166 29 Prague 6, Czech republic

The European population spends upwards of €50bn annually on water needed for sustaining of life and for industrial purposes. Nearly 30 per cent of this amount is spent in the EU countries on the distribution of potable water and drainage of urban areas, including water treatment plants. It is natural that the traditional water management objectives –water supply, drainage and flood control – on the one side, and the environmental demands for sustaining and/or improving of environmental conditions on the other, clash sometimes. Any symbiosis between the developed urban areas and the undeveloped landscape is possible only if the physical growth and consumption of the urban areas does not subtract from the environmental integrity (environmental status) of the undeveloped landscape.

Influence of human activities on the hydrologic system of the landscape

Runoff from a basin can be reduced by an increasing of the retention capacity of the landscape. The issue of floods is usually raised in small drainage basins following heavy rainfalls, typical for their short durations but high intensities. The soil characteristics influence transportation surface runoff into subsurface through the degree of infiltration capacity. The vegetation cover can provide varying degrees of capacity to reduce surface flow velocity, and/or to improve infiltration into the soil. Topography of watershed determines the gradient and length of surface runoff courses. The capability of the watershed to retain water within a landscape depends on a combination of several factors and processes, whose mutual interrelations and relations to other environmental processes have not yet been clearly explained.

The research in this area was aimed at the issues of:

- flows and transport of water in a non-saturated porous soil environment;
- erosion processes, expert estimation of soil particles transport to the outlet profile of the watershed;
- influences of individual types of revitalization measures in the basin with the objective of increasing the retention capacity of landscape and its ecological stability and bio-diversity;
- occurrence, characteristics and progression of flood events, prolonged periods of drought, and possibilities of influencing them;
- design of water structures, their technological equipment and improvement of methods of runoff and outflow management from water management system in real time during extreme hydrological situations.

Influence of human activity on the hydrological system in developed areas

The development of urban areas means the most profound change to the original natural relationships between the soil and water ecosystems. In this sense, the most significant impact of the urban development process is modification of the hydrological cycle and rainfall-runoff relationships. The increasing degree of impermeability of drainage basins

combined with loss of natural vegetation cover causes considerable changes in hydrological responses. Composition of watercourses alters, i.e. the balance between the underground and the surface components shifts in favour of the surface component. The volume of water quickly drained into the recipient during a rainfall is considerably higher and the flow volumes increase steeply to unnatural values. During droughts, the quickly drained water is missing in the groundwater balance and the low level flows are lower than natural.

The increasing volume and frequency of high flow volumes raises the demands for flood control with negative impacts on the environmental integrity of the concerned water body as well as the related flood plain, which is an important hydrological component with a direct impact on the progression of floods due to its retention capacity. The flood plains are also a possible deposit location for sediments carried on the high discharges with minimum risk to the natural biocoenosis. Simulation models for soil particle transport can derive considerable advantages from verification data on sediment volumes in selected water reservoirs in the Czech Republic.

The quality of potable water for general public consumption depends on a multitude of factors. These include the physical, chemical, and biological composition of raw water, methods of treatment, disinfection, and others. To a certain degree, the quality of distributed potable water is influenced by the distribution system itself, which is often subject to effects of human activities both in the natural landscape and urban areas. This system is also subject to its own ageing and alterations in the loading of current traffic routes, buildings, etc. It has a significant negative impact in the lower quantity of distributed potable water.

EU Directive No. 2000/60/EC, establishing a framework for EU activities in the area of water policy, states “satisfying of water consumers within sustainable limits” as one of the strategic objectives. The basis aim of the directive is prevention of the further deterioration of water quality, support for sustainable water consumption and ensuring of the good quality of water for such consumption.

Depending on hydrological relations and the characteristics of the landscape, the objectives of the research will include:

- Protection of quality and quantity of groundwater as well as surface water by integrated systems of

a) supplies of potable water to inhabitants (collecting - processing - distribution)
b) drainage of the area of interest (sewer system - water treatment plant -recipient).

The overall results of the present research in the project is possible to define as a definition of design criteria for technical measures in landscape and urban areas, including design criteria for water management, transportation, engineering and civil structures in order to minimise damage in case of extreme hydrological situations (floods – drought).

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Computer Modelling of Projects with Utility Assessment

Č. Jarský

jarsky@fsv.cvut.cz

Department of Technology of Structures, Faculty of Civil Engineering,
Czech Technical University, Thákurova 7, 166 29 Praha 6, Czech Republic

All projects have to be efficiently planned at the investor's, architect's and contractor's sides. In the planning and design stage of the project several specific problems must be solved and many points of view have to be taken into this decision process. A lot of these questions can be efficiently solved by creating of a computer model of the structure [2]. One of the most significant questions is the utility of the project. The utility can be defined as the quality or condition of being useful; usefulness. It is a very general concept for the user to be able to evaluate the utility of a building or of a project on the base of this definition. Especially the architect and the investor should have a simple computer method to be able to assess the utility of the project he wants to undertake or design.

The utility of the project is a very complex idea. It is a hard work to assess the utility - it is not possible to evaluate the utility only as one magnitude, as for different participants of the building process – the owner (final user), the architect and the contractor of the project the utility of the building or of the project means something very different. Different features of the utility can be defined from the point of view of the whole community. Therefore more aspects have to be taken into the method of the utility assessment and a vector of criteria of utility assessment must therefore be created, see e. g. [1]. Naturally, all aspects do not have the same significance, so they must be allotted their weights (significances). It would be very advantageous if all utility assessments aspects could have the same exact measure unit and if they could behave as certain resources, so that they could be calculated mathematically. Then they could be put into a project computer modeling system as resources linked to building constructions and in this way the utility of a project which consists of several building constructions could be evaluated. For modeling of the building or of a project the methodology of construction technology design, see [3], can be very efficiently used. Therefore a construction technology project preparation and management system which includes the database of building constructions with 20 resources each and a big set of typical network diagrams that enable very quick creation of the model of a building or of a project consisting of more facilities can be then used for the calculation [2]. With the help of the system the user has the possibility to simulate the proposed composition of constructions and construction processes in the project and the time and resource flow of the building process of the project on a microcomputer even if the relevant data about the project in the planning stage are poor.

During the design of the criteria for utility assessment of buildings and project three main areas for the evaluation were stated – the contractor, the investor (owner) and the community. About 15 aspects for all areas were identified and finally 10 main criteria were picked out for the definition of the utility assessment vector. The criteria of the utility assessment vector are:

- for the contractor: realization technology, environmental impact during the building process, energy intensity during the construction and risk during the construction,
- for the investor (owner): lifetime and fire resistance, quality, operation energy intensity,

- for the community: build-up of free area, noise, traffic, operation emissions, recycling of used materials.

For all aspects a common measure unit was proposed – 1 finyar (fiňár in Czech), abbreviation 1 FIN. It is something like a special sort of currency and in this way all aspects can work as resources in the utility vector assessment calculation. The lesser the amount of finyars will be allotted for a certain criterion the better is the resulting assessment. The significance of all aspects was evaluated by a group of experts and their weights were published in [4].

After creating the model of the project by the help of the typical network diagrams and the database of construction processes, see [2], the user can transfer the data about the utility aspects for all activities from the database mentioned above. The system then calculates the whole utility vector in a table form, see [4]. The system enables to print the calculated network diagram in different forms of the construction technology design documents (technological analysis sheets, resource allocation overviews, bar charts, line-of-balance graphs (time-space graphs), resource allocation graphs of price, costs and cash flow, labour consumption, need of work force etc.), in Czech, English, Russian and Italian.

All documents that are gained on the base of the construction technology network diagram can be easily edited and updated according to the actual compositions of constructions. The utility assessment method is completely free for the user. He can define his own utility assessment vector composed of his own aspects, he can identify his own values of weights (significances) of these aspects and he can even design his own database of constructions with allotting of the amount of FIN to every utility aspect in every construction that is included in the database.

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Analysis of Dynamic Behavior of Footpath Bridge Across the Litavka River in Beroun

J. Zatloukal*, P. Konvalinka*, L. Hanzal**

jan.zatloukal@fsv.cvut.cz

*Czech Technical University, Faculty of Civil Engineering, Experimental Centre,
Thákurova 7, 166 29 Prague 6, Czech Republic
**Architektonické studio HABE, Jaromírova 41, 120 00Prague 2

Description of unusual timber–steel footbridge, developed from original architectural design into employable structure. Original design suffered from insufficient stiffness of footbridge superstructure, resulting in excessive vibration. This design was modified in terms of stiffness and technology without altering the architect's visual concept.

Introduction

The proposed structure is supposed to bridge Litavka river near Beroun city center, allowing the city to expand its parks and leisure time areas to the river's so far inaccessible right bank. A 37 m single-span structure from architectural bureau HABE was chosen. It combines two usual building materials – glulam timber and steel into unique structure. This design respects existence of another nearby footbridge, massive glulam arch structure, being more subtle while crossing longer span. This subtlety brought lack of stiffness indeed, resulting in very low first eigenfrequencies and critical load. The structure required to be redesigned, in terms of structural engineering, but also keep its original visual appearance.

Description of original structure

The main load bearing elements of the original design are two 37 meters long arch-shaped trusses positioned on both sides of the footbridge. The truss girders are curved both in different radii and are made of glulam timber, rectangular cross section. The diagonals are round steel pipes. The wooden slab walkway is situated in the level of bottom girders' top surface, following their curvature. The superstructure was originally intended to be lodged directly on the concrete substructure.

All the features mentioned above turned out to be problematic: the subtle superstructure being too vulnerable to vibration yet the walkway too rigid and stiff and lodged without any bearings directly to the substructure. The first eigenfrequency was about 2.2 Hz, right in the step frequency interval (1.6 ÷ 2.4 Hz) with eigenmode representing lateral vibration with cross section deformation. The critical loading ratio for characteristic load combination was only about 4, which meant the structure is vulnerable to stability loss. These problems were fixed in the latter structure modification.

Modification of the original design

First of all, the superstructure supports were changed to elastomere bridge bearings promising better static function and longer serviceability of the structure. Then original wooden walkway was replaced by steel one, yet plated with wooden sheets to maintain its visual appearance for users. It was possible to place the walkway in between the bottom girders not disturbing the side view of the footbridge anymore. More rigid horizontal stiffener has been added under the walkway to ensure greater lateral stiffness of the structure.

The biggest changes were made to the superstructure itself. Original design allowed the main trusses to tilt freely around horizontal axis due to lack of any cross section stiffening. Many variants of cross section stiffening were judged and finally multiple U-

shaped frames were chosen. Every in-plane truss diagonal works as out-of-plane stiffener strut, supporting the top girder in lateral direction. The bottom tie beam of the stiffener is also a part of horizontal stiffener and as non-visible member is made of an I-beam. The struts however need some visual appearance level and are required to be made of round pipes. Unfortunately single pipe of reasonable dimensions was found insufficient so twin pipe vertical mini-truss was introduced to the design.

Finally, the joint of the horizontal and vertical member of the cross section stiffeners had to be designed. It had to be stiff enough to act as frame cornet and also not violating the walkway profile. The complicated design resulted from its three dimensional function, joining six members in three different planes: wooden main truss bottom girder, steel diagonals of horizontal stiffener and tie beam and two struts of cross section stiffener, altogether with technological demand of being welding free since wooden elements were connected to this joint. Twelve variants of cornet were judged, with aspect of the overall stiffness of the superstructure.

Eigenmode based design

For every variant a calculation of eigenmodes has been done on 3D FEM model in FEAT 3.0 software. The variant was found not compliant if any of eigenfrequencies was lower than 3.0 Hz, or the frequencies of three first eigenmodes (vertical, lateral and torsional vibration) differed in their order, or the critical load ratio was lower than 10. These conditions allowed us to balance the stiffness of the structure while keeping its other qualities.

The frame cornet stiffness was taken into account by calculating its torsional stiffness using shell model of symmetric half of one pair of stiffening frames with common tie beam. This calculated stiffness was introduced to the global FEM model and eigenmodes were calculated.

Conclusions

The original design was revised in terms of structural engineering. The excessive vibration under pedestrian loading was probably avoided and general increase in structure serviceability and reliability was reached. Visual appearance of the structure was not affected by the undergone structural changes, furthermore, is valued as more appealing by the author of the original design. The structure is now ready to be built, waiting only for appropriate funding from the Beroun city.

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Photogrammetric Documentation of Citadel Al-Qala in Erbil

K.Pavelka, V.Kralová, J.Svatušková

pavelka@fsv.cvut.cz

Dept.of Mapping and Cartography, Laboratory of Photogrammetry, CTU in Prague, Faculty of Civil Engineering, Thakurova 7, Prague 6, 16000

In Iraq, there are a lot of very valuable historical monuments. A great deal of monuments is in a very poor condition. An urgent need for preservation of the most important architectural monuments arose in conjunction with the post-war reconstruction of Iraqi culture. Architectural monuments were often damaged by the war and today even simple preservation is nearly impossible. In 2006, two Czech expeditions were dispatched to Erbil with the aim of basic monument documentation, archaeological investigation and finding appropriate technology for the restoration of these structures. The first step was the photogrammetric and geodetic measurement of the Al-Qala Citadel and the Choli minaret in Erbil.

The Citadel in Erbil is on UNESCO's list of the world's most endangered historic sites. It forms a vast complex of buildings and narrow streets enclosed by town walls. The Citadel in Erbil is one of the oldest continuously inhabited urban settlements in the world. According to ICOMOS data, eight thousand years of inhabitation are proved in this unique urban concentration, making it the longest inhabited place on the Earth. This has been made possible by rich water sources, still available today, which have never dried out in recorded history. The fortified Citadel itself is situated on an artificial elevation of 28 to 32 meters above the surrounding countryside, which is now the city of Erbil. Well-known records and archaeological finds proved layers of Assyrian, Akkadian, Babylonian, Persian and Greek Pre-Arabic settlements. Fortifications were primarily built in the 12th century. At the moment the number of inhabitants of the historic city center (5,000-5,500) is rapidly declining. The regional government of Kurdistan is looking for opportunities to revitalize and preserve this unique complex for the significant rise in tourism that is expected in the future. Water for households is pumped into steel tanks on the roofs and water is distributed by gravity. Electrical wiring is situated on the posts and the house elevations. There is no sanitation in the Citadel and the remaining inhabitants use dry toilets, which result in all the expected health and hygiene hazards.

The Citadel is spreads out over more than ten hectares of land (300-350m in diameter). It is a classical example of an adapted hillock - "tell". The height of the hillock averages around 30m above the flat surroundings. No maps or plans were available to us of the Citadel– only a copy of a cadastral plan from the 1920's… During the 20th century, the great Citadel was heavily damaged by the Saddam Hussein regime since it was a symbol of importance for Kurdish people. Major parts of houses and palaces inside of the Citadel were destroyed; the original major portal was completely demolished. In the 1980's a new, modern, main portal was built in a retro style. The last repairs on the Citadel were conducted in the year 1982. During this year seven houses were conserved. Today the Citadel urgently requires conservation. This is a lengthy and expensive activity; and in order to begin the restoration documentation of the actual state of affairs is necessary.

During the short time of the expedition it was not possible to collect a detailed documentation of this structure. Instead, terrestrial and aerial photogrammetry was utilized. In Citadel's case, sets of terrestrial digital images were taken (more than 250 outside the Citadel and 200 inside); the next 70 images were taken from a US Army helicopter at the height of approximately 100m. In Iraq, there are no available photogrammetric aerial images; instead, a satellite image from the QuickBird satellite with a resolution of 65cm was used for the ground plan of the Citadel (date of image acquisition: 2005, 23.8.). By using Geomatica 10.0 (pan-sharpening) and Adobe Photoshop 7.0 (the image sharpening, filtration and new sampling to 25cm pixel were used for image quality improvements) the satellite data were processed to. The outputs of this procedure are encouraging and enable the next step to process with better quality.

A provisory geodetic network in the Citadel area was built and over 600 object points were geodetically measured. Next, 16 control points were signalized and measured for aerial imaging, mainly on the roofs. The Photomodeler software was used for all photogrammetric image processing. The 33 aerial images and 19 terrestrial images were adjusted to the base model. The mathematical least square adjustment and absolute transformation utilizing the control points was sufficiently accurate: the mean co-ordinate's error of control points was approximately 15cm (mean position error 20cm). In the 3D model about 1000 object points were measured and calculated.

A comparison of geodetically measured and Photomodeler calculated object points were made; a small systematical and scale error has been found (the model from Photomodeler was a little bit bigger and moved to south; the typical differences were approximately 15-30cm in comparison to geodetic measurement by total station). These displacements were solved by affine transformation into the geodetical measurements.

Finally, we had geodetically measured object points, points from Photomodeler processing, measured control points and a transformed satellite photo plan (as an under layer photo plan). These data were then used for processing to the base vector plan.

Nowadays, the final base vector plan of the Citadel was created. The last part of this project is the creation of an information system for the Citadel, which will be used for the storage of all valuable information (historical, geographical, geodetical, archeological, photographic and geophysical data).

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The Documentation of Historical Monuments in Peru (Geoglyphs nad Petroglyphs in Nazca Region and Sechin Archeological Site)

K.Pavelka

pavelka@fsv.cvut.cz

Dept.of Mapping and Cartography, Laboratory of Photogrammetry, CTU in Prague, Faculty of Civil Engineering, Thakurova 7, Prague 6, 16000

Peru is very interesting country from archeological and historical point of view. Soil drawings in the "Pampa of Nazca" in Peru are well known but not explained. Big soil drawings are called geoglyphs; they consist of lines in many forms: long direct lines, triangles and trapezoids and interesting illustrations. The creation of geoglyphs is easy and could be explained by the kind of soil. The surface of the Pampa is made of brown rubble with some ore in it. But some centimetres lower you can find light-coloured sediments of old ocean soil, mainly sand and clay. If you take away the dark rubble from the top you can clearly see the light-coloured subsoil. Most geoglyphs were created this way. It is not easy to identify the age of geoglyphs. The creation of geoglyphs is usually assigned to the cultural period of the Nazca time, which began approx. 200 BC and ended approx. 800 AC. The meaning and importance is only partly decoded. Some of the lines were probably created as astronomical observation lines; some lines are evidently communications. Special drawings like spirals or animals probably had ritual meaning. The Nazca plain desert with geoglyphs is largely destroyed. The damages have partly natural origin (heavy rain storms with an el-Niño effect cause great soil erosion) and partly human factor (road construction, car tracks and land use). The damages in the last decades are serious and it is important to actively maintain this cultural heritage. The Dresden-born scientist Dr. Maria Reiche tried to disclose the secret around the creation and meaning of the geoglyphs. Her theory, which says that it is a huge astronomical calendar installation, has not yet been proved. But her untiring effort led to the protection of the delicate desert pictures by UNESCO. For extension of the work of Maria Reiche, there have been four German expeditions in Nazca/Peru.

In 2004 staff members and students of the Universities of Applied Sciences in Dresden and Berlin (Germany), member of the TU Prague (Czech Republic) as well as members of our Association Maria Reiche carried out a GPS Measurement Campaign and photogrammetric terrestrial and aerial measurement. The second aim of this expedition was the photogrammetric documentation of petroglyphs – drawings of animals, entities and symbols like spirals or stars on solitaire stones and rocks not far from the Nazca plain. The similarity of some symbols (mainly spirals) between geoglyphs and petroglyphs were investigated. The area of interest is very large and not easily accessible; for this reason, aerial photogrammetric methods and satellite remote sensing for geoglyphs were used. The quality and information efficiency of old black/white aerial photogrammetrical images is not high at present. For this reason, a new type of high-resolution multispectral satellite images was used. First of all the seven separate satellite images from the Ikonos satellite with the help of the field measured Ground Control Points were processed to the satellite image mosaic. The field measurement was made by use of GPS Leica1200. For about 40 photogrammetrical control points and 30 control points for satellite images the preparation of detailed sketches were made and these points were determined. Selected geoglyphs were measured in detail directly in the Pampa of

Nazca too. The Ikonos satellite image mosaic can only be used as an overview of the whole area. For details satellite maps in a scale 1:5,000 were created and completed with some vectors from Nazca GIS (major geoglyphs). Some special photographic flights were undertaken with a Cessna airplane and helicopter. Only digital cameras were used for main geoglyphs documentation (Nikon D100). These images have to be rectified (oblique photo axes), but the resolution is about 10cm/pixel. Later (2006-2007) the images from the QuickBird satellite with resolution of about 65cm were added. The quality of these images is better and major geoglyphs are good visible; these data are under processing today and the results will be approximately in autumn 2008 at disposal. Newly, the Aster satellite (2007-8) data were processed to digital elevation model and geological thematic maps. Nowadays, a new expedition is under preparation (summer 2008 with the aim of collecting of new control points and next measurements).

In the Nazca region, there are directly a few important localities rich in petroglyphs. A big one is the Palpa/Chichictara area. One of the important aims of the expedition in 2004 was the documentation and cataloguing of petroglyphs (petroglyph = engraving on stone). A lot of petroglyphs are located in very badly accessible places; the amount of petroglyphs is very high (hundreds of drawings). For this reason, a simple, inexpensive and fast photogrammetric documentation method was developed. For one photoplain at least 4 control points are needed. When determining control points high precision is not required, because stone as a subbase for the drawing is usually not ideally flat. It is necessary to take 2 photos – first one with a reference figure and a second one without a reference figure. The four corners of a paper sheet are the necessary control points with known coordinates for rectification. The second image without a reference figure is rectified to the first one by uses clear-up image points. The final processing is cutting the output and image enhancement. Line drawing of the processed petroglyphs is debatable – the result depends on the operator. On next expeditions (planned 2008) we suppose next documentation of petroglyphs.

Last project is oriented to the photogrammetrical processing of the Temple Sechín using the methods of intersection and single photogrammetry. The main output is visualization of this site on Internet. In program PhotoModeler the 3D-model and orthophotos of parts of walls with sculptures for photodrawings was processed. This model was finished in CAD system Microstation and provided with textures from original photos. Terrain model of a not excavated material, which is found inside of the temple, was computed in the software InRoads (digital elevation model). Finally the resulting animations were made. Photodrawings of walls with sculptures were finished in the program Adobe Photoshop to the photoplain.

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The Possibilities of Use of Trash-dust or Returnable Filer in Technology Cold Recycling

Petr Mondschein

petr.mondschein@fsv.cvut.cz

Department of Road Structures, CTU Prague, Faculty of Civil Engineering, Thákurova 7, 166 29 Praha 6

Building of roads is quite unique in length or volume. Sometimes they can be referred as source or storage of grain material. The trend to use recycling technologies in roadbuilding has already started.

Recent efforts for better thriftiness and increase of profit combined with limited financial and material sources are resulting in search of new ways of usage of new materials or in new technological procedures. One of problematic products of stoneware and bituminous mixtures production is trash-dust. This soft-grained fraction of stoneware originates in all phases of stoneware production (pre-grind, primary grind, secondary grind, tertial grind, transport) and its volume and granularity is depending on actual phase of production.

Requirements on pureness of stoneware used in bituminous mixtures are stricter and also general amount of allowed dust in wrapping facilities is decreasing. From this reason there are bigger volumes of trash-dust (soft-grained element gained during cleaning stoneware in quarries) and returnable filer (soft-grained element gained filtration in wrapping facilities) available. This material often ends in quarries or depos as hardly-used or even trash material. From this reason it is researched if it is possible to use this trash-dust, especially in cold recycled mixtures that need bigger share of soft-grained elements. It is also researched the possibility to partially compensate more expensive hydraulic binder added to this mixture with this secondary material.

Technology of cold recycling on-site using hydraulic binders, bituminous emulsion or bituminous foam is known for a long time and it is widely used in reconstructions of base layers on roads of lower classes. Technology of cold recycling on-site is used also on roads of higher classes too, but only for lower base layers.
During cold recycling (both on-site or in wrapping facility) it is necessary to solve two general issues of these mixtures: high level of gaping that has impact on processing and mixture consisting, and attributes that have impact on longevity of construction layer. A program of laboratory observation was designed for verifying the possibilities of use of trash-dust or returnable filer through cement of bituminous emulsion. This program should verify usage of trash-dust as soft-grained part of mixture and as partial substitution of expensive cement that is short in supply. Laboratory experiment consisted of these tests:
- determination of volumetric attributes of mixture,
- determination of solidity in transverse pull after 7 days,
- determination of rigidity modules after 7 to 28 days, regarding to temperature,
- determination of modified Marshall test regarding to time and environment of maturation,
- determination of fatigue attributes.

This laboratory observations were made on mixture based on R-material 0/11 from wrapping facility Středokluky. Possibilities of usage of trash-dust was modeled on

substitution of cement by trash-dust in ratio cement:trash-dust: 100:0, 75:50, 50:50 in cold recycling mixture.

Firmed volume weight of all three mixtures were above level 2000 kg.m-3, gapes had bigger values than 15 % because of absence of small-grained and filerical part in R-material. Extent of this article does not allow us to present results of influence of time and environment of maturation on mechanic-physical attributes of the mixture. The mixtures were observed from the point of view of maturation (7, 14, 28 days), influence of environment (different combinations of time of maturation in water and air) and also resistance of material to water and frost. Generally it is possible to say that even when with time and environment changes there was noticeable influence of changes in cement ratio in mixture.

The results of experiments did not bring positive evaluation of substitution of cement by trash-dust in mixture. It is noticeable that lowering the share of cement in mixture has big impact on mechanic-physical and functional attributes of the product. This impact is even bigger when observed in time, when there is increase of solidity and rigidity by moisturizing and lower share of cement is resulting in significant reducing of these values.

