

CTU REPORTS

Proceedings of WORKSHOP 2007 Part B

Czech Technical University in Prague

SPECIAL ISSUE

February 2007 Volume 11 These are the Proceedings of the Thirteenth Annual university-wide seminar WORKSHOP 2007 which took place at the Czech Technical University in Prague from 19th to 23rd February, 2007.

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 349 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 6

MECHANICS & THERMODYNAMICS

Experimental equipment for correction possibility verification of PLIF method on refraction index changes.

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The thesis describes designing of heat exchanger used for modeling of thermal boundary layer on flat plate. Heat exchanger has two main purposes. At first it is used for determination of PLIF method sensitivity, because of changing refraction coefficient in heat induced area, and determining of correction coefficients joined with this phenomena. The second main purpose is to create a setup for implementation of modern measurement method

PLIF to the education mainly in higher university level.

This project was divided into several parts from the beginning. The first part was to design and make the whole measurement setup. Measurement setup consists of supporting structure, heat exchanger, stilling boxes, moving plate, supply bin, pumps, thermocouple system, control unit of heating bodies and other construction parts used for holding and fixing every single part.

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.

Supporting structure is made from aluminum beams by Alutec KK Company, because of low weight and easy disassembling. Stilling boxes and exchanger are fixed on the moving plate, which could be moved along the exchanger in face of cameras and laser beam. Cameras and laser optics assembly are fixed on the construction, so there is no way of moving laser beam in face of cameras

Flow rate in cold water channel is regulated by the distance of level heights in inlet and outlet stilling boxes. In the inlet box there is an overflow used for keeping constant water level. If there was the same way in outlet box, the usage of exchanger would be limited by one velocity value in cold water channel, so the outlet of outlet stilling box consist an assembly with the orifice plate, which sets the tasked water level by its cross section. Using the couple of orifice plates it is possible to set the couple of velocity values.

Warming up the water in warm water channel is provided by the couple of heating bodies with summary power up to 3 kW and possibility of regulation. That's all that's necessary to guarantee the temperature distance between the wall and free flow of 10 °C.

Together with the measurement setup, software for regulation of heat bodies and getting measured data from thermocouples was also created. The software was created by using Matlab opposite the original plan. The main advantage is the possibility to compute measured data together with the data got from Flow Manager software by using only a couple of functions created before.

Designed measurement setup fulfills the conditions for PIV and PLIF measurement. As a prototype of measurement, setup for PLIF method will be also used for the future student's work e.g. graduate work, level work etc. From the measured data got from the PLIF method it is seen that recording measured area under the angle of 5 degrees declines the effect of changing refraction coefficient. From the comparing measured pictures with temperature field and without it for free convection measurement made in the past (0 degrees of recording) and forced convection measurement (5 degrees of recording) it is seen that virtual movement of picture is much lower in measurement using the exchanger than measurement of free convection. It results from measured data that the main usage of the exchanger is now to verify the effects caused by changing refraction coefficient in heat induced area.

For the final implementation this setup on education it is necessary to make another check measurement. This year new camera and objective will be bought from the resource of University Development Fund, which will make the whole measurement independent of commercial software FlowManager and it will be possible to use it anytime.

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Experimental Investigation of the Refrigerant Flow through Copper-Nickel Small Bore Tubes

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Small bore tubes, known as the capillary tubes, are commonly used as expansion devices inside small vapor cooling circuits such as household fridges, air conditioning, etc. Capillary tubes are sometimes used in special cooling systems where other expansion devices can not be installed. Department of Physics cooperates with CERN on the design of unique systems for particle detector cooling. These circuits use mainly capillary tubes placed relatively far away from condenser-compressor unit. A numerical simulation of the refrigerant flow through capillary tube was generated and presented in previous paper [1]. The numerical model helps us to find proper parameters of the capillary tubes for adequate cooling circuits. This study focuses on the experimental investigation of the refrigerant flow through copper-nickel capillary tubes.

For our purposes, the accuracy of the numerically simulated results was improved by investigating the friction factor correlations and the average capillary inner wall roughness. Even though both these parameters have crucial effect on modeled capillary tube performance, they did not receive much attention in the literature so far. Some additional measurements of the one-phase flow through capillary tube performed in laboratory at CTU Prague served us to find most convenient friction factor correlation and an approximate value of the relative inner wall roughness. Calculated pressure drops over the capillary tubes were compared with the experimental data. Theoretical results were corrected by taking into account channel contraction at the end of connecting pipe and the capillary tube entrance in terms of Collier & Thome relation suggested for instance by Bittle and Pate, [2].

In total eight different friction factor correlations were evaluated. The best agreement with the experimental data was achieved by using two Colebrook's correlations. Both these correlations can be used in wide range of Reynolds number from 4000 up to values corresponding to fully developed turbulent flow. All experimental data are correlated within relative deviation of $\pm 3\%$. Haaland's and Churchill's relations provide reasonable results as well, although they should not be used for Reynolds number lower than 8000.

Relative wall roughness, ratio of the wall roughness and the inner diameter, of tested copper-nickel capillary tubes was found to be 0.002 for large capillary tubes with inner diameter larger than 0.7mm and 0.004 for small tubes with diameter around 0.5mm.

The overall performance of the capillary tubes inside real cooling circuit working with refrigerant R-218 was tested in the laboratory at CERN during 2006. Set of capillary tubes with length going from 0.3m to 2.5m and inner diameters between 0.45mm and 1.0mm was measured under varying operating conditions. Both the temperature and the pressure of subcooled refrigerant at the capillary inlet were changed in relatively wide ranges. Mass flow rate of the refrigerant, the primary parameter of the capillary flow, was measured with two volumetric flow meters (Swissflow 800 series in the liquid line, Schlumberger Delta G16 in the vapor line), one corriolis mass flow meter (Bronkhorst CORI-flow) in the liquid line and IST thermal flow sensor in the vapor line. Pressures at the inlet and outlet of the tube were measured with precise pressure transducers from Keller and Sensortechnics manufactures. 392

Temperature of flowing refrigerant was detected with several Pt1000 sensors mounted on the capillary tube outer surface. An average inner diameter of each capillary tube was determined by weighing method before the test. Mobile DAQ system for automatic signal monitoring was prepared; it is based upon Embedded Local Monitor Board (ELMB) device, Kvaser CANbus card and notebook with PVSS II software.

Measured data gave us relatively accurate background for generating simple analytical correlation which could be used for the refrigerant mass flow rate prediction through the capillary tube of known geometry. Dimensionless analysis based on Buckingham π -theorem was also applied on the experimental data; π -parameters were defined in similar manner as presented by Choi, [3]. Approximately 95% of experimental data are correlated within relative deviation of ±10%. Generated correlation can be used for mass flow rate prediction of refrigerant R-218 within following operating conditions: critical (chocked) capillary flow; subcooled liquid at the capillary tube entrance; inlet pressure 7bar ÷ 13bar; inlet temperature - 20°C ÷ +25°C. The correlation was successfully used for the design of the capillary tubes installed inside cooling circuits for TOTEM experiment and for some parts of ATLAS experiment, mainly for Pixel part of the Inner detector, both for the Barrel and Disc cooling loops.

More convenient correlation function than standard power law function is being prepared. Artificial neural network can be used as another method for generating new mass flow rate correlation; see Zhang [4]. Matlab software and its Neural Network toolbox are used for testing neural network consisting of one to four neurons. First results show that approximately 95% of experimental data are correlated within relative deviation of $\pm 7\%$.

Research of the capillary tubes performance at CTU will continue, because some new special cooling circuits should be designed for CERN experiments during 2007.

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Efficient algorithms for the numerical simulation of heterogenous materials

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Recent decades have witnessed increased interest in the multi-scale modeling and simulation of heterogeneous materials and structures. Initially, the development of analysis techniques was mainly driven by the fundamental research in applied mathematics and theoretical physics with emphasis given to rigorous foundations of the homogenization theories for simple material systems. Therefore, while sophisticated composite materials have been successfully employed in virtually all engineering areas, the ability to model the real-world materials and structures still remains in its infancy. It is worth noting that the homogenization techniques are applicable not only to high-tech engineered systems, but can also provide the basis for more realistic constitutive models of traditional materials such as wood or masonry. Therefore, the application of homogenization methods to realistic engineering structures necessitates the development of efficient algorithms for different stages of the automated multi-scale analysis.

Although the majority of the available homogenization theories assume the existence of a well-defined Representative Volume Element (RVE) – a typical microstructural sample characterizing the analyzed material – its definition for real-world materials is far from being straightforward. The only situation allowing an unambiguous definition of the RVE is the case of perfectly periodic media, for which the RVE coincides with the smallest Periodic Unit Cell (PUC). Even though the periodicity is not exhibited even by carefully prepared laboratory samples, giving up the benefits of periodic homogenization is definitely not very practical. Therefore, the concept of the *statistically equivalent periodic unit cell* (SEPUC) was employed in the present project. Within this framework, the original microstructural configuration is first quantified using suitable statistical descriptors. Then, the statistically equivalent periodic unit cell is found such that it approximates the target microstructure as close as possible in terms of selected statistical descriptors. The resulting SOPUC, which maximizes the available geometrical data, can then be used to simulate the overall response using well-established periodic homogenization methods, see [1] for further reference.

Once the geometry of a heterogeneous system has been identified, it needs to be complemented with realistic *constitutive description* together with the appropriate procedures for the *calibration* of model parameters. In the multi-scale context, however, simple testing procedures, based on the assumption of uniform fields, are no longer applicable due to the inhomogeneous character of the material. The traditional trial-and-error identification of material models parameters thus becomes costly in terms of both money and time. Moreover, the rigorous gradient-based optimization approaches often suffer from the poor conditioning and non-smoothness of the inverse problem. In the present project, an alternative robust approach employing the techniques of soft-computing methods was examined. The microplane model M4 was selected as the example of a multiscale-inspired constitutive model, which is known to be notoriously difficult to calibrate. In contribution [2], we present a procedure utilizing the *stochastic sensitivity analysis*, feed-forward *Artificial Neural Networks* and real-encoded *genetic algorithms*, allowing a computationally efficient sequential determination of all parameters identifiable from introduced structural tests with error less that 5%. Although 394

the study [2] is focused on the particular material model, the procedure is quite generic and can be used for any appropriate constitutive model.

As an educated guess, more than 99% of engineering multi-scale computational simulations employ the Finite Element Method (FEM) for the problem discretization. When applied to materials with a complex three-dimensional geometry, a non-negligible part of the analysis is spent on the generation of a conforming finite element mesh. Moreover, the requirement of reasonable finite element shapes often leads to problems with a huge number of finite elements, which makes a multi-scale scheme too expensive even for modern powerful computers. Therefore, the application of alternative numerical algorithms can lead to substantial savings both in computational resources and well as time requirements. Within the current project, an efficient *iterative method* based on the *Fast Fourier transform* was applied for the analysis of woven composites. A generic criterion for the convergence of the method, valid for any distribution of individual phases within the PUC, has been presented in [3]. Moreover, the superiority of the algorithm when compared with FEM was demonstrated by a number of representative examples.

One of the unique examples where the introduced techniques prove their potential for a realworld application is a *rehabilitation project* of the *Charles Bridge in Prague* [4]. Due to the size of the problem to be analyzed, a fully uncoupled computational scheme was adopted in the computational assessment. The inherited heterogeneity of the bridge body then inevitably called for an application of homogenization to seek estimates of various quantities that appear in the formulation of the macroscopic constitutive description. In particular, the typical heterogeneity patterns observed in different parts of the bridge body were extracted using the SEPUC paradigm [1]. Then, the parameters of constitutive models on the level of individual constituents are identified using the stochastic sensitivity procedure [2] and used is the computational damage assessment of the structure. It is worth noting that although a number of simplifying assumptions was accepted along the way, the predicted cracks correspond rather well with in-situ observations. This provides a solid proof of the applicability of the introduced approaches.

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Section 7

MECHANICAL ENGINEERING

Application of a New Method for Suspension Measurements with High Concentrated Suspensions

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Suspension mixing is very important hydraulic operation. It frequently appears at preparation of dispersions, their homogenization, mass transfer operations between solid particles and liquid that is often accompanied by a chemical or a biochemical reaction. Very important parameters for designing of mixing apparatuses are the critical (just-suspended) impeller speed and the power consumption necessary for off-bottom suspension of particles.

State of just off-bottom particle suspension is often determined during experiments visually on the basis of the particles sediment observation at the vessel bottom. Accuracy of visual observation of particle layer sediment depends on subjective experience of experimenter. The method is very simple but it is difficult to apply or inapplicable e.g. in badly transparent, non-transparent or highly concentrated suspensions. This disadvantage is possible to remove by a new application of the electrochemical method (EDD).

This method is based on a measurement of a limiting diffusion current. A two-electrode cell consisting of a small working electrode and a large auxiliary electrode, a solution containing depolarizer and supporting electrolyte is sufficient for measurement of the current. Providing some certain conditions, the transport of species and, thereby, the electric current is controlled by the velocity field in the vicinity of the working electrode only. In previous works, it was suggested to observe arithmetic mean value and standard deviation of probe electric current. These parameters change with the velocity of a liquid flowing in the vicinity of the working probe. With decreasing amount of particles at the probe, the velocity increases and so does the electric current. The just off-bottom particle suspension state at ED probe location is represented by rapid increase of arithmetic mean value and standard deviation of the current.

In previous papers, there were taken some systematic suspension experiments using EDD. The results of these measurements lead to conclusion that electrochemical method provides relatively exact results in comparison with visual method. However in all experiments there was always used the same type of electrolyte and also physical properties of tested suspensions were very similar. Therefore, we took other experiments to determine the effect of electrolyte type and its concentration composition on accuracy of EDD and its applicability for suspension measurements. The method was used in experiments with wide range of particles size, their concentration and also in different types of material creating the solid phase.

The experiments were always carried out in transparent cylindrical vessels with dished and flat bottom. Thanks to the transparency of the vessels, all measurements results obtained by EDD could be verified by results determined from visual observation of particle layer sediment provided at the same time as the electrochemical measurement.

During these measurements two types of electrolyte were tested as a liquid phase – potassium ferri/ferrocyanide aqueous solution with K_2SO_4 as a supporting electrolyte and aqueous solution with NaCl as a supporting electrolyte. Different concentrations of electrolytes components were used in the measurements. The probes, necessary for

measurement, could be made only of platinum or nickel (and also silver in case of solution with NaCl) in order to have the right electrochemical reaction on the working probe. In the experiments only platinum probes were used. The solid phase of tested suspension had always the same properties.

From experiments, it was determined, that the dependences of arithmetic mean value and standard deviation of probe electric current on impeller speed obtained from all measurements at the same probe had the same shape and the differences were only in absolute values. If all dependences were then normalized by its values corresponding to complete off-bottom suspension state (arithmetic mean of a few latest values above just suspended impeller speed in each measurement), they became almost identical.

During experiments with ferri/ferrocyanide, it was also determined that conductivity of suspension (concentration composition of electrolyte) has no influence on the course of arithmetic mean value and standard deviation of probe electric current. In the case of aqueous solution with NaCl there were some limits. It was unable to use the electrolyte with concentration of NaCl above 15 % b.w. If the NaCl concentration was lower than 15 % b.w then it didn't influence results obtained by electrochemical method as in case of ferri/ferrocyanide electrolyte. More information can be found in [1]. We could then make profit of these results in following experiments.

In our work, the EDD was also used for identifying of just suspended suspension state in experiments with highly concentrated suspensions in wide range of particles size. The method provided exact results during all experiments even in high concentrations of solid phase and also in case of small particles, where the visual method was worse to use. More conclusions of these experiments are published in [2].

Certain problems with accuracy and applicability of electrochemical method for suspension measurements occurred during experiments in suspensions with fine particles [3]. When the concentration of particles was low (15 % vol.), the method allowed us to determine the just suspended state relatively exactly in comparison with visual measurements. However in highly concentrated fine suspension, the method could not be used. The required conditions for the application of electrochemical method weren't satisfied and it was unable to recognize just suspended impeller speed from EDD records. The usability of the method in highly concentrated fine suspensions requires more sensitive system and more precise work and it is the aim of future work in this research area.

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1-D Model of Engine with Pressure Wave Supercharger and its Comparison with Turbocharger

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Current research activities on new propulsion systems insist on the increase of their efficiency and power whereas it is simultaneously tried to reduce the fuel consumption and the level of the pollutants produced by these new concepts. Moreover, in case of car propulsion systems the satisfactory drive ability to satisfy driver's demands during the accelerations has to be provided at the same time.

Apparently, an approach of utilization of downsized propulsion systems may lead successfully up to these aims. Main idea of downsizing is reduction of the swept volume of the engine without lowering the original output power. The performance increase of the downsized engine to the same power level of the original one is achieved by boosting device which supplies increased amount of the air to the thermodynamic cycle of the engine.

Nowadays commonly used and developed boosting devices like turbocharger or mechanical supercharger work on principle of transformation of the mechanical energy to the pressure one using blades or pistons. On the other side, there is an interesting device which produces pressurized air directly and benefits from speed of sound.

The pressure wave supercharger (PWS) takes advantage of an unique principle of the direct pressure energy exchange between two fluids. In the longitudinal perforated drum of the PWS, also called wave rotor or simply rotor, the pressure energy is transferred from medium of higher energy (exhaust gas) to medium of low energy (fresh air) using propagation of the compression and expansion waves in a narrow channel placed on the perimeter of the rotor. In the rotor both hot exhaust gas and rather cold fresh air are placed without any separation. As the process of compression is finished within very short time, usually in milliseconds, the compressed air is available earlier than in case of common air compressor. Moreover, due to the phenomena of energy transport using pressure waves and because of direct contact of both mediums the compression of fresh air runs more effectively and with higher efficiency than at common air compressor with blades. Nevertheless, the very fast process of pressure wave propagation and possibility of exhaust gas and fresh air mixing in the rotor stresses an importance of accurate and well timed control. Moreover, hot exhaust gas must not strain the rotor too much. Although lots of effort with noticeable results have been undertaken to cope with the phenomenon of the pressure wave process and rather complex unsteady flow inside of the PWS and despite of the 50 years development of the wave machines up to the successful serial production of PWS as the supercharger for the car diesel engines in 1980's and 1990's, the technology of the PWS is not used today. As a result of the technology innovation, new control possibilities, new materials and improved knowledge of the unsteady flow, many research centers consider the concept with pressure wave machine as technology with promising potential in car engine supercharging.

In this contribution the PWS is simulated using detailed model based on the partial differential equations capturing non linear effects of gas dynamics [1]. The work has been performed using the commercial code GT-Power. Concept of modeling used enables to

integrate the PWS model with all other models which are already created in the commercial codes (like with more precise model of combustion, vehicle model, etc.).

In this study different PWS sizes have been investigated both at the diesel and spark ignited engines. The results have been compared to the turbocharged engines. The PWS has rather linear trend (i.e. more convenient) of boost pressure with increasing of engine speed than quadratic like in case of turbocharger. The smaller the PWS the higher boost pressure can be achieved. In comparison to boost pressure, the engine torque of PWS falls down at highest engine speeds. Moreover, the smaller PWS does not reach the same nominal power as the bigger one. This is caused by internal exhaust gas recirculation (egr) over the channeled rotor of PWS (due to the direct contact of exhaust gas and fresh air, the exhaust gas can be delivered direct to the engine cylinder together with the compressed air) which deteriorates the engine torque. The amount of PWS internal egr, which enters the engine manifold, is influenced in particular by rotor speed and rotor scavenging. The deviation of rotor speed from the optimum point increases the internal egr. The pressure wave process inside the channeled rotor is very sensitive to the pressure losses in the connecting engine pipings. Reduction of flow losses produces better rotor scavenging with the fresh air. Thus, the internal egr can be apparently decreased using connecting piping with a convenient enlarged diameter.

The dynamic behavior of the PWS supercharged engine was examined for the constant engine speed. It corresponds to the first instant of vehicle acceleration. The PWS reaches the steady engine torque within two seconds after the load change, faster than turbocharger. However, if the PWS speed is hold constant during the whole load step (like in the case of all so far manufactured engines supercharged by PWS) the torque of PWS supercharged engine drops bellow the torque of turbocharged one. It has been demonstrated that in order to prevent this deterioration of drive ability (caused by so called transient internal egr), the PWS speed should be step wise changed during the load step.

In framework of this study the drive-away tests in 3rd gear of the Škoda Octavia with PWS supercharged 1.91 diesel engine have been undertaken and compared to the same turbocharged engine.

As the PWS showed during the simulation work behavior which could fulfill demand on a modern car propulsion system, the PWS measurement at the test bed with the combustion chamber has been undertaken. To compare the simulation to the experiment the PWS at the test bed has been modeled as well.

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Wear Resistand Coatings and Renovation of Functional Couples by RVS Technologies

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Limited proprieties of one-component metal coat always do not correspond to all requirements pose on properties of surface. New trends of development are oriented on multi-component coating. Alongside metal coating is the development trend on alloyed and composite coating. At technologies of galvanic and chemical electroplated wear resistant and functional coating are exuded in particular on base nickel.

Nickel is a metal with typical metallic character, very high thaw point, good heat and electric conductivity and small atomic volume. Protective characteristics of nickel coating are in atmospheric conditions very good, because nickel is mostly in passive position. Nickel provides to materials on irons base barrier protect and therefore it is necessary cut-down his porosity. Hardness of galvanic secreted nickel is 300 - 550 HV, ductility is 3 - 8 % and tenacity is 600 MPa. To the galvanise secretion of nickel coating is used in practise most often acid liquor of sulphated and chloride type.

Matrix choice for composite galvanized coatings depends on requirements laying on composite material, like are for example hardness, tenacity, wear resistance, heat resistance, corrosion resistance and others. For precipitation of wear resistance composite coatings is used the most often nickel like the matrix, because nickel coating has suitable characteristics for this purpose. Service and control of liquor is not difficult. Nickel is also able to create alloyed coating with various elements whereby it is reach to improve characteristics of matrix coating.

Dispersed elements compose next component of composite nickel coatings. The most often are used elements about magnitude from 1 to 20µm. concentration of dispersed elements in electrolyte are moving in range from 5 until 100 g/l after requirements of coating. *Diamond* is form of carbon crystallizing in cubic modification about specific weight 3,52 g.cm³ It is offer in nature form, but firstly is prepared by synthesis under high pressures and temperatures. It features by good heat conductivity, heat resistance to the 860°C and it has very low friction coefficient.

Composite coatings of standard nickel-diamond are used firstly as functional coating of cutting (abrading) tool and heavy-duty abrasion coating. Composite coatings find first his great use in abrading cutting tools. Quality of cutting tool with composite abrasive coating depends except suitable choice abrasive material and service conditions deposition of coating firstly on magnitude of grow in granule of the abrasive in nickel matrix. In this time many of workplace is trying to apply these coatings for extremely stressed components of mechanisms.

From machines and mechanisms is requested long-time, trouble-free and economical service. The wear comes to gradually impairing technical and economical parameters. And it has direct effect to service life and reliability. The drift of progressive technologies of surface treatment is take off the wear of functional couples.

There is requirement of substitute ferrous alloy by new materials like plastic, aluminium alloys, ceramics and metal ceramics. At the same time are founding new surface treatment with better triboligical characteristics.

RVS Technologies are based on atomic barter reaction between components of RVS devices and base material. This reaction is incurred by friction heat and kinetic energy. It makes possible create ferrous-siliceous (metal-ceramics) surface texture on steel surface. RVS Technologies are used in manufacture as finishing operation for treatment of friction contact surface or for renovation of wear mechanisms like ball bearings, gear-boxes, motors, diesel pumps, production machines and other plants. RVS devices are gently dispersed polycomponents mixture of minerals, additions and catalysers. Base raw materials for their produce are minerals serpentine, jade and others. Usually are used oils and lubricants like carrier medium.

Friction and contact surfaces of machines parts are in its prime state created by juts and pits full of lubricants and wear particles. During motion of functional couples comes to mutual contacts of surfaces and tops of juts are weared into oil film. In contacts areas raise local high temperatures 900 – 1400 °C, which of power advance barter reactions between RVS mixtures and base material. Thereby are creating new ferrous-siliceous (metal-ceramics) layers. These new metal-ceramics particles are much bigger then prime material. Because of this comes to gradual run of dimensions surfaces layers in interval from several tenths to tens micrometers. Rising ferrous-siliceous texture has greatly lower roughness than prime surface. It means gradual dispraise friction and wear. New layer with hardness HRC 63 – 70 usually go over hardness of prime material. Metal-ceramics layer is able to grow to thickness hundreds micrometers. Friction coefficient reaches very low value, even 0,003. Temperature of decay of metal-ceramics is high, 1575 – 1600 °C. The layer does not corrode influence of acids or hydroxide and it has high cavity destruction resistance. Impact strength of metalceramics is about 490,3 MPa. It has high resistance ($10^6 \Omega$.m).

Economical and ecological savings is in multiple continuation service life and reduction of demand on change of lubricants. Other interest is in reduction of noisiness during action of mechanism. This method could be used for treatment of friction contact surfaces at produce of new parts and renovation wear parts. Interest is in treatment or surface renovation without demounting during running of mechanism. The give which is adventitious by RVS Technologies on every functional friction couples is optimal. These gives are hardly available by current productive. The result is safe, optimal, long-time running service of functional couples of all mechanism.

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Kinematic Errors

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Introduction

This report has as a goal to follow of effort errors by motor and to weight. Motor and weight are connected one-stage gearing. It is realization of geared belt. It is effort to follow a trend of errors with constant speed with variable torque to weight. Experiment was done for four speed (2,4,8,12 rev/s) and for each speed was done nine experiments with weight (-12,-9,-6,-3,0,3,6,9,12 Nm).

Characteristics

 $z_R = 72$ number of teeth belt

 $z_{\rm M} = 20$ number of teeth big pulley

 $z_L = 30$ number of teeth small pulley

 $J_{\rm M} = 0.0019$ kg.m² inertia moment to shaft of small pulley

 $J_L = 0.0042$ kg.m² 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 of errors theory

Particular about theory of errors are introduced in many literature. Here is only a brief statement a basic errors.

The errors are in a three basic groups: errors of motors, errors of semsors and errors of gearings.

Errors of motors

Don't keep a commutation angle:

This error go out of equation for torsian moment of rotating electric machine.

$$M_{\kappa} = konst \cdot \left[\vec{B}_{S} \times \vec{B}_{R}\right] = konst \cdot B_{S} \cdot B_{R} \cdot \sin \theta$$
⁽¹⁾

We ignore the error by electric motor of type DC. If the number of commutator lamells is ample, come minimal oscilation of angle θ which optimal value is 90°.

The motor with three-phase winding in a stator and magnets in a rotor (EC) rotate with magnetic field by fits and starts $60^{\circ}/P$, P is number of poles. For example bz 2-poles machine (P=1) the vector of magnetic induction of stator step by step 60° . The angle θ oscilate between $90^{\circ}\pm 30^{\circ}$

Don't smooth ufolded a magnetic induction between a stator and a rotor:

This is given a number of compole a stator slots for winding etc.

The vector B_S, and B_R oscilate in equation (1) in accordance with numerical expression.

$$B_{S} = B_{SO} + \Delta B_{S} \cdot \sin n_{1} \cdot \varphi_{M}$$

$$B_{R} = B_{RO} + \Delta B_{R} \cdot \sin n_{2} \cdot \varphi_{M}$$

.... theyr product in equation (1) get form
(2)

404

$$B_{S} \cdot B_{R} = B_{S0} \cdot B_{R0} + \Delta B_{S} \cdot B_{R0} \cdot \sin n_{1} \varphi_{M} + \Delta B_{R} \cdot B_{S0} \cdot \sin n_{2} \varphi_{M} + \Delta B_{S} \cdot \Delta B_{R} \cdot \sin n_{1} \varphi_{M} \cdot \sin n_{2} \varphi_{M}$$

after treatment

$$\sin n_1 \varphi_M \cdot \sin n_2 \varphi_M = \frac{1}{2} \cdot \sin(n_1 \varphi_M + n_2 \varphi_M - \frac{\pi}{2}) + \frac{1}{2} \cdot \sin(n_1 \varphi_M - n_2 \varphi_M + \frac{\pi}{2})$$
(3)

Oscilation of torsian moment enough determine a basic harmonic itemwith frequency n_1 , n_2 and another item of additive and differential frequency $n_1 \pm n_2$.

Errors of sensors

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.

$$\frac{\varphi_M(s)}{\Delta\varphi(s)} \approx \frac{1}{K_V} \cdot \frac{s}{\tau_V s + 1} \tag{4}$$

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. Errors of gearings

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. Result

Results of measure are in the graph of moment with constant speed. For each of speed are two graph – errors to motor and errors to weight.

Character of curve for chain moments for one speed was effort to find periodicity or dependence in peaks of graph FFT.

For zerro weight have a amplitude smallest values. With growing weight we follow a confluent of values. The growing of amplitude is not symmetrical. If a weight has positive values are the amplitude major as a identical weight but negative.

Errors to weight are major as errors to motor, it is generall validity. With growing speed an amplitud move to the right taller frequency.

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 and number of teeths to small pulley.

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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Workshop Microscope Modernizing

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This paper presents performed work on modernizing of a large workshop microscope Zeiss, which will be used in practical tasks of the subject Instrumentation Technology of the study programs Instrumentation and control engineering and Biomedical and rehabilitation engineering educated at the Faculty of Mechanical Engineering of Czech Technical University in Prague. This project was supported by grant of Foundation of Universities Development of the Czech ministery of education, youth and physical training.

The purpouse of microscope modernizing is based on two factors. The first one is the presents of the quality workshop microscope in our labs, which will be suitable to use for quality measurement of the student's products manufactured durring the practical training od the subject Instrumentation Technology. Disadvantage of that microscope for this application was the old and time consuming position measuring process based on reading of optical scale using reading microscopes. The second purpose of microscope modernizing is the presentation of good mechanical construction of this instrument ability to attain the same measuring uncertainty parameters as nowadays instruments after relatively easy exchange the olds optical reading scales with modern optoelectronic readings and data processing using computer. Presentation of this modernizing microscope will be very good example for another subject Instrumentation design educated in both study programs and accessible for all students of the faculty too.

Process of microscope modernizing consists of four following phases. The first one consists in partial strip down of the microscope, cleaning and lubricating the instrument, and its assembly and adjusting the microscope. This works were begun durring the spring 2006 and finshid durring the summer 2006. We choose the appropriate kind of optoelectronic scales used for workshop microscope modernizing within this work phase too. We heve choose optoelectronic scales product ILC N with measuring step 0,5 μ m of the ESSA company. The boths possibilities as external indicator ADL as computer data processing using IEPC card were choosen for data processing.

The second phase of microscope modernizing consists in manufacturing the reduction beds, which enable to mount the new optoelectronic scales to the mounting holes of the original optical scales. One's own digitalization was performed in October 2006 by mounting the new optoelectronic reading scales to the microscope, its adjusting and pluging in all connecting wires among the scales, external indicator and computer. This was performed by advice and assistance of DEOM company. Mechechanical parallelizm among the scales and mechanical axes of the microscope was chack using micrometer indicator and it is better then 1 µm on 200 mm distance.

The next phase of the project was the verification of the microscope measurement capability and the instalation and work with data processing software M2DWin. The microscope uncertainty was verified with calibration measurement performed using laser interferometer by TOPMES company. The measurement uncertainty of the instrument was determinate to be $\pm 1 \mu m$ in all measuring range after software corrections.

The last phase of the project was the creation of the manuals of the work on the modernized workshop microscope for the students and preparation two measuring tasks. A new lecture containing the basics of instrumentation metrology, the review and principles of instrumentation quality check technique was prepared too.

The presented grant supported project fullfiled all its goals. An old one, but quality workshop microscope was modernized using new optoelectronical scales and dataprocessing techniques. The measuring uncertainty of the modernized microscope with software possition correction application seems to be better then the original microscope configuration. Two new laboratory tascs of the subject Instrumentation technology were prepared and will be held in the summer semmester of the school year 2006/2007. Modernized microscope will be used for the education process of the next subjects – Technical etxperiment and Instrumentation design too.

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The Engineering Desing of a Universal Optical Bench for Measuring Parameters of Optical Systems

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General goal of this work is the engineering design of a universal optical bench for measuring parameters of optical systems, generally for student's purposes. The work also includes a theory explaining fundamentals and techniques of some of performed measurements, especially measuring of following parameters:

- focal length of lenses and optical systems
- back focal length of lenses and optical systems
- deviation from parallelism of plane parallel plates and wedge angles
- centration error of optical systems
- optical transfer function
- resolution
- vignetation
- surface shape of optical elements

Design concept of the optical bench uses the enlarger Axomat produced by the company Meopta-optika, s.r.o. From this product there are used the baseboard and the suspension bar with travel stage. In Meopta there were also made two smaller adjustable mounting posts (for example for mounting a microscope, CCD camera etc.). The self work was the modification of an Axomat enlarger and engineering design of the other components to realize the basic optical measurements.

According to this design there were engineered holders of measured and measuring parts (and providing necessary adjustment), useful adapters, autocollimator and observation microscope. This microscope is needed because of a vertical orientation of the optical bench and enables the observation 45° angle-wise. It's possible to use various objectives and eyepieces too. In order to perform the practical measurements it was necessary to construct and produce an adapter to join the microscope objective to the CCD camera. Another necessary part was a reticle holder for its usage in the collimator situated in the optical laboratory of faculty of mechanical engineering where the practical measurements were performed. General measurement accuracy is 0,3%. This value of the accuracy is also guaranteed while using optical bench Melos 530 produced by the company Möller-Wedel.

Main design requirements are the maximal universality and possibility of a mutual replacement of all used parts and catalogue parts. As mentioned above the bench orientation is vertical. Main advantage of this fact is a low space requirement which is very important in laboratories with a lack of space. Dimensions of the baseboard are only 600x600 mm and the length of suspension bar is 1100 mm. General manufacturing tolerances correspond to medium deviations according to the norm ISO 2768-1 (01 4240). Accuracy of precise dimensions necessary for keeping an alignment of the optical and mechanical parts is $\pm 0,1mm$ (the default value of tolerance used in Meopta).

The device consists of three subsections - source of illumination, holders and adjustment parts and detectors of illumination. As a source of the illumination was chosen, engineered and also
made the autocollimator producing a beam of collimated specified achromatic light, matching for major part of performed measurements. Focal length of this autocollimator is $f_{\kappa}' = 300mm$ and the source of light is a lamp situated in the autocollimating head produced by the Meopta. Collimator and autocollimating head are joined via adjustable reduction enabling the precise focusing. The autocollimator is mounted to the optical bench via engineered holder and locked with screw M10x16 ISO 4762. It's possible to use this autocollimator on the horizontal oriented optical bench too.

Holders and adjustment parts are made of dural and to the adjustable mounting posts they are mounted through the use of the screws M4x12 ISO 4762. It's possible to mount the high precision adjustable stages to all holders.

As a detector of illumination it's possible to use a CCD camera or a microscope. In the case of using a microscope a component was engineered and made, it enables observation 45° anglewise. Spherical mirror is fitted into the basic cube $22,5^{\circ}$ angle-wise and an adjustment is realized through the use of three screws, placed cyclic by 120° . A rubber o-ring is used as a spring providing pressure. Before adjustment it's necessary to put down the glue into the screws. The accuracy of setting is 2'. This component is designed to be used with microscope objective with a thread W0,8x1/36 according to the norm DIN 58 888. One part of this component is a draw-tube too. According to the norm DIN 58 881 the numerical value of an inner diameter of a draw-tube is $d_1 = 23,2H8$. The distance "subject - image" is 195 mm which corresponds to the norm DIN 58 887. The mounting and centring of a draw-tube in the basic cube is realized via H7/g6 fitting and draw-tube is locked with the screw M3x10 ČSN 02 1181. As mentioned above it was necessary to construct an adapter to join the microscope objective to the CCD camera to perform practical measurements. Via this adapter it's possible to join the microscope objectives with a thread W0,8x1/36 and tube length range (130 + 193)mm. The CCD camera has to be equipped with CS mount and a thread W1-1/32.

Practical measurements confirmed that it's possible to use all designed components and techniques and in future more components are planned to be designed to maximize the usage of this optical bench.

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The Usage of High-Pressure Membrane Elements in Mechanisms

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The experimental verification of composite membrane elements based on polymer matrix with kevlar fibre support is the main subject of this project. Composite membrane elements are applied to the high-pressure membranes in hydraulic mechanisms design, gripper elements of manipulators.

The main advantages of composite material are: we can influence and adapt their properties to the required properties (by the suitable combination – a ratio of mass or volume of the used materials) and we can dimension them according to the required loading. The properties become optimized (their strength and their stiffness gets improved) and the mass of material is minimized parallel. The corrosion of material eliminates. The specific stiffness, which is defined by the modulus of elasticity divided by the density, and the specific tensile strength, which is defined by the tensile strength divided by the density) are very advantageous properties. Despite the use of modern method (finite element method) there is one disadvantage – a rather complicated calculation of these materials. It is necessary to verify experimentally the most of applications at least at their basic properties of the designed composite material.

There was designed and realized an experimental stand for this purpose which consists of a hydraulic circuit (maximal value of working pressure is 40 MPa) with numerical control of the relationship between time and pressure and an experimental chamber. It is possible to carry out static or dynamic tests which are ended by destroying of tested membrane. There are obtained the strength of membrane and the vibration fatigue limit. There is measured the maximal sag of membrane under the load.

The experimental stand is universal. It is possible to add new components to hydraulic circuit, to add new sensors or new types of the experimental chambers. Wide possibilities are given in control software Matlab, Simulink and Real Time Toolbox (LabView) and in modern measuring and control analog-digital cards.

Membrane elements are used very often in pneumatic systems. It is not possible to use these elements in hydraulic systems due to the working pressure. Maximal working pressure of membrane elements in pneumatic systems are 1.6 MPa. Therefore there has been developed a high-pressure membrane. The static strength of membrane, which is made of kevlar fabric with areal density of fibres as far as 110 g/m^2 is maximal 5 MPa. The static strength of membrane of kevlar fabric with plain weave and areal density of fibres 173 g/m^2 is 10,5 MPa, membrane of kevlar fabric with twill weave and areal density of fibres 326 g/m^2 is 14,5 MPa, membrane of kevlar fabric with sateen weave and areal density of fibres 326 g/m^2 is 16 MPa. If better isotropic property is applied strength can increase nearly twice. The strength of the best membrane can reach as much as 28 MPa.

The areal density of fibres and thickness of membrane increase and its strength increases too. This results, which were obtained experimentally, were verify analytic calculation (mechanics of composite materials and theory of thin planks which are geometric nonlinear).

The membrane was designed for a membrane hydraulic motor with low stroke. The membrane hydraulic motor consists of an upper and a lower flange which are used for gripping of membrane, a piston rod, a spring, a spacer ring, screws and o-rings. Two O-rings are used for sealing of working area. These O-rings were designed for this application. When hydraulic oil is get to the working area to membrane, membrane is deformed and piston rod is moved to spacer ring at the same time. This is stroke of membrane hydraulic motor. Spring is used for doing a back stroke.

The main parameters of the membrane hydraulic motor are: the outside diameter of motor which is 145 mm, the optimal stroke of piston rod is 4.5 mm, the diameter of membrane is 90 mm and the maximal force which is made out of piston rod is 11.7 kN. The weight of whole membrane hydraulic motor is 5.9 kg. The working pressure is 10 MPa.

Membrane hydraulic motor can be used as a single-acting hydraulic motor (see the previous paragraph) or a double-acting hydraulic motor. The connection conduit can be completed with two unidirectional valves and an actuator. This construction feature creates membrane hydraulic generator. The actuator is used for actuating of piston rod straight motion. The next usage of membranes is controlling of slide-valve of distributors and valves.

Membrane hydraulic motor is used also in design of robot gripper. In this case the membrane hydraulic motor is used as an actuating unit. Robot gripper consists of membrane hydraulic motor, a piston rod with a cross head and three rotary arms. When piston rod does stroke robot gripper is opened and when piston rod does back stroke robot gripper is closed. High values of the force, which is made out of piston rod, makes possible to get high values of the force of gripping of robot gripper throughout stroke of rotary arms, which is 15 mm. Rotary arms are used partly as a lever and partly as a multiplier of stroke.

Detailed FEM calculation of membrane and experimental measurements of other parameters of membrane, membrane hydraulic motor and robot gripper are made at present days.

Application of composite material in mechanisms design supports the use of principles which have simple conceptions and are experimentally and practically verified and the creation of new principles in design.

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Section 8

PRODUCTION SYSTEMS, TECHNOLOGY, TECHNOLOGICAL PROCESSES AUTOMATION

Influence of Climatic Factors on Life-Cycle Assessment (LCA) of Product

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Project description

Life Cycle Assessment (LCA) [1] is a methodology which was developed to assess the impact of different products on the environment. Its aim is to evaluate the product's environmental impact during its whole life cycle – from raw materials acquisition over transportation, sale, and use to its final processing as a waste.

To enable to compare different products, the results of an LCA study are expressed related to a functional unit. The total sum of functional units gained from one product during its life cycle depends on the length of its technical lifetime.

Our research was focused on optical data storage media – DVD. As a functional unit one GB of data stored for one year was set down. How many functional units we are able to get from one medium depends on the length of the time after which it would be still possible to read the stored data and when would be the right time to rewrite them on another data medium.

Hence, the effort to prolong a product's lifetime is touched also by the effort to minimize its environmental impact [2]. One possibility is to protect the product from the climatic effects by some impurities or by additional coatings and surface finishing treatment. These extra materials have often higher negative environmental impact than the original ones. To avoid the worse environmental profile of the product it is necessary to determine the threshold when to use such protection.

Within this internal grant a series of climatic tests on DVD media was performed and the readability of stored data was monitored. The aim of these tests was to determine the accelerated aging and to determine the climatic conditions which have significant influence on the endurance of stored data.

A big problem of LCA methodology is the unavailability of information about particular processes of the product's life cycle, e. g. the production processes. To provide the necessary information the producer would have to spend time of his employees or to disclose secret information. The problem with a lack of data is solved in Norway at NTNU using Hybrid Analysis [2]. The basis of hybrid analysis is the data provided by statistical office. The state economy is divided into sectors and the financial flows between individual sectors are determined. The statistical data contains also average emissions from individual sectors related to monetary unit. Based on economical input output analysis it is expressed what fraction of money spent in particular sector ended up in all other sectors. Average values of emissions are calculated multiplying this fraction and the statistical data. It makes the analysis more complex, since it is necessary to estimate the price of the product and its parts during its life cycle.

The hybrid analysis provides us results which are partly average information from particular economical sectors, not individual information for any product made by one producer. Further more, only the emissions into air are provided by statistical data now, neither the water emissions nor emissions into soil. Hence, it seems that this analysis does not provide the same quality as conventional LCA analysis. It is necessary to consider the data unavailability when conducting conventional LCA study. By the results from hybrid analysis it is possible to complete missing data and to reach more accurate results than by using only conventional LCA methodology. Further more, it is assumed, that statistical data will be extended about required emissions into water and soil. The statistical data should be soon worked out also in the Czech Republic.

In cooperation with Institute for Chemical Technology we have tried to work out an LCA study of DVD media using the software tool GaBi 4. We had to face some of the problems mentioned above. Its analysis was used to closer specify the theme of Dissertation.

Project summary

The aim of this project was to observe the impact of protection of DVD media against various climatic factors on the results of LCA study of these media and to link up close cooperation with LCA Laboratory at NTNU in Norway.

Because of the unavailability of required data the first point was divided into two separate studies: LCA of DVD media and observing the climatic resistance together with prediction of the readability of data recorded on DVD media. The life time of the data is the essential input for LCA study. According to a lack of place here, it is expected to publish the results elsewhere.

The cooperation with Norwegian workplace was linked up within a project LCA of offshore floating windmill. This project should be finished during the first half of the year 2007.

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Development and Optimization of New Generation of Applicators for Microwave Heating and Drying with Increased Energy Saving

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At the present is very important to save energy in every industrial process. Microwave heating is a very prospective technology, which finds new applications in industry. It can be used as efficient technology, which can replace conventional heating.

The basic principle of microwave heating is a transformation of electromagnetic field energy to the thermal energy through the field incident on polar molecules in material. The advantage of microwave heating is a possibility to reach the maximum temperature below the surface of the material and thus significant acceleration of drying process. We can reach energy savings, improvement of ecological aspects and furthermore we use process, which does not depend on textile thermal conductivity.

We would like to describe our new microwave industrial applicators used for drying of textile in manufacture. During the drying process, we have several problems, which we have to solve. At first, drying textile material, which has very thin thickness, has not very well defined position in the applicator in this drying process. Furthermore, complex permittivity of dried textile is not constant during the procedure. Its value is changing through the time with respect to decreasing content of moisture.

The principal intent of this work was design and optimization of new applicators for microwave drying. We have designed two types of applicators, which we use to test. The first applicator is derived from the Fabry-Perrot resonator, which is open type resonator. Whole system works at frequency 2.45 GHz and used magnetron, which generates power 800W. This machine is intended for the drying at factory production of fabrics [1]. The second one is waveguide type applicator, which is waveguide with a longitudinal slot in wider side of waveguide. This slot is situated in the middle of this side, because maximum of electric field strength is here. Waveguide at the working frequency 2.45GHz [2]. Modification of second applicator is serpentine waveguide applicator [3].

The next step of design was usage of the simulator of electromagnetic field after identification of basic arrangement of microwave drying machine. We determined position of magnetron and we found out distribution of electric field strength in drying textile in this way. In parallel, we analyzed drying system with the analytical method. We created diagram of EM waves inside this structure and reached the resulting expression, which is used for calculation of electric field strength in the plane of drying textile. This quantity depends on electrical characteristics of wet textile such as permittivity and loss factor. Measurements of these dielectric properties for the coburg is complicated and this method makes it possible to solve our problem with dielectric parameters [4].

We have results of SAR distribution (by means of simulation and measurement), results of measurements of the moisture content in the dried textile with respect to time. Waveguide applicator has better results than open-resonator type, for one functional cell, in case of measurement of moisture content. These acquired results are important for the next optimization of efficiency of the whole machine.

We have also results of temperature measurement with infrared camera. The temperature on the prototype drier output has been monitored by infrared camera. In the present case, the velocity of textile belt was 10 cm/s only, and so elementary volume of textile material was inside drier approximately 6 seconds, which was sufficient to increase its temperature from 22 to 61° C.

The designed systems are in the first part of testing. At the present time we carry out the tests and research the absorption faculty of different type of textile. Both designed applicators are systems, which can be used for testing of effect of microwave energy on textile properties. The collection of these tests will be use in Ph.D. thesis with name Optimization of microwave heating and drying process in light of efficiency.

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Modernizing of Laser Rod Polishing Holder

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This article presents a contribution of authors of division of Precision Mechanics and Optics of Faculty of Mechanical Engineering CTU for modernizing laser rod polishing tool used for laser rod polishing in Crytur Company performed on base of commercial cooperation.

Optical polishing technology attaches limits of surface quality needed for high precision elements like optical calibers or crystal laser rods. The flatness necessary for right function of these elements goes down to fraction of wavelength and acquire values approximately $\lambda/20$. This value is achieved with very slow and successive production process, included polishing, quality check and precise and fine changing the workpiece position on the polishing wheel.

Polishing of tips of laser rods is make difficult cause of laser rods tips are not perpendicular to the crystal axis, but its have to be finish according an angle. Incline tips of laser rod are used like laser beam polarizer and compose a functional part of laser cavity. It demands high precision of positioning of laser rod during polishing, but demands high stiffness of laser rod gripping during the whole polishing process too.

The polishing technology is statistical process based on successive obliterating of all rough peaks on the polishing surface. The statistical process means the use of a large amount of small, approximately identical dimension, tools – polishing granules, which obliterate each rough on the surface from each side. The polishing machine performed this process is composed of very precise flat wheel on which irregularly moves the workpiece holds in the fix or adjustable polishing holder. Small workpiece position changes during polishing are performed using movement of centre of gravity of the fix holder or using fine and backlash-free screws of the adjustable holder, respectively. The modernizing of this kind of laser rod polishing holder originally used in Crytur Company was the matter of our contract.

The original laser rod polishing holder composed of two basic parts. The first one was the base slide on the polishing wheel. The second one was the laser rod holder, which was adjustable against the base with three spring preloading screws. It gives the possibility to set the position of the polished laser rod in two angles up to desired values needed for laser rod tip inclination.

Unfortunately this polishing holder appears unstable position of the laser rod set during its polishing. This problem had to be solved with new design of laser rod position setting system, which overcomes presented difficulty.

New design of laser rod polishing holder is based on using not three spring preloading screws, but two precise screws placed at two perpendicular axes with regards to symmetry axis. Spring preload was realized on the other side of both screws. The placement the screws were realized using principle of static definiteness, what was the main problem of the original solution. The maximal inclination of the laser rod tip, which is able to polish with this new polishing holder, extends to $\pm 3^{\circ}$. The control screws were equipped with 20 mm knob or 30 mm shoulder alternatively. Cause of the use fine thread of the control screws with lead 0,2 mm, it gives the laser rod tip angle adjustment precision of $\pm 0,18'$ in the case of knob and 418

 $\pm 0.06'$ what is $\pm 3.6'$ in the case of shoulder, respectively. Whole the documentation of the redesigned laser rod polishing holder is in possession of the Crytur company.

Presented article informed about commercial activity of part of CTU with private company, which deals with a redesign of laser rod polishing holder. There was identified the problem of laser rod instability during the polishing of the original solution and a new construction solution of the holder was recommended and design which should overcomes this problem. Presented new design of the laser rod polishing holder increase the possibility of precise adjustment of the laser rod during polishing compared to original solution too. Functionality of the modified system will be experimentally verified soon after its manufacturing.

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Instruction of Manufacturing Technology on Faculty of Mechanical Egineering on CTU in Prague

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For preservation of necessary hight grade and especially practical knowledge of students of Faculty of mechanical engineering on CTU in Prague was in last year resolved grant FRVŠ 1578/2006. Its title is "Innovation of subject Technology I". This innovation should help to get possession of needful information in field of manufacturing technologies.

This subject – Technology I. – groups in set of fundamental knowledge of students from 2. year based form of study on Faculty of mechanical engineering. The subject passes out every student of 2. year, which means approximately 600 and more students per year. In frame this subject students get possession of information from technologies of forming, casting, welding and surface treatment.

Globally is pay attention to these technologies at every technical university and they belong into most often applied technologies in industry. Because of this it is necessary follow up this trend in the instruction and especially in the practise in Faculty of mechanical engineering too. The practise is main part of this subject.

Up to now the instruction was rate on theoretic knowledge of the individual fields. The general scope and knowledge of practice was missing to students. The practise run by form of theoretic comment or on out of use equipment. Therefore students didn't have conception on real application of manufacturing technology in industry. Consequently this project was laboratories in Department of manufacturing technology facility by basic measurement and other equipments, extant actual using in industry.

Our tendency was build up superior practices in subject Technology I. accordant actuality trends with unmistakable exemplification. Engagement of students in practice teaching and science activity is important for faculty. Result of this project is more effective and high quality teaching not only in field of this subject.

Students are at practices acquaint with many of practical applications in individual fields. They can try on given theme in laboratories on Department of manufacturing technologies. After pass out this practices the student is able to better understand to problems of several technologies from aspect of application, control as well as construction or materials.

Instruction of mechanical engineering has big tradition on CTU in Prague and development of mechanical technologies is in Czech Republic qualify by superior qualification of students of Faculty of mechanical engineering. Department of manufacturing technologies on Faculty of mechanical engineering on CTU in Prague belongs to forefront in Czech Republic which find the persons concerned in information from field. It arranges thoroughly educational training in frame of life education on CTU and technical seminar about progressive technologies for interested person from industry.

As part of resolution of this project was introduced new practices from several engineering technologies and because of this students get at practise knowledge. This knowledge is asked for in branch stage of study on Faculty of mechanical engineering on CTU in Prague, but in industry too. This practice should provide them.

The subject Technology I., as was told, is compact of technologies forming, casting, welding and surface treatment. To each of this technology was allocated during one semester three practices that are realized in laboratories of Department of manufacture technologies. The practise that is applied in frame of instruction:

Forming:

- Four dimension container deep drawing
- Determination of deformational resistance
- Forging

Casting:

- Tests of moulding materials
- · Special methods for fabrication moulds and casting
- Casting defects

Welding:

- Special welding and thermal cutting methods laser, plasma
- · Conventional welding methods shielding gas welding
- Non-destructive testing classification welded joint quality

Surface treatment:

- Electroplating Zinc electroplating
- Powder coating
- Classification of surface treatment

During practice preparation was elaborated details for several practise to students could better orientate in browse on subject matter and could duly provide. Details are available on www pages of Department of manufacture technologies. We believe the innovation of this subject will be acquisition for students of Faculty of mechanical engineering on CTU in Prague and it help to improve grade of teaching in our technical university.

www: http://u12123.fsid.cvut.cz/?udaj=predmet&id=C31067

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Section 9

ENERGETICS & POWER ENGINEERING

Special electromagnetic drive for vibrations damping of experimental crystalizer in microgravity.

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Introduction

Quality of many industrial materials processed by melting with following crystallization or solidification is negatively influenced by the Earth's gravitation. Some alloys can not be produced on the Earth at all. Basic material experiments have been carried out in space stations in the Earth's orbit in the micro-gravity environment during several last years and next are under preparation. Samples of selected materials are processed in equipment called crystallizer, which is a mechatronic computerized facility consisting of multi-zone tubular furnace, electrical vibration-less very low-speed drives for precise positioning of processed samples and manipulating of in-sample measurement facility, furnace heaters, power converters, furnace temperature measurement and control electronics, gravitation measurement unit, crew Interface Computer (CIC), telemetry channels and other auxiliary units. Some of material experiments last relatively long time, one day or more and processing are fully automatic, based on computer program prepared on the Earth by physicists. Processed samples are transported to the Earth for analysis.

Source of vibrations

Facility basic requirement is vibration-less environment during all time material is processed. The scientific facility for material high temperature processing had been in operation in the orbital station MIR during ESA EUROMIR missions several years ago. Facility was equipped with vibration-less electrical drives. Microgravity measurements proved very good behavior of that drives, no vibration noise was measured from this source. Device for measure vibration called TEGRA. But another problem aroused; astronaut motions inside station and their contacts with the parts of station induced spurious vibrations and influence resulting quality of processed samples of material. Newly prepared facility must be equipped with damped platform, where the working part of the furnace will be placed. Model is based on following assumptions:

- The translation only considered (no rotation)
- The moving object has rigid body (no deformation by external force)

The magnet's mounting model

It was created a several suggestion of positioning of active and passive magnets in electromagnetic drive for vibrations damping of experimental crystallizer in microgravity. For others calculation and simulation was chosen one model, which had the best match with starting conditions laying on suggested arrangement (simple construction, power unpretentious, control of electromagnets in axes of furnace only, the stable magnetic position). The deduction of force active and passive magnets was done by calculation. It was used some simplification and approximation.

Experimental workplace

On the base of gained knowledge the experimental workplace was implemented. The main goal was to help with tuning of critical part of the system. As critical parts are considered:

- Dampening elements (form, characteristics),
- The power supply active dampening element (option fit wattage part of),
- The regulation structure active dampening element.

Experimental workplace assembling from:

The experimental preparations - preparation is simplified mock-up experimental crystallizer. After successful checkout, the first version will be modified to have small diversities from real environment. The control microprocessor - will be used one of the DSP processors - TMS 320C240 or TMS 320F2812 - from vendor Texas Instruments, according to needs. The wattage converter transducer - will be used two-quadrant equable converter. The next parts are position sensor and the personal computer.

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Active power filter

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Electricity is supplied from a producer to a consumer through transmission and distribution networks with the prescribed parameters, i.e. frequency 50 Hz and a nominal voltage with deviations from these parameters in the prescribed tolerances. The development of new technological resources has also manifested itself in the increase of appliances, which have a very unfavorable influence on quality of the supplied electricity (e.g. television sets with pulsating power supplies, compact lamps, variable speed drives, electric welders, industrial saws, and so on). Appliances have a negative influence mainly on voltage quality. They cause significant deviations in voltage with an unfavorable influence on light sources and hence the human eye, short term decreases as well as disruptions of voltage with unfavorable influence on computer technology and other electronic devices. Short term decreases and disruptions of voltage and interfering phenomena of transient nature can have an adverse effect on managing and controlling circuits of distribution equipment and negatively influence the quality and reliability of electric energy supply. Some appliances cause the distortion of the voltage curve, i.e. generate a harmonic in voltage and current curves in the supplying distribution network with unfavorable influence for example on mass remote control of power engineering. There are two basic filtration methods to suppress this undesired phenomenon: passive and active. The simplest method of suppressing the harmonic distortion is to use passive filters. Passive filters contain a series of LC circuits tuned in on the harmonic, which should be mitigated. By linking a few of such filters in a parallel way, the filter block can be constructed as so that it filters out all the harmonics. Active filter represents an additional electronic semiconductor converter connected to a non-linear load. The input current of the converter (APF) is controlled to produce the same levels of harmonic as well as non-linear load, although in an opposite phase. These two levels of harmonics are eliminated at the connection point.

Shunt filter is used for the compensation of undesired harmonic currents in a way that it generates identical harmonic current components with the opposite phases (into the supply network). The resulting current is then clears off the harmonic. Current supplied from the supply network is filtered and the voltage distortions, which are caused by the load, are modified and the supply network's effect is improved. Active filter is capable of compensating the current by a neutral conductor; this solution requires a 4-leg bridge inverter. It is not necessary to compensate the current by a neutral conductor in the case of a symmetrical load without a third harmonic current (three-phase controlled and non-controlled rectifiers, variable speed drives etc.). Active filter does not need an external power source, the condenser recharge is provided by the controlling algorithm.

Increased severity of harmonic pollution problems has fuelled the search for dynamic and adjustable solutions. Active filters have been recognized as a valid solution. However, the effectiveness of any active filter relies on the five following factors: (1) the configuration of the filter, (2) the model established for the system, (3) the closed loop control strategy applied, (4) the method implemented to obtain the current harmonic references, and (5) the modulation technique used. It is known that shunt passive power filters suffer from the dependency of their compensation characteristics on the grid impedance, and their susceptibility to undesirable resonance with grid and load impedances. A shunt active filter 426 offers different options for compensation, such as harmonic attenuation, load balancing, resonance elimination, and displacement power factor improvement. Thus, the control strategy and the method for extracting harmonic references will depend on the compensation objectives. A shunt active filter configuration is considered in this work in order to avoid harmonic pollution along the power line caused by a non-controlled diode rectifier load. The active filter acts as a current source connected in parallel with the nonlinear load. It is controlled to produce the harmonic currents required for the elimination of the harmonic component in the supply currents. In this way, the ac supply needs only to produce the fundamentals currents.

The modelling is based on the abc/dq transformation of the ac system variables. The currents injected by the active filter are controlled in the synchronous orthogonal dq frame using a decoupled control strategy. The reference harmonic components are extracted from the sensed nonlinear load currents by applying the synchronous reference frame method, where a three-phase diode bridge rectifier with R load is taken as the nonlinear load. A control technique is used to achieve better performance while the separation of internal and external loop dynamics is realized. A decoupled current control using PI-type compensators is utilized to force the injected current loop in order to compensate for the overshooting that could be created by the left-hand zero of the closed-loop transfer functions. The voltage level of the dc side is regulated using a linearizing feedback control. The reference. The transfer functions of the two loops are developed and synthesized to obtain the desired stability and dynamic response.

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Calculation and Simulation of Driving Characteristics for Hybrid Drive with Super-capacitor

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As a result of further development of hybrid drive with super-capacitor at the Research Center of Engine and Automotive Engineering Josef Božek, computer programming calculation and simulation has been made for that system. Main purpose of this task is calculation of every essential values that characterizes the driving regime of the hybrid drive. That's complex working system with many functional units like internal combustion engine (ICE), super-capacitor (SC), traction electrical motor (TM). Therefore is essential to be known all the needed values for each unit in each time interval of the working regime.

Simulation has been made by means of Matlab programming interface. But not only Matlab but other simulation instrument can be used. The main approach in this simulation is determination of the fluctuation of the energy in the hybrid drive during driving regime. For this purpose function and behavior of each component of the system is determined. That leads to development of the entire hybrid drive in further.

The kinematical model for simulation programming described in publication [1] has been used. For each time sub-interval ($\Delta t_{n-1} = t_n - t_{n-1}$) of driving maneuver following values has been calculated:

acceleration

$$a_1 = \frac{V_2 - V_1}{t_2 - t_1}, \ a_2 = \frac{V_3 - V_2}{t_3 - t_2}, \dots, \ a_{n-1} = \frac{V_n - V_{n-1}}{t_n - t_{n-1}}$$
 /1/

car trajectory distance

needed acceleration forces corresponding energy

$$S_{1} = \frac{a_{1} \cdot \Delta t_{1}^{2}}{2}, S_{2} = \frac{a_{2} \cdot \Delta t_{2}^{2}}{2}, \dots, S_{n-1} = \frac{a_{n-1} \cdot \Delta t_{n-1}^{2}}{2} / 2 / F_{1} = m \cdot a_{1}, F_{2} = m \cdot a_{2}, \dots, F_{n-1} = m \cdot a_{n-1} / 3 / W_{1} = F_{1} \cdot s_{1}, W_{2} = F_{2} \cdot s_{2}, \dots, W_{n-1} = F_{n-1} \cdot s_{n-1} / 4 / 4$$

By means of this equations average acceleration power P_a can be calculated for each subinterval:

$$P_{a1} = \frac{W_1}{\Delta t_1}, \ P_{a2} = \frac{W_2}{\Delta t_2}, \ \dots, \ P_{an-1} = \frac{W_{n-1}}{\Delta t_{n-1}}$$
 (5/

For aerodynamics resistances compensation additional power P_v which depends on speed v(t) must be generated in accordance to formula

$$P_{v}(t) = K \cdot \left(v(t)^{3} + v(t) \right)$$

Total needed power that hybrid vehicle needs to provide is sum of acceleration power P_a and speed power P_v :

$$P_{sum}(t) = P_a(t) + P_v(t)$$

Program calculates all this values according to desired speed for each time subinterval t_i . Obtained data are presented in characteristics which are functions of time. 428 The power of the internal combustion engine P_{spm} must follow the needed driving power P_{sum} for each time interval t_i . Also P_{spm} depends on actual energy volume W_{sc} accumulated in the super-capacitor, which is determined from actual voltage U_{sc} .

$$W_{sc} = \frac{C \cdot U_{sc}^2}{2}$$

 P_{spm} provides power to drive the vehicle and also for charging the SC and keep the U_{sc} above the critical minimal level U_{sc} min. Also power from ICE can't change its value immediately, it must be smoothly. According to all this preconditions, power of ICE P_{spm} is calculated for each time interval t_i .

The difference of the values of powers P_{spm} and P_{sum} overtake the TM:

$$P_{el}(t) = P_{sum}(t) - P_{spm}(t)$$

When P_{el} is positive ($P_{el}>0$) SC is discharged or when $P_{el}<0$ SC is charged. By knowing the actual value of the voltage in SC (U_{sc}) and the needed electric power from SC (P_{el}), the charging or discharging current I_{sc} of the SC was calculated.

The simulation starts with determination of the driving regime. For each time interval t_i can be assigned the value of the speed *V*. Also the weight of the vehicle and the number accumulative units (super-capacitors) are assigned. According to all this driving conditions calculation for all desired values can been performed for each time interval of the drive. The final result of the simulation is presentation of the calculated characteristics for each needed value as function of the time *t*.

The results are showing the behavior of all system during the driving regime. The changing of the values in function of time, gives overview of the fluctuation of energy thought each component of the system. That gives opportunities for further development of this hybrid drive with super-capacitor.

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Synchronized Switch Control Circuit

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Making and breaking operation in alternating current electric circuit produced current transient phenomena. Very serious problem is current non-symmetry when three-phase induction motor is making on the mains. Current or voltage surges usually occur and influence negatively the switch itself, switched appliance and electric network. To minimize this influence is possible by means of precise sequentional switching of motor single windings. To use electro mechanic contactor is impossible do to on-time scatter of different contactors. Important improvement brought the replacement of the mechanic switch by an electronic solid-state thyristor switch with special inner control circuits. Such a solution enables to implement the switch-on time with respect to the phase of AC voltage according to the impedance angle of the switched load. In the case of single phase load the transient current depends on the switch-on time. Would the RL load be switched on the voltage with delay angle $\alpha = arctg \frac{\omega L}{R}$ after the voltage passes zero the over current value will be zero.

That means that inductance L with negligible resistance R should be switched on the sinusoidal voltage with delay angle 90 degrees with respect to the time when the voltage value equals zero. Such rule is easily to realise on one phase loads. When the load has three phases a reasonable compromise should be taken.

The paper deals with the problem what compromise in the switching of induction three phase machines by means of electronic switch would be simple and good one.

For the mathematical model the space vector theory was used. [1] [2]. Space vector of three phase currents is given by the equation

$$i_s = \frac{2}{3} \left(i_a + \overline{a} i_b + \overline{a}^2 i_c \right) \qquad \text{where} \qquad \overline{a} = e^{j\frac{2}{3}\pi} = -\frac{1}{2} + j\frac{\sqrt{3}}{2} \qquad \text{is the complex unit.}$$

Similar equations hold for three phase voltages u_a , u_b , u_c and for three phase magnetic linkages $\Psi_a \Psi_b \Psi_c$. Mathematical model of the induction machine is described with 5 following equations written in p.u. (proportional unites) system, time is in sec:

S denotes stator, R denotes rotor, 1 denotes α component, 2 denotes β component, ω denotes angular velocity and M denotes torque

$$\frac{d\psi_{S1}}{dt} = \omega_N \left\{ U_{ef} \sqrt{2} \cos[\omega_N(t+t_0)] - \frac{R_S}{\sigma L_S} \psi_{S1} + \frac{L_m}{L_R} \frac{R_S}{\sigma L_S} \psi_{R1} \right\}$$
(1)

$$\frac{d\psi_{S2}}{dt} = \omega_N \left\{ U_{ef} \sqrt{2} \sin[\omega_N(t+t_0)] - \frac{R_S}{\sigma L_S} \psi_{S2} + \frac{L_m}{L_R} \frac{R_S}{\sigma L_S} \psi_{R2} \right\}$$
(2)

$$\frac{d\psi_{R1}}{dt} = \omega_N \left\{ \frac{L_m}{L_s} \frac{R_R}{\sigma L_R} \psi_{S1} - \frac{R_R}{\sigma L_R} \psi_{R1} - p \omega \psi_{R2} \right\}$$
(3)

$$\frac{d\psi_{R2}}{dt} = \omega_N \left\{ \frac{L_m}{L_s} \frac{R_R}{\sigma L_R} \psi_{S2} - \frac{R_R}{\sigma L_R} \psi_{R2} + p \omega \psi_{R1} \right\}$$
(4)

430

$$\frac{d\omega}{dt} = \omega_N \left\{ \frac{L_m}{2\sigma L_s L_R \theta} \left(\psi_{R_1} \psi_{S_2} - \psi_{R_2} \psi_{S_1} - \frac{M_{mech}}{\theta_R} \right) \right\}$$
(5)

Switching strategy is based on current minimizing in first two stator windings by means of switching instant with respect actual phase-to phase voltage. When sufficient magnetic flux in the machine is built after that the third phase winding is switched on. Instant of third winding switching on is again critical with respect to actual voltage in the switched phase.

Before real control circuit realisation the mathematical and computer simulation was done. Simulation outputs have confirmed theoretical prepositions and therefore experimental control circuit was built.

Switch physical model consists of three AC anti-parallel thyristors channels controlled by opto-coupler elements. The control circuits, enabling such sequentional switching consists of three blocks. The first block is synchronized impulse generator, producing square wave pulse, which front end is synchronized by mains voltage L1 and is delayed with respect to instant of voltage zero. This generator synchronized switching of first two motor windings. Other two blocks enable generate second, time delayed impulse and its amplification for third channel, switching on the third motor winding.

After switch realisation some experiments were done. Obtained experimental results verified very good theoretical prepositions.

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Computer Supported Induction Motor Type Test "Omega 2007"

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Omega 2007 measuring system is dedicated to be used as automated tool for parameters evaluation of modern induction motors. Measuring system is based on Tektronix TM5000 series devices which are interconnected by National Instruments GPIB-AT bus. Measuring system is controlled from the PC. "Omega 2007" interactive software controls overall system. Software has been developed in "Lab Windows CVI 8.0" environment and computer programme is coded in C++. With substantial help of this interactive software user can easily organize database of rating plate values of machine under test. Finally user will simply add results of induction motor type test according to CSN 35 0300 standard. Measuring system "Omega 2007" is in operation in laboratory of Department of Electric Drives and Traction – K13114, Faculty of Electrical Engineering, and Czech Technical University in Prague.

Current measurement and wastes in short run :

Metering characteristics flow and wastes short run do according to CSN 35 000 from values highers measurable tension (current limit plumbed motor systému) to lower values tension. This progress is just continual warming will force plumbed machinery. In first step come to biggest warming and in of other steps at buck happens only to even up warming first step. During metering state constancy warming. At examination short run mete U11, I11, P11, f1 and after restrained of each of map point winding resistance R1 let us say oteplení plumbed machinery T_h (nearnear). number plumbed map point get past opt for among 8 as far as 15 articles, more isn't necessary.

Evaluation measured values do by the help of simplified substitution diagram that the solve by the help of power balance - sheet machinery. Test data is requisite Tab. No. 2 and giant.No. 1 - 3 viz. příloha and mathematical description reactance for a span X_{to} .

Mathematical description spacing measured points short-circuit characteristic. Characteristic flow Ik depending on short-circuit voltage Uk is invollvement waveform that the is incurvate in dependencies on saturation leakage waies and is all the more perceptible, what is he saturation bigger. U big tool grinder and sharpener with achievement order megawatt is saturation smaller, near middle tool grinder and sharpener with modern fulfilment is this curvature bigger. His mathematical description is enough exacting and for automatic recall evaluation measured map point bears row problems that the is necessary solve. Mathematical spacing measured points is compound of the three part. Forepart in the area low tension saturation moves in linear more often characteristics that is why spacing goes through zero graph and continues to certain purview linear. In second parts, when happens to transient state saturate spacing moves after tangent circle to first parts spacing. In third parts, when come to surfeit leakage waies already characteristic moves after straight line that the is tangent to circle in second parts. This compound mathematical spacing optimal and most exact describes action that the proceeds in plumbed machine.

// - - - - - -

Calculation centre tangent circle two straight line at the beginning and end characteristics :

calculation pa	rameters tangent circle
Xprusecik= fal	bs(lk_B / (lk_C - lk_A));
Xtecna_1	Xprusecik - Ik_D*Xprusecik;
Xtecna_2	Xprusecik + Ik_D*Xprusecik*cos(atan(Ik_C))/cos(atan(Ik_A));
Ytecna_1	Ik_A * Xtecna_1;
Ytecna_2	<pre>Ik_B + Ik_C*Xtecna_2;</pre>
Xkruh	Ytecna_1 + 1.0/lk_A*Xtecna_1;
Ykruh	Ytecna_2 + 1.0/lk_C*Xtecna_2;
Xstred	(Ykruh-Xkruh)/(1.0/lk_C 1.0/lk_A);
Ystred	= - 1.0/lk_C*Xstred+Ykruh;
Rkruh	

Charge single map point Ik depending on Uk from 0.1%Un to the 105% Un : // ------ calculation functional dependence on tension Uk ------

```
for (I=0; I<500; I++) {
        Uk
         Uk_graph[I
                           Uk;
                 lk_1
                          lk A*Uk:
                          lk_B + lk_C*Uk;
                  lk_2
                          Ystred - sqrt( fabs( pow((Uk Xstred), 2.00) - pow(Rkruh, 2.00)));
                  lk_3
         lk_graph[l]
                          Ik_1*Xtecna_1) + Ik_3*Xtecna_1) & (Uk<Xtecna_2)) + Ik_2*tecna_2);
Calculation of other waveform dependence characteristics nakratko :
          Rk_graph[I] Rk_A + Rk_B*Uk;
         Darkness_graph[I] Darkness_A + darkness_B*Uk;
         Rk_graph[l]
                        (Rk_graf[I]*(235+Tm_graf[I]))/255;
         Xk
                 Rf1 * (235+Tm_graf[I])/255;
         R1t
                        (Rk_graph[I] - 1.03 * R1t) * pow(lk_graph[I], 2.00) / coal;
         Mk graph[I]
         Zk_graph[I]
         Ck_graph[I]
                           Rk_graph[I]/Zk_graph[I];
                           Uk * lk_graph[l] * Ck_graph[l];
         Pk_graph[I]
```

} // ----- end computation cycle ------

Fission reactance for a span X_{to} on leakage reactance stator relate $X_{10lT\Pi} = 55\% X_{to}$ and rotary $X_{20lT\Pi}' = 45\% X_{to}$. (ratio fission is given experiences producers induction motors) size leakage reactance depend upon sizes saturation leakage waies magnetic circuit induction motors. In an effort to about what biggest machine employment are teeth stator and rotary at heavy current considerably tired. Therefore leakage reactance $X_{10lT\Pi}$ and $X_{20lT\Pi}'$ are nonlinear and indirectly dependent on flow thorough how stator, so and rotor winding. Leakage reactance $X_{1G} - X_{2G}'$ presents that part leakage reactance rotor perimeter that the depend upon flow I_{22} , therefore be abreast of vibrational number no recalculating. Part leakage reactance rotary that the depend upon vibrational number f_2 rotor flow I_2 is marked X_{2G}' and is circumscribed with the following chapters.

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Section 10

NUCLEAR ENGINEERING

Development and Application of Anthropomorphic Voxel Phantom of the Head

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The in vivo measurement of the activity deposited in bones is a very useful source of information on human internal contaminations with transuranic elements e.g. ²⁴¹Am. The measurements are made on the skull or the larger joints such as the knee or elbow. Calibrations with physical anthropomorphic phantoms are usually performed, however such phantoms are expensive and non modifiable. Computational voxel phantoms can overcome these disadvantages. The thesis tries, with the recent approaches, to evaluate committed effective dose for two groups of the workers contaminated with ²⁴¹Am. The paper brings more precise knowledge on uncertainties and issues related with in-vivo measurement of the activity in the skeleton.

The source CT images of 38 year old woman's head and neck were acquired on a SOMATOM Sensation 64 in the Institute for Clinical and Experimental Medicine. The Original study, in DICOM format, contained 880 slices with a thickness of 0.6 mm and was scanned with 0.3 mm steps. The original plane resolution was 0.466 × 0.466 mm per voxel and iodine contrast liquid was used. Since the slices were 0.6 mm thick but were taken in steps of 3 mm every other slice was processed for this study. The selected data were resized with bilinear interpolation to isotropic voxels of size $1 \times 1 \times 1$ mm. Three bone tissues with different density and four soft tissues were segmented by various techniques. The thickness of the skin prevented the normal segmentation process, i.e. was obtained by image manipulation. Adipose tissue was obtained by using a threshold filter with setting of minimal and maximal value in Hounsfield unit (HU) similar to the settings used by [1]. Because of the high density artefact caused by dental fillings and the presence of a contrast liquid containing iodine it was not possible use the simple threshold approach for bone tissues. After the application of the threshold all the slices were checked and corrected by hand with the help of anatomical atlas. Brain and spine were segmented manually. The bone tissues were divided into three subclasses: cortical, cranial and the lowest density voxel were treated as os sacrum [1]. The division was made according to the mean value of HU in the bone regions of the study. The rest of the volume, except the parts filled with air, was assumed to be skeletal muscle. All real tissues were replaced in the model with ones described in [2].

The segmented phantom was transform from graphic form to the lattice form for MCNPX input file by a program written for this purpose in Free Pascal. All bone voxels were assumed as homogenous sources of photons with an energy of 59.6 keV in the simulations. The representation of two LEGe detectors, manufactured by Canberra, with an active area of 2000 mm² and a thickness of 15 respective 20 mm were based on available information and their inactive layers were determined experimentally. The position of simulated detectors and the head phantom were made identical to real measurement performed in the National Radiation Protection Institute. MCNPX software [3] in versions 2.4 and 2.5 were used for simulations of the photon and electron transport. The number of primary simulated particles was 2×10^7 for all simulations and the relative errors at photopeak energy bin were less than 1 % for each detector. 436

The detection efficiency of the phantom 0.0051 was determined by the simulation in reference position. The estimate of uncertainty of the detection efficiency due de position of detectors was obtained from series simulations and leads to relative standard deviation of 11 %. This value is in a close agreement with the uncertainties base on data obtained from the real cases. Another set of the simulation showed that the change of density of the bone tissues about ± 10 % and ± 5 % influence the detection efficiency by ± 4 % and ± 2 % respectively.

The estimation of the influence of the skull size on detection efficiency is very important to the detection setup used. The original cubic voxel side 1 mm was changed to range from 0.8 to 1.2. mm. The scaling tries to cover all the sizes of heads found in the population. The lowest value represents a head with a perimeter 44.5 cm (newborn, infant) and the highest value corresponds to a head perimeter of 66.7 cm. The change of voxel size influences the thickness of the covering tissues which may lead to slightly overestimated or underestimated detection efficiency. The strength of the effect was not determined accurately up to now, but the raw estimation is about 6 % for the values at the border (0.8 and 1.2 mm). The detection efficiency of the scaled phantom was in range from 0.0031 to 0.0099 for voxel side 1.2 mm and 0.8 mm respectively.

The measured activity of the skull is also affected by the contribution from bone tissue other than the skull. The most significant contribution is from activity in the vertebrae of the neck, which leads to systematic overestimation of the measured activity. The importance of this effect is related, to the geometry used and the head size. The calculations with three cubic voxel 0.8, 1 and 1.2 mm estimate contribution of neck vertebrae to 5.6, 5.3 and 4.4 %.

Based on the CT study a semi-anatomical phantom of the head and neck with cubic voxels of 1 mm³ was made. The application of the phantom brings estimation of some uncertainties: influence of position and distance of the detectors, which is together about 11% and contribution of vertebrae in neck of 4.4-5.6 %. The calculated detection efficiency is from 0.0099 to 0.0031 for heads with a perimeter from 44.5 to 66.7 cm. The changes of density about ± 10 % effect results by about ± 4 %. The efficiency of the voxel phantom 0.0051 is lower than for a physical one of comparable size [4]. The probable reason of it could be in the different density of soft tissues or the activity distribution. Further research with new simulations is needed in order to confirm the suggested explanation of the actual result.

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Measurement and Monte Carlo Simulation of the Neutron Spectra of the Subcritical Reactor Experiment "YALINA-Booster"

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The traditional concept of nuclear reactors, so called critical reactors, relies on selfsustained chain reactions. In that case, the total number of neutrons produced in every moment is exactly equal to the number of absorbed neutrons. Keeping this balance is usually ensured by inserting or removing neutron-absorbing materials inside the reactor. On the other hand, Accelerator Driven Systems (ADS) are based on a sub-critical core, where there are more neutrons absorbed than produced by fission. The lack of neutrons is compensated by an external neutron source. Additionally, the subcritical core can be composed of transuranium elements from the spent nuclear fuel and, consequently, long-lived nuclei in the radioactive waste can be eliminated in this way.

Scientific research in the ADS field develops step by step, e.g. the MUSE program (Multiplication with an External Source) in France was completed two years ago [1]. Similar experiments are also performed at the Joint Institute of Power and Nuclear Research in Sosny outside Minsk, Belarus [2] [3]. The experiment in Belarus consists of two facilities, YALINA-Thermal and YALINA-Booster.

In this contribution the results of a series of experiments made at a small-scale subcritical accelerator driven system are presented. The purpose of these experiments is to perform neutron spectrum analysis in the model, in particular to determine some physical properties of the subcritical reactor experiment YALINA-Booster. The facility consists of two main parts: a neutron source and a subcritical core. Although both parts are essential for ADS, YALINA-Booster is not the prototype of a future ADS. Its main purpose is to study neutron physics of ADS. One of the main advantages of YALINA-Booster is its small size and relative simplicity. This kind of zero-power facility is necessary for validating different neutron kinetics models that will be used in large future facilities. Without these validations, a license for building a full-scale ADS can not be approved.

The subcritical core of YALINA-Booster involves two parts: a thermal zone and a booster zone. The booster zone is composed of a lead lattice and consists of two parts with two different enrichments of fuel pins. The inner part, which is close to the target, contains 132 fuel pins made of metallic uranium with 90% enrichment in ²³⁵U. The outer booster zone contains 576 fuel pins made of uranium dioxide. The enrichment of the uranium is 36%. The thermal zone has a polyethylene lattice and there are 1180 fuel pins with uranium enrichment 10%. The pins form a circle around the booster zone.

The objective is both to simulate and to measure the neutron flux as a function of energy in two determined positions inside the YALINA-Booster core and also to provide basic characterization of the radial distribution of the thermal and epithermal neutron flux.

For this purpose two sets of activation foils are used, one for the booster zone and one for the thermal zone. Each set consists of 12 foils made of different materials (In, Au, Zn, Al, Mg, Pb, CF₂, Cu, Fe, Ti, Co and Cd). The foils are covered by a cadmium container, so that only threshold reactions on fast neutrons are employed. The measured reaction rates are used for comparison with the Monte Carlo simulation tool MCNP and for neutron spectrum unfolding using SAND-II [4]. For the radial dependence of the neutron flux indium foils at different positions inside YALINA-Booster are utilized. Namely, there are two foils in the booster zone, three foils in the thermal zone and nine foils in the reflector.

The comparison of measured and calculated reaction rates for different activation reactions proved that MCNP is a reliable simulation tool. The agreement between calculated and simulated values is generally good, especially in the thermal zone.

The spectrum unfolded by SAND-II and simulated by MCNP is in good agreement. SAND-II is thus a powerful tool for the neutron spectrum unfolding, but it is still suggested to compare the results with other sources (such as the MCNP simulation) thereby avoiding possible mistakes.

The radial distribution of thermal and epithermal neutrons follows an expected pattern. The number of thermal and epithermal neutrons is the highest in the thermal zone and there are almost no thermal or epithermal neutrons in the booster zone. In the reflector the number of thermal and epithermal neutrons decreases with increasing distance from the center.

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3D Anizotropic Steady State Thermal Calculations with 3D Half Nuclear Fuel Pellet Model

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Importance of fuel reliability is growing due to the deregulated market electricity demands on nuclear units operability and availability for the electricity grid. At these conditions of fuel exploitation, the problems of PCMI are very important from the point of view of fuel rod integrity and reliability. Condition of raised loading is thermo-physically and mechanically expressed in higher probability of cladding failure especially during power manoeuvring. Direct measuring signals from real power nuclear rod operated under such condition are unavailable. We have to be able to realistically predict safety margins expressed in the terms of margins to PCI phenomenon. This prediction may be established by method of computer simulation, which is highly difficult. As a part of this effort 3D anizotropic steady state thermal calculations with 3D half pellet model using FEM solver COSMOSM v. 2.85 were done.

Advanced ("more realistic") 3D configuration model of the half nuclear fuel pellet with cladding was natural next development step to simulate behavior of fractured pellet. Model of the pellet is created by rotation of 2D half-pellet-region, that consists of three equal volume fractured parts bonded together in the middle two thirds of radius and with three radial cracks at the outer third of radius. At the bottom of the pellet there is a tangential crack representation also. All gaps are filled with helium or mixture of gases (in case of burned configuration). Optionally, inner and outer ZrO_2 layers on cladding are also incorporated.

For finite element mesh 8-node solid elements were used. In the radial direction there are 33 elements in the pellet, 1 in the gap and 13 in the cladding and in the axial direction 50 in all substances. Total number of elements thus reaches almost 75 000.

The validity of 3D calculations was verified by comparison with 2D calculations. 3D model created by simple 360° rotation of the 2D pattern was prepared for this comparison. Different finite element meshes were compared in 2D geometry to estimate the effect of the solver.

Maximum temperature with nominal mesh differs against the 3D calculation (1844,5 °C) on 4,9 K. Automatically generated mesh gives higher difference (7 K) and rough mesh 5,2 K. From these results we assume that the influence of the mesh density to temperature distribution and maximum temperature is negligible in the investigated range on the given model and this fact we effectively use in global modeling.

For the 3D parametric calculations, the postulated nominal case has heat sources that correspond to the linear heat rate (LHR) of 300 W/cm. The maximum temperature in the middle of the pellet is 1721 K. All parametric calculations are related to this value.

Computations were done with different: oxide layer sizes, gas composition, heat sources in individual fragments, heat transfer coefficient and coolant temperature, coefficient of thermal conductivity of pellet, fragments position, finite element mesh.

If we assume that one fragment is bonded to cladding then the maximum temperature is 100 K lower due to better heat removal from the pellet to the cladding through filled "gap".

Nonuniformity of heat sources was tested by higher power of one fragment (120 % LHR) against the other fragments. The temperature maximum expectedly moves to this fragment.

The change of the coefficient of thermal conductivity of the pellet (with unchanged geometry) to the value corresponding to the burn-up level 15 GWd/tU increases the maximum temperature on 149 °C and for burn-up level 45 GWd/tU the maximum temperature is on 386 °C higher. In real situation, of course, the gap between pellet and cladding is closing with increasing burn-up and by the same LHR the temperature maximum remains roughly the same.

The comparison of 2D and 3D symmetric model showed satisfactory agreement in the temperature field – the difference in the maximum temperature reaches 5 K. The influence of the FE mesh density on the maximum temperature in 2D case is negligible (max. 2,5 K).

The comparison of more detailed 3D model of the half pellet with crack with the 2D model cannot be done easily because the presence of the gas (helium or mixture) in axial cracks changes the temperature field.

We may conclude, that the highest influence to the maximum temperature was in the case of higher heat source in one fragment. The influence of the heat transfer appears to be not so significant in comparison with other examined parameters.

In the poster, results will be presented in the graphical form. More detailed information can be found in [2] and these calculations will also be a part of doctoral thesis.

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Study of Nuclear Fuel burn-up in a Low Power Reactor

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At the end of October 2005, refueling of the VR-1 training reactor was completed. This operation was prepared in the framework of the international program RERTR (Reduced Enrichment for Research and Test Reactors), whose purpose is to reduce the proliferation potential of nuclear fuel. The insertion of fresh IRT-4M fuel elements into the core allowed to initiate long-term monitoring of the isotopic changes in the fuel and to experimentally determine fuel burn-up in a low power reactor.

The experiment included three measurements of two fuel elements from selected positions in the reactor core. The first measurement was performed several days after the refueling was completed, i.e. it was a check of the isotopic composition of the physically fresh fuel. The second measurement was performed after a seven-month operation in June 2006 and the third measurement was carried out in August 2006, during a two-month maintenance shutdown of the reactor. The basic geometry of the experiment remained unchanged, only in the second and third measurement the distance between the detector and the surface of the fuel element was extended. The reason for this change was the increase of the activity of the fuel elements due to irradiation during reactor operation.

The aim of the experiment was to determine the isotopic changes that take place in the fuel owing to irradiation, to measure the burn-up of the selected fuel elements based on the experimental data and, with regard to the neutron flux distribution in the active core, to provide the total fuel burn-up in the reactor in 1 year. The principle of this method is to specify the activity of properly selected fission products that are generated in the fuel. From these activities, the number of 235 U fissions necessary for generation of these fission products in the examined parts of the fuel element can be determined and using the known dependence of the fission yield on the mass number, it is possible to evaluate the total quantity of the 235 U spent in the sample. Using the neutron flux distribution in radial and axial direction, the total burn-up in the active core of the VR-1 reactor in 1 year can be determined.

A semiconductor gamma spectrometric system Canberra was used in the experiment. The measured data was modified by the Canberra GENIE 2000 v.3.0 software and sorted by energy in order to get an overview of the changes of gamma count between the measurements and the differences in gamma count between the individual fuel elements. The analysis of this data represents the development of the concentration of the generated fission products. All courses follow the expected trend.

The calculation of the burn-up was performed with three groups of selected fission products. The first group consisted of 95 Zr, 103 Ru, 137 Cs a 141 Ce, the second group of 95 Zr and the third group was represented by 137 Cs. Especially 137 Cs is a very suitable isotope from the viewpoint of long-term kinetics thanks to its long half life of 30.07 years. The results obtained using 137 Cs have the smallest error.

The calculation itself was preceded by a correction of the measured data for geometry (calibration by a 152 Eu reference emitter) and for decay of the generated fission products during the irradiation and the maintenance shutdown of the reactor. From the corrected data, the activities of the selected radionuclides and the number of 235 U nuclei spent in the surveyed 442

parts of the fuel elements were determined. Three approximations of spatial distribution of the neutron flux – constant distribution, a sinus curve and a distribution obtained from an MCNP calculation – were used for evaluation of the total burn-up.

The burn-up of the IRT-4M fuel elements in the VR-1 reactor estimated before was in the range of 10 - 100 mg of 235 U per year. The experimentally determined burn-up is by approximately two orders of magnitude lower than this estimate. Based on the activity of the 137 Cs generated in the examined fuel elements and using the neutron flux distribution obtained by the MCNP code, a value lower than 1 mg of 235 U per year was calculated.

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Analysis of Essential Thermal Characteristics of Nuclear Fuel

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The serious decision process about new energy source for the Czech Republic is in progress in government bodies, with the Ministry of Industry and Trade as the lead institution. The project named "New nuclear energy source for the Czech Republic" is prepared in the Nuclear Research Institute Řež plc in co-operation with others institutions for this ministry. A part of this project, which was specialized in thermal calculation of nuclear fuel, was made on the Department of Nuclear Reactors during the year 2006.

The described project contains general overview on thermal characteristics of a fuel for the nuclear reactors of generation III+ and IV. The selected reactors were:

- European Pressurized Water Reactor (EPR)
- Advanced Pressurized Water Reactor: APWR+ (Japan) and APR1400 (Korea)
- Reactors of type VVER: modification of the reactor VVER 1000, reactors: VVER 1200, V466P (NPP 2006, NPT 2006, AES 2006), VVER 1500 (V 448)
- Reactor AP1000
- Advanced Boiling Water Reactor (ABWR)
- Economic Simplified Boling Water Reactor (ESBWR)
- High Temperature Gas Reactors (HTGR), generally: Very High Temperature Reactor (VHTR)
- Molten Salt Reactors (MSR)
- Supercritical Water Cooled Reactor (SCWR)

The term "thermal characteristics" is far general. It contains wide set of calculations and analyses, e.g. calculations of the fuel temperatures at the miscellaneous of operational parameters and states (nominal, standard transient, emergency, etc.). The calculations can be made for arbitrary power density in the fuel (maximum, average, etc.) and for different fuel burn-up. It is necessary to insert the calculation of the thermal properties of the fuel to the thermal characteristic, because the thermal properties are a complex function of temperature, operation state and its history and burn-up. The temperature profile in the fuel and the average volume temperature at the average and maximal power density was chosen as a main result of analyses. The computations were made in numerical code COSMOS/M.

In the opening part of the project were defined and designed optimal relations for calculations of thermo-physical properties of the fuel rod (fuel pellet, gap between pellet and cladding, cladding), in particular relations for thermal conductivities of UO_2 , MOX, gap between fuel and cladding, Zircaloy and other alloys of cladding. The relations were considered as the functions of the temperature and the burn-up. The dependence on the burn-up is highly important for calculations of fuel for the nuclear reactors of generation III+ and IV, because the fuel of these reactors will be burn over 50MWd/kg_{HM}. The attention was given to the definition of convection heat transfer coefficient, which is highly different in individual types of reactors (pressurized water reactors x boiling water reactors). The
sensitivity analyses and comparison of results of ABWR from the two different codes COSMOS and FEMAXI-V were made for the determination of the errors.

The second part of the project was focused on an information search about fuel characteristics (geometry, operational states, etc.) for the individual reactors. The reactors of the generation III+ an IV are not yet in the operation, so the characteristics are mostly predicted and the accuracy is consequently reduced. Some characteristics, which were not found in the literature, were judged.

The calculations of the temperature profiles and the average volume temperature, which were made on the individual reactors, compose the main part of the project. The computations show that the fuel operational temperatures at every operational state will be under the limit of fuel melting point (under the boiling point of salt in the case of the MSR). High burn-up of fuel leads to the slightly high maximal temperatures in the centre of pellet and to the high temperature gradients in the radial direction of the fuel pellet. The average volume temperatures change as a function of the burn-up. They decrease from the fresh fuel to the burn-up 30MWd/kg_{HM} and then increase again. The average temperatures are for the individual reactor types: SCWR: 780.4° C - 828.8° C; AP-1000: 681.9° C - 717° C; APWR+: 647.2° C - 677° C; VVER-1000: 620.7° C - 646.4° C; EPR: 614° C - 638° C; ABWR: 558.6° C - 576.1° C. It is evident from the results, that the linear heat rates of the fuel rods have the most influence on the temperatures. The geometric characteristics are the second factor with the important influence on the average temperatures.

The project gives the main temperature characteristics of the fuel in the nuclear rectors of generation III+ and IV. The results help at the choice of the new nuclear energy source for the Czech Republic.

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Impact of high energy neutron irradiation on ITER candidate Hall sensors

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The primary magnetic diagnostics for ITER is based upon coils with analog integration. This approach becomes difficult for pulses longer than 1000 s which are planned on ITER. Therefore, the need for steady state magnetic field detectors becomes obvious. A solution could be Hall sensors that measure directly the absolute value of magnetic field and are capable of measuring the arbitrarily long lasting steady-state magnetic fields.

The output voltage U_H of the Hall sensor is directly related to the external magnetic field B via Hall constant k, $U_H = kB$. Hall constant k depends directly on the Hall coefficient k_H , control current I_H and angle α between B and I_H , $k = k_H I_H \sin(\alpha)$. Typical value of the Hall constant for commonly used materials as GaAs, InSb and InAs is from 1 mV/T to 1 V/T.

There are two main requirements connected with ITER steady state magnetic diagnostic based on Hall sensors :

- stable and reliable operation in ITER radiation environment,
- sensors must survive temperature up to 220 °C that is the maximum allowance of baking temperature. Here, the baking means the heating of the ITER wall in order to remove impurities absorbed there [1].

Taking into account the possible locations of Hall sensors in ITER, the total neutron fluence during their lifetime (4700 h) will be at least 10^{17} n/cm² which can cause especially in semiconductor type Hall sensors significant radiation damage. In other words, the incidental neutrons alter the density of free charge carriers in Hall sensor which affects its sensitivity. The improvement of radiation stability of Hall sensors is achieved by using semiconductor material with a density of charge carriers that is optimal for this type of semiconductor material and is achieved by introducing the additional selected dopants. For further increase of Hall sensor's output signal stability a periodic in situ re-calibration [2] can be used, where the residual degradation of the sensors is compensated by changing the Hall sensor is in the range 10^{16} - 10^{19} n/cm², which would mean the range comparable to the ITER life time fluence in the most optimistic case. Unfortunately, none of the commercially produced Hall transducers/sensors meet the requirements of maximum allowed temperature and radiation stability at the same time: the most of them operate up to 100 °C, several in the range up to 150 °C, however their sensitivity is changed by tens of percents under the high-energy

neutron irradiation. The new, high temperature resistant Hall sensors, compatible with temperature 200 °C are under development in MSL Lviv, Ukraine.

The aim of this contribution is to determine the influence of neutron irradiation on a selected Hall sensor. A high temperature resistant Hall sensor (up to 200 °C) developed by MSL Lviv, Ukraine, was chosen and its sensitivity was measured in-situ during the whole irradiation process. Irradiation tests were done at cyclotron U-120M at NG2 station which provides white-spectrum neutron field (E < 35 MeV) with the fluence rate up to 3.10^{11} cm⁻²s⁻¹.

Firstly, before irradiation, the dependence of sensitivity of the selected Hall sensor on temperature was measured. The Hall sensor with PT-100 temperature sensor were located together in a calibration solenoid driven by the 8 Amperes in so called irradiation head. Thus it was created the calibration magnetic field of about 2.5 mT. The output voltage from the Hall sensor was collected with sampling rate of 1 sample/second. The output voltage of the temperature sensor was collected with the same sampling rate. Multifunction data acquisition PC Board AD25HAL from AREPOC Ltd., Slovakia was used to control and collect data from the Hall sensor during irradiation. The output voltage of the temperature sensor was stored by another PC oriented DAQ system. Power source of 320W, 0-30V, 0-30A drove the calibration solenoid inside the irradiation head. The PC-controlled switch was used to switch on/off the current to the calibration coil in pre-defined time intervals of 10 seconds. The irradiation head was slowly heated up to 200 °C by resistive wires, then cooled down. The whole process took about 5 hours. The results have shown that the sensitivity decreased to 51 % for 200 °C from the nominal 100 % for 30 °C. The decrease was linear for temperatures above 90 °C.

Then, the irradiation head was installed in cyclotron hall in Řež. The system parameters and sample rates were the same as mentioned above, only the Hall sensor was not heated up by additional heating from resistive wires. PT-100 sensor measured the natural temperature increase due to the presence of calibration current and impacting neutrons which was slightly above 100 °C. The Hall sensor was irradiated for 38 hours and total neutron fluence of about 10^{16} n/cm² have been accumulated during the cyclotron operation.

This experiment proved the stability of the high temperature resistant Hall sensor made by MSL Lviv under the neutron fluence comparable to that of 200 ITER discharges (each 3000 s long). At this fluence, the sensor's sensitivity decreased by less then 1 %. This degree of stability provides a good margin for application of in-situ recalibration techniques in order to ensure stability of the sensor performance over the whole lifetime of ITER.

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Distribution of Fission Power in Molten Salt Reactor

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The current analysis of the active zone of a cylindrical molten salt reactor showed that the design of the prepared nuclear transmutor must be revised [1]. Preliminary analysis of influence of the thermal field present in the core of the reactor was conducted. Results of the computations with constant mean temperature of the fuel salt were compared with results obtained for the expected temperature distribution. This expected thermal field in the fuel salt was based on the computed distribution of fission power for the case with constant temperature of the salt and on the thermohydraulical characteristics of the reactor core. The analysis was conducted with analytical tool MCNP/4C.

The reactor is considered to have a cylindrical shape. Including the inlet and outlet regions the overall height is 440 cm. Height of the active zone is 320 cm. The core of the reactor is fueled with unmoderated fuel salt with dissolved transuranium isotopes from LWR spent fuel. Its radius is 160 cm and is surrounded by 50 cm thick graphite reflector. The reactor vessel is considered to be made from 5 cm thick nickel plate. The inlet and outlet regions are without reflector and they serve for stabilizing of the fuel salt flow.

The reactor is unmoderated for maximization of the transmutation features [2]. Also, the reflector has minimal influence on the overall neutron spectrum and is utilized mainly for protection of constructional materials.

Results for 650 °C

The model prepared in MCNP allowed simultaneous analysis of the fission power distribution in horizontal and radial direction.

The calculated criticality eigenvalue k_{eff} was determined to be 1.02087 (reactivity 2044 pcm). The power distribution in the horizontal direction was, as expected, sinusoidal. The radial direction was more interesting. The peak in the central region was also present but more substantial was the situation in the outer region of the active zone. The presence of graphite as a reflector caused a dramatic increase of fission power deposition in this area. This situation required a more detailed model to be employed to fully represent the observed phenomenon.

The peak of fission power in the central region of the core is typical for classical reactors with moderator evenly distributed in the whole reactor. This type of reactor is unmoderated but the fuel salt itself has such nuclear characteristics that it can be considered as a poor moderator. This explains the observed gentle fission power peak in the center of the active zone.

Results for variable salt temperature

In this part of the analysis, two physical attributes of the modeled reactor were taken into account: different heating of the fuel salt as a result of previously described fission power deposition and different flow rate of the fuel salt depending on the actual position in the reactor.

Two distinct fuel and graphite temperatures were modeled: 650 °C and 750 °C. MCNP does not allow the user to specify a gradual change in the material temperature; therefore, there were firmly defined two zones with different temperatures. The higher temperature was modeled to be in the outer region of the reactor in the radial direction and in the upper region in the vertical direction. The regions with lower temperature formed a rough pyramid.

The overall volume of the salt with temperature $750 \,^{\circ}$ C was $60 \,\%$ of the whole fuel salt volume. In the active zone, the salt with higher temperature occupied $75 \,\%$ of the volume.

The final k_{eff} obtained via MCNP run was 1.01880 (reactivity 1845 pcm). There is noticeable decrease from the previous case caused by negative temperature feedback of the fuel salt.

The observed fission power distribution is, in principal, similar to the case with constant salt temperature but, in detailed comparison, there are differences. Due to the negative temperature feedback, the fission power distribution is shifted to the lower regions of the reactor. The power deposition is increased in regions with lower temperature and, vice versa, decreased in the regions with temperature 750 $^{\circ}$ C.

Conclusion

Valuable information about the fuel salt flow in the modeled molten salt reactor was obtained from the previous thermohydraulical analysis [3]. These finding served as input parameters for this study, which focused on influence of uneven temperatures in the reactor on nuclear characteristics.

The difference in fission power distribution in the two described cases is substantial and reaches up to 20% in some regions. After thermohydraulical optimization of the reactor design, a more detailed study must be carried out.

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New Experimetal Instrumentation for Study of Reactor Dynamics at the Training Reactor VR-1

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The training reactor VR-1 is operated for the training of university students and nuclear power plant personnel, R&D, and information services for non-military nuclear energy. Training at the VR-1 reactor provides students with reactor and neutron physics, dosimetry, nuclear safety, and nuclear installation operation experiments.

The reactor as a state-of-the-art education centre in the field of nuclear engineering is a very attractive educational facility in both the Czech Republic and Europe, and thus it was included into the Czech Nuclear Engineering Network (CENEN) and European Nuclear Engineering Network (ENEN). Students from Czech technical and natural sciences universities come to the reactor for training within CENEN framework and from different European universities within ENEN activities.

Instant improvement of the reactor equipment and experimental instrumentation is necessary background for keeping the reactor attractive for students. The latest improvement of the experimental instrumentation was carried out in the year 2006. The new instrumentation for study of reactor dynamic based on twelve years educational experiences has been developed.

The new instrumentation consists of two independent parts: the instrumentation for study of void coefficient of reactivity and the instrumentation for study of transient behavior of the reactor.

The instrumentation for study of void coefficient of reactivity consists of three units for creating a small homogeneous stream of air bubbles, air tubes, a source of pressure air and an electronic control panel. Units for creation of bubbles are at the same time loaded to any three positions in the core, usually into the eight-tube fuel element IRT-4M, the six-tube fuel element IRT-4M and into the fuel dummy. The control panel allows easy change of air flow in the range from 0 to 101 / min.

The instrumentation for study of transient behavior of the reactor allows studying of the three fundamental dynamic characteristics of the reactor. The first characteristic is a pulse or fast jump from the initial to final position and immediate return back to initial position. The second case is a transient characteristic or fast jump from the initial to final position and remain there. The third case is a frequency characteristic or fast moving between initial and final position. The instrumentation consists of tubes for moving of the capsules, a driver, a source of pressured air, air tubes, an electronic control panel and finally capsules for loading of samples with positive or negative influence to the reactivity. The reactor staff can load the instrumentation for study of the transient behavior to any position in the core. The control panel allows easy set of initial and final position in the range from 0 to 680 mm, moving velocity of the capsule, time of the dwelling at the starting and final position and for the frequency characteristic the number of cycles.

Both instrumentations are in the process of testing. Methodology of study of zero-power reactor dynamic using two new instrumentations is upgrading too. Both instrumentations will be included into the education at the reactor by the end of February 2007.

The new experimental instrumentation for study of void coefficient of reactivity and for study of transient behavior of reactor brings new potential in the educational process and improve quality of training at the reactor VR-1.

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New Protection System of VR-1 Training Reactor

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This contribution deals with the new protection system of the VR-1 training reactor. The replacement of the original reactor protection with a new one is an integral part of the VR-1 reactor I&C upgrade. The whole upgrade of the VR-1 reactor I&C started with the human-machine interface and the control room upgrade in 2001, continued with the control rod drivers and the safety circuits replacement in 2002. The third stage, the control system upgrade was carried out in 2003. The fourth stage, the protection system upgrade consists of the independent power protection system upgrade that was completed in summer 2005 and of the operational power protection system upgrade that is under development now and will be carried out in summer 2007. All upgrades are being carried out in cooperation with Škoda Nuclear Machinery Company.

The protection system consists of the independent power protection (IPP) and the operational power measuring (OPM) systems. The IPP system works in the two highest power range decades. The OPM is a full power range system. To fulfill requirements of the safety guide [1] and the single failure criterion, the protection system utilizes redundancy. There are four IPP and four OPM channels, three of them are active, the fourth ones operate in the stand-by mode. The channels are fully independent so that consequences of a single failure in any channel cannot penetrate to the other ones. Safety signals from both IPP and OPM channels are evaluated in the logic 2 out of 3. To protect against the common mode failure, the protection system applies diversity. The IPP and OPM systems are diverse; different types and location of chambers, completely different hardware, software algorithms, development tools and teems for software manufacturing. The computers of both IPP and OPM systems independently calculate the reactor power and power rate, compare them with the safety limits, and if they are exceeded, the safety signal is initiated. A vote logic receives the safety signals. The vote logic evaluates the inputs from the IPP channels in the logic 2 out of 3 and from the OPM channels independently 2 out of 3. If the conditions for the safety action request are met in at least one group (IPP or OPM), the power supply (48V DC) to the control rods is broken by the safety circuits, the rods fall down and stop the chain reaction (reactor scram).

The IPP channel was developed according to the requirements [2]. The IPP channel hardware consists of an analog and a digital section. The analog section processes the signal from the boron neutron chamber, amplifies it, and provides proper discrimination of neutrons. The digital section counts pulses from the neutron chamber, evaluates the reactor power and the power rate. Next, it compares gained data with the safety limits and sends the safety signal (controls the safety relay). It also communicates with the reactor control system via fiber optics lines, controls the individual display on the operator's desk and provides testing of the channel. The digital section of the IPP channel consists of 5 microcomputer units. The reason for the utilization of more microcomputers was to divide single functions to separate microcomputers to guarantee easier structure of the system hardware and, in particular, of system software. The communication among individual microcomputers is provided via buffer in an FPGA (Field-Programmable Gate Array). The software was developed with respect to nuclear standards. The software design was coded in the C language regarding the 452

NRC restrictions. The μ Vision 2 software development system of Keil Software Company was utilized. The system was carefully tested during non-active and active tests. Configuration management, verification and validation accompanied the software development.

The OPM channel is developing according to requirements [3]. It also consists of an analog and a digital section. The analog section processes the chamber signal and transforms it to be suitable for the digital section. The analog section processes the neutron chamber signal either in pulse, Campbell or DC current ranges and provides signals proportional to the neutron flux density (reactor power). The digital section of the OPM channel is based on a high quality industrial PC with an appropriate additional hardware - an input unit for reading data from the analog section; a supervisory unit for the supervision of the OPM hardware and software; communication unit for communication with the control system, the control desk individual display and service computer; local display for the OPM status presentation and a safety relay to control the safety circuits. The OPM channel software has to fulfill quality requirements for the safety (protection) systems of nuclear facilities; quality assurance, configuration management, verification and validation activities must fulfill respected standards and guides]. The computer operating system is going to be the reputable system Phar Lap, the software is going to be coded in the C Language with the NRC and MISRA restrictions because of safety. The Department of Nuclear Reactors is going to take an active part during the verification & validation phase of the software life cycle.

The VR-1 reactor I&C upgrade substantially improves the reactor safety and the comfort of the reactor operation, and it also facilitates maintenance. The reactor I&C upgrade will finish with the operational power measurement system upgrade in summer 2007. The complete upgrade brings the reactor I&C to top conditions and enables a prolongation of their functionality and maintainability for at least 10 next years. Reliable and safe operation is important because the training reactor VR-1 is very intensively used for training of students and future nuclear power plant staff [4].

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Determination of a Neutron Flux Density Distribution in the Core C1 of the Training Reactor VR-1 Sparrow

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Goal of the work is a determination of a neutron flux density distribution in the core C1 of the training reactor VR-1 Sparrow, maintained by Department of Nuclear Reactors at Faculty of Nuclear Sciences and Physical Engineering at Czech Technical University in Prague. This experiment is proceeded on the new core, which is the new one with low-enriched uranium fuel elements IRT-4M (19.7 %). This fuel replaced the old high-enriched uranium fuel IRT-3M (36 %) in terms of the RERT (Reduced Enrichment for Research and Test Reactors) project.

The measurement was performed by neutron activation method. The principle of this method consists in neutron capture in a nucleus of material forming the activation detector. This capture can change the nucleus in a radioisotope, which activity can be measured. Therefore, activation detector segments irradiated in locations with higher neutron flux density shows higher activity.

To obtain absolute value of a neutron flux density from measurements of the activity of an irradiated detector, the exact cross-section value for neutron absorption in the chosen place of gold wire has to be known. The value of the cross-section for neutron absorption in chosen material is changing with neutron spectra, which is different in different locations of the core. One way how to solve this problem with cross-section value is the use of a computer code to evaluate the cross-section.

If all of the variables (the time of irradiation, the activity of the detector, the time of the activity measurement start, the time of the activity measurement stop, the cross-section value in chosen position and selected detector material, the density of nuclei of the material, the volume of the detector, measurements calibration) are known, the final absolute value of the neutron density flux can be evaluated.

Gold wires (1 mm in diameter) were used in this work as activation detectors and were irradiated in seven different positions in the core C1. The most important place is the channel of the tube post used to irradiate various samples. By absorption of a neutron the ¹⁹⁷Au changes into the radioisotope ¹⁹⁸Au and prompt gamma-rays are emitted. The ¹⁹⁸Au undergoes the beta-decay with the emission of a gamma-ray with energy 411.8 keV. The activity of segments of irradiated wires was measured by special automatic device called "Drát" (Wire in English).

Values of cross-sections for neutron absorption in segments of gold wires in all chosen positions in the core were calculated by MCNP 4C computer code. All irradiations were done at reactor power level 1E8 (1 kW_{therm}). Final evaluated results for chosen positions in the core C1 are shown in table 1. Distribution of neutron flux density at first five centimeters of the tube post is shown in table 2.

Position in the core	Ф [m ⁻² s ⁻¹]			
	thermal (<0.4 eV)	epithermal (0.4 eV–0.1 MeV)	fast (>0.1 MeV)	total
end of tube post (19 mm below the middle of the fuel)	4.66E+011	2.58E+011	3.06E+011	1.03E+012
wire #3 – middle of the fuel	3.85E+011	3.75E+011	4.92E+011	1.25E+012
wire #3 – top of the fuel	1.37E+011	7.52E+010	9.29E+010	3.06E+011

Table 1: Evaluated results of neutron flux density in selected positions in the core C1



Position in the tube post [cm]	$\Phi\left[m^{-2}s^{-1}\right]$
0	1.03E+012
1	1.05E+012
2	1.04E+012
3	1.04E+012
4	1.04E+012

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Development of the CENEN Association in 2006

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The CENEN Association (Czech Nuclear Education Network) was held on 3rd May 2005 and consists of academic institutions, which offer teaching in the field of nuclear engineering. Founding the association is in agreement with European and world-wide academic movement in nuclear engineering education and training. The CENEN members cooperate with ENEN Association (European Nuclear Education Network) and WNU (World Nuclear University). Their effort leads to create a standard of European standard of education in nuclear engineering. Also Czech institutions try to get closer to each other in shared parts of education. They work on common courses preparation, which will attend students from all CENEN institutions. In the year 2006 the Institute of Chemical Technology in Prague joined the Association, so CENEN covers all nuclear engineering area of interests – nuclear theory, nuclear safety, flow theory, nuclear machinery, nuclear electrical engineering, nuclear chemistry, fuel cycle, waste management, environmental studies etc. (see Fig.1). In the year 2006 there were held several three to five days practices at training reactor VR-1 at Dept. of Nuclear Reactors, students from CENEN institutions participate in basic measurement with nuclear reactor. There were also European course of reactor physics, called Eugen-Wigner reactor course, which takes place for all ENEN member institutions students.



Fig.1: The CENEN Association structure in 2006

The Association started discuss with leading Czech companies and state institutions to cooperate closer in educational process. Nuclear Research Institute at Rez, Skoda Machinery Ltd., State Office for Nuclear Safety are interested to become the associated members of the CENEN Association with direct impression to nuclear engineering education in the Czech Republic. They could support talented students, influent to master degree thesis subjects, offer fellowships, practices, excursions'.

The CENEN Association will continue with nuclear education development in Czech Republic in next years too. Sufficiency of well-educated specialist in the field of nuclear engineering, in all directions and specializations, is necessary for safety operation and development of Czech nuclear industry and power plants.

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The Determination of Neutron Energy Spectrum in Reactor Core C1 of Reactor VR-1 Sparrow

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Training reactor VR-1 Sparrow is unique nuclear facility in Czech Republic. Its task is to be used in preparation future expert in the field of nuclear physics, to train inspectors for IAAE and to improve public knowledge about nuclear reactors and nuclear science generally. Finally, VR-1 belongs to the class of pool light water reactors and its main advantage is possibility to do very fast change in composition of reactor core and small starting time of the reactor. The neutron flux density in reactor reach a small value on the other hand, that brings rather strong limitation to reactors application. The reactor VR-1 is managed by the Department of Nuclear Reactors, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague. In 2005 was former nuclear fuel IRT-3M changed for current nuclear fuel IRT-4M with lower enrichment of ²³⁵U (enrichment was reduced from former 36% to 20%).

The goal of the work was to measure neutron energy spectrum at the end of pipe of rabit system, which is the main position for irradiation of samples for neutron activation analysis. Neutron spectrum is necessary for better understanding of results. Pipe transportation system is equipment that enables very fast transportation (in order of seconds) of irradiated samples from reactor to gamma spectroscopy laboratory.

Neutron spectrum measurement was obtained by irradiation of activation foils and consecutive deconvolution of obtained saturated activities. Deconvolution was performed by computer iterative code SAND-II with 620 groups' structure. This code was newly acquired and replaced old version of SAND-II modified at Nuclear Research Institute Řež. Former version worked only in 100 groups' structure. SAND-II required neutron spectrum approximation in input data, Monte Carlo code MCNP-4C was used for computing of this first approximation. All gamma measurement were performed on Canberra HPGe detector with energy resolution 1.8 keV and relative efficiency 25% and analyzed on Canberra software Genie-2000 v.3.0. Activation foils were chosen according physical and nuclear parameters from the set of certificated foils. The set of selected foils included gold, manganese, indium, scandium, tungsten, copper, vanadium, nickel. Another gold and manganese foils were added for measurement with cadmium covers for more precise investigation of fast and epithermal part of neutron spectrum.

All activation foils were irradiated for time from 10 minutes to 1 hour on stable reactor power from 100W to 1kW. Following measurement of activities lasted from 5 minutes to tens hours according to relevant decay constant. Calibration of HPGe detector was done by certificated ¹⁵²Eu etalon. Due to small neutron flux in reactor were observed only (n,γ) reactions (radiation capture) and (n,p) reactions. Data from all recorded reactions were transformed to saturated activities which use SAND-II as input. Because the original reaction cross section library in SAND-II had not cover whole set of reactions chosen for measurement, the original library was filled out by cross sections for following reactions: ⁶⁴Ni(n,\gamma)⁶⁵Ni, ¹⁸⁶W (n,\gamma) ¹⁸⁷W and ⁵¹V(n,\gamma)⁵²V. Values of new cross sections were computed by program NJOY99 from ENDF-

VIB library. During the process there were revealed difference between original cross sections and new ones computed for the same reactions, mainly in resonance area. Therefore it was decided to calculate spectrum for new and original library and compare results.

The indium foil was discarded during calculations, probably due to unknown failure in measurement. Resulting spectrum confirmed the expected high ratio of thermal neutrons in spectra and very low share of fast neutrons. The differential flux at the end of pipe of rabit system agreed well with typical spectrum of light water reactor. Good visible was 1/E area. Results for calculations with original and new libraries showed only light difference both in shape and precision (probably because of dominance in thermal area). Measurement of neutron spectrum has brought better knowledge about new reactor core C1 and improved methodology of activation measurement.

Future works in this area should focus on problematic points, which are: better coverage of resonance and high energy area by involve more foils with (n,p) reaction (other exotic reaction are unlikely), comprehend self shielding effect, improve precision of measurement generally and validate results in another calculation code.

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Section 11

CHEMISTRY

Study of Behaviour of Contaminants in the Fucoid Sandstone on the Stráž pod Ralskem Site

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The in-situ leaching of uranium in the Stráž deposit, Northern Bohemia, was based on the injection of technological solutions containing sulfuric acid into underground layers of the Cenomanian age. The Cenomanian collector of the height about 100 m is here formed by (i) friable sandstone that contains uranium bearing minerals and (ii) fucoid sandstone that forms overlying back of ore. The fucoid stratum, the height of which is in the mining area about 40 m, was contaminated secondarily by acid solutions [1]. Aiming to control the spreading of the contamination from the Cenomanian into Turonian aquifer, which serves as the water source for a large populated area, it is necessary to describe also the potential transport of contaminants from the layer of fucoid sandstone.

The fucoid sandstones are formed by fine-grained sand containing, in comparison to the friable sandstone, a substantial part of organogenic components. In cavities were found crystalline pyrite particles together with organic residue [2]. The existing knowledge about fucoid sandstone in the site remains scarce, but it is supposed that fucoid stratum holds about 40% of contaminants present in the Cenomanian aquifer. The model simulation of the Cenoman remediation indicated a significant residual content of contaminants in the less permeable fucoid sandstones also in the future.

To important contaminants present at fucoid sandstone belong Al, As, Be, Cd, Co, Cr, Cu, F, Fe, Ni, Mn, Pb, V, Z, SO_4^{2-} and NH_3/NH_4^+ . The behavior of the dominant contaminants (Al, SO_4^{2-} , NH_3/NH_4^+) was found to be practically conservative without any influence of geochemical reactions on the total concentrations of them in the pore water. Some trace components are of the similar nature (As, Cr, and with some deviations also Cu and Cd). On the contrary, other trace elements (e.g. Ni, Pb, U, F) exhibit the non-linear interaction isotherm in the system pore water – rock material. The knowledge of the character of both release and uptake of studied contaminants with the surface of the real solid phase will support the modeling of the behavior of the complicated geochemical system that will help to choose the most convenient remediation technique.

In the year 2006, the preliminary mineralogical and petrographical analysis, the geochemical study of the rock and pore water, the contaminant distribution in the samples of fucoid sandstone, including the study of solution transport through these samples and diffusion experiments, were carried out. Core samples obtained from three boreholes drilled in the years 2005 and 2006 were investigated. Mineralogically, the fucoid sandstone samples mainly consist of three components, namely, grains of quartz, silt and fine-grained organic matter. The different contents of these three components characterize the individual core samples. For example, the permeability of the fucoid sandstone stratum is influenced not only

by gaps and channels but also by the content of silt (the values of permeability amounts approximately 10^{-7} m.s⁻¹ while the permeability of underlying friable sandstone stratum is about 10^{-6} m.s⁻¹); the total porosity is about 26% and effective porosity approximately 18%. As for the pore water composition, pH value, and sulfate, aluminum and iron concentrations fluctuate to such extent that the concentrations can be high but also very low or practically zero. The presence of contaminants type of SO₄²⁻, Al³⁺, Fe²⁺ and Fe³⁺ in the fucoid sandstone indicates the external source of contamination, i.e., the in-situ leaching of uranium running for about 30 years.

In the course of introductory experiments, the leaching of two fucoid sandstone fractions (0 - 0.25 mm and 0.25 - 0.80 mm) was realized. The fractions coming from the strongly contaminated parts of the fucoid sandstone stratum were leached by distilled water during 1 - 120 hours at liquid/solid ratio equal 6 - 10 - 20 - 30 mL.g⁻¹. The results reflected not only the different mineralogical composition but also the heterogeneity of the both fractions. The rate of SO_4^{2-1} leaching was very high and also the release of NH_4^+ , AI^{3+} and $Fe^{2+,3+}$ was quite evident. Further, Be, Cr, Mn and Ni were detected, too. In total, at liquid/solid ratio of 6-30 mL.g⁻¹ and contact time of 10 hours, 33% SO₄²⁻, 12.5-15% Be, 1.4-5.5% Fe and 2.2-3.2% Cr were leached. The sequential extraction [3] of two fucoid sandstone samples, consisting of three steps (1. step: H₂O, 1 hour; 2. step: 1M MgCl₂, pH 7, 1 hour; 3. step: 1M CH₃COONa, pH 4.8, 5 hours), gave the results according to which the leaching efficiency of the individual components decreased in the following order: $SO_4^{2^2} - 2.step > 1$. step > 3. step; NH_4^+ - 2. step = 3. step >> 1. step; Fe and Al - 1. step >> 2. step = 3. step. Further, the diffusion of ³H through undisturbed sample of fucoid sandstone core was studied because the diffusion seems to be an important transport mechanism. The through-diffusion procedure [4] was used and the effective diffusion coefficient ($D_e = 3.9 \cdot 10^{-9} \text{ m}^2 \text{s}^{-1}$) was calculated by means of time-lag method.

Samples of groundwater of different composition were withdrawn from Cenomanian aquifer for the microbiological characterization. The highly molecular DNA was isolated from all samples, but the highest yield was found in the weak contaminated Cenomanian groundwater. The presence of the inactive and active bacterial communities was found, too.

The complex laboratory program based on the starting experimental results was proposed with the aim the characteristics of transport and geochemical processes running in the fucoid sandstone stratum to be evaluated, and, under the cooperation with state enterprise DIAMO, the course of remediation of the Cenomanian aquifer to be modeled and consecutively also realized.

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DFT Modeling of Ethylene Oxidation at Metal Clusters

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There is a need to develop electrocatalytic materials appropriate for oxygen insertion reactions to double bonds. Specific reactivity could be achieved using metal nanostructured electrodes. The current understanding of these reactions is, at present, rather limited. Considering these limitations of the state of the art, the research programme for investigation of fundamental aspects of reactivity at e.g. bulk gold and platinum nanostructured electrodes is desirable. Theoretical calculations of reactivity and the potential energy curves for different reactant and product conformations would be done. This work addresses theoretical aspects of the electronic structure of reaction intermediates, ionic distribution at the cluster – solution interface and the more fundamental aspects of looking transiton states in order to map the reaction coordinates of reactions that take place in double bond epoxidation at metal nanoparticles, the target of these studies.

Density functional theory (DFT) was used for the study of the possible mechanism of the ethylene oxidation or electro-oxidation at metal interfaces. The understanding of catalytic properties of surfaces requires the proper modeling the interface. In this study, a cluster approach was used for the modeling of electrocatalytical epoxidation at metal interface. Pt and Au clusters were modeled as an interface simplification or as a part of real experimental systems. DFT calculations were done by Gaussian 03 or ADF program packages. Scalar relativistic effects were described either by relativistic pseudopotentials and corresponding wave functions or by ZORA approach.

The mechanisms of the O and C2H4 adsorption at the metal clusters of varying size, and the formation of M_x -Et-O intermediates and the possible intermediate transfer under the influence of electric field or electrode reaction were studied. Three-dimensional Pt and Au clusters of the size between 10 to 25 atoms were used for the interface modeling. Prior the study of surface interactions, clusters of different size were optimized in the respect of different spin states. By the interaction of the adsorbed oxygen with ethylene the stable surface oxametallacycle intermediates are formed to describe ethylene oxide reaction at Ag(111) surface [1]. The interaction with the surface depends on the type of the cluster, its size and the reaction site (the plane steps or edges).

Because of the atom platinum configuration $(5s)^2(5p)^6(5d)^9(6s)^1(6p)^0$, the lowest lying singlet state need not be the lowest electronic state and therefore the correct spin multiplicity corresponding to the ground state was looked for. Spin multiplicity equal to 7 was found for the ground state of cluster Pt₂₁. The gold clusters used for the investigation of reactivity with small organic molecules were only in the singlet state. The second possible doublet state (odd number of atoms) was not used because the experimental structure of gold clusters consists of 100-200 atoms and the spin density is nearly the same for an odd and even number of atoms.

The two spin multiplicities of intermediates and transitions states were investigated in the course of reaction path. The first path depends on deactivated oxygen. The second path depends on the activated oxygen (the triplet state of Au₂₂-Et-O complex) and for Pt₂₁-Et-O complex the spin multiplicity was equal to 9. The two types of transition states of Au₂₂-Et-O were found and optimized. The first transition state was found for the singlet state and, in this case, there is the interaction between the plane of Au₂₂ and Et-O. The second transiton state was found for the triplet state of Au₂₂-Et-O. In this case, the interaction ran on the edge of the gold cluster. One type of transition state of Pt₂₁-Et-O with activated atomic oxygen where the edge interaction proceeded was found and optimized. In the future, the influence of the solvent effect on the reactivity and structure of Au₂₂-Et-O and Pt₂₁-Et-O complexes will be included.

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Dissolution of UO2 Fuel in Repository Modelling Slightly Alkaline Solution - Electrochemical Approach

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According to Czech concept of Deep Geological Repository, spent fuel will be placed in carbon steel canisters deposited in compacted bentonite bed. Possible failure of long-lived nuclear waste container may lead to water leakage, resulting in its contact with surface of spent fuel matrix. Therefore, degradation of fuel matrix under potentially oxidizing conditions may occur, resulting in the release of radionuclides (RN) to environs. Extent of the release will be given by the rate of dissolution of UO_2 fuel matrix. In the case of container failure, the groundwater will contact both the container material (carbon steel) and spent fuel (UO₂). Interaction between corroded steel 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 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 releasing, it is necessary to understand and evaluate all potential fuel degradation processes[1].

Dissolution of UO_2 in the presence of chemical oxidants occurs via electrochemical mechanisms and therefore anodic oxidation (UO_2 dissolution) and cathodic reduction may be investigated by electrochemical techniques. (For example, prediction of dissolution rate for UO_2 is based on the extrapolation of Tafel plots to corrosion potential for anodic oxidation reaction, measurement is performed in solutions containing various concentrations of oxidants.)

Main effect obtained due to fuel corrosion process under natural or electrochemically induced conditions is a modification of thin surface layer composition with potential. Under natural conditions it is the corrosion potential (E_{cor}), for electrochemically induced conditions the potential represents applied potential. Time dependence of E_{cor} indicates the changes on fuel surface during corrosion. For evaluation of various stages of surface oxidation, suitable electrochemical polarization methods can be applied, e.g. cyclic voltametry [2].

Development and verification of suitable electrochemical methods for testing various parameters on UO₂ spent fuel dissolution were aim of this study. The experiments were performed in the corrosion cell equipped by rotating electrode formed by UO₂ disc (5 mm in diameter with surface area about 20 mm², stirring rate using in experiments was 160 min⁻¹). Standard three electrodes arrangement (UO₂-working, reference and Pt-counting electrodes) was used. UO₂ 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. Corrosion cell may be purged with nitrogen for anaerobic condition modeling.

For the approaching to the groundwater composition, $0.1 \text{ mol/l NaClO}_4$ solution, with pH = 9.5 and the electrolyte volume 250 ml was used

For electrochemical analyses we used PC4/750 Analyzer with the evaluation software from Gamry Instruments and TDC 2 Temperature Controller with controlling unit Watlow series 988 PID. Following electrochemical methods were selected [3]:

- time dependence of corrosion potential measurement
- cathodic stripping voltametry
- cyclic voltammetry
- chronoamperometry (dissolution current measured on UO₂ electrodes as a function of applied potentials are plotted).

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Electrochemical Noise Analysis of Carbon Steel Behavior in Aqueous Solutions Modeling Nuclear Fuel Repository Conditions

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Lifetime prediction of canisters used for the disposition of high-level radioactive waste (HLW) is necessary for determination of the overall *performance* of HLW repository. The extrapolation of short-term laboratory data to long-term performance is necessary for predicting of container lifetime. The short-term corrosion data in modeled repository conditions are collected from controlled laboratory tests. The corrosion is generally characterized by the dissolution (corrosion) rate determined by the time dependence of weight decrease of material or by measuring of the amount of corrosion products.

In the Czech Deep Geological Repository concept, carbon steel is considered as a reference material for spent fuel disposal canisters. Various methods have been used to understand the behavior of carbon steels in geological environment and to predict container lifetime in the environment of deep geological repository. It was primarily direct measurements of corrosion rates at anaerobic condition by determination of released hydrogen rate and electrochemical methods. For electrochemical methods like free corrosion potential monitoring and linear polarization resistance measurement were employed. These techniques may contribute to evaluation of the mechanism of corrosion processes. Used measurement system is relatively simple and easy to operate. The electrochemical noise analysis (ENA) is the most notable among used methods. ENA is based on measuring of potential and current fluctuations, generated spontaneously by the corrosion processes[1]. Analysis of fluctuations after spectral deconvolution provides information not only on corrosion rate, but also on characteristic of the corrosion process. Advantage of the electrochemical noise method is the absence of external current or voltages sources which perturbs the system. Measured signals can be mathematically processed. In the case of complicated mechanisms of corrosion, like metastable pitting corrosion, mathematical analysis becomes unsuccessful, and some researchers suggest application of chaos theory at corrosion electrochemistry.

Conducted experiments were aimed at investigation of ENA behavior of studied carbon steel in both pure water and aqueous solutions modeling repository conditions. Measurements were performed at various temperatures using two identical carbon steel wires in short-circuit related to the reference electrode in the same time. Main effort was focused on finding relation between the linear corrosion resistance and the noise (statistical) corrosion resistance[2].

Comparison of obtained results with direct measurement of corrosion rate at anaerobic condition by determination of released hydrogen rate was in the center of our interest.

The developed method for measurements of hydrogen evolution during carbon steel corrosion process enables to measure hydrogen evolution continuously at different temperatures and at constant pressure. The values of corrosion rate of carbon steel plates

 $(\sim 0.1 \text{ m}^2)$ in distilled and synthetic bentonite pore water and iron powder $(\sim 0.075 \text{ m}^2/\text{g})$ were obtained from the rate of hydrogen evolution according to the following equation:

 $3Fe + 4 H_2O \rightarrow Fe_3 O_4 + 4 H_2$

The results indicate that after several hundreds of hours the corrosion rate of carbon steel plates decreases rapidly down to the values about 1 μ m/yr. In initial phases of corrosion, the corrosion rate depends strongly on temperature. Afterward it seems that corrosion rate is determined more by nature of formed corrosion products than by temperature. Corrosion rates were impossible to evaluate at temperatures under 50 °C. Therefore, iron powder with higher specific surface area was used instead of carbon steel tablets. The values of corrosion rates of iron powder at 30 °C show a slight increase of corrosion rate at the beginning stage of corrosion and decrease after about 400 hours. Wide scattering of data may be given by an unceasing change of nature of corrosion products layers.

For ENA analyses was used PC4/750 Analyzer with the evaluation software ESA 400 Electrochemical Signal Analyzer version 2.01 from Gamry Instruments and TDC 2 Temperature Controller with controlling unit Watlow series 988 PID. The results of electrochemical noise monitoring of corrosion of carbon steel samples in distilled and bentonite water at 60 °C bubbled with nitrogen showed abrupt decrease of current after 193 min of experiment in distilled water. This is probably related to formation of corrosion product layer. By contrast, the sudden increase of potential in the experiment in bentonite water indicates breaking or damaging of already formed corrosion product layers after approximately 130 minutes of corrosion.

These preliminary results confirm that applied methods could contribute to a deeper understanding of processes occurring on carbon steel-bentonite interface[3].

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Section 12

BIOMEDICAL ENGINEERING

Biomechanic Models in Acoustics of the Vocal Tract

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Assuming symmetry of self-excited oscillations, a half physical model of the vocal folds was created. The working principle of the model is based on self-excited oscillations occurring when a critical air flow rate is exceeded. An air flow rate of 0.6 liters per second was used for generation of flow-excited oscillations of an elastic part of the model with fundamental frequency 117 Hz. The used elastic element made of polyurethane rubber was designed and manufactured by Thomson from Purdue University (Indiana) [1],[2].

The measurement of the model of vocal folds was realized in Department of Dynamics and Vibration of Institute of Thermomechanics AS CR. It was divided to parts. The fist one was an introductory measurement to check the functionality of the model. The second one was a comprehensive measurement to find out detailed properties of the model. The introductory measurements were performed using a high speed digital camera. The fundamental frequency of this self-exited system was approximately determined. The comprehensive measurements were performed using a precise microphone and three pressure sensors to determine time behavior and frequency spectra of subglottic and supraglottic pressures. A laser interferometer was also used and time behavior and frequency spectra of instantaneous velocity of the elastic part oscillations were determined.

The shape of the elastic part was chosen by Thomson as a simplification of real human vocal folds. The real smooth shape of vocal folds, which sections vary lengthwise, was replaced by a prismatic tetrahedral shape (quadrangular prism). This simplification was carried out for technology and computation reasons (in [1], [2] the Finite Element Method was used).

The elastic part was molten from polyurethane rubber to a mould made by Rapid Prototyping Method [1]. It was sealed up to a socket by silicon sealant. The socket was put into a collar, which was screwed up into an existing model of trachea. These two parts (socket, collar) were designed in CAE system Unigraphics NX and made of plexiglass by a cutting operation in a computer controlled milling machine FC16CNC.

The model of trachea with the model of vocal folds was linked to a serial measuring circuit that consisted of input pressure gauge, adjusting valve and flowmeter, in the end. The flowmeter output was connected with one side of the model of trachea (plexiglass tube - internal diameter 26mm, length 240mm). The collar of the vocal folds model was connected to the other side. Compressed air with pressure 0.2MPa and temperature 20°C, was supplied to the input of the measuring circuit. The flow of the air was regulated in range from 0.02 to 0.6 liters per second.

In the introductory measurements of motion of the elastic part were recorded by a digital high speed camera (DANTEC Dynamics, Germany). For each measurement of length 2 seconds, a sampling rate 5000 image per second was used. From the record of the self-excited oscillation of the elastic part, the fundamental frequency was detected. The value of this frequency was found to be approximately 117Hz at the maximal measurable air flow 0.6 liters per second. At this air flow the maximal intensity of acoustic pressure was determined

by listening. For lower or higher air flow (out of scale of flowmeter) the intensity was subjectively lower.

In the comprehensive measurements, three pressure sensors to measure the subglottic pressure, located along the inner wall of the model of trachea and precise microphone (Brüel&Kjær 2239) to measure the supraglottic acoustic pressure were used. The microphone was located at distance 300mm lengthwise and 20mm transversally from the orifice of the model of vocal folds. This location was chosen not to influence the microphone by the air flow outgoing from the model. Velocity of the oscillation of the elastic part was measured by a laser interferometer (Polytec OFV 302) with a control unit (Polytec OFV 3000). To improve the reflectivity of the elastic part, a reflective self-adhesive tape of size 3mm × 3mm was used. All sensors were connected with an input/output measuring unit (Brüel&Kjær 7537A) interconnected with a personal computer. This computer was used to control the measuring unit and to download measured data.

The frequency spectra of all signals of the five sensors, within the range from 5 to 6400 Hz with frequency increment $\Delta f=2Hz$, were averaged from 40 realizations. From this number of the realizations, the measurement time 20 second implied. The elastic part was preloaded by three compressions 0mm, 0.19mm and of 0.38mm in transverse direction. These compressions correspond to state caused by the constriction of real human vocal folds. For all of these compressions and for air flows 0.35, 0.4, 0.5, 0.6 liters per second, measurements were carried out.

From time response it is obvious that signals of all pressure sensors and the laser interferometer are in phase. The microphone signal is slightly phase shifted while it is relatively (compare to the pressure sensors) far from the source of self-exited oscillations. Comparing all measured data by microphone for all compressions and all air flows, following dependencies can be seen:

- with increasing compressions the fundamental frequency increases, average value of pressure increases and magnitude of pressure decreases,
- 2) with increasing air flow the fundamental frequency and magnitude of pressure increase.

The minimal fundamental frequency $f_{0min}=116Hz$ with magnitude $M_{min}=64.3dB/20\mu Pa$ was achieved under the zero compression and minimal air flow 0.35 liters per second. The maximal magnitude $M_{max}=69.7dB/20\mu Pa$ was achieved under the zero compression and maximal air flow 0.6 liters per second. The maximal fundamental frequency was achieved under the 0.19mm, 0.38mm compression and air flow 0.6, 0.5 liters per second respectively.

The results of our measurement will be compared with published values. We propose to use the model as a source of acoustic pressure for excitation of physical models of the human vocal tract.

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A mechanism for absorbing chair vibrations and concussions

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The idea for the realization of a mechanism for absorbing chair vibrations and concussions (antivibrational equipment) was inspired by the need to develop an equipment that would enable to absorb the external effects produced during the movement of any kind of a wagon used for the transportation of children of the age up to 4 years suffering due to the spastic form of the brain poliomyelitis.

The already devised equipment is located between the frame of the wagon and the seat where the child is sitting. We anticipated that the movement of the wagon is smooth when the wagon with the disabled child is running and that the vibrations coming from the road via the construction of the wagon up to the seat in the vertical dimension are the main external perturbator. The damping of the vertical vibrations coming from the movement of the wagon on the uneven surface of the road was therefore taken for the main task to be solved in our proposal.

The mechanic parameters determined by the potential users of the wagon were the starting point for the proposal of the antivibrational equipment. The weight of the child was the basic parameter for the proposal of the antivibrational equipment. This parameter was as well the starting point for the selection of the kind of the vibration absorbing elements.

Elimination of the vertical components of the vibrations had the priority in the solution of our task. A ball gear shift (a brass roller cage with the balls and their side-way) was used to provide the safety of the vertical movement of the seat affecting the transmitted vibrations during the use of the wagon. This side-way enables the movement of the seat only in the vertical dimension when the wagon faces the uneven surface of the road. Two absorbing isolators were used as the damping elements for so defined vertical movement of the seat. These isolators were designed according to the above mentioned load – the weight of the children. As the span of the mass parameters was relatively large – in relation to the age and development of the children – two series of absorbing isolators were elected. The first series was dedicated to the load going from 15kg upwards – the further called "heavy series". The second one is dedicated to the lighter weights up to 15kg. It is furher called "the light series".

There was proposed and realized the damping characteristic of the concussion and vibrations test. The results of this test enabled us to derive the transfer characteristics of the proposed antivibrational equipment for the special input parameters of the trial.

The load trial was realized for the two above mentioned mass parameters m=15kg and m=20kg. The required frequencies and amplitudes of the exciting vibrations were in the span

between f=2-90Hz and T=0,5g. The frequency increase from 2Hz up to 90Hz was continual for t=0,5s. The measurement for any series of the absorbing isolators – both for the heavy and the light ones –was made with the load m=15kg and m=20kg. Thereafter a combination was tested of one isolator from the heavy and the other one from the light series with the same process of loading. It was possible to read the relative absorbin characteristic from these tests i.e. from the transfer characteristics of the individual settings. In this way the quality of the absorbing isolators could be read.

Relatively very similar qualities could be seen in the transfer characteristics of all series of the isolators used. They were detected thanks to the use of the sensing elements of the acceleration. The pattern was the same when the load was changed, when the character of the absorbtion was changed, and even in the case when absorbtion started. The detectors were installed on several points above the base, that was the source of the vibrations above the absorbtion isolators, up to the point where the load-bearing construction for the seat mounting. The characteristics show that the greatest acceleration is at the futhermost points from the base. On the other hand the lowest acceleration values were detected above the point where the absorbtion isolators were mounted. It was possible to detect a part in the in the frequency span, where all series of isolators start to behave as real absorbters. It was the frequency span from 35 - 50Hz. Up to this point the rather unfunctional absorbing character was detected. It means that the starting working point of the absorbing isolators is given by the position of the detector on the antivibrational equipment and by the frequency level. The absorbing effect of the isolators used is pregnantly seen with the rather higher frequencies above 35Hz. The absorbtion level is related to the frequency around 50%.

The measurement data show that it is badly needed to design other series of absorbing isolators ready to react with their damping effect in the rather lower vibration frequencies.

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Design and Optimization of Applicators for Microwave Cancer Treatment

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Nowadays microwave cancer treatment (microwave hyperthermia) belongs to classical therapeutic methods of cancer diseases. Hyperthermia is a type of cancer treatment in which body tissue is exposed to temperatures increased up to 45 °C, in order to damage and kill cancer cells, or to make cancer cells more sensitive to the effects of radiation and certain anticancer drugs (the different thermal sensitivity of the healthy and tumour tissues has been used). Microwave energy is the most used way (app. 90 %) how to heat up the biological tissue. During microwave hyperthermia treatment is important to monitor and to control the temperature in the tumour area. The temperature can be measured by set of the thermal probes or by aid of MRI system. Another important thing is to determine the time and frequency of therapeutic doses. There's no rule to establish optimal combination, because it depend at the several variables as a type and size of the tumour, localization etc. With respect to the clinical experiences microwave hyperthermia is usually used once a week for one hour.

Local hyperthermia is used to heat the small areas, such as tumours, which are mainly placed at the surface of the body. We can quite simply localize this tumours, thus the area which must be heated is clearly defined. The type of the applicator selected for treatment depends on the production of sufficient thermal distribution at the treatment area (we would like to heat the tumour and minimize the increase of the temperature in the healthy tissue). As applicator for local hyperthermia the different modifications of the waveguide and planar resonance structure has been used.

For design and optimization of the microwave applicators the 3D electromagnetic field simulator has been used. FDTD (finite difference in time domain) and FEM (finite element method) are most often applied numerical methods in the commercial simulators. In the contribution [1] the design of the horn type of applicator is presented using FDTD method. Waveguide is designed for frequency 434 MHz which is one of the frequencies using for medical purposes. The parameters (width and height) of the waveguide we chose so that frequency 434 MHz is in the middle of the dominant mode TE₁₀ pass band. To decrease its cut off frequency waveguide is filled up by distilled water ($\varepsilon_r = 81$). The utilization of the 3D simulator of electromagnetic field is presented in [2]. On the results of SAR (specific absorption rate) distribution and impedance matching of the waveguide horn applicator is shown how important is 3D electromagnetic field simulator in microwave hyperthermia planning system.

Using electromagnetic field simulator the thermal distribution in treated area can be obtained. In study [3] the thermal simulations and measurements of the Lucite cone applicator are described. Lucite applicator has got the lateral faces of the horn made from dielectric material (E–field distribution in the aperture of the waveguide is more uniform). The simulations of the thermal distribution are done in commercial FDTD simulator SEMCAD. The optimal input power for this type of microwave applicator was found also in SEMCAD. The measurement was done by aid of infrared camera.

In contribution [4] the discussion about three different types of microwave applicators are presented. All mentioned applicators were designed at working frequency 434 MHz with the same geometrical dimensions and optimized by aid of 3D electromagnetic field simulator SEMCAD. On results of SAR distribution and impedance matching in the agar phantom the advantages and disadvantages of each type of applicator are discussed.

There is possibility to design and optimize the microwave applicators on real 3D models of the treated area. The set of MRI images is transferred into the 3D model using MATLAB. This model can be import into the 3D electromagnetic field simulator and than it can be used in the simulations of the thermal distribution.

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Workstation for Medical Diagnostics Based on Dielectric Properties Measurement of Biological Tissue

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Dielectric properties of biological tissues are determining factors for the dissipation of electromagnetic energy in the human body and therefore they are important parameters in hyperthermia treatment, microwave detection of tumors and in assessment of exposure doses in basic research of interactions between electromagnetic field and biological tissues [1-4]. The measurement of dielectric parameters of biological tissue is a promising method in the medical imaging and diagnostics. Knowledge of the complex permittivity in a treated area, i.e. knowledge of complex permittivity of healthy and tumor tissue is very important for example in the diagnosis of tumor cell-nest in medical diagnostics or for engineers for the design of thermotherapeutic applicators. Also a very interesting are 3D reconstruction methods of different biological tissues based on the layered uniform tissue model (skin, fat and muscle).

There are several methods for the measurement of dielectric properties. If we want to use broadband measurement method which is nondestructive, noninvasive and which can offer possibilities for in vivo as well as in vitro measurements, we should choose reflection method on an open ended coaxial line. The reflection method on the open end of the coaxial line is a well known method for determination of these dielectric parameters [2]. This method is based on the fact that the reflection coefficient of an open ended coaxial line depends on dielectric parameters of material which is attached to it. To calculate dielectric parameters from the measured reflection coefficient it is necessary to use an equivalent circuit of an open ended coaxial line. To determine the values of elements in this equivalent circuit we use calibration using materials with known dielectric properties. A typical measurement system using a coaxial probe method consists of the network or impedance analyzer, the coaxial probe and software.

The results of the dielectric measurement study are presented in this contribution. The main aim of the project is to design convenient measurement probes. This design also involves descriptions of probes by equivalent circuits. The interface between the measurement probe and sample of biological tissue presents an impedance jump [3]. Biological tissue has extremely high values of permittivity. At low frequencies its permittivity is more than 100 and the value of the loss factor is more than 0.1. The exact evaluation is very difficult because the reflection coefficient is close to 1. It means that only a very small part of incident energy penetrates into the sample and for this reason the obtainable information is very poor.

Three types of measurement probes were under investigation: coaxial, microstrip and waveguide. The coaxial probe is created by an open end of transmission line. For the reflection method we have developed a new type of coaxial measurement probe. This probe was created by adapting the standard N-connector and SMA connector from which the parts for connecting to a panel were removed. The microstrip probe is created by a section of microstrip line (patch type). As a possible waveguide probe is under analyses the section of waveguide with rectangular cross section (type H and type with dielectric cotter). The material can be measured by touching these probes to the flat face of a material and by determining the reflection coefficient.

So the objective of the research reported here is to analyze different types of sensors for in vivo and nondestructive measurements of complex permittivity in frequency range from 478

30 kHz to 3 GHz, and to develop a precision measurement system. This feasibility study of measurement method involves numerical modeling and simulations. The system that we modeled is simple and consisted of two parts, i.e. the sensor and the biological tissue. The biological tissue sample was modeled based on available published data of complex permittivity. Numerical simulation based on Finite Integration Technique (FIT) is used to calculate reflection coefficient on interface between measurement probe and sample of biological tissue [1]. FIT is a discretization method which transforms Maxwell's equations in their integral form onto a dual cell grid complex, resulting in a set of discrete matrix equations. Structure is excited in time domain with Gaussian pulse. By performing Fourier Transformation (FFT) and division it is possible to obtain response of the structure in frequency domain. Properties and duration of this time signal is considered to obtain accurate and correct results. Wave port is used to feed the calculation with power and to absorb the returning power. For waveguide port time signals and S–parameters (S₁₁) are recorded during a solver run.

Reported measurement method is convenient method for the determination of dielectric parameters of biological tissues. It was found that coaxial probe is useful in frequency range from 40 MHz. The description by two element equivalent circuit (fringing capacitance and radiating conductance) is necessary because of the probe radiation at higher frequencies. The microstrip probe excited by N connector was found as unsuitable. The waveguide probe is suitable in the construction as a section of waveguide with the rectangular cross section with added dielectric cotter. Generally the waveguide is a narrow band microwave component but dielectric cotter with defined conductivity makes it more broadband in frequency. And also achieved reflection coefficient is sufficient. The waveguide probe is useful from frequency 1 GHz.

The measurement of complex permittivity by aid of coaxial and waveguide type probes is perspective method for medical diagnostics and preparation of treatment by using the electromagnetic field. We will continue in our study with applications in medicine.

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Localization of Surgical Instruments in Biological Tissue from 3D Ultrasound Images

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Many surgical procedures consist of introducing a miniature surgical instrument such a needle, or an electrode into biological tissue. For instance in biopsy, tissue samples are taken from a particular region of body by means of a thin needle. Conversely in breast cancer therapy, radioactive substance is injected near the tumor. In the field of neurobiological research, there are experiments where the electrical activity of a single neuron is recorded by a thin electrode needle. The effectiveness of such procedures is enhanced, if the position of instrument in tissue is estimated in the course of intervention.

At the outset, stereotactic frames were used for instrument localization. Horsley and Clarke, in 1908, described the first stereotaxy procedure on small animals. They used a frame fixed with respect to external anatomical landmarks to place an electrode at a specific point in the animal's brain. However, the position of intracranial point can not be derived from external landmarks with sufficient accuracy. In the last few decades, several medical imaging modalities were developed allowing to view anatomical information of human body as well as a surgical instrument in the course of intervention. Ultrasound imaging modality commonly used in medical diagnostics is particularly suitable for the localization task: short acquisition time permits real-time imaging; no ionizing radiation is involved; the resolution of modern systems is approximately one millimeter; purchase and operational cost is low compared to other medical imaging modalities.

We are working on a novel tracking system whose core consists of a 3D ultrasound scanner equipped with radio-frequency (RF) output. This system is tested on the problem of localizing a thin metallic electrode inside human tissue. The region of tissue where the electrode is located is scanned by the ultrasound machine and a 3D image is obtained. The goal of our project is to develop an algorithm that permits to automatically determine the electrode position with respect to the image coordinate system. Processing of ultrasound images is difficult for several reasons: due to speckle noise some portion of background voxels are brighter than electrode voxels; in case of total reflection of ultrasound beam there is a signal loss that results in irregular and incomplete electrode; as the spatial resolution differs in axial, lateral and azimuthal direction, electrode shape vary with position and orientation.