When observing attributes of these mixtures, emphasis was made on functional attributes (determination of consistency modules in wider temperature and time scale and most of all on observing of fatigue attributes). We do not have enough experience with verifying and setting fatigue parameters for this kind of material. Material rigidity is positively influenced by cement, thanks to it these mixtures are less temperature reliant when compared to hot bituminous modifications. High values of gapes, forms of fragile behavior in fatigue attributes are the biggest obstacle for usage of this technology when building communications of higher classes.

It is not possible to conclude general results from laboratory observation of single mixture, but the results indicated that substitution trash-dust/cement will not be easy and maybe it will be necessary to find another use for this secondary product of stoneware and bituminous mixtures. One possibility lies in modifications of granularity lines of input R-materials, that in many cases suffer by insufficient share of soft-grained materials. For this usage it will be necessary to optimize compound of mixture and volume of binders.

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The Dynamic Public Sector Comparator - Evaluation Tool of PPP projects

V. Beran*, J. Frková*, E. Hromada*, F. Lehovec**

eduard.hromada@fsv.cvut.cz

*Department of Economics and Management in Civil Engineering, Faculty of Civil Engineering, Czech Technical University in Prague, Thákurova 7, 166 29 Prague 6, Czech Republic

**Department of Road Structures, Faculty of Civil Engineering, Czech Technical University in Prague, Thákurova 7, 166 29 Prague 6, Czech Republic

The Dynamic Public Sector Comparator represents a modified method for the calculation of the Public Sector Comparator, which is usually constructed to present a full cost pricing at an early stage in the procurement process of Public Private Partnership (PPP/PFI) projects. It is an instrument which gives insight into the possible added value of a PPP/PFI procurement by comparing the PPP/PFI procurement option with the public approach.

At the present time in calculating the Public Sector Comparator methods are used that ignore one fact, namely that its particular components cannot be defined with a comparable reliability. Consultation and advisory companies, which usually prepare the Public Sector Comparator for the public sector, have the experience and necessary know - how for its calculation. However the total range of their abilities cannot be distributed absolutely equally across all required branches. The contents of particular components of the Public Sector Comparator already leads its compiler to the necessity on some items (e.g. costs connected with the purchase of a plot of land and existing objects, non-building work, groundwork, etc.) of defining them with a higher rate of uncertainty.

Present methods of calculation of the Public Sector Comparator are based on the formulation of an economic model of a PPP project with a simplification of the objective reality. This fact leads to problems linked to the interpretation of achieved results. The next weak point of present methods is the rather static means of calculating the Public Sector Comparator. There are accepted for the basis of a solution in an economic model of PPP project once-and-for-all decisions in a predetermined time frame. However it is necessary to record the dynamic of a surveyed process.

From these aspects of knowledge there results the finding that the present methods of calculating the Public Sector Comparator are unsuitable. It is necessary to respect the fact, within the scope of determining the values of particular items of the Public Sector Comparator that its input parameters represent only point estimates that will be nearly always at variance with really achieved values. It is therefore necessary to record information about the accuracy of each realized estimation, which will be consequently utilized in the calculation of the final value of the Dynamic Public Sector Comparator.

The Dynamic Public Sector Comparator represents a significant qualitative and quantitative innovation in the method of calculating the Public Sector Comparator. The Dynamic Public Sector Comparator is based on a parameterization of input data by means of determinate characteristics of mathematical/statistical methods. For that reason input data are defined in extended format. Every item of the Dynamic Public Sector Comparator is defined by a specific probability distribution function and confidence interval.

With the method of the Dynamic Public Sector Comparator it is possible to get a more accurate calculation of full cost pricing in PPP/PFI projects. It can act as a key management

and evaluation tool during the procurement process and can provide a more reliable means of demonstrating value for money. The method of the Dynamic Public Sector Comparator provides full economic analysis of a prepared PPP/PFI project including extended financial, risk and sensitivity analysis and gives a solid idea of the total project costs over the PPP/PFI project life cycle.

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Experimental Investigation of Pull-Out Test of GFRP Reinforcement

J. Fornůsek, R. Sovják, J. Litoš, P. Konvalinka

jindrich.fornusek@fsv.cvut.cz

Experimental Center, Faculty of Civil Engineering, Czech Technical University
Thákurova 7, 166 29, Praha 6

Introduction

With increasing claims on the lifetime of structures very height requirements can be meet, which standard materials cannot fill. This is particularly true, regarding reinforced concrete. Many troubles can be found with a corrosion of the metallic bars, which impact especially the lifetime of the structure itself. Therefore a significant effort is focus on the non-metallic reinforcement, called fiber reinforced polymers (FRP). Nevertheless the topic is focused on bond between concrete and glass fibers reinforced polymers (GFRP) with a three different kind of surface arrangement.

Assemblage of experiment

FPZ 100 machine with a force range of 100 kN was used for pullout tests, where the bond between concrete and FRP bars was tested. Samples of GFRP bars were anchored into the concrete cube with the edge of 200 mm.

FRP bar was anchored in the length of 70 mm. The rest of the bar in the cube was covered with an incoherent material, like PVC. This should guarantee an absolute incoherency between concrete and FRP bar. The upper end of the FRP bar was arranged with a special anchor for a sufficient grip in the jaws of the machine.

Measuring was obtained from the inductive sensor IWT. There were three inductive sensors placed on the upper side of the concrete cube (marked IWT 1-3) and one inductive sensor (marked IWT 4) placed on the lower part of the cube. All measuring data included force was recorded in frequency of 2 Hz.

Samples

As was previously mentioned, three different kinds of GFRP bars are treated. Diameter of all bars was 14 mm. First treated kind was the bar with a string that goes spirally around the bar with a slope of 60 mm per one screw.

Second sample was arranged with a two strings oppositely winded that go up round the bar with a slope of 60 mm as well.

Third and the last one of the group of GFRP bars was made without any string. Bond was improved by a glue sand on the surface of the GFRP bar.

Basic mechanical properties were: Modulus of elasticity - 32,5 GPa
Yield stress - 471 MPa

Bond strength

Bond strength can be calculated according to the formula (1):

$$\tau = \frac{F}{\pi . d . l} \tag{1}$$

where

τ is the bond strength
F is a force at the certain level acting on the sample
d is diameter of the FRP bar
l is the anchoring length of the FRP bar

According to ACI standards, bond strength is shown at the values of slip 0.05, 0.10 and 0.25 mm. Moreover bond strength of the conventional steel reinforcement is calculated according to the CEB-FIB 1990 model code. This should give us an answer which kind of reinforcement is better in terms of bond strength. Comparison of three types of GFRP bars and conventional R 10 505 steel bar is noticed in the table 1, where:

Pullout 1: GFRP with one string
Pullout 2: GFRP with two strings
Pullout 3: GFRP with sand
R10505: conventional steel reinforcement

Slip (mm)	Bond strength (MPa)			
	Pullout 1	Pullout 2	Pullout 3	R 10 505
0.05	1.823	0.870	5.029	4.438
0.10	2.187	0.950	9.702	5.857
0.25	3.135	1.155	12.353	8.449

Table 1: Bond strength

Conclusion

As to be seen on the table 1, pullout 3 which correspond to the GFRP with glued sand provides the best cohesion between concrete and GFRP bar. On the other hand, the worst cohesion is provided by pullout 2 that corresponds to the GFRP bar with two strings. Slightly better, but still under the cohesion of the conventional steel reinforcement is pullout 1 which correspond to the GFRP bar with one string. When considered R 10 505 as a kind of recommended value, it is to bee seen that with a desirable surface modification an even better cohesion can be reached. Cohesion itself can independently on the material enhanced only with a help of the sufficient surface modification. On the other hand, with a wrong surface modification a very bad cohesion can be reached.

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Cost Planning for Renewal and Maintenance over the Life Cycle of Buildingss

D. Čápová, R. Schneiderová, J. Tománková, E. Ubralová

tomankov@fsv.cvut.cz

*Department of Economics, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

Summary

Into any decision about a project there should be entered all costs which arise at every stage in its life cycle. A potential contractor is interested in the ultimate level of costs and also their spread over time. For establishing the level of costs for repairs and maintenance which are a substantial component in the life cycle of construction cost there have been created two models. These are *the ratio model and the technical-economic analysis model.*

Field of application

The ratio model of cost enables a fast and simple estimate of framework costs for repairs and maintenance on the basis of the type of buildings. The model of technical-economic analysis enables more accurate planning of costs for repairs and maintenance in a shorter time horizon and further it can be utilized for assessment of different variants of proposed construction repairs from the viewpoint of future costs for repairs and maintenance and economies in running expenses.

Methodological and conceptual approach

The costs for repairs and cyclical maintenance as well as the costs for reconstruction and modernization of the construction are not constant in the course of its life cycle and that is why the main interest of the researchers focused on the creation of a way of setting up these costs.

The types of buildings are in the ***ratio model of costs*** distinguished on the basis of a Unified Classification of Engineering Structures (JKSO) and the structure of their material characteristics. Individual structural components are given in the details of constructional units and craft branches. The costs for repair and maintenance are in percentage terms derived from the cost of acquisition of the construction. On the basis of a calculated total life expectancy of the construction, budget costs, and their division by percentage into constructional units and craft branches there is set up a time schedule of repairs and their extent in percentage terms, for example in five-year cycles.

The ratio model of costs is able to distinguish within the framework of its detail the structurally material characteristics of the loading structure of the construction work but not yet of any individual structural element (construction unit or craft). For cost evaluation (financial analysis) of material variants of renewal and reconstruction of buildings it is therefore more appropriate to utilize the second tool namely the model of technical- economic analysis.

The model of technical-economic analysis focuses on the analysis of the area of costs and profits of the construction work within the context of maintenance and renewal of individual construction units. The solution is implemented with the help of the web interface, across which information about the construction is placed and feedback on the results of the analysis are returned.

The database of the construction production in the *model of technical-economic analysis* creates two basic databases –a database of buildings and a database of structural elements. In the database there are defined in total 102 representative items of buildings. Each of them has assigned a structure of

elements from the database of structural elements with their volumes and life expectancies with the help of a matrix of transfer formulae. The costs for repairs and maintenance of individual structural elements are derived from current market prices (therefore there is a need for regular updating).

The service life-time of individual construction work is in both variants of the model constructed with regard to technical and economic service life. It is determined so as to guarantee a trouble-free element and at the same time also to include moral wear and tear.

For the basic analysis there can be provided as entry data for the client a sufficient existing technical and operational documentation of the construction (building). The detailed analysis is based on expert findings on the physical condition of the construction, the price level of building materials and labour derived from detailed economic data about the construction as well as from specialist judgement regarding the current situation on the real estates market.

By assigning only compulsory identification data the client gains for basic analysis the advantage of a fast and cheap provision of output information. Any other data that are necessary for the processing of the analysis are automatically assigned from the internal databases of the model.

When selecting a more demanding analysis it is possible to assign more detailed and more accurate information about the building to gain outputs with a higher rate of reliability. Besides the optimum filling up of both databases, a necessary condition for the practical and full value usage of the model is the most accurate determination of the functional relationship among individual elements of both databases.

This assignment is realized through the matrix of transfer formulae compiled for all structural work and structural elements. Each transfer formula contains characteristic magnitude parameters for the analysed structural work and an empirically given transfer coefficient from which there is derived an amount for the structural element in the structural work. In summary there is set up a fictive structural work which differs from the real analysed structural work in permissible tolerance.

Research results

For the two proposed variants of the model for cost determination - *the ratio model of costs and the model of technical-economic analysis* there have been solved so far the basic relationships between the realization of the renewal and maintenance of structural elements in a division according to structural units and craft branches, in five-year cycles. A subject for further solution is the setting up of a cost determination for repairs and cyclical maintenance.

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Numerical Study of Soil Moisture Dynamics in Earth Dams during Flood Events

D. Zumr, M. Císlerová, T. Vogel*

david.zumr@fsv.cvut.cz

Department of Irrigation, Drainage and Landscape Engineering, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

*Department Hydraulics and Hydrology, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

Growing occurrence of extreme floods in Bohemia has attracted attention to the security of protective earth dams. A suddenly increased amount of water on the water-side of the earth dam may have destroying or even catastrophic consequences. Predictions of seepage patterns through the earth body are usually done considering the saturated flow beneath the free water level only, neglecting the saturated-unsaturated character of the soil water regime within earth dams. This assumption is not accurate for fine grained soils and transient problems. The importance of soil water dynamics within the earth dam is known for long e.g. [1].

A numerical study of the soil moisture dynamics within the earth body during the flood is simulated using the latest version the simulation model S_2D_DUAL [2]. In the model, the dual permeability concept [3] may be applied to simulate the general flow in variably saturated porous media, including the preferential flow and solute transport.

The geological arrangement was selected according to typical conditions for fluvial plains, as described in [4]. The dam body is underlined by thick layers of permeable sediments, which are covered with a flood loam horizon of low permeability. The subsoil is suitable material functioning as a natural seepage barrier. However, especially in urban areas, the upper soil horizon may be very heterogeneous in terms of thickness and hydraulic characteristics, and we may expect preferential flow below and behind the dam.

The studied dam is 2 m high, 12 m width at the base, slope of water face is 1:2.75, slope of the air face is 1:2,5. The earth dam body is made of a homogeneous clay-loam. The dam is underlined by 1 m thick loam layer over a permeable alluvial deep horizon. Hydraulic characteristics of the soils were taken from UNSODA database. The triangular mesh, composed of 19514 nodes (correspond to 38242 elements) was created with ARGUS ONE mesh generator.

The simulated flood event lasts eight days and reaches 330 cm in its maximum (30 cm below the top of the dam body). The flood wave was considered as a discrete function with twelve 20 cm to 50 cm high steps. It was simulated as time dependent Dirichlet boundary condition. Boundaries, which were not flooded, had prescribed zero flux. No evapotranspiration and precipitation were assumed. The initial conditions were set according to a steady pressure field, assuming the constant river water level at 80 cm.

Results for saturated and unsaturated part of the porous domain were analyzed. Distribution of soil water pressure heads during the flood event and corresponding moisture contents and horizontal and vertical velocity flow fields were obtained. The simulation showed that the considered flood does not cause seepage through the dam body. The groundwater level increased close to the surface. That might cause stability problems for potential constructions behind the dam.

It has been shown that the used saturated-unsaturated approach is suitable for engineering applications. The nonlinearity of Richard's equation is demanding in terms of computing time, hardware and experiences. Input data of hydraulic characteristics are commonly not obtainable and have to be estimated.

Preliminary results of the project to study the soil water dynamics within the flood protective earth dam were obtained. Numerical simulation of flow in large flow domains using simulation models based on Richards equation is a tedious job, still the presented method has a strong potential to increase the accuracy of the water dynamics estimate within the earth body in many applications, especially in those where the dams are constructed of fine grained soils (dam stability problems, internal erosion, impact of preferential flow and transport, functioning of drains, etc.).

The next steps of the research are a) to include the internal heterogeneity of the earth dam porous materials, b) to consider the presence of preferential flow. Based on the results, a larger domain, which includes a longer part of the protected area aside of a downstream face of the protective earth dam is considered to be used in future simulations. The proposed approach allows simulations of various extreme scenarios, including environmental accidents such as oil spills during flood events.

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Economy and Risk Analysis of Sustainable Building

J. Klvaňa

klvana@fsv.cvut.cz

Department of Applied Informatics, Faculty of Civil Engineering, Czech Technical University in Prague, Thákurova 7, 166 29 Praha 6 - Dejvice, Czech Republic

This article describes a stochastic form of assessment of effectiveness of an investment project. Discussed are especially the NPV and IRR methods. Possible risk analysis using Monte Carlo method is invented.

The author of this article identified in papers [3] and [4] the causes, why is construction on brownfields more risky then on greenfields.

Following causes were identified:

1) The phase of the birth of the investment project of construction on brownfields – the making of investment. Uncertain is the origin value of investment itself. Moreover the amount of money is used to be distributed in some time period.
2) The life phase of the investment project – the realization of cash flow. The incomes and expenses in the future are more uncertain then at the construction on greenfields.
3) The phase of death of the investment project - usually the sale. The reason is the same as above.

Further is in [3] and [4] in detail investigated the possibility of the assessment of effectiveness of investment project for an investor by usage the Net Present Value (NPV) method of the cash flow. The author doesn´t use the classic deterministic form of NPV method, but his own transformation of NPV method into stochastic form icluding risk analysis and risk management using Monte Carlo method: In the classic deterministic form of NPV method appear only deterministic values and parameters. It means that cash flows CF in each year and the cost of capital i are evaluated as deterministic values, i.e. numbers. But because our estimations of cash flow CF and cost of capital i refer to a future, the situation is more complicated, because the future is always uncertain. It is better to assume that the cash flow CF in each year and also the cost of capital i in each year are evaluated as random variables, or – in terminology of risk analysis – as risk faktors. In consequence of it is also the resulting NPV also random variable. The aim of this stochastic model is
1) to find the probability distribution (or density) function of NPV, and
2) analysis of this probability distribution to gain better prediction of assessment of effectiveness of an investment.

In this case investor can identify in time the threat of negative NPV and can realize the management interferences.

For solving this stochastic problem can be used with advantage Monte Carlo method.

Of course there exist more possibilities of assessment of effectiveness of an investment project for an investor. Except NPV method mentioned above this is especially the Internal Rate of Return (IRR) method.

Internal Rate of Return (IRR) is a rate of return that discounts the NPV of an investment project to zero. Thus IRR method consist in finding such a rate of return, which discounts the NPV of an investment project to zero. From mathematical point of view it means that we have to solve the equation NPV = 0, where of course on the left hand side of this equation is the proper formula for computation of NPV.

In deterministic form of IRR method there are of course the deterministic values and parameters only. That means, that cash flow in each year in the future of investment project we suppose to be known (deterministic) numbers and we are computing the uknown interest rate i.

Similarly as in NPV computation is also now when computing IRR clear, that if we are setting cash flows CF in each year into the formula for NPV as deterministic values, i. e. numbers, is also the solution of the equation i = IRR the deterministic value, this is a number. It is better to assume that the cash flows CF in each year are evaluated as random variables, or – in terminology of risk analysis – as risk factors. In consequence of it also the resulting IRR is also random variable. The aim of this stochastic model is
1) to find the probability distribution (or density) function of IRR
2) analysis of this distribution to gain better prediction of assessment of effectiveness of an investment.

In this case investor can identify in time the threat of the fact that the IRR will be with high probability lower then the market rate of interest and can realize the management interferences (risk management).

For solving this stochastic problem can be again used with advantage Monte Carlo method.

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Section 14

ARCHITECTURE, TOWN PLANNING, GEODESY, CARTOGRAPHY

Analyse of Study Subject Cartographic Printing and Reprography

P. Soukup

soukup@fsv.cvut.cz

Department of Mapping and Cartography, Faculty of Civil Engineering
Czech Technical University, Technická 2, 166 29 Prague 6, Czech Republic

The study subject Cartographic printing and reprography is included in educational program Geodesy and Cartography at Faculty of Civil Engineering, the Czech Technical University in Prague. Education takes place in fourth year of bachelor's study by form of obligatory subject. In the year 2007, 85 students attended this subject; more than 100 students will attend it next year. Main content of subject compose procedures used at processing printing basis, proof - sheet and printing maps inclusive reproduction of text documents. In passed ten years, this area was affected by a big progress involved in using of digital methods, which was enabled by development of new hardware and software equipments. These changes are necessary to implicate in education of mentioned subject. Practical training proceeds in a specialized laboratory, whose equipments fundamentally affects possibilities of realized tasks.

Main planned goals of subject innovation can be summarized into following points.
1. To update content of subject education by including of new lecture topics and by creation of new practical tasks.
2. To modernize equipments of mentioned laboratory at department of Mapping and cartography.
3. To create the tutorial course and make it accessible via internet for both students and public to support interest in this subject.
4. To establish narrower cooperation in field of experience and to use obtained knowledge to update the subject of education.

Analyse of current situation must certainly precede proper innovation of subject education. Inherent part of performed analyse of mentioned subject was enlargement of our knowledge of new and perspective technologies used in practice. The main resources of information have been studying of scientist sources and excursion in selected printing workplaces. Nowadays, education of subject Cartographic printing and reprography is oriented especially to using of analog methods [1], which are based on traditional photo-reproductive procedures (exposure film material and its following developing). These methods are exacting in equipments and materials and realization itself (darkroom, gallery camera, developing automat). At the same time, digital technologies of prepress preparation and printing are increasingly used in practice [2]. These methods are more ecological and for printing a few copies also more economical than conventional analog procedures are. Recently, map printing is often supplemented or replaced by their publication on the web.

Main result of performed analyse is under mentioned plan of innovation of lectures, trainings and equipments of laboratory.

In the area of lectures, following topics are planned to be included in more details or newly.
1. Computer typography - digital composition of scientific text, development, rules, fonts, encoding, alphabetical order, software.

2. Desktop Publishing - combination of graphic and text digital elements (map, legend, glossary), principles, software, data model.
3. Publication of maps on web - local and global publication, static and dynamic maps, interactive maps, web map services, software solution.

In the area of trainings innovation, next new tasks are designed.
1. Text reproduction - reproduction and digital composition of scientific text (inclusive graphic elements and mathematic formulas), OCR software, graphic layout and printing.
2. Composition of scientific publication - processing of selected topic to the form of scientific publication with compliance of typographical rules, usage of software for Desktop Publishing, combination of vector and raster data.
3. Digital reprography - reproduction of graphic and text original (historical maps, text legends of maps), digitizing documents by scanner and by digital camera, jointing large bitmap from more parts.
4. Publication of maps on web - map adjustments for purposes of web presentation, publication on web server, software solution, maps displaying.

In the area of laboratory equipments, following findings emerge from analyse.
1. To check up functionality and helpfulness of all equipments of laboratory.
2. To discard unnecessary, functionless and obsolete equipments of laboratory.
3. To set up place for building a new computer classroom in laboratory.
4. To complete laboratory equipments by laser printer and digital camera.

New web sites in the form of tutorial course will be created for support of education subject [3]. Course will contain all main tutorial materials, tasks and their solution.

Theoretic knowledge and practical procedures of technologically specialized subjects are developing very quickly. Lectures and trainings require continuous updating to make the education actual and attractive for students. In my opinion, by realization of mentioned innovation of subject Cartographic printing and reprography, students will obtain more actual view on problems of current maps reproduction and will be better prepared for their practical activity. Publication of created web pages on internet will partly increase educational comfort and partly contribute to greater presentation of our branch of study in public.

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Software for the Automated Processing of GPS Data and Digital Pictures

J. Zít*

jan.zit@fsv.cvut.cz

*Department of Mapping and Cartography, Faculty of Civil Engineering, Czech Technical University in Prague, Technická 2, 166 27 Prague 6, Czech Republic

It is possible to find some software for elementary processing of spatial data measured by journey GPS receiver and digital pictures on the Internet. All found solutions work with whole pictures and usually are distributed as a computer program for an offline usage. It has to be installed or needs the transmission of big amount of data in the case of online web service.

I designed the way of utilization and presentation of spatial and non-spatial data in connection with GPS measurement with the GPS receiver. The "GPS track & photo" has been developed. It is an online web service for georeferencing of digital pictures with timestamp produced by a digital camera. Georeferencing is based on near timestamps in digital pictures and the measurement of the track with the GPS receiver.

The GPS track & photo is designed as web service, because it is more user friendly than program that you have to download and possibly install. It needs the transmission of some data about digital pictures or whole digital pictures. GPS track & photo service uses XML format as the way how to deliver EXIF data, which contain timestamps and another information about digital pictures, to web service. Because there does not exist any standard of XML format for this type of data I had to choose one. XnView graphic software and its XML format were chosen as the base of picture processing. GPX (the GPS Exchange Format) is used for transfering GPS data. It is a lightweight XML data format for the interchange of GPS data (waypoints, routes, and tracks) between applications and web services on the Internet. It is de-facto XML standard for lightweight interchange of GPS data since the initial GPX 1.0 release in 2002. It is supported by dozens of software programs and web services for GPS data exchange, mapping, and geocaching.[1]

The GPS track & photo is programmed in PHP language and uses only standard functions and a function for parsing XML documents and it is placed in school apache server. The URL of this service is http://geo2.fsv.cvut.cz/gps.

The GPS track & photo service uses the forenamed files and set of parameters for its work. The first parameter is an output format. It is possible to make KML file for Google Earth presentation, HTML file with special JavaScript utilizing amapy.cz (recommended mainly for data from the Czech Republic) or text format (csv). It is possible to present track or pictures or both this data type.

If you do not have good timestamp in EXIF data connected to digital pictures, it is no problem for GPS track & photo, you can adjust time difference. It is possible to locate pictures separately or in groups. There are more parameters of localization and presentation digital pictures and track than mentioned.

It is possible to use web service GPS track & photo in the "simple mode" only for reformatting track data from GPX to one of three output formats. The GPX file is necessary for the usage of GPS track & photo service by contrast to XML file with EXIF data.

It is able to use this web service for presentation spatial data in the web page containing JavaScript section with description of Amapy.cz map element. Basic structure of this page is very simple and everybody who knows the basics of the HTML language can edit and adapt this page in agreement with his conception without modification JavaScript

section. It is able to use this page only for non-commercial application in accordance with conditions of utilization Amapy.cz API that is used.

KML output format can be displayed via Google Earth, which is well-known software representing Earth as electronic globe. It is also able to use Google Maps for displaying KML file. It is necessary to locate this file in some web server and enter the URL of this file to search field on http://maps.google.com. The displayed pattern is similar to Google Earth, but is shown as 2D map with our data. [2]

The GPS track & photo is a method how you can process your GPS data and digital pictures in a simple way and solve the presentation of these data. It is mainly designed for processing of trip data, but it can be used for further purposes.