The localization problem was decomposed in two subtasks: (i) localization of electrode axis, (ii) electrode tip localization. We proposed two methods that permit to automatically determine the electrode axis. The first method is based on the observation that the parallel projection of the image is maximized when the image is projected along the direction parallel to the electrode axis [1]. This operation was formalized as a Parallel Integral Projection (PIP) 480
transform. We show that the axis of the electrode can be estimated from the maximum of the PIP transformation. To accelerate the search for maximum, a hierarchical mesh-grid algorithm was implemented. In order to make the axis localization more general and faster, second algorithm based on model fitting was developed [2]. The input image is pre-segmented with a constant threshold whose value is derived from estimated Gamma distribution of voxel intensities. The electrode is described by a model that is composed of a polynomial parametric curve approximating axis and a distribution of voxel intensities given voxel-to-axis distance. The parameters of this model are estimated using the robust estimator RANSAC. To further improve the axis localization accuracy, optimization using the Nelder-Mead simplex method was implemented. Once the electrode axis is known, we proceed to tip localization. Voxel intensities are traced along estimated axis and the tip is the point where the intensity falls under predefined threshold. The threshold is set based on a priori estimated distributions of electrode, resp. background voxel given voxel intensity.

A series of tests on numerical phantoms simulated in the FIELD II program were performed to give quantitative value of localization accuracy. We investigated the influence of tissue speckle noise on the localization accuracy. Further, localization accuracy was evaluated when electrode position and orientation was varied. These tests show that the average axis localization accuracy is 0.15 mm, resp. 0.35 mm for the first, resp. second method. The average accuracy of tip localization is 0.95 mm. In order to test the algorithms on real ultrasound data, the 3D ultrasound scanner KRETZ was used to scan a cryogel phantom containing tungsten electrode of 0.15 mm in diameter. The results indicate that the algorithms are robust in terms of noise and irregularities of electrode and that the localization accuracy on is real data comparable to the accuracy achieved on simulated data.

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Knowledge Mining for Modeling of Cognitive Processes

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I've developed a model of spatial memory inspired by rodent hippocampus [1]. Hippocampus is a part of brain involved in spatial orientation. The model provides a robust and efficient method of storing several navigational maps in a single attractor neural (Hopfield-like) network. It models such phenomena as place cells, long-term potentiation, long-term depression, path integration, inhibitory interneurons etc. Structure of the model conforms to functional schema of hippocampal formation. In order to validate the model I propose a spatial task within a maze of several chambers. The robot has to follow a complex trajectory passing gateways and avoiding barriers.

As a result of preceding research [2], [3] I published a model of navigation within a single chamber inspired by Morris water maze [4]. I showed how LTP-like algorithm combined with reinforcement learning solved a hidden-target task in a single chamber. Herein I remain in line with my previous work and I propose a model of navigation within a maze of several chambers.

The world the model has to move through is formalized as a maze of several chambers. There are narrow gateways between certain chambers. Each chamber contains several cues distinguishable by symbols. In order to recognize current chamber and its location in it, the model detects position of all cues in the chamber. Whereas the set of cue symbols is the same in each chamber, model can distinguish individual chambers by standing (distances, order etc.) or appearance of the cues. Every symbol can appear at most once in each chamber.

The model describes each chamber by a separate chart. All charts are stored in a single attractor neural network. After entering a familiar chamber the model recalls the corresponding chart and detects position in it. This is based on the sensory inputs and path integration.

The model consists of several building blocks. Each subsystem consists of a single- or multi-layer artificial neural network. Sensory inputs gather and process visual information from the environment. Place recognition subsystem recognizes actual position and selects map describing the current chamber. Position is coded by both head direction system and place cells. The path integrator updates supposed location during move. As within many animals' brains, it is based on dead-reckoning method. It makes the model very robust (e.g. in case of ambiguity or lesion of sensory information) and efficient. Navigational maps of chambers are being developed during learning phase. Reading in the current map is role of the locomotion control subsystems. It sends signals to the motor and to the path integrator and head direction subsystems.

Sensory inputs detect position of environmental cues relative to the position. I pose several point cues inside the maze. Neither chamber boundaries nor any other objects in the environment are detected. I simulated sensory inputs by a pre-wired one-layer RBF neural network. For each cue symbol, a separate group of sensory neurons exists. All cues in the current chamber are detected by the model simultaneously, regardless of their position or direction of the heading. Cues in other chambers are invisible for the model.

Hippocampal place cells are simulated as a pre-wired attractor neural network consisting of several charts. In each chart, each place cell has its own place field. The closer place fields of two place cells in a particular chart the stronger linkage between the two cells. Synaptic weights between two place cells are given as a summary of all partial weights values in each chart. Distant cells have no linkage between each other. Place fields of a single place cell in different charts don't correlate.

Whereas place cells store supposed position, the path integrator moves the supposed position with respect to locomotion signals. The model updates its supposed position in a chamber without processing any sensory information for a limited time period, because it would be a time-consuming operation. After elapsing a period of time or entering another chamber the model corrects differences between real and supposed positions. That time the sensory information is being processed. In fact, I model path-integrator as a modulation of synapses between place cells.

Navigational map subsystem is the only plastic part modified by the learning process, whereas the others are pre-wired. An algorithm similar to the long-term potentiation (LTP) and long-term depression (LTD) phenomena in brain is employed. The map is built upon the place cells during the learning phase. The map evolves as neural synapses change with respect to the passed trajectory.

Locomotion control subsystem decodes the navigational map. Direction of the next step is computed by comparing navigational map cells activity with place cells activity. If the map is learned enough, both activities significantly differ and right movement direction can be determined; model is exploiting its map. If both subsystems coincide, the map is not suitable for the navigation and direction remains unchanged so that exploration is performed.

Several simplifications have been committed, e.g. usage of a simple algebraic model of neuron instead of the spiking model. Also, the regulation mechanism of neural activity in place cells subsystem is biologically implausible. Inhibitory interneurons should be modeled rather by a set of inhibitory cells to be likewise to real brain circuits. However, the algorithm should also provide a potential foundation for a future robotic use and hence it should be efficient enough to run on a common computer.

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Classification of the Hemodynamics Parameters from the Oscillometrical Waveforms

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Blood is carried from the heart to all parts of your body in vessels called arteries. Blood pressure is the force of the blood pushing against the walls of the arteries. Each time the heart beats (about 60 to 70 times a minute at rest), it pumps out blood into the arteries with different value of systolic pressure SP (highest blood pressure when the heart beats) and different value of diastolic pressure DP (lowest blood pressure when the heart relaxes) [3]. Values of SP and DP change during the whole day with dependence on person's physical and psychical activity.

Accuracy of measurement with the modern automatic blood pressure (BP) monitors using oscillometric method is highly depended on condition of cardiovascular system of the monitored person [1]. Especially, with people who suffer from cardiovascular diseases (e.g. arteriosclerosis) the resulting accuracy is much lower when compared to auscultation method. A reasonable solution for improvement of quality of oscillometric method could be an intelligent universal measuring system for evaluation of BP taking into account condition of patient cardiovascular system (CS) of monitored person i.e. the hemodynamics parameters of CS (e.g. heart rate, stroke volume, total peripheral resistance, systemic arterial compliance). Such a system has to be based on an appropriate model of the considered diseases. To create the models, it is very important to establish a database of oscillometric pulsations waveforms (OPW) complemented by the values of "auscultation" blood pressure and information about patients (age, sex, etc.) as well as their diagnosis. This requires a special HW device for measurement of the OPW - we have developed such a device and it has been validated in Czech Certified Metrological Centre, its accuracy is ± 0.5 mmHg in the measuring range 0 to 300 mmHg. Our OPW monitor is connected through the T-pieces and tubes to the cuff, mercury sphygmomanometer and automatic "oscillometric" blood pressure monitor. We plan to classify the patients according to their OPW into several groups based on artificial intelligence methods.

We have introduced the concept of oscillometric pulsations waveform (OPW) database that allows testing of oscillometric algorithms for healthy people and mainly for people whose cardiovascular system is not in standard state (arteriosclerosis, pregnancy etc.). The concept is based on oscillometric data retrieving during cuff deflation and on reference BP measurements by auscultation as in [2]. Together with the data, oscillometric pulsations and cuff pressure are saved into the database.

For records of OPW we have developed a special HW device that consists of an arm cuff, a pressure sensor, two regulation valves, batteries and electronic circuits. The device can be controlled from PC by a special SW. The connection with the PC is via USB port. The microcontroller controls the pneumatic and the electronic circuits. Cuff pressure is converted into analog voltage by pressure sensor (piezoresistive bridge).

The analog voltage is amplified by an amplifier TLV2422 and the amplified cuff pressure signal is then separated into 2 channels by a hi-pass filter. Channel 1 is cuff pressure signal (0-300 mm Hg) and channel 2 represents amplified and filtered cuff pulsations (OPW). The 2 signals are digitized by a 12-bit A/D converter in microcontroller ADuC814 with 484

sampling frequency of 200 Hz. The deflation of the cuff is controlled by the regulations valves. The microcontroller communicates with the notebook computer via FTDI chip.

Our OPW monitor is connected through the T-pieces and tubes to the cuff, mercury sphygmomanometer and automatic "oscillometric" blood pressure monitor. Auscultation values are measured by educated staff. Cuff inflation is controlled by microcontroller of the monitor (Figure 6). Then we can directly compare oscillometric and reference (auscultation) method. Moreover, we exactly know the OPW.

Nowadays, we have already collected 950 OPW records of 250 people. There are mainly people older than 60 years in the group and we have tried several algorithms (designed in MATLAB ver. 7.00) for evaluation of systolic and diastolic BP [3] and others hemodynamics parameters of the cardiovascular system (mean arterial pressure, heart rate etc.). We have compared values of BP measured by mercury sphygmomanometer and the commercial oscillometric monitor and we have got less than 80% of the measurements results in range of \pm 5 mmHg for systolic and diaslolic pressure. In more than 20% for both pressures the differences between oscillometric and reference method were greater than \pm 5 mmHg. Difference more than -5 mmHg as well as + 5 mmHg was distributed approximately similar. This is a strong motivation for the creation of our database. In such database we can apply methods of artificial intelligence, especially data mining, and then find out how much the oscillometric pulsation waveforms depend on the condition of cardiovascular systems.

This project was part of the dissertation thesis which goal is to improve non-invasive blood pressure measurement. The creation of large OPW's database was essential part of the work and it was necessary for further development of new algorithms. Based on this database we can experiment, develop and test new algorithms for non-invasive blood pressure measurement, especially oscillometric method. New way for other hemodynamics parameters is also part of our interest.

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Recognition and automated classification of significant areas in EEG signal

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In this paper we present results of the development for EEG record analysis. The main objective of our work has been the design and implementation of appropriate algorithms for EEG signal classification. We have focused on neonatal EEG. The developed solution consists of several basic parts: problem-oriented feature extraction, feature compression, comparing of various types of classifiers and visualization. In this study we have used data from newborns with a similar gestational age (normal term gestation). Data have been provided by the Institute for Care of Mother and Child in Prague (12 infants, recorded 5-10 days after childbirth, record time is about 3 hours for each infant).

The main requirement for successful classification is optimal feature extraction. The feature extraction is the automated recognition of various features on signals. We do not use only EEG signal, but also other polysomnographic signals. Power spectral density (PSD) and Wavelet analysis are the most suitable features for EEG signal. We use mainly delta and alpha range for newborn EEG signal. One of the criteria for determination of the newborn behavioral states is the regularity of respiration. To determine the properties of signals in terms of shape and periodicity the autocorrelation function we used. Eye movements are known to be good measures for stages identification. For our problem, it should only appear in stages wake and active sleep. In the quiet stage there should not be any eye movements. We detect eve movements using the modified method developed by Varri et. al. One simple feature is sufficient for detection of movement artifacts. It is the standard deviation of signal obtained from muscle activities (chin EMG). Large majority of movement artifacts are present at EMG channel (characterized by the very high amplitude). For further processing it has no sense to classify segments that include movement artifact. The amplitude and the regularity of heart rate is changed during wake and quiet/active sleep. Regularity is good indicator of quiet sleep. In this stage heart rate is low and mainly regular. From the highest amplitude it is possible to estimate wake stage. For detection of the heart rate from ECG signal, it is necessary to be able to detect QRS complexes. Various methods can be used for that. One popular algorithm was presented by Pan and Tompkins. In this work, we use a modified version of this algorithm. We apply principal component analysis (PCA) for all described features (from EEG, PNG, ECG, EOG and EMG). 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, nearest neighbour, cluster analysis 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. This algorithm is also known as the Baum-Welch algorithm. We have designed a HMM structure and we have used the probabilities for description of all relations. In our case, HMMs allow to describe relations between features and hidden states (all sleep stages) and mutual relations between individual hidden states. We use four hidden states - active sleep, quiet sleep, wake stage and movement stage. We compare results from HMMs with three other classifiers. (a) First we have used 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. (b) Next we have tested cluster analysis. In the output feature space we have tried to find significant four clusters. The found centres of these clusters are classified using the nearest neighbour classifier to individual neonatal states. This analysis is not extremely accurate, but it separates some states (active sleep and movement stage). (c) 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 has influenced number of used rules (optimal number has been 10-15 different rules, great number of rules means high accuracy but low ability of generalization). We use Weka software for finding the rules.

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 final mean accuracy of classification is about 80% for HMMs and about 70% for other classifiers. The approach has been tested on real sleep EEG recording for which the classification has been known. The aim of these methods is to ease the work of medical doctors. 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.

We have also developed a hardware solution for EEG data processing. The device allows EEG, ECG, EMG and EOG signal measuring and transfering it to PC using an USB interface. We have also developed software methods for preprocessing, classification and visualization of these signals. Finally, we have partially developed system for wireless EEG data acquisition using PDA based devices with Bluetooth interface.

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Processing and visualization of long-term ECG

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Holter ECG monitoring is used for surveillance of patients with heart problems such as arrhythmias. Heart beats with unusual timing or unusual ECG morphology can be very helpful in early diagnosis of hearts with pathoelectrophysiology.

Many different methods have been proposed to solve the problem of discrimination between normal (N) and premature ventricular beats (V). Some are based on using beat shape description parameters as well as beat representation by frequency-based features.

As, it is well known for any pattern recognition problem, the most crucial problem is the creation of the training set. Usually two approaches are used - local and global training sets.

While local training set requires partial annotation of the signal before classification can be carried out – it brings usually better results both in sensitivity and specificity of the classifier. Global training set doesn't require additional annotation but also suffer of worse results in general.

Experimental data used for testing were taken from MIT-BIH Arrhythmia Database. This database consists of 48 2-lead digitized records with annotations of the beat types. Each recording has a duration of 30 min and includes two leads – the modified limb lead II (in all cases but recordings 102 and 104), and one of the modified leads V1, V2, V4 or V5. The sampling frequency is 360 Hz. Two cardiologists have annotated all beats in the database. About 70% of the beats in the database are annotated as normal. Since we focused only on the discrimination between V and N beats, for classification only 36 recordings were selected - recordings with prevailing paced beats, or beats with permanent blocks were excluded from the set.

Power line interference, high-frequency electromyographic noise and low-frequency drift was filtered during the preprocessing phase. For this task, well known methods were applied.

Feature extraction stage plays crucial role in any classification task. For this research work, we decided to describe each beat by set of 13 parameters.

Extracted parameters that describe the basic shape of the beat are ampR — amplitude of Rpeak; ampS — amplitude of S-peak; ampQ — amplitude of Q-peak; ampTp — amplitude of positive peak of T-wave; ampTn — amplitude of negative peak of T-wave; ratRT — ratio of amplitudes R-wave; T-wave; ratRS — ratio of amplitudes R-wave;S-wave; ratQR — ratio of amplitudes Q-wave;R-wave;

The features extracted contain also well-known parameters for distinction of normal beats from the pathologic ones such us: intQRS — width of interval; intQTc — width of QT interval corrected to the heart rate.

Features for describing the visual look of the P, QRS, and T complexes are morph P – morphology of the P-wave; morphQRS – morphology of the QRS-wave; morph T – morphology of the T-wave

Rule-based Decision Tree was used for clustering. In principle the strength of this method is to decrease the amount of beats taken into consideration in the classification process. The whole 24-hour holter monitoring can have more than 100.000 beats. This amount makes unrealizable any further computation involving beat to beat comparison.

Therefore rule-based decision tree was made based on general information about the characteristics of the normal and pathological beats. Using this method, we were able to cluster beats of the 30-min recording to up to 30 classes (with median of 10 classes). Then the cluster is represented by the median of the cluster and this median might be used for further classification/diagnosis.

Template matching method was used as a second - classification - step after the implementation of the rule-based decision tree clustering. Templates for comparison were computed as a median out of randomly selected ten N and V beats from each signal.

The templates were then compared to the medians of the final clusters using correlation coefficient. The final cluster was labeled either as N or V according to the larger similarity to the appropriate template.

Template matching method using rule-based clustering had yielded results of specificity 96.63% and sensitivity 92.64%.

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Particle Swarm Optimization for Processing and Analysis of Biological Signals

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The Particle Swarm Optimization (PSO) method is one of optimization methods developed for searching global optima of a nonlinear function. It is inspired by the social behavior of birds and fish. The method uses group of problem solutions. Each solution consists of set of parameters and represents a point in multidimensional space. The solution is called particle and the group of particles (population) is called swarm. Each particle *i* is represented as a *D*-dimensional position vector \vec{x}_i and has a corresponding instantaneous velocity vector \vec{v}_i . Furthermore, it remembers its individual best value of fitness function and position \vec{p}_i which has resulted in that value. During each iteration *t*, the velocity update rule (1) is applied to each particle in the swarm. The \vec{p}_g is the best position of the entire swarm and represents the social knowledge.

$$\vec{v}_{i}(t) = \alpha \vec{v}_{i}(t-1) + \varphi_{1} R_{1}(\vec{p}_{i} - \vec{x}_{i}(t-1)) + \\ + \varphi_{2} R_{2}(\vec{p}_{a} - \vec{x}_{i}(t-1)),$$
(1)

The parameter α is called inertia weight and during all iterations decreases linearly from α_{start} to α_{end} . The symbols R_I , R_2 represent the diagonal matrices with random diagonal elements drawn from a uniform distribution between 0 and 1. The parameters φ_I and φ_2 are scalar constant that weight influence of particles' own experience and the social knowledge. Next, the position update rule (2) is applied:

$$\vec{x}_i(t) = \vec{x}_i(t-1) + \vec{v}_i(t)$$
. (2)

If any component of $\vec{v}_i(t)$ is less than $-V_{max}$ or greater than $+V_{max}$, the corresponding value is replaced by $-V_{max}$ or $+V_{max}$, respectively. The V_{max} is maximum velocity parameter. The update formulas (1) and (2) are applied during each iteration and the \vec{p}_i and \vec{p}_g values are updated simultaneously. The algorithm stops if maximum number of iterations is achieved or any other stopping criterion is satisfied.

The new application of PSO algorithm for training Hidden Markov Models (HMMs) was proposed. The problem of finding an optimal set of model parameters is numerical optimization problem constrained by stochastic character of HMM parameters. Constraint handling is carried out using three different ways and the results are compared to Baum-Welch algorithm (BW), commonly used for HMM training. The global searching PSO method is much less sensitive to local extremes and finds better solutions than the local BW algorithm, which often converges to local optima. An important aspect of the Baum-Welch algorithm is that the stochastic constraints of the HMM parameters are automatically satisfied

at each iteration. Generally, this is not true for all training algorithms. The problem of training must be therefore understood as constraint optimization task and could be described as following:

Find $\lambda = \{A, p, B\}$, which maximizes $P(O \mid \lambda)$, subject to

$$a_{ik} \ge 0, \sum_{j=1}^{N} a_{ij} = 1, p_j \ge 0, \sum_{j=1}^{N} p_j = 1, U_i > 0,$$

where i = 1...N, k = 1...N and N is number of hidden states. The a_{ij} represents the probability of transition from state *i* to state *j*, *p* is vector of initial state probabilities and B is set of N Gaussian distributions $G_i(m_i, U_i)$, where m_i and U_i are mean and variance of output signal for *i* th state respectively. The constrained optimization problem was solved by three constraint handling methods – two methods based on repairing of unfeasible individuals and one method based on penalty function. The fitness function was defined as $-\ln(P(O|\lambda))$ and thus was minimized (likelihood was maximized). The results obtained from testing on artificial models and real ECG signals shown significantly better performance of PSO approach, especially the better ability to overcome local optima.

Furthermore, fully unsupervised approach to signal segmentation using partitional clustering method with squared error criterion was proposed. The optimal partition is searched through the use of particle swarm optimization (PSO), which makes it possible to overcome local minima and find the near-optima solution with relatively good computational efficiency. First, the PSO clustering was tested using an artificial benchmark data set and then, practical results of the method on electrooculographic (EOG) signal segmentation are described. Formal partitional clustering procedures use a criterion function, such as the sum of the squared distances from the cluster centers, and seek the grouping that extremizes the criterion function. Such optimization task could be solved using evolutionary optimization algorithms. The swarm represents a number of candidate data clusterings (partitions). The quality of each particle is measured using the sum of square errors as fitness function. A solution, which corresponds to the minima of the function is searched.

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Research and Development of the Interactive System with New Biofeedback Algorithms to Be Directly Used in Multidisciplinary Clinical Research

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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 acquisition and its 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: $NN = N_{int} - N_i$ 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 models, we try to find solutions with Matlab-Simulink environment using modern multifunction data acquisition devices of the world's leading producers. The models were created in Simulink environment, using both default toolboxes and also by blocks designed by ourselves. Our blocks were created as S-function and were written in MATLAB and C language. These designed models serve to ECG signal acquisition and calculation of many different parameters: heat rate

(BPM), power spectrum, heart rate variability (HRV), stress index (SI) $SI = \frac{AINO}{2 \cdot Mo \cdot MxDMn}$

and for biofeedback systems creation.

Biofeedback is a training technique in which people are taught to improve their health and performance by using signals from their own bodies. 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.

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Research and Implementation of New Algorithms For Real-time EEG Mapping

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We present a fast method of interpolation is being presented. This method provides interpolation in two dimensional signal maps where data point can be scattered nonuniformely. Output of this method is a set of triangles described by three vertexes on a surface and a value corresponding to an interpolated signal value, which is suitable for hardware accelerate drawing.

Although this method is applicable to any interpolation- visualization problem in 2D, where the source points are scattered nonuniformly, it was primarily developed and designed for electroencephalographic (EEG) map interpolation. Modern dense-array EEG recording systems make use of even more than 513 electrodes, with 512 amplifier channels recording 512 voltages relative to a single common reference electrode. Electrodes are scattered nonuniformely on a head's surface and sometimes it is necessary to know exact position of each electrode related to underlying anatomical brain structures, so the position of electrodes should not be moved to fit orthogonal grid. Anatomical structure can be taken from tomographic examinations, usually MRI and segmented to obtain 3D model of the brain. There was a need of algorithm which would draw signal maps in real-time covering almost whole screen on common personal computer. Due to nowadays most common resolution achieving almost 1 million pixels, it is not possible to draw maps one by one point. Most personal computers today include 3D graphic accelerator, which can draw triangles at very high speed.

In case of mapping biological signals like EEG or electrocardiographic (ECG) it is first necessary to transform 3D positions of electrodes to 2D. In case of ECG, where electrodes are placed on the surface of chest, transformation is quite straight. Chest can be easily approximated by a cylinder and its surface can be easily unrolled into 2D plate. In case of EEG where electrodes are placed on the surface of sphere this is not so simple. Transformation from spherical to planar coordinates is impossible to perform without significant distortion. Fortunately EEG electrodes usually cover just upper and rear part of head so the distortion is not so significant. Transformation is done from spherical to polar coordinates, where angle is preserved and radius corresponds to geodesic distance of point from the pole Next step of this method is to divide heads surface to a mesh of triangles. There are several methods how to do this, but natural requirement is to have all triangles "symmetric". Suitable method is Delaunay triangulation, which for a set P of points in the plane does the triangulation DT(P) of P such that no point in P is inside the circumcircle of any triangle in DT(P). Delaunay triangulations maximize the minimum angle of all the angles of the triangles in the triangulation.

There are number of methods how to implement Delaunay triangulation. For a small number of electrodes (10-20 system has n=19 active electrodes) it is possible to check all combinations of 3 electrodes and test if their circumcircle does not have any other electrode inside – complexity is O (n over 4). For a larger number of electrodes, it is necessary to use some more efficient method. Elegant Guibas-Stolfi can be used, since it has algorithm which has O(n.log n) complexity. Guibas-Stolfi algorithm uses KD-tree to recurrently divide the points into regions, till every region contains 2 or 3 points. These points are then connected into elemental triangles or edges and these elements are being recursively merged. This triangulation is done only once before real-time processing, so it is not time-critical. Triangle set has to be recalculated only when position of any electrode changes, any electrode is added or removed. At this point mesh of triangles is covering surface of a head. Next step is to refine the mesh to be smooth for later displaying. This is done by recurrent dividing each triangle into four smaller. Triangles could be also divided into other number of smaller, but simplest is to divide each edge in its half and then construct triangles from old vertexes and these new vertexes in halves of the edges. During this process a tree structure is being built, as for the later interpolation it is necessary to know the parent triangles for all smaller triangles. The resulting mesh of triangles with known hierarchy is now ready for signal interpolation. The simplest method is linear interpolation, when the value at each vertex is defined as the mean value of both parent vertexes. This method however results in an angular image, with noticeable edges between electrodes, due to only C0 continuity. Much better results are achieved by using Bezier triangles. It is possible to imagine signal value at each vertex as z-coordinate in 3D space. Than we can use some approaches used in computer graphics. As the neighboring triangles are known, we can easily determinate normal vectors at each vertex and later control points to construct Bezier triangles.

Method was implemented in real-time mapping software. It can run on most current computers, displaying EEG maps in full-screen and real-time at 25 frames per second (FPS), leaving most processor time for signal processing. Method was compared only to simplest interpolation algorithm known as Shepard's method. This algorithm calculates value at every pixel as the weighted average as values from all electrodes, with the weights being inversely proportional to distance. Since a displaying area was 512x512 pixels only 11 FPS was achieved on 1.8GHz CPU. Method with triangulation provided 25 FPS at 70% CPU load, but triangles were rendered by CPU. Hardware rendering lowered CPU load to only 16%. The mesh was 8 times refined, total triangle count was 3854 and linear interpolation was used. Delaunay triangulation combined with hardware graphic enables EEG maps with nonuniformely scattered electrodes to be displayed on most current computers in real-time. Lack of hardware acceleration noticeably increases CPU load, but displaying is still fluent. Further development will point to drawing textures of underlying anatomical structure in triangles and the color light derived from interpolated signal value will reflect the signal value.

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Feedback Model of Cardiovascular System Control in Horses

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The aim of the project was to mathematically describe some unusual features in a cardiovascular system in horses. We measured ECG during dynamical experiment in horses: the records were 10 minutes long and approximately at the beginning of the 6th minute the horse was externally stimulated with electrical signal.

We analyzed measured signals and obtained sequences of RR and QT intervals. Some of them were significantly different from those obtained in human beings during similar experiment. RR intervals were significantly shortening as a response of the stimulus, but QT sequences were unexpectedly prolonged in some records.

Prolonging of QT intervals was published numerously in *static* experiment and it is considered as a significant factor in prediction of sudden death. We have recorded ECG data in horses that show clear prolonging of QT intervals during increasing heart rate in *dynamical* experiment. No drugs were used. Generally speaking it is suggested as great risk of sudden heart failure.

Paradoxically those records were measured in well trained horses. We suppose that such a phenomenon is caused by changes in nervous control of a heart. We have developed several model structures of QT intervals control. Simulation results indicated that generally accepted attitude to QT intervals control is misguiding or incomplete. We have proved theoretically that the abnormalities are caused by variant sensitivity of ventricular cells in myocardium to sympathetic and parasympathetic during plateau and repolarization phase. Another aspect for viewing on such QT responses is a fact that these unusual responses were observed only in mares, i.e. in female horses ready for insemination. There is different hormonal distribution in those animals' organism, the outflow of estrogens is greater. That is why we made a hypothesis of common nervous-hormonal control of myocardium. A group of simulation experiments suggested that hormonal system is a part that influences behavior of neural system. Strictly speaking neural system is parametrically controlled by hormonal system.

Another part of the project was developing a software tool for analyzing and storing biological signals – BioDat. The application is written in Java and ANSI C, so that it is assumed to work on all devices (including modern mobile phones and personal digital assistant – PDA), which implement Java interpreter and ANSI C compiler. Currently the product is in a stable release, which integrates large number of various features:

- Natural format for storing signals is world-widely used standard for biological signals physionet.org.
- Signals can be easily exported to different formats (European Data Format EDF, ASCII, Matlab[®]), there is a built-in module for implementing export to other formats.
- The application can be easily extended with user-defined plugins.
- The application can run standalone, i.e. locally on a single computer or a device.
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- Another possibility is to run in a client-server relationship. It means data are viewed and analyzed locally by a user and they are stored centrally on a server. There is a possibility for distributing computational operations on more powerful server side in case of using time-consuming data analysis. The communication protocol between client and server is HTTP. The client side can run either standalone as Java archive (jar) or as a part of a web page (Java applet), which requires no installation of the application.
- The data and analyzed result can be viewed through a web page without any needs for Java interpret.
- In case of client-server version, the system supports a safe multi-user mode and includes configurable authorization system.
- In case of client-server version, the application includes version control system, which
 provides an administrator or regular user (depends on authorization rules) making backups
 or roll the database back to any of previous states.

The application is still in hard development and is distributed as an open-source software under GNU GPL License. There is a webpage http://biodat.fbmi.cvut.cz, where the program source and compiled archives can be downloaded. Also a public forum for regular users and developers was established on the same webpage.

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Characterisation of biocompatible thin films by optical spectroscopy

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Introduction:

In today's world biocompatible materials such as hydroxyapatite, diamond like carbon (DLC) films, ZrO_2 ceramics and others are widely used in medicine. The main contribution of their usage is better adoption of implants in living tissue and smaller immunity reaction. They can be used as coating layers for various types of implants (for example dental implants, heart valves, vascular and bone replacements). Thin layers on the surface of implants can be created with various techniques such as Pulsed Laser Deposition (PLD), Matrix Assisted Pulsed Laser Evaporation, Magnetron sputtering etc. In our research we used DLC layers prepared by Pulsed Laser Deposition combined with Radio Frequency (RF) sputtering. These coatings are used for their excellent wear protective properties together with high hardness and low friction coefficient.

We present here the results of optical measurement of diamond like carbon (DLC) thin films deposited on fused silica substrate, prepared by PLD with RF sputtering. Samples are created at different deposing conditions.

Materials and methods:

The experimental setup consists from a KrF excimer laser and the vacuum chamber where a target and substrate were placed. The laser was focused on the target through quartz optics at angle of 45°. As the target was used graphite or glassy carbon with high purity. The target was rotated during deposition. The fused silica (FS) substrates were used. The substrates were placed directly on the resistively heated stainless steel holder. During the deposition the vacuum chamber was pumped out to the pressure of 10⁻⁴ mbar by turbomolecular vacuum pump.

We used fibre optics spectrometer Ocean Optics S2000. Our spectrometer setup can be used in the range of wavelengths from 200 to 1200 nm. As the light source we used halogen for visible spectrum and deuterium lamp for UV spectrum. This sources are coupled to fibres a through them the sample is illuminated. The light passing through the sample is than coupled back to the fibre and processed with spectrometer. The measurement proceeded on wavelengths in range from 250 to 900 nm depending on the layer. Measured data were consequently processed in specialized software, which is able to calculate appropriate (applicable) mathematical models. On the basis of these models it's possible to determine searched optical constants.

Experimental results:

We studied their thickness and optical properties in dependence on deposition parameters. The measured thicknesses of layers were typically in hundreds of nanometres. Due to this we talked about thin layers and optical interference was proposed on wavelengths which we use for measurements. The main optical properties we were interested in are refractive index and absorption coefficient and their dependence on wavelength. Our investigation method was based on measuring transmission and reflection spectra (spectrum) of a thin layer deposed on fused silica plate.. The maxims and minims of the reflection are due thickness of the layer. The layer is so thin that the normal light can interfere and the layer has the maxims and minims that correspond with constructive or destructive interference on the layer. These spectra are input data for the computing of the thickness, refractive index n and extinction coefficient k of layers. The computed thickness differs only for about +-10 nanometers from measurement on profilometer.

Conclusion:

The main goal why we did these measurements is to optimize the deposition process of PLD. Then we will be able to prepare better layers with parameters on demand. In the future we want to create smaller measuring spot in the spectrometer that enable us the measurements of the spatial profile of thickness on layers. Than we can study the coverage inhomogenities of the DLC layers.

Samples were created in cooperation with Institute of Physics, Academy of Sciences of the Czech Republic.

Tools for 3D Visualization of Structures in Biology

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Modern laser scanning confocal microscopes are capable to focus a laser beam into a layer of an investigated biological specimen, and by the gradual scanning of this layer they acquire an optical section. By consecutive scanning of all preset layers of the specimen we obtain a stack of optical sections, i.e. a 3D digital representation of the specimen [1].

Our research focuses, among others, on volume reconstruction of large biological tissues, i.e. tissues greater than field of view and/or thicker than maximal depth of scanning of a confocal microscope. 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. The reason for applying the elastic registration lies in the possibly extensive deformations of large specimens caused by their cutting and manipulation during preparation. E) Image enhancement of optical sections in the resulting volume using our own developed algorithms [3].

As a result of volume reconstruction we obtain a high resolution 3D image of the biological specimen. In order to visualize 3D objects on 2D computer screens we developed several tools. 3D visualization is offered by either our Rapid3D software package suited for three-dimensional reconstruction and visualization of biomedical images or Ellipse modular software package devoted to biological image processing (created by ViDiTo company, Slovakia). Both software packages are capable to work with specialized VolumePro 1000 board [4] performing volume rendering of digital volume scalar data using Phong Lighting model in real time. VolumePro board is a PCI board capable to perform 1000 million trilinearly interpolated Phong-shaded samples per second with ability, among others, to embed objects drawn by standard graphics packages (OpenGL, DirectX), cut, crop and trim objects, and perform filtering of samples based on various thresholds.

Moreover, Rapid3D is capable to perform 3D real-time visualization using common graphics cards supporting DirectX technology. Since consumer graphics cards do not support direct volume rendering, 3D visualization is performed using texture-based methods, in our case we apply three-dimensional textures. This visualization was implemented on the .NET platform in C# programming language and HLSL shader language using Microsoft XNA Game Studio Express.

Ellipse performs texture-based 3D visualization on common graphics cards using OpenGL graphics library, which was implemented in C++ programming language and was optimized for fast 3D visualization using "bricks", i.e. during every 3D movement of the 500

object, volume data are specially organized in small 3D portions (bricks) which are then rendered in back-to-front order.

Thus several possibilities for real-time 3D visualization of scalar data were briefly described and all approaches are routinely used in our department for research work.

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The Universal Data Storage primary for medical applications

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Currently databases are used mainly for common type of data, for example in business and information systems. In the most cases data are stored in database as simple text or common numbers (for example decimal numbers are used for price). Information about format and type of stored data is well known or in many cases they are stored in separated external file. This additional file must be supplied with database to developers and advanced users to be able to manipulate with stored data. Situation is quite different in medical domain. Each medical record has its own type and format of data according to medical equipment used for particular measurement (pulse, blood pressure, ECG, EEG, etc). In this case, type and format of data are very difficult to be described by hand using for example external file. Current databases are used only for storing own data, but not information about their native types and formats and how to used them.

Our system tries to eliminate mentioned disadvantages of common techniques. Our goal is to store into database not only own data but also all necessary information about their types and formats. Each record of data stored in database has link to information describing its type (string, integer, decimal point number) and format (single value, field of values). Our system also tries to create universal structure of medical information within database. This structure will be created like a tree. Root of the tree will be information about patient, next level will store information about type of measurement (blood pressure, ECG) and last level will store own measured data (values, fields). In our case, database will contain not only own measured data, but also additional information (type and format). With help of this additional information, many applications can retrieve data from this database and use them for next processing. In this case for example some application can go throw whole database, retrieve all data about blood pressure from records of all patient stored in database fallen into requested time interval and calculate some result. Created result can be of course stored back to previous database. Because application understands additional information about type and format of stored data it can also be able to store result back in database using this additional information.

In our approach, only one interface for particular programming language will have to be created. This interface will be responsible for retrieving data from database and storing data into database. For both of these actions the interface will use additional information stored in database side by side own data. Because our system must be able to store data into any type of database (with various supported types of data) it will be used only few type of data (string, integer and etc.). Other complex types of data (for example structure and filed) must be converted into supported ones.

Mentioned interface first retrieves all data (own data and additional information) from database and it separates additional information contained types and formats of own data. Finally it is able to convert own data into types and formats of particular programming language. Each programming language has different types of data and it is up to interface how to transform data from database into new types without lost any information included in database. Reverse process (store data from programming language into database) is not such easy. Universal database system has only few possible types of data (compare to programming language) and interface must correctly decide which type will use for data coming from programming language.

Next problem that our system wants to solve is kept path of which data were used for processing or calculation to create other data that was stored back in database. Using such created path, somebody can check in the future if stored result is correct. To solve this problem properly it is necessary to complete all data with for example digital signature to prevent their replacement in the future. In the case of replacement of measured data it is impossible to check any calculated results.

Our system tries to solve not only how to store medical data into database and process them in the future, but also other problems for example how to combine data about one patient that was measured by different specialists - doctors. Medical workers are willing to provide some data for scientific purposes but they are not willing to provide any personal information about their patients (for example personal identification number or first and last name). On the other hand, scientific researches want to have various types of data (pulse, blood pressure) from one patient to be able to detect hidden dependences of some diseases using large among of measured data. But without any information how to combine data from many sources (for example according to patient identification), this task is impossible. But one simple solution may exist to solve this problem. Medical workers need not provide original personal identification of patient, but they can use some type of hash function. This hash function can convert for example personal identification number into other identification number (with more digits) that is unique for input personal identification number. Medical worker can easy create mentioned unique identification number from personal identification number, but nobody can retrieve personal identification number from newly created identification number. This newly created identification number does not say anything about measured patient, but it is very important for scientific researches to be able to combine various data (pulse, blood pressure) from one patient provided by many doctors.

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Hand motion detection using MATLAB software environment

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The topic of my project was to analyze hand motion from video sequence provided. There were two camcorders. One placed above the patient and the other one was facing him. The goal was to capture the motion of the hand marked with blue markers. We used blue beads as the marker to ensure its good visibility on the recording. The camcorders are placed statically at a certain distance. The algorithm I used determines the position of the markers in the 2D video. The goal of my project is to tract the patient's movement. The markers are placed as follows: The first is placed at the object, the second at the index finger joint, the third in front of the wrist and the fourth to the forearm. This layout is suitable to track the wrist movement. When the wrist moves, a triangle made of the second, third and fourth mark changes. The patient is instructed to move the object to a specific place. The algorithm that evaluates the hand position has to be sensitive enough to recognize any tremor. It is also necessary to calculate hand velocity and how precisely was the object placed at the desired location. The patient is instructed the grab the object and move it as quickly as possible to its destination. This is to be performed several times. The video taken by both camcorders is exported to MatLab® where it is analyzed.

The algorithm realized in Matlab software environment has the following basic parts:

- 1. Preprocessing
- 2. Load frame from the video sequence
- 3. Motion detection based on the difference of two successive frames
- 4. Image size reduction based on the motion detection above
- 5. Image segmentation of RGB color components
- 6. Prediction of markers positions

The results are used by doctors to determine if there is any change in patient's condition after a drug was administered.

The hand motor function is easily disturbed in neurological disease and this may represent a serious handicap. Lesions in different structures of the central and peripheral nervous systems cause specific disturbances of hand function in the resting position (e.g. resting tremor and dystonia in Parkinson's disease), when movement is initiated (Parkinson's disease), in reaching a target (cerebellar disturbance) etc. It can be assumed that different lesions would influence also the various phases of a manual transport movement, such as: the forming of the grip, establishing the grip, lifting the object, the transport phases, and placing the object on the target point. A method based on a simple manual transport act could therefore be useful for an objective description and quantification of certain hand movement disturbances.

The camera recorded two-dimensional displacement of passive markers attached to the hand and to the object.

The marker positions were extracted by the camera resolution system and resulting x and y values were delivered for each frame. The raw data file containing coordinates of the markers in time was stored in the computer. The path of the object movement and the spatial orientation of the hand were subsequently reconstructed from the spatio-temporal coordinates of the markers (offline processing). Velocity and acceleration of the object were calculated from the movement data delivered by the camera (=first and second derivation of the trajectory).

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Content Enhancement in the Subject "Practice of Biomechanics"

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The main aim of this project was to upgrade tutorials of the compulsory subject "Practice of Biomechanics" for MSc. students "Biomedical and Rehabilitation Engineering". This new and progressive branch should follow the stale of the art and all latest findings should be always available for students as well. Two tutorials for the subject "Practice of Biomechanics" were prepared containing the theoretical and the practical part. Students should have learnt about the process during development of a new total joint replacement. The temporomandibular joint (TMJ) was chosen as an example. The TMJ is one of the most frequently loaded joint of the human body and in conjunction with individual uniqueness of this joint places high requirements on its design and reliability.

First, there should have been background research to find out existing findings which showed the missing information about the data which were important for the total TMJ replacement development. There was number of papers dealing with finite element models of the TMJ and temporomandibular (TM) disc with various types of analyses e.g. [2]. Sophisticated TMJ material models were developed and masticatory muscle forces during some jaw movements (loading and kinematics) were obtained. But there was a lack of information about the TM disc and the mandible movement during mouth opening and closure.

Second, there was a requirement to determine the relative displacement of the TM disc and the mandible. While the movement of the mandible has already been published [1], though only for a small mouth opening, the behaviour of the disc during the same movement has not been well depicted. The movement of the TM disc was studied using a magnetic resonance imaging (MRI) in the quasi-static scan sequence. A customised mono-directional "spreader" device to achieve proper mouth opening positions was designed. Six sagittal static images in revolved sections of the TMJ in various positions of jaw opening from 0 to 50 mm (distance between lower and upper incisors) were obtained. The head was fixed to avoid major displacements; smaller displacements such as swallowing and position discomfort of the head were corrected using the geometric transformation [4]. The motions of the TM disc and the mandible were observed. The results provided a description of the TM disc displacements as a function of jaw opening. The maximum displacements of TM disc reference points (markers) were 10.5 mm and 18.06 mm for the anterior (DA) and the posterior (DP) point respectively. The motion of the mandibular condyle was investigated in two directions and one angle. The maximum displacement in the x-direction was 31.38 mm, and in the *y*-direction it was 6.61 mm. The maximum rotation of the mandibular condyle was 34.4°.

Next, a three-dimensional finite element model of the TMJ has been developed according to the CT data. The geometry of the model was obtained from 50 years old male head showing no abnormalities. The model consists of a half skull, a half mandible and a TM joint disc.

In the theoretical part of the tutorial students were informed about the development process of a new total joint replacement consisting of the literature studies, processing of CT and MRI data (AMIRA, Mercury Computer Systems Inc.), geometrical model creating (Unigraphics NX2, EDS), development of the FEM model with different types of elements (ABAQUS v. 6.5, Hibbit, Karlsson and Sorensen, Inc.), assignment of the suitable material properties to appropriate tissues, definition of loadings for different types of jaw movements, technical standards, clinical tests and the ethic problems etc..

For the practical part of the tutorial the elementary exercises in mentioned graphics and FEM programs (AMIRA, Unigraphics, and ABAQUS) were prepared. Some examples of basic functions for each part of the model were demonstrated. Visual and applied demonstration could significantly broaden students' theoretical knowledge and provide appropriate base for their individual creative work. It could show the possibility how they can progress in such kind of research or just how to process their diploma thesis.

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New Equipment for Teaching and Laboratory Experiments in Biomedical Engineering

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In the year 2006 the sixteen EMG channels, eight foot switch channels and four instrumentation channels MA-300-16 was purchased. The Laboratory of Biomechanics at Faculty of Mechanical Engineering CTU in Prague, got the system for measurement of muscular signals and activity.

Easy to setup and use, this innovative digital EMG system has been designed for use in any Gait, Rehabilitation or Physical Therapy laboratory. The MA-300 continues to uphold high standards of system integrity and reliability to produce a fully calibrated EMG signal at all times while providing the user with the convenience of individual gain controls and a signal level indicator for each EMG channel.

Accurate and reliable, the MA-300-16 uses sophisticated digital, error-correcting, telemetry techniques to ensure that EMG data is always exact. A user-controlled anti-alias filter is built into the subject back-pack and, together with the correct choice of sampling rate, can be set to eliminate signal aliasing in any EMG recording situation.

The MA-300-16 is a sixteen channel EMG system that provides detection of fullbandwidth EMG activity from DC to 2,000 Hz across all EMG channels. It is supplied with sixteen EMG preamplifiers, each with a bandwidth or 20-2,000Hz (-3dB) for gait use, while EMG preamplifiers with a bandwidth of 10-2,000Hz (-3dB) are available for ISEK standard protocol research. The system supports eight contact switches as well as four additional research channels that can handle signals from DC through to 120 Hz, making them suitable for EKG, goniometers, and pressure sensors etc. Isolated DC power is available from the backpack making this system ideal for both clinical and student research projects.

The EMG system uses a single thin, super-flexible, 3/32" diameter coaxial cable to transfer information from the lightweight backpack (worn by the subject) to a slim desktop receiver while supplying isolated DC power to the backpack. This eliminates the need for batteries thus reducing operating costs while improving system reliability. The MA-300-16 is compatible with most major data collection, commercial gait and motion analysis systems.

The MA-300 is very easy to setup and connect to almost any Motion Capture system that supports analog data recording. An optional real-time ADC can be added to provide real time EMG displays while simultaneously recording data on any other system without interference. The following highlights are important when working in a Motion Capture environment:

- The MA-300 system are suitable for both gait analysis and research projects.
- All EMG channels are full bandwidth (backpack bandwidth is DC to 2,000Hz, -3dB).
- The systems include support for up to eight foot contact switches in addition to the EMG channels.
- The system include support for instrumentation needs with four extra research channels (DC to 120Hz, -3dB).

Note that the electrical isolation provided by the MA-300 ensures the complete isolation of the subject from both the AC line and any third party recording system. The safety of the EMG system is built into the product and is independent of any third-party system to which you connect. The MA-300 is compatible with any data collection systems supported by common research tools such as LabVIEW, and MATLAB.

The MA-300 system can be used with any modern Windows PC to record and view EMG signals. The convenience of a stand-alone system for viewing the raw EMG in real-time improves the overall quality of the subject data in almost any circumstances. Also was purchased the USB analog data collection system. Dataq - the DI-720 can display real-time EMG data on PC as the subjects muscles contract - offering substantial advantages over the traditional record and review afterwards approach. The compact DI-720 data units can be connected via USB, EPP printer port or TCP/IP network, offering simple plug-and-play connections to a PC or laptop. The DI-720 can record up to 32 channels of analog data with a total throughput that is high enough to allow monitoring of the raw EMG signals and offers many useful features such as data over-sampling, channel labeling, time and date stamping and programmable gain, making it a perfect solution for all of EMG monitoring needs.

The purchased EMG system was first tested (summer 2006) in the course of measurement the human muscular activity timing during the complex measurements of dynamic interaction of a vehicle and its occupants [1].

The EMG system is put to use for the muscular activity collection and after processing are the signals for the developing and driving of so-called "EMG-driven models" for muscular force calculation and for solving the problems of loading of the musculoskeletal system. Due the new laboratory equipment will become the teaching of musculoskeletal biomechanics and simulation can be brought closer to current trends. The department of mechanics, biomechanics and mechatronics has big experiences with processing the EMG signals and with development of EMG-driven models, see [2] [3] [4]. The new laboratory equipment MA-300 is very important for the practice of students.

From the spring semester 2007 start the usage of the MA-300 EMG system in the teaching and laboratory courses from Biomechanics at CTU in Prague.

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Simulation of the Function of Upper Limb Prosthesis in the Hands-on Training of the Study Branch "Biomedical and Rehabilitation Engineering"

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Global trend of scientific development is focused on branches, which apply to human. One of them is biomedical engineering, highly advanced branch. It combines the design and problem solving expertise of engineering with the medical expertise of physicians to help improve patient health care and the quality of life of healthy individuals. As a relatively new branch, much of the work in biomedical engineering consists of research and development, covering an array of fields: orthopedic surgery, rehabilitation engineering, image processing, physiological signal processing, biomechanics, biomaterials, cellular, tissue and genetic engineering, etc. Examples of concrete applications of biomedical engineering are the development and manufacture of biocompatible prostheses, medical devices, diagnostic devices and imaging equipment such as MRIs and EEGs. Every year there is increasing the students' interest in this branch. Therefore, the Faculty of Mechanical Engineering of Czech Technical University in Prague attaches importance to development of this branch. The main aim of this work is to introduce to students the problems from orthopedic surgery and rehabilitation engineering. This work focused on realization of the laboratory practice. The aim of this practice is to make a presentation of upper limb prosthesis.

Upper limb prosthesis is a device designed to replace, as much as possible, the function or natural appearance of a missing limb because the hand is a very important human instrument and means of communication. Prosthesis must be comfortable to wear, easy to put on and take off, light weight and durable, and cosmetically pleasing. Furthermore, prosthesis must function well mechanically and have reasonable maintenance. Modern types of prostheses are controlled by the electric signals (myoelectric signals) produced when the remnant muscles within the residual limb of the user contract. These myoelectric signals are successfully recorded using surface electrodes, and are amplified and processed with the use of genetic algorithms, fuzzy logic, the adaptive filtering technique or neural networks.

The laboratory practice consists of several parts (theoretical and practical). First, anthropometric data describing the kinematics of the upper limb are collected from the available literature and by measurements (length of individual phalanges, ranges of motion of joints, centres of rotation, weight of segments, tendon insertion distances). The minimum numbers of actuators of the upper limb are 14 muscles to control a particular degree of freedom (DOF) of articulation. Other muscles clearly ensure fluent and fine work. A finger goniometer is used to measure the joint angles.

The next step is to develop a kinematic model to simulate the prehensile capabilities of the human upper limb. The kinematic skeleton of the upper limb is characterized by ideal joints and simple segments. The nine interphalangeal joints (PIP, DIP and IP) are described as hinge joints capable of only flexion and extension. The five metacarpophalangeal joints (MCP) are saddle joints, and the wrist is an elliptic joint capable of both flexion-extension and abduction-adduction motions. The carpometacarpal joint of the thumb (CMC) is a saddle joint 510

with 3 DOF for movement, because there is considerable rotation of the first metacarpal due to the incongruity between the trapezium and the metacarpal base.

In the next part there are studied six basic prehensile muscle interplay algorithms (palmar, tip, lateral, and hook, spherical, and cylindrical prehensions) by the help of the surface electromyography (EMG). The myoelectric signal is obtained via surface electrodes from muscles within the upper limb. This signal is then electronically amplified, filtering, offsetting, rectifying and processed. Tip, lateral, and palmar prehension are primarily the function of the thumb working in opposition to the index and middle fingers. Tip prehension is used mainly to grasp small objects. In lateral prehension, the thumb holds an object against the side of the index finger, as is the case when using a key. In palmar prehension, the thumb opposes either a single finger or two of more fingers. Palmar prehension is the grip most commonly used in daily activities. That is reason why palmar prehension uses all the fingers of the hand to provide an encompassing grasp that firmly stabilizes the object being held. Hook prehension is an achieved by flexing the fingers into a hook; the thumb is either alongside the index finger or used to lock the object held.

The new laboratory practice helps students to meet with problems of prostheses and also obtain summary of current possibilities of prosthesis design (amputation level, expected function of the prosthesis, materials, and technological process).

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Bolus Processing Analysis as a Data Source for Finite Element Models.

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Clinical observations and mathematical models show that dental implants are influenced by the magnitude of loading [1]. Therefore, the knowledge of mandible movement during mastication is important to assess occlusal and masticatory force vectors.

The mandible and the skull are able to move with respect to each other and are guided by two temporomandibular joints. The mandibular condyle articulates with the articular fossa of the temporal bone in each joint. The articular capsule is slack (freely moveable). Due to this construction both joints allow for movements with six degrees of freedom (rotation – detrusion (opening) and elevation (closing), lateral movements - laterotrusion, mediotrusion and translation – protrusion, retrusion) [2]. If joint surfaces are assumed to be immovable and maintain contact all the time, the mandible is still able to move with four degrees of freedom [3]. Jaw movements in particular anatomical directions can be defined by the three dimensional path of a point that is rigidly connected with the lower jaw. The movement of this point can be scanned and its path can be reconstructed by the motion analysis technique [4].

This pilot study was designed to: 1) detect the path of lower jaw movement during the mastication, 2) determine the duration of the processing of one bite depending on its character (hard and soft aliment), and 3) analyze the timing of the chewing. Knowledge of mandible movement during mastication is important to assess the dominant anatomical and bite force direction during mastication.

Motion analysis was used to record three-dimensional mandible movements. Individualized sensors were rigidly attached to the mandible of 51 study participants. At the beginning of the measurement, all subjects were asked to move the mandible in extreme positions (maximal opening and maximal lateral movements). Then, each subject masticated a bite of hard and soft food. The following hypotheses were tested:

I. duration of the hard bolus processing is longer than for the soft bolus ($\Sigma t(H) > \Sigma t(S)$),

II. duration of each stage of hard bolus processing is longer than those for the soft bolus (t1(H) > t1(S), t2(H) > t2(S), t3(H) > t3(S))

III. frequency of closing movements of the hard bolus processing is greater than for the soft bolus (f(H) > f(S))

IV. duration of the bolus processing for men is longer than for women - influence of gender V. duration of the bolus processing is longer for older people - influence of age.

Duration of bolus mastication and peak amplitude of mastication movement in mesiodistal, cranio-caudal and vestibulo-oral axes related to peak amplitude of marginal movements were evaluated for each subject. The chewing record of each subject was divided into three phases (chopping, grinding and swallowing), and the duration of mastication and number of closing movements were evaluated. Results of this pilot study suggest that masticatory movements vary in individuals. Relationships to directions and magnitudes of acting chewing force should be more precisely examined since transversally acted forces during grinding are important factors in implant overloading.

The data support the first two hypotheses that the bolus character influences the process duration. The hard bolus was chewed significantly longer than the soft one $\Sigma t(H) > \Sigma t(S)$ (p= 0.001). Also, the duration of the each stage of hard bolus processing was longer than those for the soft bolus. This difference was statistically significant for t1(H) > t1(S) (p=0.005) and t2(H) > t2(S) (p=0.025), but not for t3(H) > t3(S) (p=0.064). The third hypothesis regarding the influence of the bolus character on the frequency of closing movements during the mastication (f(H) > f(S)) was not supported, because the same average number was achieved for both types of boluses (Figure 6). Only during swallowing phase the frequency of closing movements was significantly higher (p=0.003) for the hard bolus than for the soft one. The gender and age influenced nor time nor frequency of bolus processing, so hypotheses IV. and V. are not confirmed.

Understanding masticatory development and physiological relationships are important in determining the principal anatomical direction during closing movements and the resultant direction of the loading during mastication. Such findings can be used to plan treatment and to reconstruct defective dentition from a masticatory point of view, as well as to validate treatment procedures. Results can also affect the design and the usage of materials for the dental implants, their position in jaws and the shape of the occlusal surface of bridgeworks and dentures.

The information obtained in this pilot study suggest that masticatory movements vary by individual and that their relationship to the direction and the magnitude of the chewing force should be more precisely examined.

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Methods and Technical Tools for an Analysis of Sudden Cardiovascular Death in the Horse

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Despite of great advances in veterinary anaesthesia the risk of death associated with general anaesthesia in the horse remains obstinately high. Recently an accurate perioperative mortality rate in a large population of horses was published as 1.8 % that is more than hundred times more than in human population and ten times more than in small animals. Even if emergency abdominal cases are excluded the death rate is still 0.9 %. The 39 % cases of sudden death were due to cardiac arrest.

The aim of the project was to monitor and analyze vital signs describing quality of cardiovascular system in horses. While perianesthetic mortality at emergency surgery procedures is rather high in particular due to difficulties following from the primary problems and the surgery often ends by euthanasia [7], the most frequent primary cause of death at elective procedures is just the anesthesia.

The research work has been divided to three parts:

- ☑ design and construction of equipment for recording ECG, phonocardiographic and thoracic bioimpedance signals in horses;
- ☑ modeling mechanisms of cardiovascular control to find reason for differences of cardiovascular signal parameters in human population and horses;
- ☑ developing algorithms for recognition of different states of horses during surgery.

First, besides more or less standard equipment for recording ECG and phono signals, acquisition mobile wireless unit has been developed and verified for recording bioimpedance signals. The measuring unit consists of three modules: generator, observing module and one channel ECG module. The generator contains microprocessor unit which allows setting of power and frequency of actuating signal. Frequency generator can be set in range 1 kHz – 400 kHz. Produced sine wave is digitally regulated by microprocessor unit and used as a control signal for current generator. Current generator can be set in range 10uA – 200uA. Bioimpedance changes caused by heart activity are obtained using envelope amplitude detector. After measuring of absolute impedance value of measured signal is the signal amplified more without dc part and then the small changes are apparent. The whole unit is powered by LiPol accumulators and uses the wireless interface for data transfer to acquisition computer

Second, several versions of mathematical open loop models describing mechanisms of cardiovascular control have been developed. The most important investigated phenomenon

was a relationship between duration of RR and QT intervals in equine ECG. We had recorded ECG data in horses that show clear prolonging of QT intervals during increasing heart rate in dynamical experiment. No drugs were used. Generally speaking this fact was supposed as one of the reasons that could increase risk of sudden heart failure. Surprising fact was that those records were measured in well trained horses. Simulation results with the developed models indicate that generally accepted attitude to QT intervals control is misguiding or incomplete. We have proved theoretically that the abnormalities are caused by variant sensitivity of ventricular cells in myocardium to sympathetic and parasympathetic during plateau and repolarization phase.

The third part of the work dealt with an analysis of signals that describe the status of equine cardiovascular system under anesthesia. We have focused on the oscillations in sequence of intervals between consecutive heart beats determined from ECG and blood pressure signals. Time and frequency domain methods have been used to obtain set of features that assess Heart Rate Variability. The goal was to select such a feature subset that allows to distinguish between two groups of patients - 'healthy' and 'unhealthy'. The 'healthy' 'unhealthy', group consists of patients where were not or were observed any heart rate related problems. In the study, the quality of a feature subset has been measured by leave-one-out correct classification rate of the nearest neighbor (1-NN) classifier. The features have been determined as it follows: SDRR - RR intervals standard deviation, SDARR - standard deviation of average RR intervals over 1 minute record, RMSSD - the square root of the mean squared differences of successive RR intervals, HRV triangular index - the normalized integral of the density distribution, ELF - energy in the range of low frequencies (0,04-0,15Hz), EHF - energy in the range of high frequencies (0,15-0,5Hz), EL/EH ratio – the ratio of the areas above and below the equilibrium line of the curve ELF(t)/EHF(t), Entropy, Hurst exponent - mathematical descriptor of time series self-similarity. The Sequential Forward Feature Selection algorithm were used to find the best feature subset and we were able to distinguish between the two mentioned groups by means of three features - Entropy (determined from ECG), Hurst exponent (determined from both ECG and blood pressure signals).

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Biomechanics of Power Grip of Hand

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The grip of had can be divided to power and precise grip. The motivation of research is to search the joint and tendon forces and bone stress state as an effect of power grip of hand. The results are used as loading of any finger implants. It is solved the power grip of some object for example the tongs and/or grip of bar with circle cross-section for example if a man hangs on horizontal bar. It is supposed that the hand clamps the object between wrist and any finger link,

the diameter of clamped object is a free parameter, thumb doesn't work, the finger link lengths make Fibonacci's sequence [1], tendons are at tendon vaginas and follows finger bones form, tendon curvature has near the joints radius r, f_{ij} is perpendicular distance the tendon from joint center, at tendon vaginas aren't friction, the bending moments aren't at finger joins, each finger links has its flexor and extensor, bones are ideal stiff and tendons are ideal flexible, metacarpal part can be solved as one joint, the 1st finger links are connected (corpus ossis metacarpalis) and there bounding enable a small difference of their slopes.

The hand geometry is search the first. The object grip of hand has follow schema: $A_i(x_i,y_i)$ are turning center of finger links, $B_i(X_i, Y_i)$ are connection points between object and finger surface, $S_i(x_{is}, y_{is})$ are bone links axis centers. The coordinates of points A_i can be calculated from

$$x_{i+1} = x_i + L_i \cos \alpha_i, y_{i+1} = y_i + L_i \sin \alpha_i$$

 α_i is slope of ith finger link and L_i is its length (distance between turning centers). The position of poits B_i are

$$\begin{split} X_1 &= -r_1 v \frac{y_2}{L_1}, Y_1 = r_1 v \frac{x_2}{L_1}, \\ X_{i+1} &= \frac{x_i + x_{i+1}}{2} - r_i v \frac{y_{i+1} - y_i}{L_i}, Y_{i+1} = \frac{y_i + y_{i+1}}{2} + r_i v \frac{x_{i+1} - x_i}{L_i} \end{split}$$

 r_i is bone radius and v is parameter which defines distance between finger surface and bone axis.

Rotation angles α_i of bone link axis are

 $\beta = \alpha_2 - \alpha_1, \ \alpha_2 = \alpha_1 + \beta, \ \alpha_3 = \alpha_1 + (1+k)\beta, \ \alpha_4 = \alpha_1 + (1+1,5k)\beta$

The 1st approximation is $\alpha_1 = 0$. Angle β will be determined to be distance between $B_1 a B_{n+1}$ equal size of grip object *d*, the value of *k* is calculated to be for *d*=0 the points $B_1 a B_{n+1}$ at the same position, it means that for its distance is valid

$$\Delta x \equiv L_1 + L_2 \cos \alpha_2 + \dots + \frac{L_n}{2} \cos \alpha_n - r_n v \sin \alpha_n = 0$$

$$\Delta y \equiv L_2 \sin \alpha_2 + \dots + \frac{L_n}{2} \sin \alpha_n + r_n v \cos \alpha_n - r_{c,1} v = 0$$
(1)

If we set to (1) formulas for angles α_i we have the system of equation with unknowns β and k which can be solved with help Newton's iteration method. Now we rotate the hand to be the grip force *F* vertical

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n

$$tg\alpha_1 = \frac{X_{n+1}}{Y_{n+1} - vr_1}$$

The geometry of hand finger position for power grip of round post can be determined likewise.

The tendon forces F and joint forces H, V which have influence on finger links can be calculated from the equilibrium conditions (moment and force conditions)

$$\begin{split} \sum_{j=i}^{i} R_{j} f_{i,j} &- \sum_{j=i+1}^{i} R_{j} f_{i+1,j} - H_{red,i+1} c_{y,i} - V_{red,i+1} c_{x,j} + F_{y,i} r_{x,i} - F_{x,i} r_{y,j} = 0 \\ H_{red,i} &= H_{red,i+1} + F_{x,i}, \ V_{red,i} = V_{red,i+1} - F_{y,i} \end{split}$$

where H_{red} , V_{red} are reduce forces without tendon forces influence. The final joint forces are

$$V_i = V_{red,i} - \sum_{j=i}^n R_j b_{y,i}, H_i = H_{red,i} + \sum_{j=i}^n R_j b_{x,i}$$

Now can be calculated tendon forces and stress state at fingers. The hand load can be divided to fingers to be equal tendon forces or stress maximum at all fingers.

The poster will show the algorithm for power grip of post with circular diameter too. The finger position geometry is deferent but the stress state calculation is same.

The maximal values of stress are calculated from

$$\sigma_{x1} = \frac{N}{A_{r1}} + \frac{Mz}{I_{r1}}, \qquad \sigma_{x2} = \frac{N}{A_{r2}} + \frac{Mz}{I_{r2}}$$

where σ_{x1} , σ_{x2} are maximal normal stress at compact and spongios part of bone and

$$A_{rl} = \pi(r_1^2 - \lambda_l r_2^2), A_{r2} = \pi(\lambda_{r2} r_1^2 - \lambda_3 r_2^2), I_{r1} = \frac{\pi}{4}(r_1^4 = \lambda_l r_2^4), I_{r2} = \frac{\pi}{4}(\lambda_2 r_1^4 - \lambda_3 r_2^4)$$
$$\lambda = \frac{E_2}{E_1}, \lambda_1 = 1 - \lambda, \lambda_2 = \frac{1}{\lambda}, \lambda_3 = \lambda_2 - 1$$

The maximal value of shear stress is

$$\tau_1 = \frac{0,90412966.Q}{2(r_1 - \lambda_1 r_2)} \left(\frac{r_1^3 - r_2^3}{I_{r1}} + \frac{r_2^3}{I_{r2}} \right)$$

The described algorithm was implemented on computer. The program has as output the graph of hand position and the values of stress and tendon forces.

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Hardware and Software Support for EEG Biofeedback

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EEG Biofeedback, also known as neurofeedback or neurotherapy, is a form of biofeedback based on scanning and processing of the electroencephalogram (EEG) from the head surface.

Biofeedback has been used to successfully treat a number of disorders and their symptoms, including temporomandibular joint disorder (TMJ), chronic pain, irritable bowel syndrome (IBS), Raynaud's syndrome, epilepsy, attention-deficit hyperactivity disorder (ADHD), migraine headaches, anxiety, depression, traumatic brain injury, and sleep disorders.

Illnesses that may be triggered at least in part by stress are also targeted by biofeedback therapy. Certain types of headaches, high blood pressure, bruxism (teeth grinding), post-traumatic stress disorder, eating disorders, substance abuse, and some anxiety disorders may be treated successfully by teaching patients the ability to relax and release both muscle and mental tension. Biofeedback is often just one part of a comprehensive treatment program for some of these disorders.

Biofeedback techniques use special sensors on the body. These sensors measure the bodily function that is causing the patient problem symptoms, such as heart rate, blood pressure, muscle tension (electromyographic feedback), brain waves (electroencophalographic feedback), respiration, and body temperature (thermal feedback), and translates the information into a visual and/or audible readout, such as a light display, or a series of beeps.

While the patient views the instantaneous feedback from the biofeedback monitors, he or she begins to recognize what thoughts, fears, and mental images influence his or her physical reactions. By monitoring this relationship between mind and body, the patient can then use these same thoughts and mental images as subtle cues, as these act as reminders to become deeply relaxed, instead of anxious. These reminders also work to manipulate heart beat, brain wave patterns, body temperature, and other bodily functions. This is achieved through relaxation exercises, mental imagery, and other cognitive therapy techniques.

Based on studied questions of technical and medical approaches to EEG biofeedback, both in our country and abroad, an open project OpenEEG was chosen for our experiments. The project is continually being developed by a community of professionals and enthusiasts from all over the world. Its principal advantages are reasonable cost, sufficient preprocessing of captured signal, scalability and last but not least the open source of all software

OpenEEG is a modular system that comprises of one digital and one to three analog boards. Each analog board provides two EEG-channels. The amplification is done in three stages (x12, x40, x16). Between the first and the second stage, a high-pass filter removes DC-voltage offsets. The amplification of the second stage can be adjusted from 10 to 100 using a trimmer. In the last stage a 3rd order low-pass filter at 59 Hz is implemented. To achieve a high common mode rejection, a right-leg driver (DRL) is used. The A/D-conversion is done by the internal converters of the Atmel AT90S4433 with resolution 10 bits. During system 518

operation, the digitized channel-values are transmitted to the host-PC or PDA via RS232 using one of three possible transmission-protocols.

Test measurements showed that the resolution and sampling rate of used transducer was sufficient for our experiments when scanning two EEG channels. Currently, we focus on creating simple software for communication with the module, which would act as start point for the development of an interactive therapeutic software for EEG biofeedback support.

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Section 13

CIVIL ENGINEERING

The Ultrasonic Method of Tree Vitality Testing

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The objective of this project was to determine the scope in which ultrasonic methods can be used for woody plant vitality measurements. A Dio562 low-frequency ultrasonic defectoscope was used for the purpose. Within the meaning of this work, tree vitality was understood as a physiologic and biomechanical property [1, 2]. Physiological vitality of a plant is a manifestation of growth, development, reproduction and ability of the organism to response to various effects of the environment at the same time. In this respect it can be understood also as an expression of durability and regeneration of the organism. Biomechanical vitality of a tree can be described as its resistance to windfall and fracture, or, in practice, as the static aspect of vitality.

Special tipped probes were developed for vitality spot measurements, which can be used for measuring below tree bark. The probes designed for block measurement are of cylindrical shape. The electro-diagnostic method of electric impedance measurement using a Mervit instrument was used to provide reference data to those obtained by ultrasonic measurements of tree vitality. Visual evaluation was not considered significant, as the participation of a specially trained operator would have been necessary for performing this work. From the definition of physiological vitality it ensues that this property of trees undergoes continuous dynamic changes and this fact should be taken into account. A low correlation was found between the ultrasound surface velocity and the tree age (represented by its trunk diameter) in the study involving a set of 23 beeches (Fagus sylvatica). Other stage of the project included the study of the age dependence of ultrasound velocity made on the set of about 400 spruces (Picea abies). It was found that the ultrasound velocity increased slightly with tree's age, showing the opposite but much more statistically significant trend to that observed with the small group of beeches. Based on the results one cannot arrive to any unambiguous conclusion, as the observed relationship was not marked and might be caused also by an interdependence of ultrasound velocity and the volume weight. Repeated measurements made with the abovementioned set of beeches demonstrated the full independence of ultrasound velocity on tree's age. On the contrary, the results obtained by the reference method of impedance measurement were shown strongly dependent on the age of trees. The physiological vitality of trees undergoes certain changes in the course of the year (and it should reach its highest level in the growing season). The ultrasonic method, however, failed completely and no reasonable relationship was found. One could come to the conclusion that the tree structure is too complex for ultrasonic measurement and any repeated spot measurements cannot be carried out without providing for identical initial conditions. There is also a possibility to make measurements of the tree in its cross section, but this method cannot be realized because of the lack of suitable equipment. Biomechanical vitality: The ultrasound velocity was measured in Weymouth pine (Pinus strobes). Already in initial measurements this method identified that sector of a trunk, which is solid and which could be damaged. In this case, taking account the temperature dependence of sound propagation, a working hypothesis was proposed, i.e., that ultrasonic measurements were affected by possible trunk heating due to the exposition of various tree parts to sun radiation or their orientation in respect to the cardinal points. The exposition to sunlight was analyzed

in the next step. The abovementioned set of spruces was used for the statistical evaluation of the results. By the analysis of those results [3] a relatively high dependence of ultrasonic measurement results on the orientation of measured parts in respect of the north-to-south direction. In the measurement of vitality it will be necessary also to determine the orientation of measurements in respect to the cardinal points. Other measurements of ultrasound velocity peripheral profiles were made with a pair of selected beeches (Fagus sylvatica) differing each other apparently by vitality. A reduced velocity was found at the north side of a dying tree. The east side showed a reduction in velocity, while an increased velocity was measured on the northwest side. A sound tree was selected as the other member of the pair. A reduced velocity was measured at its south side, while an increase in ultrasound velocity resulted from the measurements made on the north side of the tree, contrary to expectations. Any interdependence between ultrasound velocity and electric impedance along the tree perimeter was not found, as ensued from the comparison of the two sets of measurement results. Peripheral profiles were tested, at the height of 100 - 145 cm. The method was used, e.g., for the measurement of a low quality fork-stemmed spruce. It was assumed that significant differences would appear in the measurement made along the trunk periphery as a result of trunk forking. The tree was measured at four altitudinal levels and considerable differences in measured ultrasound velocities were observed. It was supposed that it was due to the fact the tree was subject to a substantial stress caused by forking into two separate trunks and to the incidental structure disturbance making any reasonable interpretation of result impossible. The tree in the same location shows much less scatter of ultrasound velocity values measured around the trunk perimeter.

The physiological vitality determined by the ultrasonic method at the described level cannot be evaluated and is not comparable to the results of both the electro-diagnostic method and the visual observation. Spot measurements are insufficient for determining tree vitality and a given cross section or a whole trunk part should be involved in. Consequently, the number of measuring points will increase considerably and the task cannot be handled in practice using spot probes only. Laboratory measurements of vitality changes should be made independent on moisture, but this requirement cannot be met using the laboratory facilities currently available. At the present level of available equipment the ultrasonic method is absolutely unsuitable for the measurement of growing trees. It is recommended either to replace the existing instrumentation with a more suitable system or to develop a completely new one, designed for more specifically for tree measurement.

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Monitoring of Thermal and Moisture Behavior of Rendering System of External Thermal Insulation Composite Systems (ETICS)

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Trend of reduction energy heftiness, especially needs of warm to heating, faces to reduction of heat transmission coefficient of building claddings in recent years. In case of external walls meant this trend crossing from single-layer masonry to application multi-layer sandwich constructions. In current building industry is one of the most frequent solutions an application of external thermal insulation composite systems with rendering (in shortcut ETICS). Two matters conduce to tidy enlargement of these systems. The first reason is, that the forms a continuous thermal insulation protection from the outer side of wall, which eliminates whole number of heat bridges. Secondly belongs to financially most effective solution. Therefore are these systems frequently used to additional heat cladding by block of flats. But it is necessary deal with questions lifetime and durability just with regard on massive usage of these systems. The research project has been specialized to hygrothermal analysis of ETICS especially to rendering system.

The basic function of rendering is thermal insulation protection against weather attack, primarily moisture. The moisture balance by ETICS is determinate mostly by water vapor diffusion, rainfall and condensation on external surface, which hang together with influence of long wave radiation.

It has been paid markedly interest to long wave radiation, as an influencing factor of hygrothermal behavior of building structures, in last 10 years just in connection with ETICS. Long wave emission makes itself felt by heat flux between external surface of construction, surroundings and sky. Heat flux between construction and surroundings surfaces is minor with reference to in effect identical temperatures. Dominant is emission from construction surface to sky, they express oneself in clear sky night mostly. It is coming to cooling of thin rendering system owing to this phenomenon. If the surface temperature sinks under dew-point temperature, it can happen to condensation on external surface.

The concrete solution was divided to two basic parts. Primarily it has been in progress experimentally measurement of thermal and moisture behavior of ETICS (especially of rendering system) in atmospheric conditions. At the same time has been done a numerical analysis.

The measurement has proceeded by sample of ETICS with thermal insulation and without thermal insulation (conforms to one-layer masonry). It is possible obtain a view of hygrothermal behavior between construction with ETICS and one-layer masonry from confrontation of measurements results. Simultaneously one of the samples with thermal insulation is situated so, that it is screened again the night sky. This makes possible observe an influence of long wave emission between construction surface and sky. It has been measured surface temperatures, temperatures and relative humidity of external and internal air.

It was constructed a sensor for radiation measurement. It is possible observe total radiation balance on external surface of constructions with this sensor. From present outputs 524

result that the emission reaches in the extreme (in clear-sky nights) $35 - 40 \text{ W/m}^2$ by vertical surfaces (matches building walls).

The results reflect a cross-correlation between emission intensity and temperatures drop by external surfaces. By ETICS can the surface temperatures sink more than 3,5 °C against the air temperature. If the surface is not exposed to emission to sky, it comes not to overcooling of rendering system in the night. It comes to temperature sink by one-layer masonry, but it is so strong. The present outputs advert also to, that the differences between surface and air temperatures don't change in principle along the year. It can be noted on this account, that the influence of long wave radiation to overcooling of rendering system by ETICS is fundamental and overreach effect of temperature difference between interior and exterior. With surface temperatures cohere also risk of surface condensation. It exist a possibility of condensation by one-layer constructions, but it is markedly lower compared to construction with ETICS.

For checking a premise, that the moisture balance in ETICS (especially in rendering system and just below in thermal insulation) is essentially impressed with external condition, was filled the sensor to moisture measurement. This measurement is realized indirectly via monitoring relative humidity. Humidity sensors are situated under rendering by the outer face side of thermal insulation. Pursuant to these measurement outputs cannot determine directly the moisture content. More likely can be monitored via these results trends of moisture behavior and dependence on external condition.

The measurement results reflect that with increase relative humidity on external surface of ETICS happen to rising humidity in system. To the most expressive growth has been come in case, when the relative humidity on external has reached 100%, then has come to surface condensation.

On measurement has connected a numerical analysis. These analyses have realized via non-stationary software tools designed to solving combined thermal and moisture transport in multi-layer building constructions. Like an essential it can be point out two pieces of knowledge. Primarily the moisture content in ETICS is higher, if is include the influence of long wave radiation against analysis without this effect. Secondly from outcomes of numerical analyses result, that the thin rendering system by ETICS response more on external conditions, then the plasters on one-layer masonry.

Results of this research project will be used in dissertation on the theme "Analysis of hygrothermal behavior of external thermal insulation composite systems with rendering".

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Degradation of Waterproofs by Biotic and Abiotic Effects

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The research is concerning with influences, which are probably responsible for degradation of waterproofs in foundations. The subject of research was chosen science no serious information in literatures is present. Conclusions of waterproofs control on building from first half of 20th century (the period, where the bitumen's waterproofs begun widely used) proves the enormous degradation of bitumen's belts. Unfortunately it isn't only in sporadic buildings, but this problem we can find in many standing buildings. Obviously, in buildings with damaged or no waterproofs layer we can find very high wetness. This wetness produces not only some problems in building structure, but also aesthetical defects. In extreme situations the building static can be disturbed. The aesthetics defects on plaster are one of the first noticeable marks. Aesthetical defects results in ample amount of efflorescence, which are crystallize on surface of buildings. The health hazard caused with mould cannot be neglected. There are a lot of problems, which can cause the wetness in building construction. For this reason is very important to design function and correct waterproof layer. Contemporary we have many kinds of fine materials for waterproof purpose. These materials are much more durable than bitumen's belts which were used in period of "first republic".

Question is how long these modern materials indeed stay in buildings without broken of their waterresist function. It is obvious, that modern materials also degrade due to biotic and abiotics influences affected in foundations. Unfortunately, the common mechanisms of waterproof degradation have not been seriously investigated until now. Therefore in our laboratory we focused on experiments which could help to clarify the biotic degradation of plastics materials commonly used as waterproof foils. The selected plastics have been tested under microflora together with some abitotic influence (as gamma radiation).

The goal of investigation is to summarize not only common information about waterproofs systems, which are used in foundations, but also gather all relevant initial tests, which help to understand of degradation mechanism and which aren't commonly in literature. The design and build of quality, function, permeable and durable waterproofs protection is very important and hard task, since system have to be resistant to hydrostatic pressure. It is evident, that waterproof repair is very difficult task due to its position in building. Therefore such repair or waterproof replacement is very expensive.

Waterproofs in foundations are nonbearing structure. Waterproofs are made of various kinds of materials. These materials can be either natural or synthetics. Further, these materials must meet the various special requirements like easy build in, durability of functionality, adaptation for strain and morphing of structures, etc. Suitability of materials is given of theirs volume stability, resilience, ductility and resistance to aggressive matters.

The original material for waterproof is bitumen. In last time (since seventies) the original materials has been replacing with plastic foils with various chemical composition. These advance materials we can use in unfriendly climatic condition. Waterproofs have unsubstitutable function in foundations, which is given their inaccessibility for repairs. For this reason must be waterproofs design from highly resistant materials. Waterproofs in

foundations are inaccessible after theirs build in. Unsuitable solutions (materials or technical) which lead to duff waterproofs can cause leakiness of water and chance of static failures.

For experiments were selected some waterproofs which were attacked by moulds. This experiment was performed in compliance with the ČSN 72 4310. Next experiments were examined with bacteria. Degradation with bacteria was proved with decreasing of waterproof sample weight and with degradation of mechanics properties (like is hardening and embrittlement of material). Further, waterproofs were exposed to low gamma radiation. The biggest degradable changes were observed on synergic effect gamma radiation and soil microflora. Polymers from PVC-P become markedly darker after this synergic effect. Experiments have attested that the greatest degradation of waterproofs brings combination of biotic and abiotic influences. Lifetime of waterproofs probably depend on intensity of wetness in structure and on amount of microflora with synergic effect of low amount of radiation. This radiation implicates probably some instability of carbon chains of polymers. These attacked chains are more susceptible to attack of microorganisms. Probably it is beginning of degradation plastics and bitumens. After such degradation initiation the further factors can more easily impact on waterproofs. Oxidations of polymers depend on character of carbon chain. The most resistant polymers to oxidation are these ones with saturated ramify disbranch chain. On the contrary, the most sensitive polymers are these ones with double bonds chain. Contemporary, the oxidation is explained with hydroperoxid's theory. According this theory the plastics changes can be explained with following equation: bond C- $H \rightarrow$ hydroperoxide \rightarrow ketone/ aldehyde \rightarrow carboxyl acid. Thus, the plastic degradation starts on reactive carbons, in place, where the chains are furcated or in place of activated groups. The result of this degradation is peroxide. Peroxidation of polymers probably leads to theirs degradation.

Plastics which were considered are resistant for mildews. On samples which were situated in mineral solution with bacteria the changes were found. These changes were compared on infrared spectra. There were seen absorbefacient belts of esters (-CO-O-, 1712 cm-1). By synergic effect of γ -radiation and microorganisms there were found increase of carbonyl (C=O, 1745 cm-1) and absorbefacient belt of alkenes (-C=C-H, 1465 cm-1). Some changes were found when the double bond arise (there were found marked darken of polymer by 1465 cm-1, -C_C-H). In next experiments will be consider mainly physical and mechanical duality of exposed polymers.

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Extension and Adaptation of Measuring Chamber for Definition Hybrid Ventilation Efficiency

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Introduction

Indoor pollutant concentration is more significant for human health than outdoor atmosphere because people spend most of their time in buildings. Pollutant concentration enhancement, rise of relative humidity, mould reproduction and environment not corresponding to human organism needs because of insufficient ventilation is in the space. The aim for thermal losses lowing directed to limiting natural ventilation by windows. Tight windows have insufficient infiltration, they are unsuitable from the hygienic point of view. It leads to pollutant concentration enhancement relative humidity, mould reproduction and rise of environment not corresponding to human organism. So it is necessary to ensure sufficient ventilation. In spite of minimal ventilation, the poor window sealing of old windows ensured sufficient ventilation rate, but it led to higher thermal losses. The residential space ventilation should ensure taking away of the depleted air, pollutants, moisture and smell to ensure the pleasant microclimate in rooms.

Indoor air quality depends on many factors, especially on: outdoor air quality, air amount per person or ventilation rate, ventilation plant, amount of air pollutants, that sources are: inhabitants and their metabolism, inhabitants' activities, construction materials, social settlement, flat cleaning and housekeeping. Pollutants influencing indoor air quality are: carbon dioxide, carbon monooxide, nitrogen oxides, sulfur oxides, formaldehyd, VOC, asbestos, dust, ozone, hydrocarbones, odours, radon, relative humidity, acarides and microorganisms. Some of the chemical compounds presented in the indoor air belong among potential or evident human carcinogens. Classic Pettenkofer rule 25 m³.h⁻¹ per person is based on the request to abolish unpleasant body odour evoking strain of depleted air by adhering carbon dioxide concentration 700 ppm. Pettenkofer rule is still a basic value for standards of most developed states. ASHRAE standard is based on it as well.

Present, it is necessary to solve the problem how achieve that low-energy building is also healthy building.

Hybrid Ventilation

Hybrid ventilation is system which combines natural and mechanical forces. This system with greater airflow has one disadvantage – here is no possibility for heat recovery. Hybrid ventilation in residential building is used as mechanical return and natural supply by doors and windows (for example – system with permanent return from toilets, baths and kitchens, or with occasional return from these rooms).

Measuring Chamber

Measuring chamber is situated in space A031 at Department of Microenvironmental and Building Services Engineering, Faculty of Civil Engineering, CTU in Prague. Twelve openings are situated in installation wall – six openings is for supply elements about dimension 100 mm and six for supply elements about dimension 160 mm. The openings fur supply outdoor air are situated at pairs – 100 mm a 160 mm side-by-side, three pairs are at top of installation wall and three at window-sill part of this wall. Each opening is closed by tight sealing. One opening is provided with supply element and other openings are closed for

measurement. A large close opening $(0,5m \times 1,1m)$ is situated in installation wall for space between installation wall and window maintainance. The window is used for outdoor air supply to space between window and installation wall and during measuring the window is open to let outdoor air to supply element.

Return air is solved by fan with fluently controlled speed and by flexible duct. Flexible duct allows changing position of return air at opposite wall. There are 12 alternations for supply and 4 for return in measuring chamber, it means 48 alternation for measuring.

Supply Elements

There are used four types of supply elements – two supply elements by dimension 100 mm (first is with handle control and second is controlled with thermostat) and two supply elements by dimension 160 mm (the first is classical and second is with façade element in thermal insulation).

Axial Duct Fan

Maximal airflow through fan is 500 m³.h⁻¹. Return air amount is controlled by changing fan speed. Fluent fan control is by lowing supply potential by electronical speed control. Single-phase electronical triace regulator differs fan motor speed by differing its supply potential.

Measurement

Indoor air quality is and will be measured in this laboratory during different operational conditions. Measurements run at 13th November 2006, 14th November 2006 and in January 2007. I assess indoor air quality on the base of actual carbon dioxide concentration in measurement chamber. I use anemometric sonde for determination airflow speed in return duct and subsequently determined return air amount. Two carbon dioxide sondes are used – the first is for outdoor and the second for indoor. Digital measurement central provides data collection. Dates are imported to computer and then I process them.

Results

The results show, that CO_2 concentration run is similar to interior occupation and ventilation air amount, measurement chamber volume, increasing time of concentration to constant value and decreasing time of concentration to ventilation air concentration depend on chamber volume, carbon dioxide production and ventilation rate. Outdoor carbon dioxide concentration is practically insignificant, because it has changed only a little. I compared results with computation in Excel model based on physical principles and measurement results and computed results are similar. Carbon dioxide concentration 1200 ppm is a required value according to EN CR 1752 CEN for Class "C" and 1000 ppm according to ASHRAE Standard.

Carbon dioxide concentration was overstepped during all measurements. It is caused by insufficient ventilation, because during measurement were in chamber two, three ao four persons and one supply element ensures only 40 m^3 .h⁻¹ 25 m^3 .h⁻¹ per person (Pettenkoferův normativ) is necessary for ensuring concentration 1000 ppm.

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The Dynamic Model of the Public Sector Comparator

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The contribution deals with the explanation of the Dynamic model of the Public Sector Comparator that has been prepared within the scope of the CTU grant.

The Public Sector Comparator estimates the hypothetical risk-adjusted cost if a project were to be financed, owned and implemented by public sector. The Public Sector Comparator is divided into four elements: Transferable Risk, Competitive Neutrality, Raw PSC and Retained Risk. The Raw PSC includes all capital and operating costs associated with building, owning, maintaining and delivering the service over the pre-determined time (usually over 15 - 20 years). Competitive Neutrality removes any competitive advantages and disadvantages that accrue to a public sector by virtue of its public ownership. The Public Sector Comparator also includes risk assessment.

The Public Sector Comparator promotes full cost pricing at an early stage in the procurement process. It provides a reliable means of demonstrating value for money, provides a consistent benchmark and evaluation tool and encourages bidding competition by creating confidence in the financial rigor and probity of the evaluation process.

The Public Sector Comparator is expressed in net present value terms. It is based on the recent actual public sector method of providing that defined output including any reasonably foreseeable efficiencies the public sector could make and takes full account of the risks which would be encountered by that style of procurement.

The purpose of the Public Sector Comparator is to provide a benchmark against which to form a judgment on the value for money of PPP bids. This exercise is distinct from the process of establishing what level of service charges is actually affordable to the client. There is no reason to presume that a good value for money project will be affordable or that an affordable project will represent good value for money.

The method of the Public Sector Comparator is currently solved in the Czech Republic only on basic general level. The major goal of the CTU grant was the preparation of the Dynamic model of the Public Sector Comparator. The Dynamic Public Sector Comparator is based on the parameterization of input data by means of determinate characteristics of mathematical/statistical methods. For that reason are input data defined in extended format. Every element of the Dynamic Public Sector Comparator is defined by specific probability distribution function and confidence interval.

By reason of usability of the method of the Dynamic Public Sector Comparator for users that have not good knowledge of mathematical statistics, the process of the data entry was adequately simplified. The model requires a discreet probability distribution for every element of the Dynamic Public Sector Comparator. On the basis of input parameters the model of the Dynamic Public Sector Comparator calculates for every element continuous probability distribution and characteristics that trustworthy reflect input parameters of discreet probability distributions. The users of the model of the Dynamic Public Sector Comparator are not obliged in searching of proper continuous probability distributions of input parameters. Within the scope of searching of particular types of continuous probability distributions it was found to be just number of continuous probability distributions applicable for the definition of input parameters of the Dynamic Public Sector Comparator. Input parameters are generally determined by set of common properties depending on some physical and economic regularities. For that reason it is acceptable in the model of the Dynamic Public Sector Comparator to apply only qualified set of continuous probability distributions that includes: Normal distribution, Log-normal distribution, Modified log-normal distribution and Uniform distribution.

The model carries out the simulations of cost and time distribution probability occurrences of particular input parameters after completing the definition of input parameters. The results of the simulations represent input parameters for the calculation of the Dynamic Public Sector Comparator. The program algorithm carries out simulations of particular scenarios of progress of the Public Sector Comparator. The number of executed simulations depends on reliability requirements of analysis results. It is recommended to carry out at least 1000 simulations. The results of the simulations are continuously recorded and serve as a basis for statistical evaluation. The recorded simulation results are sequentially analyzed with utilization of mathematic-statistical methods.

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The Saint Vitus Cathedral - Deformation Comparison Between Numerical Model and Geodesy Measurement.

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Introduction

Geodetic monitoring of the deformation of the Saint Vitus Cathedral has been running since 2000. Displacements have been measured on the columns of the nave. There are two points on each column between which the horizontal and vertical displacements are measured. Geodesists record changes of the geometry of the columns in different seasons during the year. During the first four years of the monitoring 11 measurements were made. The Result of the first of them is considered to be the basic size when we assume that displacements are zero. Measured values of the deformations have been compared with the values obtained by the theoretical calculations of relative displacements in the first stage of the project. They included only the impact of the temperature changes of the air surrounding the Saint Vitus Cathedral.

Numerical model

For the numerical analysis two programs of the finite elements method – Feat and Adina - were used. Feat is a program for calculating displacements and internal forces caused by temperature differences. This program can not count with transient heat transfer. Adina was used to calculate the mean value of the temperature in the parts of the structure (columns, walls, ribs). The outputs of Adina defined loads which were used in numerical model in the program Feat. In Feat there was created numerical model of the old and new part of the cathedral. The model includes one bay of the structure. 3 - D model which consists of 2 - D (walls, shells) and 1 - D elements (beams) was created.

Loading

The columns of the nave are supported by the flying buttresses which are part of the external bearing system. This caused that the outside temperature has substantial influence on the deformations of the internal parts of the structure. The model in Feat has been loaded by temperature differences. There are used differences between the results of the first (basic) measurement and other measurements. Three variants have been used to define temperatures of the structure. The third variant is the best and tries to solve the problem more exactly. The loads caused by the temperature are calculated by using heat transfer. The temperature is computed for each section separately. Along its boundary the section emits heat. The heat transfer caused by the radiation was ignored. In the calculation humidity of the structure was also vanished. These two assumptions caused simplification of the problem. For the thermal analysis of the flying buttresses of the bearing system3 – D model in Adina was necessarily used. This model simulates heat transfer and shows the deformations caused by the temperature extensibility. For other parts of the structure the 2 - D model to calculate average temperature was sufficient.

Results

The most exact outcomes are obtained from the third variant of loading on the south side. By comparing the values from the numerical model and values from the geodetic measurements we get almost the same mean-root-square error as by the geodetic

measurement. On the northern side the results are a bit worse. One of the reasons could be the fact that except for thermal extensibility the humidity of the structure has also the influence.

Measurement of the surface temperatures

The relative displacements on the columns of the cathedral nave were measured again in the July of 2006. Earlier to these measurements the surface temperatures in the exterior as well as interior had been measured daily. The infra telethermometer (based on the principle of the wave-length of the radiation from the structure surface) was used for this purpose. The calibration precision of such a thermometer is $\pm 1^{\circ}$ C in our typical climatic conditions.

Measurement of the sunshine (radiation) intensity

After the agreement of the Prague's Castle Office and the church a detector of the global sunshine (radiation) intensity was installed. The values of the radiation intensity obtained by this detector were compared with the values obtained by the hydrometeorological station Prague Karlov.

Theoretical calculations of the cathedral surface temperatures and comparison with the measurements.

A computer program Adina has been used to calculate the cathedral surface temperatures. Because of the lack of sunshine on the northern side of the cathedral during the whole year, only the heat transfer between the air and the cathedral structure has been considered there.

On the southern side of the cathedral, however, it was necessary to consider also the sunshine radiation influence upon the temperature of the cathedral structure surface. The sunshine radiation falling on the cathedral structure surface is considerably reduced by the shadows of other parts of the cathedral.

An array of temperatures inside and on the surface of the cathedral structure has been calculated. The calculated values were compared with the measured values. The difference is about 1°C. This evidence confirms that the calculation of the surface temperatures of the northern side of the cathedral, which was described in the first part of this contribution, is realistic. In its average values it corresponds to the reality. A similar conclusion holds for the southern side as well. (It is necessary to include the sunshine radiation and shadowing of the structure. The data from the meteorological observatory may be used as the input values.) The southern bearing system is being bended and twisted by the influence of the sunshine radiation.

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Estimation of maximum service loading of roadway masonry arch bridges with embankment.

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Masonry arch bridges are one of the oldest of a kind in the world. There are many with embankment on the roads in the Czech Republic (estimate is 10.000) and many are rather in a bad condition. Evaluation of their right maximum service loading is very important therefore.

Currently the most used method is an evaluation of maximum service loading of masonry arch bridge on truss model by using Bernoulli-Navier hypothesis. Maximum eccentricity of normal force N (e = M / N) is 1/6 of cross-section height, i.e. cross-section is pressured as a whole.

If using TP144 (Technical Condition of Department of Transportation of Czech Republic) maximum service loading of masonry arch bridge can be evaluated with an assumption of tension part elimination of a cross-section. Maximum eccentricity of a normal force N is 1/4 of cross-section height, i.e. maximum crack height is 1/4 of cross-section height.

This work is focused on development and verification of a "simple" and credible method for evaluation of maximum service loading of masonry arch bridges with embankment. Method is based on a simple software, which is usually used to design structures.

Following assumptions are used :

- a) Embankment is passive part of a structure only, is used for distribution of loading to a superstructure and is a dead load by itself (self-weight in vertical direction and earth pressure at rest in horizontal direction).
- b) Traffic loading is considered as a loading by rear wheel of a truck of configuration ,Seskupení I' defined in ČSN 73 6220 placed in 1/4 of free span of the arch. Load distribution is considered to an upper edge level of the arch and is symmetrical to an axis of wheel.
- c) Material is considered as linear. Modulus of elasticity E is considered by real values for each material of structure (vault-stones and mortar).
- d) Model for evaluation of internal forces is considered as combined from 1D and 2D elements (trusses with permission of tension for modelling of mortar and shell elements for modelling of vault-stones).

Internal forces are calculated by software IDA NEXIS 32. Program is based on the finite element method (for 1D and 2D elements). All assumptions are respected during the calculation. Loading of structure was increased until one of the following conditions were fulfilled:

- a) Maximum normal stress in material (mortar or vault-stone) exceeds maximum value.
- b) Crack height in an arch exceeds 2/3 of cross-section height.

- c) Maximum shear stress in material (mortar or vault-stone) exceeds maximum value given by product of maximum normal stress N and friction coefficient $f: Q_{max} = N.f$ (friction coefficient is considered by value of 0,5).
- d) Maximum curvature of a central line of deformed arch exceeds curvature of a central line of non-deformed arch.

Maximum weight of vehicle (load-bearing capacity) on the bridge is given by combination of maximum service loading of structure (as in previous statements) and crosssection arrangement of road superstructure. Maximum load-bearing capacity depends on load distribution in lateral direction.

Maximum service loading of six arches with different shape and height of embankment was computed considering conditions in line with TP144 and conditions defined in this work. Increase ratio of arch maximum service loading in line with conditions defined in this work was 1,9 at least (some of tested arches have negative maximum service loading, because conditions defined in TP 144 were fulfilled for part of self-weight only).

Maximum service loadings of tested arches were compared with non-linear 2D analysis performed by M.Posch and P.Řeřicha at Department of Structural Mechanics, CTU in Prague. Maximum service load given by the method presented in this paper was compared with the load reached when height of crack in structure was equal to 2/3 of cross-section height. Maximum service loadings were 1,5 less than loads given by non-linear 2D analysis at least.

When developed method for evaluation of maximum service loading of masonry arch bridges is used, higher values of load-bearing capacity are reached. Increase of structure loadbearing capacity is possible by use of more complicated computational model and controlling more conditions to ensure structure serviceabillity. On the other hand the computational model is simple and can be performed with any common computing software.

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Fatigue of Short-Span Reinforced Concrete Bridges

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Fatigue is a process of stable progressive changes in the structure of a material exposed to cyclic loading. Research related to fatigue of metals started in 1840's with construction of railways. Fatigue of concrete and concrete structures was first described at the beginning of the 20th century and became a significant topic in 1920's with the development of highways. Nowadays, the use of high strength materials results into design of more slender structures with high live load proportion of the total load. High stress ranges in structures like bridges or crane-ways can result into fatigue failure with fatal consequences.

Fatigue load spectrum [1] can be divided into three parts according to the total number of load cycles; low-cycle fatigue can be defined with an approximate $1 - 10^3$ load cycles with big stress ranges, high-cycle and super-high cycle fatigue can be defined with an approximate $10^3 - 10^7$, $10^7 - 5*10^8$ respectively, load cycles with small stress ranges. Low-cycle fatigue occurs in structures subjected to earthquakes, high-cycle fatigue in airport and highway pavements, railroad ties and highway and railway bridges, super-high-cycle fatigue in mass transit structures and maritime structures.

In reinforced concrete structures, load is resisted by a force couple consisting of a tensile force in the steel reinforcement and a compressive force in concrete. A fatigue failure can occur either in the reinforcing steel in tension or concrete in compression.

The process leading to fatigue failure of metals, i.e. reinforcing steel, can be divided into three stages. In the first stage, mechanical characteristics of the material are changing due to local cyclic plastic deformations. In the second stage, cracks are nucleated in the places where the local cyclic plastic deformations take place. The first two phases can be described as the stadium of crack initiation which ends with surface cracks forming. In the third stage, the crack propagation phase, the cracks propagate and unite into one which can than result into fatigue fracture when it starts to propagate unstably.

Concrete is a heterogeneous material full of flaws and pores, thus the processes running in its structure under cyclic loading are much more complex. Nevertheless, the process leading to fatigue failure of concrete can be divided into three stages, similar to metals. The phase of crack initiation takes place in weaker parts of the cement mortar and is usually finished after 5-10% of the total load cycles. The phase of stable crack propagating can be characterized by stable growth of initial cracks up to their critical length; this process is often described as micro cracking and takes place up to 80% of the total life cycles. The phase of instable crack propagation leading to fatigue fracture takes place in the remaining 10% of the total life cycles and sets on when the concrete is already saturated with a sufficient number of unstable cracks. These than unite themselves into one which can result into fatigue fracture. The development of these three stages of fatigue damage can be plotted on a "cyclic creep curve", which on the x axis shows number of cycles and on the y axis, strain or deformation.

Each load cycle woks on a concrete with slightly changed material characteristics, cracks do not close. Stress concentrations on the crack tips cause damage in every load cycle. Repeated load causes propagation of existing cracks and their linkage which can result into failure of the structural element, though the stress within in does not reach its static strength.

Only reinforcing steel can be checked for fatigue according to present Czech design codes. According to the ratio of stress in the reinforcing steel under permanent load and stress in the reinforcing steel under combined permanent and live load, a reinforcing fatigue coefficient is obtained, which then reduces the permissible stress in the reinforcing steel.

The Eurocode [3] gives a range of methods for fatigue verification of reinforced concrete structures, from simple methods based on equivalent stress range, up to sophisticated methods using Miner's rule.

The goal of this project was to verify the limiting slenderness of reinforced concrete bridges, for which the fatigue of concrete will not be a significant issue. A parametric study has been undertaken using simplified methods for verification of fatigue of concrete in compression. The bridges have been loaded by Eurocode Load model 1 [2] and checked for fatigue, ULS capacity and SLS requirements including crack width.

Single span reinforced concrete bridges are worldwide used up to spans of 20m with slenderness L/h=15. The parametric study showed that the limiting slenderness for the bridge to satisfy simplified methods, i.e. no need to use Miner's hypothesis, is only about 11 to spans under 10m and 9 for spans from 10-20m.

Double span girder is not effective, thus double span reinforced concrete bridges are not designed very often; anyway this system can be used for spans up to 20m. The parametric study has been performed and showed that the limiting slenderness for the bridge is about 10.5 though the design slenderness would be 15.

Three span reinforced concrete bridges with side spans smaller than the main span are used quite often for main span up to 40m and its slenderness form 15 to 20. For the most used side span to main span ratio 0.7, the limiting slenderness for the bridge is 13-15, depending on the reinforcement area.

Parametric study showed that the fatigue checks in the Eurocode are very conservative and can present a major obstacle in using reinforced concrete for road bridges although in some cases reinforced concrete is much more effective and requires less maintenance than prestressed concrete or steel-concrete composite girders.

Additionally, concrete deck of an expressway steel-concrete composite bridge designed according to Czech design codes has been checked for fatigue according to Eurocodes [4]. The check showed that the slender bride deck is not satisfactory in the lateral direction.

In the project theoretical analysis of the topic has been undertaken, parametrical study verifying limiting slenderness performed and a real structure checked for fatigue of reinforced concrete.

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Influence of Different Sizes of Specimens and Test Arrangement on Tensile Strength of Fibre Concrete

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The aim of this summary is to inform about the project and discuss the results gained from the tests performed in the frame of the project concerning the tensile strenght of fibre reinforced concrete, especially tensile strength in bending. Understanding of crack and fracture propagation and mechanical behaviour in tension of fibre reinforced concrete materials and structures is very important for esign analysis of structures. After forming the first crack in a critical section the behaviour of concrete and fibre concrete differs essentially. While a crack in the plain concrete propagates and tensile strength corresponding to required strain cannot be taken into account and tensile strength is neglected in the ultimate limit check, for fibre concrete it may be assumed that the critical section is capable to resist tensile strain; in the analysis residual tensile strength or equivalent tensile strength can be taken into account. One of the characteristics important for description of concrete fibre behaviour in tension is a rupture modulus i.e. the stress, at which the first crack occurs.

The strength determined from the laboratory test in bending is influenced by the size and the shape of test specimens, by the arrangement of the test and by the proper evaluation of he test. Nowadays testig specimens commonly used for determination of the tensile bending strength have the size of 100/100/400 mm or 150/150/700 mm for spans of 300 mm and 600 mm, or if there is a need prisms of 150/150/650 mm tested at span of 550 mm (RILEM), or of 450 mm (BEKAERT). In some cases the specimens are provided with a notch at bottom surface, the widths and depths of which differs according to the testing practice of the laboratory. The arrangement of the loading for the test is chosen between three point bending or four point bending. The arrangement with one mid-span force (three point bending test is used in the case of tests according the guidelines of the RILEM and the arrangement with two forces in the thirds of the span (four point bending test) provided in the harmony with the Czech Standard and the BEKAERT Company. The prism with a notch is used for failure of the specimen, for observation of the crack propagation and crack widths, as the notch predestines the location of the first crack.

The experiments designed for the purpose of this specific project were performed on the prisms of 100/100/400 mm and 150/150/700 mm. The smaller size was used for both three point bending tests and four point bending tests, the bigger one for four point bending tests only. The test specimens were produced from plain concrete and from fibre concrete with synthetic polypropylene fibres Forta Ferro with volume dosage of 1%, which means 9.1 kg/m³. Used fibres belong into the fibres group called Structural Synthetic Fibres intended for application in structural concrete members.

From measured values of destructive tests it can be summed up:

Tensile strengths in bending determined from the specimens of 100/100/400 mm in four point bending test are different for plain concrete and for fibre concrete with about by 15% (5,32 MPa; 4,60 MPa) better results for plain concrete.

The strength determined from three point bending tests on prisms of 100/100/400 mm is about 20 % higher than the strength measured from the four point bending tests on the same size of specimens.

Tensile strengths in bending determined from the specimens of 150/150/700 mm in four point bending test are different for plain concrete and for fibre concrete with about by 5% better results for plain concrete.

When compared the values of tensile strengths in bending determined from the specimens of 100/100/400 mm and of 150/150/700 mm in four point bending tests, the higher strengths are gained on smaller specimens (4,67 MPa; 4,09 MPa).

Slower values of strengths for fibre concrete can be seen in the changed structure of fibre composite material caused by bigger dosage of Forta Ferro fibres (1%). This conclusion can be confirmed by smaller value of volume density measured in fibre concrete (2 370 kg/m³ compared to 2391 kg/m³ for plain concrete).

The difference in measured values of strengths, with better results in three point bending tests shows the influence of location of the decesive cross-section.

The higher strengths measured on smaller specimen proved the influence of the size of crosssection of the test specimen.

From the stated results and observations it can be concluded: it is not proper to examine tensile strength in bending on specimens of various sizes and in various arrangements. It is evident that it is not possible to derive the values of tensile strengths of fibre concrete by means of conversion coefficients from the values of compressive strengths as it is usual in the case of plain concrete. Various types and amounts of fibres affects the material properties to the extent that relations between strengths cannot be simply expressed and should be tested all the time.

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Reliability enhancement of slender reinforced concrete members based on the computation

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EN 1992-1-1 [1] recommends for estimation of the second order effect on reinforced structures two simplified method and general method. Experience in practice shows that simplified methods give sometimes results significantly different to the exact solution obtained using the general method. In some cases the structure designed according to these simplified approaches might be significantly undersized, i.e. the reliability index is considerable lower than the recommended target value 3,8 of the reliability index applied for the 50 year design lifetime of common structures. Obtained results of internal forces and deformations are further influenced by way of application of the partial factors of materials in calculation model. For estimating the design resistance in the non-linear analysis of structure, it is allowed in Eurocode EN 1990 to use average values of resistance, which are further reduced by global safety factor γ_M , which is based on the coefficient of variation of resistance (commonly Lognormally distributed).

One of main aims of the project is to compare all above mentioned simplified methods for calculation of the second order effects [2] given in EN 1992-1-1 [1], and to develop the probabilistic solution of the general method for very slender structural members using numerical integration. The task was modeled in mathematical program Mathcad 13.1. Stress-strain diagrams of the reinforcement and concrete were adopted from EN 1992, pulled part of stress-strain diagram of concrete is considered as bilinear according to the Model Code CEB/FIP.

The analysis was carried out on the cantilevered isolated column, which was divided along its height on 18 identical elements. Using simplification given by EN 1992-1-1, 5.8.8.2(2), it is possible to demonstrate different restrictions in foundation. Simplification allows us to convert restrictions into internal forces along the cantilevered column.

For different slenderness and percentage of reinforcement, the statistic sets of extent n=30 are created using the program FREET and method Latin Hypercube Sampling – Mean.

The random variables are distinguished on geometrical and material variables. Geometrical variables include inclination of the column axis from vertical direction and concrete cover, among material variables belong strength of concrete in pressure, tension, strain limit of concrete, modulus of elasticity of concrete and yield strength of steel in tension.

The properties of basic variables are applied as input parameters. On the basis of Latin Hypercube Sampling and the program FREET, the resulting pressure and bending capacity are obtained that correspond to stage of column collapse.

Relevant probabilistic distribution of random variables and their parameters are adopted from Probabilistic Model Code of JCSS (Joint Committee on Structural Safety), the mean and standard deviation of the concrete resistance in pressure was adopted from publication [3]. Average values of basic variables are applied on analysis, therefore, the average resistance is obtained. For different slenderness ratio is determined the influence of reinforcement ratio on coefficient of variation of average load-bearing capacity. Based on reliability analysis it may be estimated the global safety factor, which is possible to be evaluated as the ratio between the characteristic resistance (corresponding to 5% fractile) and design resistance (corresponding usually to 0,1% fractile).

Global safety factor replaces the partial safety factors and it is easily applicable [4]. Up to now were analyzed only axially loaded columns with minimal eccentricity according to EN 1992-1-1 [1], 6.1 (4). The computation of the whole statistic set (about 270 values) was rather time demanding, therefore it was necessary to make the optimization of program in the beginning. It was found out that the global safety factor is dependent mainly on the slender ratio and reinforcement ratio, less on used concrete class.

It is shown on the basis of probabilistic methods that the application of simplified and general method may lead up to 20 - 30 percent different results.

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Experimental and Numerical Investigation Behaviour of Failed Structures Additionally Strengthened by Prestressed External Reinforcement.

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The goal of this experiment is to verify behavior of failed structures strengthened by prestressed external reinforcement. There is wide range of ways to strengthening concrete and masonry structures. The classic ways and classic materials are proofed and verified by practical use. Nowadays there are new materials with better mechanical characteristics, so it is necessary to develop corresponding methods.

One of these materials is fibre-reinforced polymer (FRP). This material is unique for his lightweight and high tension strength. Nowadays these materials are used for conventional reinforcing instead of steel. This method fully use lightweight of FRP (easy transport, easy manipulation) but cannot use high tensile strength of this material. To fully use all mechanical properties of FRP is better way to prestress it.

Making prestressed structures is known for a years, but all of these structures are new and they are not cracked. The business of reinforcing must work with damaged structures. In some cases is necessary repair and strengthened hardly cracked structures loaded close to its capacity. This structure has also big deflection. Theory and experiments with non-cracked structures shows that prestressing these structures can solve both problems (resistance of structure to additional load and big deflections).

Goal of our experiment is to apply a load near ultimate limit state, leave the load, prestress beam and apply load until strengthened member is destructed. Behaviour of concrete with prestress FRP bar is observed while load is applied. In addition, capacity of prestressed structure is measured. It is compared with theoretical backgrounds. The experimental beams are 2250mm long, cross-section is 165mm wide and 200mm high, concrete C20/25, simply supported with span 2.1m. Reinforcing steel is 2x2ØR6 and shear reinforcements is ØR6/200. The loads are two forces located at 1/3 of girder's span.

Design principle getting on philosophy limiting strain when will be need set down and verify size structure before thickness, e.i. in time application prestressed.

Sight on distribution strain inside of cross-section reinforced and prestressed element, that after application prestressing have to verify size of stress in upper face side, let us say after application loading write up stress in under face side. Prestressing may be design for full prestressed beam, but in most cases in part prestressed beam, when tensile stress transmit original reinforcement strengthened beam.

Using prestressed FRP strip fordize their taking advantage of tensile strength but 60 %, while bond strip is use for 15 as 20 % its tensile strength.

For mathematical model is used nonlinear finite element method. This is well supported by commercial software ATENA. It is a well-established finite element program for realistic computer simulation of damage and failure of concrete and reinforced concrete structures. In the program special constitutive models for concrete are employed:

Tensile behaviour of concrete is modelled by non-linear fracture mechanics combined with crack band method and smeared crack concept. A real discrete crack is simulated by a band of localized strains. Tensile softening (i.e. drop of tensile stresses after crack initiation) is assumed in an exponential form and is driven by fracture energy consumption. Concrete in compression is covered by special theory of plasticity with a nonassociated flow rule and compressive softening damage. It can reflect influence of lateral stresses to the compressive strength, so called confinement, which can play an important role in 3D and plane strain situations.

These material models are important and necessary to realistic simulations. The results of numerical simulation made by ATENA and real laboratory tests shows good equivalence. So, it is possible to use this mathematical model to next simulations. Main problem is to anchor prestress forces in FRP bar to cracked concrete. This calibrated model will be use to various simulations of anchorage area of a FRP bar in drilled fold.

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Prediction of fire resistance of prestressed panel

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This paper describes determination of fire resistance of prestressed concrete slab SPIROLL. Prestressed panels are excellent solution in usage for large span slabs. They have small thickness and cove large span with small amount of reinforcement. Being lightened with holes and reinforced with prestressed cables, the slab is very slight even if the span and load are considerable. The deformations are small as well. After the evaluation at ambient temperature, they are checked at elevated one under fire design conditions to provide adequate fire resistance, see (Wald, 2005).

The concrete panel SPIROLL SPW 718/20 05 was analysed to compare the design model to test. The panel is 200 mm thick and has trapezoidal section. There are six cavities in it and the element is reinforced with five prestressed cables Fe 7S 1770 12,5 mm with low relaxation. The panel is designed from concrete B55. Fire resistance of this panel according to provider's data should be from 45 to 90 min. It depends on the type of the panel, its reinforcement and on the ratio of load. The panel is simply supported, at experiment.

The code TCD 5.0, provided by Swedish company FSD International AB, was used for analyse, see (Anderberg, 1999). This program solves two-dimensional temperature field of specific cross-section with finite element method and also calculate resistance of the cross section under elevated temperature based on the material reduction factors. In the program was defined the following input: silicate concrete with humidity 1,5 %, material characteristics according to EN 1992-1-2. The increasing temperature is considered according to nominal standard time-temperature curve on the lower face of the panel. The constant temperature 20°C was assumed on the upper face.

Other inputs included geometry and corresponding boundary conditions. The material strength and its reduction with elevated temperature were defined for evaluating of the resistance of the element. The position of prestressed cables and its characteristic were defined for the last step of calculation.

Within first step of calculation the cross section was heated, see (TCD, 2005). Results of this part of analyses are the temperatures in several points of cross section during of heating. We also plot temperature fields and isoterms for different times of heating.

Within second step of calculation was determined curve of decreasing of fire resistance. This curves shows the decreasing of moment capacity.

Designing of load bearing capacity was simplified according by reduction factor of $\eta_{fi} = 0,7$; where η_{fi} is the ratio of design effect of actions for normal temperature design to design effect of actions in the fire situation, see (Buchanan, 2003).

The level of the resistance 70 % was reached in time 53 minutes. This relates to the reduction of the resistance of the prestressed cables due to elevated temperature.

The predicted fire resistance is to check against results of two fire tests of panels SPIROLL SPW 718/20 05. The fire resistance of the first one was 65 min and the second one reached 74 min. The fire resistance during the test is evaluated based on the deformation criteria according to the standard EN 1365-2: 1999. The limit state of the fire resistance is reached by two conditions concurrently: the deformation limit and the limit of the speed of the deformation.

For the elements in bending is the deformation limited by the deflection of $D = L^2/400 d$, in mm, and simultaneously by the speed of deflection of $dD/dt = L^2/9000$, for d in mm · min⁻¹. Where L is the clear span of the tested beam, d is the distance between the end fibres in compression and in tension of the observed section in mm at the ambient temperature. The criterion of the speed of the temperature is taken into account after the deflection reaches the value L/30.

By the calculation was is observed the fire resistance of 53 min at the level of utilization of $\eta_{\rm fi} = 0.7$. The experiments approved the fire resistance of 65 min. The prediction is conservative of about ten min, which is caused by taking into account the standard characteristic material properties instead of measured ones.

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Influence of Fiber Reinforcement Volume in Concrete Member on Crack Development and Crack Width

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Test of concrete members reinforced with fibers and steel bars have no basis in current standards now. There is some reference in RILEM guideline but only for steel fiber concrete. Purpose of IGS 2006 project was to design the test examining crack development, crack width and bond. The aim of the project was a selection of convenient shape of specimens, suitable for wide range of concrete mixtures with different dosage and types of fibers. For this test accessible laboratory equipment should be used in Department of Concrete and Masonry Structures. Next step was to design repeatedly used forms for production of specimens. The objective of the project was verification of possible production of specimens and implementation of designed test into laboratory practice after evaluation of results.

The basic problem with tensile test of concrete is an application of tensile force. Common used specimens are sensitive on precision of production and mainly during own testing. The greater problem is to take hold jaw of the machine producing tensile force and concrete specimen without an eccentricity. This problem is often solved by specimens shaped as a bone with enlargement on the ends or with gluing. Results could be influenced by the size of the test elements too, as it is difficult to choose between good manipulation and proper size of specimens. Larger size minimizes influence of local hardening or softening and material characteristics reach smaller values than in case of smaller specimens where aggregate and reinforcement have normal size. When the dimensions are too small, orientation and position of fibers is affected by closeness of member surface.

Next possibility is to use an inbuilt steel bar for application of tensile force. The force is taken into the member linearly and the coated part of bar is damaged on whole length. In this test the tensile strength is not the main attribute to be observed but it is width of cracks and theirs spacing. Is is expected that concrete without fiber reinforcement will show less wider cracks than concrete with added conventional reinforcement. Crack width should decrease and number of cracks increase with greater dosage of fibers in the mixture.

The first specimens made for pilot testing had dimensions of 50x50x500mm and were made in six modifications, from plane concrete, fibre concrete with addition of steel and synthetic fibers. Inbuilt bars were of two steel grades (10 505 and 10 206) with diameter of 6mm. All of these specimens were tested on machine for tensile testing of steel bars. The results had shown unsuitable selected dimensions and chosen steel rods. In cases of fiber reinforcement concrete the steel bars from 10 206 were broken outside of the coated part without concrete failure so the grade of steel is not suitable for the next testing. The others were close to the expected results but occurrence of crack could be affected by shortness of coated part. Anchor length could be comparable with the whole length of the specimens or their essential part what means that cracks appear less than it is necessary for good influence of fibers.

The following specimens had dimensions of 75x75x800mm what should ensure better appearance of cracks and take note of concrete coverage. For the second test a new form was designed which made possible to produce four specimens at a time. This solution is eliminating 546 problems with close surface of the member related to the length of fibers. Mixture of concrete was C25/30 in three modifications: Plane concrete, concrete with admixture of 0,5% steel fibers and concrete with admixture of 0,5% synthetic fibers. Steel bars were only of 10505 grades this time and two diameters 6 mm and 12 mm. Twelve specimens were concreted. It was necessary to cut a concrete member into single specimens by saw before testing, this was made after 15 days. Own test was made after 28 days. Specimens were painted with white colour for better visibility of the cracks. The test was performed on the HACKERT machine for tensile testing of steel bars.

First members with 12mm steel bars were tested, these members have very good behaviour and the positive influence of admixture of fibers was evident. Then members with 6mm steel bars were tested, this set has showed the same problems as in case of the first type of specimens with 10 206 grade steel. Steel bars were broken outside of coated part and concrete shows only a few cracks not corresponded with expectations.

The designed form and used method of testing is capable to tell us more about influence of fiber reinforcement on concrete behaviour. For the precision of results it will be necessary to carry out more tests for statistical evaluation of the results.

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Prestressed concrete bridges with stiff suspension walls

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Prestressed concrete bridges with stiff suspension walls are special type of the "extradosed" bridge structures, where prestressing cables upon internal supports are situated outside the cross-section in suspension walls. It is modern bridge structural type, possible to use for length of the main span more then 100 meters. Within this project were made two particular statical analyses of two arrangement of this structural type.

There are basic two differences between cable-stayed bridges and extradosed structures (generally, bridge structures with stiff suspension walls are special type of this structure, where cables are situated inside these stiffening walls). The first one is the height of the pylons (walls) - for extradosed structures it is about 1/10 L (the length of the main span), for cable-stayed bridges it is about 1/25 L. The second one is the cardinal statical behavior and prestressing arrangement. The function of cables in cable stayed bridges is only elastic supporting of the structure elements (compressive axial force in superstructure's elements as a reaction of hangings forces in cables). Whereas cables in extradosed structures are common prestressing tendons situated outside the cross-section (high eccentricity). This arrangement of prestressing tendons is very beneficent, because total effect of prestressing is given only by the rise of parabolas their shapes (Gyom theorem). In case, that tendon is situated out of crosssection upon internal support area, it is possible to design its shape as parabola with high value of the rice (due to line connected theoretical place of the anchorage at the end of the bridge and the end of the parabola upon internal support). Substitutive continuous load is function of this parabola's rice. For the higher value of rice is also higher value of the loading. Suspension walls are also very effective for the increasing of total stiffness of the structure. Due this fact is possible to design relatively slight cross-section of the superstructure, for example for highway bridges one cross-section for the both directions with suspension walls situated in the middle of the structure.

The first analysed structural layout is continuous beam with five spans -17,0+30,0+15,0+15,0 meters. The cross-section is designed as the slim deck with three point supports in transverse direction. The cross-section width is 28,8 m, for both highway lines. The external supports are situated relatively far from the end of the structure, the length of the cantilevers is 9,1 m. Due to this, also effect of transversal prestressing was analysed. Prestressing tendons of this structure are divided to two basic branches. The first are cables situated by their all length inside cross-section. These cables were applied immediately after concrete hardening to reduce stresses from the structure's weight. The second are cables situated in suspension walls. These tendons are applied after construction finishing to reduce stresses from the rest of dead load and imposed load. This structural layout was compared with two others – arched bridge with down level superstructure and the composite structure (precast T-section beams with monolithic deck). Total value of concrete is lower for structure with suspension wall,

also the aesthetical view is much more favourable. Disadvantage of this layout is complicated shape of the "wall" tendons and more exacting construction in generally.

The second analysed structural layout is continuous beam with four spans -45,0 + 70,0 + 70,0 + 45,0 m, with two system of the suspension walls upon internal supports. The croos-section is design as a box girder with precast struts and ties for distribution of forces from prestressing tendons in the walls. Arrangement of the prestressing (subdividing to the group) is the same as in the previous example.

Detailed statical analysis was made for these two examples. Combined wall-deck model and normal beam model was used. Effect of prestressing layout (tendons situated outside cross-section) was very rigorously examined.

Bridge structures with stiff suspension walls are effective solution for lengths of the main span about 30-80 m. It is possible to use this structural layout in case of small construction high of bridge (low difference between communication level and passing inhibitions). Also aesthetical view of these structures is very good. Analysis of the statical behaviour is relatively very difficult, but due to structural severity, it is important to do it closely.

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Composite Truss Steel and Concrete Structures

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Experimental investigation of two steel and concrete composite truss girders is described. Perforated shear connector was used to reach full shear connection. Experimental results are compared with simple theoretical analysis according to Eurocode 4 and serve for calibration of non-linear 3D numerical FE model formulated using ANSYS software package. The pilot parametrical study of shear distribution at the shear connection is presented for various shear connector strength and rigidity based on push-test results performed recently at CTU of Prague. The distribution of shear above truss nodes and along the connection is analysed both in elastic and plastic region. Possibility and extend of plastic redistribution of the shear flow is discussed in relation to degree of partial shear connection and rigidity of the connectors. Finally some recommendations for practice are given.

Two full-scale composite girder bending tests were performed (span of 6000 mm, steel truss with hollow web sections). Basic perforated shear connector designed at CTU in Prague [1] was used to reach full shear connection with level of $\eta = N/N_f = 136$ %. Steel part was made from steel S235JR (f_y from coupons detected between 329-376 MPa), and concrete slab of size 1500x80 [mm] from concrete C 25/30 ($f_{c,cyl,EX1} = 23.7$ MPa, $f_{c,cyl,EX2} = 24.2$ MPa).

Testing of both experimental girders was controlled by hydraulic jacks. In the first phase (elastic behaviour) the girders were loaded in steps and always subsequently unloaded to value of 5 kN. Afterwards the gradual increase of loading led to girder collapse (transverse crack of concrete slab at midspan) at load value of 138.5 kN (EX1) and 122.3 kN (EX2) per hydraulic cell. End slips were practically zero. Small end slips confirm high resistance and low ductile capacity of the perforated shear connector with introduced full shear connection.

Experimental results were compared with simple theoretical analysis according to Eurocode 4 and non-linear 3D numerical FE model formulated using ANSYS software with beam (BEAM24), shell (SHELL43), concrete 3D (SOLID65) and non-linear spring elements (COMBIN39). All steel finite elements enable elastic-plastic analysis (furthermore with large deflections), concrete elements involve smeared reinforcement, crushing and cracking (for shear transfer in opened and closed cracks were used coefficients C1=C2=0.5).

Theoretical elastic and plastic capacity and elastic deflection at midspan according to Eurocode 4, with real material properties and full composite action, corresponds with test results and Ansys FE modelling. Analytical calculation takes into account reaching of yield stress in upper chord of steel truss. Test strengths (both elastic and plastic) correspond well with standard theoretical values and Ansys FE modelling.

The numerical model was used for pilot parametrical study of shear distribution at the connection between concrete slab and steel truss. The studied girder represents a secondary floor beam. Numerical analysis of Warren composite truss with span of 13.5 m as performed using software package. Various data concerning shear connection were investigated. Pilot parametrical study covers examples labelled L1 - L10 having various strength and ductility, starting from L1 (full shear connection, high ductility) to L10 (partial shear connection, low ductility). In total 10 variants of shear connections was studied, having various load-slip relationships in accordance with research [1].

Shear connection was modelled by non-linear springs located uniformly in distance 100 mm along span and placed between upper surface of perforated shear connector modelled with reduced height "basic perfobond shear connector" and concrete slab. Vertical and transverse displacements of concrete slab (perpendicular to the girder axis) in place of springs were defined the same as for the shear connector.

Preliminary conclusions on distribution of shear flow between concrete slab and steel truss may be presented based on results of the pilot parametrical study.

Within elastic behaviour of shear connectors the distinctive peaks in shear flow above nodes of the composite truss occur even under uniform loading of the girder. While numerical solution leads to complete description of shear connection behaviour along all span and redistribution of shear forces. Practical example [3] confirmed, that approximate solution according to Eurocode 4 gives good approach to estimate higher shear above truss nodes. This may be important especially for connectors loaded in fatigue (bridge composite trusses, see [2]).

Within plastic behaviour of shear connectors the plastic redistribution of shear loading can be envisaged depending on connector's $P-\delta_s$ diagram. In the case of full shear connection the amount of redistribution depends on massiveness of the shear connection. For very strong shear connection the redistribution is low and loading of connectors in nodes area is very high in absolute value. For full shear connection approaching to plastic resistance of the girder a noticable plastic redistribution may be expected with vanishing of shear peaks above truss nodes.

In the case of partial shear connection the sufficient ductility of shear connectors is important (e.g. such as defined in Eurocode 4, i.e. $\delta_{uk} \ge 6$ mm), otherwise the resistance of the composite truss decreases significantly even if the strength capacity of shear connectors remains the same.

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Stability of Glass Structures Subjected to Bending

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Introduction

Glass is a material that has been used for a long time in windows as a filling material and has much to offer in this regard due to its very high compressive strength and transparency. For this reason, there is a growing trend to extend the use of glass sheets to load carrying elements such as beam, columns and shear panels. Due to their high slenderness and high compression strength, such load carrying elements tend to fail because of instability (e.g. column buckling, plate buckling or lateral torsion buckling). Existing design methods for other materials, such as the use of buckling curves for steel, cannot be directly transferred to glass, because influences of the following aspects must be investigated in a different way for glass: production tolerances, initial deformations, the ideal elastic material behaviour without plastic deformability or strain hardening effect as is the case in steel, and the ultimate breaking stress in glass, which is not a material property but depends on the embedded compressive surface stress due to the tempering process, the degree of damage of the glass surface and composite behaviour between glass and PVB interlayer, which depends on the temperature and load duration.

This research is focused on the last case of instability - lateral torsion buckling. Earlier studies showed that the buckling strength of structural glass elements is always limited by the tensile strength of the glass surface. A design concept with lateral torsional buckling curves based on slenderness ratio similar to the design of steel is not useful for glass, because the slenderness ratio must be defined in terms of the tensile strength. But it is possible to define a slenderness ratio $\overline{\lambda}_D$ and a reduction factor $\chi_D = f(\overline{\lambda}_D)$, which are based on the tensile strength. Then the maximum bending moment is dependent on the reduction factor. For different types of loading, glass geometries, shear modulus of PVB interlayer and initial deformation reduction factors can be generated in buckling diagrams. These diagrams may serve as a preliminary orientation in determining lateral torsional buckling curves for glass.

Experiments

Lateral torsional buckling tests on single layered and laminated glass are carrying out. For the test setup a simply supported beam with overhanging ends is subjected to a concentrated load on the ends of the beam. The beams are 3000mm long and the supports are situated 650mm from the ends of the beam. The main difficulty was the load application that had to prevent the lateral displacement and inclination of the ends of the glass beam. To allow only vertical displacement of the end section of the glass beam the gantry bar couple was connected to the load application mechanism and the additional column. During the tests the stress distribution on the glass surface is controlled with strain gauges. The lateral and horizontal displacement and inclination of the section at mid-span are measured too. 12 beams with depth of section 360mm and width 8,10,12 mm from single layered glass and 12 beams with the same dimension from laminated glass are prepared for testing.
Properties of PVB-foil

The interlayer of laminated glass beams is mostly consisting of PVB-foils. PVB-foils have a significant visco-elastic material behaviour that is characterised by a time and temperature dependent material stiffness. Special tests were carried out in RWTH Aachen to receive available data of material stiffness of PVB-foil. Results of these tests will be used for evaluation of test carried out in CTU in Prague.

Experiments were carried out in this way: The test specimens were distorted to a constant angle and the torsional moment was measured over the time. The tests were carried out for different loading durations and different temperatures. By using the equations derived by the extended bending and torsional theory the effective PVB-foil shear stiffness $G_F(t,T)$ was determined depending on the angle and torsional moment. Experiments showed it is possible to describe the time and temperature behaviour of the PVB-foil by using this formula: $G_F(t,T) = 0.008*(100-T)-0.0011*(50+T)*log(t)$, where T is temperature [°C] and t is time[sec].

Numerical study

The software package ANSYS 8.0 was used for the numerical analysis. Beams and supports were modelled using shell elements. Full Newton-Raphson geometrically and materially nonlinear procedure was used in the analysis, the large deflection effect wasn't used. A number of alternative boundary conditions was tested until the model corresponded to the specimens.

The shell element SHELL181 was used for the modelling of the beams. To give a true picture of influence of real support constructions on the model the real support from the steel and polyamide belt was created. The CONTA174 element was used for the modelling contact elements and TARGE170 for the target elements. Boundary conditions were defined according to the real test specimen arrangement. Load was applied as concentrated loads on the top side of the beam.

Comparison of Experimental Results and Numerical Study

Results from numerical model and from experiments will be compared. Then it will be possible to carry out the parametric study.

Results of Study

Continuing experiments should better the knowledge of behaviour of glass beams subjected to bending and show influence of properties of the PVB foil, types of loading, glass geometries and initial deformation on the maximum bending moment. The results of the experiments could serve as a preliminary orientation in determining lateral torsional buckling curves for glass based on the tensile strength of glass.

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Load capacity of perforated shear connector

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The important attribute in composite structures is shear connection which provides transmission of shear forces between concrete section and steel profile. Different types of connector used for composite structures were developed during last years. At present the following connectors are mainly used. Welded headed studs belong to the most popularly ones due to their high load capacity and deep knowledge of their behaviour under static and repeated loading which is included in EC 4 [1]. Main disadvantage of their usage is possibility of creation and initiation of fatigue crack under cyclic loading which is incurred by performance of weld. The HILTI bracket technology developed by HILTI Corporation is used mainly for short and middle-span structures and requires portable installation equipment only. The installation cost of brackets is little higher in comparison with welded studs. The bracket connector's usage is limited due to its relatively lower shear resistance. Last one, perforated shear connector was developed to eliminate drawbacks of mentioned connectors such as poor fatigue performance of studs and lower shear resistance of HILTI connectors. The perforated shear connector is a flat plate including the open and closed holes and concrete which flows through those holes forming dowels that provide resistance in the vertical and horizontal direction. The reinforcement bars placed in the open holes in concur with surrounding concrete dowels could improve transfer of longitudinal shear forces between concrete slab and steel profile. The main advantage of this type of connector is its high shear resistance and good fatigue performance.

The shear connector properties and behaviour are based on experimental investigations of push-out tests according to EC 4. Two mainly types of perforated connector were developed and tested at CTU in Prague at 1994. First one, called basic connector could by used mainly in composite beams in building structures. Next one, called high connector was designed for bridges or long-span beams in building construction.

The possibility to use a standard reinforcing mesh 100x100 mm was reason to small modification of basic connector as: the distance of holes was changed from 45 mm to 50 mm. A 3 push-out tests under static loading have been carried out by the Standard. The results of experiments with above connector are comparable with range of results obtained from previous testing of basic connector [2]. The observed slip, if the reinforcing bars are placed into the open holes only, is approximately half in comparison with reinforcing bars placed into the closed holes. But the important conclusion of experiment with modified basic connector is that formula derived for basic connector is also capable to really good prediction of connector's shear resistance.

Comparison of 3 tests results is shown in following Table 1.

No.	Reinforcemen t	Concrete compressive strength		Shear resistance	Load capacity	Slip	Characteristi c slip
	A _{st}	f _{ck,cyl}	f _{ck,cub}	P _{R,exp}	F	δ _{0,9}	δ_k
	[mm ² /mm]	[MPa]	[MPa]	[N/mm]	[kN]	[mm]	[mm]
1.	0,25	42,065	57,349	678,0	800	1,821	1,638
2.	0,25	42,065	57,349	635,6	750	2,142	1,927
3.	0,25	42,065	57,349	635,6	750	1,96	1,764

Table 1. Values of shear resistance and measured slip.

Experimental research isn't mainly part of research with perforated shear connector at CTU. The modern trend of theoretical research is based on usage FEM software. The main goal of modelling is to prepare model which would by able to determine load shear capacity and slip between steel and concrete sections using different strength of concrete, alternating parameters of connector and different type of reinforcement. At present three versions of FEM software have been used to find best solution in numerical modelling [3].

Last numerical model is prepared in FEM software ATENA by first author of this paper and results will be expect in near future. Program ATENA is especially focused on reinforced concrete structures from materials of concrete and steel. The main goal of the model with modified basic connector is estimating the reciprocal slip between steel section and concrete slab. Author will try to calibrate models results with experimental values. Numerical modelling is compounded from two parts; first one is based on creation of geometry by procedure called pre-processing in program GID. GID is a general program for variety of numerical problems developed at UPC Barcelona. Second step will be the main calculation in program ATENA which is still developing by Czech IT Company Červenka Consulting.

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Residual Stresses of Austenitic Steel Hollow Section Members

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In last years stainless steels are becoming common in the construction industry and their use has grown significantly. The project is focused on research into shape and size of residual stresses in cold formed longitudinally welded square/rectangular hollow sections (SHS/RHS) made from the most common austenitic steel grade 1.4301 and their influence on strength capacity of the members. The results of the project will enable to formulate universal simplified shape of residual stresses in austenitic steel square/rectangular sections for potential further numerical analyses (column behavior, fatigue etc.).

The residual stresses were measured both by non-destructive X-ray diffraction method and destructive sectioning method, the second one for verification of results.

The common result of the X-ray diffraction measurement is a stress in a thin (5-10 μ m) surface layer. The X-ray beam used within the project had always diameter of 1,8 mm. The high gradient stress parts, i.e. corner and weld areas, were measured with a high density of measured points. For through thickness stress gradient the electrolytic removing technique was used. Comparing use of the technique for mild carbon steel and austenitic steel, here it was more time-consuming. The volume of material taken away compared with the whole sample is negligible which justified belief that the redistribution of stresses is also insignificant. Due to big grains of the austenitic steel material the diffraction pattern was sometimes not fully correct despite 10 mm oscillation of X-ray beam along the specimen axis.

The results show that the residual tension area in vicinity of weld of the investigated stainless steel RHS 100x80x2 mm is larger than in common mild steels. The results at point situated in centre of the weld showed average longitudinal tension stress of about 170 MPa and the point located at distance of $4t_w$ from the centre of the weld showed average tension stress of about 120 MPa. Tension residual stresses inside the thickness are in equilibrium with the compression ones both within the thickness and along the cross-section.

The transversal surface residual stresses (perpendicular to the longitudinal axis of the RHS) significantly grow near the corners and taking into account the transverse through thickness residual stress shape estimated by Key and Hancock [1] on mild steel SHS this indicate an increase of flexural transversal stresses in the corner area. Further measurements are in progress to confirm such hypothesis.

The sectioning method is in progress and results will be presented soon. For measurement of relaxed elastic strains on each stripe a couple of strain gauges were used, covered with 0.05 mm aluminum foil coated with 3 mm thick kneading compound. Cutting of stripes was made with thin disk cutter. The membrane and flexural residual stresses were measured on three sides of the SHS (welded, perpendicular to welded and opposite to welded) with four (SHS 100x100x3 mm) or five (SHS 120x120x4 mm) stripes for longitudinal residual stresses and one stripe for transversal stresses for each web.

A large experimental programme for testing of 14 stub columns is designed. The SHS columns have web width ranging from 60 to 120 mm and web thickness from 2 to 4 mm. The length of specimens is equal three times web width and numerically was proved no influence of global buckling. The series covers also annealed specimens to exclude influence of residual stresses. Stub column tests are designed in accordance with Galambos [2] recommendations. Two inductive gages as well as strain-gages in each corner are used for recording the force-deflection relationship. On both ends of specimens the plate corners were grinded off to allow for free rotation in supports.

Geometrical imperfections along sections were measured with a special jig with centesimal graduation dial gauge.

The stub column tests will serve for calibration of FEM full Newton-Raphson GMNIA numerical model created in general software package Ansys. To model a stub column section the SHELL181 elements were used. This element has four nodes each with 6 degrees of freedom, linear shape functions and is recommended for large-strain analysis. The analysis enables to use non-linear stress-strain relationship and introduction of residual stresses. The main advantage of this element is modeling in layers. For each layer a unique value of residual stress is possible to set. An influence of residual stresses through thickness) may be estimated within the analysis.

For simulation of conditions at supports the SOLID45 and COMBIN7 elements were employed. These elements were used to model duly an influence of hinge under load jack. For saving of processor time the symmetry of the model (all in length, section and shape of residual stresses) was used and only one half of the section was modeled.

In addition to residual stresses, the model includes geometrical imperfections (initial deflections), non-linear stress-strain relationship and enhanced strength corner properties to obtain relevant solution. Temporary the nominal compound material stress-strain diagram recommended in EC3 [3] and Gardner and Nehercot recommendations [4] for corner area and local imperfections are used.

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Trapezoidal Sheeting Acting as Multi-span Beam

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Introduction

Trapezoidal steel sheetings are modern building members, which are frequently used for floor, wall and roof structures. These members are sensitive to local buckling and to web crippling if the profile is subjected to concentrated load. In area of internal support of continuous beam the interaction of bending moment and concentrated load occurs, causing redistribution of bending moment to span areas. After yielding and/or buckling at the internal support, "plastic hinge" action occurs, possibly accompanied by a reduction in the moment of resistance, until failure takes place when the full moment of resistance is attained within the span. Because the mid-span moment of resistance is often greater then the (reduced) moment of resistance at a support, the increase in the ultimate load as a result of this moment redistribution can be considerable [1]. General calculation procedure for determination of actual value of support bending moment does not exist. The present state of art requires either testing or quasi-elastic design based on the calculated moment of resistance at the internal support.

Design equations described above-mentioned behaviour of cold-formed steel members (web-crippling strength and interaction web-crippling and bending moment) have always been empirical formulas developed by curve-fitting of experimental data (Tsai and Crisinel [2], Hetrakul a Yu [3], etc.). These design equations have been put in the specifications (AISI, Eurocode 3, Canadian Standard, etc.) but do not give value of moment redistribution at the internal support.

The redistribution of moment at the internal support depends of many factors. Section type, cross sectional parameters, bearing length and loading conditions are major factors that affect load capacity of cold-formed trapezoidal sheeting acting as multi-span beam.

The main aim of the project is the development of the method to the determination of the rate of redistribution of moment at internal support. This aim will be reacted with help of experiments and modelling this problem using by finite elements.

Experiments

A set of experiments will be carried out in the laboratory of CTU in Prague to determine the distribution of bending moment on trapezoidal sheeting acting as multi-span beam.

A profiled sheet, continuous over two equal spans, will be used (double span test). Two lines loads will be applied to each span, arranged to produce internal moments and forces that are appropriate to represent the effects of uniformly distributed loading. The length of span of specimens will be ranging between 2 and 4,5 meter. Loading will be static with displacement control. Various values are: type of trapezoidal sheeting (TR50/250, TR100/275), length of span (between 2 and 4,5 meter), thickness of steel sheet and width of internal bearing plate (between 40 and 200 millimetre). During testing the internal reaction,

web-crippling deformation of specimens over internal support, deflection of specimens at mid-span and relative deformation in the specific location on the cross-section will be measured as a function of acting load.

Numerical Study

The software package ANSYS 10.0 was used for the numerical analyses. Various finite element models were made for this case. The trapezoidal sheeting was modelled using shell elements. Because the failure modes are symmetric, in order to save solving time, only one quarter of one wave of trapezoidal sheeting was modelled. Contact between the sheeting and load bearing plate was the same as it will be 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 was tested until the model corresponded to the results, which were verified with results of Hofmeyer's experiments [4]. The shell element SHELL181 was used for the modelling of the sheeting, solid element SOLID45 was used for bearing plate. A contact pair was created between the sheeting and the load bearing plate, to prevent the penetration of material: the CONTA173 element was used for the modelling contact elements and TARGE170 for the target elements. Boundary conditions were defined according to the real test specimen arrangement. Load was applied as displacement of the load bearing plate.

The developed model corresponds to comparative case [4], the difference of bearing resistance for all compared cases is up to 12%. The model was verified with results of other authors as well with satisfactory results.

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Horizontal loads between overhead bridge crane and the crane runway

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Introduction

In the present there are various design procedures to calculate the horizontal loads between the bridge crane and the crane runway that arise from skewing of the crane – e.g. a procedure according to Hannover [1], Forestier, Chocharin, or Lobov [2]. Some of these methods served as a basis for normative design procedures, e.g. EN 1991-3 [3] is based on the works of Hannover. When the given design procedures are compared, there can be found significant differences both in physical models of skewing of the crane and the calculated horizontal loads.

Dynamical Model

In 2005 the grant solver constructed a dynamical model of a crane to analyze behaviour of the bridge crane during its acceleration and therewith to obtain also the magnitude of the given horizontal transverse loads. The model consists of rigid bodies that are connected with equipollent springs that represent the flexibility of the system. The equations of motion of the model are constructed by means of Lagrange's equations of the 2nd type. The model is analysed in detail in [4].

The model is constructed under certain conditions. The system damping is not taken into account as the magnitude of damping is of minor importance with the steel structures and difficult to measure. The crane runway is considered as rigid, the geometry of the crane is considered as perfect. The model is to be constructed with only wheel flanges on one side of the crane. The model will serve to analyze the behaviour of the crane during its acceleration, when the crab is in its extreme side position. The points of interest are the horizontal loads acting on the crane runway girder which is on the same side as the crab. The wheel flanges are to be considered on this more loaded crane runway girder. This case can occur in practice when the wearing of the flanges is considered.

Experiments

In order to measure the real behaviour of the crane during its acceleration, an experiment on a real crane was planned and performed during 2006. The experiment was performed on an outside overhead bridge crane, that was moving on the crane runway. The period of operation of the crane was approximately 5 years in two-shift operation.

The acceleration of the crane was measured. The crab with the load was in its extreme position. On the more loaded side of the crane (the side of the crab position) there were wheels with the wheel flanges, on the other side wheels without flanges.

During the experiment horizontal transverse loads between the wheel of the crane and the crane runway were measured. Further the driving moment and revolutions of the engines during the acceleration of the crane were measured. The driving moment and the revolution of 560

the engines were measured on both sides of the crane. Another quantity measured was the transverse shift of the wheels of the crane with the flanges.

In order to perform the experiment, it was necessary to produce devices for measurement that were equipped with strain gauges, calibrated and consequently mounted on the crane.

In order to measure horizontal transverse loads a device which consisted of two parts was constructed. The first part was mounted on the transversal beam at the wheel position and it became a component of the transversal beam. The second part was mounted on the first part and it consisted of two vertical thin plates. The crane wheel was supported by these plates. These plates were designed so that they could carry the self-weight of the crane and meanwhile to measure the horizontal transverse loads between the wheel and the crane runway.

The driving moment of the engine was measured by means of the reaction that arises between the engine and its fixing. The original fixing was removed and replaced by the part that was mounted on one side to the transversal beam and on the other side to the engine. The mounting of the engine was done by means of the flexible plate that was equipped with strain gauges and designed so that it could measure the magnitude and time behaviour of the reaction of the engine.

The revolution of the engine was measured by means of speed voltage generators, measuring the voltage. The generators were mounted on the back cover of the engine and on the drive shaft of the engine by means of the component part that enabled this mounting. The measurement of the transverse shift of the wheels with the wheel flanges on the rail was measured by the sensor of the movements. On the transversal beam of the crane the component part was mounted with the sensor of movement. The rod of the sensor was equipped with the bearing and was pushed against the rail.

Lange number of different cases was simulated during the measurement. The position of the crane load, the acceleration period of the crane, the crane position with respect of the supports and the crane speed served as variables during the experiment. All measured quantities were recorded as functions of time. The examined behaviour of the crane was in accordance with the dynamical model.

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Rehabilitation of Timber Structures with Reinforced Epoxide Resin

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Introduction

Timber structures can be very complex in their composition and state of conservation. The first aspect is typical of the material: high variability in terms of wood species, type of treatment, sapwood and heartwood distribution and amount of defects affect the physical and mechanical properties of the wood as well as its natural durability. Because of its organic nature, wood is exposed to biological attack from fungi and insects. This type of decay is not always easily visible and may be difficult to detect. The damage is different depending on the type of organism that attacked the wood, the extension as well as the location of the damage within the structure. Often the damage is concentrated in one point and requires a less taxing intervention that does not entail the complete substitution of the piece.

Restoration of timber structures by epoxy resin

The restoration of timber structures in historic buildings is a major concern for conservators. The choice of repair technique is made according to the need for strength in the repaired timber in different ways. This choice can be affected by the limited accessibility for tools to in situ timbers. The existing timbers will also be old and harder to work than new parts being prepared on the bench from new green oak. One of the most acceptable methods for structural rehabilitation is the installation of reinforcing elements, embedded in epoxy glues. However, such a technique should be performed following a correct procedure for the application of the materials. In particular, the durability of the intervention is strongly dependent upon both the quality of the interface formed between the adhesive and the reinforcing material (e.g. rods, plates, etc.).

Technique of glue-in steel rods

The decayed beam end is substituted with a seasoned solid wood element which is connected to the sound part of the beam by four steel rods, glued with a component epoxy adhesive into slots.

At the first time support the decayed beam end and breach the wall, cut the beam and remove the decayed part. The beam end will be splay cut to avoid shear forces being transferred to the reinforcement as a transverse load. The recommended splay angle α (measured from the horizontal) is generally between 45° and 60°. The top is cut vertically to allow the flexural compressive force to be directly transferred. Failure to do this generates a force parallel to the splay cut, where is the total compressive force at the section. This force would then have to be resisted by the reinforcing bars as a transverse load.

Than we prepare seasoned timber elements of equivalent (or better) quality and durability of the existing wood. It is important that wood moisture corresponds to the expected moisture content in service (in any case the moisture content of the new timber should not be greater than 6% of that expected in service). Next we drill holes in the beam and in the new timber element (the surfaces of the holes should be clean cut), and glue the rods in place (ensure that

the hole is completely filled with adhesive). Once the adhesive has cured, reconstruct the breach, remove the supports and finish the wood surface.

Experiments

The purpose of this work is pilot experiments. In 2006 was made some series of experiments, where was used epoxy resin CHS-EPOXY 517 with filling agent. Filling agent in epoxy resin is silica sand ST 10/40 in rate 1:7.

Sample piece number EP1C is large 100x100x100 mm and it was pressed in pressure on the machine EDBU400 and EU 40. Sample piece mark like EP2T is 7x25 mm huge. Breach of sample piece by pressure occurred with load force 376 kN (\approx 40 MPa). With straining of tension was sample piece destroyed with action of the force 0,7kN (\approx 4 MPa). These qualities are average from three sample pieces of every type experiment.

Next experiment was extraction of steel bonded-in rods from cube of epoxy resin with filling agent. We used many kind of anchorage length from 50 mm to 100 mm. we use steel bondedin rod with average 14 mm (M14 4.6). With medium compaction of epoxy resin with filling agent and with anchorage length 100 mm came to rupture of steel bonded-in rod with force 58 kN. Next experiment was with anchorage length 50 mm in medium compaction. It come rapture of steel bonded-in rod from epoxy cube. This breach arrived with incidence tension force 39,5 kN. Next experiment was the same, but consolidation was heavy. With anchorage length 50 mm came to rupture of steel bonded-in rod. It was force 59 kN.

Last experiment, which we realized, is loading of reconstruction timber beam. Timber beam is redevelopment by epoxy resin. Size of beam is 120x160 mm and length 900 mm. Two ends are from wood and the middle is from epoxy resin with filling agent. In the centre of beam are four bonded-in rods. They are 120 mm glued in wood construction and 70 mm in epoxy resin. Epoxy resin was compact. This bean was load in the middle of the beam by one force size 42,69 kN. Breach of beam grew up in the middle of epoxy resin.

Conclusions

Our planned research have one end, it's expansion of knowledge in section of rehabilitation. With this experiments we want define relations for load-capacity and for ultimate reformation of restoration elements and than propose some structural design.

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Lightweight Sandwich Construction under Fire

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The sandwich construction behaves during fire as an heterogenic element. The sheet of the steel face, which is exposed to the influence of the temperature, forms by elevated temperatures. The deformations are limited by the bending rigidity and supports of sandwich panel. Adhesion between the core and the sheet steel face is losing at elevated temperature, because the mechanical properties of adhesive and face layer of panel core lose decrease. After loosing the support of the core the compressed steel sheet locally buckle, see [1]. The filling of panels at elevated temperatures degrade, which causes finally a full disconnection of the steel faces from the core of sandwich panel.

The experiments with sandwich panels show, that required criterions are mostly lost into the connections between panels, see [2]. To obtain the certificate of fire resistance the system of panels including a connection is tested

The sandwich panel fire resistance is based on fire tests according to the standard [3]. For the panels of walls is required the temperature conductivity, which is determined from the temperature on unexposed steel sheet. Tests on cut-outs, used in the laboratory Czech Technical University in Prague and by test in Ostrava in June 2006, were focus to temperature on the exterior surface of panels with the filling from the polyurethane foam.