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Old maps of Prague and web information system for a visualization and comparision of old plans and views using map server and databases

J. Krejčí

jirikrejci@fsv.cvut.cz

Department of Mapping and Cartography, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

This short text is briefly describing former and future research of old maps and city plans displaying the area of the present Prague city. The first part discusses Prague plans from a historical point of view. The second part handles with a rising project of creation of the web information system for a visualization and comparison of old city maps and views.

Mankind had tendencies to depict and write down a situation and knowledge about its neighborhood from past times. As well as other cartographic works, plans of towns and cities were points of interest of former cartographers. Nice example is the ancient city plan of the Rome displayed on the mosaic paving. Attempts to represent view and situation of towns in the Czech lands came later, in the beginning of the modern period. Primarily it was usually view (vedut) or prospectus made from an uphill place above the town, from a place within a level of river surface, or from a "bird's horizon". It is relevant to appearance of a perspective in a painting. These townscapes had more decorative than topographical importance. On the other hand, they are excellent way to familiarize with a past appearance of the town. Later the real planimetric plans were made. They were usually based on some type of field-measurement and used orthogonal projection. A plan was still partly art product and very often it was well decorated by veduts and interesting views of the town and important buildings.

First known illustration of the Prague is the Prospectus from the Vysehrad hill in the Schedel's World Chronicle from 1493. Then era of making of prospectus started. Namely only some of them: Sadeler's prospectus from 1606, Hollar's prospectus from 1650, Ouden-Allen's prospectus from 1685. Important person in the Czech cartography should be also Tadeas Hajek z Hajku, who was attempting to measure Prague towns as far back as in the middle of the 16th century. His attempt was unsuccessful because of lack of interest of Emperor Ferdinand I.

Plans of towns were made from the beginning of the 17th century. Most of them haven't come down till the present times. Müller's plan is a first one, which kept up to date. It was made as a part of the Müller's mapping of the Czech lands during 1712-1720. Interesting is its orientation to the north-west. Next important plans are for example: Huber's plan, which was made during the I. military mapping of Austria-Hungary Empire, and Herget's plan from 1790.

Really revolutionary plan was made by Josef Jüttner in 1816. It is the first plan based on a practical geodetic measurement. Jüttner, an artillery officer with the experience with astronomical and trigonometrical measurement, was well prepared to make the most precise plan made till his time. Plan in the scale 1 : 4 320 was published in black-white and colored version. It was many times reprinted, remade, copied, and was used as a pattern for other

plans of the Prague. The Jüttner's plan will be subject of the future research. A cartometric analysis as well as an analysis of topographical content will be done. On-coming research will be also focused on the other city plans founded until the end of the 19th century.

Next part of the research will be creation of the web information system for a visualization and comparison of old city maps and views of the city. Visualization of maps on the Internet is still more and more popular. About this problem was written a lot of papers. The best and most effective way how to published georeferenced maps is a map server. Aim of the next research is a concept of a web interface based on map server and databases focused on displaying of town plans a processing of them.

The web information system about old city plans will be based on popular open source UMN MapServer. MapServer focused on old maps has been already working at the Department of mapping and cartography. It is expected processing and visualization of raster images of a large data volume and supplemental information. PostgreSQL database system will be used for better storing and processing with the data. PHP language for a connection between map server, web server and database system will be used. Main goal is to make instruments: for displaying and comparison of various plans, for displaying of views to the town and important buildings, their position, orientation in map and information about them, for searching in database in the terms of various parameter.

Jüttner's map of Prague and some present city map will be base of the application. Many of old views will be possible to display. It is necessary to process and prepare old maps for the visualization in map server. The first step is usually creation of a raster image of the entire plan. It is advisable in case of map on the few map sheets, like city maps are. The second step is georeferencing. It is essential to make a spatial localization of the map for the publication through the map server. There is usually not the exact geographical grid on the old map. The solution is transformation of the raster image to the net of identical points of topographical content of the map. The coordinates in current coordinate system and coordinates in a map system are possible to get in any GIS software, for example ArcGIS. Different types of transformation can be used and it is necessary to choose the most fitting one.

Works on this project are based on the successful cooperation with the Historical Institute of the Czech Academy of Sciences, which will continue.

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Data Models of the Oldest Czech Maps

J. Cajthaml, J. Krejčí

jiri.cajthaml@fsv.cvut.cz

Department of Mapping and Cartography, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

It has been published earlier, that old maps are huge source of valuable information about our history. At the Department of mapping and cartography we are working on the research project focused on the early maps of Bohemia, Moravia and Silesia. These maps were created within the years 1518-1720. Almost every map from this era was created only by one cartographer. Among many maps, there are some important pieces which are objects of our research. Information from these maps can help us understand some historical processes (human or natural).

Every old map contains historical information about landscape (rivers, mountains) and about man-made changes in the environment (settlements, trade routes). Traditionally, these map elements were studied only by visual comparison. If we want to compare map elements on the old maps more precisely, we have to georeference these maps. The georeferencing means spatial localization in some common coordinate reference system. Because of huge distortion of the oldest maps, there is no exact method how to do that. If we want to find the best method, we have to create the database of identical points from as many maps as possible. After studying many old maps, we find out, that the best way for later maps comparison is to create digital data model of every map in GIS software. When having these data models in many different coordinate systems, we can start georeference them with respect to current position of identical points.

The data model of an old map consists of basic map elements. On the old maps from the area of Bohemia, Moravia and Silesia, we can find settlements (cities, towns, villages, castles and chateaus), rivers and streams, trade routes, hills and mountains. These elements are usually represented by point or line cartographic symbols. Before creation of a geodatabase of these objects, there is necessary to decide, which attributes of elements should be stored. For example, if we are creating database of cities on the map, there is advisable to store the old name of the city, current name of the city, population category and some other attributes depending on the map symbols. For every map element on the map should be created one feature class with appropriate attributes. Attribute domains should be well described in the data model documentation. Once we have created the data model (feature classes, attributes and attribute domains) we can start with filling up the database. The image of old map (usually scanned) is opened in desktop GIS software. There is necessary to transform the original image into well defined coordinate system that could be used if it is needed in the future. This transformation may not change the spatial relationships of map elements. Therefore, the similarity transformation must be used. For doing that, it is important to find very well significant point as coordinate origin. The direction of coordinate axes should be defined by other significant point (defining one of the axes). We found out, that the best solution is to choose two symbols for cities and use them as written above. After the transformation, the image of the old map is prepared to digitizing.

Map symbols are digitized as point or line feature classes. Their attributes are stored together with the spatial information into the geodatabase. The final product is the database of all map elements of the old map in defined coordinate system. This database can be used for next research. We started with the oldest map of the Bohemia, Klaudyan's map. This map is very valuable, till today survived only one original printed copy. Klaudyan's map has untypical south-orientation. The map was created by Mikulas Klaudyan in 1518. The map image contains 280 point symbols of settlements. These are distinguished according to the king's towns or other towns and towns with a catholic or protestant church, with map symbols. Besides towns and castles, some rivers are displayed also on the map. Trade routes are symbolized by miles-dots.

After creation the data model of this map in ArcGIS software we transformed the map into defined coordinate system. As the origin the town "Kladsko" was chosen. The direction of the "x" axis is defined by the town "Frydlant". In this coordinate system, all map symbols were digitized and stored into the geodatabase. Now we have the digital model of the map in vector form that can be used for the georeferencing.

In the first phase the global transformation models to the contemporary system S-JTSK were tested. All digitized towns (except one that was not found) were used as identical points. Testing many types of transformation gave us interesting results. The affine transformation (the first-order polynomial) gave the RMS error 14.3 km, the second-order polynomial transformation gave the RMS error 12.7 km, and the third-order polynomial transformation gave the RMS error 10.5 km. The image of the map was badly distorted using second- and third-order polynomial transformation. After omitting 33 identical points (with high residuals) the affine transformation gave the RMS about 10.0 km. This global transformation was chosen as the best, because of better preserving spatial relationships.

The local transformation models are being tested now. IDW (inverse distance weighted) and TPS (thin plate spline) transformations are probably the best solution. Other old maps are being digitized also and will be transformed as well. The aim of our project is to transform these maps into contemporary coordinate system S-JTSK. After that, we will be able to say, which map elements keep their position, and which are moving (e.g. rivers). We will be able to recognize how the newer maps were influenced by older ones by comparison of map images. Georeferenced data can be also used for finding some disbanded castles or towns. The output of our project will be also the table with spatial characteristic of maps (in fact their spatial precision).

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Application of New Visualization Methods with Interactive Elements for Monument Preservation

V. Králová*, J. Höhle, K. Pavelka***

veronika.nemcova@fsv.cvut.cz

*Department of Mapping and Cartography, Faculty of Civil Engineering, Czech Technical University in Prague, Thákurova 7, 166 29 Praha 6, Czech Republic

**Department of Development and Planning, Aalborg University, Fibigerstræde 11, DK-9220 Aalborg, Denmark

This project is based on modern visualization methods used in photogrammetry and computer modeling for monument preservation. We work with digital cameras and images, up-to-date hardware and software for getting and processing data from images. The goal of the project is to apply these methods to a historical monument, to create an information system of this monument. It includes a 3D model of the monument, a database with data, describing the monument, and a platform necessary for comfortable work with graphical data and database content. Interactive elements are built in this informational system. If you click on a chosen object of the 3D model, you will display the data describing this object. Our system will be available on the Internet. We have a platform, including a model and a database which you can view simultaneously. It also includes an administration system, allowing remote users to manage and edit the stored data.

For practical applications the citadel in Erbil, Iraq, was chosen as a worldwide known historical monument. The citadel is a place of 8000 years continuous settlement and it forms the historical core of the city Erbil. This project is unique because the whole citadel has never been documented before. Our system will store the data from archaeological excavations. Archaeologists will use this system and update the database. For general users of the system, there will be some restrictions.

The components of the system are the 3D model, the database and the platform.

3D model

So far, a wireframe of the citadel has been produced as a result of photogrammetric surveying of houses from the digital images and has been produced by means of the photogrammetric software “PhotoModeler 4.0”. The wireframe consists of points and lines and is exported into a CAD format file. We also have some terrain points because the citadel is situated on the top of a small hill. We need to edit the wireframe, texture the houses and the terrain and export the complete model with textures into VRML (Virtual Modeling Language) format. Then we are able to interconnect the model with a database. In the project, there is also a demand for connecting the model with satellite images of the inner part of the citadel and a ground vector plan of houses. For the purpose of texturing the houses, we have tested different kinds of modeling software. With a new version of the PhotoModeler (the version 6.0), we have good experience. Photo texturing and exporting to VRML works perfectly, but it is rather slow.

Database

The VRML export file was then connected with a MySQL database, containing detailed information on individual houses of the citadel. The VRML code was manually edited in the "VRML Pad" software to add links (anchors) to each house, referring to a dynamical web page (PHP) that lists the available information from the database for the given ID number of the house. The database content is composed of data describing the monument (e.g. building characteristics, type of damage, other photographs, etc.). The content and the structure of the database were created in the database administration tool "phpMyAdmin". It is a freeware tool intended to handle the administration of MySQL over the Web. Currently it can create and drop databases, create/drop/alter tables, delete/edit/add fields, execute any SQL statement, manage keys and privileges, and export data into various formats.

Platform

Using PHP (a language for creating the dynamic web pages), SQL (a language for communicating with the databases), and HTML (a language for creating web pages), we created the user interface for viewing the 3D model of the citadel and managing the content of the database. You can click on a house in the 3D model, and in the neighbouring window you can see all the information about this object stored in the database. If you are registered in the system and logged in, you can add or edit the information. It is also possible to add other images of the object, longer text descriptions etc.

The creation of the 3D model of the citadel still continues. The wireframe of the citadel is finished, the texturing of the houses is in progress. It is necessary to integrate the satellite image and ground vector plan of houses into the model to achieve natural appearance of the model. A trial version of main components of the described information system is also finished. It will be tested and improved in the near future. This grant is a part of PhD thesis of Veronika Kralova.

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Semiautomatic Edge Detection of Building Structure Using Laser Scanning Data and Digital Photo

J. Řezníček

jan.reznicek.1@fsv.cvut.cz

Department of Mapping and Cartography, Faculty of Civil Engineering,
Czech Technical University in Prague, Thákurova 7, 166 29 Prague 6, Czech Republic

In the last ten years, direct 3D documentation techniques are very popular and on big advancement. Historian or restoration specialist demands documentation of hundreds sculptures and monuments annually. Unfortunately, destruction, vandalism, wars, terrorism and environmental status are faster than documentation and restoration process. For preservation the good documentation is needed. Laserscanning is prefered technic.

The reconstruction of measured object from laserscan data can be done in several ways. The main difference in those methods is whether the process use meshed point cloud or raw points. Meshed point cloud is used when working with irregular shaped objects like sculptures. The final triangulated surface is than sliced with cutting planes. Different situation is with regular shaped objects (e.g. buildings, facades). Here we are more interested in vector model than slices. Lines, curves and other features are drawn in 3D space right into the point cloud. Three methods are usually used here. 1) Drawing in a CAD-based software (e.g. Menci software). Drawing is possible only in the plane, defined by manual selection of proper part of the point cloud. If we need to work in a different high level, new plane has to be defined first. With this method it is not possible to draw general curved spline crossing multiple planes (e.g. vaults). 2) Drawing in stereomode with use of the special crystal glasses (e.g. PhoTopol laserscan software). Model is reconstructed directly to the point cloud visible in virtual reality. 3) Automatic edge detection on meshed surface (e.g. Geomagic Studio, Inus Rapidform). The algorithm search for the parts of the meshed surface with high curvature and calculates the most probable position of the spline that can be manually edited. All above mentioned methods are based purely on the dataset from laserscaning which means that the reconstruction is done with some difficulties. The noise in the point cloud makes the drawing more difficult. The laser beam diameter has a value of several centimeters (depends on the measured distance) and so the corners and edges can not be detected precisely. All edges and corners are than rounded.

The proposed method overcome this problems by adding high resolution (> 4Mpix) digital metric images with known inner orientation of camera and calibrated lens. The combination of methods of laserscaning and photogrammetry has the advantage for both technics. With images, the point cloud can be precisely coloured. On the other hand, the 2D images can get the third dimension by referencing the point cloud (3D image). This principle is used in proposed method. The vector-based reconstruction of model is than simplified to simple vectorization of the “2D” image. Working in 2D environment is very easy and fast, especially if the software is CAD-based. Computer vision branch describe lots of filters that can do the vectorization fully automatically.

This solution requires the knowledge of geometric relations among the image and point cloud in 3D space. This is fully described by projective transformation. Its parameters

are derived from calculating outer orientation of the image. With knowledge of these relations, the 2D vectorization becomes the matter of 3D space. The minimum number of pairs of tie points necessary for calculating outer orientation parameters is six. Those points had to be referenced in the image and the point cloud. This is very important step that has the biggest impact on the precision of edge detection.

The main part of the work was to find the right algorithm for calculating the relative orientation parameters and automate the process of finding pairs of tie points in laserscan data and image. Manual registration seems to be very faulty and slow and so I worked with image correlation technic. First, the image representing laserscan data was generated. The solution was simplified, and the projection centre of image has been chosen similar to the laser machine. Than the image is generated as a projection of laserscan points to a plane with similar relative orientation parameters as image has. This image can have three types of color value representation. Most of the laser scanners have a small digital camera inside with the known relative orientation. Than, the point cloud can be exported with coloured points. Because the camera parameters are usually very poor, the color representation of pixels is faulty. Second option is to export the data with intensity values. Intensity (rate of emissed and incoming signal) is calculated automatically by scanner and because the value is recorded directly for every single ray of laser, the position precision is perfect. From intensity we get grayscale image that can be in most cases compared to a metric rgb image. Third option is to make dense depth grayscale image. The grayscale value represents radial distance from the center of the scanner. The relation to the metric rgb image based on daylight spectrum is very weak, but can be also used for correlation. In the next step, at least 6 points were located on the digital metric image. The location on the second image representing laserscan data was found by image correlation technic. Those picture coordinates were used for calculation of outer orientation parameters. Finaly the 3D image was generated. Vectorization was done manually.

This method was tested on the laserscan data of St. Bernard chapel in Plasy and portal in Bílina church. The software was written in Matlab 2006b.

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Industrial Architecture Gets Its Second Wind

P. Vorlík, B. Fragner, T. Šenberger, Z. Drahotušská

vorlik@fa.cvut.cz

Research Centre For Industrial Heritage, CTU Prague, Pod Juliskou 4, 166 34 Praha 6, Czech Republic

A collection of student projects presented in an exhibition organised during the 4th International Biennial "Vestiges of Industry" in September 2007, focusing on the applied new use of industrial heritage as a stimulus and instrument of regional development.

The objective of this exhibition and volume of student projects on the theme of the applied new use of industrial sites is to present alternatives to established planning and development practices. These projects confront the atmosphere and values of the industrial age with the contemporary aims of the architect and the real world of construction. The volume also contains comments from teachers and students, and it should therefore serve as a valuable aid in teaching and in planning work. Students' opinions tend to reflect the wider picture of the general changes in lifestyle, the environment, and attitudes, and provide a cross-sectional view of the state of contemporary architecture and architectural education at schools of technology, the humanities, and art.

Exhibitions and publications of this kind moreover do much to better inform the public about this topic and consequently also to protect the values and material substance of industrial sites. To this end, after the exhibition of student projects opens in the former grounds of Jeřábek's Ham Factory in Prague-Holešovice (symbolically, at the centre of the reviving industrial neighbourhood of Holešovice and in the raw industrial environment of the M Factory, revitalised according to designs by Olgoj Chorchoj Studio), it will then travel to other towns, and the published volume of work especially will be available as a source of information.

In the 2006 / 2007 academic year, the Research Centre for Industrial Heritage approached universities specialising in architectural education with a call for students to take part in this thematic exhibition. It is necessary to admire the willingness of the teachers and especially the students who took up this initiative as an opportunity to exhibit their projects outside the confines of the school and perhaps even to contribute to changing the way society regards and values industrial heritage. Many of the students clearly took the authenticity of the atmosphere of industry to heart and made the idea of sustainable development and the conservation of the vestiges of our collective past their own. However, it should also be noted that assignments in which students are asked to develop projects for the applied new use of industrial heritage sites has long been one of the more popular activities at universities. The frequency with which industrial heritage conversion projects are published in the professional architectural press is moreover a sign of the pressing and relevant nature of this topic today. Perhaps that, too, is why the disinclination of some of those approached to participate is surprising.

The projects included in the exhibition and the publication were submitted by students from the Faculty of Civil Engineering and the Faculty of Architecture at ČVUT in Prague, the Academy of Arts, Architecture, and Design in Prague, the Faculty of Art and Architecture TU in Liberec, and the Faculty of Architecture VUT in Brno. The forum for this confrontation of ideas was organised by the Research Centre for Industrial Heritage ČVUT in Prague as part of the 4th International Biennial "Vestiges of Industry" 2007.

Each of the student projects addresses a very specific assignment of converting a selected industrial site or zone, but each project also incorporates conceptual and more general ideas about formulating value criteria and strategies of urban development.

From some of the projects it is apparent that the powerful atmosphere evoked by a deserted site can at times be detrimental, because it influences the creators of such projects to such an extent that they rely more on their feelings and their emotional artistic perception of the topic and a rational analysis of the site's historical context is somewhat overshadowed. Nevertheless, all the student projects are united by an effort to preserve at least something of the site's genius loci. The conceptual focus and key to a successful project seems above all to be the right choice of a new function.

An interesting motif that runs through most of the projects is the emphasis on meeting spaces, communication, culture, and pleasant environments and an effort to revive and invigorate a space – perhaps as a reaction to the directed, mechanical, and impersonal planning conducted by the socialist apparatus. But this tendency may also be a result of the post-modern humanisation of the living environment or be influenced by the poetic atmosphere. Or it may simply derive from the fact that avid sociability is a natural part of student life.

Many of the views are based on a concept that in this country unfortunately has thus far only been reflected in academic circles. This is the assumption that the revitalisation of industrial heritage cannot be viewed as just a one-off investment effort and instead must be conceived as a long-term project – divided into stages and incorporating flexible strategies or creating the right conditions for natural, long-term development – and as an environment that will have a higher utility value because it is able to respond better to the changing conditions. This very broad spectrum of approaches to this understandably also reflects the diversity and innovativeness of contemporary architecture, ranging from Utopian, poetic, and graphics-inspired visions, to Neofunctionalist aesthetics, the prevalence of which obviously stems not just from current events but also from the rationalism of the industrial structures the students were working with. The selection of materials also usually has a strong influence on the atmosphere.

The powerful atmosphere of industrial heritage almost eliminated the differences between individual schools and studios – each project was more a reflection of the individual nature of each student, sometimes slightly steered by their teachers (but not necessarily). In this regard it is interesting to compare identical assignments addressed by different studios, showing that a simulation of the real environment is somewhat lacking from the assignments in school. A single assignment is addressed in one case purely in terms of urban development, in other in terms of landscape, in another as an interior, or eventually as an unrealistic Utopian vision. Perhaps this is a mistake – students enter into practice unprepared to confront reality. Or maybe this is a good sign, that they are still able to dream, usher in fresh air, and inspire.

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Check Execution of Earthmoving Works by an Automatically Controlled Dozer

T. Křemen, J. Pospíšil, B. Koska

tomas.kremen@fsv.cvut.cz

Department of Special Geodesy, Faculty of Civil Engineering, Czech Technical University in Prague, Thákurova 7, 166 29, Praha 6, Czech Republic

Automatically controlled earthmoving machines are currently beginning to find use during carrying out extensive earthmoving works as for example building motorways. It is possible to achieve significant time, material and fuel saving and also labour force saving by using automatically controlled earthmoving machines. Automatic control systems can be installed in many types of earthmoving machines as dozers, diggers, graders etc.

Automatic control systems consist of several basic components: a control unit, a hydraulic system operating a tool and a navigation system. Two types of navigation systems are used in earthmoving machines – a total station (TS) placed outside the machine pointing a receiving and a transmitting sensor placed on the controlled machine and a global navigation satellite system (GNSS) consisting of a reference station placed outside the machine and a station placed on the controlled machine.

This is description of the working procedure of an automatically controlled earthmoving machine: Firstly, a digital version of the ground work project is prepared, this version is recorded into a control unit installed together with hydraulics into the machine. A navigation system is prepared afterwards. When using a TS it is necessary to ensure direct visibility between a machine and a total station in the working area. Only one machine can be operated by means of the TS. Direct visibility does not have to be ensured when using a GNSS. More machines can be operated by means of a reference station. At this moment, the engine driver is already wheeling the machine through the adjusted locality and the automatic control system is already setting a tool into a correct position by itself.

Introduction of automatic machine control results according to manufacturers in significant fuel, material and time saving and increases execution accuracy of earthmoving works. Unfortunately, most manufacturers do not state concrete examples of savings. That is why an experiment with an automatically controlled dozer by means of a GNSS was conducted within a grant number 103/06/0617 called “Influence of using progressive technology on acceleration of technological and measuring processes”. Checking of earthmoving works by geodetic methods and its results will be described in more detailed way in this article.

The experiment took place from 6th to7th November 2007 on a field situated in cadaster of the Lahovice municipality. The earthmoving works themselves and stabilization and measuring three points of the local system of coordinates by means of the GNSS took place on the first day. Checking of the earthmoving works by geodetic methods was carried out on the second day.

The earthmoving work project used in this experiment contained a digital terrain model (DTM) of the background layer of the traffic way. It was a 90-metre-long plane section, on which two counter sweeps with radius of 15 m and alpha angle of 104° were situated. It came to significant changes in transverse tilts of the background layers in the whole section.

Two geodetic methods, a space polar method by means of a total station and a terrestrial scanning system [1] were used to check execution of earthmoving works.

For the purposes of check measurement, the TOPCON GPT 2006 total station was placed approximately in the middle of the area of interest and connected to the local system of coordinates. 100 detailed points in 15 transverse profiles were measured. The whole measurement was executed from one standpoint.

The point field was compressed by one point to four points for purposes of the check measurement by the Leica HDS 3000 terrestrial scanning system. Then the point field was signalized by special targets and measured by the laser scanning system for connection of the check measurement into the local system of coordinates. The scanning system was placed approximately in the middle of area of interest so that as big part of the adjusted surface as possible were seen.

Processing the measured data from the total station was carried out in the Geomagic Studio program, where a DTM of the area of interest was created from the measured detailed points. The data acquired from the scanning system were first processed in the Cyclone program. Then they were converted into the Geomagic Studio program, where they were diluted and where a DTM of the area of interest was created from them.

Evaluation of both check measurements were carried out in the Geomagic Studio program. Digital models of height differences between the projected DTM and the DTM from measuring by the total station and from measuring by the scanning system were created. A difference model between the DTM from measuring by the total station and the DTM from measuring by the scanning system was created afterwards.

It implies from evaluation of the check measurement that difference of heights between the project and the check measurement by the total station moves in the range from 0 to -80 mm (model of the total station is lower). Difference of heights between the project and the check measurement by the terrestrial scanning system moves in the range from +60 to -40 mm. Difference of heights between measuring by the total station and measuring by the terrestrial scanning system moves in the range from +20 to + 80 mm.

It implies from results of the conducted experiment that execution of the earthmoving works by the automatically controlled machine is accurate with respect to objective conditions of execution of the earthmoving works. Standard deviation of execution of the earthmoving works from the project is approximately 30 mm. According to the achieved accuracy of execution of the earthmoving works by the automatically controlled machine it is possible to recommend definitely automatic control of the earthmoving machines.