This report is based on the results of eight tests on spacemen of the wall sandwich panels KINGSPAN at elevated temperature. The tests were performed in electrical furnace at Czech Technical University in Prague and at condemned building in Mittal Steel Ostrava.

The structure of the building was composed of tree storey steel structure with composite slabs, beam to beam and beam to column header plate connections and diagonal wind bracings. Internal size of fire compartment 3,80 x 5,95 m, height 2,78 m. Opening of 2400 x 1400 mm ventilated the room during the fire. The mechanical actions was represented by dead load and by 1 m water, which was placed into 26 steel barrels and 50 plastic boxes equally distributed on the floor. Fire load was simulated by the unwrought timber bars 50 x 50 mm of length 1 m from softwood placed into eight piles. The comparison of the development of the gas temperatures show that at the beginning of the fire, till 30 min about, was warmer the gas in the front part of the compartment of about 200 °C. During the full developed fire, after 30 min, were the highest temperatures recorded in the back of the fire compartment, max 1050 °C.

The spacemen, witch consist of two panels and its connection was chosen to study the temperature the temperature development in the connection and on the face of panel not exposed to the elevated temperature. In the experiment in furnace were tested specimens with regular connections, connections equipped by intumescent strips, and connections with modified geometry. Opening of 1 mm and rotation 0,05 rad to the heated side simulated the deformation during fire situation. Temperature was measured by thermocouples inside the furnace and on sheet not exposed to heat. The exterior surface of panel was scanned by thermo imaging camera at interval 30 s. Thermograms were calibrated to the temperature of reference point measured by the thermocouple on the surface of the specimen.

Series of laboratory tests confirmed the higher temperatures near connections compare to the temperature on the surface far from connection. The intumescent strip helps to keep the temperature of the connection and to retard the temperature on not heating s of panel. The criterion of integrity increase by modified geometry of connection.

The temperature inside of the panel was simulated by a numerical model FE using ANSYS code. The FE model of sandwich panel was used to observe the temperature development through the panel. The material degradation of the mineral wall filling of thickness 100 mm was simulated by material degradation. The internal wall was exposed to nominal fire curve. The prediction by the FE model shows a good agreement to the measured values during the test after 45 min.

The visualisation of the measured temperature of the connection showed the temperature distribution on the specimens from the same panel. On the regular longitudinal connection was in 30 min measured 41,2 °C, in 60 min 142,8 °C. In case of adding of an intumescent strip was in reference point measured 28,0 °C at 30 min, and 36,0°C at 60 min. Reference point was situated 130 mm horizontally and 85 mm vertically from the left bottom corner of the spacemen. The experiments and thermo imagine cameras allowed to optimise the shape of connection and the position of the strip to decrees the temperature of outside facing by 32 % at 30 min and by 75 % at 60 min. The highest measured difference was 106,8°C at 60 min.

The natural fire test in Ostrava approved, that the temperature on non exposed side increase rapidly after the degradation of polyurethane. On surface of panel was measured temperatures by thermocouples placed on exposed surface of the panel and on the external sheet. Difference of temperature between thermocouples with distance 60 mm on the external surface was maximum 15 % (69,4 °C) at 38. min.

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Bolted Connections of Glass Structures

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Modern trends as well as new technologies in production and materials are used in civil engineering. Glass, with its new function, is nowadays one of the most progressive materials. Considering the fast research and development, glass is used for bearing glass structures more often. Contrary to common materials (steel, aluminium), which can reach plasticity, glass behaves elastically until it breaks by a brittle fracture. This means, that the critical part of the glass structures are usually connections. The main questions for these types of connections are to determine the state of stress and the level, to which the forces of individual bolts act together. In this case, we used the photoelastic reflecting method, which is suitable especially for transparent materials, such as glass. One of the major questions in the design of glass structures is the connection between glass components and the joints to the supporting structures. Designers have limited coherent approach to these problems at present. The knowledge in the area of glass connections is limited even though it is one of the most important parts of the structure [1].

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 from different materials, e.g. silicone, polyamide, neoprene, epoxy resin. Research was aimed to investigate stress redistribution around bolts. Considering the natural properties of glass (transparency and optical sensitivity) the photoelastic reflecting method was used [2].

Photoelasticity is an optical method, which is appropriate for determination of stress in models or on the surface of structures. The models have to be manufactured from a transparent and an elastic material, which is characterised by temporary birefringence. A plane polariscope is composed of a white or monochromatic (one wavelength) light source and two linear polarizers with crossed axes named the polarizer and the analyzer. The glass element to be analysed is placed between two polarizers. The light ray, emitted by the source, crosses the first polarizer. The luminous ray then meets the glass panel. Glass like several other non-crystalline transparent materials are optically isotropic under normal conditions but becomes birefringent, like a crystal, when it is loaded. This phenomenon is called accidental birefringence. The shape of the model has to be geometrically similar to the real structure. The loading too shoud be similar. Test specimens of glass panels were observed in polarized light. By using white rectilinerly polarized light we can see black and colour strips. The black strips are called isoclinics; they correspond to the points, where the principal directions of stress are parallel to the directions of the palarizer axes. The isoklinics are changed during the synchronous rotation of the polarizer and analyzer. The colour strips are called the isochromatics and they are the points of the difference between the principal stresses. They are the geometrical points with the same colour of birefringence in which the directions of the principal stresses and maximum shear stresses are constant. Dark black places can start appearing in the glass specimen where difference of the principle stresses is equal to zero. Each isoklinic is going through the points during the rotation of the polarizers and these places

are called singular points. From the isoklines and the isochromatics, we can find out the individual principal stresses.

Continuing experiments are directed towards bolted connections of bearing glass structures by using steel splices. The main question for this type of connection is to determine the state of stress and the level, to which the forces of individual bolts act together (one or two bolts in line for two types of glass – float and toughened glass). The experiments of bolted connections are carried out on the simplified model with steel splices. This method is appropriate especially for the determination of stress. At present, the first phase of experiments has been completed. This phase was focused on determining the state of stress of float glass with one hole [3].

The test specimens were made from float glass with nominal dimensions $680 \times 300 \text{ mm}$ 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 from steel S235 with dimension 165 x 100 mm and thickness 10 mm. The test specimens were held in loading by the machine with special hinge, which was from one side of glass panels due to using of the photoelastic reflecting method. The free side of the panel was paited with reflecting coating. The points (sections) to be investigated were marked out on the.

Glass specimens were attachted one-by-one to the testing machine Testatron by means of a special steel hinge. This steel hinge was manufactured universally for both types of glass specimens (1 and 2 holes in-line). The polariscop was situated in front of the test specimen. The luminous ray pointed at the area with the holes. The value of 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 compenzator. This process was carried out for the 10 test specimens.

Continuing experiments should better the knowledge of behaviour of bolts, which are loaded by shear in the joints of bearing glass structures. The first results in the first phase of the evaluation show that the photoelastic method is the appropriate method for determining the state of stress of glass elements of bearing glass structures. The state of stress of the glass specimen depends on an accuracy of drilling, technology of fabrication and the material of inserts between glass and bolts.

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Timber elements with composite layer

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Glued laminated timber (glulam) is a highly engineered building material, extending in many cases the traditional use of solid timber. The main reason for this is that the production process provides a number of advantages compared with solid timber. Glulam beams are produced by gluing together laminations by end jointing boards to the required length.

It is generally assumed that the lamination results in a strength increase; that there is a lamination effects. The lamination effect is often explained by the following:

- In a glulam beam the defects are smeared out, resulting in a more homogeneous material than solid timber. The probability of a defect having a serious influence on the strength of the beam is less than for a single lamination. This is referred to as a "dispersion effect".
- A lamination containing knots or other zones of low stiffness will be reinforced by adjacent laminations when it is contained in a glulam beam. The stiff and strong laminations take up a larger part of the tensile stresses. This is sometimes referred to as a "reinforcing effect", a "bridging effect" or a "stress redistribution effect".

Based on experience, the models for the strength of glulam take as reference the individual lamination – see below. This means that they a priori disregard the influence of the "dispersion effect" since typical lamination thicknesses are in the range of 20 - 50 [mm] and strength reducing defects, such as knots, are of the same order of magnitude. Glulam can be made more efficient through the use of high-strength fibre-reinforced lamella as a tensile reinforcement.

There are several models for the strength of glulam beams. One of the best-know model is the so-called Karlsruhe model. The Karlsruhe model uses a subdivision of a glulam beam into cells. A cell corresponds to a 150 [mm] long part of a lamination. The lamination is assumed to consist of two "materials" - wood and finger joints. The model is based on two computer programs, first that simulates glulam beam lay-up, and second that performs finite element calculations. The weak point in the model as in all other models is related to the failure criteria of the beam. The Karlsruhe model has not been used directly for the European design method described in EN 1194. It was felt that it was too complicated and some of its implication - e.g. a strong depth effect independently of length - was not supported unambiguously by tests. Instead a simpler model was chosen where the strength depends solely on the tensile strength of the outer lamination in the tension side. According to the model the characteristic strength values shall be calculated from the conventional characteristic tensile strength $f_{t,0,1,k}$ and the mean modulus of elasticity E_{0,1,mean} of the laminations. For the characteristic tensile strength of the finger joints it is required that $f_{t,f,k} \ge f_{t,0,1,k} + 5$ [MPa] The required over strength of the finger joints stall take care of the brittle failure. For reinforced glulam beams different failure modes are possible. Failure above the reinforcement is the most often. Possibilities to reinforce glulam beams parallel to the grain to increase bending and axial stiffness and ultimate load have been investigated within this research project. One of possible methods is to use Fibre-Reinforced Plastics (FRP) as a tensile reinforcement. Fibres used where glass fibres and carbon fibres. The design model was developed taking into account the plastic behaviour of timber loaded in compression parallel to the grain.

FRP reinforced timber elements have the potential mainly to:

- allow the use of lower grade timber in structures,
- enhance the properties of new and existing timber structures,

• repair damaged structures.

Glulam beams loaded by bending moments fail at the tension side at the position of knots or finger joints. Due to this mode failure mode glulam beams are mainly reinforced at the tension side to strengthen the weak cross-section. The reinforcement for glulam beams should have a high modulus of elasticity E and a large tensile strain at failure. Materials considered were steel, glass fibre reinforced plastics (GFRP) and carbon fibre reinforced plastics (CFRP). The disadvantage of steel is the low yield strength leading to plastic deformations before the timber fails. FRP reinforcement does not show this behaviour. An effective reinforcement leads to a plastic behaviour on the timber compression side. In non reinforced glulam beams this effect hardly occurs and design models therefore do not take into account this effect. For FRP reinforced beams therefore different design models are necessary. There are two main types of cross section studied. In Type 1 is FRP reinforcement layer covered by another timber layer, the other Type 2 does not have any cover of reinforcing layer. The width of the reinforcement usually equals the width of the cross section. For reinforced glulam beams different failure modes are possible. Assuming constant modulus of elasticity, constant tensile and compressive strength and a linear elastic ideal plastic stress-strain relationship within a cross section the following failure modes are considered. Failure modes at tension side of cross section:

- Mode **a**: Failure of the timber facing, on bottom face of beam, while the cross section is in linear elastic state.
- Mode **b**: Failure above the reinforcement, on face of the latest timber lamella before reinforcement layer (layers are counted form top of cross section), while the cross section is in a linear elastic state.
- Mode c: Failure of the timber facing, on bottom face of beam, while the cross section is in a linear elastic ideal plastic state.
- Mode d: Failure above the reinforcement, on face of the latest timber lamella before reinforcement layer (layers are counted form top of cross section), while the cross section is in a linear elastic ideal plastic state.

Failure modes at the compression side by a defined compression strain:

- Mode e: Compressive failure, on upper face of the beam, before the timber facing fails in tension, cross section is in linear elastic ideal plastic state.
- Mode **f**: Compressive failure after the timber facing failed in tension with subsequent tensile failure above the reinforcement, cross section is in linear elastic ideal plastic state.

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Physical and Numerical Modelling of Helical Micropiles

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Helical (micro)piles are often called screw anchors. They are used for foundations and reinforcing of slopes. Helical piles consist of one or more helically shaped steel plates and a steel rod connected by suitable means or a prefabricated steel screw helix element and steel shaft. Piles are screwed in the ground by applying torque and so a neighbourhood is not damaged with a vibration and there are not wet trades. The installation is easy and it is possible to load anchors immediately. Piles provide stabilization against overturning and uplift forces.

For a determination of uplift capacity screw anchors in sand are divided as shadow, transit and deep anchors. It depends on a depth and a diameter of a steel plate and on characteristics of sand. A general shear failure of shadow and transit anchors spreads between a steel plate and a surface and its dimensions are different for shadow and transit anchors. The uplift capacity is calculated as a sum of a weight of sand wedge within the failure surface and a vertical component of the total passive earth pressure on the failure surface [1]. For deep piles a whole failure pane forms inside the sand. The uplift capacity is a sum of a weight of sand wedge within the failure surface, a vertical component of the total passive earth pressure on the failure surface and a downward force due to vertical earth pressure [1].

The uplift capacity depends on geometry of piles (depth and diameter of plate) and characteristics of sand (unit weight, angle of shearing resistance and modified coefficient of passive earth pressure K_p). When sand is compacted, K_p increases. During the experiment the compaction comes when sand in layers is compacted, when anchor is screwed into sand and when anchor is load by a vertical force.

Experiments were carried out in a lab, in a box which has internal dimensions 56×66 cm and a height of sand was 53.7 cm. Dimensions of the box do not affect an uplift capacity of piles.

Characteristics of dry sand were measured: γ =15.3 kN/m³ and ϕ =34°. Sand in layers was placed and compacted into the box and during this process the anchor was placed in a required depth. A stabilization of the anchor was secured.

Anchors were made from a steel threaded rod (diameter 6 mm) and a steel plate (diameter 30 mm) connected by hexagonal nuts. The shape of a plate was not helical because piles were not screwed into sand.

Vertical forces were measured by a dynamometer of 7.17 N sensitivity. Knuckle joints were between the pile and the dynamometer and between the dynamometer and a lifting attachment which was hung up on a steel frame. A vertical force was deduced by screwing a lifting attachment. A lifting of anchors was measured by two means of dial gauges of 0.01mm sensitivity.

For three piles of different depths the uplift capacity was measured. Two piles were deep and one was shadow. Uplift capacities were not linear dependent on depth and were smaller than capacities calculated according to [1]. Piles were not screwed into sand and so a compaction of sand around piles did not increase.

The uplift capacity of an anchor with three steel plates was measured too. Its value was nearly same as a value of a pile with one plate. It can be supposed that a number of plates do not influence uplift capacity of piles.

A model is formed in the program PLAXIS. This program employs the finite element method and has several different models of soils and rocks.

It was chosen the drained Mohr-Coulomb model (elastic perfectly-plastic behaviour) for sand. This model is determined by five parameters: E –Young's modulus, v – Poisson's ratio, φ - friction angle, c – cohesion and ψ – dilatancy angle. Piles were formed as line elements of linear behaviour. Model of pile is axisymmetric and boundary conditions are standard fixities (vertical geometry lines obtain a horizontal fixity and horizontal lines obtain a full fixity).

Program PLAXIS makes automatically a mesh. 15-node triangular elements were selected and medium coarse mesh was generated.

At first dimensions of the box was tested. No effect on uplift capacity was observed.

Models of piles were determined with a dilatancy angle between 0° and 4° because the dilatancy $\psi \le \varphi - 30^\circ$.

It supposes that models will be formed in the non-linear hardening-soil model (isotropic hardening) too. This model is determined by six basic parameters: ϕ , c, ψ , E^{ref}_{50} – secant stiffness in standard drained triaxial test, E^{ref}_{oed} – tangent stiffness for primary oedometer loading and m – power for stress-level dependency of stiffness. Contrary to the Mohr-Coulomb model the hardening-soil model's yield surface is not fixed in principal stress space.

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Measurements of 3D Deformations in the Body of a High Gabion Retaining Wall

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Both portals of the highway tunnel Valík (highway D5/E50 Praha – Pilsen – Germany) are built in deep cuts. The side-slopes were temporarily stabilized by nails with shot-crete and the final support has been provided by a gabion retaining wall, [1]. The gabion retaining wall is 9 m high at the tunnel portal, its height decreases with the distance from the tunnel. Nine-meter high gabion is one of the highest ones in the Czech Republic, its structural design was proposed with a very low reserve of bearing capacity because of limited building space, [1]. Therefore monitoring of the structure was recommended. Two measurement lines at the Prague portal and one at the Rozvadov Portal were instrumented during May and June 2006 with combined casing for inclinometer and sliding deformeter commonly used for monitoring of subsoil deformation in boreholes with measurement casing as described in [3], [4], for example. Proposed means of instrumentation allows measurements of 3D deformations of the retaining structure and subsoil. According to our information, this method of instrumentation has been used for the first time in Europe, [2].

Each measurement line (measurement casing) starts in a 4-meter deep borehole under the base of the gabion body. The line is parallel to the rear face of the gabion in about 1 m distance. The instrumentation of each measurement line was done simultaneously with the construction stages of the gabion wall. The interaction of gabion and measurement marks (mainly to measure axial deformation of the casing) was achieved by building gravel-mortar brickwork reinforced with standard gabion wire mesh pieces (with an opening cut for the casing) around every measuring mark. The strain transfer from gabion to the measurement casing was ensured by careful backfilling of the area surrounding the smooth part of casing with gravel gabion fill. The means of measurements and data evaluation had also to be adjusted according to the sequence of measurement line development. There are several cases from the monitoring practise known, where the borehole was shortened after some time, [6]. In our case, the measurement casing was continuously prolonged as the gabion wall was built, [2].

The measurements performed between May and July 2006 represent the behaviour of the raising structure and its subsoil during its construction phases and resulting loading states. During the first phase, there were mainly dynamic loads acting, caused by backfilling of the gabion baskets and by the backfill compaction along the back side of the gabion wall. Based on technological reasons, a temporary embankment was continually built at the front face of gabions. Further significant lateral deformations of the gabion body were awaited after its excavation. The second phase followed after finishing the construction. The backfill of the rear gabion side consolidated and therefore horizontal stress acting on the gabion's rear side increased. Because of high resistance of massive gabion body and its temporary low height during the construction, the development of horizontal displacements during the construction phases was practically negligible. This was also caused by continually rising embankment at the

front gabion wall side. An excavator filled the gabion baskets and provided backfilling of the rear wall side from the embankment. The development of horizontal deformations was important between 28/05 and 14/06/2006, when the construction of the gabion wall was finished together with backfilling of the final slope at the back of the retaining wall. During this time the worst combination of loading states and construction technology occurred, because the embankment on the front side was excavated up to the foundation depth level prior to construction of highway embankment layers. This type of critical load combination should not appear any more during the lifetime of the retaining structure.

The horizontal deformations reached 27 - 28 mm at the top surface of the gabion wall and developed within acceptable limits. The total settlement of the gabion body was about 65 mm. Based on the development of vertical deformations, we can assume that the gabion baskets were filled quite evenly, which is also indicated by practically equal slope of axial strain graphs. In both cases of horizontal and vertical strains the subsoil rock (partly weathered to weathered shale) behaved as a very stiff support.

The results obtained until July 2006 indicate, that the design of high gabion constructions with use of the GEO4 [1] programme corresponds with the building site conditions. The measured displacements are acceptable although the inconvenient combination of excavation at the front side of the gabion wall built to the full height and backfilled slope of the cut at the back side of the wall. The monitoring results and their future development will be further used for analysis of gabion construction behaviour, [2].

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Water Yield in Small Mountain Basins

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Since the 1970s and 1980s, the Jizera Mts. Region has been significantly affected by the acid atmospheric deposition and forest die-back. Considerations of some serious changes in hydrological regime were related to the decline in forest cover, clear-cut of existing spruce stands, and reforestation practices. Hydrological regime in headwater basins of the Jizera Mts. declined as a consequence of the acid atmospheric deposition (namely sulphate from the lignite combustion) and commercial forestry practices (spruce plantations of a low stability, extensive clear-cut harvest using heavy mechanization, non-effective control of insect epidemics, and unsuccessful reforestation) [1]. Although the headwater area was a protected area, ecologically oriented watershed management was not realized until the 1990s. Soil erosion and sediment runoff resulted in deterioration of the water quality in watercourses and reservoirs. This led to significant changes in water balance and started deterioration processes related to water yield and vegetation cover. To describe and estimate these processes and their influences the correct evaluation of water yield is necessary. Commonly used approach for estimation of water balance on the catchment is based only on simple equation including the input (precipitation) and the output (runoff and evapotranspiration).

In this contribution we offer approach based on spatial distribution of vegetation cover and other spatial varying features affecting components of water balance. This approach offers more precise evaluation and especially reveal areas where are the significant changes present.

Research project Water Yield in Small Mountain Basins runs in the frame of other projects concerning hydrological and ecological research. These activities started in the region of the Jizera Mountains in 1980s when six experimental watersheds became to be monitored. Contemporary research keeps working on these catchments. The largest one, catchment of the Josefův Důl reservoir (19.64 km²) is presented.

The hydrometeorological data necessary for the application were obtained from Povodí Labe s. p. (rainfall and runoff), Czech Hydrometeorological Institute in Jablonec nad Nisou (meteorological data measured in experimental basins CHMI in Jizera Mountains) and Czech Hydrometeorological Institute in Prague (meteorological data from standard meteorological stations located in Jizera Mountains). These data were merged in database system based on SQL to fulfill the gaps and create analogical relationships. The measurement - at the point – had been later extrapolated with various geo-statistical functions (kriging, inverse distance) to obtain raster GIS layers necessary for further calculation.

The spatial information as well as the aerial photographs (with resolution $1 \ge 1 = m$) was obtained from 19 map lists from Czech Office for Surveying, Mapping and Cadastre. Using these data the digital elevation model (DEM) has been created. The resolution to describe precisely important spatial features and vegetation distribution was set to 5 meters grid. The separation of vegetation classes was done by analyzing of aerial photographs.

Precipitation data depends generally on altitude and site exposition. Data from 26 rainfall recording stations were analyzed and their dependence on altitude have been evaluated

and used later while building the precipitation as GIS layer. Dependence on site exposition was not statistically proved.

Evapotranspiration as a component of water balance is usually the most difficult component to estimate. This is mainly caused by the lack of spatial data as well as by the errors in equations describing complicated physical process as the evaporation and transpiration is. GIS offers strong tools how to describe the evapotranspiration varying in space (according to vegetation cover especially) and separate the evaporation and transpiration fractions.

Modern methods for evapotranspiration evaluation combine the radiation and aerodynamic approach. Method of Penman-Monteith is used in this study. Aerodynamic fraction was calculated with using wind speed, vegetation height and density data and the net radiation was simulated in separate mathematical model developed to calculate all components of radiation balance (upward and downward, shortwave and longwave) on earth surface using routine meteorological data such as sunshine duration, air temperature and position of the point on earth [2]. Also the subroutine recalculating radiation on sloping plane has been included in the model.

Runoff depth is component of water balance that is measured directly at the catchment outlet, so its evaluating is comparing to evapotranspiration simple, but obtain spatial distribution of runoff depth (means how much water run of certain point in the catchment) is much more complicated. Using GIS, this depth is calculated such as difference between the input (precipitation) and second output (evapotranspiration), neglecting the changes in storage of water in the catchment. According to previous research, storage of the water is at the end of hydrological year (last of October) almost invariable (with changes in few percent).

There are tools to estimate the runoff depth using GIS tools, but as their output usually offers only hydrograph at the outlet, they solve in most of the cases only storm episodes considering only direct runoff (Watershed Modeling System, TOPMODEL [3]). Further research is necessary to conclude this topic.

Results of the simulation offer raster layers of components of water balance. Three scenarios of catchment development were assumed to describe potential changes in catchment vegetation cover – the contemporary situation (Sc.0), critical situation that occurred in the 70's and 80's (Sc.1) and situation of optimal development (Sc.2). Water balance is calculated for hydrological years 2001 – 2005 in various experimental basins in Jizera Mountains, Focus is put on Josefův Důl reservoir; where some related phenomena are simulate as well (soil erosion, etc.). The results of the research offer interesting tool for detailed hydrological simulations in the catchments, which can be connected with other hydro-ecological scientific activities running in the frame of general research in Jizera Mountains.

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OBSERVATION OF RAINFALL-RUNOFF EPISODES IN THE SOIL PROFILE OF THE MOUNTAINOUS WATERSHED

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Uhlířská (1.78 km²), is a typical watershed with the crystalline bedrock forming Cambisols as 60% of the area of the Czech Basin. It is situated in a humid mountainous region the northern part of Czech Republic where soils are typically shallow and highly permeable with preferential pathways. As a result of these facts, outflow caused by storms can be of a quick response and high magnitude. Focusing on the flow processes in the subsurface, the aim of the hydrological research is to reveal the flow mechanism transforming rainfall into runoff in both variably saturated soil profile on the instrumented hillslope and within the scope of the watershed. To record also other factors of the hydrological cycle, the site is accompanied with the basic climatic station recording air temperature, net radiation, wind speed and humidity on a continuous basis.

Based on the observations performed, it becomes evident that soil profile plays dominant role in the rainfall-runoff transformation [4]. Flow of the water in the heterogeneous porous environment, including the soil profile and hydrogeological saturated structure can not be satisfactorily described using quantitative hydrological variables only. Quantitative measurements lack the information about the nature of the transformation in space and time. Therefore additional techniques have to be utilized. Due to the fact that the behavior of flow of water in the heterogeneous porous media and highly heterogeneous hydrogeological structure is not fully understood, a targeted study of these phenomena in the field scale becomes very urgent. The tracing by means of the natural substances is the only noninvasive tool available to render the mechanisms of the outflow. Study of the water dynamics by means of natural tracers is targeted to employ effects of stable oxygen isotope ¹⁸O [1] and silica as SiO₂ [2] within the elements of the hydrological cycle. Such investigation increases the quality of the present research fundamentally by adding an independent set of information for subsurface stormflow generation.

Both of these elements are sampled at selected spots in the watershed since the spring of 2006. These activities cover the sample collection of rainfall, snowmelt, snowcover, subsurface stormflow, groundwater, soil water from suction lysimeters and the stream outflow at two gauging stations. Silica is not sampled in the meteoric water (snowmelt and rainfall) assuming not to be present. During 2006, two significant episodes were observed - the snowmelt in March-May and the frontal extreme storm in August. Snowmelt lasted in the period of 25.3.-18.5.06. Total amount of snow at the watershed was estimated in the range of 500-600 mm of the water equivalent. In addition, 81 mm of the rain contributed since 12.4.06. Here, there is transparent impact of the melting water at the beginning of the episode. At the last phase, the subsurface trench outflow was also sampled. Complex picture indicates the replacement of pre-melt water in the subsurface outflow and the stream outflow as well. Outflow is being transformed by the variably saturated soil profile and then in the saturated aquifer. Variation of SiO₂ prior to the snowmelt shows the range of low concentration values, however since the commencement of the snowmelt, a rapid rise is observed. Possibly, the preevent baseflow drains the aquifer via paths, which are washed permanently, where silica can 576

not be dissolved into the water at higher concentration. On contrary to, the snowmelt water replaces the soil water stagnant during the winter season in the soil profile. Given a sufficient time to dissolve silica in soil water, this contributes to its rapid rise in the streamflow.

Significant storm rainfall occurred in the period of 4.8.-8.8.06 with 247 mm of rain, resulting in one of the two highest discharge intensities (estimated as 3.2-3.8 m³/s) since the establishment of the observations in 1981. Here, the quicker response of the soil profile to the change of δ^{18} O is evident. It supports the hypothesis of the partial transformation of the rainfall onto runoff within the soil profile, employing the preferential pathways. Later the differences of the oxygen isotope signatures found in the subsurface stormflow and the watershed streamflow are diminished, probably due to the extreme nature of the event, where the most of the pre-event water is already displaced with the causal rainwater. The course of the concentrations of SiO₂ at the same checkpoints is similar. The fall of SiO₂ concentration during the culmination of the flow is observed, due to the extreme amount of the outflow from the soil profile and from the watershed.

At the selected locations, soil water and shallow groundwater is being sampled for the discussed elements during 2006. In longer period of time, analyses of the samples should help to determine the basic signature of the pre-event water.

Analyzing geochemical and isotope data, the hypothesis of the dominant impact of the subsurface outflow on the watershed streamflow has been supported. Quick subsurface outflow from the soil profile and the outflow from the watershed exhibit similar dynamics, analyzing both quantity and quality of selected natural tracers [3].

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Creation and Testing of Methodology of Ecological Evaluation of Trenchless Technologies of Urban Networks for their Renovation and Development

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Every implementation of construction, maintenance and reparation of urban networks is condition of preservation and development for the infrastructure, housing and total economical growth.

Since every construction work has a negative impact on the environment. Therefore, the planning and implementation documentation of every project and the preparation of its construction must take into account also ecological criteria. Ecological impact of human activities is and will be even more strictly monitored in the future. 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.

The first step of ecological evaluation offered the graduation thesis of Tomáš Kubát (Ecological evaluation of trenchless technologies on the example of water supply feeders - water supply tank "Zdoba" - water supply tank "Varta" - water pumping station "Sudoměřice"-water supply tank "Hodušín").

The ecological TT assessment was made in the three steps:

- 1. The step of plain ecological assessment in the form of mutual comparison of individual TT steps,
- 2. The step of ecological assessment in defined representative model situations,
- 3. The step of direct ecological assessment of specific examples.

The aim of this project has been to draft and offer a methodology providing a consistent approach to the evaluation of TT impact on environment considering both public interest and the interest of all parties concerned and prevent from "black – and white" look at TT e.g. through the prism of contractor's interest only, but consider them primarily as an integral, equivalent and useful applied engineering discipline.

For this purpose was used modern means of generation of variant solutions their assessment such as value analysis.

Every step of ecological TT assessment is important, irreplaceable a significant. The objective of ecological assessment is to point out the differences (advantages and disadvantages) of technological processes of individual TT and their environmental impact in a universal model situation.

The so oriented work may be of substantial benefit both to the firm – users of TT and for all other parties concerned: investors, operators and users of utilities etc.)

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Optimization of Coagulant Doses Using Artificial Neural Networks

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Water treatment involves physical, chemical and biological processes to transform raw water into drinking water. Coagulation is one of the most important components of water treatment process, allowing the removal of colloidal particles. The main difficulty is to determine the optimal coagulant dose related to the influent of raw water.

The traditional method of controlling coagulant dose, called jar-test, relies heavily upon human intervention. Operators change the dose and make new jar-tests if the quality of treated water changes. Disadvantages of this procedure are the necessity to rely on manual intervention and as a result of the length of time slow response to rapid changes in raw water quality.

The processes that occur during coagulation are very complex and not fully understood and therefore the development of physically based models is extremely difficult. To overcome these limitations, artificial neural networks (ANN) are used. The main advantage that ANNs have over physically based models is that they do not have to know the physical processes explicitly. Artificial neural network approach focuses on finding a repeated, recognizable and predictable pattern(s) between the causes and effects from the past operation data records.

In practise there exist two models: process and process inverse [1]. Process models use as model inputs process inputs (e.g. raw water quality - pH, temperature, turbidity) and process control parameters (e.g. coagulant dose) and as process outputs the outputs of the process that is being modelled (e.g. treated water quality parameters). 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.

To build effective ANN models of drinking water treatment process, the methodology consisting of 4 stages is proposed – suitability assessment, data collection and analyses, application of the model and performance evaluation.

The ANN model highly simplified with respect to biological neuron. The ANN architecture consisted of a multilayer perceptron (MLP). MLPs have already been used successfully for the prediction of coagulant doses [2,3], chlorine demand [4] or other processes in water treatment. Optimal number of input layer, hidden layer(s) and the output layer neurons were found by trail and error. In this paper, ANN was a multilayered neural network structure with backward error propagation. The processing elements were structured into 3 layers: 1 input (5 neurons), 1 hidden (15 neurons) and 1 output layer (1 neuron). The process neural network has five input variables (flow, temperature, alkalinity, COD_{in}, coagulant dosage) and one output

parameter COD_{OUT} at the filter inflow. The process inverse model has coagulant dosage as the output variable and DOC_{OUT} as one of five input parameters.

The determination of ANN parameters was carried out using RMSE (root mean square error) and R^2 (multiple coefficient of determination).

The artificial neural network models are initially developed and trained using historical data. The data from water treatment plant Písek (Southern Bohemia) collected in the year 2003 were randomly separated into 3 sets – training (70%), testing (20%) and production set (10%).

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Comprehensive methodics of measuring and long-therm monitoring of cracks in concrete structure

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The initiation and development of cracks reduces not only the durability of structures but also their serviceability. This paper contains examples of methods used for measuring and monitoring cracks. There are several limit values of crack width in standards and codes, or in the conditions set by developers. With commonly used methods we can obtain only subjective values of crack width. Hundreds of crack widths were measured by three methods and were analyzed statistically. The results will be used to estimate the accuracy of the measuring methods.

Reliability, durability and usability of concrete structures is limited by the occurrence of cracks. Concrete is an inhomogeneous material with low tensile strength in comparison with its compressive strength. In structures, where the deformation exceeds the limiting value of tensile strength (several µm), cracks occur. In order to examine the reliability of concrete structures it is necessary to analyze the width of cracks, which should not exceed the limits defined in the standards for various types of structures. Currently used cracks measurement methods (crack scale, magnifier) are influenced by subjective classification, and for this reason the classification of crack widths leads to arguments between the client and the supplier of structures.

The limiting value of tensile deformation depends on several factors: constitution of the concrete, age of the concrete, rate of loading, etc. Stimulated deformation is caused by:

- concrete mixture,
- interior elements (for example armature),
- external conditions.

In laboratory conditions and in the conditions of real structures, many experimental methods are used to identify the occurrence of cracks. These include:

- visual observation
- white paint on the surface of concrete (gypsum, lime),
- varnish painted on the surface of concrete,
- gypsum corpuscles on the surface,
- · wetting the surface to increase the visibility of cracks
- using instrumental facilities:
 - o acoustic analyzers
 - o ultrasound instruments
 - o impulse method

There are many contact and contactless methods based on mechanic, optical and electric measurement for time change.

Examples of mechanical measuring instruments:

- deformeters
- mechanical indicators

Examples of optical measuring instruments:

- enlarging magnifiers (sensitivity 0,1 mm),
- microscopes (sensitivity 0,01 to 0,02 mm),
- inductive sensors (sensitivity 1/100 to 1/1000 mm),
- potentiometer sensors (sensitivity 1/100 mm),
- string tensometers,
- optical sensors with optical fibres.

Existing cracks in concrete structures are usually measured using an enlarging magnifier or a crack scale. To determine the measurement accuracy of each method, cracks were measured on a test specimen by 5 people with different levels of experience. The test specimen was constructed using boarding in the shape of a ring. The inner part of the boarding inhibits shrinkage of the specimen. After 2 weeks, several shrink cracks appeared. 21 cracks were measured using a microscope (sensitivity 0,01 to 0,02 mm), an enlarging magnifier (sensitivity 0,1 mm), and a crack scale (sensitivity 0,1 mm). We consider measurement using a microscope to be the most accurate method, so we compared the differences between the measurement using the microscope and using the enlarging magnifier, and the differences between measuring with the microscope and with the crack scale.

To achieve the most accurate measurement procedure it is necessary to develop a method that will exclude errors associated with subjective classification of crack width. Crack widths can be determined accurately using a microscope with a digital camera or webcamera. The digital record can be analyzed by software, which provides a detailed preview in the image.

The experimentally observed course of strain in concrete is compared with the theoretic values presented in Czech and foreign standards.

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Operative Management of Building Industries with Use of Artificial Intelligence Methods

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Artificial intelligence (AI) is one of the newest disciplines formally initiated in 1956, although at that point work had been under way for about five years. Genetic algorithms (GA) are inspired by Darwin's theory about evolution. Artificial neural networks (ANNs) are inspired by biological neural networks. This article provides a brief overview of the theory elements, an introductions, and applications of the operative management of building industries with use of AI methods problematic.

Genetic algorithms encode a potential solution to a specific problem on a like simple chromosome data structure and apply recombination operators to these structures so as to preserve critical information. An implementation of a genetic algorithm begins with a population of chromosomes which allocates reproductive opportunities in such a way that those chromosomes represents a better solution to the target problem are given more changes to reproduce than those chromosomes which are a poorer solutions. GA is any population based model that use selection and recombination operators to generate new sample points in a search space. Some of GA applications are oriented as nonlinear dynamical systems - predicting, data analysis, others designing neural networks, their architecture and weights, and others strategy planning, traveling salesman problem, sequence scheduling etc.

The outline of GA is very general. There are many things that can be implemented differently in various problems. There are some theoretical problems, such as how to create chromosomes, what type of encoding choose, how to select parents for crossover, how not lost the best chromosome from the last population etc.

The development of modern theories of learning and neural processing and appearance of digital computers both occurred at the same time, about the year 1940. Since then has accumulated a large body of neurophysiological research. From the neuroscience field we borrow concepts and ideas to our area of science and engineering. The definition of artificial neural networks has been inspired by our current understanding of the brain, but that do not necessarily conform strictly to that it.

The individual computational elements that make up artificial neural network system are called artificial neurons, nodes, units, and processing elements. Like a real neuron, processing element has many inputs and only a single output, which can fan-out to many other processing elements in the network. The ith input receives from the jth processing element is indicated as value Xj. Each connection to the ith processing element has associated with it quantity called weight. The weight on the connection from the jth to the ith node is denoted wij. Each processing element determines a net-input value based on all its input connections. In the absence of special connections, we typically calculate the net input by summing the input values, multiplied by their corresponding weights. Once the net input is calculated, it is converted to an activation value, and then we can determine the output value by applying an output function. The learning process consists of finding weights that encode the knowledge that we wanted the system to learn. For most realistic systems is not easy to determine a closed form solution for this system of equations. Techniques exist, however, that result in an acceptable approximation to a solution. Neural networks being builded into the control systems as approximators are called the neural control systems. There are some new theoretical problems in applications neural networks as elements of control systems of management and building industries, such as properties of theoretical problems are deduced from models with different structure than the systems, and some sense, like a similarity of output signals are close of the modeled systems.

Planning is a very important generic AI problem which is about generating a sequence of actions in order to achieve a given goal when a description of the current situation is available. Planning is usually realized as an interactive task which has major phases repeated until the termination condition is reached: read data – current situation, goals, evaluate the input data, generate a plan and it's execute. A planning system can be represented functionally as a graph where the nodes represent situations and the arcs represent actions that cause changes in the situations. Monitoring is the process of interpretation of continuous input information, and recommending intervention if appropriate. Diagnosis is another typical generic AI problem. This is the process of finding faults in a system. Control is the process of acquiring information for the current state of an object and emitting control signals to keep the object in its possible and desired states. The methods are mainly used in AI for solving control problems are fuzzy systems, based on fuzzy rules and neural networks, based on training with input output data collected when the object has been operating properly.

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Changes Acoustic Situation at the Airport Prague Ruzyně -Build-up Parallel Runway 06R/24L

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The problem with noise stress is the most important environmental characteristics associated with under consideration intention build-up new parallel runway on Prague Ruzyně airport. Studies of noise for contemporary and development plan aerodrome traffic Prague – Ruzyně was processed by company TECHSON.

Study deals with starting situation derived from statistic data about aerodrome traffic in the year 2003, further deals with expected final situation for the year 2010 for aerodrome traffic with parallel runway(further only RWY) 06R/24L. Further study deals with variation for case of failure intention with expected aerodrome traffic in the year 2010 with present configuration runway system. From results of study arise that a realization of parallel RWY will bring changes in noise stress in the surroundings of airport Prague – Ruzyně. Increment of noise stress in localities (Nebušice, Jeneč south) is balanced by decrement of noise stress in locality Horoměřice and first off all in localities Prague (Ruzyně, Fialka, Řepy, Bílá hora, Motol etc.).

In term of development acoustic situation is possible according to above quoted study benefit of new RWY 06R/24L state there that the enlargement of runway system of airport Prague – Ruzyně and increasing of runway capacities will enable exercise modern proceeding to noise reduction in wider size. It deals first of all about preference of runway by design night aerodrome traffic, tighter specification of conditions for executing of flights etc. By distribution of aerodrome traffic to more runway will decrease range of noise stress area with higher values of noise from airport. By building RWY will quite eliminate incidence of short - time extraordinary operating situation (i.e. closure of main RWY 06/24 in consequence of reparation and transposition aerodrome traffic on RWY 13/31), that are now the main subject of complaint of citizens.

Study of development of acoustic situation also deals with effect other transport in term of traffic accessibility of airport Prague – Ruzyně.

Aerodrome traffic is according to data for comparative year 2003 year round well balanced only with small variance. Average number of movements of aeroplanes in summer period was 320 in time of day and 30 of movements of aeroplanes in night time. Aerodrome traffic is balanced during week and of the day. Aerodrome traffic is balanced during week and of the day. Mostly disturbing night traffic (between 10:00 p.m. - 06:00 a.m.) is adjusted by limitation on 3 flights and touch - down per hour. In year - round average was number of movements of aeroplanes at night all of 25, in critical months July and August was increased on 35. Original estimation of perspective condition aerodrome traffic in the year 2010 was increased on the basis of extraordinary growth achievements of airport in the year 2004. In summer time it is hypothesized increasing of movements of aeroplanes on average number 696 in time of day and 58 of movements of aeroplanes in night time. This increase of the total of the number of movements aeroplanes in summer period them of 115% greater compared to year 2003. It is hypothesized that the aerodrome traffic in night time should be in the future regulated and for flights and touch - down would had been used only existing RWY 06/24 except in period when will closed from reason of necessary reparation. Existing RWY 13/31 would had been totally without night aerodrome traffic. After opening newly made RWY 06R/24L gradual restraining of night running is supposed so that the area bounded by limit izofone 55dB for night time was smaller, than area bounded izofone 65dB for time of day. In case of failure intention of construction of new runway is supposed necessity of gradual decrease present operational restriction and increasing night aerodrome traffic especially in summer season.

Orientation estimation of the number of resident afflicted with air noise is in single assessed variants (year 2003 – present condition, year 2010 – RWY 06R/24L, year 2010 without RWY 06R/24L) following : in the year 2003 is estimated number of people importuned by noise 4380, number of people with bad sleep 1430 and number of people with higher morbidity 350. For second variant (year 2010 with newly made RWY 06R/24L) is number of people importuned by noise estimated on 4860, number of people with bad sleep 1580, number of people with higher morbidity 395. Last variant (year 2010 without RWY 06R/24L) is at least positive because of total number of people importuned by noise 7675, number of people with bad sleep 2475 and number of people with higher morbidity 635.

Present knowledge about incidence of air noise on health of resident together with restriction of possibility of calculation of noise dosimeter exposition at wider environs of airport does not offer sufficient data to quantitative classification health hazards of noise for resident in the surrounding. Conclusion of processed study of risk rating is therefore mainly qualitative risk characterisation flowing from common knowledge about incidence air noise on health of residents and from specific conditions of airport. Consequence of realization of intention building - up parallel RWY 06R/24L will be change of acoustic situation given by noise from aerodrome traffic. In consequence of rising of the number of check - in aeroplanes necessarily will come to enlargement of territory touched by air noise and increasing of the number of markedly exposed residents. This growth should be according to acoustic study notably higher in comparison with supposed development without realization building - up of this runway and without possibility of optimalization aerodrome traffic.

Total present level of stress from land transportation presents near by house - building in the surrounding arrival communications to airport real health hazard in consequences unfavourable effects of noise on residents of contiguous localities. By building - up of new parallel RWY 06R/24L would not have been this condition notably impressed with. Supposed changes of noise stress from land transportation related with aerodrome traffic are in term of quantitative classification measurement of health hazard practically secondary.

Accuracy of Total Stations Topcon GPT-2006 and its Dependence on Climatic Conditions

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This report apprises of results of the project [1], which is developing questions, which was worked up within the scope of thesis [2], and is focused on determination of dependence between the accuracy of measuring instrument, which is represented by sample standard deviation of determination of horizontal direction, and climatic conditions during measurement, that are represented by air temperature and pressure.

At the beginning of this report is necessary to remind the fact, that the accuracy of total stations is while the operation of geodetical working in building-up necessary to attest as consistent with ČSN ISO 17 123-3. Standards of series ČSN ISO 17 123 are provided by execute public notice &31/1995 Sb. of law about surveying &200/1994 Sb. as mandatory standards. The result of attestation according to ČSN ISO 17 123-3 [1] is a full characterization of the accuracy that is represented by sample standard deviation of determination of horizontal direction. The previously used standards for determination of the accuracy of measuring instruments were invalidated in 31^{st} December 2005.

Testing procedure was realized on the test baseline, which was created for this project. This baseline was created in agreement with ISO 17 123-3. Locations of aiming marks and position of total stations were defined, stabilized and signalized exactly along the measurement. A good sight distance between aiming marks and position of total stations was ensured. The test baseline fulfilled the usual conditions for uniform distribution of aiming marks in sector, which is minimally 100gon large, and it fulfilled the condition of standard ISO 17 123-3 on a minimally distance between aiming marks and position of total stations, which is 100m, too. The baseline was located in the surrounding of Faculty of civil engineering, CTU in Prague. The Accuracy of measuring of horizontal direction was determined for three total stations Topcon GPT-2006, these production numbers - VU 0566, VU 0582 and VU 0577. These three total stations are a part of a set of twelve total stations. This set was bought by a successful solution of the project "Innovation and development of labs for practical education of engineering surveying" with a financial support from Fund o development of Universities (H2397/2003) in 2003 from GEODIS Brno Company. Three total stations, which were tested, were from the set of twelve total stations randomly chosen.

By testing according to procedures (in total three different procedures, more in [2]), which are included especially in the standard ČSN ISO 17 123-3, we obtained a set of seven sample standard deviations of determination of horizontal direction for every one of three total stations. Every measurement for determination of sample standard deviations of determination of horizontal direction was done by uniquely defined **climatic conditions**. During the measurement were observed air temperature round about the total station (measured with mercury thermometer, which corresponds to standards ČSN 25 8130), it was in interval <10,5;19,5> °C, and air pressure (determined by weather station ČHMÚ AMS MILOS in Prague Libuš [3]), it was in interval <1000,0;1021,5> hPa.
AMS MILOS is determining present condition of atmosphere and is producing current synoptic data. The vicarious determination of air pressure with the help of AMS MILOS [3] is useful not only at metrology works but also e.g. for monitoring of climatic conditions, that effect on building construction. It is necessary to say, that not every working unit has its own calibrated aneroid. AMS MILOS is periodically calibrated by the certified calibration lab ČHMÚ.

In the next step were compared accuracies of total stations. For this we used statistical tests, we were working with critical values of F-distribution [4]. Results of statistical tests showed us, that all three total stations have approximately the same accuracy. So into the task Demonstration of dependence of the instruments accuracy on climatic conditions enter all of twenty one (three total stations, seven sample standard deviations) date ternaries (sample standard deviation, air pressure, air temperature).

The dependence of the instruments accuracy on climatic conditions is going to be determinated by method of regression analysis. In general we can formulize the dependence of the total stations accuracy Y on air temperature t and air pressure p this way:

$$Y = f(p,t) + e, \quad (1)$$

where f is unspecified regression function and e is random error.

As the regression function was in [1] subsequently used linear, polynomial, square and logarithmic functions. Then were calculated regression coefficients statistical tested, the "Stepwise backward selection" [4] method was used too. In accordance with this method we do again statistical testing procedure after previous eliminations of that regression coefficient, whose null hypothesis H_0 (the total stations accuracy doesn't depend on some kind of the value) was confirmed the most resolutely.

Projects results [1] showed high accuracy of horizontal direction measuring of total stations Topcon GPT-2006. It not only confirms the accuracy, which is specified by the producer, but this determined accuracy is much better then specified one. All testing total stations show high accuracy of horizontal direction measuring. This project was engaged in influence of air temperature and air pressure on the accuracy of horizontal direction measuring. The dependence among these values was mathematically defined, but it was not statistically confirmed. It is probably caused by relative stability of climatic conditions while determination of the instruments accuracy. We can say, accordance with project results, that air temperature has major, but not statistically confirmed, influence on the accuracy of horizontal direction measuring. Air pressure has a minimal influence on the total stations accuracy.

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System Energy Flows and Variability in Civil Engineering from Aspekt of Sustainable Development

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In civil engineering are created large and long-term products from all sectors of national economics. Building structures are characterized in quantity and differences in energy demand. Energy demand of the structures is defined by material and technology input. Chosen variant of the building material determine particularly operation and material-energy demand of output. Creation interchangeable variants from material, construction and operating aspects are sources for total energy demand of the long-life cycle building. Energy potential of building is in comparison with others industrial sectors very high. Reducing energy demand from aspect long-life cycle building depends on strategy decision. Instrument is probing of energy importance of components long-life cycle, theirs comparison and association.

In presents is majority of technical literature in Czech republic and abroad interest in energy demand of building at the meaning energy demand operation of building mostly by heating. Many authors solve relationships among thermal insulation, choosing suitable types of it and resulting demands in heating of structure. Results of these processes are low-energy houses, in next level passive houses. Interest and new chapter in thermal insulations is return on investment. Well-developed and often novelized are regulations in thermal protection of building. One of the most visible results is the implementation of thermal shields of building. In lowest amount are solved energy demands in producing of building materials, which are not put together with civil engineering. In present we knows only parts of the process long-life cycle building (LCA).

Solution of energy demand in long-life cycle building must put together all parts not only studied, but also not yet studied. First chapter of this process is identification of the system LCA and energy valuation of theirs part, which are:

- 1. Producing of the building materials,
- 2. Transporting demands,
- 3. Structure processes demands,
- 4. Operating demands,
- 5. Renewal and reconstruction demands,
- 6. Total or particular demolition,
- 7. Producing of the waste,
- 8. Using of the waste in the other structures.

In other chapters it is necessary to pick statistic dates about energy flows in each part of process and divide all parts of material variant. Main part is creating of LCA energy model, looking for the best variant and find out improving of design including differences among the variant.

Last chapter is exploration relations between energy demand and total cost of the variant. Comparing of energy with cost can help best orientation in sustainable development of building.

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Beam Flange Resistance under Natural Fire

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The fire safety increases in last ten years by the performance based design by the development and application of the prediction of the behaviour of the structures under the fire conditions. The prediction consists of the calculation of the temperature in compartment, from the evaluation of the heat transferee into/in the structure and from the modelling and check of the behaviour of the structure under the high temperature. The analytical and discrete simulation of the element behaviour reached the good level of the prediction. The prediction of the whole structure suffers by the lack of models of the connections and by the limited knowledge from the tests on the whole structure. The connection behaviour is guided by the temperature distribution and by the resistance of the connection components. The connection is colder during the heating phase of the fire, because in the joint is concentrated the mass and is less exposed to the fire compare to the connected elements, see [1].

One of the major components affecting the beam behaviour, in contrary to the room temperature behaviour, is the compressed flange. During the heating the unprotected beam loses his bending stiffness and the connection stiffness, even for the simple connection, starts to influence the behaviour. The lower flange during the heating elongates and the gap between the primary beam end and the column/secondary beam is closing. The lower flange of the beam is compressed by high forces and the lost of its resistance change the behaviour of the beam qualitatively. In the next stage the catenary action transfers the loads, because the floors resist well to the horizontal forces.

The research project, 103/04/2100 of the Czech Grant Agency, was focused to the study of the compressed flange of beams in multi-storey buildings. The research was based on the knowledge reached by seven large scale tests in Cardington, namely of the seventh test, which was directed to connection behaviour. The detailed prediction of compressed flange behaviour enables to precise the beam behaviour during fire in the multi-storey frame. The work has start by a summarisation of the existing knowledge by preparation of a databank of the published tests under room temperature. A numerical simulation helped to observe the high temperature parameters. It was be continued by the experiments on the beams under room temperature, under a high temperature as well as by the test on the real structure. The analytical prediction model suitable for the prediction of the behaviour of the beam compressed flange is ready to be integrated into the prediction of the whole joint by component method and was tested the frame global analyses. The model is prepared to be accepted as a background documents for the European praxis, see [2].

The experimental programme of the project confirms the assumptions of the model by three sets of three tests at ambient temperature, the compressed flange on stub, the beam test with fin plate connection, and the cruciform test with beam flange and welded connection. Two sets of tests at elevated temperature were studied the beam behaviour in the structure. The structure was simulated by the rigid frame placed on the top of the furnace. The heating simulates the fire curve measured during the natural fire by the seventh large scale fire test in Cardington laboratory. The supporting frame, which was thermal protected, was design the represent the boundary conditions of the beam into the structure of a multi-storey building. Twelve beams were tested with different connections and loading. The influence of the shear of the web and the connection to the behaviour of the lower flange was studied.

A numerical simulation was developed to observe the sensitivity of the parameters influenced the behaviour. The analytical prediction model suitable for the prediction of the behaviour under fire will be the major output. The analytical model of the behaviour of the beam compressed flange will be integrated into the prediction of the whole joint by component method and into the beam behaviour taking into account the resistance including the centenary action.

During the last year of the project was performed a compartment fire test on structure of Ammoniac separator II in company Mittal Steel Ostrava on June 16, 2006. The main goal of the experiment was to verify the prediction methods; namely of the joint temperature and its improvement during the cooling phase, the internal forces in the beam in the structure, and the behavior of the unprotected beams, see [2 and 4]. The structure of the building was composed of tree storey steel structure with composite slabs, beam to beam and beam to column header plate connections and diagonal wind bracings. Internal size of fire compartment 3,80 x 5,95 m, height 2,78 m. Opening of 2400 x 1400 mm ventilated the room during the fire. The mechanical actions was represented by dead load and by 1 m water, which was placed into 26 steel barrels and 50 plastic boxes equally distributed on the floor. Fire load was simulated by the unwrought timber bars 50 x 50 mm of length 1 m from softwood placed into eight piles. The comparison of the development of the gas temperatures show that at the beginning of the fire, till 30 min about, was warmer the gas in the front part of the compartment of about 200 °C. During the full developed fire, after 30 min, were the highest temperatures recorded in the back of the fire compartment, max 1050 °C. The beam lower flange temperatures correspond to the beam positions in the fire compartment. The front beam reached maximum temperature of its lower flange of 775 °C compare to the secondary beam in the back of the fire compartment with the measured maximal 970 °C.

The analytical prediction of the gas, element and connection was well confirmed by the natural fire test on the whole structure. The mechanical behaviour showed the influence of the fixing and developing of the internal forces, which was observed by the local deformation of the columns by strain gauges.

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Sustainable Construction of Buildings and Sustainable Development of Urban Space - Doctoral Project

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The main target of the doctoral project "Sustainable Construction of Building and Sustainable Development of Urban Space" was to support and co-ordinate scientific activities of students in doctoral study programs whose themes of dissertation works were focused to specific problems of sustainable built environment. The project was supported by Czech Science Foundation GAČR.

The goal was to integrate in the doctoral team students oriented to technical aspects of construction and operation of buildings, students focused to social, sociological, functional, urban and architectural aspects of built environment and students engaged in development of methods for assessment of environmental and social impacts, and economic efficiency. Financial support of members of Doctoral Team was very important part of this project. Financial resources were used for supporting of scientific and study activities of members of Doctoral Team including regular scholarship, study tours, short term intership, taking part in foreign and national conferences or buy of technical literature and so on.

This project started in October 2003 and was planned for 3 years duration. The project finished successfully with the last term of doctoral Workshop W3-610 in November 2006. Last meeting of members of Doctoral Team was held in December 2006.

The project was organized "across" different departments of CTU in Prague, taking into account the multicriterion character of the problem of sustainable construction [1]. The aim was to involve into the team students and supervisors working in different segments of the research in this specific field of investigation. Therefore 29 PhD students from 9 departments from Faculty of Civil Engineering and Faculty of Architecture were integrated in the Doctoral Team. Supervising board of the Doctoral Team was formed by 6 selected teachers - supervisors of PhD students – three of them from Faculty of Civil Engineering, three from Faculty of Architecture.

The educational activities of Doctoral Team were performed on three levels (1) Working Discussion Meetings, (2) Seminars, (3) Workshops.

Working Discussion Meetings were organized ten times annually. Each of them has been focused to specific scientific topic and was conducted by every member of Doctoral Team. About 32 meetings have been held during this project, some of them were focused to presentation of defended dissertation work.

Also special seminars were organized in order to enlarge knowledge in the sphere of sustainable development. These seminars were intended not only for members of doctoral team but also for all other students and public interested in the field. Following seminars were organized in the framework of Doctoral Project:

- 2003: Dachverband Lehm, Germany: Earthen Constructions in Contemporary Building
 Rode C., DTU Lyngby: Overall Hygrothermal Performance and Related Computer Simulations
- 2004: Jackson, Halenková, Jínová: Brownfields
 - ISES, FSv ČVUT: Solar Academy

- 2005: Hájek P., Tywoniak J., Novák J., Kabele K., Morávek P., Žďára V., Horný P., Smola J.: Low Energy Buildings
 - Gloser H.: Revitalization of Business Area Skoda Works in Pilsen
 - Semidor C., Laboratory GRECO, Ecole d' architecture et de paysage, rance: Quality of Public Space

• Kujawsky W., iiSBE Canada, Carleton University School of Architecture, Ottawa, Canada: Emerging Sustainability Issues in Architecture

2006: ■ iiSBE, CSBS iiSBE CZ and CIDEAS: Sustainable Building – Experiences from Implementation into Construction Practice

Scientific workshops W1-410, W2-510 and W3-610with presentations of research results of members of doctoral team and special guests have been held once a year at the CTU in Prague. Presentations were grouped into 3 thematic sessions: A) Energy in Buildings, B) Environment and External Relations and C) Building Structures. These presentations were mainly focused to the main topics of thesis of PhD students involved. Those Workshops were an ideal opportunity for all participants, guests and visitors to exchange experiences within implementation of sustainable principles into different kinds of building as well as urban design processes. Poster session was an important part of those workshops. The proceedings books from Workshops [2], [3], [4] are also available and contain contributions of student members of the doctoral team and guests presented in oral and poster form.

Also other activities like technical exhibitions (2004: Wood in Contemporary Austrian Architecture – Corinthia; 2004: Harmony, Ecology and Economy in Housing) or technical trips (2005: Industrial Heritage – Brewery in Kostelec n/Č. L., 2006 Ventilated Building Integrated PV Facade) were organized in the framework of doctoral team

All activities of Doctoral Team are presented on internet pages which are incorporated to existing web site www.substance.cz/grant.

Study results of members of Doctoral Team show effective support of Doctoral Projects for PhD study. 13 of 19 members of Doctoral Team which left the team after 3 years of PhD study according to rules of GA ČR have finished their PhD study passed successfully final doctoral exam, 4 of them defended their dissertation works during last year and other 3 - 5 students are going to defend dissertation works in 2007.

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Serviceability Limit States of Fibre Reinforced Concrete Structures

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Concrete is one of the fundamental materials used in civil engineering and has many beneficial features such as high compressive strength, relatively low cost, convenient production and placement, and good durability. However, due to its brittle nature, it tends to crack under tensile loading, resulting in loss of tensile strength in the post-cracking deformation regime. For reinforced concrete, the lack of ductility of concrete has implications on the structural performance as well as long term durability. Internal fibre reinforcement can improve the tensile strength and ductility of concrete beyond the elastic limit. According to behaviour of the material fibre reinforced concrete can be categorized into material with softening and hardening in direct tensile loading.

After forming the first crack in a critical section the behaviour of fibre concrete and concrete differs essentially. While crack in the plain concrete propagates and tensile strength corresponding to required strain cannot be taken into account (tensile strength is neglected in the ultimate check; $f_{ctd} = 0$), for fibre concrete it may be assumed that the critical section is capable to resist tensile strain; in the analysis a residual tensile strength is taken into account.

Reliability of fibre concrete elements in service could be provided in two ways. The first possibility is to prevent cracking for characteristic combination of service loads. Second possibility is to admit cracking and limit crack width according to aggressiveness of environment and type of fibres or disposition of fibres to corroding respectively.

Determining of the crack width in a fibre concrete without bar reinforcement is a problem as after crack formation the width of a crack increases quite quickly with contemporary decrease of the load-bearing capacity of the critical section. In an element reinforced by a longitudinal bar reinforcement the steel bar prevents fast crack opening.

The crack opening may be described with help of the stress-crack width relationship. This relationship is connected with fracture mechanic theory which becomes the basis to an understanding of crack and fracture propagation and mechanical behaviour in tension of fibre reinforced concrete materials and structures. In this approach the fibre reinforced concrete material is considered a composite material with specific material properties which can be predicted according to the type and amount of fibres used in the mixture.

The crack opening depends on many factors – tensile strength of fibreconcrete, aggregate interlock, the amount of fibres bridging the crack and fibre dispersion, inclination of fibres, possibility of pulling out of the fibres from the concrete mixture or rupture of the fibres. So complicated influences could be hardly described analytically; simplifying considerations must be introduced: bridging of fibres is assumed normally to the fracture plane only, the crack is divided into parts where particular effects are considered – part with aggregate interlock, part with bridging of fibres and area near the crack tip, where the stress is just reaching the tensile strength of the material. Fibre reinforced materials have a linear

response in uniaxial tension up to peak load. After peak a discrete crack is formed. It may be assumed that the discrete crack formation is dominated by the stress-crack width relationship. This is a well known approach in the description of crack formation in plain concrete and it is valid for cracking of fibreconcrete too. Fibre reinforcement has fundamental influence on the stress-crack width relationship but almost no effect on the pre-peak behaviour.

With cracking are connected other features assessed in serviceability limit state – deflection and durability. In general fibreconcrete structures have smaller deflections as fibreconcrete has usually bigger tensile strength (especially SFRC) and therefore the cracks occur later and flexural stiffness which is affected by cracking drops later.

Durability becomes controlled property lately. Durability is affected by permeability of concrete. And permeability is affected by cracking and porosity of concrete. Increasing demands on durability may be met by fibreconcretes. As an example high performance fibreconcretes may be mentioned. They resist extreme temperature conditions, dynamic loading and fatigue loading.

For all followed features limits must be determined. The most important limit which affects all mentioned features is crack width. Maximum crack width limit is related to pull-out or rupture of fibres and preventing of corrosion. Particularly for steel fibreconcretes the limit must be monitored carefully because of possible corrosion and deterioration of the of the appearance of the face of the structure, decrease of the positive material properties – toughness, ductility, tensile strength, which cause worse structural element behaviour of related member properties – stiffness, load-bearing capacity and deflection.

Based on the experimental results and analytical predictions the following conclusions were drawn: 1. The addition of fibres to the concrete beams was found to enhance both the cracking and ultimate flexural strength of the beams. The presence of hooked steel fibres in HSC changes the basic characteristics of the load – deflection curve. The ascending portion of the load - deflection changes very slightly, but the descending portion becomes less steep, which resulted in a higher ductility and toughness of the material. At a particular load level the various deformational characteristics, deflection, strain in deformed bars, and curvature were reduced due to an increase in the fibre content compared to plain concrete beams at the corresponding stages of loading. 2. Addition of fibres in half the depth in the shear span alone resulted in little increase in the ultimate load and deformational characteristics when compared to plain concrete beams. The toughness and ductility of the concrete beams increased with an increase in the fibre content. The ductility ratio is greater for full depth fibre-reinforced concrete beams compared to partial depth fibre reinforced beams. Addition of fibres increased both the ductility and energy absorption capacity. The maximum increase in ductility was 18%, 45%, and 68%, and percentage increase in energy absorption was 25%, 78% and 88%.

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Humidity and Thermal Effects in Porous Materials

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Environmental effects, humidity and temperature changes in particular, significantly affect the stress distribution in porous materials. The moisture diffusion as well as temperature fluctuations, both caused by environmental conditions, results in very complex stress and strain distributions and in tolerable or intolerable cracking. To ensure such damage would be tolerable, an appropriate method of analysis to predict the realistic state is needed.

The current methods, based on codes and standard recommendations, generally do not yield adequate information on the stress and strain distributions produced by changes of moisture content or temperature. They are capable of furnishing only approximate and sometimes quite inaccurate values. The linear assumption of stress distribution, which is generally accepted, does not provide any possibility to obtain an actual stress distribution. These limitations are due mainly to the omission of moisture diffusion effects and inadequacy of the simplified material laws, which characterise only the overall behaviour, and especially ignore the diffusion aspects.

During the process of wetting or drying, as well as changing the temperature, the change of the moisture content or temperature occurs first in the surface layers and only much later inside. The deformation tendencies first develop in the surface layers. This produces tension in the surface layers, which must be balanced by compression in the core of the cross section. As the wetting or drying process advances, the induced stresses vary throughout the thickness of the wall. Because of irreversible strains due to distributed microcracking, the process does not end up with a uniform state of stress and strain, and residual stresses remain.

Instead of sudden stress reduction to zero after the attainment of the strength limit, it is necessary to consider gradual strain-softening of material, i.e. a gradual decline of stress at increasing strain. Cracks produced by drying are normally so fine and finely distributed, or restrained by adjacent compressed parts, that a sudden formation of continuous cracks is impossible except for very large sections.

It has been proved that strain-softening stress-strain relations are inevitable for describing the observed deviations from linear elastic fracture mechanics or from strength criteria, and for obtaining the correct structural size effect. Also it is known that strainsoftening stress-strain relations of the same type as used in fracture analysis yield the correct results in the cracking stage. Furthermore, the use of the stress-strain relations coupled with an additional rule for unloading contraction after strain-softening explains the existing test data. Thus, the tensile strain-softening emerges as a fundamental property of material which must be taken into account when analysing the effect of cracking on structural performance affected by drying.

It is a typical property of fracturing materials that their elastic stiffness degrades during fracturing. If the microcracks were perfectly smooth, without interlock and rubble inside the crack space, and if the matrix were perfectly elastic with no nonlinear regions at the crack tips, the material would have to unload according to the secant elastic moduli all the way to the origin of co-ordinates. Comparison with test data, however, reveals that this is not so. The initial unloading slope is much steeper than the secant slope, although often still much smaller than the elastic modulus for the virgin state. During unloading, the material gradually stiffens and eventually regains its original elastic stiffness. This happens at very large compressive stresses rather than at zero stress. The stiffening of the material is due to the fact that cracks, once formed, cannot close completely partly because of rubble and interlocking fragments within the crack space, and partly because of irreversible material behaviour in the nonlinear crack tip regions.

The precise law governing the specific moisture content and its rate of change is difficult to determine from measurements because test specimens are typically in a non-uniform moisture state, and consequently have non-uniform stress distributions with self-equilibrated residual stresses, and usually undergo tensile cracking as a consequence of these residual stresses.

An important fact about moisture transport is that it is essentially uncoupled from the stress-deformation problem. This is confirmed by the fact that loading has no appreciable effect on water loss due to drying. However, when the formation of large cracks due to stress is expected, there is a two-way coupling with the stress deformation problem. The diffusion equation of moisture transfer is strongly nonlinear. This is due to the fact that at a high degree of saturation the moisture transfer occurs mainly in the capillary phase of water, while at a low degree of saturation the moisture transfer involves surface diffusion along absorption layers of water on the pore walls, as well as vapour movements.

It may be concluded that the effect of wetting and drying considerably alters the stress distributions in porous structural members. The effect is so important that the stresses obtained by the usual analysis, which ignores the diffusion and drying phenomena, are merely fictitious. This is why an appropriate analytical tool is needed to predict a realistic distribution of stresses to avoid considerable errors and further problems like intolerable cracking, higher maintenance and repair costs and often also shorter servicelife. Buildings are often plagued by long-time serviceability problems and have to be either closed or repaired well before the end of their initially projected design life. The cost to the society is tremendous, and in fact greatly exceeds in strictly economic terms the cost of catastrophic failures due to mispredicted safety margin. These economic costs are not only reflected in the actual damages but also in wrong economic decisions in the selection of design alternatives.

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Cavitation in Structural Engineering

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The term cavitation denotes generation of cavities (bubbles, caverns) in a liquid, their growth and contraction due to a static or dynamic drop in the pressure of the liquid below a certain critical value. With a falling pressure in a liquid, the mean distance between its molecules grows until, at a certain critical value of pressure in a homogeneous liquid, called **cavitation threshold**, the neighbouring molecular layers of the liquid are torn apart and the liquid bursts – cavities appear in it, cavitation has occurred.

At the start of the 20th century it was discovered that the performance of ship engines and the velocity of ships driven by them failed to grow as fast as was theoretically presumed. The reason for this failure was the generation of vast areas of bubbles in the immediate vicinity of the propeller, which reduced the driving force of the propeller, and, at the same time, the destructive effect of the bubbles on the surface of metallic bodies was manifested, called **cavitation erosion**, causing early wear of the propeller and its surrounding parts. Cavitation and its accompanying phenomena exist, with varying intensity, nearly in all cases of liquid flow through pipes or during the movement of bodies in liquids, e.g. the motion of water pump and water turbine blades, in the flow of liquids, liquid metals, blood in veins etc. Cavitation sets off a number of phenomena of physical, electrical, chemical and biological nature.

Since the very start of its appearance, cavitation has usually been connected with considerable technical problems in the operation of all sorts of hydraulic devices. Cavitation reduces the above-mentioned driving force of the propeller, causes erosion of machinery as there is no material that would be completely immune to cavitation erosion, produces noise and vibrations of these devices impairing their characteristics, disintegrates animal and vegetable cells, causes luminescence and a number of chemical reactions.

Cavitation and its related phenomena, however, also possess a number of beneficial properties, which have been successfully exploited in practice for decades. Acoustic cavitation is used e.g. in boring holes and in making hollows of complex shapes in hard materials, for cleaning surfaces and complex machinery parts or at points with difficult access, for cleaning lenses, for the degasification of liquids, for dispersing solid and liquid substances. Cavitation excites some chemical reactions that do not occur without cavitation, while other chemical reactions are accelerated due to cavitation. In biology, cavitation is utilized in processing microbiological objects (cell disintegration, killing bacteria, removing viruses from infected tissues etc.). In such cases, intensive cavitation is deliberately excited. Cavitation noise generated by collapsing bubbles, which is useful for locating points of cavitation appearance in underwater acoustics (e.g. for detecting submarines) can be marked with both a positive and negative label.

Cavitation initiates a number of characteristic phenomena of various types, such as: A. Local temperature and pressure increases at points of collapsing cavitation bubbles. B. Sound emission and dispersion. C. Luminescence of a cavitation zone conditioned on high pressure and temperature in the microvolumes of a collapsing bubble. D. Evaporation or condensation of liquid vapour in a cavitation bubble. E. Degasification of liquids at points in the cavitation

zone with low pressure. F. Changes in physical properties of liquids in the cavitation area (electrical resistance, thermal conductivity etc.). G. Chemical reactions. H. Disintegration (mechanical, thermal, electrical) of surfaces of solid parts at contact with liquids and changes in the structure of their materials.

During the collapse of a bubble the surrounding liquid penetrates inside the bubble at a great velocity so that in the final phase of the bubble collapse this liquid precipitates in the middle of the vanishing bubble, or it stops due to strong gas compression in the bubble. At this moment, the kinetic energy of the surrounding liquid is transformed into the energy of the pressure (shock) wave and partially into heat so that local high pressures arise in the collapsing bubble and its close vicinity, and the medium at these points heats to a high temperature. Successively, the pressure propagates as a shock wave from the point of the bubble collapse into the surrounding liquid. If the bubble collapses at a surface of a solid body, then the liquid penetrating inside the bubble bumps, at a great velocity, onto the surface of the body on which it collapses causing locally its considerable mechanical, electrochemical and thermal stress. This, in total, is manifested by cavitation erosion (destruction) of the solid body surface which no known material can resist. It was experimentally established that during the collapse of a gas bubble the related local pressure amounts to values in the order of 10^9 Pa, and the local temperature even over 10^4 K.

It was discovered that all known materials (steel, stone, concrete, diamond etc.), including the hardest and strongest ones, are subject to cavitation erosion in the cavitation zone. It is a highly complex process as its course is determined by a series of parameters of the respective liquid and the gases contained in it, the properties of the eroded body and, in a chemically active medium, also by processes of chemical and electrochemical nature. In general, it is assumed that cavitation is caused by numerous factors of physical and chemical character. Depending on the properties of the liquid (density, viscosity, surface stress, compressibility, thermal conductivity, chemical activity etc.) and the amount and properties of gas both dissolved and undissolved in the liquid, and on the physical and mechanical properties of the eroded material (hardness, plasticity etc.), some of these factors may, in a specific case, have a decisive effect on cavitation erosion.

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The Comparison of Temperature Loading of Supporting Construction of Bridges

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The design of bridge support structures is generally done according to standards. There is specified the type of loading with its values. One part of it is loading by temperature. We are solving the effect of loading by temperature according to different standards and the problem is described below.

For the comparison the temperature load according to standards ČSN 73 6203, ENV 1991-1-5 and DIN 1072 is used. Every used standard divided the temperature influence in two to basic parts – the uniform temperature component and the difference temperature component. Uniform temperature component means that the whole cross-section of the support construction is warming or cooling to the same temperature. The difference temperature component means that the upper construction flank is warmer or cooler than the bottom.

As the support structure is generally made by an isostatic construction, a continuous beam, the uniform temperature component takes only free displacement. Displacement values depend only on the construction type and the construction length. The difference temperature component on a simple beam takes only deflection, but on continuous beam takes deflection and internal forces. This loading by difference temperature component is researched.

For temperature differences, the standards generally use a nonlinear temperature gradient in the vertical direction. For easy constructions it is possible according to standards CSN and EN to use an easier linear gradient. This gradient is given in each standard for basic types of support structures. The basic bridge support structures are concrete structures, composite structures and steel structures. According to standards each type has its own gradient type for loading by temperature.

In research, the effect of temperature was solved on any types of constructions. The temperature gradient was transformed in to cross-section rotation. By this rotation the continuous beam of the support structure was loaded and internal forces were solved. If the structure has only one straight seated bearing, there arise only moments. These moments arisen by loading according to individual standards were compared. The comparisons have been done without any coefficients only in the basic values.

In spite of the fact that we can suppose that the loading according to the standards may have the same effect or the effect may not be very different, contrary is the case for some construction types. For example, the composite beam loading by cooling cause according to the DIN standard internal forces as minus moment, and the other two standards cause plus moments. In other case took the difference between standards values was up 70%. But these

are the maximum differences we have detected. Generally, the differences take values up to 30%. It must be mentioned, that comparing the standards is made only with respect to basic values without any coefficients (loading coefficients or combination coefficients).

Without measuring the temperature gradient on real structures we cannot say, which standard determines true a value or which one is nearer to the truth. It is necessary to support the theoretical considerations and calculations according to standards by experimental measuring the temperature fields on bridge structures on the site. Temperature fields and temperature gradients should be measured during day cycles (24 hours) and year cycles. By the evaluation of these cycles it would be possible to fix whether the extreme measured effects do not exceed too many the values given in the standard, or it would be possible to fix the frequency of such exceeding. It would be possible to fix how precisely and how reliably the individual standards give the temperature gradients for bridge construction design.

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Green Bridges

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Introduction

The situation in the Czech Republic after accession in the EU requires improvement of the highway network and the question, how to solve the problem arises, which comes up with the construction of new highways. This problem is solved by green bridges.

Europe has the world densest road network and it keeps growing. The road network causes a barrier effect. Natural habitats of many species are disturbed with this road-traffic infrastructure, they are divided and busy roads become invincible obstructions. Animals lose access to important feeding, breeding or escape areas and migration paths. Their territories are limited. The ways out of this are green bridges.

In the Czech republic there were designed and built a couple of ecoducts. The first one was built as a tunnel construction on R35 near Lipník nad Bečvou. An example of today are three green bridges on D11 the highway between Prague and Hradec Králové and another construction is built on the Prague belt highway, the part of Lahovice-Vestec.

In the area of Germany, which has the second densest traffic network in the world, there are now 32 green bridges, another 8 are under construction and another 20 are planned. Projects of ecoducts are closely associated with EU directions and EIA reports.

The Swiss methods are the most effective and worldwide used. From simple animal crossings, tunnels, underpasses and tubes, to warning devices. Placing these elements must be well chosen, preferably by local, regional and supraregional biocorridors and biocenters. Here the GIS technologies and monitoring can be very good used.

Impacts on the environment, impacts on fauna

Impacts on the environment have been divided into four basic groups:

- Devaluation of the area (air pollution, dust)
- Disturbance of the area (noise light)
- The road as a barrier in the landscape (avoidance of migration)
- Hurting and killing animals by traffic

The study of impacts on the environment is already an integral part of the technical and economic analysis of all projects of transport. The primary measure is to stake out the route in a way not to cross sensitive areas. If this is not possible, then it is necessary to find out a solution that would be the most acceptable. This means to preserve the area close to its natural quality.

Requirements, construction demands

Green bridges in natural habitats' areas are helping to renew and reconnect previous wildlife paths. The bridge is covered with soil, vegetation (as protection against light and noise from the road). Both-sided guiding lines, for example a hedge, a forest foot, can show animals the way to the bridge. The bridge is appropriate for animals such as deer, fox, badger, but can also be used by smaller animals, who prefer to be hidden. To keep their function, they should be wide enough (ca. 50m), which will be shown in the price of the construction. The most expensive will naturally be a narrow bridge, because it will not be used at all and it is concerned to be a lost investment. The depth of the soil depends on vegetation, for grass and herbs 30cm are sufficient, and for trees ca. 3m.

Bigger constructions, known as landscape bridges, have a width of more than 100m, they are designed to recover the vegetation and landscape elements that were present before destroying them. Usually they look like a normal tunnel, but are built by the "cut and cover" method.

To assess the effectiveness of the construction is monitoring necessary. This will show the usage and the species, which use these crossings. It is done by observing sand traps or using ink-pads. Electronically only the frequency can be measured.

The efficiency was controlled at 21 crossings in Switzerland. In the pictures can be seen deer, roe-deer, pigs, rabbits, badgers, and martens. The analysis proves that bridges of less than 50m in width are not used. When there is a bridge in an appropriate place, well revegetated and well dimensioned, then it is frequently used.

Conclusion

When designing green bridges, it is necessary to develop guides and recommendations for conceptional decisions and their planning, together with the tools and methods for their structural design, construction and maintenance, respecting the ecological and economic aspects, so that the structures comply with the requirements for load-carrying capacity, durability, safety fulfilling simultaneously the required appearance. Also an environmental risk assessment should be required. This process examines impacts on soil, air quality, hydrology, noise, fauna and flora.

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Prestressed Concrete Structures with Fibre Reinforcement

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Concrete is known from ancient times. To all intents and purposes may be said that the ancient Romans knew and used concrete. During ages relative negatives of concrete were compensated and removed. 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. Therefore a pre-stressed concrete came into being, where concrete high compressive strength is better utilized. This was not the last improvement in the field of concrete structures. Architects design structures with bigger spans and smaller cross-sections and for such pre-stressed structures high strength concrete was developed. Nowadays concretes with strength higher than 100MPa are available. High strength is paid higher brittleness of the material. Hence new materials are inquired after which will hold positives of high strength concrete and will have also higher tensile strength and ductility. This could be reached by adding fibres into the mixture of concrete.

There are two main groups of pre-stressed concrete structures and use of fibres have different aspects according to the type of pre-stressed concrete and matter of fibre utilization.

Pre-tensioned concrete is cast around already tensioned tendons. The cured concrete adheres and bonds to the bars and when the tension is released it is transferred to the concrete as compression by static friction. With fibreconcrete a good bond between the tendon and concrete is reached and transport of the pre-stressing force from tendons to the rest of the section is provided.

The manufacturing procedure requires firm anchoring points between which the tendon is to be stretched and the tendons are usually in a straight line. Thus, most pre-tensioned concrete elements are prefabricated in a factory and must be transported to the construction site. During transporting members are often harmed; the surface may spall or rub off. Fibreconcrete element is more tough and ductile and the damage during transport is less probable.

To ensure durability of the pre-stressed element corrosion must be avoided. Using of fibreconcrete leads to favourable layout of cracks and smaller widths of cracks a thus a better protection of pre-stressing tendons is provided.

In post-tensioned concrete the compression is applied after pouring concrete and the curing process. The concrete is cast around a plastic, steel or aluminium curved duct, to follow the area where otherwise tension would occur in the concrete element. A set of tendons is thread through the duct and tensioned by hydraulic jacks that react against the concrete member itself. When the tendons have stretched sufficiently, according to the design specifications, they are wedged in position and maintain tension after the jacks are removed, transferring pressure to the concrete. The duct is then grouted to protect the tendons from corrosion. Post-stressing is used in the construction of various bridges or for slabs of large spans.

Forces transmitted to concrete via tendons are quite high and they are concentrated in relatively small area below anchors and jacks. This may cause cracking transverse to pre-606

stressing or even a splitting of the element. In the anchor area fibres may provide confinement and avoid failure. In general in areas with extreme forces and local peaks of stress, where brittle failure threatens, fibre increase ductility and hence safety of the structure. Using of fibreconcrete at least for strengthening of extremely stressed areas should be analysed.

Recently a question of durability, life cycle assessment and cost is considered in structural analysis.

The durability aspects are mostly influenced by cracking. Both synthetic and steel fibres have been shown to improve toughness and cracking, let it be cracking due to loading and stresses or shrinkage. Other factors, such as low permeability and resistance to freeze-thaw to chloride ingress, carbonation and other chemical attack may be features affected by fibres, too.

Concerning LCC contribution of fibres may be appreciated both in the initial of the life cycle and later during service of the structure. Reduced initial construction costs result from wider girder spacing and longer spans, saving of conventional reinforcement which is replaced by fibreconcrete. Long-term costs are reduced due to fewer replacements and fewer repairs. For instance repair of pre-stressed bridge may be very complicated and cost demanding.

On some newer structures lightweight aggregate concrete is used. Lightweight concrete provides reduced dead-loads and thus enable increase of spanning. But at the same time this material is more brittle; this negative may be reduced by fibres.

The benefits of fibreconcrete are already beginning to be applied. Recent developments in fibre-reinforced concrete hold promise in terms of performance and cost-effectiveness of the structure. But effectiveness will be kept only with proper design of the fibreconcrete mixture only adding of fibres into common concrete is not a way to smart design.

The contemporary trend in design of concrete structures is developing towards the high quality, robustness, reliability and durability. The requirements of codes and also of the clients are stronger than those some years earlier. In order to guarantee the mentioned quality requirements it is necessary to develop new materials of a higher standard and to eliminate the human factor in execution of concrete structures as much as possible. The high strength fibre reinforced concrete belongs to the new materials which are able to satisfy the requirements on mechanical properties and on durability. In the field of prestressed structures the work on site must be simplified. The elimination of the mild reinforcement is possible and this will accelerate and simplify the site works. The reduction of mild reinforcement e.g. in the anchorage zones, provides good conditions for easy casting. Good access for concrete will results in a good quality of the pre-stressed element and less risk in terms of poor filling of the area with concrete.

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Application of Fibre Reinforced Concrete in Precast Elements and Structures

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In spite of progress of technology in fibre concrete production, plenty of fibreconcrete offered for purchase, the most common use of fibreconcrete lies in producing of fibreconcrete floors for storage buildings, roadways and landing grounds. Advantageous properties of fibreconcrete deserve to be exploited in structural elements and extension of fibreconcrete into wide utilization in structures. Within the scope of research project, where construction companies collaborated with academic sphere, possibilities of utilisation of fibreconcrete in practical building industry were inquired. Application of fibre concrete in structures leads to costs savings. Expenses decrease results from change of structural behaviour and from savings in the course of manufacturing. Savings are reached only if a structural element is convenient for application of fibreconcrete. In the first stages of the research programme these convenient structural elements are sought for. The pilot planting is prepared and abilities of possibilities of plants are verified. In pilot planting and subsequent experiments suitability of the element for fibreconcrete application is analysed and proper choose of particular fibreconcrete is specified. A structural analysis must be performed for service load and for ultimate load. Critical sections must be determined and which properties could be improved and which disadvantages of the element could be eliminated by using of the fibres. At the same time convenient fibreconcrete must be find that could meet requirements on the structural element behaviour

Utilisation of fibre concrete as additional reinforcement of replacing of classical bar reinforcement by fibres is economically beneficial if higher cost of fibres is offset by decrease of labour consumption, faster and better production. Labour consuming process of forming, bending and binding of conventional bar reinforcement may be completely removed by using of fibres. Fibreconcrete elements could have smaller dimensions (thickness).

In this stage of project mainly small-sized precast elements were chosen. They are not subjected to big loading and therefore the area of reinforcement is often determined with respect to minimal reinforcement ratio to avoid brittle failure. In the cases application of fibre concrete is advisable. As an example bridge cornice plates and light-weight lintels will be noticed briefly. Thus cornice plates are not the load-bearing member of the bridge, their strain may be quite high. They are subjected to action of atmospheric effects, temperature changes, saltary attack. Due to volumetric changes cracks develop. Cracks could be formed during manipulation and transporting of the member. Cracking is a problem both in terms of aesthetic demands and the safety aspects; in a cracked concrete there is more probable corrosion of anchors and pulling out of anchors from the element and fall of the cornice plate and injure of passing persons or damage of vehicles. Considering all these problems of cornice plates a fibre concrete with synthetic fibres (SSFC) was chosen to be a good solution. The use of the correct concrete composition and suitable shape of the element enhance the engineer's ability to make the best use of the advantages of FRC even in difficult circumstances.

In co-operation with manufacturer a mixture for pilot product in the plant was prepared with 1% of fibres. Due to ductile behaviour of the SSFC favourable failure of the member is provided and also the amount of conventional steel bar reinforcement may be decreased. In the pilot plant was proved that the SSFC could be mixed, the mixture has good workability and the manufactured element has smooth surface without defects in order to satisfy aesthetic demands[1].

Possibilities of application of fibre concrete are in elements subjected to shear forces. Replacement of conventional shear reinforcement by fibres has been investigated at our department. In the research project a practical application in this field is being verified. A manufacturer of lightweight aggregate and the lightweight concrete members joined the project in effort to improve its production. Members with lightweight gravel on ceramic clay basis are relatively brittle and susceptible to surface damage during manipulation. Fibres in the mixture increase ductility and toughness and prevent splitting of surface of elements. From the production of lightweight elements a lintel was chosen to verify benefits of fibres in lightweight concrete. From the wide range of fibres polypropylene fibres were determined to improve properties and behaviour of the lightweight element. Synthetic fibres do not corrode and this property is important in air entrained concrete. In the introductory phase of the project two comparable mixtures were prepared with the lightweight aggregate. The first one with polypropylene fibres, the other without fibres. Laboratory specimens were made - cubes for compressive strength and splitting tensile strength examinations and beams with dimensions 100 x 150 x 1800 mm with longitudinal reinforcement. The measured strengths of mixtures with and without fibres were similar. The strength of lightweight fibreconcrete was 5% less than strength of lightweight concrete without fibres. Significant differences were in the flexural load-bearing capacity of the beam with conventional longitudinal reinforcement. Fibre concrete beams had bigger load-bearing capacity and failed in completely different mode than beams without fibres. While fibre concrete beams had typical flexural failure, beams without fibres failed in a shear mode. Thus was empirically proved that fibres may serve as shear reinforcement. Optimization of the amount of fibres must be performed. SSFC with 0.5 % of fibre content seems to provide a tough structure that will resist surface damage. Higher fibre content (about 1%) is assumed as sufficient to ensure higher load-bearing capacity and enables omitting of shear reinforcement. Properly chosen material for the structure plays an important role in analysing of economic benefit. Fibre concrete meets the demands on sufficient load-bearing capacity and reliability of the structure. Furthermore it conforms to requirements of durability and service life. Exploitation of SSFC increase fire protection as well. Additional research will be conducted to discover new and innovative ways to ensure the durability of these types of members and careful monitoring in situ is necessary.

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Tendon Layout to avoid Excessive Deflections of prestressed Concrete Bridges

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Prestressed slender bridges are extremely sensitive to deflections in general. Deflection is a result of two opposite actions: the first one is caused by the external (vertical) loadings like dead load and live load, the other one, which has the opposite direction, is the effect of prestressing. Both mentioned actions, when acting separately, would produce individually significant deflections of opposite directions. The resulting deformation due to simultaneous action of the both loadings - due to external (vertical) loads and due to prestress – is the difference of the mentioned deflections - this difference of large numbers is very sensitive: a small change in one of these numbers may result in a very significant change of their difference, i.e. in a significant change of the final deflection value.

It can be shown that low deflections of the bridge during the cantilever construction stages do not automatically result also in acceptable deflections during the bridge service life. The cantilever tendons, applied in erection stages, are usually very efficient during construction. However, after changes of the structural system making the structure continuous in the final structural system (e.g. closing of the midspan joints), their efficiency on the long term growth of deflections may be significantly limited, since the additional forces are developed due to the redundancy in the new structural system.

Analyses of two bridges, elucidating significance of the tendon arrangement layout, were performed.

As the first example, the bridge over the River Labe in Melnik built in 1992 in Central Bohemia – a three span continuous box girder bridge (72.050 + 146.200 + 72.050 m) with tapered shape, erected using the cantilever technology – was considered and analyzed. The task was to identify a possible unsuitable arrangement of the tendon layout that can result in harmful effects – as such tendons cause long-time increase (instead of reduction) of the midspan cross-section deflections.

It was found that 22% of the total prestressing tendons affect the investigated bridge unfavorably, contributing to an increase of deflections. The tendons located at the bottom surface of the first and third spans proved to be extremely harmful, since all of them produce deflection increase in the central region of the main span of the bridge.

Among the tendons located at the top surface, applied during cantilever erection, the straight tendons, which are passively anchored in the vicinity of internal supports and follow the top surface, are harmful. In the discussed bridge, the unfavorable tendons in the first (and in the third) span are anchored typically at distance of approximately 15 m from the ends of the bridge, the unfavorable tendons in the main span are anchored typically at distances of approximately 30 m from the midspan.

The second example, the bridge on the motorway D8 over the river Ohre built in 1996 in North Bohemia – also three span continuous box girder bridge (70.5 + 137 + 70.5 m) with tapered shape, erected using the cantilever technology – was considered and analyzed in the same way as the first example. Here, only the tendons located at the bottom surface of the first and third spans were proved to be harmful; all of them produce deflection increase in the central region of the main span of the bridge.

All other tendons reduce deflection at the midspan of the bridge. Thus, in contrast to the first example (bridge over river Labe in Melnik), all the top surface located tendons of this bridge are efficient for deflection reduction. This arrangement is also very beneficial to reduce shear forces nearby internal supports.

Practicing engineers can benefit in the design of sensitive bridges from a developed computer program OPTI 1.1. making the assessment of the tendon layout immediately accessible to any engineer. This program is free to download from the internet address: <u>http://concrete.fsv.cvut.cz/veda/science_en.php</u>.

The significance of the tendon arrangement layout and presents approaches to assess its efficiency on bridge deflections was clearly proven. There is no longer any need for blindly trying to find an optimal tendon layout that is really efficient from the point of view of reduction of deflections. The developed simple tool allows the tricky tendons (that – on the one hand - are beneficial to eliminate tensile stresses but whose layout – on the other hand – significantly contribute to deflection increases) to be eliminated.

Lessons from assessment of existing bridges can be learnt: bridge design should be performed on two different levels, including two equivalent parts – not only common stress analysis, but also optimization of prestressing tendon layout should be compulsorily performed to reach acceptable deflection variations.

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The Software of Reliability Estimation and Risk Evaluation

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This contribution gives publicity and supplements the poster presentation at 3^{rd} International Conference on Project Management (ProMAC2006) which was held in Sydney on $27^{th} - 29^{th}$ September 2006. The poster presentation was discussing about the model that is able to simulate construction duration and cost for a building project. The model predicts set of expected project costs and duration schedule depending on input parameters such as production speed, scope of work, time schedule, bonding conditions, maximum and minimum deviations from scope of work and production speed.

The presented application software is designed for building contractors and submitters as a tool for rational comparison of bid price of construction complying with proposed time schedule of the building process. The application software carries out from input parameters the simulations of time schedules of building activities and its corresponding financial, material or operating needs. On the basis of a statistical evaluation of enacted simulations a program algorithm calculates the assumed value of compared bid price and its corresponding assumed start and end terms of particular building activities and the assumed end term of entire construction.

The application software is possible to use at many levels of project management. The possible fields of application are for example: decision about realization of intention, cost assessment and inference of bid price, dynamic schedule, detailed calculation of costs and time schedule of building activities, optimization of building process, information source usable in realization of future projects etc.

The application receives input data through "Module of input data." The Module defines particular activities of the building process, scope of work of these particular building activities in physical or financial units, its production speed and bonding conditions.

The application records input data through user-defined data file with filename extension CSV. The users are enabled to resume their work or to prepare more building projects simultaneously.

On the basis of input data the algorithm of application makes it possible to calculate an instant dynamic progress chart of the building project, which includes a schedule of demands through time. The dynamic progress chart creates a comprehensive methodically uniform model. Among the model's outputs belong information about the start and end terms of production activities and information about cost schedules. The application makes possible graphic visualization of demands through time.

Important information regarding the proposal of a future project time schedule is specified by tests of potential scenarios of the project development with current fixing of certain parameters of the building model. It is possible to obtain important information about critical parameters of the planned project, for example by fixing of deviations of scope of work of particular activities.

It is widespread to present the probability of the total construction time of a building project without a cost viewpoint. Better-expressed project cost is presented as a respected fixed value that will be stable and independent on project duration. Facing this notion the proposed approach of simulation interrelated values time and cost is more comprehensible and complex.

The application is able to calculate, on the basis of input level of probability, the adequate construction cost and time duration of a project. The reciprocal view may focus to find out the adequate level of probability for construction cost and activity durations.

The application outputs can be used for bid preparation of investment projects. However the application is able to carry out interesting simulations of predefined development projects. On the basis of input minimum and maximum deviations from input data the application carries out simulation of the presumed development of the building phase. It is possible to identify the effects of changes to scope of work and time schedule in particular activities.

The results of simulations are utilized for graphic visualization of the assumed progress of the building project and are also possible to save them into the user-defined data file with filename extension CSV. The application makes it possible to examine the detailed progress of many parameters of the defined building project.

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Experimental and Numerical Analysis of Timber Concrete Composite Floors

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In recent years the refurbishment of old buildings with timber floors has drawn attention to an efficient floor system, the timber-concrete composite slab. Compared to traditional timber floors the main advantages of this type of composite structure are increased strength and stiffness, improved sound insulation and fire resistance.

In the reconstruction of old timber structures an important role is played by a good knowledge of the properties of timber. The estimation of the properties of timber by means of the visual grading method is not entirely reliable with respect to a series of factors influencing the mechanical properties of timber and, further, with respect to the influence of the human factor in the grading proper.

Behaviour of timber-concrete floors

Basic behaviour of a timber-concrete beam with semi-rigid connections is following. Cross sections do not keep their planarity. Concrete layer is under compression and bending, timber beam is under tension and bending and fasteners are under shear. The strain distribution has the same slope because the section parts keep the same curvature; stress diagram is the result of compression-bending and tension-bending stresses.

Design models

Analytical model is based on the following general assumptions and conventions:

• The vertical deflection is equal for both elements and is given by one function. This means that a gap will not occur between the concrete and the timber in the model.

• The single cross sections remain plane, shear deformations within the two elements are not considered.

Compression strengths and stresses should be entered with a negative sign.

The model can only be used for elements subjected to bending, so external axial loads are set to zero.

In the FEM model, the following assumptions are introduced:

• The member, the applied loads, and the deformations lie in a plane; the plane of the loads is the plane of symmetry of the member;

• Material properties of each layer are constant along the length, but they can differ from one layer to the other;

• No separation occurs between layers at any point along the member;

• There is no friction at the interface between the two layers; the interaction between the layers follows the connector load-slip characteristics;

• For each layer, a geometrically nonlinear Reissner's beam theory is assumed with small interlayer slip; geometrical (displacements and rotations) and deformation (membrane, bending) variables are finite;

• Materials in all layers and the load-slip characteristics of the interface are assumed to be nonlinear.

Recommendations

Do not use wet timber. If it is unavoidable, use timber without pith or be sure that fissures will not affect fasteners lines. Leave the propping in place for more than the time allowed for all-concrete elements.

Use corrosion-free fasteners: passivated steel or zinc-coated steel or stainless steel.

Reinforce the concrete especially if thick concrete sections are being designed, in order to ovoid loss of stiffness due to large cracks on the concrete tension side.

When casting try to protect the timber from moisture, i.e. using plastic layers or using concrete with additives in order to reduce the water/cement ratio (that also allows smaller concrete shrinkage). This is not crucial for timber but for appearance undemeath. Pay attention to timbers that do not allow the concrete to harden (e.g. in the case of larch, due to sugar extractives).

If the spans are long prefer the use of soft connections in order to minimise eventual constraint actions, and, when possible, prefer a structure where the concrete layer is mainly important for reducing deflections rather than for reducing a lot of the stress values in the timber.

The deformation of concrete showed a significant influence in the joint stiffness. This could be included in calculations by decreasing the factor by which the slip modulus is multiplied in the models given in Eurocode 5.

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Analasys of Property Valuation Kinds in the Czech Republic and Abroad

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The questions of the real property valuation in the Czech Republic adhere to the Act. No. 151/1997 Coll. "Act of the Property Valuation" as amended and to its implementing ordinance number 640/2004 "Implementing Ordinance of the Act of the Property Valuation" as amended.

The above mentioned act defines the property valuation generally (chattels, real estate, asset values, rights etc.) and valuation of services. The implementing ordinance determines more in detail valuation methods for each type of the property, whereas its majority treats the valuation of the real estates.

This act is not used for the determination of the purchase price between a seller and a buyer. The purchase price is determined only depending on the relation between the offer and the demand and its level depends only on the accord between the seller and the buyer. Nevertheless the participants of the trade will need to know the value estimated according to this law for the reason of the real estate-transfer tax. The real estate-transfer tax amount is calculated from higher value of these two: the value estimated according to the above mentioned law or the purchase price.

The above mentioned implementing ordinance determines the prices, coefficients, surcharges and deductions from the prices and valuation procedures for things, rights, asset values and services. Problems of the real estate valuation are divided into chapters depending on property type (buildings, one-family houses, mains, roads, cottages, garages, flats, secondary constructions, lands, vegetation etc.) and applied method (cost approach, income approach, comparative approach). In the Czech Republic, in comparing with other countries, the system of rules, principles and regulations of real estate valuation is quite complicated. There are several laws, ordinances, standards and other forms of regulation that should be followed.

In this paper we present our research started in July 2006. We had gathered data from 3 financial institutions (mortgage providers), from Czech Statistical Office and partially from Ministry of Finance to evaluate the kinds of valuation approaches used from July 2006 till December 2006. The records were compared against date inquired from questionnaire fill by professionals - real estate estimators and authorized expert.

Primary goal of research is to determine the percentage of estimation of open market value and estimation proceeded accordance ministerial regulation. By the end of December 2006 we have received 43 questioners. There are 35 of them (81%) fully completed and can be used in analysis. Our current finding show that 40% of valuation is done to estimate open market value of property, 13.5 % of valuation is done just for tax purpose (accordance

ministerial regulation) and 46.5% valuation has been done for both type of valuations. Our results are based on the small amount of information; nevertheless we hope to receive more questioners in the January a February 2007 (second wave of information letters will be launched).

The progressing globalization in all fields of our economies (not only within European Union) will be cause of stronger and quicker harmonization of the national valuation rules with the international rules, represented for example by European Valuation Standards and International Valuation Standards. This harmonization can bring some degree of simplification of the valuation regulation in both countries.

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LEnSE - Methodology Development towards a Label for Environmental, Social and Economic Buildings

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In January 2006 started the 2-year project of the EU Sixth Framework Programme entitled **LEnSE** - Methodology Development towards a Label for **En**vironmental, Social and Economic Buildings. 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 certification.

To reach the goals following steps are performed:

- 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.
- 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.
- **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.
- 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)

There are different possibilities in standardization of rating system. A first standardization method scales the scores for each criterion according to the relative distance between the origin and the maximum score (distance to target). A second method scales these scores according to their relative position on the interval between the lowest and highest scores. Most LCA-tools use the normalization step for standardisation.

National stakeholders meetings

From June to July 2006 there was held the first series of national stakeholder meetings in all eight partner countries. Between the participants were national stakeholders, including architects, property developers, construction industry and building owners as well as representatives from governments, local authorities, research institutes and universities. The main purpose of the meetings was to discuss selection of relevant issues for a label for environmental, social and economic buildings, and to identify national and regional priority issues taking into account the national situation in each country. A total of 106 participants representing different organisations met during the eight national stakeholder meetings.

Explicit feedback on sustainable construction in general, and the LEnSE objectives in particular, was obtained by means of a questionnaire. The results showed that a very large majority (79%) of the participants feel that the development of a Europe-wide methodology for a sustainability label for buildings is important or even very important for their country.

Surprisingly, although the importance of the development of a sustainability assessment for buildings was deemed to be very high, the willigness to implement it in practice was considered much lower (especially in the Czech Republic). This means that there still exist important barriers between theory and practice. LEnSE hopes to be able to remove some of these barriers and to increase the chances of a successful implementation of the methodology.

The objective of the LEnSE project is to form an international framework for the development of a common building labelling methodology with creating a set of the main assessment criteria. On the basis of the main criteria there will be designed a prototype assessment tool that facilitates testing of the methodology on a specific building types (new residential and commercial buildings).

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Modernization of Education of Reinforced Concrete Structures Design According to Eurocode

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The project covered two basic topics; one of them aiming to make the concrete structures design education more attractive, another one being concrete structure design in accordance with valid code.

Recently, the system of education at the university is being changed into structured programs (bachelor, master and doctor), according to Bologna declaration. Faculty of Civil Engineering CTU in Prague is as of 2003/2004 school year admitting students for bachelor study programs. Therefore, new subjects taught by the department of Concrete and Masonry Structures emerged. New tools had to be prepared for those new subjects. These tools comply with recent trends and leverage modern computer technology. Recent trends result also in less contact hours; exercises in particular are being reduced. Therefore it is desirable to make the exercises more efficient and use tools which help the student with orientation in the subject.

The transition to European code is in progress in the normalization area. The code for concrete structures design, EN 1992-1-1, so called Eurocode 2 [1], was already approved and translated into Czech language. In the course of 2006 year, national application document was appended to the code. It was necessary to familiarize the students with this new code as well as introduce new pieces of knowledge in the area of design.

Outputs of the project cover the basic course of the subject Concrete structures; therefore they are being used in a number of subjects. Design of simple as well as complicated concrete structures is being taught in bachelor study program Civil Engineering (subjects BEK1 – Concrete and Masonry Structures 1, BEK2 – Concrete and Masonry Structures 2) and bachelor study program Architecture and Building Engineering (subjects BZ1A - Concrete and Masonry Structures 1, BZ2A - Concrete and Masonry Structures 2). Tools are being used by students of higher classes as well. They are used in subject Project in study program Civil Engineering. In this subject, students are designing real structures, therefore they benefit from the access to the tools which will help them designing load-bearing elements of reinforced concrete structure of an object.

Theoretical as well as practical tools were prepared during the project. Some of them are helping the students already now; they are displayed on the web page of the department [2] or they were distributed during the exercises. Other tools will become effective as of next semester in subsequent subjects.

Practical tools are in a clear and understandable way explaining the process of reinforced concrete structures design taking into account bending and shearing. They come with concrete illustrative examples. All the examples were elaborated based on new European code for design [1], as well as the final version of the European code for structures loading [3].

Based on work experience with students, production of the tools in a form of posters was selected. Posters are displayed in the corridor of the Department of Concrete and Masonry Structures close to the lecture rooms. Students have the opportunity of familiarizing with the results of the FRVŠ project. As quite many of them wanted to get the posters with the tools, all the posters were displayed on the web page of the Department of Concrete and Masonry 620

Structures [2]. Format of posters was selected so that they can be printed in A4 format in reasonable quality. Using of internet is nowadays standard way of communication between students and teachers. Department of Concrete and Masonry Structures decided therefore to make most of the tools accesible on the internet to help the students with excercises and with preparation for the exam.

Another tool which is bringing new trends into tuition of civil engineering students is interactive education program EuroCADcrete [4]. Program EuroCADcrete is made for education and testing of students' knowledge in the area of reinforced concrete structures design. It should simplify and make more efficient the transition from national codes to the Eurocode. Program EuroCADcrete is developed as an extension of static software MxFrame, for more details see [4]. Using computer technology for tuition of design of concrete structures is allowing for generation of infinite amount of assignments, which forces each student to work independently. Student is able to verify his calculation himself, using the interactive approach of the program. Program EuroCADcrete should help in particular to the teachers, not to spend most of their time by verification of students' calculations. Students will benefit from having more time for discussions about theory and principles of reinforced concrete structures design.

Main output of the project is a set of tools which is serving to the students of the Department of Concrete and Masonry Structures as theoretical as well as practical instructions for the exercises. All the tools are freely available on the web page of the Department of Concrete and Masonry Structures. In addition, tools for lecturers were developed, which can be used during the lectures for energizing the presentations.

It turned out that the poster format is most suitable for the tools. Posters vitalized the area next to the lecture rooms of the Department of Concrete and Masonry Structures. Students could familiarize themselves with the posters during the semester. Every student can download poster of his interest from the web page of the department and use it for elaboration of the assignment or for preparation for the exam.

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Interactive Utility for Teaching Designing Recontructions -Stregthening of Masonry Structures

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This project helps to create an interactive utility for a subject called Reconstruction of concrete and masonry structures. This subject is accredited subject for bachelor and master study at the Faculty of Civil Engineering at Czech Technical University in Prague. The utility consists of Powerpoint presentation and manual in pdf data format, which includes photographs of damaged structures, descriptions of the reasons of failure and consequential structure's savings. There has been also made an Excel file with program to make design of strengthening of masonry structures. This file can be downloaded from the website of the Department of Concrete and Masonry Structures.

The project has been divided into two parts.

First is analysis of accessible literature (regulations, lecture notes, publications, archives, etc.), evaluation and selection's composition of typical malfunctions representing these problematic. Second is creation of utilities for teaching, which are at disposal for the employees of the Department in order to facilitate their preparation for lessons and also for students for easy, interactive designing of possible ways of saving, to obtain quick output of several variants of possible solutions of chosen problem.

In the first part, a collection of accessible literature for solving this problematic (books, regulations) has been compiled. This literature can be borrowed from this report's author. In order to respect the Authors' Act it is not possible to copy or publicly make accessible this material or its parts.

And then an archive of photographs has been converted into digital form. It captures much of vocational practice of Prof. Ing. Tomáš Vaněk, DrSc, in particular the part that deals with reconstructions and savings of buildings. For this archive over 4000 photographs has been obtained, which is over 100 GB (diapositives scanned in color with High Resolution). Some of them with comments are published on the website of this report's author. The entire archive is for purposes of teaching at disposal for the members of the Department of Concrete and Masonry Structures of CTU in Prague within the frame of the department's Intranet.

There has been created utilities for the design of strengthening vertical masonry structures (method of steel and concrete collar) for teaching. This utility is in the form of an Excel file. And another utility has been made - for quick estimation of charge for typical masonry residential buildings built respecting regulations for constructing between years 1860 and 1950.

Process of design is based on the manual in the book Rekonstrukce staveb, by Prof. Ing. Tomáš Vaněk, DrSc., SNTL 1989.

Steel collar:

N=γ_u · ψ · φ · k_d · [(γ_k · R + δ · (2,5μ)/(1+2,5μ) · (R_{aq} /100)).A_k + R_a · A_a]

Conrete collar:

 $N = \gamma_u . \psi . \phi . k_d . [(\gamma_k . R + \delta . (3\mu)/(1+\mu) . (R_{sq}/100)).A_k + \gamma_b . R_{bc}. A_b + R_{sc} . A_s] = 0$

Armored parging collar:

 $N=\gamma_u \cdot \psi \cdot \phi \cdot k_d \cdot [(\gamma_k \cdot R + \delta \cdot (2,8\mu)/(1+\mu) \cdot (R_{sq}/100)) \cdot A_k] =$

For more information, please see:

http://concrete.fsv.cvut.cz/~vytvar/granty.htm

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Instruments for courses in fire design of concrete and masonry structures

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Fire design issue is very actual these days. This fact caused that new course dealing with this topic was established as part of civil engineering courses taught by Department of Concrete and Masonry Structures at Faculty of Civil Engineering at Czech Technical University. New course is called Fire design of Concrete and Masonry Structures and it became part of studying branch Civil Engineering. For student studying this program is this new course optional.

To work out all necessary information, we gained money from fund and thanks to this we developed some useful instruments for new course. These instruments can be used in other related courses, in students' projects or their thesis as well.

First we searched for students needs in this area. Together with Department of Steel and Masonry Structures we taught course called Fire Design of Load Bearing Structures. During this course we search for their needs, requirements, interest etc. Next step was calculating of temperature fields using software TCD. Results from this software were used to create some instruments for excercises and homeworks. All information and data obtained during our work we used to provide information for student and to make their work easier. We placed some data on internet web page and students can get them at class as well.

Provided set of instruments includes: algorithms of some calculation methods, examples, temperature fields, examination tests, poster and web page.

To make students work easier we prepared some algorithms of simplified calculation methods. These methods are: Isotherm 500°C method and zone method. Other algorithms and instructions ate incorporated in examples.

Examples made out within this project are: Example of load calculation for standard situation and extreme situation, this includes fire situations. Second example shows how to design and verify simply supported slab exposed to fire. The resistance of this slab is determined by using tables, then by accurated table values and by using simplified method. Last example is fire design of column. This structural element is verified by table values and by Isotherm 500°C method.

To use simplified calculation methods we need to know temperature field of the cross section of the element. These fields we can find in code, but there are only few examples, or use some software to calculate them. We calculated temperature fields with software TCD from Swedish company Fire Safety Design AB. We used this software to calculate some basic structural elements and their cross sections like slabs of different thickness, column with circular and square cross section, beam of different sizes. Some temperature fields in pdf format can be found on department web page.

Next output of this project is set of examination tests. To examine students and their knowledge we made out three tests, which include the whole issue, that student learned during semester like material properties under elevated temperature, requirements for fire resistance of structures, simplified and advanced methods etc. Each question is evaluated by one, two or three points. This depends on the difficulty of each question. Student need to gain at least six points of maximum 10 to pass the test succesfully.
To present this project we made poster, which is now situated on the board at department of concrete and masonry structures. This poster was also present at conference Concrete Days 2006 at Hradec Kralove. On this poster can students find some useful information about fire design course.

Internet web page is the last output of this project. At these pages students can find some instruments mentioned above. These pages are located at: http://concrete.fsv.cvut.cz/pozar.

We finished this project succesfully, we manage to make out all instrument to provide necesary information for student. Students have already used these instruments to solve problems in fire design safety and this branch of study become for them very interesting and attractive.

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Learning tool for evaluation of load-bearing capacity of road bridges

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Objective of this project is to develop a learning tool (software) for estimation of loadbearing capacity of bridges. This tool is intended to help students of the Course K133BEM1 (Concrete Bridges 1), teached in 2nd year of undergraduate study of Structural and Transportation Engineering.

The software helps students with estimation of load-bearing capacity of concrete bridges, but it can used for any structural systems (form of structures) and materials. All important data and decisions are made by student himself. It supports use of knowledge obtained during the study.

Because this software produces unified results, it helps teachers to check inputs and calculated load-bearing capacities of structure.

Calculation of internal forces is based on loading of influence line of structure, in both longitudal and lateral direction. Values of influence lines are inserted by student himself, program doesn't caltulate it. Values of influence lines are entered on relevant card of program through an interactive table or from an external file. Grafic control of inserted influence lines is integral part of the program.

Loading is placed on the structure in the plan view and the longintudal section as a point, line or area load in vertical direction. There are four types of loading in accordance with their character : self-weight of superstructure, variable loading by vehicules, other non-traffic variable actions and permanent actions caused by self-weight of non-structural part of bridge. Input of load coordinates and values are entered into an interactive table on relevant card of program or from an external file. Grafic control of inserted loadings is integral part of the program. Dynamic effect of traffic actions is considered by dynamic ratio in accordance to ČSN 73 6203. There are two groups of loadings : old standard (used for design structure) and current standard (used for evaluation of load-bearing capacity of structure). Database of predefined load models in all standards used to design brigdes in the Czech Republic is integral part of the software.

Calculation results of internal forces are displayed on relevant card of the program. Dynamic ratios (for both old and current standards) and ratios for considering of lightening structure by variable actions are set on this card. There are two tables with results of calculation, one for each standard and group of loading. Effectiveness and corresponding value of internal force are displayed for all partial actions of loading groups.

Estimation of load-bearing capacity of structure is made in accordance to Standard ČSN 73 6220. There are three possibillities to estimate load-bearing capacity of bridge structure :

- a) detailed statical evaluation, considering real resistance of considered structural part
- b) comparing statical evaluation, considering resistance of considered structural part, which is calculated in line with a standard used to design structure
- c) comparing evaluation, comparing actions in line with a standard used to design structure and actions of loading in line with a standard used for estimation of loadbearing capacity

Values of load-bearing capacity could be adjusted by ratio of structural condition and ratio of material accordig to ČSN 73 6220. There are tables for estimation of these ratios in help desk of the program.

Input data (with schemes of influence lines and loadings), results of computation and evaluation of load-bearing capacity of structure could be printed to an external file (.rtf). Last card of the program contains simple text editor with print buttons of individual computation parts.

In addition, the Web site for support and distribution of this software has been created (http://concrete.fsv.cvut.cz/~drahorad/veda.htm). It includes information about the software, help desk, links for download of the latest version, pre-defined load models and more.

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Revised Technique for Measuring Lateral Deformation of Hardening Concrete by Image-Processing-Based Method

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The competition in the concrete building industry always asks for acceleration of the construction process, which results in premature loading of yet hardening concrete. As a result, there is a demand for material models of concrete which can take into account the rapidly progressing hydration process at the very early ages. A reasonable concept for such modelling is represented by the solidification theory introduced in [1]. The main difficulty in measuring the lateral deformation of the hardening concrete specimen, necessary for derivation of the Poisson's ratio, arises from the rather soft consistency of the hardening concrete, which prohibits the use of contact devices applied commonly to the already hardened concrete specimens. The contact-free non-destructive methods should be then applied, such as method based on image capturing and further image processing described in [2]. An attempt has already been made in [3] to measure the lateral deformation of hardening concrete, where an image of a hardening concrete specimen illuminated by two spotlights was captured and further processed. As described in [4], this technique suffered from the pronounced reflection of the spotlight caused by the free water which was squeezed out of the specimen, which ultimately affected the accuracy of the measured data for load level less than 20 %. Since the applied load at such early ages results in overloading, that means the load level well above 50 %, this issue does not constitute any significant drawback for practical application. However, to eliminate this limitation, the test configuration needed to be altered. In this paper, a new measuring technique, where the test configuration is rearranged so that a shadow cast by the specimen is captured, is presented. The proposed technique, where the shadow of the illuminated specimen is measured, follows this assumption. The experimental data obtained by this method were used for derivation of a generally applicable relation between the Poisson's ratio and the load level, which is also presented.

In order to further improve accuracy of the measuring method, the test configuration was rearranged so that the shadow cast by the specimen was the subject to the measuring. As shown above, the problem was the light reflection on the wet surface which changed the condition in the edge detection, when the images captured were directly those of the specimen. In order to prevent this problem, images of the specimen's shadow were taken instead, which helped to maintain the light condition unchanged during the entire test. In this case, the contrast of the edge was obtained by installing a whiteboard with a smooth surface behind the test set-up. The camera was focused on the whiteboard and the focus was arrested. The shadow grew asymmetrically on the whiteboard with the progressing deformation, which needed to be born in mind while placing the camera before the loading started. The distances between the specimen and the whiteboard and the specimen and the spotlight are about 40 centimeters and their ratio represents the parameter which controls the size of the shadow cast on the whiteboard. The distance between the camera and the whiteboard is another parameter which controls the size of the specimen's shadow in the captured image. The longitudinal deformation was measured by standard contact equipment. The loading force induced by the electric actuator was monitored by the actuator itself and checked by a load cell.

The image processing tools used were the same as those described in [3]. The processed image, however, was this time inverted, which means the measured object was dark while the background was light. The center of gravity method used for edge detection proved efficient when dealing with the slight blur at the edge of the shadow.

The results obtained by the revised method are identical to those presented in [3, 4] for the stress-strength ratio above 20 %. The measured diameter of specimen also show the thickness of water layer on a specimen, when a not loaded specimen was captured once dry and once sprayed with water. It should be noted that the thickness of the squeezed-out water cannot be measured by this method separately as it is impossible to distinguish the part of the total lateral deformation, which is contributed by the deformation of the concrete mass, from the contribution of the squeezed-out water. The discrepancy caused by the glistening of the squeezed-out water has been solved by using this method. However, the values of the Poisson's ratio for stress-strength ratios below 15 % are affected by initial settling of the data for stress-strength ratio below 15 % is always questionable. The experimentally obtained relation between the apparent Poisson's ratio $\mu(S)$ is a function of S with $S = f/f_c$ as the load level, where f stands for the actual compressive stress and fc stands for the compressive strength at the moment of loading.

A revised test configuration was presented in this paper, which was based on measuring a shadow cast by the investigated specimen on a smooth whiteboard. This arrangement allowed including the thin layer of squeezed-out water, which represents a valid part of deformation, in the total lateral deformation. Moreover, this arrangement helped to avoid the glistening effect of the squeezed-out water, when the specimen was captured directly in a digital image. That means the accuracy of the previously presented method was enhanced.

The outcomes of this work along with the extensive review on other relevant experimental methods summarized in ppt presentations and brochures will be used for updating the information provided to students in the following courses on concrete structures design and concrete technology: BZ1, BZ1A and CMS1.

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Guidance on Fatigue of Concrete Bridges

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Though fatigue is an important phenomenon in structural and bridge engineering, it is not part of the basic courses provided by Department of Concrete and Masonry Structures. This paper presents results of FRVŠ project 686/2006/G1, whose goal was to develop guidance on fatigue of concrete bridges which would guide students to perform fatigue checks of concrete bridges designed in subjects 133BEM1 and 133BEM2.

By definition, fatigue is a process of stable progressive changes in the structure of a material exposed to cyclic loading. Research related to fatigue of metals started in 1840's with construction of railways. Fatigue of concrete and concrete structures was first described at the beginning of the 20th century and became a significant topic in 1920's with the development of highways. Nowadays, the use of high strength materials results into design of more slender structures with high live load proportion of the total load. High stress ranges in structures like bridges or crane-ways can result into fatigue failure with fatal consequences.

Fatigue load spectrum [1] can be divided into three parts according to the total number of load cycles; low-cycle fatigue can be defined with an approximate $1 - 10^3$ load cycles with big stress ranges, high-cycle and super-high cycle fatigue can be defined with an approximate $10^3 - 10^7$, $10^7 - 5*10^8$ respectively, load cycles with small stress ranges. Low-cycle fatigue occurs in structures subjected to earthquakes, high-cycle fatigue in airport and highway pavements, railroad ties and highway and railway bridges, super-high-cycle fatigue in mass transit structures and maritime structures.

In reinforced concrete structures, load is resisted by a force couple consisting of a tensile force in the steel reinforcement and a compressive force in concrete. A fatigue failure can occur either in the reinforcing steel in tension or concrete in compression.

The process leading to fatigue failure of metals, i.e. reinforcing steel, can be divided into three stages. In the first stage, mechanical characteristics of the material are changing due to local cyclic plastic deformations. In the second stage, cracks are nucleated in the places where the local cyclic plastic deformations take place. The first two phases can be described as the stadium of crack initiation which ends with surface cracks forming. In the third stage, the crack propagation phase, the cracks propagate and unite into one which can than result into fatigue fracture when it starts to propagate unstably.

Concrete is a heterogeneous material full of flaws and pores, thus the processes running in its structure under cyclic loading are much more complex. Nevertheless, the process leading to fatigue failure of concrete can be divided into three stages, similar to metals. The phase of crack initiation takes place in weaker parts of the cement mortar and is usually finished after 5-10% of the total load cycles. The phase of stable crack propagating can be characterized by stable growth of initial cracks up to their critical length; this process is often described as micro cracking and takes place up to 80% of the total life cycles. The phase of instable crack propagation leading to fatigue fracture takes place in the remaining 10% of the total life cycles and sets on when the concrete is already saturated with a sufficient number of unstable cracks. These than unite themselves into one which can result into fatigue fracture. The development of these three stages of fatigue damage can be plotted on a "cyclic creep curve", which on the x axis shows number of cycles and on the y axis, strain or deformation.

Each load cycle woks on a concrete with slightly changed material characteristics, cracks do not close. Stress concentrations on the crack tips cause damage in every load cycle. Repeated load causes propagation of existing cracks and their linkage which can result into failure of the structural element, though the stress within in does not reach its static strength.

Only reinforcing steel can be checked for fatigue according to present Czech design codes. According to the ratio of stress in the reinforcing steel under permanent load and stress in the reinforcing steel under combined permanent and live load, a reinforcing fatigue coefficient is obtained, which then reduces the permissible stress in the reinforcing steel.

The Eurocode [3] gives a range of methods for fatigue verification of reinforced concrete structures, from simple methods based on equivalent stress range, up to sophisticated methods using Miner's rule.

The goal of FRVŠ project 686/2006/G1 was to develop guidance which should give the students basic knowledge about the phenomenon of fatigue of concrete structures. In form of educative posters, Theoretical manual and Practical spreadsheet, the students should obtain enough information to be able to run a fatigue check according to the Eurocodes.

As for the posters, two have been prepared. The first one gives the student basic knowledge about fatigue of metals, explains the difference in fatigue behavior of reinforcing and prestressing steel and mentions possible reinforcement coupling details. The second poster explains the difference between failure modes of concrete under static and cyclic loading and gives basic introduction into the fatigue checking procedures within the Eurocodes.

The Theoretical manual details the basic information provided by the posters and focuses on practical issues e.g. the use of S-N curves for performing the fatigue check.

The Practical spreadsheet helps the student to perform the basic fatigue checks form the Eurocodes and understand the importance of structural elements slenderness in fatigue checks.

The outcomes of this FRVŠ project are free to download on the websites of the Department of Concrete and Masonry structures.

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The Software of Risk and Sensitivity Analysis

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The major goal of the presented project is the interactive tutorial software of risk and sensitivity analysis of investment projects and the methodical manual of risk and sensitivity analysis. The software and the manual were created for improving the quality of education of study subjects "Integrace do EU 1", "Integrace do EU 2" and "Evropské fondy - možnost spolufinancování projektů."

It was realized a detailed analysis of economical literature relating to the preparation of economic analyses in the first project phase. The software was programmed in Microsoft Visual Basic. It is necessary to have installed the spreadsheet processor Microsoft Excel for the utilization of this tutorial software. When the tutorial software of risk and sensitivity analysis is started, user is due to set the input data of prepared investment project. The input data of investment project are segmented into following groups: the characteristic of the investment project, investment costs, operating costs, taxes depreciation, revenue from sales, sources financing, operation (working) capital and completive input data.

After fulfillment of input data the tutorial software of risk and sensitivity analysis of investment projects compiles consolidated statements of financial analysis hereinafter structure: operation capital, credits, statement cash flow, profit and loss statement, balance sheet and financial indicators (profitability indicators, insolvency indicators, liquidity indicators, activities indicators, present value /PV/, net present value /NPV/ and internal rate of return /IRR/).

For easy utilization of the tutorial software it was created so - called "Working modulus" by the help of whose it is possible to simply walk up and down among particular modules of the tutorial software. It is possible to load semi finished project and carry on the work. The input data of the investment project are recorded by the data file with filename extension "CSV". CSV (comma separated values) files are commonly used to record tabular data. The CSV files are easily editable using common spreadsheet applications like Microsoft Excel.

The tutorial software includes two basic modules: sensitivity analysis and risk analysis. Sensitivity analysis is a simple technique to assess the effects of adverse changes on a investment project. It involves changing the value of one or more selected variables and calculating the resulting change in the net present value or internal rate of return. It is possible to use in the tutorial software any of the inputted project costs or revenues as the variable to the sensitivity analysis. As a result of the sensitivity analysis used in the tutorial software is the selection of the critical variables of the investment project, that have the greatest effect on the net present value or the internal rate of return, that is they cause the most significant changes in these parameters.

The risk analysis used by the tutorial software is based on the Monte Carlo simulation. Risk is the chance of an event occurring which would cause actual project circumstances to differ from those assumed. The method of the Monte Carlo simulation uses as the input data probability distribution appearances and impacts of particular project risks. Within the frame of the simulation there are generated the series of values of particular critical quantities in corresponding distribution probabilities, during which time for each series (simulation) is calculated according to the inputted mathematical definition the value of the total project risk. It is possible to obtain frequency distribution of the total project risk in case of large number of repetitions of this procedure.

The first phase of the risk analysis is identification of possible project risks. For this purpose the tutorial software contains form with list of common project risks. Users tick off the relevant risks which are consequently used for the risk assessment. The list of common project risks contains risk categories: construction risks, demand (usage) risks, design risks, environmental risks, financial risks, force majeure risks, operating risks, performance risks and change in law risks.

Within the scope of the risk assessment it is realized the Monte Carlo simulation. The results of the risk analysis are presented as a table of risk distributions, a graph of statistical interpretation of the results of the Monte Carlo simulation, a table of scenarios of risk progression and a graph of frequency distribution of values of the total risk of investment project.

The tutorial software of risk and sensitivity analysis of the investment projects is designated for continuous study and preparation of the engaged investment project. The tutorial software contributes to improvement of education process of economical subjects on Faculty of Civil Engineering, Czech Technical University in Prague. It makes possible better understanding of subject matter and better explanation of mutual dependences among economic quantities.

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Calculation Modules for PointClouder

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Software for processing outputs of laser scanners, so-called point clouds, is being developed at the Department of Special Geodesy within the grant "Processing and the Analysis of the Product of the Mass Data Collection Realized by Terrestrial Scanning Systems". The reason for developing own software is unknown algorithms of commercial software, its very high price, impossibility to use covariant matrices of the input data and absence of open source or at least freeware alternative. Basic demands on software for processing point clouds are: works with point clouds (viewing, selection, measuring lengths, reduction of number of points, etc.), mutual transformation of clouds in different coordinates systems into one system (registration), generating and editing the triangular network (digital model of surface), basic calculations on the triangular network (volume) or modelling (fitting) of the chosen geometric figure by the selected points. Implementation of some stated features is described below in more detail.

The main user boundary of the system will be graphic user interface (GUI) PointClouder developed by Ing. M. Štroner, Ph.D. The main feature of this GUI is ability to display large number (millions) of 3D elements. The interface OpenGL is used in PointClouder for displaying 3D graphics. Fitting of geometric figures and space transformations belong also to the planned advanced functions of GUI PointClouder besides creating the triangular networks. These features will be ensured by means of the Spatfig [1], [2] and Alltran [3] libraries.

Spatfig (Spatial Figure) is a library of classes and functions for fitting geometrical figures in 3D space by the least square method. There are solved estimations of standard deviations of adjusted variables and their covariant matrix and there are considered the covariant matrix of measuring. The library is written in C++ language under the condition of General Public Licence GNU.

The following figures have been up to now implemented and tested in Spatfig: line, plain, circle, sphere and cylinder. Suitable conditions (perpendicularity, verticality, etc.) can be forced for these figures. A simple console programme was created for testing reasons and communication with CAD system Microstation was tested by using of the dll (dynamic link library) libraries. Language Visual Basic for Application was used for communication in the Microstation. At the moment we are working on deeper interconnection of Spatfig with the Microstation system for purpose of visual check of convergence of calculation for more complicated geometric figures. Communication with GUI PointClouder will be ensured by a similar method after testing.

Alltran [3] is a library of classes and function for computation of transformation key and for transformation of coordinates. It was suggested especially for transformations based on the least square method. All included transformations are in close relation with the branch of geodesy and photogrammetry. The library is written in C++ language under the condition of General Public Licence GNU. The simple console program Alltran_console was created for using the library and another one Alltran_test for testing of the suitability of used transformations. The Alltran library will be used in GUI PointClouder for transformations of coordinates of points measured from different points. This issue is called Registration of point clouds in terminology of the laser scanning. The only transformations used in GUI PointClouder will be general affine, affine, similarity and identity in 3D. Communication between Alltran a PointClouder will be ensured by means of the dll libraries.

As already mentioned, dll will be used for communication between PointClouder and other computing libraries. The reason is using different programming languages in GUI PointClouder (Borland Delphi) and in the Spatfig and Alltran (C++) libraries. That is why functions ensuring this communication have to be created. Parameters of these functions can be only basic types equivalently defined in both languages (or simple structures). Both libraries use template of classes and functions libraries matvec for matrix calculations.

Initial state of software development for processing outputs of mass data collection, socalled point clouds, was presented in this paper. Software will consist of GUI PointClouder and other computing modules. One of the presented modules is the Spatfig library that has been up to now developed independently and used in the form of console application. The other module is the Alltran library that was developed for needs of GUI PointClouder. Both libraries will be interconnected with GUI PointClouder by means of the dll libraries.

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Modeling the Fate of Nitrate in the Soil Profile by a Dual-permeability Approach

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The groundwater quality in the regions under intensive agriculture is frequently affected by nitrogen compounds. Complexities of the nitrogen cycle are often reflected in large spatial and temporal variations of nitrate in the soil profile. Areal application of nitrogen fertilizers may lead to enhanced nitrate pollution mainly driven by shallow subsurface flow of water along the slopes and/or by percolation of water through the soil profile. In addition, the nitrate leaching can be increased by preferential flow, which may cause short residence times of the nitrogen compounds in the porous medium.

A field scale experiment was carried out at Valečov in the Bohemo-Moravian highland. The main objective of the field experiment was to optimize the drip irrigation and nitrogen fertilization of potatoes. The soil is classified as deep loamy Planosol, underlain by weathered paragneiss.

The fate of nitrate in the soil profile during the period of October 2003 through April 2005 was simulated by means of a one-dimensional numerical model. The data characterizing the respective sources/sinks of nitrate were derived from the Daisy model [1] and subsequently used for the S1D model (Vogel, 1999, Documentation of the S1D code, version 2.0, CTU Prague, internal report). To model the transport of nitrates in the soil profile, fertilizer application, nitrification/denitrification processes, and the nitrate uptake by plant roots, as occurred in the simulated period, had to be considered in the simulations. The features used in this study also included the spatiotemporal variability of the plant root water uptake as well as the variability of the zero-order nitrate transformations.

Two principal scenarios were evaluated: (i) transport of nitrate in a dual-permeability porous medium, and (ii) transport of nitrate in a single-permeability porous medium. The dual-permeability approach assumes that the porous medium consists of two pore systems, i.e. the soil matrix domain and the fracture domain. The two domains exchange water and dissolved solute by means of first-order transfer terms. The exchange is controlled by the effective resistance of the matrix-macropore interface.

Nitrification and denitrification are important parts of the nitrogen cycle in soils. Nitrification refers to the biological oxidation of ammonia into nitrite followed by the oxidation of these nitrites into nitrates. For the simulations, the process of nitrification as a source of nitrate is assumed to take place only in the plough layer of the matrix domain. Denitrification is the process of nitrate reduction when the bacteria degrade nitrates to nitrogen gas, which returns to the atmosphere. For the simulations, the process of denitrification, as a sink of nitrate, is assumed to occur only in the preferential flow domain for the entire depth of the soil profile. A higher bacterial activity usually takes place in the more aerobic preferential flow domain than in the less-aerobic soil matrix domain.

The initial condition for simulations was set equal to the measured soil water pressure profile at the start of the simulated period. The free drainage condition was used as the bottom

boundary condition at the depth of 150 cm. The atmospheric condition, accounting for natural rainfall, potential evaporation and potential transpiration, was used as the upper boundary condition. The evaporation from bare soil and the transpiration of the potatoes (*Solanum tuberosum* L.) were estimated based on the FAO methodology. The initial solute condition was based on the measurement of the nitrate concentration of soil water at several depths. The initial concentration profile of nitrate was relatively high which resulted from the fertilizer application prior the beginning of the simulated period. The flux type boundary condition was used for the lower boundary so that the nitrate could leave freely the soil profile. Soil characteristics of the soil matrix and fracture domains as well as the volumetric proportions of the two flow domains and the inter-domain transfer coefficients were taken from the previous study [2].

The simulated breakthrough curves (BTCs) at the depth of 75 cm below the soil surface provided a valuable insight into the nitrate dynamics throughout the period of interest. The matrix domain BTC showed continuously changing nitrate concentration in time, while erratic behavior of the fracture domain BTC revealed two major mechanisms of nitrate transport: (1) The storm related transfer of nitrate-loaded water, which suddenly increases the concentration at the depth of interest at the beginning of the storm event, (2) the leaching of cleaner storm water at the end of the storm event. As a result, the simulations assuming dual-permeability porous system does not deliver more cumulative nitrate leakage through the bottom boundary than the one assuming single-domain approach. The high cumulative leakage of nitrates through the bottom boundary, obtained for both simulation scenarios, is caused by a high nitrate load present in the soil profile at the beginning of the simulation period. The single-permeability scenario disregards the episodic nature of the nitrate movement.

Although just a few rainstorm events occurred during the simulated period, a rapid transfer of nitrate was clearly visible in the space-time plot of the nitrate concentration for the fracture domain. In contrast, the soil matrix domain contains much less variable nitrate concentrations. What is worth noticing, is the role of the water and nitrate root uptake by potatoes with the most active nitrate withdrawal during the vegetation season, when the transpiration is intense and the root zone reaches the depth of 80 cm below the soil surface.

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Precast Floor Panel with Lightening Shell Elements from Recycled Non-Sorted Plastic

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Optimization in the environmental context is becoming an important tool of integrated design of building structures. Reducing the consumption of energy and structural materials derived from primary raw material sources is one of the most important tasks in the domain of sustainable buildings.

A box reinforced concrete cross-section effectively utilizes the material, both from the point of view of structural behavior (pressed top slab + slight shear ribs) and technology (bottom slab forms a flat lower ceiling). This type of structure represents effective form (i) to the intent of consumption of structural material and (ii) self-weight that decreases the amount of reinforcement on one side and increases load-bearing capacity on the other side.

The goal of the optimization of box RC cross-section in environmental context is to decrease the environmental impact by decreasing (i) the consumption of non-renewable raw materials and energy sources, (ii) the consumption of embodied energy, (iii) the production of embodied emissions of CO_2 and SO_x above all, (iv) the amount of waste at the end of a structure lifetime and all of that by improving the functional characteristics.

Within the scope of the previous research several alternatives of floor structure crosssections were designed and optimized. The design of precast panel lightened by recycled nonsorted plastic fillers is coming out of these alternatives.

It is possible to use the precast floor panel with the installation of recycled plastic fillers for small-width span (up to c.6.0 m). In case of the installation of passing space inside the floor structure, it could be used for wiring, water or heating system conduction. The reduction of the self-weight (c. 40% in comparison to a full reinforced concrete slab) positively influences also smaller loading of vertical load-bearing structures and foundations. The environmental and economical advantages of panels are the following: (i) using of recycled material from municipal waste (non-sorted plastic), (ii) reduction of primary unrenewable sources consumption, (iii) reduction of transit and material manipulation costs and (iv) savings on supporting constructions.

The design of panel box cross-section was made according to the Czech national standards ČSN P ENV 1992-1-1 Design of concrete structures – Part 1-1 and ČSN P ENV 1992-1-3 Design of concrete structures - Part 1-3: Precast concrete elements and structure. The first three panels' prototypes were manufactured in spring 2006 by the ZPSV Uhersky Ostroh company in the factory for precast construction located in Borohradek.

The experimental attestation of two panels was made according to the Czech national standards ČSN 732030 Loading tests of building structures in the Experimental centre of Faculty of Civil Engineering CTU in Prague in summer 2006. The goal of the experiment was to verify the mechanical characteristics of designed panel and to prove the possible usage of such panels in practice. The width of the panel is 2.4 m, length 4.45 m and the total thickness 200 mm. The thickness of lower part of panel slab is 50 mm. The axial distance of ribs is 580 mm, width 80 mm (rib's height – or fillers is 100 mm) and the top covering reinforced concrete slab is also 50 mm thick; concrete C30/37. The bending reinforces are made of profiles R10, profile spacing is 120 mm (there are two profiles R10 at panel peripheries,

profile spacing 70 mm), distributive reinforces of lower part of panel slab are R6, profile spacing 140 mm. The ribs are reinforced by "filligran" space reinforcement girders. The top covering slab is reinforced by reinforcing steel "kari" net made up of wire W4 in relation to shrinking and manipulation loading.

The experimental verification of mechanical characteristics of 2 in total 3 of the designed box panels was done on standard bending test (four-point bend). The pattern of strutting simulated by simple beam with the span width 4.2 m. Each of panels was shouldered by five wheel indicators of deflection and five strain gauges HBM 50/120 LY for surface tension scanning. The panel was weighted in grades: 1^{st} grade. $G_k = 40$ kN, 2^{nd} (G+Q)_k = 65 kN, 3^{rd} G_k+Q_d = 70 kN, others grades were always 15 kN more until the bending failure occured. At bending failure the maximum force was on the 1^{st} panel $F_{max,1} = 295$ kN, on the 2^{nd} panel $F_{max,2} = 310$ kN. To verify the concrete quality esp. the concrete compressive in strength there were made 3 routing specimens. The measured compression strength is the following: the 1st panel 43.7 – 48.7 MPa (C30/37), the 2nd panel 63.7 – 76.6 MPa (C45/55). The deflection limiting value of panels is in the agreement with limiting state of usability v_{lim} = 14 mm, real value in span centre for $(G+Q)_k = 65$ kN was 8.9 mm after stabilization, for the 2^{nd} panel deflection value was 6.0 mm. The relative deformation dependence on loading is evident on the graph. The most compressed top fibers, the concentration of compression stress fibers is evident in a rib place. The relative deformation value (according to the strain gauge T12) is in its absolute value half than the value in the rib place.

The floor structure made of box reinforced concrete panels with installation of fillers will be used in the construction of the Senior Centre in Ujezd close to Brno. Its realization consists of c. 6000 m² of floor structures. During the environmental analysis of floor structures the values of embodied emission CO₂ and SO_x, embodied energy and self-weight per a square meter have been also measured. The values were compared to the referential full reinforced concrete slab. Floor structures alternatives comparison: Self-weight – full RC slab 486.4 kg/m², precast box RC panel 301.1 kg/m², i.e. reduction -38.1% (reduction 1111.8 tons at realization 6000 m² of floor structures), Embodied energy – full RC slab 501.4 MJ/m², precast box RC panel 489.6 MJ/m², i.e. reduction -2.4% (reduction 70.8 GJ at realization 6000 m² of floor structures), Embodied emission CO₂ – full RC slab 69.4 kg CO_{2,equiv}/m², precast box RC panel 52.9 kg CO_{2,equiv}/m², i.e. reduction -23.8% (reduction 99.0 t CO_{2,equiv}, at realization 6000 m² of floor structures), Embodied emission SO_x – full RC slab 271.7 g SO_{x,equiv}/m², precast box RC panel 189.1 g SO_{x,equiv}/m², i.e. reduction -30.4% (reduction 495.6 kg SO_{x,equiv}, at realization 6000 m² of floor structures).

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Verification of New Computational Method of Box Girder for Time Dependent Analysis

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Deflections of large prestressed concrete bridges are significantly affected by creep and shrinkage. These effects as well as influence of complex space behaviour must be included in the relevant analytical computational models. New method of structural analysis was developed, intended as a tool for the design practice, which takes into account all changes of structural system during the construction process as well as the effects of creep and shrinkage of concrete. This combined method (beam solution with time dependent step-by-step analysis and 3D behavior analysis applying shell (slab & membrane) model – software NEXIS with program unit TDA) was verified by a non-linear analysis based on 3D bricks finite element method, with numerical solution of creep and shrinkage (software ATENA).

Creep and shrinkage phenomena depend heavily on current material moisture and temperature, which means that the mechanical analysis must be in many cases accompanied by heat and moisture transport analysis. The presented model basically supports two approaches, which differ mainly in the way, in which time-dependent properties of material behaviour are introduced. The first model type of analysis assumes the same time-dependent behaviour for all material points in a structural cross section (or a certain structural element volume), while the second model type is more accurate and its creep and shrinkage properties are evaluated for each material point taking into account the local moisture contents.

The implemented creep and shrinkage analysis is based on assumption of linear creep, which in other words means that material compliance function $\Phi(t,t')$ and accompanying function for shrinkage $\varepsilon^0(t)$ depends only on material composition, temperature, shape and time at observation t and at loading t'. It does not depend on stress-strain conditions. In spite of the simplifications the provided analysis is in most practical cases sufficiently accurate and it is fast and efficient. Significant improvement of computational efficiency is obtained by introducing approximation of time history of creep compliance function $\Phi'(t,t')$ by Dirichlet series.

The numerical methods for long term creep and shrinkage analysis are implemented the finite element software package ATENA [1] and form a part of a system for verification of structural performance. ATENA is dedicated for non-linear analysis based on finite element method. It offers a range of material models for concrete, which are based on theories of fracture mechanics and plasticity, models for steel based on plasticity, models for bond between reinforcing bars embedded in concrete as well as those for interface behavior. Models for transport of heat and moisture are also available. The solution core is supported by user environment for efficient pre- and post-processing of the analyzed problems. This computational tool makes possible to analyze large bridge structures in design practice using simplified cross section approach as well as complex material point-based coupled thermohydro-mechanical problems. The developed combined method, intended as a versatile design tool, consists in the first stage of beam solution based on time dependent step-by-step computer procedure in which the time domain is subdivided by discrete times into time intervals [3]. A finite element analysis is performed in each time interval. The resulting redundants, obtained from this procedure for creep and shrinkage analysis respecting changes of structural system during the construction process, are converted to loads for the 3D structural model applying shell (slab & membrane) approach (software NEXIS with program unit TDA).

As the example for the verification of the developed method, the bridge over the River Labe in Melnik built in 1992 in Central Bohemia – a three span continuous box girder bridge (72.050 + 146.200 + 72.050 m) with tapered shape, erected using the cantilever technology – was used. The task was to verify assumptions and results of the new method and to identify possible differences. The results of both methods exhibited very good agreement in prediction of the overall structural time dependent behaviour of the investigated bridge as well as in description of the stress states in its singular regions. Practicing engineers thus can benefit in the design of long span prestressed concrete bridges from the new developed method of structural analysis supported by currently accessible software.

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Dynamic Fatigue Loading of a Prestressed Concrete Element

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In many civil engineering structures, various kinds of damage appeared. Undetected damage can lead gradually to the failure of structural members or the structure at all. Therefore, health monitoring of structures is very important. Many structural health monitoring techniques and damage detection techniques was developed in recent years. One group of these methods is based on monitoring of modal characteristic changes. These techniques are still in development and it is suitable to verify these new methods on simple structural elements where we know their damage state.

The experiment described in this paper is focused on monitoring of the influence of high intensity fatigue loading on the change of the modal characteristics of the fully prestressed concrete structures, which are designed to be no tensile stress there when maximum design load is applied.

For the purpose of this project, SMP CONSTRUCTION a.s. made a prestressed concrete slab. The specimen height was 130mm, the width was 1115mm and the length of the slab was 4500mm. The ends was expanded to the height 400 mm for tie of the prestressing bars. The slab was put on the two bar bearings. The arrangement of bearings allowed the slab to be a simply supported of span 3500mm with cantilevered ends 500mm on both sides. Slab was made from concrete C45/55 with eleven prestressing bars of diameter 15.7 mm.

The tested slab was designed as a fully prestressed concrete slab to not comply the safety condition in the lower part of the slab when the high intensive cyclic loading is applied.

Tests of the slab were carried out in laboratories of Faculty of Civil Engineering, CTU in Prague. The prestressed concrete slab was loaded in four points bending to get a constant bending moment in the mid-section of the slab. The cyclic load was applied to the slab in several steps (each step = $125\ 000$ cycles). This fatigue load of the slab was induced by harmonic force with frequency 5 Hz. The amplitude of the dynamic load was chosen to not comply the safety condition for the fatigue loading of the concrete.

After each load step, a complete experimental modal analysis was carried out with separate measurement system.

For the excitation of the slab during the experimental modal analysis the Modal Exciter Type 2732 (Bruel & Kjaer) was used. The exciter was placed under the slab linked to the slab with the flexible drive rod. The exciter produced a random driving force over the frequency range of 5 to 400 Hz. The force transducer Endevco 2311-10 placed between the flexible rod and the slab measured the excitation force. The exciter was placed eccentric to the longitudinal axis of the slab. It lies on the right side of the slab in the four fifths of the slab span. The position of the point of excitation was designed to be able to excite basic modes of natural vibration of the specimen. For the purpose of measuring the forced vibration modes a spatial network of points was chosen on the upper face of the slab. The total number of points of a network was 216 (8 points in transverse direction, 27 points in longitudinal direction). The vibration of the slab was measured in vertical direction in all points of the network.

Values of the Frequency Response Function were obtained as an average from ten measurements. The window length of the time signal processing was 32 s, the frequency range of the window was set to 400 Hz.

The program MEscopeVES (Bruel & Kjaer) was used for modal characteristic evaluation from measured Frequency Response Functions. With regard to a frequency range of the dynamic analysis 5 to 400 Hz nine natural frequencies and mode shapes were evaluated. Modal characteristics of the slab, which were measured after each loading step, were mutually compared. For comparison of natural modes, changes of a mode surface curvature CAMOSUC_{(i),x}, changes of a modal flexibility matrix [δ] and the second derivative of changes of diagonal members of a modal flexibility matrix $\Delta[\delta]''$ were used.

The model of the slab was created by FEM using the program FEAT. The prestressed concrete slab was modelled from 2D elements. The bearing was designed to the slab be a simply supported. The first nine natural frequencies and natural modes of vibration were calculated by program FEAT. The comparisons of calculated and measured natural vibration characteristics were done.

In this experimental dynamic study, the influence of the dynamic cyclic fatigue loading to the change of the modal characteristics of the fully prestressed concrete element was monitored. The modal characteristics after several loading steps were evaluated. Mode shapes were mutually compared using three different methods: CAMOSUC_{(),x}, $\Delta[\delta]$ and $\Delta[\delta]''$. In present days, the slab is loaded by 2 000 000 cycles. From the lower values of previous methods evaluated after each loading step (125 000 cycles) up to 2 000 000 cycles it results that no significant changes of dynamic behavior of the slab occurred. Some isolated peaks only indicate few measurement inaccuracies near the node lines of the mode shapes. The project still continues, more measurements will be done on this slab and two more slabs will be investigated to make more general conclusions.

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Operating Quality Control of Ground Machines by Means of the Terrestrial Lasetr Scanning System

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Within a research project dealing with acceleration of technological and measuring processes of construction and agricultural works with emphasis put on earthmoving machine control, the department of special geodesy is dealing with obtaining geodetic data and control of accomplished earthmoving works operated by construction machines. The measuring machines are currently controlled especially by means of ultrasound, satellite navigation, laser and total station [1]. Tachymetry by the total station, surface leveling, measuring lengthwise and transverse profiles or GPS measuring are most often used for terrain adjustment control. We used a terrestrial laser scanner in our experiment. Terrestrial laser scanning systems are a relatively new geodetic method used approximately in the last five years. They enable a contactless measurement on space subjects, their modeling and visualization [2], [3]. Scanner HDS 3000 was used in our experiment. Before beginning the scanner measuring itself it is necessary to set several scanning parameters, size and position of the scanner field of view (the area that will be measured) and scanning density. Scanning density for the HDS 3000 scanning system is defined as a horizontal and a vertical distance of neighboring detailed points in a certain distance from the scanner. For control measuring of a plane terrain a certain density of the detailed points measured on the surface is required. During setting the scanning density, a certain length interval is chosen for horizontal and vertical direction is chosen that will be kept in the set distance. The scanner transfers these length intervals into angle intervals and then it measures these similar points in this set raster. But distance of the detailed points in lengthwise direction measured on the scanner placed in a small height above terrain will be higher in the set distance. When we take this fact into consideration and set the vertical distance of the detailed points so that it complies with the required distance of the detailed points on the terrain, the detailed points nearer to the scanner will be measured much more densely. The volume of the measured data and time of the measuring itself will consequently grow. The HDS 3000 scanning system enables to set a sequence of scans where each scan will have its own set density of the detailed point and an extent of distances for which the measured data will be registered. This enables to prepare in advance this sequence of individual measurings on the basis of knowledge of the measured territory. The result will be measuring process automatization and reduction of measured data volume.

The accomplished experiment was measured on practical verification of using the HDS 3000 scanning system and for creation of DTM. The process of accomplishing the experiment was following. The chosen territory will be measured with the scanning system from two height levels. Identical points and check points proportionally spread across the measured territory will be measured by the Leica TC 1700 total station. Then a DTM will be created from measuring of the scanning system and height differences will be compared between DTM and control points determined by the total station. The crossroads near the building of student cafeteria of the Faculty of Civil Engineering was chosen as a place suitable for experiment. Surface of the crossroads is covered with asphalt, there is no vegetation there and the surface is solid. Solidity of the surface and absence of vegetation were important, so

that it would not come to undesirable changes of the surface during measuring the check points. Closeness of the student cafeteria building enabled measuring the crossroads from two height levels. The HDS 3000 was placed under gallery of the student cafeteria building up to the height of around 1.5 m above the surrounding terrain. The crossroads was measured from this position with three scans. Then 8 identical points were measured with the scanner. This was an end to measuring with the scanner on this height level and the scanner was moved onto the student cafeteria gallery. Height of the scanner above the terrain on this height level was approximately 6 m above the surrounding terrain. The crossroads was measured with three scans from this position and the identical points were measured again. Measuring with the Leica TC 1700 total station was carried out then. 8 identical points and 144 check points on the crossroads surface were measured.