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Cartographic Presentation of Settlements on the Old Maps of Bohemia

M. Mikšovský, R. Zimová

zimova@fsv.cvut.cz

Department of Mapping and Cartography, Faculty of Civil Engineering,
Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

The cartographic works, maps, map series, state map works, globes etc. represent a part of the national culture. The maps show the geographic picture of the landscape and its dynamic changes in the given period. This claim applies especially to the period limited by the years from 1518 until 1720, when ancient maps of the Bohemian territory compiled by individual cartographers originated. An initial study of the research aimed at identification and assessment of regularities in successive evolution of cartographic language, namely the cartographic presentation of settlements, on the following investigated maps: the famous map of Bohemia of Nicholas Claudianus (1518) and further the maps of Bohemia of Johann Criginger (1568), Paul Aretin (1619) and Johann George Vogt (1712).

The only original print of Claudianus' map of Bohemia is kept in the Episcopal library of the Litoměřice archdiocese in North Bohemia, nevertheless this beautifully decorated map has been re-printed many times till present. The map was also overprinted in the famous Műnster´s Cosmography. The map of the scale approximately 1 : 637 000 is remarkable also by its southern orientation. The topographic content of the map consists of 280 signs of topographic objects with their geographical names. Cartographic presentations of settlements involve 37 Royal towns, 53 feudal towns and 59 other towns and villages and 131 castles, monasteries, mansions and strongholds, which differ by the signs and the type of letters. The Royal towns are marked by a crown, feudal towns by a shield, both described in larger letters. Catholic towns have a picture of crossed keys added to their symbol, the Utraquist towns a picture of a chalice. The other places are signed by a partly closed circle, castles or monasteries by the picture of a tower.

In the year 1568 Johann Criginger issued a map, which contains the sketch of 224 towns and villages at the scale approximately 1 : 683 500. One copy of this map is kept in the library of the Prague Strahov monastery, the second one was found in Salzburg (Austria). The copy of the map is a part of the well known Ortelius Atlas Theatrum Orbis Terrarum. It was published in an improved form by the significant Dutch cartographer Gerhard Mercator as well. The settlements are represented by four kinds of symbols: a group of buildings in a plane for towns, small towns and villages; a picture of buildings on a hill for castles; a church with two spires for some places with known monasteries; an isolated symbol of a simple cottage for small settlements.

In the 17th century the Prague citizen Paul Aretin issued a relatively detailed map of Bohemia (1619) with 1157 towns and villages, which was often published in Dutch and English atlases. The map scale was 1 : 504 000. The map includes the political division of Bohemia into 15 districts. The description of settlements distinguished between free Royal towns, smaller Royal towns, baronial towns, castles, fortresses, monasteries, small towns and

villages. Larger settlements are presented by quite complex pictorial signs accompanied by symbols listed in a map legend (crown, cross, pike etc.).

The so called Vogt's map, a fairly large and detailed map of Bohemia of the scale approximately 1 : 400 000, was published in Frankfurt o. M. in 1712. Except from towns and villages, rivers and main mountain chains it presents by conventional signs also the mining of mineral resources (gold, silver and other ores) and ironworks, glass factories and vineyards. The map contains fortified towns, other towns ("civitates"), smaller towns, castles and fortresses, monasteries, villages, chapels, ruins, corn-mills etc. – in total 3110 localities. Larger settlements are presented by pictorial signs (including fortification), smaller towns and villages by a simple circle which may be supplemented by simple symbols presented in a map legend. Apart from conventional symbols the map contains also some perspectively drawn miniatures (e.g. for the castle Bezděz).

The development of cartographic language has been documented on a set of selected settlements of various types (Rakovník, Kadaň, Pelhřimov, Benešov, Litoměřice, Konopiště, Křivoklát, Zbraslav). In addition to the cartographic presentation of settlements, the variety of their geographical names on the above mentioned investigated maps has been traced. The names of the settlements on Claudianus' map and Aretin's map are mostly written in old Czech (e.g. Pelrzimow, Pelhrzimow). The nomenclature of Criginger's map is influenced more by old German or Latin (Pilgram), some of the geographical names on Vogt's map are bilingual, other adapted to the German manner of spelling.

Presented research is focused on depiction of settlements and geographical names on the old maps of Bohemia. It is a part of initial contribution outlining the orientation of the research of the development of the ancient map cartographic language within the grant project focused on cartometric and semiotic analysis and visualization of old maps of the Czech Lands from the period 1518 – 1720. The set of the investigated maps will be enlarged with the ancient maps of Moravia and Silesia and the research will continue towards the identification and assessment of regularities in successive evolution of cartographic language of the maps.

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SPOT Image Pre-processing Level for Change Detection

L. Halounová, V. Berková

veronika.berkova@fsv.cvut.cz

Department of Mapping and Cartography , Faculty of Civil Engineering,
Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

Geometric correction and image registration are important for change detection; the objects of interest in multitemporal imagery are spatially matching. Scene-dependent variables, such as varying atmospheric conditions, illumination angles and sensor calibration coefficients influence result of change detection and must be accounted for. This paper presents the pre-processing level of SPOT images as an important part of the change detection.

Raw uncorrected satellite images commonly contain severe geometric distortions. For the study of a dynamic process (change detection), multitemporal data must be geometrically registered to the map base or at least co-registered. Wrong registration can result in apparent scene disparities. These disparities would represent false land cover change indications due to different observed targets in two time levels. Moreover, satellite data pixels have to be related to exact ground locations to allow a direct per-pixel comparison with other spatial data (e.g. topographic maps). The process of geometric correction involves identifying several clearly distinguishable points (Ground Control Points) such as road-intersections or corners of buildings in the distorted image and matching them to their true position in ground coordinates. True ground coordinates can be defined by a map, either in the paper or digital format (image to map registration), or another image which is already rectified and acts as a reference image (image to image registration).

Multispectral SPOT images with 10 m resolution (High Resolution Instrument HRG on SPOT 5 satellite) or 20 m resolution (High Resolution Instrument HRV on SPOT 1, 2, 3 satellite and on satellite SPOT 4 HRVIR) were ordered since the year 1989. Multispectral SPOT images comprise green, red, near infrared and short-wave infrared bands. The data were ordered at 1B preprocessing level. Preprocessing level 1B contains radiometric corrections of distortions due to differences in sensitivity of the detectors of the viewing instrument and geometric correction of systematic effects (panoramic effect, Earth curvature and rotation).

Image to map registration was used in the project. SPOT images were geometrically corrected to the ground base of geographic data in the Czech Republic – ZABAGED. It is the vector format map in 1:10 000 scale and in the S-JTSK coordinate system. The first-order polynomial transformation was used yielding better results (smaller rms error for all GCPs - less than 1 m) than higher-order polynomials. The nearest neighborhood method was applied for resampling.

The digital number (DN) of a pixel of non-standardized satellite imagery received from the data provider affected two groups of factors - factors related to the surface (composition and structure of the vegetation, surface exposition, spectral brightness of the soil background) and circumstantial factors (solar elevation, sun-earth distance, sensor look-angle, sensor radiometric calibration settings, pre-processing from the data provider, atmospheric conditions and other environmental factors).

For image standardization, which is aimed to minimize circumstantial factors, two different approaches can be used – absolute and relative correction methods. Absolute image correction methodologies consist of a conversion of DN values to surface reflectance units. Surface reflectance is regarded as a fundamental property of the surface observed by the satellite sensor. In relative correction approaches these factors are not accounted for. Mutlitemporal image normalization is achieved by defining a reference image and normalizing the other images to this reference. Although relative calibration can successfully normalize DN values for change detection applications, the methods cannot eliminate atmospheric impacts. Thus, relative calibrated data is not suitable for quantitative analysis such as image rationing. After a review of various image standardization methods it was decided to apply an absolute image standardization methodology.

This radiometric correction is necessarily provided before geometric correction, while the digital number of a pixel is unchanged through the resampling process. Atmospheric correction which we used is described in [1]. This modified methodology (referred to as the COST – model) was selected to carry out the atmospheric correction. The general equation incorporated in the correction model is mentioned in [1].

Testing of map algebra methods and image classification methods along the highway connecting Prague and the northern Bohemia is ongoing. SPOT images acquired on Sep-25 1992, on Jun-8 1996 and on Oct-9 2005 were first used to demonstrate their utility for temporal change detection in land use. Different change detection techniques such as image differencing, image rationing and image regression were attempted to assess the amount of change in the study area. The best of them will be applied for other remote sensing data to obtain complete results of the new industrial units, business areas, and other human activity localities in the highway buffer zones for all found changes.

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Simulation model for sustainability appraisal of urban development

Prof. Ing. arch. Karel Maier, CSc
Ing. arch. Jakub Vorel, PhD
Mgr. Jiří Čtyroký
Ing. Filip Drda
Ing. Aleš Vokáč

jakub.vorel@gis.cvut.cz

Department of Spatial Planning, Faculty of Architecture, Czech Technical University in Prague, Thákurova 7, 166 34, Prague 6, Czech Republic

The assessment of sustainability development has become a common part of urban planning practice. So far there are not explicit and operational criteria that would help the public as well as planning offices to assess ex antem the benefits and costs that the planning concepts bring to the territorial and community development.

The goal of the reseach was to create a model that would enable in advance evaluation of the impact of the planning concepts that are operationalized in the forms of planning documents, prescriptions and regulations on the future quality of the environment. Several requirements result from this goal, the tool should:

- present alternative scenarios of future development in long-term horizon;
- enable a user to evaluate the effectiveness of the investment into public infrastructure and the impact of the land-use control;
- be adaptable to locally available data and it should be accessible to experts as well as to the public without requiring exessive technical equipment on the part of the user.

The model is based on the following assumptions:

- Number of active agents acts in territory. By following their own "selfish" aims, they change the use of territory. The strategic goal of the individual free agents is to maximise their own utility ("satisfaction").
- The development value can be menaced by mutual incompatibility of neighbouring land-use activities, inconvenient or nonexistent access to infrastrucure and unconvenient scale of functional zones and urban tissue.
- Planning has considerable impact on the development of the territory by imposing limits and regulations.
- The territorial development is influenced by the investment in infrastructure: transport, utilities, facilities and by provision of services.
- Any change of use is conditioned by spending transition costs – demolition, construction, new infrastructures, releasing limits on regulations.

The model intentionally abstracts from the non-spatial economic principles and it focuses explicitly on the effects resulting from the spatial location and functional compatibilities of the cells. Therefore the model cannot be considered a classical economic model that derives the value from the yield from particular use of land.

A user of the model determines the initial state of territory and the factors that will influence the future development of land-use. The output of the model includes the set of scenarios that presents alternative ways of land-use allocation. The scenarios can be confronted with each other on the base of quantitative and qualitative criteria. Visualization makes it possible to judge the spatial configuration of funtional zones, built-up areas, the size and configuration of monofunctional clusters.

Quantitative judgement is posible based on numeric indicators:

- amount of total "satisfaction" change (functional fit);
- amount of "satisfaction" change coming out of total functional fit;
- amount of public expenditures and their impact on the total "satisfaction" (effectivity of public expenditures);
- cost of overcomming the development tresholds of future development;

Based on the outputs presented it is possible to make the assessment of how the public investment in infrastructure, spatial land-use limits and regulations will impact the dynamics of land-use changes and overall configuration of built-up areas with regards to the open landscape.

The model validity is based on the correspondance of the modelled processes with the real world processes. The model, assuming that the complex processes can be decomposed on several partial processes, assess the validity of each partial process on its own. It is possible to decompose each process on single variables, their states and the transaction rules.

Apart from the objective description of the factors (land-uses, limits, planning regulations, and transformation costs) the model uses also the subjective information inserted by the authors of the model or the model users. The model keeps the processes transparent and it distinguishes the transactions that are based on descriptive and normative knowledge.

The value criteria that are implanted into the model correspond to the values of selected groups of experts (expert focus group): in this case the values express the consensus of model authors. It is intended to verify these inserted values by representative sample of respondents.

Scenarios of future development being just hypothetical, it is impossible to verify the correspondence of model outputs. Their realization is based on both known and unknown factors. At this moment it is hard to assess the predictive power of the model; in future the historical data can be used for the assessment of predictive power of the model.

From the technical point of view the model is web application. The processes are distributed between the server and clients. Majority of model functionalities are located on the server side so that the clients' side could be as simple as possible. The best reason for this arrangement is that the model will be continuously calibrated and upgraded by the authors. The advantage is that clients do not need any installations on their part.

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Verification of levelling and level instruments for measuring vertical shifts of buildings on brownfields

J. Suchá, J. Pospíšil

jitka.sucha@fsv.cvut.cz

Department of Special Geodesy, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

We deal with the issue of measuring vertical and horizontal shifts by reasons of observing state of current and new objects and their influence on the near environment. All buildings are influenced by various factors that affect their stability and functionality. When measuring shifts we gain information about how surrounding influences affect the building and on the contrary, how the building affects the subgrade, whether it does not have a negative influence on the surrounding objects and last but not least about how it behaves in terms of safety during comparison of the measured data with the expected data. The concrete measuring and comparison of optical-mechanic and electronic level instruments was carried out on the dam of the clarifying basin in the premises of the Vápenka (Limeworks) Vitošov s.r.o. Plant after increasing the dam by 8m. The Vitošov s.r.o. Limeworks is situated in the North Moravia in the district of Šumperk, approximately 7 km far from Zábřeh na Moravě and belongs to the three biggest limeworks in the Czech Republic.

Measurement of the zero stage was carried out by the geodetic company ing. Jiří Olšar -ZEMĚMĚŘICTVÍ JESENÍK between 13th and 17th October 2005. Criteria for a high-precision levelling were used for measuring itself. The digital level instrument WILD-LEICA DNA 03 and the optical level instrument ZEISS NI 007 were used for measuring. When contracting the work, the regular half-yearly observation of shifts of the dam by the Zeměměřictví Jeseník Company was supposed. Later the management of the Vitošov s. r.o. Limeworks decided to give up the half-yearly measurings for financial reasons and planned the next measuring only for autumn of the next year, i.e. after approximately one year. Therefore it was necessary to add measuring of the 1st and the 2nd stage within the research. These measurings were carried out without cooperation with the Zeměměřictví Jeseník Company when using aids and instruments from the inventory of The Department of Special Geodesy, ČVUT, The Faculty of Civil Engineering. Measuring the 1st stage was carried out from 27th to 28th May 2006, the 2nd stage from 19th to 20th August 2006 and the 3rd stage from 14th to 16th October 2006. The digital level instrument SOKKIA SDL2 and the optical level instrument ZEISS NI 005 were also used for measuring in the next stages.

Points are divided into reference points and observed points for purposes of measuring vertical shifts. Reference points are points with known height. We determine heights from them and thereby also vertical shifts of the observed points. The reference (starting) point for the zero observation stage was point no. 2072, the verifying point of this benchmark is benchmark 2073. Three new points SB1, SB2, SB3 were further created especially for purposes of observing geodynamic changes of the building. Heights of points 2073, SB1, SB2 a SB3 were determined from levelling of height network in the year 2005. 12 points K1 – K12 were created for purposes of observing height changes of the dam. Points K1 – K5 are placed on the fill slope, K6 – K8 are placed on

the first storey, K9 and K10 on the second storey and K11 and K12 on the buttress wall over the ammunition stock.

The goal of this article was to describe very briefly the issue of observing vertical shifts and to carry out comparison of opto-mechanic and electronic level instruments. This evaluation should be carried out on the basis of results from measuring on the object of the slime pit dam in the premises of the Vápenka (Limeworks) Vitošov s.r.o. Plant. On the basis of the calculated values it was found out that it came to vertical shifts on all twelve observed points. The most distinctive shifts arose on the fill slope between the zero and the first stage amounting to several centimetres. The shifts between the zero and the 1st observation stage are very probably caused by finishing works on the fill slope that were carried out soon after focusing the zero stage. Shifts on the next observed points, placed on the first storey of the dam, were a bit smaller. The most distinctive shift, amounting to several centimetres, was noted on point K7. Shifts on the remaining two observed points of the first storey are several millimetres. The observed points on the second storey and the dam buttress walls showed the smallest shifts. Values of these shifts are several millimetres. These shifts can be caused by settlement of the whole building. It can be concluded from the observation results that the whole building moves, and therefore it is in principle suitable to recommend further observations in the next years. The final decision must be nevertheless left to the static experts.

In the end it can be said that the basic demands and conditions stated by the chosen method were kept during measuring. The calculated marginal divergences were kept when using all types of level instruments. With respect to demandingness of the terrain and length of levelling line approximately 2 km. Operating time was about twenty hours for opto-mechanic level instruments and about fifteen hours for electronic level instrument. This definitely proves big time saving when electronic level instruments are used. Moreover, the inbuilt software enables continuous check of gross errors and carries out check of the parameters of the measurement (i.e. minimum height of sight over the terrain). It is therefore obvious that these instruments provide definitely higher comfort during measuring and for these reasons they can be preferred to opto-mechanic instruments for measuring vertical shifts of buildings on brownfields.

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Section 15

TRANSPORTATION, LOGISTICS, ECONOMY, MANAGEMENT

The Environmental Accounts System from the Microeconomics and Macroeconomics

Viewpoint

H. Pačesová

Hana.pacesova@fs.cvut.cz

Department of Management and Economics, Faculty of Mechanical Engineering, Czech Technical University, Horská 3, 128 00Prague 2, Czech Republic

Our body and our world constitute a more general extension of our initial ego and subsequently of our wider world. The ground that we step with the mountains and the plains, the lakes, the seas and the islands, the smells and colours, the sounds, the sky with the sun during the day time and the stars at the night as well as the noisy state with our similar constitute the essential natural space for each operation of our existence. This space that encompasses us and through this it is realized each operation of the human being was initially determined as a term with undesirable clarity from the ancient Greek pre-Socratic philosophers through the concept of the content.

The content according to the ancient Greek philosophers constituted likewise the multifarious and a complicated socio-economic natural system which as a whole contain us in a shape of aq closed space. Also the content as a concept describes with an absolute clarity the functional relation of the human and his activities as a subset af actions which is always contained inside a wider total and this content constitutes a constinuous mutual covering and inerrelations framework. The degree of this interrelation exists in a point that the smaller subsystems are included inside the immediately biggest ones creating thus a compound and single complicated interrelation and interdependences context. The inter-content of its systems, of a more wider content creates a framework of interdependences without exists direction of dependence from smallest to the bigger subsystems or the opposite one, but the dependable factor is shaped by each case, from which is developed a corresponding activity, so that the bigger system /Macro-system/ and the included in this immediately smaller one /Micro-system/ constitute an inter-influences and interdependences chain.

Futhermore, one of the basic features of our systematic and multifunctional world inside which is realized every activity, is its continuous flow. The continuity of this flow in combination with the inter-content which distinguishes the separate subsystems of the multisystem of the content they are summarised also with the expression of the Ancient Greek phiklosopher Heraclitus. Everything flow, everything is contained and nothing remains.

According to the above conceptual approach the organisational segmentation of entirety of the content does not have any sense if it´s initially realized in three, four or more portals, actually the content constitutes an entirety, the question of the hierarchical segmentation is the consequence how each one facesit.

With the acceptance of the approach according to the reasoning of the three portals that is to say of the environmental, economic and social.

We realize that the content is immediately coincides with the concept concept of the wider environment. The concept of the content approaches with more clarity and completeness the operation of human actions on our planet due to the reason that these actions took place inside its content. Furthermore, the content constitutes a continuously altered, cohesive and continuous framework of socio-economic and natural character which is called

space-socio-economic being, which in short is formuilated with the following definition: With the space-socio-financial economic being term, we mean that territorial framework inside which is realized every financial or social action.

If the space-socio-financial economic being concerns the action of the total of institutional units that compose the national economy of country, then we refer to the Macro-space-socio-financial being. If the space-socio-financial being concerns the operation of institutional unit, then we refer to the Micro-socio-financial being.

Futhermore if the space-socio-financial being concerns the operation of the institutionalunits of territorial unit, then we refer to the regional-socio-financial being of the particular territorial department.

The content or according to others the environment conastitutes a real complwexity which is found in perpetual movement. thw continuous movement is distinguished by a total of complicated and multifunctional actions that creates a multi-framework system.inside this multi-framework system which distinguishes the world space-socio-economic being, they are developed two-basic estimation of influences systems that exercise the human activities to the environment. These systems are: The environmental account system and the sustainable growth account system. In spite that these systems oprate as communicated vesssels so much in the level of the objective and target level, their role is distinctive.

As regards the Environmental Accounts System aims in the measurement of the influences to the environment that mainly exercises the social and the financial activity of the man. The measurement of these influences is mainly based in the recording of emissions of waste - solid, liquid and gases.

The estimation of these emissionss of gases is mainly realized in combination with a series of financial and social charakter. These measurements are the GDP the employment and the others.

The establishment of the systematic principles and rulers regarding the recording, the estimation as well as the cross-correlation of these measuremrnts, constitute the content of Environmental Accountancy.

The sustainable growth Accounr System aims to the systematic establishment of rules and principles according to which are organised the indicators series though which is estimated the sustainable growth.

The determination and the representation of the dispensable situations through special indicators as they are the indicators of the sustainable growth constitute the most suitable way of approach of process which represents the sustainable situation.

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A Contribution to Pavement Skid Resistance Measurements in the Czech Republic and in Germany

Filip Hanzík

filip.hanzik@fsv.cvut.cz

Department of Road Structures, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Praha 6, Czech Republic

Skid resistance of pavement is an important factor influencing the road traffic accident frequency. The worse skid resistance the higher probability of a traffic accident. Furthermore, pavement skid resistance varies depending on life-time. In order to provide safe roads, measurements should be carried out not only at the checking acceptance trials and after the expiry of guarantee period, but also in appropriate intervals during the whole construction´s life cycle.

Basically, there are two important factors influencing skid resistance. The first of them is the texture of pavement (macro texture), characterized by depressions and elevations of the laid mixture. Because of them surface drainage capacity is ensured and they also prevent the appearance of aquaplaning, i.e. separation of tyres from pavement with a water film. That is especially the type of the used mixture what affects this property the most. The second factor is the property of used aggregate, characterized by its surface and by the number of edges, which come in touch with tyres. The property of the surface of an aggregate is often connected with the term micro texture. Micro texture is mainly affected by the resistance to polishing of the aggregate, determined by the PSV (Polished Stone Value). The higher the PSV figure the greater resistance the aggregate has to polishing and the better micro texture the road surface has. The optimum value is PSV $\geq$ 60, but such an aggregate appears in the Czech Republic very rarely and so for the extremely strained roadways it is necessary to require the aggregate with a PSV value in range from 50 to 56.

Measurement methods and skid resistance observations usually follow the mentioned data. Considering elementary methods used in the Czech Republic, the macro texture could be measured with the Sand Patch Method and the micro texture with the Portable Skid Resistance Tester (also known as the "Pendulum Tester"). Nowadays, there are no doubts that the best solution is to carry out the skid resistance measurements with dynamic skidding devices. In these days, especially TRT device is used in the Czech Republic. This device has been used to determine longitudinal friction since 1990 and has been the national reference device since 2005. Another option is using relatively new device Griptester, which is produced in Scotland. With TRT longitudinal friction (f_p) could be measured usually by the testing speed from 40km/h to 120km. Measurements on the highway, roadway and municipal road network is carried out in the regime of constant slide of measuring wheel 25%, naturally on the wet surface. The result is usually a dependence of longitudinal friction coefficient on travel speed, recalculated to the lowest year value.

Because of my current work internship in the laboratory PEBA Berlin I was able to compare testing methods in the Czech Republic and in Germany. In Germany, skid resistance is mainly measured with SCRIM (in German SKM - Seitenkraftmessverfahren) device, in some cases also with the Pendulum Tester SRT and with using Sand Patch Method. SCRIM (Sideway-force Coefficient Routine Investigation Machine), in contrast to TRT, enables to

measure sideway-force coefficient (SFC). The principle of the machine is that a test wheel, mounted mid-machine in line with the nearside wheel track and angled at 20° to the direction of travel, is applied to the wet road surface under a known load (1960N). The testing speed for the machine is 40, 60 or 80km/h; the track temperature must be from 5 °C to 50 °C. The force generated by the resistance to sliding is related to the wet skidding resistance of the road surface and measurement of this sideways component allows the sideway-force coefficient (SFC) to be calculated.

By the comparison of both dynamic devices (TRT, SCRIM) I found out that - in frame of comparison trials – relatively fair correlation dependence exists between them. This dependence can be expressed with using the following formula:

$$SCRIM = 1{,}14677 \times TRT^{0{,}977189},$$

where SCRIM is sideway-force coefficient measured with this device and
TRT is longitudinal friction coefficient f_p.

Because of the mentioned correlation dependence I was able to compare the requirements specified in the Czech Republic and in Germany. It has been proved that for the checking acceptance trials Czech requirements are up to more than 30% higher and requirements valid at the expiry of guarantee period are 20-25% higher than the German ones.

Nowadays, with relationship to implementation of European Standards in asphalt mixtures field, many discusions to the question of skid resistance and resistance to polishing have been held and various opinions have been formulated. It seems that the mentioned comparison should be used for formulating many requirements (PSV, f_p) so that their values correspond not only to road traffic safety, but also to requirements and possibilities of practice.

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Hour Overhead Tariffs Method and Its Contribution to Time Driven Activity Based Management

M. Zralý

martin.zraly@fs.cvut.cz

Department of Enterprise Management and Economics, Faculty of Mechanical Engineering, Czech Technical University in Prague, Horská 3, 128 00 Prague 2, Czech Republic

Recent management control is getting more and more time-driven [Cokins, Drucker, Horvath, Kaplan, etc.]. *Time* as an exact, measurable characteristic has an essential role in the effectiveness of the company activities (that combine into processes) and in the amount of a product's cost. The other recent decisive influences on management control are *growing sunk costs* of the installed capacity *of the resources* (equipments, intangibles, staffers) and also *the expected improved production performance* of these resources. These are the reasons why there is a focus on the reduction of the product unit time and also the maximization of the capacity utilization that supports the activities (that belong to processes). The Hour Overhead Tariff (HOT)-Method is a managerial tool that contributes to these improvements.

We started our research of *the HOT-Method* at the beginning of the 1990s. Its first practical application was in 1992 and others followed. A combination of theoretical research and the results from practical application in operations and services led to the specification of four alternatives of *the HOT-Method: Basic, Items, Vertical and Controlling* ones. Each alternative is based on the *hour overhead tariff (HOT)*, which is the ratio of the costs [CZK, $, €] and capacity [hours] of the particular entity (e.g., activity, process, center, department, workplace, worker):

$$\mathbf{HOT} = \frac{\mathbf{OC}\,[\mathrm{CZK}, \$]}{\mathbf{CAP}\,[\mathrm{hours}]}$$

The *Basic alternative* considers only one value of the HOT for the particular entity and time period.

In the *Items alternative* this single HOT value is split into more items according to the most influential costs (e.g.; personnel, space, maintenance costs, depreciations). This decomposition focuses on the higher HOT values, and it enables analysis of the significance in changes of partial costs on the total size of the HOT. Then it is easy, e.g. to indicate, how much can influence the changes in wages or the situation, if the lease payments are finished on the total size of the HOT.

The *Vertical alternative* operates with more (usually two) HOTs in one entity. Its applications in industrial companies are mostly in production or pre-production phases of product creation. In production phases are fixed a HOT for each workplace in the entity and a HOT for the common facilities of the entity. In pre-production phases are fixed a HOT for each staffer or a group of staffers and a HOT for the common facilities of the entity. Other significant areas of application are projection and advisory areas. It is a more labour-intensive alternative but enables a better capability for assessment and with more precise costing with changes in the cost amount or capacity utilization at the partial part of the entity is made.

The most effective alternative is the *Controlling alternative* of the HOT-Method. This one directly identifies the decisive factors causing the deviation of the actual HOT size compared to the planned one. This alternative can determine how influential are single key factors, which can affect the size of the HOT deviation between a planned and actual value.

Major areas of the *managerial benefit of the HOT-Method* are (a) *cost-capacity integrated assessment of the entity*, (b) more accurate and visible *product costing* and (c) *staff motivation.* The broad areas of an effective HOT-Method application are in activity-based cost management (ABC/M) projects and Target Costing procedures.

Hour Overhead Tariff includes time in its numerator - the overhead costs are mostly the "time costs" (from 80-100%), as well as in its denominator - capacity expressed in time measures (mostly in hours). Then the *entity assessment is tightly linked to the time characteristics*. *The staff motivation* has to be related to this measure. And it is appropriate measures, because the lower value of HOT, the better precondition for higher performance. In *product costing*, the costs linked to the particular product on each entity are calculated as the multiplication of the HOT of a particular entity and the time, which is consumed by product there. Then the costing for particular product is counted as a sum of costs over all the entities, which take part on product creation. The controlling role of a time is in this way of a product costing dominant. If the recent Target Costing procedures are based on time control, then HOT-Method is an excellent tool, to be applied.

To demonstrate how the HOT-Method can be applied to support the *integration among the technical* (with special emphasize on *time duration and time utilization*) and *cost characteristics, the Costing model-3P* was developed. It deals with cost control in pre-production, production and post-production phases of the product life cycle. *Model-3P* focuses on modeling how the technical characteristics of a product's design and the activities (or processes, or centers) influence the final cost size of a product. *Basic* and *Vertical* alternatives of the HOT-Method are applied in Model-3P in connection with variable costing using ABC/M principles and Target Costing procedures.

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Cooperation of University and Secondary School Teachers

B. Stieberová, M. Žilka

barbora.stieberova@fs.cvut.cz

Departement of Enterpeise Management and Economics, Faculty of Mechanical Engineering, CTU, Horská 3, Prague 2, 128 00, Czech Republic

The Department of Enterprise Management and Economics, Faculty of Mechanical Engineering, CTU in Prague and partners from Secondary Schools in Prague are taking part in the project "Cooperation of university and secondary school teachers in the technical-managerial-economical field". This project is being supported by European Social Fund, budget of Prague and state budget of the Czech Republic.

The objective of this project is to create an education course with emphases on technical-managerial-economical integration of business processes - the basic stone of this course is to inform about the latest findings in the field of enterprise management. The course serves as life long learning for secondary school teachers in this field. Further aims consist in the mutual experience exchange between university and secondary school teachers and in the development of relationship and close cooperation between university and secondary schools (for example in consultancy form).

The education course has been divided into 10 modules. The structure of particular modules is following:

A) Text part – these texts help participants to gain the basic overview on problematic and to identify connected integration linkages.

B) Computer models – these models has been created in MS Excel setting. They serve for illustration of particular integration linkages through visual model study cases. Furthermore they make testing of managerial tools on concrete cases possible.

C) E-learning part – this part enables self-study of participants, revising and testing of their knowledge and skills. E-learning as complementary part of this education course has been elaborated in attractive multimedia form to increase the effectiveness of whole course.

Course modules:

Module 0: Objectives, sense and tasks of the project and its solution

Module 1: Structure of enterprise management system (it provides an overview of actual conception of enterprise management, it explains structure and content of business plans, it presents actual managerial tools)

Module 2: Creation and monitoring of product and capacity enterprise plan (it explains problematic of integration in the process of annual product enterprise plan creation in the context of complex enterprise planning.)

Module 3: Relationship between non-financial and financial plan (it shows the structure and the creation process of the annual general enterprise plan, the content of its parts and link to the accounting, it points out the integrative linkages between non-financial [ks, kg, m^3,…] and financial part of general enterprise plan, which represents reflection of non-financial part in financial units [Kč, USD, EUR,…].

Module 4: Budgets of units, processes and activities (it brings out the role, the content and the structure of budgets of units, processes and activities in the enterprise management, principles of creation and of evaluation of budgets)

Module 5: Cost control and Calculation (it shows the role of costs and revenues in enterprise management, cost analysis and cost structure and it describes approaches of calculation as

HOT method and Target Costing method. The linkage between calculation and non-financial management, budgets, accounting and operative evidence is stressed.)
Module 6: Cost and financial impacts of investments (it presents basic approaches in decision making process of investments, most frequent types of investment financing and its impacts)
Module 7: Principles of human resource management (it stresses the importance of HRM as integral part of enterprise management)
Module 8: Mathematic methods as the support of decision-making (it takes advantage of the use of multicriterion evaluation of variants in the field of human resources management)
*Module 9: Easy IT support of managerial-economics calculation for decision making (*it is focused on possibilities of programming in Excel setting – easy creation of macros, basic elements of VBA language)

Examples of computer models:
Model PP shows connection of particular characteristics of processes, units and product design in the modeling of enterprise profit in dependence on the product structure.
Model 3P demonstrates the influence of technical factors of product and process, including time factors on its costs. It shows how every change of technical factor in preproduction, production and postproduction phases influences the cost level (useful for Target Costing).
Model NF demonstrates the influence of non-financial factors on financial plan. It models different t-m-e situations base on enter data. In this way it helps users to realize mutual linkages between non-financial and financial items of plan. Due to this model it is easy to understand three-balance system, its particular items and the linkages among them.

Concerning the instructional form the education course has been designed as the combination of two parts:
A) Seminar part where the participants will familiarize with the actual trends in business under the leading of the lector and where they will learn how to use the prepared computer models and where they will solve problems tasks in teams.
B) Consultation and self study part where the participants will study on its own with computer models and study texts, they will revise and verify their knowledge through e-learning and they will consult with lectors.

In November 2007 the pilot education course has started and it will be finished in February 2008. The content of the course will be adapted on the basis of the pilot verification and it will serve as life long learning for the secondary school teachers.

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Sustainability Performance Indicators – Key Proposals of Company Environmental Profile

Th. Beran

Theodor.Beran@fs.cvut.cz

Department of Management and Economics, Faculty of Mechanical Engineering, Czech Technical University,Horská 3, 128 00 Prague 2, Czech Republic

Development of a comprehensive framework for sustainability accounting is a necessary condition for making operational the conceptual aspects of the sustainability problematic. Why is a comprehensive framework needed? Because for sustainability accounting to be relevant, the principles behind sustainability need to be recognised. These principles include amongst others:

A. The need to consider the long term in decision making, conceptualized as taking intergenerational equity into account. In essence, sustainability accounting has to provide information for decisions that have both short and long term impacts and consequences.
B. The requirement to err on the side OF caution when making decisions that could lead to a serious threat to sustainability. Although fraught with operational difficulty this precautionary principle means, simply, take risks into account, identify them, recognise them, measure them where possible and balance the returns from corporate in an unregulated manner.
C. The provision OF information that supports the decisions on hand. If the decision relates to long term investment in heavy industrial capacity then ad hoc information about such lumpy decisions is required, as it ongoing regular information about progress toward expected outcomes of the decision.
D. The presence of metrics that assist decision making in the most relevant way possible. On some occasion monetary measures may serve this purpose- on others biophysical measures will be relevant- also it needs to be recognized that measurement may be so unreliable that it is best to use qualitative judgment supported by best practice guidelines for some decisions.

Size and number of industrial estates are expanding at a time when the world´s remaining natural ecosystem are rapidly shrinking, particularly in countries undergoing fast industrialization. This industrial development polices that encourage the concentration of industries can have major impacts on the environment, and human health and safety. These can lead to serious financial consequences as a result of increased health care costs, damage to coastal fisheries, water treatment costs resulting from water pollution, rapid depletion of groundwater supplies, restrictions in land use capability due to contaminated soil, traffic congestion and reduced worker productivity.

But responsible and sustainable methods can be applied to utilize resources without exhausting them. A collective sustainable management at the level of industrial estate can provide cost – effective services for a number of industries, like for example management of water, provision of environmental training and efficient treatment of wastes. The environmental estate management can enhance the competitive advantage of the estate, increase land use efficiency, increase land values in and around the estate, reduce infrastructure and servicing costs, encourage tenants not to move and reduce overall risk and environmental liability. There is clearly advantages not only for the regional development but also directly for companies, municipalities etc.

Industrial ecology, a quite recent science, consists in the establishment of natural ecosystem, the only living example with high evolution and viable in a long period as model for our industrial system. Industrial ecology advocates a new direction for industrial development . In an industrial ecosystem, the consumption of energy and materials is optimized and the effluents of one process serve as the raw a material for another process. Goal is to manage industrial estate like natural ecosystem, becoming only renewable energy and reusing all its wastes. If it is quite hard to reach such stage of evolution, an intermediate step should be more easy- an industrial ecosystem, which limits energy and resources input and wastes output.

This vision of management for industrial estate is now used like a regional development tool by promoting economic development and employment, introducing diversification within the industrial base of the region etc. The main effect of such a strategy is the improvement of the image for the region and companies.

The principal benefits likely to be available from the use and publication of performance indicators in reporting on environmental issues are that:

1. It is difficult to measure sustainable development directly so there is a need to look at environmental and other impacts via a range of performance indicators.
2. Stakeholders are often interested in particular issues, for which performance indicators can provide readily assimilated information.
3. Comparisons of the environmental impacts of an organization over time and between different organizations in the same sector are assisted.
4. Preparation and internal use of performance indicators encourages and facilitates management of the key issues.
5. In many cases, environmental indicators are not yet well defined, with the resold that data reported by different organizations operating in the same sector may not be comparable.
6. The methodology for calculating some of the performance indicators is complex and there is limited reference material available to provide guidance.
7. Underlying systems for recording and processing data are not normally integrated with mainstream information flows, posing a threat to completeness and reliability.
8. Credibility may be in doubt without some form of independent verification or assurance.

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Progress of Cargo Traffic Load on Highways

M. Uhlík, P. Mondschein

michal.uhlik@fsv.cvut.cz, petr.mondschein@fsv.cvut.cz

Department of Road Structures, Czech Technical University, Thakurova 7, 166 29, Praha 6

As the count of cargo transport rises, the quality of traffic is decreasing significantly. One reason for this is bigger strain on road construction leading to faster derogation and lesser safety, another outcome is traffic itself with when cars are significantly smothered by cargo transport. Entrance of Czech Republic to European Union and introduction of road pricing in Germany resulted in big increase of cargo transport in Czech Republic. This contribution is concentrating on development of cargo transport on Czech highways and expressways in last four years.

As the traffic load on roads increases, also the information about this load grows on importance. We can get this information from nationwide traffic census (that takes place only once in five years) or from automatic counters. It is this automatic traffic counting that is very important for us. It takes place on selected road and highway profiles and it gives us picture of traffic variants in whole year. When comparing data from different years, if gives us also general trends in increase of traffic.

In past years the network of checkpoints for automatic counting was built on Czech highways and expressways. Data are being collected by several types of devices. At the beginning there were only checkpoints for counting of passing vehicles, later on there were also checkpoint able to provide classification of vehicles. The most interesting for us are devices called "classifiers" or "analyzers" because with their data we can determine the traffic structure.

Primordially planned summary of development of heavy transport for last decade failed because of lack of source information about traffic structure for each year. From this reason we had concentrated only on development of intensities after entrance of Czech Republic to European Union, when inability to introduce electronic road pricing system dramatically increased the count of cargo traffic in Czech Republic.

Comparison of years 2003 to 2006 was quite difficult because automated classifiers and analyzers were broadly introduced in 2004. Some detectors were also damaged and data were corrupted. From this reason we limited ourselves only on several checkpoints that had credible data and that were able to provide information about traffic structure. We also needed checkpoints that were functional and credible for all four years. From that reason we had to lay off several checkpoints too.

We were comparing average day intensities in both directions (at two checkpoints on highway D2 it was necessary to use only one direction from the reason of credibility). Vehicles were divided on personal vehicles and transport vehicles (freight car, bus and trailer). As result values was set increase of vehicle count in percents and share of cargo vehicles in traffic.

The most complete system of automatic counting devices is on highway **D1**. **Increase of cargo transport after entrance of Czech Republic to EU** (comparison of years 2003 and 2004) **was between 10 and 40 %** and share of cargo vehicles has increased by 2 – 8 %. In year 2004 was this share between 29 and 39 %. **Increase of personal traffic was only about 6 %**.

In following years the increase of cargo traffic was not so significant, however it was still around 10 % in 2005 and 8 % in 2006. Share of cargo traffic on several checkpoints slightly exceeded 40 %. Increase of personal vehicles was minute, on several checkpoints there was even a decrease.

Increase of cargo traffic on highway D2 is even more significant. After entrance of Czech Republic to EU it was **63 %** on 2nd kilometer and **45 %** on 49th kilometer. In 2005 the increase on 49th kilometer was even bigger - **56** %. In 2006 was the increase similar to D1 – up to 12 %. **Share of cargo traffic** reached in this year maximum value of **56 %**. Personal transport on D2 is on the same level.

The biggest increase of cargo transport is on highway **D5**. Close to Prague, on 5th kilometer, it was in 2004 almost **57 %** and on 144th kilometer, near borders with Germany, even **82 %.** There was big increase on border checkpoint also in year 2005, when it reached almost **55 %**. In 2006 was this increasing trend slowed down, same as on other highways. Checkpoint near German borders has also the biggest share of cargo transport. In last two years it was **62%**. Increase of personal transport is also the most significant here. In 2006 it slightly exceeded 10 %.

The same trend in increase of share of cargo transport can be observed also on **R46**. **In 2004 it was 26 %, in 2006 only 6,5 %.** Personal transport is on the same level for several years now.

At last we would like to note that we entered into European Union in May 2004, that is in 5th month. That means that increase in 2004 was much more significant than it looks from our results because they show average numbers from whole year. Year 2005 shows us the impact of entrance of Czech Republic to EU on cargo transport (although there is one more factor there - introduction of road pricing in Germany).

It will be very interesting to observe trends in cargo transport after introduction of electronic road pricing system in Czech Republic. We would like to deal with this next year.

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Prediction of Residential Building Market

D. Vytlačil

vytlacil@fsv.cvut.cz

Department of Engineering Informatics, Faculty of Civil Engineering, Czech Technical University in Prague, Thákurova 7, 166 29 Prague 6, Czech Republic

The presented model predicts the changes of the residential building market in a certain region. The stock of flats in the Czech Republic includes 3.8 million flats in housing units and in family houses. 72% buildings were built before 1975.

Introduction.

The construction sector has been growing for last seven years quite fast. Most projects were realized in the fields of the infrastructure. The residential buildings sector had the share only 15% from all projects in the construction sector. In old EU countries it is 40%. It means that big potential exists but this potential will be different in the particular region of the Czech Republic.

The goal of the project was to develop the dynamic model that will predict the next development of the market.

Description of the model.

The model is based on a system dynamics method. This method allows us to develop the models that calculate the most important parameters in the investigated system in a certain time period. The model is built as the system of interdependent elements – stocks, flows and complimentary elements [1-2].

The most important part of the model is the supply chain that includes stocks: houses under construction and finished houses. These stocks are influenced by the starting rate element that represents the effort of the developers for new projects launching. The evaluation of the projects is based on the ratio between the square meter selling price and the construction price.

The construction rate is influenced by the capacity of the companies. The demand can be increased by new people arriving to the investigated region and decreased by buying houses from the stock of finished houses.

The model includes also elements representing the fact how the region is attractive for people (potential buyers) from other regions.

More detailed description of the model is given in [3].

Results.

The designed model was used in the region with 200000 residents and with 25000 newcomers per year. The simulation was done for the period of ten years.

The calculated parameters are:

- houses under construction, starting rate, construction rate, selling rate;
- construction sqm price, selling sqm price, land sqm price;
- project effectivity, demand for construction work, demand for houses;
- number of potential buyers, increasing and decreasing rate influencing stock of buyers.

Another investigation was done with the goal to find out the influence of buyers increasing on number of houses under construction. For this purpose the sensitivity analysis was done. Resultant graphs are depicted in [3].

Conclusions.

The model for the prediction of the changes of the residential building market has been developed. For the calculation in the specific region the model has to correspond to the local conditions. The use of the model can be described by the process:
Input data reflecting local situation in region → Simulation by means of designed model → Output data → Decision making and implementation of solutions.

The next development of the model will be focused on the introduction of the subsystems dealing with:
- project financing (to ensure financial resources for the developer),
- project financing II (to ensure financial resources for the customers),
- the influence of the resources on the capacity of the construction companies (to introduce the supply chain also for suppliers of the materials).

There are many other possibilities how to increase the number of the subsystems and the elements in the model but we have to consider only relevant elements that have the important influence on the simulated parameters.

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Simulation Models for Construction Company Management

D. Vytlačil

vytlacil@fsv.cvut.cz

Department of Engineering Informatics, Faculty of Civil Engineering, Czech Technical University in Prague, Thákurova 7, 166 29 Prague 6, Czech Republic

The paper presents simulation models that are used for teaching management of construction companies in Czech Technical University, Faculty of Civil Engineering and for the research work of Ph.D. students.

Introduction.

The construction industry comprises of 2355 companies with more than 20 employees. They finished in the half year 2007 projects for 55.6 billion CZK. It was more by 28.7 than in the half year 2006. It brings new problems in the economic environment. The construction companies suffer from worker shortage and from material shortage.

This situation is the challenge for the development of new management models for the prediction of the next development in the construction sector.

Characteristics of the models.

Models are used for finding solutions in these problem situations:

- Prediction of the market
- Management of supply chain - main production
  - materials
- Management of resources - workers
  - facilities

The methodology used in the models is the system dynamics [1-2]. During last two years these dynamic models have been developed: Residential building market prediction, Resource management in projects [3].

There are different kinds of using the models:
Understanding the behavior of the system → using ready-made model
Definition of output values → finding input parameters

The relationship between problem situation and model can be described by this chart:

Problem situation → Simulation models → Output from the simulation → Implementation of proposals
↑ ↑ ← Changes influencing model ↓ ↓
↑ ← Changes influencing reality ← ↓
Other aspects of the problem →

Conclusions.

The developed models are good basis for the investigation of very complex socio-economic systems [3, 4]. Results from the simulation increase knowledge concerning the system and the problem situation.

The use of system dynamics models improves the research work as well as learning process. The main advantages are:

- The real world experiments are very expensive
- The computer simulation compresses time
- Students can practise decision making without any apprehension
- The computer simulation brings new experience for students – they have the opportunity to improve input parameters but also to change the model structure

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Factors Affecting Correctness of Road Pavement Design

L. Vébr, P. Pánek, F. Eichler

vebr@fsv.cvut.cz

Department of Road Structures, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

On public roads serving for road vehicles only (as specified by respective provisions of Regulation No. 341/2002 [1]) the method of weighing vehicles "in motion" (Weighing In Motion, abbreviated as WIM), which represents the measurement of immediate pavement load by vehicle wheels or axles, is currently being introduced as part of today's trend for more detailed specification of traffic volumes.

Selected factors affecting correctness of road pavement design under TP170

Within the work on the project "Specification of the mathematical model of non-rigid pavements based on the evaluation of measurement results using the WIM system"[2], which is part of the research project of the Ministry of Transport CR "Accurate prediction of pavement surface service life. Specification of total weight, axle load and vehicle speed with no traffic flow limitations and investigation of their characteristics.", the researchers made computation simulations of the road pavement behaviour under real-life conditions and the comparison of actual input data with the data used by designers in the preparation phase of the design of the road pavement structural composition. They specified that the appropriate design and evaluation of the pavement construction under the design method TP 170 [3] is significantly affected, among other things, mainly by the following factors:

Coefficient C1 – expresses the proportional volume of heavy-duty vehicles (HDV) in the most loaded traffic lane and affects the design traffic load specification. In accordance with TP 170 it has the following values :

- for two-way roads with
  - one traffic lane in one direction ..... C1 = 0.50
  - two traffic lanes in one direction ..... C1 = 0.45

In the case of "K Barrandovu" Street, which is a four-lane dual carriageway, the C1 value considered in keeping with the recommendations of TP 170 should be 0.45. The situation on the road, however, is different: the vertical traffic signs installed here, IP 21a "Traffic lane limitations", ban the lorry drivers' driving in the left traffic lane, and so practically all heavy haul traffic keeps to the right traffic lane. This fact was verified within a "brief traffic survey", which discovered only one "heavy vehicle" driving in the left lane during the whole survey, which was a long-distance coach.

If we compare the presumed heavy haul traffic driving in the right traffic lane specified by using the coefficient C1 = 0.45 and reality, there is a 10 % difference (error) to the disadvantage of the road construction i.e. earlier pavement damage may be presumed (amounting to 2.5 years for a design period length of 25 years).

Coefficient C2 – expresses the fluctuation of vehicle tracks. Here, among other factors, the actual construction (wheel distribution) of the HDV chassis is applied where there is a contradiction between the "standard design axle" with two dual wheels on one axle as

considered in TP 170 and the most frequently operating HDV with only two single wheels on one axle (but usually with dual axles).

The "brief traffic survey" included the verification of the composition of HDV represented in the traffic flow. The survey resulted in a finding that the "truck train" most frequently represented in the traffic flow was composed of a two-axle tractor with a three-axle semi-trailer. This type accounted for 49 % of vehicles in the traffic flow. The expression of the proportional effect on the deterioration of performance conditions of the pavement construction is relatively complicated depending on numerous factors – above all the individual axle type percentage in the traffic flow and, in particular, the wheel tyre inflating pressure of the vehicles.

Coefficient C4 – expresses the effect of the vehicle motion speed on the pavement with layers from asphalt mixes. In accordance with the design method TP 170 its value is considered in relation to the design or allowed speed on the roads:

- at a speed of and over 50 km/h C4 = 1.0
- when vehicles stop and at a speed of under 50 km/h C4 = 2.0.

The evaluated road (four-lane dual carriageway which may minimally be classified as a sally road of functional group B) should be considered for smooth traffic at a speed of and over 50 km/h and therefore the pavement should be designed using the coefficient C4 = 1.0. In reality, however, there are considerable differences between the maximum speed allowed (limited to 70 km/h by vertical traffic signs) and the speed at which vehicles really travel here. This refers mainly to days or time periods where congestion arises on the road and the speed of moving vehicles is very low, in the worst case the whole string of HDV only stands and stops and starts. Such motion can be quite unambiguously matched with the coefficient C4= 2.

The comparison of the presumed impact of the heavy haul traffic volumes in the right traffic lane as specified on the basis of the coefficient C4 = 1.0 and reality results in a 100 % difference (error) to the disadvantage of the road construction, i.e. earlier pavement damage may be presumed (amounting to 12.5 years for a design period length of 25 years).

Conclusion

Even if we neglect the negative effect of load axles of a different than the standard type on the damage of road pavements (see coefficient C2), the above mentioned evidently shows that it is mainly an incorrect assumption on the designer's part concerning the "traffic flow and its speed" on the designed road that may in the case of asphalt pavements cause their inadequate degradation and principal shortening of their total service life.

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The Influence of Pedestrians on the Capacity of Crossroads

J. Filip

xfilipj@fd.cvut.cz

Department of Transporting Systems, Faculty of Transportation Sciences, Czech Technical University
Konviktská 20, Praha 1, 110 00

Within the scope of grant solving the summary of norms, which are stated in the text bellow including important formulas, have been made. Crossroads suitable for traffic monitoring were chosen. Trial measuring was made on them to determine the methodology of the census. Possible procedures of the traffic inquiry and intensities were consulted with specialists during a conference about the crossroad capacity.

T Crossroad Without Traffic Lights

The capacity of a crossroad is set by the number of vehicles that can go trough the crossroad in a specific time period. The worst possible combinations of traffic flows will be decisive for the total capacity of a crossroad.