Processing measuring from the scanner was carried out for each height level separately in the Cyclone program. At first, registration and transformation of the measured clouds from the height level 1,5 m into the coordinate system of identical points determined by the total station was carried out. Then purge of the final cloud from all the disturbing points was accomplished. The cloud purified in such a way was interlined with mesh TIN (Triangular Irregular Network). Points from the control measuring were imported into the created network and the height difference between the TIN mesh and check points was determined. The same procedure was used also for processing the measuring from the other height level. Results of this experiment are height results between check points and the created TIN mesh. Height determination accuracy with the Leica TC 1700 total station is 0.62 mm for 30 m distance with approximately horizontal sight. The accuracy of the HDS 3000 scanner in the height of the detailed point is approximately 2 mm for 30 m distance with approximately horizontal sight. Considering that measuring with the TC 1700 total station is ordinally more accurate, it can be taken for error-free in relation to measuring with the HDS 3000 scanner.

The results of the accomplished experiment showed, that the HDS 3000 scanning system can be used for obtaining data for creation of DTM serving as a basis for automatic control of earthmoving machines, for which accuracy of earthmoving works 10 mm is required, and as a check method of accomplishing earthmoving works. The HDS 3000 scanning system can be used for most earthmoving machines (except the road finisher), where the expected accomplishment accuracy ranges around 10 mm.

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Suitability Analysis of the Process of Check Survey of Roads

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Standard ČSN 73 0212-4: 1994, Geometric Accuracy in Construction, Checking of Accuracy, Line Building Structures, stipulates in the part dealing with roads that accuracy of check surveys must be verified. It specifies the extent of the check depending on the importance of the monitored geometric parameter, but does not stipulate the use of suitable statistical methods.

Therefore in this paper we deal with statistical verification of the accuracy of check surveys and with assessing the suitability of the geodetic survey process.

Check survey of roads

For roads, geodetic survey methods are used mainly to check elevation (above mean sea level or relative), transversal gradient, road deck's planeness and thickness of the construction layers.

Spatial position, defined by main axis points and main elevation points, is checked only in order to assure that the route is aligned with bridges and tunnels constructed in advance, in places of interchanges and also inside municipal borders.

In our study we will assume that the given road section has been constructed using identical, well established construction technology, and that the setting out geodetic methods and the check surveys were maintained identical (homogeneity of processes condition).

Standard methodology of verifying accuracy of check surveys

Accuracy of already conducted check surveys is verified by repeating these surveys using a geodetic method with accuracy greater by an order of magnitude. From the results of a survey of the same geometric parameter in *n* randomly selected identical points we obtain quasi-real errors ε_i , and calculate selective standard deviation *s* of the original check survey. Value *s* is tested against required (theoretical) standard deviation $\sigma = T/10$, where T is the construction tolerance of the monitored geometric parameter.

Value n = 50% of the set of the original checks if it is established that (construction) tolerance T for critical geometric parameters has been exceeded, otherwise n = 10% is used.

Suitability analysis

Our methodology enhances the accuracy verification method defined in ČSN 73 0212-4 by introducing a coefficient of suitability of the check survey process in accordance with ČSN ISO 8258:1994 Shewart Control Charts.

We calculate coefficient of suitability: $C_p = \frac{T}{2.u.s}$,

where T is (construction) tolerance,

u is standardised random normal quantity (u = 2 is selected), 646

s is selective standard deviation

If $C_p \ge 1$, the process of check survey is regarded as suitable, if $C_p < 1$, the process is regarded as unsuitable, and it is necessary to analyse it using a control chart which we are going to discuss.

The road is divided into **k** sections in such a way that *n* repeatedly checked identical points lie within each section (*n* has identical value for all sections). For each section we calculate **z** quasi-real errors ε_i and selective standard deviation s_k , for which we then construct a control chart in line with the principles defined by ČSN ISO 7870:1995, Control Charts. Upper control limit S_H is calculated using the following formula:

$$s_H = \frac{T}{5.u} \sqrt{\frac{\chi_{\alpha}^2(n-1)}{(n-1)}}$$

where T is (construction) tolerance and T/5 is limiting error of the check survey,

u is the value of normalised random quantity (u = 2 if probability that the check survey process error is within limits p = 0.95),

 $\chi^2_{\alpha}(n-1)$ is: α - critical value of χ^2 division, $\alpha = 0.05$ with (n-1) degrees of freedom,

n is the number of checked points in one section.

The control chart enables us to analyse stability and causes of unsuitability of the check survey process as a consequence of reduced accuracy in one of the sections or overall. This may have been induced by unfavourable configuration of the setting out grid from which the check survey was carried out, by changes in atmospheric conditions, etc.

Conclusion

Statistical tools such as coefficient of suitability and control chart for selective standard deviation may contribute significantly towards verification of accuracy of check surveys of roads.

These statistical tools also illustrate the behaviour of the geodetic survey along a line structure, and provide special guarantees of suitability of the performed checks.

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Contribution to Testing Outliers

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Introduction

The reliability of submitted results of surveying works in construction, e.g. in staking out, control measurements, the measurement of shifts and load tests may be significantly supported by the reliability of measured input geometric variables (angles and lengths). In this respect, it is necessary to make these measurements with the use of calibrated instruments, to select a suitable measurement time in order to eliminate atmospheric effects, to measure by means of a verified procedure with experienced operators etc. The reliability of determined geometric variables may also be increased by testing outliers.

The testing procedures of outliers are offered in ČSN 01 0222, and e.g. in [1]. In practice, however, there are cases where the application of various tests provides different results. Therefore, this paper has been made as a brief message on measurement and numerical experiments with various tests of outliers with the intention of contributing to these problems [2].

Experimental part

An experimental data set was created by means of:

- a) repetitive measurement of the parallactic angle onto the subtense bar (theodolite Zeiss Theo 010 A),
- b) measurement of the skeleton of horizontal directions in a larger number of groups (theodolite - Zeiss Theo 010 A),
- c) modelling of a set of random variables.

These sets served for a gradual application of several tests, e.g.

- a test with an unknown standard deviation of the basic set (PEARSON) [1],
- GRUBBS test [3],
- DIXON test [3],
- tests under [4].

In order to ensure the occurrence of outliers, one or two measurement results in the sets ad a) and c) from the top were artificially and by a small step distorted.

Another procedure consisted in obtaining the set ad b) from the top under deteriorating light conditions – the measurement of the skeleton of horizontal directions was planned and executed in afternoon hours overlapping to dusk, which gradually evolved a growing occurrence of outliers.

These measurements were used to study the function and sensitivity of individual tests in the assessment of outliers.

For a larger-size investigated set, we may state that the results of individual tests were principally identical – without any significant dependency on the knowledge or ignorance of the parameters of the basic set of variables.

For the set size ≤ 6 , problematic situations occurred, and mainly the test with an unknown standard deviation failed to provide unambiguous decisions.

Conclusions and recommendations for practice

The test which proved usable in standard conditions, mainly for the measurements in geodetic engineering, was McKAY – NAIR test [1] – i.e. with the known standard deviation σ .

This implies the need for knowing a priori the standard deviation as an important parameter of the measurement accuracy. The standard deviation for the respective instrument and measurement method is taken over from the manufacturer's documentation. It is e.g. the basic standard deviation of the horizontal direction measured in one group. Another possibility is to estimate the parameter σ from a sufficiently large measurement set using the procedure under ČSN ISO 17 123.

In cases where the number of repetitive measurements is very small ($n \le 3$), the results of any tests of outliers, which are in fact only a tool of mathematical statistics, must be assessed with due care. In eliminating marginal measurements, the preferred practice is to make an objective analysis whether e.g. there has been a change in atmospheric conditions, the target lighting, instability of the instrument positioning etc. In this respect the experience of the operators may play an important role as well.

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Problems of Airport Pavement Design

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Due to the fact that air transport in Europe and the Czech Republic is presently going through a phase of dynamic development, extension of the runway system at international Praha – Ruzyně airport is currently being prepared consisting in a new parallel runway 06R/24L and related surfaces. The project preparation required the design of road constructions of individual airport surfaces. These were, in particular, the following:

- □ runway RWY 06R/24L,
- □ taxiway TWY,
- \square apron APN.

All designed surfaces are presumed mainly for the travel of aircraft, but in individual cases also of other airport machinery. Based on the investor's requirement, the pavement construction types considered for individual transport surfaces were:

- □ RWY asphalt pavement on the inside part, concrete pavement on both outside parts,
- □ TWY asphalt pavement,
- □ APN concrete pavement.

The assessed transport surfaces required considering extreme differences in traffic load characteristics, both in terms of the type of loading (mostly static x dynamic), irregularity in circulation on individual transport routes, or fluctuation of travel trails, but also load distribution (occupancy rate, types) of individual airplanes and vehicles. The background material provided led to a finding that the circulation of a total of 370 different types of aircraft with considerable variations in total weight must be theoretically considered at Ruzyně Airport, from very light ones with a total weight not exceeding 300 kg to giant airliners, e.g. of the Antonov AN-124 Ruslan type with a total weight of 405,000 kg or the Antonov AN-225 Mrija type with a total weight of even 600,000 kg. Such giant aircraft, however, are naturally absolutely exceptional and their share in the total amount of circulation is negligible. The calculation further confirmed that aircraft with a total weight below 6,000 kg exert low to nearly negligible load on the pavement, and so their effect in relation to dimensioning was neglected.

With relation to weight and a probability of their presence at the airport, the "design" (dimensioning) aircraft selected was the Boeing B747-400 type with a total capacity of 450 passengers and a total weight of 395,000 kg. Using the ACN method, all other aircraft types were recalculated into the design aircraft, and it was considered that the total number of movements (take-off + landing) of the design aircraft determined would include:

- □ in 20 % of cases a fully loaded aircraft (max. ACN value),
- □ in 80 % of cases a mean ACN will be used, i.e. half way between the max. and min. ACN (50 % of the total number of movements are aircraft landings).

The calculations considered that the traffic volume will not be fully channelled, either on RWY, or on TWY APN surfaces. The determination of actual loading intensity on individual runways or load repetition in one trail is highly complex, and it cannot be unambiguously defined. The design was, therefore, based on empirical data and probability.

In determining the presumed loading intensity by design aircraft it was considered that the total number would be divided into both parallel RWY and that the ratio of the number of directionally oriented movements (take-offs/landings) on one RWY would be ca 70 % / 30 %. The highest "channelling" (repetition of travels in one trail) of loading will occur on the RWY threshold, which will be designed with a concrete pavement. Here, additional fluctuation of travels was not considered. The RWY itself, which will have an asphalt pavement, was considered to account for trail fluctuation and mainly buoyancy action at the start, through so-called reduced loading of the construction. Both of these effects were included into the calculation by reducing the number of movements in one trail, with regard to the type of construction (the central part of RWY with the highest load-bearing capacity x 7.5 m wide strips with basic load-bearing capacity x side strips 7.5 m in width designed mainly for the effects of TNV travels of airport service).

The design aircraft considered was Boeing B 747-400. Its parameters are:

- □ total weight of aircraft: 395.0 t, i.e. a load of ca 3 885 kN,
- □ load acting on the front undercarriage is 30.2 t (296.3 kN), on the most loaded main undercarriage 91.2 t (894.7 kN). As the undercarriage of the main leg is a four-wheel type, the load acting on one wheel of the main undercarriage is 22.8 t (223.7 kN),
- □ tyre pumping is ca 13.8 kg/cm², i.e. ca 1.38 MPa,
- □ radius of the equivalent circular loading tyre surface determined is 0.2271 m.

Based on calculations, the following compositions of RWY pavement constructions were designed:

RWY – outside part

1			
Cement (airport) concrete	CB L	360 mm	ČSN 73 6123
Gap-graded concrete	MCB	150 mm	ČSN 73 6124
Cement strengthened aggregates	KSC I	200 mm	ČSN 73 6124
Granulated gravel	ŠD	200 mm	ČSN 73 6126
Total		910 mm	
RWY – central part			
Asphalt medium-grained concrete, modif.	ABS M I	50 mm	ČSN 73 6121
Asphalt very coarse concrete, modif.	ABVH M I	80 mm	ČSN 73 6121
Asphalt mix with high modulus of rigidity	VMT A	140 mm	TP 151
Gap-graded concrete	MCB	250 mm	ČSN 73 6124
Granulated gravel	ŠD	250 mm	ČSN 73 6126

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Total

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Requirements for Subgrade and Unbound Pavement Layers

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Requirements of TP 77 and TP 78

From 1996 to November 2004, road pavement design was regulated by technical regulations TP 77 Designing Road Pavements and TP 78 Catalogue of Road Pavements. Both regulations applied identical definitions of the requirements for subgrade and unbound pavement layers. The only requirement for subgrade was reaching the required load-bearing capacity of the earth roadbed (the modulus of deformation under the plate load test) as follows:

- \Box E_{def,2} = 45 MPa for fine-grained soils, or
- \Box E_{def,2} = 120 MPa for coarse-grained (gravelly) soils.

In the case of fine-grained soils, this represented a requirement for reaching a CBR value of subbase soil of at least 5 %. If subbase soil fulfilled this minimum value, it was presumed that the required value of the earth roadbed would be reached. In the case that subbase soil failed to reach the CBR value of 5 %, it had to be improved or replaced. On the contrary, if the CBR value of subbase soil was greater, in theory the protective layer thickness could either be reduced, or (for CBR > 20 %) the layer could be completely eliminated.

The required value of the modulus of deformation $E_{def,2}$ of the protective or unbound structural layer was set in relation to the design level of pavement failure and the traffic load class. In practice this meant that in order to achieve the required values of the moduli of deformation, the following materials and thicknesses of structural layers were necessary:

	Protective layer:	120 MPa =	SP 250, SD 180, MZ 200 (mm)
		100 MPa =	ŠP 250, ŠD 17, MZ 200 (mm)
	Base course:	180 MPa =	MZK , ŠV 200 ± 20 , ŠD 220 ± 30 (mm)
		150 MPa =	MZK, ŠV 180 ± 20 , ŠD 200 ± 30 (mm)
		120 MPa =	MZK , ŠV 160 ± 20 , ŠD 180 ± 30 (mm).
(ÅT		1 1/7	1 11 1 1 1 1 1 1 1 1 1

(ŠP – gravel, ŠD – broken stone, MZ – mechanically compacted soil, MZK – mechanically compacted aggregate, ŠV – vibrated gravel)

In practice, however, this system not always worked without errors. Approximately 10 years of practical implementation showed that if the actually reached value of the modulus of deformation of the earth roadbed was only 45 MPa, reaching the required values of the moduli of deformation of 120 or 100 MPa respectively in the protective layer was very difficult and often unfeasible. This problem was not solved until new technical specifications TP 170 Designing Road Pavements were issued.

Requirements of TP 170

The design method TP 170, which is based on the principles of road building materials optimization in terms of increased reliability and durability of road structures, newly introduced a road subgrade classification depending on its mechanical and physical properties into three clearly defined types, including the requirements for its final acceptance (see 652

Table 1). Also, a system of setting reference values of $E_{def,2}$ of individual unbound structural pavement layers was introduced in relation to the material and layer thickness and the modulus of deformation of the layer below (see Table 2).

Table 1 -	- Subgrade	types	used in	catalogue sheets	ТР	170
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Subgrade	Design modulus of	Minimum modulus of	Subgrade frost susceptibility		
type	elasticity E _d (MPa)	deformation E _{def,2} (MPa)			
ΡI	120	90	nonsusceptible to frost		
P II 80	80	60 (45) ¹⁾	slightly frost susceptible to		
	80		frost susceptible		
PIII	50	$45(30)^{2)}$	extremely frost susceptible		
1) Valid for soils S and G, invalid for improving binder admixtures.					
2) Valid for pavements and structures at design failure level D2 or D1 under TDZ VI.					

Table 2 – Required minimum moduli of deformation of unbound pavement layers in relation to material and layer thickness and modulus of deformation of the layer below

	Required moduli of deformation $E_{def,2}$ set at protective layer (MPa)					
Subgrade	MZ with layer thickness, mm			ŠD with layer thickness, mm		
	150	200	250	150	200	250
30 ¹⁾	45	50	60	50	60	70
45	60	60	60	70	80	90
60	60	-	-	90	100	110
90	-	-	-	120	-	-
Protective	Required moduli of deformation $E_{def,2}$ set at base course (MPa)					
layer	ŠD with layer thickness, mm			MZK with layer thickness, mm		
	150	200	250	150	200	250
45 ¹⁾	70	80	90	-	-	-
50 ¹⁾	80	90	100	100	110	120
60	90	100	110	110	120	130
70	100	110	120	120	130	140
80	110	120	120	130	140	150
90	120	120	-	140	150	150
100	120	-	-	150	150	-
1) Valid for pavements and structures at design failure level D2 or D1 under TDZ VI.						

This solution allows optimum usage of specific design conditions given mostly by the subgrade quality. This quality (mainly for subgrade P I and P II) is reached either by subbase soil replacement or (very frequently) by soil improvement with lime.

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New Technical Specifications "Catalogue of Pavements of Rural Roads"

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Since 1998, the design of pavements of rural roads and other purpose-built routes has been regulated by the technical instruction of the Ministry of Agriculture of the Czech Republic – The Central Land Register Office – TP Catalogue of Pavements of Rural Roads (hereinafter referred to as the Catalogue), developed in cooperation with academic staff members of the Faculty of Civil Engineering, CTU in Prague – Department of Road Structures and Ing. Pavel Gallo, an expert in the problems of land redistribution and rural roads.

Catalogue Review

In connection with a review of the standard ČSN 73 6109, Design of Rural Roads, issued in 2004 and technical specifications of the Ministry of Transport of the Czech Republic, TP 170 Design of Road Pavements, in force since December 2004, the Catalogue authors were asked by the Ministry of Agriculture to review it taking into account the changes introduced by ČSN 73 6109 and TP 170.

Prior to the commencement of work on the Catalogue review itself, a survey was made among its users representing land register offices, designers and contractors aimed at collecting practical experience and potential requirements for changes and addenda to the Catalogue. The survey evaluation shows that the majority of users are satisfied with the Catalogue, but there were also demands for its complementation with cross sections of the basic types of recommended rural roads in accordance with ČSN 736109, or introduction of more structures with newly applied materials and technologies respectively, such as recycled materials, various stabilizations and gravel road surfaces etc.

The work on the Catalogue update was based on practical experience of implemented structures from the last years and mainly on the results of research projects and grants in the field of road structures focusing mainly on the technology of road building materials and structures and their optimization in terms of increased reliability and durability. The road structures included in the Catalogue were designed while respecting the basic reliability and other principles of road design as specified in TP 170 and ČSN 73 6109 as follows:

1. All structural types of pavements are designed for a design period of 20 years and a design failure level of D2 (introduced in ČSN 73 6109),

2. Pavement design was based on the classification of rural roads according to design categories and corresponding presumed types and volumes of traffic load. The calculation involved the following coefficients:

□ Coefficient C1, expressing the number of traffic lanes:

- Pavements for traffic load class IV were considered as two-lane,

- Pavements for traffic load classes V and VI were considered as one-lane,

Coefficient C2, expressing fluctuation of wheelings of heavy trucks in the driving track,

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- Coefficient C3, expressing a spectrum of axle weight as standard traffic load and
- Coefficient C4, expressing the effect of the heavy truck movement velocity.

3. Following TP 170, two types of subgrade were introduced, defined by the required value of the modulus of deformation $E_{def,2}$, as follows:

- □ 45 MPa recommended value in accordance with ČSN 73 6109,
- □ 30 MPa minimum value in accordance with ČSN 73 6109.

For these two subgrade types, individual catalogue structures were designed.

4. Following TP 170, the required values of reference moduli of deformation were introduced, determined on unbound pavement layers in relation to the thickness and material of the structural layer and the modulus of deformation of the layer below. These values are listed for individual catalogue structures and in a table in the TP text.

- 5. The Catalogue was extended to include structures with:
- □ stabilized road surfaces and road surfaces of unbound materials (gravel),
- □ layers of recyclates (concrete or brick) and
- □ layers of R-materials (compacted recycled asphalt mix).

Contributions of New Catalogue

As compared to technical specifications TP 170, which consist of three different sections (introductory part, catalogue and design method) adding thus unnecessary complications for the majority of common users and design situations while working with them, the Catalogue of Pavements of Rural Roads possesses the following advantages:

- it was completed in a "standard" catalogue form, i.e. its focus is namely on catalogue structures, and the additional text has just the role of its necessary support,
- it includes not only pavements for heavy-duty traffic (flexible, rigid and sett pavings), but also structures for special traffic surfaces (parking lots and lay-bys, non-motorist routes),
- □ as compared to the original Catalogue and TP 170:
 - the problems of subgrade characteristics were principally simplified: unlike four requirements (soil classification and soil frost susceptibility, water regime and earth roadbed bearing capacity), the scope of background data required by the Catalogue was limited only to soil classification and expected water regime,
 - the problems of climatic conditions were completely removed, i.e. it is no longer necessary to consider pavements in terms of frost action on subgrade.
- it makes users' work easier by including individual notes to catalogue structures directly on catalogue sheets,
- it contains a graphic appendix with examples of recommended width layout of rural roads of various design categories (in keeping with the requirements of ČSN 73 6109).

The developed Catalogue of Pavements of Rural Roads was approved in December 2005 and in the third quarter of 2006 was published.

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Local Stresses Inducated by Anchorage of Prestressed Reinforcement

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In the engineering structures many locally stressed areas arise. The concentrated stresses arise above all in the areas of local forces (supporting location, anchorage), at the locations of openings and sudden cross-section changes. In these areas very complicated tensions appear. It is not easy to describe these tensions in isotropic materials such as steel, and things even more difficult it is if we consider for example inhomogeneous concrete as the structural material.

The significance of treating these areas is growing with slenderness of designed structures. The number and the significance of locally stressed areas grew considerably up with the introduction of prestressed structures and recently namely with designing and practical use of bigger prestressed tendons. It is necessary to research these locally stressed areas created by the anchorage of prestressed tendons properly.

According to [2] it is not possible to solve the stress distribution in the anchorage area caused by the prestressing forces (at the ends of the girders combined with the reaction of the support) by the technical elasticity method. Such calculations are laborious and questionable owing to the plasticity of the concrete. Tensions in concrete calculated this way do not describe the real stresses in the anchorage area, and so they usually are not calculated at all and mainly the already performed tests of the whole anchorage systems are used instead. Generally only the size and the position of the resultant force of transverse tension in anchorage area are determined. The resultant force must be carried with reinforcement.

At present the stresses in the anchorage area are solved only approximately, either for an applied or for an embedded anchorage plate (spread footing). The force impact brought by one tendon can be imagined as a force concentrated on an anchorage plate which is diffused into equal tension in the anchorage area in the so-called substitutive prism. The stress trajectories have a convex shape in the location near the anchorage plate and in a certain distance the shape turns concave. At the end of the anchorage area they are parallel with the loading force. Transverse presses and transverse tensions appear in the area of convex and concave shape respectively.

For an approximate determination of the resultant transverse tension force a simplified strut-and-tie model can be used, which can supply the distribution by the stress trajectories. Provided that the resultant transverse force will take effect in the middle of the length of the anchorage area, we can determine this force easily. This tension must be fully carried by reinforcement.

Gyuon [3] was concerned with a more detailed research of these anchorage areas. He made graphs of tension distribution by the anchorage force. This tension was verified by tests on real anchorage areas. It is valid particularly for bearing areas of anchorage plates with level surface.

We have been dealing with this problem using the Finite Element Method. We made a 2D desk model, where we first modeled the substitution of the whole anchorage system by a similar plate placed on the surface of a concrete body. The tensions under this plate are similar to the tension values according to Guyon and to the tension values searched out from strut-and-tie model. The anchor in more stand tendons systems is composed not only of the spread footing, but also, with respect to the prestressed system, of a variously structured and shaped anchorage body. It may be composed of the spread footing with a truncated cone for unraveling the prestressed reinforcement. The distribution of forces under such an anchor is not very different from the distribution under a spread footing. The longitudinal tension σ_x moved approximately as far as the anchorage length into the structure. The resultant of transverse tension force σ_y moved approximately half the anchorage length into the structure. The tension values sank about 20%.

For anchoring more tendons, anchorage bodies in the form of castings with stumps - rings are used. They transfer the force into the concrete using primary anchorage desk in the same way as the desk anchor, in addition they are equipped with rings on their circumference. These rings enable a better transfer of the prestressed force into the concrete. The anchor is much bigger and it is not possible to replace it only with a spread footing on the concrete surface in modeling. There is a big area of the proper anchor under the anchorage plate, which weakens the concrete cross-section significantly. This must be taken into account in the model as well. The stress becomes more complex when using several anchors, which influence each other (especially with bridge structures). At the end of the girder the stresses is influenced by the reaction of the support, which itself creates a locally stressed area that must be included in the solution.

In case of a uniform distribution of anchors in the front of the girder, the strut-and-tie model is sufficient for the approximate design of reinforcement for carrying the transverse tensions caused by the anchorage of the prestressed reinforcement. For more extensive research of anchorage areas even the 2D model solved by FEM is not sufficient. This problem will be further investigated in 3D models in the ANSYS program and the results will be verified by tension measuring within prestressing of a real construction. Checking the stresses on the front of a prefabricated bridge T-girder is planned, wherefore the tensiometers have already been bought.

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Extreme Design Situations in Bridge Design

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With regard to the present geo-political situation, the design of bridges and civil structures to extreme design situations comes to the front of the professional public interest. Extreme design situations may cause the bridge to fail before the expiration of its design useful life. The article specifies possible causes of a bridge failure.

The Eurocode [1] defines the accidental design situation as a design situation involving exceptional conditions of the structure or its exposure, including fire, explosion, impact or local failure. According to the Eurocode [1], the accidental action as an action, usually of a short duration but significant magnitude, that is unlikely to occur on a given structure during the design working life. The extreme design situation can be defined as a situation which caused a structure which was designed and constructed in accordance with up-to date standards and design requirements to fail before reaching its design working life.

There are many aspects the bridges failures can be systematized according to. One of them is the cause of failure; it is most suitable because of its flexibility and simplicity.

Bridges can fail because lacks in design, construction and maintenance or a combination of these factors. The only way to eliminate this is a thorough supervision in all the stages of the design and construction process.

The other possible causes of bridges failure are environmental effects. These cover floods, scour, wind, ice formation, extreme temperature swings, earthquakes, volcanism, etc.

Bridges can and do fail in the majority of cases because of negligence. Negligence in steering or negligence of traffic mitigations results in collisions with the construction, its substructure or superstructure.

One possible source of bridges failure is an act of terrorism. Though it has been neglected upto present days, it has to be considered nowadays in design of bridges, in particular of bridges with hollow cross-sections with the traffic flow being lead inside it.

Other sources of bridges failure are fire and explosion which are mostly a result of other types of failures previously named, e.g. a truck tank collision with a bridge substructure with a resulting fire, a formwork catching fire while being warmed up during winter concreting, fire or explosion as a result of an act of terrorism.

The proposed systematization of possible bridge failures from the point of view of cause of failure can help revealing the real originator or their combination thus simplifying the resulting decision process of consequences elimination.

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Photovoltaic in the Built Environment

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Since the reserves of traditional energy resources are decrease inevitably, new ways of energy production have to be searched. Photovoltaics (PV), a relatively new technology, offers a pollution-free and noiseless technique of electricity generation directly from the solar radiation. When PV devices are placed on a suitable area of the building envelope, the generated electricity is available at the place of consumption and the transmission losses are minimized compared to a usual long-distance transmission network. Furthermore, when adequately designed, photovoltaics can considerably contribute to the fresh and original architectural appearance of the building.

An experimental 40 kW_p PV installation was raised at the FCE building in 2005. The system consists of two parts - a ventilated PV façade and an open-rack roof PV installation. The total number of 386 PV panels was used. The PV facade is divided into two parts along the central glazed strip. A frame steel-aluminum supporting structure is mounted on the insulated (160mm) external wall of the building. A continuous 100 mm wide air gap is created between the PV panels and the wall. The system is ready for mechanical ventilation, although the ventilators have not been installed yet. A detailed measurement of electrical and nonelectrical physical quantities at the facade started in the first quarter of 2006 and the relationship between the power output and changing meteorological conditions is closely monitored. The temperature on the PV facade is measured at more than 50 measuring point so that the influence of temperature on the system's efficiency can be analyzed in detail. The output power is measured at the converters and total delivered electrical energy at the switchboard. Furthermore, the airflow speed in the ventilated gap, global irradiation and ambient temperature are measured. An analysis of the measured data shows that the design of photovoltaic elements integrated into building envelopes requires a specific approach. Low operating temperature of the solar cells must be ensured by a properly designed ventilation system (either natural or mechanical). In case of a PV facade, this can be done by creating a ventilated gap between the PV panels and the wall surface. On the contrary, it was shown that the temperature at the solar cells increases extensively when a sufficient ventilation system is missing.

Another experimental 8 kW_p PV system was built up in Koberovy in cooperation with industry (Atrea s.r.o.). The PV system is integrated in a pitched roof at one of thirteen passive houses that are currently being constructed in the area. In this unique project a traditional roof tiling was replaced by the PV modules, in a way bringing a new visual impression into rather conservative wooden-framed house. This house should reach the level of zero-energy-house, considering the produced energy (PV on-grid) and delivered energy (for space heating, hot water preparation and electricity for appliances). The system is also equipped with an extensive measurement so that the long-term efficiency and output power can be monitored.

Presently a project aimed at optimizing of sun blind shading with integrated photovoltaics has been launched. The optimization studies together with physical model under real condition will be performed. The indoor comfort of a room behind movable PV-shading system together with overall architectural quality is studied here.
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Sustainable Building Construction - Material and Energy Efficient Buildings

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Research and Development of techniques and tolls for design and construction of sustainable buildings represent essential part of the research of the centre CIDEAS. Wide range of building sustainability aspects is considered.

Life cycle assessment and development of assessment tools. Green building assessment has been acknowledged as one of the most effective ways to encourage development of energy and material efficient buildings. Different tools and methods for complex assessment of buildings have been developed and are used around the world (e.g. EcoHomes, LEED, GBTool, SBTool, CASBEE). Based on the methodology of GBTool and LEnSE (methodology being developed within the 6FP program LEnSE) the new tool with new structure of indicators, benchmarks and weights is being developed and implemented in the Czech specific conditions.

Alternative materials - Possibilities of utilization of modern earthen structures in Czech conditions. The goal of the past research was to assess mechanical physical properties of unburned bricks in dry state and under the influence of moisture. Unburned bricks of the size 296x140x70 mm at 3 levels of the working pressure (2.0; 4.0; 8.0 N/mm2) and using 3 ways of stabilization (only by pressure, with admixture of lime 5% and cement 5%) were tested in compressive strength and bending tension strength in dry state and under the influence of 3 levels of moisture (3%, 6% and 9% of massic moisture).

Consequential research is focused on more effective applications of earthen structures, such as pre-formed structural elements. Load bearing prefabricated wall panels of the size 900x2700x150 mm are designed in the framework of pilot project of a family house. Technological process is verified in cooperation with construction company Alterstav Ltd. Maximal bearing capacity of wall panels and tension course between wooden frame and earthen core will be tested in laboratory on specimens of scale 1:1.

Recycled materials. In the field of application of recycled material, specifically recycled materials from municipal waste, several materials were investigated. The goal was to (a) find their effective way of use and subsequently to optimize the whole structure or component, (b) experimentally verify mechanical properties and (c) carry out the final environmental assessment. The research in the last year was mainly focused on the use of lightening fillers from recycled plastic for precast reinforced concrete panels. The panels were optimized from the point of view of material demand and environmental properties. At the end three test samples of these panels in the scale 1:1 were made and experimentally tested. There were observed growth of deflection, overall behavior and the load-bearing capacity. Another goal of the research was the verification of selected mechanical physical properties of structural boards from recycled laminated cartons,

Low-energy and passive houses. Air leakage reduces thermal performance of a building envelope. A suitable design (as a part of the energy concept) may contribute to a good airtightness of the final building. The effectiveness of design solutions has to be proven by means of field tests. Airtightness of several buildings was tested by means of the fan pressurization method (CSN EN 13829). A standard blower door device was used for this purpose. The results of overall air permeability tests show a poor level of airtightness commonly achieved in Czech building practice. The detection of leakage paths was performed together with the air permeability tests in order to identify the causes of such unsatisfactory situation. A set of common design and construction mistakes was deduced from the results and a concept of methodological guidelines to prevent these mistakes was developed. The collection of airtightness data is still in progress. The guidelines are further developed using this data.

Earth-to-air heat exchangers. The thermal comfort requirements and cooling energy demand have significantly been increasing over last twenty years. Air heating and/or cooling in an earth-to-air heat exchanger is the approach to reduce energy consumption and improve thermal comfort in a building. The earth-to-air heat exchanger is a pipe buried in the ground through which air is sucked into a building. The proper design of the earth-to-air heat exchanger requires deeper understanding of heat and moisture dynamics in the earth-to-air heat exchanger. An ongoing research on earth-to-air heat exchangers is the combination of a theoretical study and experimental measurements. The theoretical predictions of the developed hygro-thermal model for simulation of the earth-to-air heat exchangers are compared with in-situ measurements on real-size earth-to-air heat exchangers connected with mechanical ventilation in two low-energy family houses. The comparison between measured data and numerical simulation does not correlate absolutely. Nonetheless, the model brings clear information about processes which take place during earth-to-air heat exchanger operation and reveals limitations and energy saving potential of the earth-to-air heat exchanger operation is to building ventilation.

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Specialized Computer Graphics Workstation

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Within the transformation and development programme of the Ministry of Education, Youth and Sport No. 61/2004 "Computer Graphics Workplace", the principal objective of the project was to establish and run a top-level computer graphics training workplace (hereinafter referred to as a workplace) focusing on teaching modern application software for the support of interactive design in building construction, corresponding by its level to the-state-of-the-art technology and teaching needs. The workplace was presumed for use by students in Bachelor's and Master's degree and follow-up Doctoral study programmes, but also for enhancing and extending the professional and pedagogic level of academic staff members of individual, mainly professionally oriented departments.

The newly established computer graphics workplace is situated in Building A of the Faculty of Civil Engineering, CTU, in Room A 233. The workplace is equipped with the total of twelve graphics stations STRAETON Silver 4150m (or STRAETON Gold 6040 respectively) in basic configurations with min. Intel Pentium IV processors, RAM 2 x 256 MB, 200 GB hard disks, CD/CD RW burning mechanics + other standard devices and accessories. In order to solve graphic problems in the AutoCAD (Microstation) environment, the stations had to be fitted with large-size and top-quality monitors – with a view to space demands the stations were fitted with flat LCD monitors 17" TFT LG 1730P (or 19" TFT LG 1930P respectively). To enable the printing of final large-format drawings from all graphics stations, the workplace is equipped with a large-format network-linked colour printer HP DesignJet 500ps with a resolution of up to 1200 dpi and print-out width of up to 610 mm.

As for software, the workplace is equipped with the following applications:

- universal supporting software such as the operating system Windows XP, MS Office, the graphics programme AutoCAD ADT (Architectural DeskTop) by Autodesk company, suitable mainly for Building Services applications in graphic environments and allowing applications of graphics extensions for heating, air-conditioning, sanitary plumbing and wiring, but also for the support of application software in the field of road design and construction. To ensure full compatibility and the widest possible use of the software potential, the workplace is also fitted with a graphics programme MicroStation by Bentley company, and to allow additional, specialized graphical processing of drawing documentation also with the COREL Draw application.
- specialized application software for Building Services subsystems there are professional applications for the design of heating systems (programme lines STU and PROTECH) containing a complete tool for the processing of all related calculations, including graphic outputs; for the design of air-conditioning systems there is application software KLIMA Praha, solving individual air-conditioning computations (h-x diagram, design of piping and elements for air-conditioning machine rooms, thermal load computation), while for sanitary technology GEBERIT GIS software has been installed serving for the design of installation partitions and water and sewage connecting piping.

To deal with the problems of road structures, the workplace is equipped with a programme package for the creation of a digital terrain model and successive fully interactive road design by Pragoprojekt a.s. company. It incorporates mainly the DTM '04 module (a digital terrain model, fully interactive processing of terrain data and field measurements linked up to the ROADPAC '04 module), the ROADPAC '04 module (a complex automated system of road and motorway design, including interactive design of the layout, longitudinal and vertical section alignment, cross sections and passive graphic outputs, including conversion into MX) and the ROADCAD '04 module an (interactive graphic system as an extension to AUTOCAD R2002/2004 system for the creation or final touches of final drawings in connection with the ROADPAC '04 module, creation of 3D site plans and 3D route design models, including surveyed surroundings with potential use of the model for photorealistic picturing of individual perspective views or for animations of travel along the route or in its vicinity in a 3D setting). In order to enable the modelling of a multi-layer structural system of road pavements, including computation of stress and strain due to input traffic load, the workplace is also equipped with a computation programme LAYMED-D for road dimensioning in accordance with the Czech design method TP 170 currently in force.

programmes for modelling and simulations – such as the ESP-r simulation programme (developed at University of Strathclyde, Glasgow) serving for simulations of energy behaviour of buildings and TRNSYS software for the modelling and simulation of building services, and licensed software for the CFD (Computational Fluid Dynamics) modelling of fluid flow FLOVENT.

After the installation and putting all the hardware and software into service, the newly established computer graphics workplace was opened for use at the end of 2004. By the beginning of the spring semester of the 2004/2005 academic year, its full operation began. The workplace caters mainly for the students of Bachelor's and Master's degree study programmes, both for teaching parts of selected compulsory and compulsory elective courses, but mainly for teaching closely specialized elective courses oriented on building services and road structures. Among others, the workplace is used mainly for processing studio work by the 4th- and 5th-year students and for specialized elective road-oriented courses: Road Software and Road Mechanics. Further more, the workplace is used by departmental diploma students for processing their diploma theses or by graduate students in the doctoral study programmes.

Despite the fact that by its size (it comprises twelve graphic stations), the newly established workplace is relatively small and its professional orientation is relatively specialized, i.e. it has a potential ability of "addressing" only a narrow spectrum of future graduates, its contribution may be seen mainly in the fact that after completing the study programme, or at least some of its parts, the graduates will go to practice possessing skills for working with modern programme systems, which are presently among the standard equipment of the majority of design companies. We believe that this will considerably raise the credit of not only the workplace, but the whole Faculty.

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Water Areas Used for Recreation Purposes: Urban Indicator

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This paper focuses on the present situation and prospects for future provision of recreational water facilities in the Czech Republic (evaluation of the planning and construction of current facilities and assessment of future plans) [1].

Despite the popularity of swimming, most traditional public pools are poorly attended, are not being used by adults, and have limited family participation. Traditional pools are characterized by a dominance of deep water, narrow concrete decks surrounded by chain link fencing and are usually very unattractive to the eye. They normally offer limited opportunities for the user beyond sitting in the sun or standing in the water. Little swimming or water activity actually takes place. When it does, the user is participating in a crowded atmosphere which detracts from their leisurely enjoyment of the activity.

Activity opportunity was the key to moving forward with the revitalization of the existing and constructed pool. We have specializes in the development and revitalization of community aquatic facilities and a plan to revitalize the existing pool urban index. This revitalization plan was based on four broad objectives [2]:

- To attract greater youth, adult and family participation.
- To increase attendance and be financially self-supporting.
- To satisfy a broad range of aquatic interest for all ages.
- To be attractive, exciting, safe and a quality leisure experience.

It was necessary to analyze the new data from the point of view of pool design parameter U, which represents the relation between population and m^2 of water areas [3].

$$U = \frac{\text{Xm}^2 \text{ of } \cdot \text{water } \cdot \text{sheets}}{\text{inhabitant}}$$

An analysis of the present situation regarding natural and man-made swimming and bathing pools in the Czech Republic, confirmed by a detailed investigation was performed.

The ongoing process of gradual urbanization has led to gradual growth of pollution and a reduction in places suitable for recreational use. It is no longer possible to rely on the capacity of nature and man made facilities to satisfy demand.

It appears that most open air pools do not have adequate sanitary facilities (toilets, shower rooms, changing rooms, refreshment rooms, entertainments), hygienic control (the hygienic properties of water, disease prevention), and also do not have adequate, modern treatment technology (hydrobiological problems, organoleptic properties, methods of changing the water in reservoirs).

It has been taken the view that values U_K as per Doc. Sklenar from 70-th of last century are already out of date. It is therefore because people behavior has changed from last 30 years. For up to date new U_K parameters were setup, See Tab. 1.

1 dot = 0 for date 0 k parameter [+].										
$10^{3} O_{z}$	do 20	20 - 50	50 - 75	75 - 100	100 -125	125 -150	150 - 200			
U _K (2006)	0,0098	0,0056	0,0043	0,0036	0,0032	0,0028	0,0024			

Tab. 1 Up to date U_k parameter [4].

The new U_K parameters properly shade an actual approach and way of using water areas for recreational purpose.

In building up new or in reconstruction of swimming pools is necessary to take into consideration that a nowadays recreational constructions subserve not only sportive but also recreational.

Additional new indoor pools or reconstruction of present pools need some of larger cities like a Prague, Brno, Kolín, Pardubice et al.

The above-mentioned problems (quantitative and qualitative water source requirements, the capacity of water treatment installations, economic and ecological questions, and experience gained in existing facilities, etc.) will provide tasks for future research projects and also employment for engineering companies.

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Analysis of Biofilm on the Internal Surface of Drinking Water Distribution System

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Internal pipe surfaces within drinking water distribution systems are colonised by bacteria forming a biofilm. These bacteria are fixed onto the internal wall of the pipes by exopolymers composed of proteins and polysaccharides.

Biofilms on drinking water distribution system pipes may lead to a number of unwanted effects on the quality of the distributed water. Excessive bacterial growth may affect the turbidity, taste, odour and colour of the water.

Biofilm growth and detachment could contribute cells to the bulk water. Investigations of biofilms in a full-scale drinking water distribution system indicated that coliforms in the distribution system originated from the pipeline biofilms [1].

Biofilm may promote the deterioration of metallic pipe surface through a process known as microbially influenced corrosion (MIC) or biocorrosion. Biofilms induce a disinfectant demand and consequently promote disinfectant decay in distribution systems.

The factors that may influence the development of biofilm in drinking water distribution systems include the concentration of biodegradable organic matter (BOM), the disinfectant residual, the temperature, the pipe material, the presence of corrosion, and the shear at the biofilm–liquid interface. In the work of Ollos [2] it appeared that the key controlling factors of the biofilm level were the biodegradable organic matter (BDOC) and the disinfectant residual. Lund and Ormerod [3] reported that the maintenance of a free chlorine residual of 0.05 mg/l was able to prevent biofilm formation on new plastic pipes during an 18-month investigation period.

In managing the distribution system as a bioreactor the maintenance of a disinfectant residual is often chosen as the approach for controlling biofilm levels. Although a number of studies have demonstrated the importance of disinfectant residual and DOC in the control of biofilm accumulation, relatively little quantitative information is available regarding the combined effect of disinfectant residual and BDOC on the control of biofilm.

The purpose of this study was to identify and tests the biofilm formation in drinking water at low nutrient conditions. 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 colonisation in order to perform microscopic study on the biofilm.

During each sampling campaign, water samples were collected from all places where coupons for biofilm analysis were removed. Chlorine, DOC, BDOC and few other parameters in water samples were determined as well as the bacterial abundance. BDOC concentrations in water were estimated as the difference of DOC concentrations measured before and after 30 day incubation at 20°C with indigenous bacteria. Abioseston composition of biofilms after scraping was estimated.

The measurement of the biofilm which had developed on the plates from five different materials was carried out. It was shown that an iron surface again produced the greatest biomass with bacterial growth ranked in the order iron > iron protected with bitumene> different samples of MDPE.

The chemical composition of material accumulated on the inner wall of a mild steel water pipe showed that the dominant element was Fe (about 75% Fe₂O₃). The results clearly 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 distribution system.

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Internal Corrosion of Water Distribution System

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The quality of drinking water can be affected by the nature of the material used in a water distribution system. Various pipe materials, such as iron, galvanized steel, concrete, PVC etc. have been extensively used in the drinking water distribution systems. Unlined iron pipes are very prone to electrochemical corrosion and their internal surfaces can become severely corroded over time. Typical iron corrosion products formed on aged surfaces can be described using three different layers: a macroporous layer of black rust (magnetite, Fe₃O₄) in contact with metal, a microporous film of mixture of Fe²⁺ and Fe³⁺ species that covers the macrolayer, and a top layer of red rust (mainly goethite, α -FeOOH and hematite, α -Fe₂O₃). The exact composition and structure of iron corrosion scales, however, varies significantly with water qualities as well as flow properties [1].

Corrosion of iron is also the primary factor controlling biofilm growth. Corrosion products of iron pipe provide habitats for microbial growth and react with disinfectant residuals, preventing the disinfectant from penetrating of biofilm [2]. In order to optimize rechlorination procedures, the different sources of chlorine consumption must be identified.

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". Alkalinity, pH, chloride and sulfate are primary water quality parameters affecting iron corrosion. 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 [3].

This research was conducted to design a simple corrosion monitoring program, to evaluate a current corrosion control program applied at a full scale conventional treatment plant and to determine a corrosion control strategy that can minimize corrosion rates and to evaluate its short term effects on bacterial water quality. The objective of our study was also to determine biofilm formation on steel substrata in order to understand what factors might relate to biofilm formation on the walls of drinking water pipes within drinking water distribution systems.

The experimental part of this study was performed in the Plav WTP which provides potable water for about 450.000 inhabitants in many cities and small towns in the region of south Bohemia. The treatment process in the plant is coagulation with ferric sulfate, flocculation, sedimentation, rapid sand filtration and disinfection with chloramine. The Plav WTP takes its raw water from the Římov surface water reservoir.

Three places were chosen as locations for corrosion monitoring – inlet to the WTP, outlet from the sand filters and outlet from the drinking water reservoir.

Individual cradles were developed for the coupons study. Each craddle consisted of four steel coupons and one glass coupons for biofilm and chemical deposit analysis. Corrosion rate were measured after 35 and 70 day exposition in pipeline. In addition, the water samples from the same places were taken. All samples were tested for temperature, pH, alkalinity, Ca and Mg, Fe, Mn, COD and BDOC. Chlorine concentration was determined on site.

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Formation of DCA in Chlorinated Water

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Haloacetinitriles (HANs) are nearly ubiquitous contaminants in chlorinated drinking water although the levels is lower that those of trihalomethanes (THMs) or haloacetic acids (HAs). These compounds constitute an important group of chemicals, the action of which include reproductive, mutagenic and carcinogenic effects. The World Health Organization, based on the additional cancer risk 1/100000, has set qualitative target levels of 90 μ g.l⁻¹ for DCAN and 100 μ g.l⁻¹ for DBAN in drinking water.

The important factors affecting the formation of HANs and other disinfection by-products include the concentration and property of the organic precursors, disinfectant type and dosage, the pH, temperature, bromine ion content etc. The first two factors have the most important effect.

Humic acids are thought to be a major carbon resource in drinking water during the chlorination and become a principal precursor of DBPs such HANs or THMs. This material is heterogenous poly-condensation products of carbohydrates, peptides, fatty acids, phtalates, lignins, tannins, metals and many other constituents, whose compositions depends on the origin in the natural environment. Empirical studies have shown a strong positive correlation between the overall nitrogen content of aquatic humic substances and their tendency to form dichloracetonitrile (DCAN). Algal suspensions, rich in proteinaceous material, have also been shown to readily form DHANs. Thus, it seems that the proteinaceous material is the most likely precursor for DHANs in drinking water.

Chlorine reactions with amino acids form the unstable intermediate dichloroacetonitrile (DCAN), which can continue to react with chlorine to form chloroform, di- and trichlorinated acetic acid, trichloracetamide and carboxylic acids [1]. As an intermediate DCAN produces more dihalogenated acetic acids than chloroform, and therefore DCAN may be more closely correlated with HAAs than THMs.

DCAN is susceptible to chemical degradation in treated waters. While THM concentrations in chlorinated water increase with contact time, DHANs initially formed decay as a result of hydrolysis and reactions with residual chlorine [2]. It was shown, that haloacetonitriles undergo a base-catalysed decomposition that is dependent on the nature of the bound halogens. DHAN degradation was accelerated at pH 7 and pH 8 by the presence of free chlorine. DHAN degradation reactions have not been adequately characterized to allow for quantitative predictions under a range of pH and temperature. DHAN concentration is almost always lower when chlorination is conducted at higher pHs. In addition, their concentrations accumulate rapidly to a maximum and either level off, or sometimes even decrease. Decrease in concentration is clear evidence of decomposition [3].

The purpose of our research was to quantitatively define the overall potential formation of DHANs (PDCANs) in raw water. The source of the raw water was the Flaje reservoir situated in Ore Mountains. The results from this study can provide a reference basis for water treatment processes or high-level removal processes for disinfection by-products. PDCANs were quantified according to the TNV 757549 method "Determination of THM Potential". Residual chlorine measurement was made by the DPD colorimetric method. PDCANs values range from $0,3 \ \mu g. \Gamma^1$ to $10,6 \ \mu g. \Gamma^1$ according to the DCO value between 3,5 to 9,8 mg. Γ^1 . It was found, that seasonal variations occurs in PDCANs. The highest values were found on spring and autumn, the smallest in summer.

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A Possibility of Improving of Reservoir Operations with Use of a Long Term Continuous Rainfall - Runoff Simulation.

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One of the actual problems of water management is improving of flood control. In catchments where there is a reservoir or water resources system with retention function, correct reservoir operation can take considerable part in overall flood control efficiency.

The present practice in Czech Republic for determining operational rules for a specific reservoir is to develop (or obtain from Czech Hydrometeorological Institute) a theoretical (or mostly theoretical) design flood and derive the rules with respect to this flood. Thereby derived rules are generally applied to all incoming floods in real time situations (of course according to hydrometeorological forecast, which is essential in flood control).

In our work, the possibility of improving of reservoir operations was investigated. Generally, there could be more than one proper set of operational rules with respect to flood characteristics – magnitude (culmination, volume) or type (precipitation, snowmelt or both). To evaluate this, it is needed to create a set of various floods. In our study, this set was created by means of continuous simulation of inflows to the Lipno I reservoir with use of the calibrated hydrological model Aqualog and a stochastic weather generator. It has been shown, that for this particular catchment (950 km²) precipitation and temperature time series can be generated uniformly for whole basin as a single site and also three – hour rainfall average values can be generated instead of hourly ones [1]. Generated weather time series were used as the input to the hydrological model and the inflows to the Lipno I reservoir was desired result. The final time series of the inflows is one thousand years long with hourly time interval.

In the next step, a set of synthetic floods was chosen from the final time series. The set consists of groups of floods whose culminations approximately equal to return period of five to thousand years. The floods in each group were sorted to cumulative distribution function (CDF) according to their volume and finally, every group consists of four (where possible) floods with values of CDF equal to 5 %, 50 %, 75 % and 95 %.

The set of chosen floods, which contains twenty five floods (including the observed August 2002 flood whose culmination return period is approximately five hundred years), were routed through Lipno I reservoir. In this particular case, flood routing rules obeyed presently valid handling regulations of Lipno I reservoir (with the value of non – damaging release and the volume of flood control storage given). Four scenarios simulated various measure of hypothetical hydrometeorological forecast, with practically no forecast in scenario V0 and the greatest one in scenario V3 – here discharging of non – damaging release begins six hours before main causal rainfall in case of precipitation floods and one day before thaw in case of winter floods. Additionally, scenarios V4 and V5 represented theoretical simulations of how high the water level would rise if non-damaging release were maintained, even after the maximum allowed level was reached. During rising limb of flood hydrograph, in scenario V4 operational rules obey V0 and V5 obey scenario V3 respectively. Table 1 shows summary of flood routing in scenario V0, V3, V4 and V5 together with some of

synthetics floods characteristics. Flood control storage in winter is about three times greater than in summer (33 vs. 12 million m^3) and the "S" column in table denotes this.

Sce	nario:				V0			V3			V4		V5	
i		S	Im	V ₉₂	H _m	Om	ΣV_{92}	H _m	Om	ΣV_{92}	H _m	t	H _m	t
9	Q ₂₀	S	204	6,3	725,53	92	0							
10		S	236	9,9	725,59	92	0							
11		S	210	13	725,60	165	2,0	725,51	92	0	725,64	46		
12		W	238	18,3	725,47	92	0							
13	Q ₅₀	S	291	11,9	725,60	165	1,1	725,53	92	0	725,62	16		
14		S	300	14,8	725,60	258	5,1	725,60	92	0	725,70	57		
15		S	307	15,9	725,60	297	8,2	725,60	219	3,2	725,77	88	725,66	45
16		W	280	29,3	725,60	121	1,5	725,41	92	0	725,63	68		
17	Q ₁₀₀	S	330	16,2	725,60	273	5,5	725,60	211	2,7	725,71	59	725,65	35
18		S	332	18,2	725,60	304	7,8	725,60	183	1,6	725,76	78	725,63	28
19		W	371	20	725,38	92	0							
20		W	330	41,5	725,60	316	15,4	725,60	192	5,1	725,92	>170	725,70	146
21	Q ₅₀₀	S	542	31,2	725,65	418	20,6	725,62	415	16,5	726,01	126	725,93	106
22		W	532	65,9	725,67	420	36,2	725,62	415	20,2	726,32	>170	726,00	165
23	2002	S	470	67,1	725,61	414	50	725,61	414	45,2	726,57	>170	726,49	>170
24	Q ₁₀₀₀	W	653	37,8	725,60	311	6,4	725,60	235	3,6	725,73	87	725,68	68
25		S	656	40,5	725,70	424	29,7	725,68	421	27,0	726,19	>170	726,14	>170

Table 1: Summary of flood routing of synthetics floods by Lipno I reservoir.

Legend: V0 – V5...scenario of reservoir operation, S...season (S – summer, W – winter), I_{max} [m³/s]...maximum inflow to the reservoir, V_{92} [10⁶ m³]...volume of flood above non – damaging release O_{NEŠ,2} = 92 m³/s, H_{max} [m M.S.L]...maximum reached water level, O_{max} [m³/s]...maximum outflow from the reservoir, ΣV_{92} [10⁶ m³]...volume of outflow greater than non-damaging release O_{NEŠ,2} = 92 m³/s, *t* [hrs]... duration of overrun of maximum water level at scenario V4, V5.

Even in this case, with the values of the non – damaging release and the flood control storage given, there could be more than one proper general operational rules. For floods whose volumes just little exceed the flood control storage of the reservoir, the results suggest that a sufficiently long and quality hydrometeorological forecast can significantly affect the maximum outflow from the reservoir. Additionally, theoretical scenarios V4, V5 show the possibility of temporarily overrun of maximum allowed water level and thus enable non – exceeding of non – damaging release. On the contrary, when routing floods with volumes much greater than the flood control storage, the reservoir can be used just for gaining time for preparing downstream area for incoming disaster.

The methodology of continuous simulation provides us a promising tool for further research, and not only for reservoir operations improvement, but for various number of other water management application.

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Design Approach for Helicoidal Stair Slabs

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The helicoidal stair is increasingly getting popular among architects because of its elegant appearance. However, the analysis and design of helicoidal stair slabs are more difficult because of their complex geometric configurations. The degree of difficulty is further enhanced when an intermediate landing is introduced within a helicoidal slab. While design charts for simple helicoidal stairs are available in literature, no such aids are found for helicoidal stairs with intermediate landing. This necessitates the development of a simple design chart and design procedure for this type of structural members.

In addition to its own weight, the helicoidal star slab is subjected to live load. In this work the dead and live load are considered uniformly distributed over the entire surface on the horizontal projection of the stair. The stair slab considered here is fixed at its ends in all directions. Helicoidal slab, being a space structure, has six stress resultants at any cross section (vertical moment M_{ν} , lateral moment M_h , torsion T, thrust N, lateral shear force V_h and radial horizontal shear force V_h).

To facilitate the analysis procedure, the following assumptions have been: (the material is elastic, homogeneous and isotropic, deformation due to shear and direct forces, being small in comparison to the deformations caused by twisting and bending moments, are neglected, the bending and torsional stiffness of a section of helicoidal slab may be defined by that of a straight prismatic member, the cross section is symmetric about the two principal axis of the section).

Because of symmetry in geometry and loading, four of the six redundants at the mid span of a helicoidal stair slab with intermediate landing become zero. Only two, vertical moment (M) and radial horizontal shear (H) remain to be calculated. The equations for the landing are same as those suggested by Morgan [1], with the slope of the helix $\alpha = 0$. At the end of the landing section the stress resultants are found by replacing θ by Φ . Using these resultants at the end of the landing, the stress resultants for a section along the upper half of the flight are defined as ($\theta = 0$ at the beginning of the flight and increases going upward):

$$M_{\rm V} = M \cos(\theta + \phi) - (g + q)R_1^2 [1 - \cos(\theta + \phi)] + HR_2\theta \, tg\alpha \sin(\theta + \phi)$$

$$\begin{split} M_{h} &= M \sin\alpha \sin(\theta + \phi) - HR_{2} \cos\alpha \sin(\theta + \phi) - HR_{2}\theta \sin\alpha tg\alpha \cos(\theta + \phi) + \\ & (g+q)R_{1}^{2} \sin\alpha \sin(\theta + \phi) - (g+q)R_{1}R_{2} (\theta + \phi) \sin\alpha \end{split}$$

$$\begin{split} T = M \cos \alpha \sin(\theta + \phi) + H R_2 \sin \alpha \sin(\theta + \phi) - H R_2 \theta \sin \alpha \cos(\theta + \phi) + \\ (g + q) R_1^2 \cos \alpha \sin(\theta + \phi) - (g + q) R_1 R_2 (\theta + \phi) \cos \alpha \end{split}$$

 $V_h = H \cos(\theta + \phi)$

$$V_{V} = (g + q)R_{1}(\theta + \phi)\cos\alpha - H\sin\alpha\sin(\theta + \phi)$$

N = -H sin(\theta + \phi)cos \alpha - (g + q)R_{1}(\theta + \phi)sin\alpha

Castigliano's Second theorem states that, the first partial derivative of the strain energy with respect to any particular force is equal to the displacement of the point of application of that force in the direction of its line of action. Mathematically expressing, $\partial W / \partial P = \delta$, where W is 676

the strain energy, P is the force, and δ is the deflection in the direction of force. The partial derivative of the strain energy function of the helicoidal stair slab with a landing at mid span with respect to V_h is,

$$\frac{\partial W}{V_{h}} = \int_{0}^{\phi} M_{v} \frac{\partial M_{v}}{\partial V_{h}} ds + z_{1} \int_{0}^{\phi} M_{h} \frac{\partial M_{h}}{\partial V_{h}} + z_{2} \int_{0}^{\phi} T \frac{\partial T}{\partial V_{h}} ds + \int_{0}^{\beta} M_{v} \frac{\partial M_{v}}{V_{h}} ds + z_{1} \int_{0}^{\beta} M_{h} \frac{\partial M_{h}}{\partial V_{h}} + z_{2} \int_{0}^{\phi} T \frac{\partial T}{\partial V_{h}} ds = 0$$
$$\frac{\partial W}{M_{h}} = \int_{0}^{\phi} M_{v} \frac{\partial M_{v}}{\partial M_{h}} ds + z_{1} \int_{0}^{\phi} M_{h} \frac{\partial M_{h}}{\partial M_{h}} + z_{2} \int_{0}^{\phi} T \frac{\partial T}{\partial M_{h}} ds + \int_{0}^{\beta} M_{v} \frac{\partial M_{v}}{M_{h}} ds + z_{1} \int_{0}^{\beta} M_{h} \frac{\partial M_{h}}{\partial M_{h}} + z_{2} \int_{0}^{\phi} T \frac{\partial T}{\partial M_{h}} ds = 0$$

EI/EI_h = $z_1 = (h/b)^2$, EI/GI_k = z_2 , for the landing ds=R₂d θ and for the flight ds=R₂d θ /cos α

Simultaneous solution of these two equations yield the values of $M_h a V_h$, which can be expressed in the form of: $M_h = k_1(g+q)R_2^2$ and $M_h = k_2(g+q)R_2^2$, k_1 and k_2 depend on geometric and elastic properties of the section. Once the forces are determined, equations can be used to determine the six stress resultants at any section of the helicoidal stair slab. However, derivation of equations requires tedious mathematical computations. To facilitate the design procedure a series of design charts have been proposed. The charts provide the values of k_1 and k_2 for following range of parameters: (width to thickness ratio b/h 10 and 15, total central angle subtended by the stair $\theta_f = 135^0-360^0$, slope of the tangent helix centre line with respect to the horizontal plane $\alpha = 20^0-35^0$, ratio of radius of the centre line of load to the mean radius of the stair $R_1/R_2 = 1.00$, 1.05, 1.10, total angle subtended by the landing $2\phi = 10^0-70^0$).

The vertical moment at the support often becomes the critical design criteria for helicoidal stair slabs. Therefore a third coefficient k_3 has been introduced, where $M_{pod} = k_3(g+q)R_2^2$. The values of k_3 are also presented in the proposed design charts. Like helicoidal stair slabs without landings, $k_1 a k_3$ are not sensitive to the stair slope, but k_2 is.

Parametric study results the effect of landing on various stress resultants for a 180⁰ stair. Only landing angle has been changed, keeping all other geometric parameters constant. All the stress resultants, but vertical shear, increase with increase in landing span, but in differing proportions. The landing has a significant impact on design vertical moment and torsion while its influence on the maximum values of lateral moment, radial horizontal shear, vertical shear and thrust is subtle. The local effect near the landing region is pronounced for vertical moment, torsion and vertical shear.

Based on the strain energy principle, a simple design chart has been proposed for design of helicoidal stair slabs with a landing at mid span. The chart makes use of various geometric parameters to determine two mid span redundants, which can then be used to find stress resultants at any section. It is expected that the use of the charts would expedite the design process. Parametric study reveals that the presence of landing increases the design vertical moment and torsion significantly, while its influence on the maximum values of other stress resultants can be neglected. The local effects on the vertical moment, torsion and vertical shear are also very important when a landing is present.

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Section 14

ARCHITECTURE, TOWN PLANNING, GEODESY, CARTOGRAPHY

Freestanding Hospice as a Specific Kind of Social Buildings

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This project proves was part of thesis named "Social and Economical Aspects of Inpatient Units Hospice Typology". In this particular part is main focus put on a certain relationship between a built environment and specific user needs. Building and environment attributes are analysed mainly from the view of possible benefit for life quality of users with handicap.[1]

The project further responses to the contemporary tendencies of a demographic development (in the Czech Republic and also in Europe), tendencies of increasing tasks for environment quality and sustainable development too.

A case study in this project is focused on inpatient hospice units, which have very specific purpose and also they have very humanized philosophy for primary users – terminally ill patients. Theory and general principles could be used analogically for some close building types too. Solutions for environment adaptability, regarding sensory, kinetic or cognitive failures, are applicable also in a wider typological scale.

After a confrontation with theory and practical investigation, I found out certain deficiency, which occur often in the buildings for elderly, ill or handicapped people. This deficit is often caused by insufficient knowledge of specific user needs or ignoring them. Some building are also purseless of technical details or interior settlement.

In this point, I see a great potential, how to rehabilitate this situation and conform to building details or interior to have certain compensative characteristic for users with sensorial, kinetic and kognitive problems.[2]

If the basic understanding of a man as a complex being and individual is not included, the suite of knowledges about structure and architecture is not compact. The level of building culture and care about environment depends on many agents, mainly politics, economy, social and cultural maturity of a certain state.

The form of environment and architecture could not be overlooked, in the point of view of possible benefit, because it has direct or indirect effect on us. The environment quality is possible to evaluate, from the viewpoint how it satisfied complex user needs.

For the further development of quality environment designing, is necessary to be concerned with particular needs and tasks, which are demand by individual users. In the certain cases, there are some special needs so specific, that compromis is necessary, the it would be impossible to put all tasks in one environment. [3] There will be need for compromis, which could be used in some environment, not to forbid or complicate common usage.

Further, there is also need to pecify particular inter-disciplinar knowledges about sensorial perceiving, kinetic and intellectual possible capacities in the consequence to the relationship to environment and then those knowledges apply to built structures and law.

There is also need to think about contemporary form and building structure, which have a relation to the forthcoming demographic change. There should be dine some suitable steps to the maximal adaptability and flexibility of environment, which can copy a development of human being and there should be a stres put on creating of natural environment too.

From the viewpoint of built environment, there should be strengthen also some fields of education of technical profession, and most of all the knowledge of general theory of human needs and its consequences for buildings, also knowledge of specific needs handicapped people, the perceiving of space, materials, colors etc.

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A Baroque Landscape Composition and Taking Advantage of Its Potential in Current Regional Planning

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In the region west by south from town Jičín were preserved unique fragments of baroque landscape, known as "A Marian Garden". This landscape composition was realised in the first half of 18th century by count František Josef Schlik. There is no doubt that it is a significant cultural heritage of a region. The question is, how to incorporate and use that historical compositions in current regional, urban and landscape planning. For research work six villages from this region were chosen - Bukvice, Drahoraz, Chyjice, Kostelec, Ohaveč and Staré Místo, as an example for potential development of region with due regard to preserved historical components, broader relations, cooperation in region and landscape ecology.

At first it was essential to make a detailed field survey – by foot or by bike, not only of these six villages, but of broader region. Above all, I was interested in old ways, but also I detected old lines of view, troughviews and of places with an exceptional view. Furtermore I documented small monuments in the landscape, public places in villages and popular architecture. On the basis of obtained data I proposed a new system of ways, designed for everyday but also recreational pedestrian and bicycle transportation.

In every of six studied villages I identified some significant and interesting objects, that should be noticed and incorporated to the system of ways. Ways were proposed with due regard to other routes and villages in the region (for that it was really important to have cognizance of whole the region). Every route that I proposed is designed for pedestrians and bicycles, also it must be available for baby-coaches. In some cases ways can be used by agricultural machines. The surface of ways should be consolidated and stony, in no case asphaltic.

Bukvice

Bukvice is a small village, approximately in the centre of studied region – so called Marian Garden. Village Bukvice had once responsible position on the pilgrimage routes via neighbouring Loreta chapel. Also nowadays renewed processions start in this village. In Bukvice I was in particular interested in restoration and building of connections via village Chyjice and visual connection with church in Chyjice. Connection from village Chyjice through village Bukvice to chapel Loreta should become a part of broader system of touristic routes in the region.

Drahoraz

Drahoraz is a small village near to town Kopidlno, in the south part of studied region. Nowadays, it is accessible only by road in the direction north-south, every other connections were destroyed. In historical and current air maps and also by field survey there were identified some destroyed old ways, that should be renewed. One from them was probably an important trading or military way to Jičín. Then I proposed a restoration of connection in the direction west-east in the route of one of historical ways. Moreover I proposed a new way on the horizon – on the ridge above village, that offers a beautiful view to the surroundings. This way should become a part of broader system of touristic routes in the region.

Chyjice

Chyjice is a village in a deep valley of a little river Mrlina. The most expressive point of that village is a church of St. Simon and Juda. It is a very viewable dominant, that can be seen from distance of many kilometers. Moreover, it is involved in some lines of view. In the surroundings of the village there were found two hillocks with significants views. These points should be noticed and take a part in the system of touristic routes in the region. Also, as a part of that system, I proposed a restoration of a historical way in a baroque line of view involving church in Dolany and tower of castle in Jičíněves.

Kostelec

Kostelec is a small village in the west of studied region. Nowadays it is out of every important routes. Once it was situated on an important trading route. In the village I found some interesting but forgotten buildings: a church with Renaissance tombstones, a fountain and a statue of Virgin Mary. On the ridge above Kostelec, there is a way to Chyjice in a line of view with tho church in Chyjice. This way should become a part of broader system of touristic routes in the region. Then I proposed a new connection with village Jičíněves. This route should be used by local people for everyday ways to school and work (in Jičíněves there is a train station). Moreover I noticed a line of view towards the castle in Jičíněves.

Ohaveč

Ohaveč is a small village in the north of studied region. It is situated almost in the neighbourhood of Prachovské skály, a very touristic attractive area. In the south of Ohaveč there is a way, that could be involved in a broader system of touristic routes in the region, as a connection of Jičín and a pilgrimage place – chapel of St. Ann. I proposed a restoration of that way, but also some safety improvements on a very frequented road in the north of the village.

Staré Místo

Staré Místo is nowadays a small village near from Jičín, in the east of studied region. Staré Místo was probably original centre of settlement, that was later moved a few kilometres to the north and town Jičín was founded. In the village Staré Místo once was a great service yard, up to this day there are some residues of its buildings. In the village I identified two historical ways, the first one goes to Čejkovice, then to Jičín. The second one goes on the ridge from Staré Místo to Veliš. These two ways should be restorated as a part of system of touristic routes in the region. The way along the ridge offers beautiful views to the landscape. There is a lot of small monuments concentrated. Moreover I proposed some safety improvements on a very frequented road going through the village.

The most important part of my work was to detect forgotten baroque and older components in the region, to propose their current accessing and utilisation, almost by restoration of old ways. This research will be used especially for a project of broader system of ways in the region, but also as one of backgrounds for planning of development of local settlement. Documentation was also important, especially surveying of old ways, small monuments, lines of view and places with exceptional view. Moreover, I worked a lot with historical maps (from 19th century) and current air maps. My work should contribute to better understanding of cultural heritage of baroque landscape not only in studied region, but, as I hope, also in general.

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Research into Public Funding in Support of Countryside Renewal

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At the present time, most settlements in the Czech Republic do not have much capacity to finance themselves, to provide a minimum level of growth or to maintain and reconstruct objects and equipment in their ownership. If they are trying, in accordance with the theory of "sustainable development", to manage future growth in areas of "brownfields", it is impossible to finance this process from their own funds. Possibilities for the use of brownfield sites have been indicated in a few publications [1, 2]. This process we can describe as "countryside renewal". We can define this idea as the restoration of the countryside, care about the countryside, development of business and social services in provincial regions, the recovery of cultural traditions and the comprehensive development of attractive Czech countryside. Almost all small villages are dependent on finance through the state budget. By virtue of this project was to gather maximum information about the process of getting grants from different funds. The main emphasis was given to the opinion of the mayors in small villages. All of this information will be used as entry data for subsequent landscape research in selected villages.

To research the support of countryside renewal from public funds the Usti Region was selected. This area was selected as an example of one of the fourteen administrative units in the Czech Republic. At the beginning of research there was recorded in the territory of the region a whole 354 settlements. 46 of them had the status of a town. In accordance with the aim of researching into small settlements, there was selected villages and towns with under 5000 inhabitants. This criterion was selected by reason of capital rationing to village budgets based on the number of occupants in a settlement. This criterion was satisfied by 328 settlements in the Usti region.

In getting the results of research the printed form was selected. Thus an address book was created with printed forms sent to mayors of selected villages and towns in the region. This process was financed by the Czech technical university internal grant No.CTU0601111. Of 328 forms sent there was returned 170 (almost 52%). We can consider this response rate a success because of this selected method of research and pressure of time.

Printed forms, which were sent to municipal offices, included many different questions. We can divide these questions into four basic categories, which are described in more detail in the following sections.

The first category of questions was aimed at getting statistical information about settlements. This information will be used for detailed analysis in subsequent landscape research, which will be connected to this grant. These questions concerned the number of occupants, the number of cadastral territories, the dimensions of the territory and the main sources of access to the village budget.

The second group of questions was directed at facts which directly or indirectly influence the process of getting grants and the success of villages and towns in the application process. Primarily these concerned the number of years in office (mayor), the quality of computer equipment and internet connection, and the possession of a master plan or urban 684

study. Then there was taken the extent of membership in different microregions and associations and the availability of grants through this membership.

The third category of questions pursued the process of getting grants and the success of villages in the application process. The main part of this category was created by the following questions: Did you ask for any grant in the last four years (2002-2005)? If yes, from which source (Europe Union, Ministry, Region, etc.)? In line with these questions there was asked the degree of success in each case, and the volume of their financial participation in these projects. Then there was sought knowledge about grants which had been publicised by the regional authority of the Ústí region in year 2006 and if they had applied for these grants. Next the projects which were realized from grants finances in the last four years was requested. Also asked was the importance of this realized project for villages and towns. The next question was aimed at the actual problems in villages and towns when they cannot finance projects from their own resources. After that it was asked who is working on administration connected with the grant process (mayor or anybody from the council, municipal office, special firm, etc.). Then information about knowledge regarding getting grants from the Europe Union and about the possibility of getting grants "for the countryside" was sought.

The last group of questions was aimed at the subjective opinion of mayors and councilors on the process and form of distributing grants. In this part their opinion was sought as to any slowness in the process of distributing grants, too many forms for, and supplements to, grant applications, or if they lack a summary of grants offered (special "internet grants pages") and if they agree with a yearly specification of grants which has been offered by Ústí region.

In addition to these exactly defined questions, a space was allocated for mayors to give their own opinion of the process of getting finance from different funds. They are then given a place to describe their ideas for improving the chances of villages to get better and more efficient grants. They could then propose adjustments which could be used to eliminate the difference between small villages and big towns. Finally, they could propose adjustments which assured transparency in an accelerated process for getting grants.

The returned printed forms were put in the new database. With this database we can do a detailed analysis for this research. All of this information will be used as entry data for follow-on landscape research in selected typical villages and towns. This will be used as a source of information for a complete classification of the situation in the process of getting finance directed at small settlements under 5 000 inhabitants. All of this data will be used in my doctoral thesis which is concerned with countryside renewal.

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Identification of Top Medieval Rural Urban Structures Near Town Rakovnik

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One of characteristic features of a considerable number of historical villages in the Czech lands is regular order of their ground plans. In these villages, peasant estates are either centered around green, usually of oblong shape, or their allotment is arranged into shorter or longer sections. These were mainly placed on the opposite banks of sources of water – springs or brooks. The regular ground plans usually are connected with the peak period of medieval reorganization of the agricultural economy and of legal relations between authorities and retainers. This change in the organization of older ones was realized in the Czech lands from the mid-13th century through the 14th century.

Although the ground plans of medieval villages understandably changed somewhat during following centuries, their medieval disposition was substantially preserved. The plans are easily recognized on the oldest set of exactly measured and sufficiently detailed maps in land registers. The maps were acquired officially for all Czech lands in the first half of $19^{\rm th}$ century, mainly during the second quarter of that century. Already in the past, typological, chronological and regional connections concerning the medieval ground plans were researched. Nevertheless, an attempt to recognize the principles of their rational measurement had not yet been made to identify the ground module – the width of allotments – in the measures of that time.