Roundabout capacity

When setting capacity of roundabout, we must consider it as a group of T crossroads. The total capacity of roundabouts is set by the capacity of entry points. Roundabout capacity is limited by the worst capacity of entries.

If there are crossings over the branches of a roundabout, it is possible that the intensity of pedestrians has an influence on the capacity. For setting this capacity we must use the coefficient of pedestrians influence – set by the norm as interval from 0,8 to 1.

Traffic Light Controlled Crossroad Capacity

The total capacity of a traffic light controlled crossroad is set by the sum of the individual traffic lane capacities which are entering the crossroad.

The capacity of a traffic light controlled lane is independent of the intensity of collision flows, with the exception of the left turning influenced by contra flow lanes which has to be considered specifically.

Saturated flow depends primarily on the rate of slow vehicles in a traffic flow, on the radius of a bend, lane width, gradient, and the possible influence of pedestrians which is set within the rate from 0,8 to 1.

The Width and Spatial Organisation of a Sidewalk

It is important to separate pedestrians from motor traffic. The recommended degree of separation depends on the type of communication and permitted speed.

The quality of the movement on a sidewalk is set by operational schedules A to F which express the level of comfort.

The individual schedules correspond with the size of the space that one pedestrian has at his/her disposal.

The Capacity of Pedestrian Communications

It is assessed according to the highest intensity per hour of an average working or free day.

- the capacity the first and second lane of a more than two-laned sidewalk is 900 pedestrians per hour.
- The capacity of every other 0,75 metre long lane of a more than two-laned sidewalk is 800 pedestrians per hour
- The capacity of the first and second lane of a sidewalk along shops and shopping-windows is 360 pedestrians per hour
- The capacity of every other lane along shops and shopping-windows is 800 pedestrians per hour

With an increasing gradient falls the capacity. For the gradients the intensities fall by the following coefficient:

Gradient of pedestrian communication up to %:	4	6	8	10	12
Coefficient	1	0,97	0,90	0,79	0,71

The Sidewalk Capacity

$$K = \frac{t + \frac{L}{v}}{\frac{l}{v}} \bullet \frac{B}{b} \bullet A[person/hour]$$

Where:
K .... capacity [persons/hour]
t … duration of green light for pedestrians [s]
L … total length of a crossing [m]
v … speed of pedestrians on a crossing (v = 1,2 – 1,5 m/s)
B … total width of a crossing [m]
b …width of a pedestrian lane (b = 0,75 m)
A … number of cycles per hour [1/hour]
I … distance between pedestrians walking behind one another [m]

Conclusion

The influence of pedestrians on a crossroad capacity is only marginally considered in the contemporary used norms and technical standards. It is only mentioned in the Czech state norm (CSN) 736102 for setting the capacity of a roundabout. The right way for traffic intensity measuring, which would be a basis for a research on the influence of pedestrians on the capacity of crossroads, will be determined by exploring the relations, dependencies and definitions of foreign norms, and expert articles. It is necessary to find crossroads with a high pedestrian traffic which would reflect the influence of vehicles.

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Problems of Noise in Traffic

I. Smejkalová

xismejkalova@fd.cvut.cz

Department of Transportation Systems, Faculty of Transportation Sciences, Czech Tchnical University in Prague, Konviktská 20, 110 00 Prague 1, Czech Republic

Development of traffic and using vehicles bring many positive aspects. On the other hand it brings also negatives which influence the quality of life. We can name noise, exhalation, accidents, barrier effect and so on. With development of vehicles also increases the speed of moving, with them is connected the increase of accident frequency and noise which has badly impact especially in urban area. The noise is being very often connected with the road traffic in advanced countries.

The noise is defined as each sound considered annoying, disturbing or in other way harmful for human health. There are some descriptors which are used for evaluation of noise in the environment: equivalent sound level ($L_{Aeq,T}$), sound exposure level (L_{AE}) and maximum sound level (L_{AFmax}). Equivalent sound level is determined as an energetic average from equivalent sound level incident in a given interval. Sound exposure level is used to quantify short duration noise events such as single vehicle passing by. It is the sound level that if maintained constant for 1s contains the same acoustic energy as a varying noise level. It allows compare events among each other. Maximum sound level is a maximum value reached in a given interval. The unit of all mentioned descriptors is decibel [dB].

Recently it has been enforced increase on the safety on the road. One way is to reduce the speed of vehicles, especially in urban area where also pedestrian and cyclists move. There are various constructions to reduce the speed on the road like narrow or wide spreader bars or other shapes of elevated areas. These structures force the drivers to slow down. The question is how these measures influence the value of the noise because the drivers have to brake in front of the spreader bar and then accelerate behind the spreader bar. People complain very often of increasing the noise in places where are these measures implemented. I would like to cover this problem area in my PhD thesis.

The value of the noise depends on many factors, i.e. the traffic intensity, the portion of the trucks in the traffic flow, the vehicles speed, the quality of surface, the gradient of the road etc. One of the factors which is possible quite easy to correct is the speed of the vehicles. With the reduction of speed happens also reduction in the noise depending on the portion of trucks (more noticeable is this difference in higher speed). The decrease of the noise with speed reduction from 50 to 30 km/h and 0 % portion of trucks is about 2 dB (according to Czech calculation methods). With the portion of trucks about 10 % and more the value of the noise increases a little bit for the speed <40 km/h.

I made several traffic noise measurements in sites with the spreader bars and in sites without them. I chose various types of spreader bars (narrow from cast-iron or hardened rubber, wide from asphalt concrete or interlocking pavement). The measures were made with one particular vehicle and then in traffic flow with random screen of vehicles. Together with the noise measurement was measured also the speed of vehicles with a radar. It was always measured passage of one single vehicle not influenced by other vehicles noise or by surrounding noise from the city and roads.

From measured results is seen that the speed of the vehicles crossing the spreader bar decrease of about 20-35 km/h, the speed of the vehicles is about 10-35 km/h according to the type of the spreader bars. The higher and for driving over less “comfortable” the spreader bar is the more drivers have to slow down and then again accelerate.

It is possible to analyze the cast-iron spreader bar as the noisiest (the problem of this spreader bars is that they are very often in bad condition and on the noise also participate the bad fixation to the road) and the hardened rubber one as the quietest from the first results. The speed of vehicles in first case is from 15 to 20 km/h, in second case is from 20 to 40 km/h (these spreader bars are very quickly damaged what allows the drivers to drive over them faster). The different in the noisiness between the spreader bar from asphalt concrete and from interlocking pavement is not so big. In this case the value of noise is depending on the speed of the crossing vehicles which is influenced by the size of the spreader bar. The value of the noise is also influenced by the surrounding house-buildings so the places were chosen that they were as much similar to each other as possible.

The noisiness of the personal cars crossing the spreader bar is about 5-8 dB lower than in the place where no spreader bar is and their speed is about 40-55 km/h. It was also discovered by field measuring of a particular car that at the same speed as it crosses the spreader bar it produces 2-4 dB less of noise.

The biggest problem from the point of noise is trucks traffic. The drive of the truck across the spreader bar is about 10 dB noisier then the drive of personal car. The drive of a truck across the spreader bar produces the same noise or about 5 dB higher than the drive of the truck in a place with no spreader bar (in dependence of the type of trucks). In case of a big truck or truck in bad condition can the noise increase of about 10 dB. The difference between the noise of truck and personal car in place with no spreader bar is only about 5 dB and less.

Generally it is possible to say that it is important to consider which spreader bar is more suitable in which urban area. The question of using spreader bar also comes to the fore if there is a road with higher traffic of trucks or busses. The discussed measures could in that kind of place even lead to worse the acoustic situation in surrounding area.

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Development of the Accelerating Apparatus for Powered Two Wheelers Dynamic Passive Safety Tests

M. Šotola*, J. First*

xsotola@fd.cvut.cz

*K616 Department of Transporting Technology, Faculty of Transportation Sciences, Czech Technical University in Prague, Horská 3, 128 03 Prague 2, Czech Republic

*K616 Department of Transporting Technology, Faculty of Transportation Sciences, Czech Technical University in Prague, SZZPLS a.s., Třanovského 622/11, 163 04 Prague 6 - Řepy, Czech Republic

Opening

Motorcycle (Powered Two Wheeler - PTW) safety is the result of a combination of human factors, vehicle factors and environmental factors. Motorcycle technology of brakes, frames, tyres, etc. can be improved also through racing experience. Human factors can be improved through training focused on theory, practice and effective action in crisis situations. Environmental factors are for example: visibility, road conditions, road barriers, traffic signs, markings, etc. I solve the motorcycle driver's sitting influence and fair-minded evaluation of it in my doctoral thesis.

PTW active safety

Some elements of motorcycle active safety are the same as for example those of cars. That means: antiblock systems, dual CBS (circuit brake system), etc. Other systems are: anti-dive systems, steering dampers, adjustable damping, good visibility, the triangle of seating, thermal well-being, etc.

PTW passive safety

Motorcycles accidents are the worst-case crash for a motorcycle driver and his pillion passenger. There is another access to the problem solving passive safety in comparison with cars because all passengers of a car have to stay inside the car during collision. But both people sitting on the motorcycle have to leave the place of collision. Driver's leaving of motorcycle during the collision is a very difficult problem and it depends on the triangle of seating too.

Other critical factors concerning our health or life are: a standardised helmet, cloths (with protectors), protective gloves, boots, or an airbag inside the jacket.

PTW Passive safety tests

Passive safety is checked by dynamic passive safety tests. The tests are mandatory and standardized by ECE (Economic Commission for Europe) direct regulations for passanger cars, but not for PTW.

The voluntary regulation ISO 13232 solves passive safety tests for PTW only. ISO 13232 proposes basic configurations of the accidents between PTW and passenger cars based on accident statistics from last years. ISO 13232 appoints speeds of the vehicles, positions and directions of the collisions, type of dummy, measurement for performance criterion and standards for computer simulation of the accidents too. This regulation can be used for fair-minded evaluation of the repeatable tests.

The accelerating apparatus for PTW dynamic passive safety tests

Many research, development and acceptance test centers carry out passenger cars passive safety tests. Apparatuses for these tests are similar and high end. But only a few research and

development centers prepare PTW dynamic passive safety tests. The reason why is that stability of the passenger cars in comparison with PTW is much better, and devices for passive safety tests are simpler.
ISO 13232 specifies basic properties for apparatus for PTW dynamic passive safety tests. The apparatus properties have been designed based on weights, dynamics, speeds and stability of PTW too. The apparatus with motorcycle and driver is pulled to crash by passenger car. We have solved these problems:
- positional stability of the system PTW with driver during accelerating and mainly after apparatus leaving;
- directional stability of the system PTW with driver during (system) accelerating and mainly after apparatus leaving;
- system leaving from apparatus continuously;
- deceleration and stop of the passive safety systems tests apparatus in time;
- insurance policy of the apparatus unblocking from towing vehicle in time and insurance policy opposite deformation or destruction of the apparatus;
- cable connection of the apparatus with measuring equipment influence minimization;
The second version of the apparatus has been designed with reference to safer system of braking, motorcycle leaving of the apparatus, weight and long life surface treatment optimization.

Dissemination
This apparatus has been presented within following actions:
Česká hlava – Projekt na podporu vědecké a technické inteligence - Věda v ulicích 22.-23.6.2007, Praha
Presentation of the apparatus for high schools students in frame of the project "Nadaná mládež" – Crash test, October 2007
This apparatus will be presented within following actions:
Prima TV – Autosalon, January 2008
Motocykl 2008 – Exhibition, March 2008

Exploitation
This apparatus has been used for research activities - crash test (29th October 2007) with motorcycle Jawa. Results from crash test will be used in proposer's doctoral thesis. Main contribution is possibility to do real dynamic passive safety tests and to verify effectivity of the developed passive safety systems on motorcycles and drivers within collision.

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Application of Modern Technologies for Optimalization of the Transport in Urban Conglomeration

M. Chvátalová

xchvatalova@fd.cvut.cz

Department of Logistic and Transportation Processes,
Faculty of Transportation Sciences,
Czech Technical University,
Horská 3, 128 03 Prague 2, Czech Republic

In last few years the problems connected with the car transport have come in the limelight throughout the whole world. At this moment every big city faces transports problems in the form of streets full of cars. Permanent increase in car transport results in a slowing-down of traffic – congestion. The transport congestions are more frequent and not only in the center. That influences the environment too, causes ecological damages, damages to roads and more traffic accidents.

Implementation of charge – electronic fee is offered as the solution to the problem with the insupportable increase in car transport. The city charge is the one of the modern methods, which can positively and operatively influence not only the car transport but also thanks to interaction the public transport, environment and other functions in the city. In Europe there have been a lot of the cities for example London, Rome or Stockholm that have introduced the city charge – the electronic fee in the center of the city. The aim was regulation of the transport – reduce entrance to the center and decrease congestion. There are, however, cities, whose aim for introduction of city charge was to gain financial resources for development of transport roads in the city, for modernization of public transport or for some transport project.

Various technologies and ways of charging were applied in different projects, whether place, time and tax payer are on our mind. The projects, which are based on the technologies ANPR (Automatic Number Plate Recognition) and DSRC (Dedicated Short Range Communication) are among elementary and most approved versions.

The technical solution of the ANPR system is relatively simple. The technology uses cameras and evaluation device for control of the cars and their evaluation according to registrations marks – number plate. The great advantage of this system is that it does not need cars with one board unit and the payments can be made through all available means of payment. This is quite reliable solution. In connection with this system no technical problems appeared besides the sophisticated part – to record high proportion of the cars in city transport by camera. The proportion of the right number plate recognition can be maximalized by proper installation of cameras. It also depends on the efficiency and accessories of the hardware and of the software from the supplier. This technology is appropriate especially for cordon charging zone or for usually charging zone. For the cordon solutions to charging the roads this system is more expensive regarding physical infrastructure, which includes installation of cameras, power supply and communications infrastructure. But in the future this system for charging users will be probably overcome.

The technology DSRC using OBU (One Board Unit) for control of the cars is simple, too. It is verified in operation and it works without problems. It is comfortable especially for small road networks. From the point of use is convenient especially for cordon charging city zone and for corridor solutions to road charging, but in this case there are area limits. The disadvantage of this system is high share of the physical infrastructure and complications in enlargement of the charging zone or the flexibility in the changing rates in the times and area too. For the large road networks is the system expensive. Charge of the users connected with acquisition and running OBU-s, which are simple and they need any special usage, are however acceptable.

Within the framework of testing the technology GNSS (Global Navigation Satellite System) was tested in the city area, too. This technology is very modern. It is the most suitable for the effort to make a charge according to the number of drives or kilometers. But when testing in the city technical problems appeared. The inaccuracy and the problems with receiving signal in a heavy build-up area belonged among the greatest defects. In future accuracy and availability of the signal should be improved thanks to European system GALILEO. Also from the point of view of interoperability in Europe this is the most suitable technology. It allows a lot of other additional functions. The advantage of this system with GNSS is also its flexibility in time and space. The system does not need any physical infrastructure. It is true that such technologically sophisticated solution is of higher costs but it has fundamentally lower operating costs or costs for modification of the system. The disadvantage of the system with GNSS technology, similarly to the system with DSRC, is the necessity to ensure possibility of alternative payments for occasional users.

All the systems achieve the aim in better or worse way depending on the conditions of the city if the aim is to reduce car transport, congestions and improvement of the environment. But the aim – to raise financial resources is closely related to choosing the convenient technology or the whole system. Specifications of the selected area can considerably influence capital expenditure. If we pass over high initial capital, the success of the aim – to create financial resources - depends particularly on the operating costs and the assessment of the city charge – electronic fee.

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Expansion of a visual field of our driving simulator with rear mirror projection and measurements of its influence on a quality of the simulation

Stanislav Novotný, Petr Bouchner, Roman Piekník

novotny@lss.fd.cvut.cz

Czech Technical University in Prague, Faculty of Transportation Sciences, Department of Control and Telematics, Konviktska 20, Prague 1, 110 00

Driving simulators are successfully used in the wide field of human-machine interaction (HMI) discipline. We use the driving simulators for many years mostly for the research purposes. During last four years of work we have done plenty of experiments concerning investigations in so called "driver-car interaction" [1] (a special case of HMI [2]) with more than 500 experimenting persons.

Visual perception

Most of the information which the driver's brain needs for driving (i.e. correct response to the outer conditions and various stimuli) are visual ones [3]. The driver from the observed virtual scenery gathers information primarily about shape and color of the surrounding objects (including the road), distance of the objects and self motion (eventually the relative movements of other objects). From those primer cues he/she derives majority of secondary information used for driving.

Projection of the virtual picture

Generally, it is desirable to provide the driver with as wide angle of view as feasible. Ideally the projection should be fully surrounding the driver. The primary information which the driver perceives via visual input is what he/she sees on a frontal projection screen. In principal this information is satisfactory for majority of experiments. Mostly it is accompanied with two or more side projection screens (placed under different angles with the frontal one) which simulate a peripheral vision, useful mainly for self-speed perception and for tasks where driver should look around his/her car. Although, the side projection significantly increases the overall fidelity of the simulation, common drivers (when driving a real car in a real traffic) spend most of the time watching the scenery just in the front and overlooking the situation behind their car via rear mirrors. This fact proves that the realistic simulation of the rear mirrors plays a very important role within the scope of overall fidelity of driving simulators.

Virtual mirrors

Besides of the facts described above, testifying for need of realistic rear mirror simulation, it is necessary take into account driver's actions which strictly require rear mirrors to be implemented. They are essential for better identification of the self driver's (car) position on the virtual road, watching of the surrounding (and mainly tail) traffic, parking / reverse driving. The mirrors within the driving simulator systems could be realized in several ways, they differ in financial and spatial expenses and off course quality of the perceived picture. Those approaches can be divided as follows:

• A conventional method which utilize real mirrors in combination with fully surrounding scene projection. It is space demanding and expensive.

• Small LCDs placed inside real mirrors frames. This approach has several disadvantages, mainly that they cannot take into account movement of parallax planes when an observer's head is moving.

• Hybrid mirrors – they combine LCDs and real mirrors approaches.

Hybrid mirrors

This solution inherits advantages from both above described solutions. It is cheep, not demanding for a space and on the other hand it provides the driver feel of parallaxes movements as the full projection can give. Over more it can be realized with the very high image resolution for relatively low price. We had to synchronize the picture generator and adaptable stands (and suspension inside car) had to be constructed so that the particular images fit into the each mirror.

Experiment

To approve quality of the solution we built, an experiment utilizing it was performed. The pilot experiment starts the series of measurements which are focused on the investigation in general issues of car driver's field of view. This project will study different aspects of driver's field of view related to the useful field of view (UFOV), speed of response on different stimuli, influence different sources of distraction etc.

Experiment was preformed with eight testing drivers driving on the highway, while reacting to the red signals in rear mirrors by pressing the light horn handler (left and right signals were switched on randomly). His/her drive is recorded for further analysis.

Reaction time - Analysis

We did a statistical analysis using t-test; first to know whether the reaction time on the left and the right mirror stimulus is really different. In six cases the null hypothesis was rejected, for two it was not possible to reject. So, there is significant difference in majority of cases. On the other hand in mean value all the probands exhibited higher reaction times when reacting on the stimulus in the right mirror. Also variance is usually higher in "right mirror" reactions. We can explain both of those observations with the fact that the driver has better conditions to continuously observe the left mirror meanwhile the right one is in his/her "discrete" attention.

Conclusion

We approved need of their implementation for normal driving tasks and experiments with special purpose as well. This solution appeared to be valuable enhancement of our driving simulators. We can say that it successfully competes with fully surrounding projection not only by its lower cost but also by its fidelity (how real the testing drivers feel it). A usefulness of the system of realistic mirrors was illustrated by the real experiment requiring visual information coming from behind. We approved that there is significant difference between driver's reactions on the stimuli appearing in the left and right mirror. The results and experiences from this experiment gave a valuable background for future series of experiments focused on deep investigation in different aspects of driver's field of view and alternative methods for visualization of a situation behind and aside the car.

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Measurments of driving in car simulation under the influence of alcohol

Roman Piekník, Petr Bouchner, Stanislav Novotný

pieknik@lss.fd.cvut.cz

Czech Technical University in Prague, Faculty of Transportation Sciences, Department of Control and Telematics, Konviktska 20, Prague 1, 110 00

Alcohol behind the steering wheel is still a very serious problem. Car accidents indisputably caused by the influence of alcohol make at least within Czech Republic 5% from all the accidents [1]. Our task is to develop a battery of tests which could be reliably used for the experiments dealing with impaired driving under the influence of alcohol. Such experiments are very dangerous and in normal conditions are at the edge (or behind) of the law. If they are performed on the special closed road, a common traffic should be excluded. Use of driving simulators gives us several advantages. Besides its safeness it brings wide range of possibilities of simulation of different situation. Moreover all the probands can pass the experiment under same condition.

Experiment

Main task for us was to prove correlation between the alcohol blood level and drivers errors. Our focus was on the investigation driving under the influence of the levels in between 0 – 2 ‰ [2]. The experiment was composed of the driving on the simulators (under influence of alcohol), tests focused on driver's attention and coordination of movements and filling out of anamnesis questionnaires. All the experiments were done under medical supervision.

Testing tracks

Experiments focused on alcohol influence present very specific tasks.

I. Testing polygon - The first part presents slalom (300m) with cones distanced 30m from each other. The second slalom is of the same type but inter distance between cones is lowered down to 25m, than there is narrow corridor and part where the driver should follow the line with the car left wheels. Last driver's task was precise stop on transverse line. The probands were instructed to pass the testing circuit as fast and as correct as possible.

II. Testing polygon – two lane road - The first part is presented by the straight road of 3 km length, the second part is slightly curvy. On the road there are equidistantly placed semaphores where the driver is expected to stop on the red signal.

All the probands had to pass all the tests once without any influence of alcohol. After completing first round of tests the drivers took their first dose of alcohol. During 2 hours of experiment the drivers took 6 doses of 16g of alcohol each. The intervals in between two successive doses were increased during experiment.

Data Analysis

We treated the outputs form the two different testing circuits separately.

Two lane road circuit

Drivers were instructed to react as fast as possible on the red signal. After switching to green they had to speed up to 80 km/h and keep this speed.

Reaction Time - the response time to the stimuli is one of the basic measures which testifies about driver's vigilance. The driver was instructed to stop as soon as he/she recognized the red signal on the semaphore. The red signal on the track is randomly generated when the car approaches the semaphore.

Speed press of break pedal - all the tested drivers exhibit relation between the response on the brake pedal and the speed of the pedal depression. With increase of the

response time a speed and consequently force of the pedal depression also increased. The longer the response lasted the more effort to compensate it with higher force. In those cases, when there was no significant prolongation of response time with higher blood alcohol level, almost no pedal depression speedup was noticed.

Deviation from an Ideal Path - lane departure is very useful when finding serious driver's state. We looked mainly for overall variance. From the contemporary research it is also possible to say that the movement of car within the lane borders (originated in steering wheel movements) could be promising marker of driver's impairment of safe driving.

Proving ground (testing polygon) circuit

Drivers drove on the testing polygon. They were instructed to drive as fast and as good as possible.

Steering wheel movement velocity and its variance - the driver is permanently in contact with the steering wheel as it is only one control tool on which he/she keeps his/her hands in standard situation. Therefore the record of the driver is controlling movements of the steering wheel could serve as a basis of very good information of his/her driving abilities.

Changeability of car speed - some of the probands exhibit higher variation of speeds with higher level of alcohol in their blood. To prove this theory much more experiments have to be performed.

Time needed to drive correctly through a segment - beside other measures, an overall time needed to pass the circuit (i.e. successfully fulfill the task) was investigated. The passes where a driver's error occurred were excluded form this analysis.

Conclusion

From the experiments performed up to now and the analysis which we made upon the measured data, it is possible to derive very promising results. From the results of analysis it is possible to derive that drivers under influence of alcohol are less concentrated and their driving performance is lower. This is apparent even from very low alcohol blood levels. They drove more aggressively and did more errors (starting with 1 per mille, number of their cone hits increased significantly, starting with 0.5 per mille, prolongation of reaction time appeared). On the other hand, if they were loaded with secondary tasks they drove much more safely but the time of driving was incomparable longer. It was proven that the response time increased with alcohol blood level but the intensity of braking (and applied force on the brake pedal increased) was higher.

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Internet Support for Small and Middle Size Companies

N. Matejickova*, M. Tousek **

nada.matejickova@fs.cvut.cz

*Department of Management and Economics, Faculty of Mechanical Engineering, Czech Technical University, Horská 3, 120 00 Prague 2, Czech Republic

**UTRIN s.r.o., Budějovická 73, 140 00 Prague 4 - Krč, Czech Republic

Today's trend reflects the increase of competition and the influence of globalization in the field of production and services and therefore there is a need of small and medium companies to react to changes on the market place. That is why an educational center Harmoni, together with the Department of Management and Economics, Faculty of Mechanical Engineering at the CVUT University , created a project called BusinessMAT. This project is designed for owners and managers of small or medium companies located in Prague. Its intention is to made information accessible to businessman and business representatives of small and medium companies, to show methods and possible solutions that could increase a competitive ability and satisfy the need of further professional training of businessman and employers, focusing on deepening their knowledge in the application of methods of business management. Goals of this project can be summarized into following points:

- increase competitiveness of entrepreneur and employees through appropriate training of workers that reflects specifics of educating employees in management,
- to form an instrument for educating businessman in the field of an effective business management to increase the products and servises' ability to compete
- apply a principle of partnership in advising, offer information and educating with entrepreneur and employers with the intention to support advising and following services
- develop organizational, personal and communication oriented platform for offering information and advising on-line.

During the 29th and the 30th of October 2007 was the last cycle of pilot educational program targeting the workshops. On the official pages of the businessMAT program there will be prepared a client account, where the registered users will have the access to information and services, such as ePrůvodce through entrepreneurship, online advisory center with the possibility of direct consultation and access to materials and audio -visual records from seminars and workshops.

The content and the form of the educational program businessMAT for small and medium companies are designed with the consideration of specifics of small and medium companies. There is an emphasis on the use of informational and communication technologies (ICT) throughout training and it includes practical application of methods of management and decision making that is based on concrete life situations of employers and employees. The selection of educational modules reacts to the needs of business activity and generally is based on the application of laws in business, economics, and knowledge of trends in the field of business management, and can help clients:

- independent orientation in the problematic of operational business management with the connection to concrete knowledge and skills of related specialized fields

- being able to solve complex problems and appeals in the company's operational management on the level of top management as well as on the level of middle managerial positions,
- communication during a creative cooperation with individual specialists from economics, such as accountants, tax advisers and lawyers. Additionally, he will be able to communicate with partners during outsourcing of certain services.
- confront personal managerial experiences with the new acquired knowledge.

Combined form of teaching, seminars, consultations and e-learning, offer users an effective use of their time. Through the web site www.harmoni.cz, participants can access:

- electronic guide through business management,
- audiovisual records from seminars and consultations,
- online consultations,
- complete materials from lectures and workshops.

The cooperation of the employees of UTRIN s.r.o. and the employees of the Department of Management and Economics led to the Interactive guide of business management, mentioned above. It is a multimedia application that through used technology allows an illustrative orientation within the problematic of organizational business management. The guide follows life cycles of a company to which it adds typical problems occurring in the life situations and which managers or business owners often have to deal with. Through those life situations, the guide offers possible solution on a practical and a theoretical level of fields such as: Economics (finance, accounting and taxes), Operation Management, Marketing and Law.

The content of the interactive guide is structured into three basic parts:

- THEORY AND EXAMPLES that point out the characteristic of a problem and focus on the main aspects of solutions
- LIFE SITUATIONS, show an illustrative example, explanation of methods or solution steps. Life situations come from definable influence of the surrounding as well as from the „inside situation" of the company in any of its life cycles. The case study is developed with the intention to understand how to apply learned knowledge in practice and how to use concrete methods.
- ANALYSIS AND INSTRUMENTS, are practical documents used at work: different „calculculators" (Excel) with functions that are set up to calculate proposed methods in the theoretical part (cash flow, financial analyses etc.) or documents, requests, stencils of legal documents.

According to references, clients were very pleased with the first part of project. As David Nevečeřala, a director of EMICO group s.r.o. said: „Workshops and seminars are very positive, especially the level and quality of lecturers that were able to hold it on the high level. To summarize it, some new information, showing possible perspectives to look at problems are taught in a very interesting form. I did not expect such high level of a seminar offered for free. The outcome was a seminar better than many paid seminars. If there will be similar possibility of such training, I am not going to hesitate."

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Scheduling of Inventory Projects

M. Kavan

michal.kavan@fs.cvut.cz

Department of Enterprise Management and Economics, Faculty of Mechanical Engineering, Czech Technical University, Horská 4, 120 00 Prague 2, Czech Republic

Scheduling of inventory items is a vital facet of production scheduling. If components are not available as required, no production schedule can be maintained. Inventory can be an internal raw-materials and purchased-part scheduling problem, or it can be considered from the viewpoint of the supplier furnishing specific parts. Inventory control required monitoring of massive amounts of data, and its application to digital computer techniques is a natural one.

I has suggested the following principles in regard to inventory control and scheduling:

1. Quantity – inventories should be as small as compatible with the best delivery and the appropriate longest run or largest order.
2. Flexibility – should be built in to production and inventory plans so that they can be readily changed to accommodate current customer requirements.
3. Records – should be limited to those which contain information that is usable only for controlling current operations or making decisions for future operations.
4. Controls – appropriate control systems must be used to integrate the production and inventory scheduling, using basic unit measurements as a common denominator.
5. Trend – inventory should reflect the trend toward larger sales or levelling off.

The principal characteristics of each inventory, regardless of type, are the number and distribution of items within it. It is not unusual to find inventories of 10 thousands to 100 thousands items. This would be at the general company level or the wholesale-house level. The recommended approach to inventory scheduling involves understanding the characteristics of inventory. However, this is an excellent area for the application of management by exception. Investigation of thousands of items individually, most of which are of low value and have little impact upon the scheduling of the inventory, would probably be prohibitive. However, by evaluating the impact of the various items upon the overall inventory, it is possible to direct attention primarily to those items of inventory with high impact value.

A listing of the inventory is the first step in this analysis by distribution of value. This listing is particularly easy to prepare if the inventory is in machine-readable form. This permits various simple accounting operations and sorting. For the base listing, the item records are arranged and listed in descending sequence by annual cz-crown sales or usage values.

Because of the extensive volume of communication and interdependence with other departments, inventory control must keep the problems in proper perspective with an efficient system. The inventory control system will follow a basic cycle regardless of the size of the firm. The cycle of operations begins with determining the production need and is completed with filling the customer order. Records and information will flow from similar sources, although the timing, accuracy, frequency, and completeness will be a function of the firm's size and reliance on data processing systems.

The most basic record is a material list of the products to be manufactured. The parts from the materials list times the scheduled quantity–plus any loss for scrap–are deducted from existing inventories. A negative figure of inventory indicates the need to requisition parts for delivery prior to production. A travelling requisition is well suited for repetitive

requisitioning. This contains the part number, specifications, drawings, historical purchase data, and sections for quantity and delivery instructions.

Centralized stores provide advantages of fewer personnel, less space requirement, less dated inventory, better record control, and less record duplication. The case against centralized stores is that the time for material movement to using areas is lengthy, involving added labour and handling equipment. Certain low-value materials are better controlled by no control. The change of inventory item to an expendable supply item without a requisition reduces the overhead associated with that item, and inventory control effort may be placed where control is needed.

Adequate space and sufficient containers help to make an inventory easier and more accurate. It's a good idea too, to have extra containers available to allow separation of mixed loads and permit counting while transferring parts from full to containers. A good housekeeping program prior to physical inventory can pay off.

The importance of production control and scheduling in a continuous manufacturing process is directly proportional to the ease and the amount by which the flow may be varied. If the rate of flow can be varied easily and significantly, management is more apt to vary it. The more it is varied, the more effort is required to keep the system under control and the greater the need for the production control function.

There are several other factors which are important in process manufacturing. The production equipment is usually single purpose and used for one product or type of product. Because of this, it is difficult, if not impossible, to make a non-standard product. Since standard products are made in large quantities, they are usually made for inventory rather than for a customer's order. Because process manufacturing is continuous, and because shutdowns are usually costly, it is very important to keep adequate supplies of raw materials flowing to the process.

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Subgrade and Base Course Optimization in Pavement Performance Enhancement

B. Novotný, F. Luxemburk*, P. Herrmann**

novotny@klok.cvut.cz

Klokner Institute, Czech Technical University in Prague, Šolínova 7, 166 08 Prague 6, Czech Republic

*Faculty of Civil Engineering, Czech Technical University in Prague, Technická 7, 166 26 Prague 6, Czech Republic

**Ing. Pavel Herrmann – RODOS, Janouškova 300, 162 00 Prague 6, Czech Republic

The project aimed at obtaining new knowledge on function and mechanical behavior of the subgrade and base course systems of pavements and using it in the pavement design optimization. Using computer modeling in combination with experimental research in laboratory and in-situ, the methods of rational designing of aggregate base layers as well as of the subgrade soil were to be verified. The experimental research was based on FWD (Falling Weight Deflectometer) testing. The research results should be confronted with current subgrade and base course evaluation procedures of the current Czech pavement design method TP170, which procedures seem to be substantially inadequate when compared to foreign research trends.

In the first stage of project, the problems of modeling and performance evaluation of the pavement subgrade and of unbound layers of asphalt pavements in the Czech design procedure TP170 were analyzed. It was found out (quite unexpectedly) [1] that the correct specification of the values of Poisson's ratios for subgrade soils is of a crucial importance. In the Czech design method TP170, the limit value of 0.5 has been ascribed to soils of weak subgrade, which lead – in combination with fatigue based evaluation criterion being expressed in terms of subgrade deformations – to anomalous increase in performance of pavements with weak subgrades. The immediate action proposed is to prescribe lower values (say 0.42 or 0.45 – at the maximum) for weak subgrade Poisson's ratio, and also to reconsider fatigue characteristics for weak subgrades.

Further, the pavement design procedure modification has been proposed concerning the fulfillment of the TP170 design specifications requirements on deformation moduli measured on the subgrade surface as well as on surfaces of sub-base and base pavement layers. The proposed procedure allows to assess the actually measured values of deformation moduli influence on pavement performance in a way compatible with TP170 basic assumptions.

The influence of nonlinear mechanical behavior of the subgrade soil and of the base unbound layer on pavement performance evaluation were thoroughly studied [1] using the US DesignGuide2002 model. The application of this model in the classical pavement evaluation scheme has been made possible by introduction of structural numbers of soil and of unbound materials. These structural numbers represent the stresses induced in the soil structure by the soil composition and in the aggregate material by the unbound layer compaction. In-situ methods (FWD testing) for determination of these material characteristics were analyzed. FWD testing was performed by the RODOS equipment on four pavement construction sites and showed promising results for material characterization of subgrade and unbound layers when compared to traditional static testing.

Pavement optimization requires also better understanding of processes running in asphalt layers during pavement exploitation. Attention was, therefore, given also to the development of a structural model of the asphalt mix. The model is based on Aboudi's approach to micromechanical modeling of fiber reinforced composites. The method generalization [2] for the asphalt mix modeling comprises three modeling levels: (1) asphalt paste, (2) asphalt mortar, (3) asphalt concrete (mix) combined with two intermediate stages to incorporate voids in the mortar and concrete structures. Basic input data are volume fractions and mechanical characteristics of components and compliance moduli of deformable interfaces between cells. Using laboratory tests results, the structural model of the asphalt mix may be calibrated in a desired temperature range. The mix design, laboratory testing and pavement diagnostics seem to be most promising areas of potential applications of asphalt mix structural modeling in the field of pavement engineering.

The structural modeling was further used to derive material characteristics of special mix used in asphalt plug joints (APJ are flexible asphalt segments that span between the bridge deck and abutment, serving as expansion joints). The effect of heavy vehicle loads on stress and deformation state of APJ has been addressed using approximate methods [3]. Then the DesignGuide2002 formulae were used to determine the APJ rutting. The computations indicate that the APJ material is overstressed and overstrained, which may result in excessive premature distress formation. At the same time, the application of DesignGuide2002 rutting formulae seem promising when considering enhancement of the Czech design procedure during its possible innovation.

The basics of structural modeling were used also in the assessment of the effect of reinforcing elements (geosynthetic grids) on mechanical capacity (performance) of the pavements in a way compatible with the current Czech design procedure [4]. The reinforcing effect of the grid placed on weak subgrade is caused by the higher stiffness of the membrane formed by the grain locking in the grid openings. This effect is evaluated using micromechanical modeling and the procedure has been established taking grid reinforcing effect into consideration when evaluating pavement performance with built-in geosynthetics.

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Does Design Method TP 170 Provide Correct Results?

L. Vébr

vebr@fsv.cvut.cz

Department of Road Structures, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

The design method TP 170 [1] is valid for the design of pavements of not only roads carrying standard road traffic, but also constructions of traffic and other surfaces including non-motoring roads and hard shoulders. Various types of traffic surfaces are exposed to the effects of really extreme loading exerted by various types of vehicles and machinery travelling across them. This extreme load need not always be exerted by large air liners as similar (and sometimes even more unfavourable) effects are caused e.g. by various loaders at container transship points etc. The problem of dimensioning these surfaces usually consists not only in the magnitude of load per axle, but, above all, in very specific conditions of its transfer onto the pavement, i.e. the number of wheels per axle (and distribution geometry) and mainly in the tyre inflating pressure, which is replaced by contact pressure in calculations.

In order to verify the correctness of the results of the non-rigid pavement construction evaluation as provided by the design method TP 170, the calculations below were carried out simulating the acting of various design axles (or their units) on the pavement. The simulations considered the following axle modifications:

- single axle loaded by 100 kN /115 kN and modified by axle configurations:
  - two single wheels,
  - two dual wheels (distance of wheel centres of 0.344 m),
- two axles loaded by 190 kN with axcle configuration - 2 x 2 dual wheels,
- three axles loaded by 240 kN with axle configuration - 3 x 2 single wheels.

Tyre inflation pressures of goods vehicles considered were:

- 0.50 / 0.55 / 0.60 / 0.65 / 0.70 / 0.75 / 0.80 / 0.85 MPa.

Calculation simulations were made using two different design methods:

- TP 170 – design method presently in force,
- TSm – former design method.

In assessing bonded layers of the pavement and subbase exposed to repetitive load the design method TP 170 uses the values of their normal deformations ε (-), specified by the stress and deformation calculation of a multi-layer system. The design method TSm, on the contrary, used the values of their normal stresses σ (MPa).

Simulated relations

The simulations aimed at specifying the effects of individual axle types on non-rigid pavement damage served for the specification of the following relations:

- TP 170 method :
  - values of normal deformations ε in bonded pavement layers and subbase in relation to the tyre inflating pressure,

- values of relative damage D_{cd} of bonded pavement layers and subbase in relation to the tyre inflation pressure,

- modified TSm method :
  - values of normal stresses σ in bonded pavement layers and subbase in relation to the tyre inflation pressure,
  - values of exploitation coefficient S_v of bonded layers and subbase in relation to the tyre inflation pressure,

Conclusion

The evaluation of the results of computer simulations relatively unambiguously shows that:

- thanks to "calibration" of the design method TP 170 to the conditions of standard road traffic, this method is relatively very well calibrated to the effects of a single load axle with two dual wheels and load of 100 kN, and changes in the characteristics of the substitute contact loading area (area size / load intensity) have no principal effect either.
- TP 170 method has somewhat worse results in the assessment of the effects of this load axle on the pavement with the load of 115 kN where its effects as compared to the 100 kN axle are already by ca 80 % greater (in the assessment applying the TSm method the growth in the effects is only by ca 15 %).
- TP 170 method brought absolutely the worst results for load transferred onto the pavement by an axle (or axles) with single wheels. Here, a relatively enormous growth in the value of relative damage occurs as seen from the comparison:
  - single axle with single wheels damages the pavement by ca 3 x more than with dual wheels,
  - single axle with single wheels loaded by 115 kN damages the pavement in the case of tyre inflating pressure of 0.85 MPa by ca 3x more than in the case of tyre inflating pressure of 0.50 MPa and dual wheels,
  - single axle with single wheels and load of 100 kN damages the pavement in the assessment under TP 170 by ca 2.3 x more than in the asessment under TSm (for axle load of 115 kN even by 3.3 x more).

The above-mentioned is caused mainly by the fact that in the assessment relation where the values of calculated normal deformations are substituted the exponent has the value of "5", so that even a relatively small growth in deformations has once it has been squared a significant effect on the value of relative damage specified. This problem does not apply to the TSm method as the assessment relations here do not contain any quadrates.

This leads to a conclusion that the application of the design method TP 170 for the specification of pavement construction degradation or residual service life of roads and traffic surfaces carrying non-standard traffic may be rather problematic as the design method TP 170 does not provide very positive results for “single wheels”.

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Analysis of Traffic Load Using WIM System

L. Vébr*, B. Novotný**

vebr@fsv.cvut.cz

*Department of Road Structures, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

**Klokner Institute, Czech Technical University, Šolínova 7, 166 08 Prague 6, Czech Republic

The last decade has seen a steep growth in road traffic volumes leading to relative overloading of the existing road network designed only for a certain capacity of passing vehicles. This is mainly caused by the opening up of the borders after 1989 and the position of the Czech Republic, which is situated in the heart of Europe being therefore an ideal transit territory. The advantageous position of the Czech Republic is used by truck forwarders also because, unlike other neighbouring states (mainly Germany and Austria), it still lacks sufficiently developed legislation in terms of protection of its road and railway network.

In dimensioning road pavements, loading with vehicles with a total weight under 3.5 t is not considered as their effect on pavement damage is negligible. Road damage due to loading with goods vehicles is in the order of 10.000 - 100.000 times greater that loading with passenger cars. In the case of an overloaded goods vehicle this ratio is still far greater, and an enormous growth in road pavement wear occurs due to the passage of a relatively correctly estimated number and type of goods vehicles. For this reason, corresponding pricing of such overloaded vehicles must be provided in the interest of efficient road network management. But to be able to accurately weigh the overloaded vehicles and successively price them, first they must be identified. Here, weighing vehicles "in motion" (Weighing In Motion, abbreviated as WIM) may be used, which represents the measuring of immediate road pavement loading with vehicle wheels or axles. The loading is determined by means of sensors usually placed on the pavement or imbedded directly into the pavement. With the help of a suitable algorithm, static load corresponding to this compressive action, or the weight acting on the wheel or axle, is estimated.

Weighing point

The practice of weighing vehicles in motion was introduced last year and is performed among other places also on the territory of the capital city of Prague. The measuring point selected was a section of the street "K Barrandovu" between junctions with streets "Ke Smíchovu" and "K Holyni" (both junctions have been controlled by traffic lights for about 1 year now) ca 800 m in length, which presently carries the majority of transit traffic between the D5 (or roads R7, R6) and D1 motorways, or also D11, or R10 respectively. The present-day traffic volume on "K Barrandovu" Street is ca 48.000 vehicles/24 hours, of which ca 11.000 are HDV. At this measuring point, a high-speed dynamic Jama–Cardinal scale (so-called HS WIM - High Speed Weigh In Motion) with sensors embedded in both traffic lanes of the road capable of continual simultaneous weighing in both traffic lanes at speeds from 10 to 130 km/h with the weighing optimum at speeds of 60 - 80 km/h.

General classification of vehicles

WIM systems must be fitted with software for vehicle identification, specification of the vehicle type according to the determined number of axles and the distance between the

axles. For each vehicle type distinguished by the software distances between the axles must be put in. Their values must be easily accessible to the user and the user must be given a possibility of their easy changes. Negotiations are presently going on within the European Union concerning the specification of individual vehicle classifications on all roads. Up to now the FHWA (Federal Highway Administration) classification system has been used for the conditions of trial operation, which subdivides vehicles into 13 classes. Data is presently collected allowing creation of an initial vehicle classification [1] which will also enable classification of the vehicle types that are not common, but may occur on the road.

Analysis of data obtained by WIM system

In order to analyze the data obtained by WIM systems, a computational programme with a working name WIM-ANALYSIS [2] was developed and gradually further improved, which allows obtaining through the analysis of the data recorded by the WIM system the basic vehicle characteristics necessary for the analysis of pavement damage. These are in particular the following:

- loading per axle,
- axle distance,
- axle subdivision into - single axles with single wheels,
  - single axles with dual wheels,
  - two axles,
  - three axles,
- specification of axles of tractors, semi-trailers and potential trailers.

This data allows:

- assessment of vehicle overloading in accordance with Czech regulations,
- data control of the WIM Barrandov system,
- data preparation for the assessment of pavement damage by traffic under TP170 [3] by determination of:
  - number of axles with a single wheel in loading groups 5 to 150 kN (5 kN increment),
  - number of axles with dual wheels in loading groups 5 to 150 kN (5 kN increment),
  - number of two axles in loading groups 10 to 300 kN (10 kN increment) and potential classification according to axle distance of 100, 120, 140, 160 and 180 cm,
  - number of three axles in loading groups 15 to 360 kN (15 kN increment) and potential further classification according to axle distance of 100, 110, 120, 130 and 140 cm).

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Results of Model Assessment of Indirect Benefits of Motorways for Socioeconomic Development

F. Lehovec, P. Karlický

lehovec@fsv.cvut.cz

Department of Road Structures, Faculty of Civil Engineering, Czech Technical University,

Thákurova 7, 166 29 Prague 6, Czech Republic

Based on previous research of the effect of transport infrastructure on territorial development [1] the following four assessment factors were devised to determine indirect benefits, i.e. benefits for the inhabitants of the serviced territory:

- increased number of job opportunities
- the effect of mobility on economic growth
- increased value of the territory
- environmental effects on the territory and inhabitants [2].

In order to prove that these factors are sufficient, objective and available for the determination of indirect benefits of high-capacity roads for the development of the respective territory, their assessment in specific conditions had to be performed.

The investigation was carried out on the D8 motorway whose construction was completed in 2001. Therefore, it is a motorway whose indirect benefits for its surroundings may be investigated from the data of the Census of population, houses and flats of 2001 (CPHF); despite the small time lag between this survey and putting the motorway in operation, some of the socioeconomic indicators were visibly affected by the motorway. The report of implemented works [3] is divided into two parts. The first part describes and analyses individual socioeconomic indicators whose values may be affected by the motorway performance. Attention is focused mainly on the indicators related to selected factors, in particular The increase in the number of job opportunities – F 1, and The effect of mobility on economic growth - F 2. The second part deals with the relation of the indicators to these factors, here the correlation and regression analysis were performed. Seven socioeconomic indicators were used: economic activity, economic entities, job opportunities, unemployment, commuting to work, education level, quality of human resources. The studied relations encompassed the accessibility effect on the number of job opportunities, the effect of the level of education on the number of job opportunities and the effect of mobility on economic growth.

The effect of the D8 motorway on the number of jobs and mobility, or its effect on economic growth was determined on the basis of correlations and regressions of individual indicators already applied in the analytical part of the complex assessment [1]. The effect of the D8 motorway may be seen as improved accessibility of the municipalities located in its vicinity to Prague, which provides, in the first place, higher mobility towards a greater scope of job opportunities, which are, moreover, better remunerated in Prague. This is, of course, reflected by a lower unemployment rate. Also, large storage facilities have been built close to motorway exits and near Prague itself in the last 10 years, which, in turn, further reduce the unemployment rate in the respective municipalities and their surroundings.

Based on the knowledge of these links observed from practice, statistical relationships between individual factors were sought. The problem, however, is that the processed data comes from the latest population census, i.e. of 2001 when the D8 motorway was just put in operation. If the data were related to the present-day situation, the effect of the motorway on the indicators would probably be still higher.

The results obtained to-date imply that indirect benefits of the D8 motorway for its surroundings have currently been proved to only a small extent. This results, among other things, from the database used (CPHF) which comes from 2001 when the motorway was just completed, and therefore its benefits are not so clearly reflected by the data. A significant factor which affected the investigated region in the 1990s was the phenomenon of Prague. It was manifested mainly by a falling unemployment rate, rising education level, growing business activity etc. in the direction towards the capital city. All these variables went through a positive development trend in the 1990s in the hinterland of Prague in particular being, among others, influenced by sub-urban planning. The effect of Prague is, to a considerable extent, related to its accessibility; we may expect that by new accessibility improvements after putting other motorway sections in operation the influence of Prague will further grow. However, we cannot expect that this effect will apply to an unlimited distance or to all municipalities. Other important factors are changes in the education level of the inhabitants and advantages related to commuting to work (i.e. particularly financial benefits of commuting as compared to remuneration for work within the region). Negative effects of the motorway, however, cannot be eliminated either, which may be manifested mainly in peripheral or rural areas whose opening up to the capital city may have negative consequences, e.g. in the form of migration of local population.

The knowledge obtained will be applied in on-going analytical works, and results from other surveys will be presented such as the monitoring of the effect of enterprise and commercial zones in the vicinity of the motorway (developed in more detail for selected municipalities) and changes in tourist trade (hotel industry, tourist destinations). The complemented methodology will be used for the analysis of other model regions, both regions situated close to the motorway, and reference regions without a motorway.

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Transport, Economic Growth, Region, Utility

B. Duchoň

duchon@fd.cvut.cz

Department Economics and Management in Transport and Telecommunication, Faculty of Transportation Sciences, Czech Technical University, Horská 3, 128 03 Prague 2, Czech Republic

Passenger and freight transportation, private and public, provides an important condition for development of economic and social activities. The economic growth, competition and employment depend on the perfect functions of transportation system.

Every entrepreneurial activity has had limits influencing the next development of this one. The current changes of economic paradigm, global economics, point out the facts that prosperity and wealth by the growth of microeconomics is created.

The relation of location and transport is possible to search from the microeconomic and macroeconomic point of view. Microeconomic level can study of entrepreneurial subject and his/her decisions. Economic subject takes location decision and final choice as a function of transport possibilities and availability. Macroeconomic point of view involves structure and level of economic activities in geographical areas, cities, regions and countr ies, especially as a function of quality, safety and other factors.

People provide very wide range of activities which can be characterised as follows: living, working, trading, consuming, visiting and relaxing. Many of these activities have performed concurrently so that their requirements differ and geographical areas and spaces have to be adapted to accommodate them. The space where activities happen depends on many factors as location, climate, and availability of production factors, historical and social development.

The space is extensive in highly developed place especially in towns and cities. The space includes industrial, commercial and residential areas, health and social complexes (hospital, schools, universities, libraries, theatres and sports places).

The analysis of alternatives and possibilities how to find ways that are more attractive for the citizens of city and urban agglomerations can influence the urban development, mobility and revitalization of public transport. To raise the quality of public transport and through this also to rise marketing activities and urban management must support the demand and satisfaction of client and passenger. The conception of integration of factors providing the operation of sustainable personal transport in the frame of urban mobility including not only transport factors but also the production, commercial and administrative characteristics.

The transport has provided the spatial and time movement of people and goods. Human activities satisfy people's wants. The activities have a certain utility (value) for the people concerned. Through activities the goods and services must be created for future satisfactions. This creation through manufacturing process brings the products providing given needs passing the utility for users. This kind of utility is referred to as utility of form.

Transport provides, like the production, the utility which is called the utility of time and place. This utility is created by both, passenger and freight transport. It is clear that transport has derived nature of needs. Because of derived nature of the need for transport, the user's set of requirements for transport service is different and depends on purpose for which it is used.

The role of transport in economy can be concentrated to the following items: contribution to GDP, support of employment (transport means production, infrastructure construction and maintenance, oil and refinery industry and so on), support of trade, creation of transport enterprises (transport market), traffic output of transport in terms of services (passenger and goods), prices as an indicators of differences among modes of transport, contribution to the state budget (wide spectrum of sorts of taxes).

Economic role of transport can be considered in specific factors: production, utility, prices, competition, land-use, social approach, policy and strategy.

The solution of traffic modes competition in the frame of transport system is not still quite satisfactory. The competition one can understand on one hand as state and on the other hand as process. For this reason, different kinds of market situations can appear with time.

The similar problems have accompanied the transport system. There are different ways to put competitive pressure on railways. These possibilities offered by microeconomic theories can influence also practical application in organization and management of railway system.

Having described this ways the search works have discussed the difference between coordination by means of direct control and market mechanism, the determinants of the size of an enterprise, nature of competition in the various modal markets and effects of economies of scale and scope influencing the optimal size of transport enterprise. The term economies of density is unique for transport and from the short-term time is particularly important for rail transport.

Rail transport systems operate in an environment consisting of various sets of relationships which are influenced by economic, technological, social and political factors. The activities are going to be aimed at these factors and its importance for railway subsystem as a part of regional transport system. Railway in this way will also be discussed and considered as a serious determinant of region development. Economic subject takes location decision and final choice as a function of transport possibilities and availability. Macroeconomic point of view involves structure and level of economic activities in geographical areas, cities, regions and countries, especially as a function of quality, safety and other factors.

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Sustainable Management in Microeconomy and its Social and Legal Aspects

J. Šafránková, M. Sedláček

jana.safrankova@fsv.cvut.cz

Department of Social Sciences, Faculty of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech Republic

In the Department of Social Sciences of the Faculty of Civil Engineering of the Czech Technical University and within the research objects No. 5 The management of sustainable development of the life cycle of buildings, building enterprises and territories. We deal with the topics of economical, social, philosophical, legal aspects of civil engineering impacts on the environment and the problems of social conditions of technological innovations, which belong to the necessary targets of the program of sustainable development in the European Union.

In 2007, we concentrated on the problems of sustainable developments in terms of utility, on the conception of externalities, communication with the general public, on the analysis of sustainable development in construction industry, the problem of the quality of life, the social dimensions of sustainable development and the analysis of some related processes in the Czech Republic.

In our approach to this issue we draw from the conclusions of international UN summits, especially Agenda 21 (adopted on the summit in Rio de Janeiro in 1992) and the 16th summit in Johannesburg in 2002 under the title „People, Earth and Prosperity“ that defines three buttresses of permanent sustainable development, i.e. social, ecological and economic ones. The aim of humanities is to study these individual fields and their interrelations at global and national levels.

The quality of life is expressed by the quality parameters of a way of life, lifestyle and conditions of a society in contrast with the quantity and profit criteria of its performance and successfulness. WHOQOL defined the quality of life in 1996 as follows: “The quality of life expresses how people perceive their life in the context of the culture and its values and in relation to their goals, expectations, standards and interests.” Therefore it is important to know how people understand this concept and which way of life they consider satisfactory.

“The quality of life” of an individual is now set against the consumption lifestyle in the global society preferring property that can not satisfy spiritual needs. It is more and more connected with non-material values, such as good and appropriate communication, interpersonal relations, the development of personality and aesthetics. It tries to express the quality aspects of life. It can be perceived as a complex of individual qualities or as a whole with its own structure and importance. The basic premise of sustainable life is its quality, i.e. its quality way. Such a way of life ensures a man economically, is considerable to the environment, utilises the effectiveness and productivity of work and supports education.

The building industry, the architecture and the urban space have an important role for a human being and further, there are sociological and psychological influences to mankind, to our well – being. Sociology analyse a role of the architecture in the conscious shaping of an urban space in the 21st century. This dilemma is very important for a sustainable development, as well as for the knowledge of civil engineering graduates and for the urban sociology too. However, the concerning on those problems in sociology is relatively low in Czech Republic. In these problems, which have a direct impact on the formation of a social and spatial urban structure, we can count the residential segregation, the suburbanization of

cities periphery, the depopulation of downtowns, the revitalization of habitation, the revitalization of industry areas and integration.

The topic of sustainability is approached in its general theoretical level, in practical level we have the bladeless Water Turbine SETUR. This Micro Water Turbine is capable of utilizing very small sources of water and it is highly suitable for closed circuit production of electrical energy. This turbine is very effective in areas of low available water energy so far untapped by any other means. Its strengths are in reliability, considerable long term financial savings, improving living standards, while utilizing renewable energy resources, and most of all it is Environmentally Friendly Device. SETUR is protected by patent in many advanced countries DVE-120 (Mikro-Turbine Setur: Currently this turbine is being manufactured for the use in relatively small water ways) is an environmentally friendly self-contained electricity generating unit. This generating unit is powered by the patented bladeless rolling turbine which is attached to a concrete block containing the inlet plumbing. The attached generator produces output of either 12 or 24 Volt AC. The produced electricity can be used directly and/or stored in batteries. Operating parameters of the Micro Water Turbine DVE - 120 are:

Q = 3,5 – 15 litre/sec, H = 3,5 – 15 m, P(mech) = 50 W – 1500W Also, the Turbine SETUR can be effectively used where water level differences are extremely low. Specifications (currently under research and testing): Q = 30 – 600 litres/sec, H = 0.5 – 1.5 m.

Our participation in the research project is interdisciplinary, theoretical and practical. the results bring contributions to the development of philosophy, sociology, ethics, aesthetics, psychology, law and economy and practical realisation of water turbine in sustainability of society

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The Sustainability Approach to Buildings Appraisal

R. Schneiderová Heralová*

heralova@fsv.cvut.cz

*Department of Economics and Management, Faculty of Civil Engineering, Czech Technical University, Thákurova 6, 166 29 Prague 6, Czech Republic

The interpretation of sustainability in building and construction has gone change over the years. In the beginning the emphasis was on how to deal with the issue of limited resources and on how to reduce the impact of buildings a building's processes on the environment. Ten years ago, the emphasis was placed on the more technical issues in construction. For example on materials, buildings components, technologies, and on energy related design concepts (low energy houses, passive houses). Today, the emphasis on soft issues of sustainability is growing. There are the economic, social, cultural issues, and cultural heritage, that gain ground.

Sustainability development and sustainability building are in the global context characterized as three pillars:

- quality of environment (internal and external),
- economic constraints,
- social equity and cultural issues.

Traditional approach to buildings appraisal is based only on financial return. Net present value, recovery of investment, internal rate of return are calculated and represent only economic point of view on building or project. Traditional project appraisal does not adequately and readily consider environmental effect and therefore does not satisfy the requirement of sustainable development.

This traditional approach to building appraisal can be modified with life cycle cost calculation. The life cycle costs are the cost of a building over its entire life. Life cycle costing (LCC) is a method for analyzing the total cost of the acquisition, operation, maintenance and support of a building throughout its useful life, and including the cost of disposal. This LCC analysis can provide important inputs for the decision making process. Classification of life cycle costs can be:

- investment, maintenance, repairing, reconstruction, modernization, disposal – the costs associated with technical parameters of building
- energy, cleaning – operational costs
- realty tax, insurance, property management – administrative costs.

It is evident, from this classification, that the approach to building appraisal using the life cycle calculation considers energy consumption. The social and cultural issues are not considering.

Sustainability approach to building appraisal has to consider quality of environment, economics constraints, social equity and cultural issues. Proposed building appraisal using sustainability index includes the following four criteria:

- financial return,
- energy consumption,
- external benefits,
- environmental impact.

The four criteria are measured by different methodologies and in different units. Criteria can be individually weighted to reflect particular client motives and community requirements.

Energy consumption consists of embodied energy (manufacturing energy of building materials and component, energy for transportation, energy used in processes) and operational energy.

External benefits consist of functional layout, maintenance, recycling/refurbishment potential, aesthetics impact, heritage preservation, social benefits and environment.

Environmental impact consist of manufacture (recycled materials, hazardous materials, greenhouse gas, pollution, manufacturing waste), design (evaluation of products, energy consumption, energy efficient), construction (air and noise pollution, water run off, construction waste), site context (groundwater, natural, rare/endangered species, transport system, traffic noise, access to site), disposal (non-recyclable waste, demolished waste/materials).

Traditional building's appraisal considering only economic returns, does not adequately and readily consider environmental effects, social, and environmental issues. This approach is shown to be no longer feasible. Buildings have a long life, so any improvement in their appraisal techniques can reduce their future environmental impacts and can satisfy the requirement of sustainable development. The sustainability index includes financial return, energy consumption as well as social and environmental issues in decision making framework.

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Intersection Geometric Design and Drivers´ View from Vehicles

Z.Čarská*, J. Coufal**

carska@fd.cvut.cz

*Institute of Transportation Systems, Czech Technical University, Konviktská 20, 110 00 Prague 1, Czech Republic

**Metroprojekt Praha a.s., I.P. Pavlova 2/1876, 120 00 Prague 2, Czech Republic

With growing GDP per person in Czech republic there is increasing number of motor vehicles especially passenger cars per one person. Number of accidents grows in relation with increasing number of cars and no giving of way from a minor road causes plenty of accidents every year. (No giving of way in Prague per year 2005 [1] caused approximately 30 % of all road accidents.)

Causes of upper mentioned kind of road accidents are different. Some of them were caused by bad technical conditions of vehicles or pavement surface, some of them by bad weather or /and light conditions (dark, snowing, fog etc.), the drivers were tired and did not pay enough attention to traffic situation sometimes and finally some of accidents were caused by drivers who simply didn't give a way because they did not see the other vehicle from priority traffic flow in time, in spite of that the vehicle approached into the intersection quite correctly (by common allowed riding speed and in the correct approach lane).

The finally mentioned group of accidents was interesting for us because the main reason of this described kind of road is caused unsuitable geometric design of intersection in combination with limitation of driver's viewpoint. Reasons, why drivers have limited their viewpoint, are different. The driver's viewpoint can be reduced for example by unsuitably situated road lights, billboards, trees or other physical barriers in intersection surrounding, but sometimes the intersection surrounding (important for good driver's viewpoint) is quite clean and in spite of this fact the driver did not see the other vehicle on the major road. The reason was the limitation of viewpoint by front or side vehicle columns rarely back columns. There is also necessary to note used terminology for these car elements: "A – columns" is a used term for front columns, similarly "B- columns" are side columns and "C – columns" are back columns.

The problem is more serious in last years. Vehicle columns care the car roof – the important element of vehicle stiffness. The stiffness of vehicle coachworks grows with the thickness of vehicle columns and this is the reason, for which vehicle producers began to do these columns wider a few years ago then earlier. Passive safety of vehicles is principally good priority for wider columns and in this relation there is reducing of driver's viewpoint by vehicle columns more important today than earlier.

For our research we chose the most frequent kind of passenger cars in Czech Republic. No doubt that these are passenger cars produced by the car factory Škoda. In the concrete we chose the type Fabia and Favorit, both these types of Škoda are numerous on our Czech road network.

For the research of driver's viewpoint reducing there is necessary to explain, how the next important angles are marked for the aim of this research. The angle α is the angle between the middle of a left A-column and a horizontal axis, which is perpendicular to flow-

line between both A – columns. The angle β is the angle between the middle of a right A-column and a horizontal axis, which is perpendicular to flow-line between both A – columns. The angle γ is equal the angle of driver's viewpoint, which is shielded by a left A-column and finally the angle δ is equal the angle of driver's viewpoint, which is shielded by a left A-column. All angles are measured from the supposed average position driver's head during driving a car. The intervals of measured values for both types of Škoda cars are the next: The angle α is from interval 22° to 23°, the angle β is from interval 54° to 56°, the angle γ is from interval 8° to 10°, the angle δ is from interval 5° to 6° [2].

We will suppose a level intersection with angles among all legs 90°. Next we suppose that a vehicle on a minor road (one of intersection leg) rides by speed V1. The second vehicle on the major road rides by speed V2. If the share of speeds V2/V1 is equal tg α - for situation that the second vehicle rides from left side – or the share of speeds V2/V1 is equal tg β - for situation that the second vehicle rides from right side -, it means that driver on the minor road may not see the other car on the major road in situation, when also the share L2/L1 of their changing distances from the middle of the intersection is constant and equal tg α or tg β .

The worst situation increase when the first driver has the second vehicle riding from left side shielded by his left A-column and at the same time the driver of second vehicle does not see the first vehicle through his right A-column. This described situation can occur when angle between intersection legs is equal angle ω = 180° - α – β. It means that this angle is from interval approx. 102° - 103°. This result corresponds with road accident analyses, because intersections with angle 100° – 105° have significantly higher accident rate comparing with intersections with leg angle 90° [3].

The different dangerous situation of driver's viewpoint shielding by the left A-column can occur on the large roundabout with two or more lanes on the ring road belt. We suppose that first vehicle rides in a left lane and the second vehicle rides behind the first vehicle in the right lane of ring road. It was calculated that for unfavorable distance between cars and the same angle speed around the middle island, the driver of the second vehicle doesn't see (through his left A-column) the light signal of right turning of the first vehicle. Unfavorable outer diameter of roundabout is approximately 50 meters. This is of course frequent value of large roundabout diameter.

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Management of Sustainable Development

F. Freiberg

frantisek.freiberg@fs.cvut.cz

Department of Management and Economics, Faculty of Mechanical Engineering, Czech Technical University, Horská 3, 128 00 Prague 2, Czech Republic

The need for sustainable development increasingly affects the behaviour of the corporate sector. The main influencing factors include an expanding regulatory framework and more stringent environmental protection standards. However, if a better match between the corporate behaviour and the principles of sustainable development is to be achieved, businesses themselves will have to be active in seeking ways of meeting social, environmental and economic objectives. Corporations seeking to exercise sustainable development must make sustainable development part of their value oriented strategic management. This strategic management is based on the idea that value is created through satisfying the needs of the corporation and those of the relevant interest groups – so-called stakeholders (shareholders, customers, creditors, investors etc.).

Delivering value to shareholders is presented as the primary responsibility of a corporation. It is shown that there are good reasons to support shareholder value not only with regard to shareholders but also in respect to other stakeholders. Stakeholders are presented as key drivers of business value. Potential benefits created through collaborative stakeholder relations and the main competencies required for value creation are outlined.

The strategy of sustainable development directly concerns all stakeholders both inside and outside a company. In all industries each product or service delivered by a corporation impacts upon the shareholders as well as customers, suppliers, creditors, employees, investors, the general public, the environment and other entities. All these stakeholders are potentially affected by both the benefits and the risks resulting from corporate activities. They influence business profitability and the opportunities and threats the corporation faces.

In the light of efforts to achieve higher profits the pursuit of sustainable development may seem as counterproductive. However, many examples of good corporate practice show that this is not the case. The strategy of sustainable development leads to cost savings based on the use of less expensive and more environmentally sound mineral and energy resources, re-use and recycling of material waste, manufacturing of new products from waste, recycling of components and materials from returned products, the use of new manufacturing processes for recycling, and improving the economy of material and energy use. The strategy of sustainable development may also lead to expanded market opportunities for existing products and services, and to a substantial reduction of the market, operational and capital risks associated with corporate activities.

Although the benefits of sustainable development are obvious, this concept is only sporadically pursued in practice. There are several reasons for this. One of them is that, frequently, the potential effects of sustainable development are not sufficiently known. Corporate managers are not always aware of the potential impact sustainable development may have in terms of productivity increases, cost reduction and higher yields. Another reason why managements show weak interest in the creation of sustainable value may be their

insufficient belief that such potential effects may be achieved, and an absence of the relevant management tools for quantifying these effects.

The creation of sustainable value based on co-operation with all stakeholders requires specific financial, strategic and evaluation competencies that facilitate integration of stakeholders' needs into value creation processes. Using his experience with several hundred companies, Ch. Laszlo identified eight groups of competencies. These competencies are derived from rules that may be used for a step-by-step identification and creation of corporate sustainable value.

The first step concerns understanding of the existing value situation – i.e. the ability to identify the factors that either create or squander the value for shareholders and other stakeholders. As part of the next step future expectations of owners and other stakeholders are anticipated (how they will change and what this means in terms of business opportunities and risks). This is followed by defining sustainable value objectives – i.e. the vision and objectives as regards the creation of shareholder value while increasing stakeholder value at the same time. The next step consists in proposing action to achieve the objectives. Activities must be in line with principal strategies – e.g. alleviation of risk, process cost reduction and process improvement, product differentiation with a view to satisfying customer needs, and market penetration into new areas with the aim of establishing new fields of business based on sustainability. The next step is concerned with developing a convincing example of activities that create sustainable value and that facilitate implementation of plans. The impact of the plans on owners and other stakeholders is quantified, as well as the relevant costs and benefits and the impact of the plans on shareholder and stakeholder value. Then the process of value creation is established. Cross-functional teams are created and co-operation with business partners is intensified. The necessary activities are integrated into corporate management structures and processes. The process ends by verifying the results (the rate of progress in achieving objectives is verified, potential barriers to the value implementation process are identified, existing approaches are reviewed and their results are verified), and by developing sustainable value capacities that are necessary for implementation of sustainable value strategy within corporate structures.

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Administrative-Legal Tools in Strategic Urban Planning

L. Jilemnická

jilemnic@fsv.cvut.cz

Department of Languages, Faculty of Civil Engineering, Czech Technical University in Prague, Thákurova 7, 166 29 Prague 6

Strategic urban planning of cities in the 21st century should focus on the citizens, reflecting their needs in a rapidly changing world. At the same time it should foster a long-term vision for the future development of cities, embracing the principles of sustainable growth.

Radical changes in governance are affecting the context for the planning of cities. Many cities are facing to the enormous financial and social problems as public authorities withdraw from many sectors of public life leaving parts of their responsibility for the collective interest to the free market. Planning activities may be an instrument to create genuine involvement and to safeguard collective interest, a tool toward social sustainability. The environmental changes also emerge, the physical environment being heavily affected by the increased scale of economic activities, sub-urbanization and urban sprawling, which means, in effect, spreading into the urban fringe and shrinking in the stock of farmland.

Urban planning should involve also environmental aspects, because the city should be regarded as an eco-system, where the citizen is at the centre of the planning process. All plans and programs should be based on the principles of sustainable development; sustainable appraisals should be prepared as integral parts of plans, and be linked to the process of public participation. From an environmental point of view, planning should encourage and ensure:

- the conservation;
- the limitation of suburbanization, of spreading urban functions in rural areas;
- improvement of urban spaces;
- the management of land as a resource, the rehabilitation of buildings urban structures and brownfield sites;
- energy conservation and clean technologies;
- the maintenance of local traditions and the augmentation of urban well—being;
- flexibility of decision-making to support local communities.

Within the State Environmental Policy of ČR there are some administrative – legal tools that can be used in strategic urban planning. One of them may be the Local Agenda 21. This agenda is an instrument for enforcement of the sustainable development principles on the local and regional level aiming at the increase of the quality of life in all its aspects. Regional planning is a very effective device of promotion of sustainable development goals, having a tradition, stabilized legislation and good organizational, technical and professional basis. However, it is necessary to collaborate between the Ministry of the Environment and municipal planning authorities already at the initial stage of gathering the basic data and formulation of assignment and conceptions of regional planning documentation.

There are many measures to support Local Agenda 21, e.g. to ensure a support of strategic planning on all level of public administration; to improve quality of management in regions on the Local Agenda 21 basis; to use maximally abandoned and underused grounds and buildings, so-called brownfields, for human activities; to prevent excessive fragmentation of the landscape and to support its ecological stability.

Active participation of all key groups and the public is one of the principles of sustainable development. On the national level there are, besides the legal measures, as well soft tools, e.g. institute of referendum, institute of ombudsman or possibilities of public debates in creation of economic, legislative instruments, system of grants, etc., important.

Ecological action program summoned to creation of the thematic strategy of the urban environment with objective to improve the citizens quality of life. Sustainable growth is one of the priority spheres of this strategy. The necessary pre-requisite for achievement of long-term improvement of the urban environment is an integrated approach of the local governments. Adequate municipal planning of sustainable cities should significantly assist at stopping the urban sprawl and liquidation of natural habitats and biological diversity.

Directive of the Ministry of the Environment of ČR No. 3/2007 presents the Program on urbanized environment protection. It follows, besides other goals, support of regeneration of biological values of underused and derelict areas, damaged by the former industrial and transport activity (brownfields), contributes to the remedy of the natural components of the environment of the territory overloaded by industrial and transport function and enables system and conceptual approach to the development of natural areas in settlement as well as brownfield revitalization. Financial means can be provided to the feasibility study aimed at conceptual design of brownfield revitalization and their possible use for sustainable development of settlement, as a future basis for municipal planning, where the purpose is reuse of abandoned areas and prevention of acquisition of the free landscape for building development as well as creation of green belts around settlements as a limit of sub-urbanization pressures in the urban fringe. Some administrative-legal tools facilitating brownfield rehabilitation will be also involved in amendment to the Act No.100/2001 that is now in parliamentary debate.

Sustainable economic development and increase of the quality of life is indispensable and cannot be stopped. However, such development should be regulated on all levels of the public administration (state, regions, municipalities).Administrative-legal tools in strategic urban planning should contribute to the sustainable urban management and land use. The brownfield redevelopment inside the cities as well as creating green belts around cities should be favored against sub-urbanization and urban sprawl.

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Dynamic Model Structure for Change Management

V. Beran*, P. Dlask*

beran@fsv.cvut.cz, dlask@fsv.cvut.cz

*Department of Economics and Management of Civil Engineering, Czech Technical University, Thákurova 7, 166 29 Prague 6, Czech republic

The managerial *decisions* in technical-economic applications are specific. These decisions are a basic platform for process[1] management. Principal information for any management is the ability to bring into play the process *memory* for involved process components. *Long memory* has in terms of management subject point of view two observation direction – *retrospective* (history of data) and *perspective* (prognosis of process behaviour). Decision once taken influence economical output for a long Live-Cycle. Rectifications of decision pathway are difficult and expensive in effort. Risk, forecast, economic decision evaluation, value of information play important role in dynamic management. These aspects create platform for the modified dynamic models in risky surroundings and long memory impacts. *Modified Dynamic Model* (*MDM*) is SW for technical-economic problem solving. However, every managerial decision is related to a portion of uncertainty, risk and long memory aspects. Not for every problem there is a possibility for exact determination of starting conditions and influencing interactions factor. For such situations it is appropriate implement *Risk Modified Dynamic Model* (*RMDM*), a SW extension that eliminated limits of the basic variant of dynamic modeling and practical applications.

Fixed decision rule D˜ and long memory dependent decision space.

The *Risk Modified Dynamic Model* is an effective tool for verification of a Manager Strategy [1]. It is worth nothing that any decision rule influences the structure (location in time and placement of implementation) of process **P.** We speak about

- dispersion in time,
- value change of implemented action (activities) in time,
- present value change according to profit rate (discounted value),
- changed value in time according to construction of decision rule,
- changed value in time according to stick to memory of input data.

The memory dependent decision space is written as

$$[(\mathbf{D}^{\sim} \mid Mem)\ ,\ Mem = (dBase,\ time\ series,\ \ldots)] \tag{1}$$

Risk interactions are created by means of a random number generator. The generator needs several characteristics for its process. Risk and uncertainty exist in different time periods. The model has to be able to describe the risk in these periods. Risk description contains the following information:

Starting time (beginning of interval)
Ending time (end of interval)
Decision about using (YES/NO symptom)

The risk parameters described above are basic for method solving under risk and uncertainty. By means of *RMDM* we can determine critical conditions and elements that might indicate

[1] whatever process might be, live cycle of technical goods, construction process, deconstruction, project proposal, design, conflict situation, crisis situation, act.

instability of model structure. Basic steps of *RMDM* applications reflect of *memory* and *risk* impact in process

$$\mathbf{P} = \langle \mathbf{A}, \mathbf{K} \rangle | Risk \tag{2}$$

where **A** is set of process activities and **K** set of causal interactions [1].

The most of practical applications are influenced by risk. In our application we will deal with risks in interactions of elements **A**. The impact of risk exposition in **K** is very often time-limited. The software tool enables the time dependent exposition of risk. Resulting simulation trajectories of influenced elements enable insight into consequences of *risk exposition* [2]. The examples are solved as risk exposition of investment. *New Hotel Investment* addressees risk into determined time periods. The diversity of consequences is broad. In the critical negative case we are obliged to calculate with the total collapse of element *New Hotel Investment*. In the positive case may appear sharp improvements. Simulation opens space for management interactions and regulation in design.

The probability of possible positive prospect is visible on multiple simulations. The sharp (critical) collapse or increase of *Standard* of simulation trajectory enables visible control of management interactions. The statistical analyses of multiple simulations enables evaluate probability of process recovery after disturbances (shocks). Most risk expositions leads to immediate improvements or after risk exposition recovery followed by growth in touched standard.

Under these circumstances, there decisions have long memory. Long-live decisions are mostly irreversible and have a very high critical mass of energy needed to change the decision path for the future. We might speak about applications like inventions, innovations, lost opportunities, disasters, crisis, accidents or other events, very briefly about *long memory strategic decisions*. The economy is mostly technical skill arbitrator and an unwanted witness of generation lasting burden. Moreover, during the technical artifacts *life cycle* the evaluation criteria changes. In spite of this, the *dynamic modeling* and *dynamic simulations* (Forester, J., W. 1961-1971) may support decision making (3).

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