To analyze the measures, a group of ground plans of villages situated near town Rakovnik in the Central Bohemia was chosen. The group is distinguished by extraordinary great, regularly oblong greens, similar to the Rakovník main square. The ground plans of these villages (newly founded or recognized older villages) are usually supposed, according to historical sources, to have originated in the first half of the 14th century. The research succeeded in discovering the ground plans (schemes): the unit of measurement was doubtless the width of lot. This value was re – counted into units of measured used in the peak period of Middle Ages so – called Prague ell (i.e. cca 60 cm). The ells were used in bigger multiples during measuring, with the application usually in ternary or duodecimal multiples.

Whether the analyzed structure of ground plans, mediated by rather young maps, really originated in the peak medieval period was verified on the ground plans of medieval origin by examining medieval villages destroyed shortly after their founding and discovered later by archaeological research. These villages (in fact were studied maps of destructions of villages Svídna, Mstěnice and Pfaffenschlag), with evident regular plans were analyzed. The analysis came substantially the same results as in the case of the ground plans of medieval villages mediated by maps in land registers.

The width of lot is equaled module or his fraction. It shows to different social level of the inhabitants in village. If some particular differences from module system appeared, measurement of longer part proved that module system was used in global and local parts (lots) were measured later, may be their width was only guessed. Prove of existence of module systems of destroyed high middle age villages in different part of Czech lands

endorsed us systems founded on base of maps in land register come really from high Middle Ages.

The factor of social difference was projected to ideal founding schemes - which were gathered on base of maps in land register, the basic module (width of lot very often repeated in ground plan of village) is simply repeated in ground plan of village - and probably founding schemes rose. Lots of fracture of basic module value appears in their structure. Working out scheme accepts more the allotments according to the map in land register.

Documents from regional archive in Rakovnik don't indicate that the urban scheme of chosen group of villages was lately dramatically changed in their central historical part. Of course, particularly the borders of lot between neighbours changed and the green was built out of small houses. But the concept of urban scheme stayed intact till the 60's of the last century. In the middle 20th century was changed the system of agriculture and that was the reason why the medieval urban structure came out of practise. The long medieval lots were divided into the smaller squared parts irrespective of medieval urban module system.

The number of acres, which were given each village at its foundation, is known for some villages of chosen group near town Rakovnik. Thanks to the knowledge of number of acres was possible to work out the real founding scheme of village. It seems the width of lot is equalled to the value of basic module.

The knowledge of these modules of lots may explain methods used by medieval locators and may help us with evaluation of historical centers of villages. Used module system is still readable in allotments of historical centers of villages and that is why we should protect it as a cultural heritage of our ancestors.

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Testing of Automatization of the Laser Calibration System Renishaw ML10 for Comparation and Vibration Measurement

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In Czech Republic, there is the problem of calibration and control of distance measurement or digital levels solved mainly by means of laser interferometer. For example, in metrological laboratory of Research Institute of Geodesy, Topography and Cartography (VÚGTK), there is done the comparation of level staffs by using laser interferometer, but the comparator do not support system calibration of digital levels (parallel measurement of digital level and laser interferometer). At VSB-TU Ostrava there is laser interferometer used as length etalon for comparation of level staffs and for testing of distance measurements. This interferometer (Renishaw ML10) has still hidden reserves even by application of online measuring and monitoring of micrometrical changes of position in real time. Limits of the device sequent of using of the original software, which do not fill demands for possibility of online measuring and it was needed to innovate the software.

Main aim of the project was the development of universal software for control of the laser interferometer Renishaw ML10 and modifying this software for possibility of vibration measurement and distributing data in real time. Next goal was to applicate this software for system calibration of digital levels and herewith automates the comparator, which is under construction in laboratory of Department of Advanced Geodesy.

Structure of realization of the project:

- new interface DX10 connection of the laser interferometer with PC
- driver for DX10 data flow between USB and TCP
- software for reaching data form TCP online measuring and control
- testing of the updated device parallel measuring with the same instrument

The first step of innovation of the work with laser interferometer was physical change of interface, which arranges data flow between the device and PC. Old PCI card, which does not support direct and open access to data and which can be used only in standard case of computer (no notebook), was replaced by USB interface DX10. This interface is produced by the same manufacturer as the interferometer. This accessory is supplied with .dll library of supported functions.

Because of complication of the USB port communication protocol, it was necessary to write brand new driver for the interface in C++. PhD Student from Department of Advanced Geodesy, Ing. Jiří Matoušek, programmed this driver as independent running program – local server. It is possible to communicate with this program trough TCP protocol on the implicitly defined port. This short program is for the project very helpful, to reach the data from it is now easy by TCP.

Brand new control software for the laser interferometer was developed by PhD student from the Department of Advanced Geodesy Ing. Zdeněk Vyskočil similar in Matlab and LabView. The structure of the program will not be shown in this paper; the program is complied to .exe file. It allows fluent control of laser signal and measuring of relative distance.

New software was tested by parallel measurement of two same devices Renishaw ML10. In metrological laboratory at VSB-TU Ostrava, with cooperation with Institute of Geodesy and Mining Surveying, there were tested two instruments. Differences between measured lengths are in micrometer rank.

Conclusion

New software for laser interferometer measurement was written and tested. It is still in developing process of modification for non-standard measuring tasks.

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Application of Remote Sensing and GIS for Change Detection from Various Data Type of Remote Sensing

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Many changes can be detected in surrounding environment. Various different approaches for changes detection are used in practice. Remote sensing is one of the most popular methods for land use/land cover changes detection. The changes were classified into several categories according to the theme, frequency of changes, data source, and applied method of remote sensing. To complete this purpose many technical information sources and papers describing different case studies from all around the world in last ten years were studied. The resulting output was also used for the temporal change detection monitored and calculated from the SPOT satellite images. Several map algebra methods and image classification methods in the region along the highway connecting Prague and the northern Bohemia were tested.

A complex overview and summary of existing change detection techniques and methods were created and used to distinguish variety of Earth's surface objects and features and their temporal changes. The evaluation of feasibility of applying different remote data sources and remote sensing methods for land use (land cover) change detention was encompassed.

Common attributes of thematically groups of changes were evaluated, the research also focused on outputs and using the GIS tools. The results showed that approximately only one fifth of studied projects were worked out with the GIS tool support with results in the vector format. From the above mentioned results we can estimate that GIS tools represent a significant part of the remote sensing data evaluation process in the temporary change detection. The results of remote sensing are only a part of the wide information collecting process.

The combination of GIS tools and remote sensing methods was used in the testing area. The GIS tool was used for the two time level CORINE data, where changes were determined from overlaid areas. The result of the GIS analysis was the first data selection survey, serving for other selection of more detailed remote sensing SPOT data for the region along the highway connecting Prague and the northern Bohemia, where the changes in land use area are significant. SPOT data for this area were ordered (first image from the year 1992, second from 1996 and third from 2005).

Several change detection methods were tested in PCI Geomatics software, which is specifically focused on the processing and analysis of the remote sensing data. PCI Geomatics was primarily used for the pre-processing of the satellite images. Remote sensing data received from satellite platforms in their raw form generally contain flaws or deficiencies. Although basic corrections are carried out at the ground receiving station, in most cases further pre-processing by the user is still necessary. Suitable pre-processing techniques are particularly important when multitemporal image sets are used. Most obviously, a geometric

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correction and proper image registration has to be carried out in order to ensure that the objects of interests in multitemporal imagery are spatially matching. To perform accurate change detection, it is necessary to be certain that the images are spectrally comparable. Scene-dependent variables, such as varying atmospheric conditions, illumination angles and sensor calibration coefficients could principally render multitemporal data incomparable if they are not included in the calculation. In the research, the SPOT scenes had to be geo-corrected and co-registered to ancillary spatial data in vector format – ZABAGED in the scale 1:10 000. The coordinate system S-JTSK was chosen as the target coordinate system. Atmospheric correction was performed according to [4]. The pre-processed data were later used for testing of change detection methods. The results were compared with the results of the technical information sources study.

Generally the methods for the change detection can be divided into two main groups (preclassification methods and post-classification methods) where both of them are being used approximately equally in practice. The first group of methods is focused mostly on the changes in the risk areas (flood, land slide, fire, etc.), the second group of method is focused on general land cover changes. Eventually there might be also the third group of methods based on the mathematical models, but this group of methods is being used only in approx. 5% of the projects in practice.

The most used change detection method is the post classification comparison (using exactly maximum likelihood classification method, image substation method, image dividing method and principal component analysis).

Concerning the used data sources, the changes were mostly detected in the Landsat data (approx. 2/3 of all cases in practice). SAR data were also very frequently used for change detection (mostly for changes in the surface water, risk areas and global and climate changes). As a supporting data, aerial photographs, historical topographical, thematic maps and ground truth data, digital elevation models and GIS were used in all thematic groups except the global and climate changes. The supporting data were mostly useful for land use/land cover changes and then for surface water changes.

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Georeferencing of Historical Military Mappings and Later Map Internet Publishing

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Old maps are valuable source of information about our landscape. It is very important to make these data accessible for as many experts as we can. There are some possibilities how to do that. It has been published [1], that the best way how to make this data more accessible, is to scan original maps, georeference them and publish them within the frame of web map services. I am interested in this field of study for 3 years. I would like to present results of my work in every part of this process.

In the beginning there must be data. If I am talking about old maps from the area of Czech republic, I am focused on historical military mappings of Austria-Hungarian Empire. Older maps are not suitable for georeferencing, because of their scale and preciseness. Historical military mappings were created for the whole empire in 18th and 19th century.

1st military mapping was first systematic geodetic survey in Austria-Hungarian Empire. It was done in the Czech lands in 1764-1768. The scale of maps is 1 : 28 800. Unfortunately, graphical base for these maps were enlargements of older Müller maps, no geodetic measurement was done. Therefore, maps are very imprecise. I was trying to georeference these maps using some identical points on the map. The result was similar to other research done [2]. The positional accuracy of these maps is about hundreds meters (from 200m to 1000m depending on map sheet).

2nd military mapping was done in the Czech lands in 1819-1858. The mapping has been preceded by trigonometric measurement for cadastral survey. Therefore, these maps are much more precise than 1st military mapping. For the area of Czech republic, 2 coordinate systems were used (11 for the whole empire). The scale of maps is 1 : 28 800. In every coordinate system every map has round coordinates of corners of map sheet. If we found transformation of these coordinates to some contemporary system, we can easily georeference these maps and then compare them with other contemporary data. Transformations from coordinate systems used in Austria-Hungarian Empire to contemporary coordinate system S-JTSK was invented by doc. Čada from West Bohemian University in Pilsen. 2nd military mapping is main dataset I used within the frame of my research.

 3^{rd} military mapping was done in Czech lands in 1870-1883. The scale of maps is 1:25 000. Unfortunately, these maps are not scanned yet, because of many map sheets missing. I hope, maps will be found and I will be able to continue my research on these maps.

Back to 2nd military mapping. If I wanted to georeference maps to contemporary system I had to compute coordinates of corners of map sheets. In my first dataset, I used S-JTSK coordinates computed by doc. Čada. In my second dataset, I transformed corners to UTM (Universal Transverse Mercator projection, zone N33). Transformation was done using PROJ.4, open source transformation software.

Coordinates of corners of map sheets were imported into KOKES geodetic software. This software was chosen from variety of possible software due to high speed of transformation. Then every scanned map was opened and transformed to corner coordinates. There are many types of transformation of raster data. After initial testing phase, I decided for 692

projective transformation. This transformation is non-residual for 4 points and so rasters are precisely placed. Very difficult is to find exact position of corner on the map. 150 years old maps are destructed specially in corner areas. For right transformation key, affinity was tested. The error of affine transformation for map sheets was maximally 30 meters. After transformation of every map sheet, the data was prepared for later internet publishing. From the native format of KOKES (BMP) was data transformed to TIFF format. This format was chosen for possibility of transparency of saved raster. LZW compression was used for reducing data amount.

If we have prepared rasters in one coordinate system, we can publish them on the Internet. The best way how to do that is WMS service. WMS is web service defined by OGC (Open GIS Consortium). Using this service, georeferenced raster data can be published on the Internet. For my data publishing, UMN MapServer software was used, because of well WMS implementation. If I wanted to publish such great amount of data as raster data from the whole Czech republic I had to increase the speed of MapServer WMS reply. For every map sheet I created pyramids (overviews) in 9 scales. Using this method, only needed overviews can be sent. The second method of increasing is to index the data. Native indexing of MapServer was used – tileindexing. Rasters are indexed as tiles by shapefile (SHP) vector file. After these improvements, data are distributed by WMS in acceptable speed.

In this moment, two raster datasets are distributed through WMS: Bohemia (originally in Gusterberg coordinate system) and Moravia (originally in St. Stephan coordinate system). Both parts are distributed in UTM coordinate system. Very interesting part of research is to join these datasets into one. There is need to mask the Bohemia-Moravian boundary and then the whole area of Czech republic can be distributed together. I am working on that now.

The other possibility of old maps publishing is web application, where anyone can view the data. This application was created and is being improved. It is based on UMN MapServer CGI application. Web page contains standard mapserver features as zoom or pan. These features are based on JavaScript library msCross. Other JavaScript functions enable interactive coordinate displaying. The newest improvement is possibility of zooming to any village or town in Czech republic. The database of all villages in the country was created in the relational database PostgreSQL. On the web page AJAX (Asynchronous JavaScript And XML) function connects this database and generates the index of villages after writing some characters into text field. This index contains hypertext links which references to map zoomed to selected village.

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Geodetic Instrument Height Measure

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The short article describes the prototype of new tool for precise measurement of the height of geodetic instruments mounted on tripod or some types of pillars.

Aim and purpose

For some geodetic measurements with higher accuracy requirements (e.g. local 3-D setting-out or monitoring networks) is necessary to determine the exact instrument height. This mean vertical offset of the optical-mechanical centre of the instrument, target or some other special equipment over centre-ground (or pillar) point. The most often used steel tape measure isn't able offer better accuracy then approx. 2 millimetres. Some manufacturers offer rather better solution: tapes with some special hooks, tribrach carriers and/or reading indexes, which allow direct vertical distance point – centre of the instrument mounted on a tripod (e.g. Leica GHT 196, GHM 007). Accuracy is so improved to standard deviation ≤ 1 mm. However, it is still not enough for high precision works as trigonometric levelling or 3-D local or micro-networks. When higher precision is needed, some indirect method of the instrument height determination should be used (e.g. with supplementary field baseline for distance and vertical angle measurement). These methods give good results (approx. 0.3 mm st. dev.) but they are very time consummating and demand extra equipment (such as baseline point fixing bolt, levelling rod).

Design and construction of the new tool

For this purpose, the new simple tool for precision measurement of the instrument was designed at Department of Special Geodesy CTU. The first functional prototype has been manufactured and tested.

The device consists of the two-part steel vertical rod, aluminium or brass tribrach insertion piece (Wild standard or Zeiss tribrach adaptor) and the slide calliper/gauge (precise mechanical engineering depth indicator). The lower part of the first rod (steel pipe) has plane levelling base at the bottom that is in contact with ground-centre point. At the top is bedding/carrier for stable fixing of the second part – the thin rod that passes up through the fixing screw of the tripod and trough the tribrach with inserted adaptor. The assembly of both rods represents the gauge with well-known length. The upper part of second rod overhangs the plane of the tribrach adaptor and this section must be measured using the slide gauge. Then the resultant instrument height is the sum of following: actual length of the rods – slide gauge reading – tribrach adaptor thickness/height + base-geometrical centre of the instrument offset. (At most pillars for forced centering only the tribrach insertion piece and slide gauge can be used.)

The first set of the new instrument height measure has been manufactured in the mechanical workroom of the Dept. of Special Geodesy in 2005. The exact length was calibrated and the thermal expansion coefficient was determined with the length measuring device Zeiss 3m at the Department of Manufacturing Technology at the Faculty of Mechanical Engineering CTU. The rods are made of stainless steel, not of invar, so it's necessary to calculate the thermal expansion for each measurement and the set may not be exposed to

direct sun (calculation with actual air-temperature only). Set includes table of total lengths for variety of temperatures including all corrections and constants for easy computation.

Range and accuracy

Instrument height measurement is possible between approx. 1.1 m to 1.8 m; accuracy better than 0.1 mm (standard deviation) for the average of two separate measurements can be reached.

Results of tests

First prototype was tested by measurement of the research 3-D small network "Mariánská" in Ore Mountains and some imperfections were found. Primarily used material – invar will be better for it's negligible thermal expansion; and the second problem is with dirt silting into the bedding of upper rod. Hopefully it will be possible to construct some more efficient set early.

Conclusion

Described whole new device for geodetic instruments height measurement could be very useful, essential tool for cases mentioned in preface (high precision geodetic height measurement), which are not frequent, but so much the difficult and important.

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Development of Software for Processing Point Clouds

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Laser scanning systems enable contactless determination of 3D coordinates, 3D modelling and visualisation of complicated buildings and constructions, interiors, underground spaces, random terrains etc. with extraordinary speed, accuracy, complexity and safety. Weak point of effective and exact using of scanning systems is up to now software for processing the measured data. Without software, which effectively processes the measured data and enables their analysis including accuracy calculations, is processing inaccurate and its result is problematic. Software that will enable independent processing of products of measuring laser scanning systems is being developed within a grant project.

The programme is developed in object-oriented programming language Borland Delphi. The OpenGL boundary (Open Graphics Library) is used for displaying space, which is a standard specifying a multiplatform boundary (API) for creating applications of computer graphics. A low-level basic object core of programme for administration, displaying and manipulation with points and point clouds is currently being processed. Record of each point contains (beside other data) 3D coordinates X, Y, Z, value of intensity of the accepted signal, colour, and symptom of visibility, symptom of choice. Points are organised into independent named memory spaces (buffers) according to choice of the user. Displays and adjustments run always only in an active buffer. It is possible to load data from different files into separated spaces, to copy and to remove them among them, to create other buffers as suspensory ones for acceleration and more efficient programme work. Data are possible to be loaded into buffers in this development stage from a text file in the form of X Y Z coordinates or in the form of X Y Z coordinates and intensity of the accepted signal. Data can be loaded into the text in the same formats. When loading data into a binary file, not only coordinates and intensity, but also complete features of the point including visibility and information whether the point is chosen are being loaded.

To simplify and increase clarity during work it is in some cases efficient to dye the chosen points with a suitable colour, which the programme enables as well. Colours can be also generated from intensities and from number of points. Other possibility to clarify the situation is to hide unnecessary or impedimental points, which however does not reduce the volume of the processed data. Two selective sets of points are thus available for most basic operations with points: invisible points and chosen points.

Choice of points for further processing is possible in two ways, in a body (Multi mode) and with defined sequence (Single mode). Choice with defined sequence is suitable for carrying out e.g. calculations of transformation key; each point is marked with a cross and a number. It is possible to delete and exchange the points in a special form. After Single mode choice, the individual points are chosen by pressing the left mouse button. Choice in a body is carried out in Multi mode; the chosen points are framed into the choice oblong by pulling with the pressed left mouse button. The points can be also chosen individually by pressing the left mouse button, the already signed point will be demarked by clicking. Demarking will visually differ the point by enlarging.

Simple functions for getting information about the individual points (printout of the sequence number of the point, coordinates and intensity) and information about the point 696
cloud in the active buffer (buffer name, total number of the points, number of the chosen points, number of the visible points, maximum and minimum coordinates in the cloud) will be implemented into the system. Further it is possible to calculate oblique, horizontal length and superelevation, zenith angle and bearing for two marked points.

It is also possible to define several operating settings and display of the programme. It is possible to choose a step in an angle for rotating of view (small, big), a step in length for approximation/distancing (small, big), size of the displayed points, size of the chosen points, colour of the choice oblong. Further it is also possible to choose a maximum distance of the chosen point from the marked point (it is not suitable that it would be necessary to click exactly for marking/demarking one point, but the nearest point is chosen in case that it is not further than the maximum distance). It is also possible to set colour, size of the cross and size of letters for marking points chosen in Single mode. All those settings are saved into the initialisation file.

The presented components implemented into the programme will have to be added with functions that will use up to now prepared graphic and data boundary and enable processing measuring of lasers scanning both in the direction of spacing with geometric primitives, or with their parts, and in the direction of processing based on the triangular network. The further development of the programme supposes implementation of the Virtual Laser Scanner library (VLS [1]) enabling simulating measuring with the laser scanner onto a plain, a sphere, a cylinder, a cone, an elliptical cylinder and an elliptical cone in common position with simulating measuring errors and setting direction of the laser scanner.

An independently developed library of the SPATFIG classes (Spatial Figure, [2]) will be included into the programme. It is a library of classes and functions ensuring orthogonal spacing of geometric primitives in space (2D primitives: a line, a plain, a circle; 3D: a sphere, a cylinder, a pyramid,...) according to the MNČ. Estimations of standard deviations of equalled unknown coefficients and their covariance matrices are solved in the library.

Beside the above stated libraries, the further development of the programme will also aim at processing measurings with using triangular networks. We suppose implementation of algorithms for generating triangular networks keeping the condition of Delauney triangulation and other related problems including algorithms of diluting points with keeping accuracy of the subsequent approximation of a body by generating the triangular network. The development will carry on not only by adding functions, but also by adding externally modifiable localization into any language.

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Georeferencing and Cartographic Analysis of Historical Military Mappings of Bohemia, Moravia and Silesia

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The research on "Georeferencing and Cartographic Analysis of Historical Military Mappings" (2004-2006) has been carried out by the team built-up in cooperation of three Czech universities: the Czech Technical University in Prague, J.E. Purkyně University in Ústí nad Labem and University of West Bohemia in Pilsen. The project involved a complete cartographic research of the accuracy of historical military mappings focused mainly on methodology of interpretation of old maps content, localisation of those maps sheet layouts into current coordinate systems, verifying the relations between cadastral mapping and the 2nd military mapping and also the development of web interface for making the images of map sheets available on Internet.

The 1st military mapping was the first systematic military geodetic survey done on the territory of former Austro-Hungarian monarchy. The mapping (1763-1783) was done in a quite detailed scale 1: 28 800 without any geodetic control and with minimum of measurements. The content of coloured maps included settlements, roads and stone bridges, rivers, meadows, forests and grasslands. The altitude was presented by hachure which indicated the topography of foots of significant terrain slopes. Insufficient quality of maps from 1st military mapping led to beginning new surveys in the 19th century (1807-1869). The 2^{nd} military mapping in the scale 1 : 28 800 had been preceded by creation of a trigonometric network used also for cadastral survey used as a background for topographic survey therefore the mapping was done relatively very precisely. Several coordinate systems were used for the territory of the monarchy. Mapping was done using a measuring table, distances were derived from spacing or estimated. The height of important objects was derived trigonometrically, hypsometry was presented by slope hachure. Colored originals of maps from historical military mappings are stored in the Military Archive in Vienna, Austria. Raster files (TIFF, 200 dpi) of colored copies of these historical maps have been used for the research work [4].

The first topics of the CTU project team was the investigation of the maps accuracy. The analysis of positional accuracy of map elements on maps from historical military mappings has been made for four testing areas at the territory of the Czech Republic The sets of suitable map objects have been selected: these points had to be identified in corresponding map elements within old maps and current map sheets and preferably also on the real objects in the field (churches, village chapels, way-side crosses, corners of important historical buildings, pond dams, bridges, etc.). Raster files of particular map sections of historical mappings were georeferenced by transformation into the S-JTSK system using several identical points. The coordinates of selected points identified in raster files of historical map sheets were compared with coordinates of corresponding points obtained from the digital terrain model DMU25 (scale 1 : 25 000), from coloured orthophoto with resolution 1m and from direct GPS measurements in the field. The detailed results of the analysis were presented in the papers [2, 3]. The average standard deviation (and shift of point) for the position of 698

objects on the maps of the 1st military mapping ranged from 176 m (shift 160m) for the area of Jindřichův Hradec to more than 1000 m (shift 870m) for the region of Nové Město. Positional accuracy of the maps from the 2nd military mapping is much better (the mentioned values less than 50m) especially due to much more precise geodetic background of those maps. It is supposed that the accuracy of old maps may differ with also various mapping localities (landscape parameters, quality of mapping work, various time periods of mapping, etc.).

The second field of interest of the CTU team was the development of web interface for visualization of these old maps. In [1] it was published that the best way how to make the data more accessible through the Internet is to georeference and publish it within the frame of web map services. The data from the area of Bohemia were georeferenced in the geodetic software KOKEŠ which provides the best results in the speed of data transformation. It is necessary to transform the data to some contemporary coordinate system because of later usage in GIS. Every map sheet was georeferenced in the national coordinate system S-JTSK to the corner coordinates using projective transformation (corner coordinates computed by Čada). Final map sheets were inserted into a mapserver. Our mapserver application is based on the Open Source CGI application UMN MapServer. There are two ways of publishing the data with UMN MapServer: web application (for displaying) and web map service (for distribution). Web application interface enables standard internet map functionality such as zoom and pan. Some other functions as interactive coordinates display or village searching were programmed in JavaScript. The data distribution using WMS (web map service) is the most valuable part. Everyone who keeps the standard of WMS can join our data to his own GIS application. Then the data can be used as GIS layer either in other web applications (mapservers) or in desktop GIS

The results of the research project may contribute to extending the possibilities of exploitation of these unique maps especially in current GIS applications.

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Change Detection in Land Use Areas from SPOT Sequences

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This study is a part of the Sustainable Management in the Micro Economy and its Socially Legal Aspects grant, awarded to the Department of Economy and Management of the Faculty of Civil Engineering, CTU in Prague. One of the hypotheses of the project is a presumption that the road network is a reason of land development and a condition of the local economical growth, where the growth is evaluated according to the road network. The goal of the project is to define relations among various civil constructions, their prices, life expectancy, maintenance costs and other features connected to constructions. This part of the project (goal of the Remote Sensing Laboratory) aims to detect changes around new highways in the Czech Republic. The data choice for change detection is based on three level data sets – CORINE data, SPOT data and aerial photographs.

CORINE data were the first data sets. Two time level data were used for change detections. The changes were determined from overlaid areas created by GIS tools. As a result of CORINE data processing, the first areas selection was performed being used later for further data choice from more detailed remote sensing SPOT data. From CORINE data, land use changes around the highways were determined, changes situated in 15 km buffer zones around highways exits between years 1993 and 2000. 15 territories around the highways were identified where significant changes in the land use were detected. 362 areas in these territories were determined in total where individual changes were defined: from agricultural areas, forest and semi-natural areas and water bodies to urbanized areas, etc. Most changes were formed by changes from non-irrigated arable land to discontinuous urban fabric (156 changes) and from non-irrigated arable land to industrial and commercial units (56 changes). The smallest mapped units in the CORINE data are 25 hectares, this fact caused that the second step of the analysis continued in other data – remote sensing data.

21 SPOT images were ordered covering all places of our interest. The SPOT images were ordered in terms of OASIS program of the French Space Agency CNES (financed by EU) allowing free of charge access to SPOT data for study purposes.

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).

For the study of a dynamic process studying change detection, multitemporal data must be geometrically registered to the map base or at least co-registered. Wrong registration can 700

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). In the project image to map registration was used. 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.

To perform accurate change detection, it is necessary to perform atmospheric and view angle correction. 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].

Testing of map algebra methods and image classification methods along the highway connecting Prague and the northern Bohemia is ongoing. 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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Interdisciplinary Perspectives on the Development of Technical Fields and Industrial Architecture in the Czech Republic and the Creation of a Typology

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The aim of this project is to bring together information from various disciplinary perspectives on the relationship between development in individual technical fields and the structural characteristics of industrial enterprises in the Czech Republic, approached primarily from a typological outlook and with a view to the possible future uses of a site. The aim is to create a thematically consolidated study subject with interdisciplinary foundations, uniting the experiences and approaches of various professional backgrounds and sectors.

Study programmes at technical universities in the Czech Republic do not yet adequately incorporate the crucial topic of the relationship between individual industrial sectors from typological, technological, technical, cultural, economic, social, and urbanplanning perspectives. This synthesising approach to the development of industrial enterprises, which has thus far been unfairly overlooked, makes it possible to collect studies on the relevant industrial fields.

The preparation and implementation of the project has required the broad involvement of professionals from worksites outside the VCPD and partly also outside the Czech Technical University. Although it also largely makes use of materials already gathered as part of the preparation of the database of industrial heritage, the involvement of external collaborators from the ranks of teachers and historians is of key importance in the project's development.

Work on the project is based at the Research Centre for Industrial Heritage (VCPD), which since 2002 has been collecting and building up information drawn from all industrial branches and storing it in the "Register of Industrial Heritage", which focuses on industrial structures and sites. Colleagues from other faculties at the CTU, the Institute of Economic and Social History at the Faculty of Arts, Charles University, the National Heritage Institute, and the Technical University of Liberec played an important advisory role in the first stage of the project.

In the preparatory stage of the project the following themes were established for an interdisciplinary collation of information gathered to date:

industrial brownfields / the urban-planning context

developing a typology of industrial structures in relation to production

the form and content of industrial structures / the symbolic sub-text

structural works and industrial archaeology

developing approaches to changes in the function of industrial buildings and sites

the iconography of industrial structures / company culture of industrial enterprises This will be followed by the continued development of the "Register" database with the addition of entries on sites in which an important role is played by the technological equipment (e.g. the transport mechanisms of the company F. Wiesner Chrudim). 702 In 2006 a model topic was selected to illustrate and demonstrate all application of all the planned themes in the project, which in 2006 included the interdisciplinary conference "Waterworks in the Landscape".

Among the industrial regions that are no longer serve their original function, or are no longer evolving, is the region of the Central Elbe River, which became the site of numerous waterworks projects in the past – weirs, bridges, hydro-power plants, etc., all designed by top Czech engineers and architects. In general, waterways regulation was intended to make rivers navigable, make use of water energy for industry, irrigate the surrounding agricultural land, and protect the land against flooding. It became a stimulus for economic growth in the region and an opportunity for construction and mechanical- and electrical engineering firms to perfect their skills.

The proceedings from this conference, at which top experts from the Faculty of Arts of Charles University, the Academy of Sciences of the Czech Republic, the Archives of the Czech Technical University, and the Faculty of Electrical Engineering and the Faculty of Architecture at the Czech Technical University, offer several perspectives on the topic: from a chronological overview of the formation of the legal and financial conditions of river regulation, through the development of the field of hydro engineering at the Prague polytechnic and related fields, which facilitated the rapid spread of electrification, to the technological transformation of waterworks' facilities, which had an impact on their practical design and their shape. Art history examines the symbolic sub-text and the visionary ideas of architects against a background of the technical pragmatism involved in the assessment of the effect of waterworks on the surrounding landscape.

The next step was to collate the thematically more generally oriented texts dealing with the relationship between the development of technology and the typology of industrial buildings – *Interdisciplinary Perspectives on the Development of Technical Fields and Industrial Architecture in the Czech Republic.* The texts are divided up into chapters that correspond to basic types of industrial production, categorized according to their structural features and a typology of production buildings and their history. This approach allows for an instructive approach to the topic of industrial heritage, including categorization and a temporal breakdown into periods. In addition to its education function (lectures on "Building Studies – Industrial Structures" at the Faculty of Civil Engineering), the text serves as a resource for the preparation of a publication on industrial heritage in a cultural context, published on the occasion of the 300th anniversary of the Czech Technical University in Prague.

In 2007 the project will be carried on with research on the aspects of typological development of buildings and sites in the textile and glass-making sectors, the appearance and layout of which were influenced and shaped by their production technology.

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Database of Industrial Regions

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The objective of this development project was to create a model database containing an inventory of industrial regions and to connect it to the other information and database systems of the Research Centre for Industrial Heritage (VCPD) and of the Faculty of Architecture at CTU. The database is intended, as is customary in other countries, to be used as a tool for mapping abandoned industrial regions and industrial regions potentially at risk, and the information it contains can then be used by academic institutions for teaching purposes and can also be used in evaluations of these regions as part of the decision-making procedures connected with regional development. The database is therefore intended to serve as a medium that draws that practical and theoretical sides into a mutually beneficial relationship and presents both practical and theoretical solutions and perspectives.

To date brownfields have been documented in the Czech Republic by academic and state institutions primarily focusing on narrowly defined regions or purely economic factors (environmental effects, accessibility, ...), or has not been very accessible to the public. Conversely, the newly created Database of Regions of the VCPD is intended to be an accessible source of information for anyone interested in the topic of industrial regions. An integrated system of databases, texts and maps offers an active medium for the study of industrial regions in all their aspects.

In the first half of 2006 source research was conducted, criteria elaborated, and the exact structure of the Database of Regions will be devised. In the second half of the year the interactive Web application for the Database of Regions was set up on the server of the Czech Technical University and connected to the existing Database of Objects and Authors, and the public interface of the entire system was set up on the Web site of the VCPD. The system will then be tested on model examples of various industrial regions. At the end of 2006 the Database of Regions was connected to the map server of the Faculty of Architecture of CTU.

The database is designed according to the basic principle of ensuring that the information in the individual entries is stored and can be used and updated within a fixed, clear, and easy-to-use structure. This structure allows for "on-line" development of the database, the introduction of additional information or updates to entries on an ongoing basis, and, at the other end, allows users to easily orient themselves in studying the entries and use filters to select from a range of search options or sort the information into thematic blocks. The entries are thus presented in a format that makes them relatively easy to compare and contrast, which opens up space for interpretative work, for example, in teaching, research, and even in the practical decision-making process relating to the future of industrial regions. Considerable emphasis is placed on ensuring the compatibility of data exchanged with other academic institutions and the compatibility of data with regard to needs in the practical sphere. The structure of the database is based on a detailed study of other similar databases in this country and abroad. It benefited greatly from an exchange of experiences at the XIIIth International Congress of TICCIH (The International Committee for the Conservation of the Industrial Heritage), an international organisation engaged in the protection of industrial heritage in an international context.

However, this database differs fundamentally from other activities in terms of its focus on information that has permanent applicability and can be used in the mid- to long-term and thus is capable of providing a better foundation for specific financial planning over a longer period. The structure of the Database of Regions significantly takes into account both the cultural and structural-historical development of the region along with other aspects of the environmental context.

Over the course of 2006, as part of work on this development project, cooperation was initiated with the City of Kladno, the City of Liberec, and with the agency Czechinvest. The aim of this cooperation was not just to explore the issue and individual industrial regions, but also to determine the criteria for the protection of the regions, for their sustainable development, and above all for integrating the activities of each of the subjects involved.

The database system has also become a very valuable resource for the work on preparing the exhibition and catalogue of student projects on the topic "Industrial Heritage as a Motor and Tool of Regional Development" that will take place as part of the 4th international biennial "Vestiges of Industry" in September 2007. This new source of information offers students current data and real examples of industrial zones in the Czech Republic, teaches them to appreciate the issue in a broader context, and provides them with methodological guidelines for the study of brownfields. The database is also an essential source of comparative information for state administration – especially the National Heritage Institute, municipal and regional authorities, the creators of other related databases, and potential investors.

The Database of Regions is another essential step in the development of the "VCPD Register" – a system of databases documenting industrial sites and areas and the development of industry in the Czech lands. The internal and the public parts of the VCPD Register were launched on the CTU server over time between 2002 and 2006. Next year the VCPD Register will be connected with a database prepared by Czechinvest and more broadly incorporated into the use of the Register for university teaching outside the CTU.

The cooperation that has been established with other bodies is a guarantee of the continuation and development not only of the Database of Regions, developed as part of the development project, but also of the entire system of the VCPD Register. The Database of Regions can thus become an important bridge between academic institutions, the teaching sphere, and practical applications.

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Testing of set of the total stations TOPCON GPT - 2006

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Twelve total stations Topcon GPT-2006 were gained in 2003 within the project H2397/2003 of the Development Fund of Universities "Innovation and Development of Laboratories for Practical Tuition of Civil Geodesy" for support of tuition of the subject of Civil Geodesy of the Faculty of Civil Engineering ČVUT in Prague. Thanks to that there appeared a unique possibility to verify competence, stability and accuracy of TOPCON GPT-2006 machines on larger amount of specimens from the same production runs with intention to determine whether and how significantly the individual machines differ in accuracy from one another. It is eventually possible to observe development of accuracy of machines in stage measurements repeated always after one year. Comparison with more accurate machine Leica TC 1800 was also part of the experiment.

An experimental testing field for measuring at shorter distances was made for this purpose, where outlines of horizontal directions, zenith angles and oblique lengths were measured. With regard to the fact that the machines are used for tuition almost continually during the semester and also with regard to their number, the testing field was designed in the room of study laboratory so that it would be possible to carry out measurements without necessity to transport the machines and gadgets in short time. To create a testing field there was made an experimental determination of shape of proportions of a suitable object for measuring at shorter distances (the largest length cca 7 metres). The most suitable shape and size of the target were determined on the basis of analysis of the relevant standard deviations. Then there were stabilized twelve points in total approximately in three altitude levels, the measurement standpoint was placed approximately in the middle of the laboratory.

The total station Topcon GPT-2006 is a basic device for geodetic works especially in civil engineering. Standard deviations of measuring angles are 1,8 mgon, relation 5 mm + 2 ppm·d is valid for standard deviations of length measured prismlessly at a distance larger than 25 m, size of standard deviation for a smaller distance is 10 mm. Relation 3 mm + 2 ppm·d is valid for measuring length on a prism.

The following measuring procedures were chosen to determine accuracy characteristics of the Topcon GPT - 2006 total stations (both individually and of the total set of all twelve machines):

- To determine momentary targeting accuracy of meter, repeated targeting at the same target was always carried out fifty times before each set of measurements, and value of horizontal and zenith angle was registered. With respect to lower accuracy of the used distance meter, influence of targeting on the measured lengths is not supposed.
- 2. To determine subtraction accuracy of the measured values with the machine, repeated registration of horizontal and zenith angle at one point without retargeting was carried out fifty times simultaneously with targeting of length.
- 3. Repeated registration of horizontal direction and zenith angle at one point without measuring length and retargeting was carried out fifty times as well.

4. Measuring outline of horizontal directions in three groups with simultaneous measuring of zenith angles and oblique lengths by means of prismless distance meter (including registration).

Measurement with one machine took approximately 3 hours and ran always without interruption. All measurements were carried out by Ing. M. Štroner, Ph.D.. The total number of targetings and measurements for 12 machines was 1464. An identical measurement with the Leica TC 1800 machine except for measuring lengths was carried out for comparison with more accurate machine. The machine has no prismless distance meter and accuracy would not be sufficient for verification. Lengths were therefore measured on a reflection foil stuck on a metal label 1 mm thick placed onto the target and calculations with lengths reduced to thickness of the label were carried out afterwards. The machine was targeted at the point to ensure identity of the target, then the label with the foil was placed in such a way that the middle of the foil would match to the observing cross and that length would be measured subsequently. Lengths were measured only twice with the Leica machine with respect to this more laborious measuring methodology, in the first and in the second position of binoculars (so only in one group).

It implies from the resulting testing that inner accuracies of the Topcon machines oscillate in dependence on condition of the meter, but in spite of that they do not reach by far the nominal value of 1,8 mgon (standard deviation of measuring angles) stated by the manufacturer. Measuring and testing of horizontal directions showed that nominal accuracy was met in case of eleven machines and only one total station did not meet accuracy stated by the manufacturer. Significant influence of systematic errors from different height of trunnion axis of the binoculars showed in evaluating accuracy of zenith angles. This influence prevented from statistical testing but it does not lessen quality of the tested total stations for current construction works because it shows only during measuring at very short distances. Testing of prismless measuring lengths showed higher accuracy than stated by manufacturer for ten total stations, the remaining two machines correspond to nominal accuracy. Evaluation of the whole vast experiment showed statistically significant differences in measuring accuracy of the individual total stations. The machines are significantly loaded during measuring in tutorials of the subject of Civil Geodesy. The resulting different standard deviations can be influenced by quite demanding way of using in the basic course of Civil Geodesy. The students do not have suitable previous training for using this type of machines and two years of intensive using have marked the tested machines.

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Simulation model for urban development

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The objective of the research is to create the tool that could help to define, predict and evaluate the future development of an urban territory based on the criteria of long term sustainability. The intention is to create the practical tool that could serve the purposes of research, education or planning practice. The tool offers multiple interfaces for the interaction to serve different kinds of users. Among the users, public administration employees and planners are the main target group. In that sense the tool should support the planning, development and management on the local level. The tool can assist the evaluation of the development of urban areas based on various land-use regulatory measures (land-use plans, regulatory plans).

The tool uses the model representation of urban environment reflecting the externalities that stem out of various types of land uses and the relative accessibility of each site in the represented area. The model purposely abstracts from non-spatial economic factors that would obscure the real influence of the spatial arrangement of the city.

The dynamics of the model is influenced by following factors:

- positive and negative externalities stemming out of the uses in immediate neighbourhood;
- · relative spatial accessibility of the site;
- relative spatial accessibility of the infrastructure;
- spatial and functional constraints of spatial development declared as by-law regulatives;
- cost of transformation from one function to another.

Besides the endogenous factors presented above that are delivered by the model itself, the model takes into account numerous external factors, too. They enter the model as the assumptions at the start of its running or they are purposely entered by user in the course of model performance. The user of the tool can control the rate of influence of each of the external factor. The experimental nature of the model allows the user to learn from different outcomes based on different assumptions about the strength of each factors.

The cellular automata was chosen as the best way to represent the spatial influences of various land-uses. The cellular automata were created by Ulman von Neumann in 1966 as a tool intended for complex system simulation. Since that time the cellular automata have been frequently used for simulation of urban change dynamics.

The cellular automata conceptualizes the space as discrete variable. Space is represented by one-dimensional or multidimensional grid of cells. Each cell has a certain number of neighbourhoods depending on the defined size of neighbourhood. In the model, each cell represents one type of land-use. The change from one land-use type to another is determined by the transition rule. Multiple factors (neighbourhood effects, relative accessibility and cost of land-use type change) enter the transition rule and the best possible use from the point of view of a single cell.

The transition rule represents the decision of autonomous cell and its output is based on the conditions that are valid only for the cell. Therefore it is necessary to introduce city-wide constraints that would determine the rate of change of the whole area. The city-wide constraints describe e.g. the total benefits of all cells in the area, the total amount of available resources, and threshold costs for infrastructures.

Practical use of the model will be supported by multiple interfaces that will serve three groups of users:

a) Ordinary users can change the relative strength of factors and choose different groups of global constraints. They can compare the output scenarios based on qualitative and quantitative criteria. Qualitative comparison can be based on the observation of spatial configuration of urbanized and non-urbanized areas and spatial relation of various land-uses. The model supports the qualitative comparison of scenarios by visualization of cell land-uses. The model provides with the following information: relative occurrence of each type of land-use in the area, the cost (private and public) of the change and the efficiency of the change.

b) Project builders may wish to develop the representation of the area in the model. They will need to use the GIS technology to develop and run a tailor-made model based on their specific data. If a project builder will not have necessary pre-processing equipment or GIS experiences s/he can use the web client application to manage all processing.

c) Model developer of the model will be responsible for calibrating and testing of the model with the objective of enhancing the validity and usability of the model. Only the model developer is granted by the access to the internal variables of the model.

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Section 15

TRANSPORTATION, LOGISTICS, ECONOMY, MANAGEMENT

Verification of the flow field around a slotted flap numerical solution vs testing

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This article deals with the comparison of the results of the aerodynamic characteristics obtained from CFD solver FLUENT and from experimental investigation. Experimental investigation was carried out by experimental facilities at ARTI. This calculation and experimental investigation were performed around the NLF 0115 airfoil equipped with the single slotted flap. Three position of the slotted flap were calculated and measured (take-off, cruise and landing position). This grant was utilized to produce of the model into the aerodynamic tunnel.

Computation domain and grid generation

The size of the airfoil was selected with respect to the size of the airfoil model for the experimental investigation at ARTI. The chord of the airfoil was set to the value which corresponds to the size of the model that was measured at ARTI. All of the computational examples and measurements have been solved as two-dimensional problem. Dimensions of the computation domain were selected so that their boundaries were in sufficient distance and they did not influence the flow over the airfoil and the pressure backwash could be expanded to the computation domain. In the rear part of the domain a sufficient distance was given to let the wake extend. The computational domain was created in UNIGRAPHICS NX2. The shape was designed according to the commonly used shape, which consists of the half circle in the front part and the rectangle in the rear part. This shape makes possible to change the angle of attack without affecting the boundary of the flow.

The grid for program FLUENT was created in the program GAMBIT as unstructured hybrid mesh, which was formed from the rectangles and the triangles.

The boundary layer was generated by the prisms and the remaining part of the domain was created using the triangles. The rectangular elements (prisms) in the boundary layer were used to simulate the viscous sub-layer near the airfoil. The domain where the viscous effect of the flow is neglected (due to the potential flow), the triangles are used to generate the mesh.

The number of layers of rectangle elements was chosen with respect to the supposed thickness of the boundary layer. The thickness of the first row was adjusted 0,1mm as a result of this equation.

$$\delta^* = \frac{1}{\sqrt{\text{Re}}}$$

The reason of using the equation [1] is based on the presumption that the boundary layer thickness is significantly smaller then the airfoil size. The growth function in the boundary layer was chosen as a linear with the value of 1.2.

Set-up the program FLUENT

The FLUENT solver uses the cell-centered, segregated or implicit formulation. The model of turbulence Spalart-Allmaras was used. As an option for the study, the analyses of 2^{nd} order upwind scheme were chosen for all variables based on previous experience from 2D airfoil analyses. The input velocity and intensity of turbulence were set up with respect to the experiments at ARTI. The Reynolds number was $5 \cdot 10^5$ for all cases. This value of the Reynolds number corresponds to flow field velocity 25m/s. 712

Description of the model

Model of the airfoil with slotted flap was designed in UNIGRAPHICS program. The dimensions were follows. The chord of the model was 0.3m. The span was 0.6m. Aspect ratio was 2. The diameter of the boundary desks was 90% of the span of the model. Those dimensions are in the some scale as the dimensions of the models which were used in aerodynamic low speed wind tunnel with the test section of 3m diameter. Hence utilization of the some tunnel correction was possible.

Experiment

Experimental investigations of the flow field around the airfoil with slotted flap were carried out at ARTI in aerodynamic low speed wind tunnel with the test section of 1.8m diameter. The aerodynamic coefficients were acquired from force measurements. They were obtained lift, drag and moment coefficients from the measurement.

They were measured three position of the flap. Cruise position with 0° deflection, take-off position with 15° deflection and landing position with 40° deflection of the flap. For the cruise position the slot between airfoil and the flap was pasted up. This prevented leak of the flow from pressure side to suction side of the airfoil through this slot.

For all cases was used flow visualization by means of the tufts. It was found out that the slot stabilize of the flow and allow achieve higher angle of attack.

Comparison

The results, which were obtained from the FLUENT program, were compared with the results gained from the experimental measurements at ARTI. Especially the lift coefficients were compared, because the drag coefficients gained from ARTI measurements were affected by the measurement methods. The flow field around the airfoil is distinctly affected by deflection of the flap.

FLUENT brought the lift coefficient differences of up to 6% for cruise position of the flap. The measured maximum lift coefficient was 1.3 and the value of maximum lift coefficient from FLUENT was 1.378. This differences was maybe caused by neglected of the slot between airfoil and flap during the computation

For the take-off position was the differences between measured and calculated maximum lift coefficient of up to 5%. Maximum lift coefficient from experimental investigation was 2.17 and from FLUENT was value of the maximum lift coefficient 2.27.

For landing position was maximum lift coefficient 2.89 from experimental investigation and 2.85 from FLUENT. The differences were of up to 1.5%

Conclusion

The calculated aerodynamic coefficients are corresponding to the experimental results. It was managed found out the optimum adjustment of the FLUENT program for this case of external aerodynamic. This adjustment will be used for future calculation of this problem of the flow field around airfoil equipped with high lift devices.

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Projection and Assessment of Systems of Integrated Transport

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Integrated transport system (ITS) is the highest form of transport providers cooperation for the benefit of passengers as a customers of this system. ITS means association of all means of city-transport as well as regional transport, provisions of identical services to passengers from the tariff and transport conditions, timetable coordination, informations and marketing point of view etc., it means increase of attraction of public transport together with costs saving. This assumption is valid only on condition of mutual cooperation of organisational authority, operators and other involved subjects, they should struggle for the passengers together and don't fight with each other. For the ITS quality is deciding factor not only quality and supply of particular means of transportation but also level of cooperation with one another. The result is not only simple summation of its particular details due to the synergic action.

ITS started in 1960s when Western Europe, especially Germany, learnt the need to make public transport more attractive. The first ITS was established in Hamburg in 1965 followed by Munich in 1972 and Stuttgart in 1977. Next ITS development boom was caused by change of regional law in 1990s (Karlsruhe 1994) and affiliation of new federal states (Dresden 1998, Berlin 1999), at this time German ITSs cover about 2/3 of country area and 80% of population. All ITSs register a increase of passengers and earnings, public transport role improvement, positive changes of modal-split (decrease of stress by individual road transport) and decrease of operator's risk.

In German speaking countries is concrete form of cooperation in range of ITS socalled "Verkehrsverbund" which is also organisational authority of ITS. It is the professional corporation in form of trading company with towns, districts and lands like shareholders. Generally (but not always) are these shareholdes simultaneously clients responsible for public transport and its funding. This way of public transport organisation is called 3-level model. The first "political" level (districts, towns, villages) establishes the second "coordinating" level (see above). Organisational authority orders services from the third level, it means from particular operators. In the beginning were some operators shareholders of some organisational authorities, this kind of organisational authority is already transformed (or will be transformed in near future) to above mentioned form with towns and districts like shareholders. The reason of this transformation is firstly possible conflict of interests in public tenders, secondly the fact that operators for understandable reasons often prefer their own profit before interest of passengers.

Opposite trend is in Great Britain where in contrast to continental Europe is developement of public transport affected by governmental policy, so-called ,,deregulation city and regional bus transport" (except London) applied from 1986. The matter of this deregulation is maximum operators competition instead of cooperation and integration. Practically as a result there is a lot of bus lines of many operators without any cohesions between lines, without timetables coordination and with different prices. Furthermore, these operators focus on profitable transport relations and time periods (radial lines to city centre, 714

peak hours) on the other hand it make worse the transport to pheriferies, tangential lines and services except peak hours (evenings, weekends). The result is worse public transport at all, further decrease of passengers and increase of individual road transport

As a part of ITS developement appears in some German towns appears new possibility of bus transport quality improvement – metropolitan bus, so called metrobus. Firstly was realised this idea in Hamburg in 2001, in 2004 also in Berlin and Munich. This hiearchical organisation of bus lines was supported by multiyear transportation survey and studies including analysis of competetive strength with individual road transport. One such analysis shows that most of passengers prefer lines with shorter intervals despite of longer walking distance. On the basis of this studie was made the decission to make system of lines more transparent, it means decrease number of lines and make simple their layout. Metrobuses operate lines with strong demand and are established like transformed current bus lines, connected more current lines together or new lines. They have higher transport priority than individual road transport, this advantage is used for their promotion.

In Hamburg increased supply of bus transport due to metrobus implementation, especially except peak hours, in Munich and especially in Berlin increased supply on the most important lines together with savings of beaten kilometers. In all three towns was recorded increase of passengers up to 25% as a result of hiearchical bus, respective tram network organisation. These experiences show us the opportinuity to achieve attractiveness of public transport together with increase of its effectivity by bus network reform, the highest growth potential is in tangential relations. The more uncompromising change and global marketing and transport priority means the better results due to the synergic action.

Town Karlsruhe as the first on the world implemented tram-train in 1990s which can be operated on the tram track as well as train track and due to this advantage provides connection between downtown and regions. Tram-train has dual electric equipment and must fulfill all technical and legal requirements of both transport means. This expensive investment was favourable, from the beginning rapidly increased number of passengers and system is further develped. Tram-trains can travel on the railway more then 100 km/h and increase of passengers exceed on most of lines 100%, on the one particular line even 700%. Tram-train in Karlsruhe was used as a example for other towns like Saarbrücken or Kassel, there are planned similar projects in Czech republic (Regiotram Nisa, tram-train in Orlová) as well as in Slovakia (Košice).

Integrated transport systems give us the opportunity to make public transport more attractive and cost-effective, the more level of integration means the better results. Application of building and organisation actions in range of ITS can contribute to resolution of difficult traffic situation in many Czech towns and regions.

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Determing the Financial Relation between the Bus Terminal Operator and Carriers Using the Services of the Bus Terminal

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The aim of this project was to determine the financial relation in a form of a mathematic tool (formula) between the bus terminal (BT) operator and bus carriers using its services. The term financial relation means determination of the price per an entrance to the bus terminal and price per parking (laying up) of the bus in the bus terminal.

Creation of a mathematic tool (formula) for determination of the entrance fee to the BT – This formula should be universal and suitable for determining the entrance fee per any BT under the pre-determined conditions that are as follows: economic information of the BT, operational information of the BT, information of the interest of carriers in using the services of the BT. The following four procedures were chosen for creation of the mathematic tool: the first procedure was creation of a demand function for entrance to the BT, the second procedure was creation of a cost function of BT operator, the third procedure was creation of a profit function of the BT, both for the price for which the operator's profit is maximum, and the price when the capacity of the bus terminal will be maximally used.

Creation of the demand function – demanding the entrance to the BT – The demand function of the entrance to the BT is created by mans of a regressive analysis of the first degree based on the data as acquired from the records of connections using the BT. The analysis includes connections operated during the analysis as well as prospective new connections. A database of connections presenting a weekly demonstration of traffic on the BT was generated from all above-mentioned connections. Average costs and profits may be calculated from such completed database as well as the profit per every connection may be calculated from their difference. For such determined profit a decisive rule is applied that should state whether the bus carrier who runs the given connection is or is not interested in entrance to the BT. Bus carrier's interest in the entrance of the connection to the BT is determined by the following conditions: The profit is positive and the bus carrier is interested in the entrance of the given connection to the BT or the profit is zero or negative and the bus carrier is not interested in the entrance of the given connection to the BT. Based on this decisive condition we may state the number of connections and subsequently the number of buses that are interested in the entrance to the BT for the given entrance fee. By means of a regressive analysis and from the collected data we may get the demand function describing the demand of bus carriers for the entrance to the BT.

Creation of the cost function – Costs of the BT operator – Costs associated with the existence and operation of a company are its basic economic indicator and their cut-down is the main tool for profit creation at present. Therefore it is extremely easy for the BT operator 716

to create the demand function from his own inter-company economic information. This function consists of two components: fixed component – costs independent on production and must be thus covered even though the company does not produce, in case of the BT this is the status when no bus enters the BT; and the variable component – costs dependent on the volume of production mostly related to a production unit, in case of the BT there are the costs related to a single entrance of a single bus to the BT. The decision of what costs belong to what group is not currently arranged by any regulation and it is purely the subject of economic arrangement of every company.

Creation of the profit function – profit of the BT operator – For creation of the profit function of the BT operator it is necessary to define the function describing the dependency of receipts on the number of entrances of buses to the BT. The amount of the entrance fee at which the profit is maximum, may be calculated from the first derivation of the function profit. This shall be laid equal to the zero and then we can calculate the corresponding fee. This value may be added to the demand function, cost function, receipts function and profit function and thus we can determine the demand, costs and receipts at maximum profit of the BT operator. For determining the amount of the entrance fee with maximally used capacity of the BT it is necessary to determine first the price from the demand function at which the BT is maximally used. Subsequently we may determine the costs, receipts and profit for the maximally used BT.

Creation of a mathematic tool for determination of the parking fee in the BT – Laying up the bus in the BT within the meaning of parking the bus is not arranged by any regulation and it is considered a service that may be but does not have to be provided by the BT operator (see the Czech National Standard ČSN 73 6075). This is also the basis for the economic approach to this problem. This service may be rendered within the frame of a contract of using the BT or separately as another business activity of the BT operator. If it was the case of a separate business activity, you may use a similar tool for determining the amount of the parking fee (most probably an hourly rate) as you did for determining the amount of the entrance fee to the BT. The only difference would lie in the creation of the demand function describing the interest in the parking.

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Measurements and analysis of data measured from real car driving used for development of research driving simulators

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A Common Laboratory of Systems Reliability of Faculty of Transportation Sciences CTU and Academy of Sciences of Czech Republic (LSR) works many years on research in the field of reliability of operator-machine interaction [1]. Driving simulators, which are continuously developed by the DSRG (Driving simulation Research Group) are successfully used for experiments dealing with investigation in driver's behavior under normal and marginal conditions, and influence of in-car devices on driving safety and comfort [2, 3].

Aim of the work

Although the experiments were originally focused mainly to obtain data for development of driving simulators, they opened us additional ways of usability. The aim of this work is now divided into three parts:

- 1. Investigate in possibilities of measurements of Driver-Car interaction in real cars in real traffic, first approach for future development of so called "instrumented vehicle".
- 2. Obtain data from different testing scenarios which would be used for development and tuning of physical model and motion cuing modules of our driving simulators.
- 3. Validation of contemporary features of our simulators.

Data collection

The measuring car was instrumented with measuring devices to obtain following quantities: *Trajectory*

The path of the vehicle is obtained from GPS signal in 2D coordinates. Unfortunately, correct usage of GPS signal for trajectory is not always enough frequent and also correctness of the immediate localization while moving is problematic. The range is at about 3-8m and from that reason it serves for car localization. Average localization frequency is about 3-4 seconds, the points for example in highway segments in average around 100m from each other. Therefore it was necessary to interpolate within the measured points. A spline interpolation seems to be suitable.

Car performance data

All the necessary data were collected via car CANbus protocol and CAN diagnostics protocol. They give evidence of car response to driver behavior. Those were actual values of:

- 1. Car velocity in km/h (and proportional speed of rotation of each of car wheels)
- 2. Vertical in g and longitudal in m.s⁻² accelerations
- 3. Spinning velocity of the car in degrees/s
- 4. Rotates of the engine, the gear
- 5. Position of throttle pedal in percentage, depression of brake pedal (here only on/off position)
- 6. Position of steering wheel in degrees and its velocity in degrees/s
- 7. Torque, which the driver forces on the steering wheel and force developed by power steering, all in $N\!/\!m$

Camera recording 718

Video record from the drive was recorded using common digital sensitivity video camera with wide FOV had to be used, so that it would be possible to record a same visual field and distance as the driver see even under limited visual conditions.

Procedure

All the devices are roughly synchronized by common time clock, the resolution of CAN data is in magnitude of milliseconds. From above described devices it is possible to obtain a complete information about where the car is riding, how the driver behaves, how the car reacts on the driver and on the environment and also about the actual situation around the car (traffic, light conditions, weather).

Analysis and Results

All the collected data had to be synchronized and resampled on common base. Linear interpolation was used for continuous data and nearest neighbor interpolation for discrete data. Data from each segment are than stored in a big matrix. For manipulating of such huge data the scripts in Matlab were created. Those allow selection of different segments in appropriate resolution for further classification. From set of tested rides it was possible to derive statistical values which can be parameters (e.g. maximal values, quartiles of values, relative occurrences, etc.). Those statistics would be used for determination of either physical limits or mean range of operation of the simulation. From the point of segmentation and with respect to above described intrinsic properties, data were differentiated into different segments, Starting, Stopping, Slalom, Overtaking, etc.) Each of those segments is specified with very different characteristics of driver and car behavior.

Conclusions

From above results it is possible to see a very promising view for further continuation as this work had to serve as a pilot set of experiments. The results of analysis discovered also many limitations. It is not possible to rely on GPS data unless those are corrected by terrestrial reference signals. Also the accelerations obtained form ESP are of not enough resolution and not enough frequent for analysis of marginal situation like braking on slick surfaces etc. There is also no relevant information on vertical acceleration which should be gathered using additional devices (preferably with much higher resolution and sampling frequency). The same conclusion holds for synchronization of gathered data. Simple synchronization is fine for analysis which was done within this work but for very fine analysis of marginal situations, this approach is not enough and needs to be treated differently with use of some additional time triggers. Collected data and results from above described analysis are very valuable either for development of motion cueing algorithms of new generation driving simulators currently being developed or for tuning of physics of contemporary simulators operating in LSR.

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Brain Activity and Behaviour Analysis of Pilot by Electroencephalogram

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None of many artificial systems which human society have dealt with throughout its history and are dealing with today, are able to operate independently – to date, all of them have had to be controlled, or at least supervised by man. All artificial systems need of interaction with a human subject. The human ability is the weakest point in such an interaction. The limitation or the decreasing of human vigilance and attention, in the course of his/her operation service or control of respective system has always been the most frequent reason of many system failures and accidents. The requirements on the human operator of an artificial system can be concentrated into the following main categories[1]: 1. Requirements on attention level and its continuity, 2. Requirements on the speed of the operator's reaction, 3. Requirements on the correctness of operator's decisions. We are not able to measure most of these parameters in direct and non-invasive way. That's why; we use more indirect methods, which are based on measurements of some suitable physiological indicators from which the actual level of the proband attention can be calculated. One of these methods, we used for our analysis is the electro-magnetic activity of the brain. The reliability, accuracy and small delay are the most serious reasons for choosing this method.

Electroencephalogram (EEG) is generated of interaction of thalamus- and cortex- neurons [2]. Basic EEG spektrum is ALPHA activity (8-13 Hz), which is typically mostly placed in rear area of the brain [3]. Alpha activity is an attribute of the healthy, vigillant and adult brain by closed eyes. This activity is a demonstration of synchronisation in thalamo-cortical domains. By open eyes this activity is blocked.

Above the front area of the brain is mostly dominant BETA activity (14-30 Hz). Beta activity is not sensitive to open/closed eyes. Over the temporal area of the brain appears sometimes theta activity (4-7 Hz). Theta activity is not sensitive to open/closed eyes as well as beta activity. This activity is typical by occuring emotive state. EEG analysis can be performed either in time series area (the observation is mere complicated because of the lots of technical and biological artifacts) or in frequency area (this was more suitable four our purposes - because of the fast furriers transformation filtering and in this consequence possibilities to read spectral maps). It is to be mentioned, that EEG time series are mostly quasi-periodical and quasi-stationary nature. There is already some noise level coming into EEG measurement analysis record, which is called artifact (technical nature and biological nature-changes in skin resistance, muscles artifacts, and eye movements). We divided our analysis into

stages: 1. Subjective evaluation of the experiment 2.More objective observation by the instructor observer and 3. experiment evaluation by objective electro-encephalographic analysis. Our experiments were performed by good weather conditions, the sky was clear. The visibility was more then 8 km, wind 3-6 knots, the average height was 300 meters above the ground level. If we allow to insert cap with electrodes with an acceptable galvanic contact on the surface of the proband's head, and if the transient resistance of a contact is below 5

 $k\Omega$, the measurement using the standard electronic technology does not represent any serious problem, in the laboratory conditions or in practice.

In the designed case, we prepared our measurement equipment on board a four-seated aircraft Zlin 43. It has been demonstrated in numerous papers [3] as well as in our experiment-by non-flying aircraft that ALPHA activity appears mostly by closed eyes. By pilot-proband brokening up during performing pre-flight checks and opened eyes was ALPHA communication. In the same time was BETA and DELTA risen, which is typical for mental activity. In the next stage of the measurement test, during taxiing was different distribution of DELTA activity which is typical for this frequency band and much more significant THETA activity. This is with high probability typical for emotional activity/stress because it was in the central part of cortex, which is very resistent against biological artefacts any art (muscles etc.) ALPHA activity was reducing as a typical sign of increased mental activity of the pilot's-proband's brain. During taking-off ALPHA activity was most decreased which is related to more incerased attention. Horizon - level flight: DELTA activity was staying in a quite same values, it was only redislocated in other parts to to cortex. ALPHA activity increased. We can explain it: After critical stages (take-off, climbing) was the proband's brain well concentrated at the same time as this brain was a bit relaxing. We can observe a lot of artifacts in the EEG curves in this stage of the flight. After 6-7 minutes from beginning of the measurement (after aprox. 3 minutes of the flight) the proband's DELTA activity was increasing more (the highest amount from the beginning of the measurement). We can judge, that the pilot-proband was advised to perform more complex tasks in the same timemanoeuvring of the aircraft, comparative navigation with the map, communication with the instructor and air traffic controll. ALPHA activity was reduced in this time quite a lot. Since the time 7:35 minutes (aprox. 4:35 flight time) ALPHA activity was slightly growing up proband was lightly reducing his mental performance. Since the time 9:07 the proband was advised to perform some numerical calculations-with small unitary numbers. The artifacts has been reducing by falling-down BETA 2 (20-30 Hz); optical alertness rose because of increasing BETA 1 (13-20 Hz); ALPHA frequency has been still reduced-because of the open eyes and mental activity; the proband's mental performance remain still very high because of the still high level of the DELTA activity. The proband has been relaxed in muscular way in this time. By the calculating of two digits numbers in the next part of our experiment - DELTA activity has been increasing more then before - and has been disseminated through the all cortex in energy range of approximately 2,5-3 microvolt which is typical for more complex and difficult tasks, carried out by the pilot's brain during numerical calculations with two-digit numbers. The same task, performed by closed eyes (Now is the pilot-instructor operating the aircraft) indicated the very similar results although it could be expected, that the ALPHA activity rise in consequence of the closed eyes. Explanation consists in high level of mental activity and performance of the proband's brain.

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Analysis of Cognitive and Emotional Processes of Pilot's Brain During Flight in Visual Meteorological Conditions

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Human behavior is not fully deterministic - it varies from subject to subject and also from situation to situation [2]. All of the artificial systems, which we need for our life – require some kind of interaction with human objects. In contrast with artificial systems, humans cannot operate too long without having a break - they need to relax, rest and to sleep. The reliability of human subject – artificial system interaction is limited, dominantly from the human side. The reason for this we can see in requirements on operator's skills, level of their attention and reaction time, which has been risen since last centuries. We have analyzed the possibilities of how to classify the level of attention and how to detect its decrease by stating attention level parameters. Among the general factors, which have the influence on human subject's attention and cause its decrease, the following are most significan:1.Extreme length of a particular operator's service without breaks 2.Operator's physical and mental exhaustion, 3.Monotonous scene the operator has to observe for a long time.4.Extreme temperature in which the operator has to serve (too high or too low), 5.Extreme humidity in which the operator has to serve, 6.Extreme air pressure, 7.Air smell, dust density, etc.

For the purpose of brain activity measurement we designed and carried out continuous vigilance monitoring using electroencephalography (EEG). We found the following new facts and confirmed the validity of some of earlier ones: Vigilance is marked by alpha activity in the EEG record (oscillation of 8-13 Hz) and reaction time of 200-400 milliseconds, delta activity (0, 5-3, 5 Hz), theta activity (4-7 Hz), beta activity (14-30 Hz), gamma activity (over 30Hz). The most suitable sites for the detection of changes in ratio between the frequency bands on the skull surface are temporo-pariento occipital (TPO) regions, i.e. those over the posterior parts of the skull with the least muscle and oculomotor artifacts and with the most energy for alpha and delta activities. In somnolence, the cortex does not behave as a whole, which means, that different areas show different spectra while getting of to sleep, a fact easy to express by means of the alpha/delta ratio, separately for each of the cranial areas. In our cases was the spectrogram taken during mental concentration (controlling, maneuver of aircraft, calculating mathematical tests etc.) resembles that vigilance, with the alpha/delta coefficient being greater than one. There are differences between somnolence and vigilance and attention state. In somnolence state the delta activity is on increase but not so during mental concentration.

We measured the brain electrical activity on the board of small aircraft Zlin 43 during the taxiing and flying in visual metrological conditions. For security reasons there was except pilot a pilot –instructor on the board, as well as measurement technician and observer. Because of the vibrations and muscle movements, there were a lot of technical and biological artifacts in the electroencephalogram.

We have detected a lot of delta activity during critical phases of the flight-start; landing as well as alpha activity was falling down in the same time. 722

In our analysis, we were mostly interested in significant theta activities-which detect mostly emotional processes. We can observe that the most theta activity was detected after landing and while repeating the debriefing check lists. We carried out our experiment in Visual Meteorological Conditions. In our case it was mostly few (1/8 clouds) and scattered in order to be allowed to perform the flight with Visual Flight Rules. We was searching for a correlations between the phases of the flight and alpha/delta coefficient and theta activity as well as for correlations between perfect/good/average weather conditions (sky clear/few/broken) and pilots performance (represented by delta activity) and limbic system activation (represented by theta activity). For our experiments we used following methodology: Measurement performed by closed eyes, open eyes, calculating of small numbers, calculating of high numbers and after finishing our measurements, we compared the EEG-maps measured by individual phases of the flight. For example: State 1:aircraft on the ground, engine off, proband is sitting with closed eyes, state 2: aircraft on the ground, engine off, proband's eyes are open, proband is performing his pre-flight check, state 3: aircraft is taxiing on the ground, proband's eyes are open, proband is operating the aircraft and communicating with the air traffic control, state 4:before take-off check(open eyes) -proband is performing his take-off check-lists, State 5: Take-off-(open eyes) pilot is fully concentrated on his tasks on the board-he is very mentally activated (significant delta activity and none alpha activity) mostly in optical way.6. Climbing (open eyes). State 7: Horizon flight-(open eyes). State 8: Horizon flight: Aircraft is operated by instructor, pilot-proband was advised to hand over his control to pilot -instructor, then to close his eyes and try to rest. State 9: : Horizon flight: Aircraft is operated by instructor, pilot-proband's eyes closed-and he tries to calculate small numbers. State 10: Horizon flight: Aircraft is operated by instructor; pilotproband closed his eyes and try to calculate large numbers. State 11: Horizon flight: Aircraft is operated by instructor, pilot-proband's- eves are closed and he is performing a hyperventilation. State 12 : Horizon flight: Aircraft is operated by instructor, pilot-proband was advised to hand over his control to pilot - instructor, then to open his eyes and by opening eyes try to calculate large numbers. State 13: Horizon flight: Aircraft is operated by instructor; pilot-proband was advised by opened eyes and by opening eyes try to calculate large numbers - by performing hyperventilation. State 14: Approach: Proband is operating his aircraft in order to perform approach to landing. Pilot – instructor is controlling his activities. State 15: Landing -Proband is operating his aircraft in order to perform landing. State 16: Aircraft is on the ground, engine off; proband is performing his debriefing check lists with open eyes.

We have measured the most theta activity in phase 16-after landing. It can be explained as a relaxing state in which proband was happy and stress-free to pass a test flight.

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The Trends of Post-Secondary Education

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Post-secondary education, formerly known as higher education, has undergone dramatic changes over the past decade. The new label reflects new realities, such as the increasing orientation of traditional higher education providers toward vocationalism and the emergence of a new breed of higher education providers. Publicly traded, degree-granting providers of post-secondary education we shall call for-profits. These "mutants" now represent about 10 percent of the post-secondary education institutions in the USA - for example. The major publicly traded, degree-granting providers of post secondary education in the USA will generate in excess of 4 billion US dollars in revenue which represents about 2percent of the higher education market as traditionally understood. The divergence between market share in terms of number of institutions and revenue reflects the particularities of the ways for-profits operate: typically they have centralized administrative and curricular development facilities. Indeed, teachers' curricular liberties are severely restricted and teachers' role may be best described as learning facilitators. Campuses - learning centres are no frills and located for easy access.

Not-for-profit and public institutions of higher education do not have to pay investors a reasonable return. Thus for-profits were and are handicapped. How then could they succeed? For-profits invaded higher education initially by providing services to market such as information technology training and continuing education - workplace training for adults, so they entered post-secondary education through segments in which one typically finds community colleges. Over the past few years, for-profits have successfully moved up to segments in which one typically also finds state universities. It is thus an interesting question whether this invasion of ever higher segments of higher education through for-profit "mutants" can be stopped, or whether for-profits will ultimately invade the "brand-name segments". In other words - could a liberal arts college / arguably the paragon of the brandname segment/ be organized as a for-profit institutions? To understanding how for-profits managed to invade higher education as we knew it, and what the future of these "mutants" is, we are interested in studying the consequences of the opportunistic behaviour of colleges and universities /e.g., admittance of unqualified students for fiscal reasons, viable quality improvement strategies for such firms, the emergence of behaviourally different consumers /traditional "patronisers" versus "hoppers"/, and various other issues.

Buyers /prospective students or their parents/ and sellers /colleges and universities/ of post secondary education try to match optimally in a decentralized market for a number of periods. In the first period, buyers are randomly and uniformly distributed along a quality spectrum. Buyers and sellers are supposed as boundedly rational decision makers that sometimes "tremble", i.e. they select actions that, in their experience, worked best but they select these actions probabilistically. Buyers and sellers are characterized by preferences and internal states, behavioural rules /rulers for selecting actions out of the current choice set/, the number of behavioural rules, internal rules for selecting and modifying rules/, and specifications of the decision makers' interactions with the world. /For the remainder of the

text we use as synonyms the words buyers, consumers and students on the one hand, and sellers, firms, colleges and universities on the other hand.

Currently, our consumers do not change their quality, i.e., exactly what school they attend has no consequence for their educational outcomes. Firms thus face a fixed distribution of consumers in quality space. Given our current focus nothing seems lost through this restriction which could be relaxed easily. We note that there is quite some discussion about the value that colleges and universities add to human capital formation. Competency-based certification is also propagated by institutions such as Western Governors University which has made considerable headlines by offering its prospective students that skills and knowledge acquired at other universities, on the job, or just through life may be counted towards one's Western Governors University degree. What all these developments point to is a new kind of students - "hoppers" we call them - who takes classes here and there and then consolidates her or his portfolio at a school of her or his choice. The practice of the overwhelming number of students is not to go to colleges and universities that are significantly worse than they are. It can also be interpreted as the result of decision making under constraints such as time or knowledge.

Since typically a student will be signalled by several colleges or universities, the question arises how he or she prioritizes among multiple offers. We assume that consumers collect all their offers and put those firms that satisfy a minimum quality on the list of desired firms. For consumers who patronize, this list consists of only one firm whose quality they do not check because they must have done so at some point in the past and because quality changes typically not happen suddenly.

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Relation of Education and Incomes as Revenue from Education

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This indicator deals with relative incomes of employees with various levels of education attained as well as financial revenues related to investments in attaining such levels of education. This indicator thus presents data describing the distribution of income before taxation within five levels of education (ISCED 97) using the comparison of levels of attained education as well as using the revenues from education, which differ in various countries.

Basic conclusions

- Attaining a higher level of education may be viewed as an economic investment consisting of costs of an individual (including the decrease of income prior to attaining the final level of education), which subsequently generates profits in the form of higher incomes throughout one's life.
- Individual countries vary significantly in their variance of incomes for the same level of education. Even though it is possible to say that people with a higher level of education form higher income groups, it does not apply to each and every case.
- Individual countries also vary in the proportion of men and women in the categories of higher and lower incomes.
- > It holds true in all countries that women have lower incomes than men at the same educational level. For individual levels of education attained the typical income of women varies between 50% 80% of income of men.

The key factor of the decision-making process about the fact, whether an individual will invest in attaining further education, may be income differences related to the level of education attained as well as reflection of different offers of educational programs of different education levels (or, as the case may be, barriers of admission to these educational programs). Higher incomes resulting from a completion of a tertiary education are evident when comparing average annual incomes of those, who completed tertiary educational programs, and average annual incomes of those, who completed higher secondary or post-secondary non-tertiary educational programs. The lower income level for incomplete higher secondary educational programs is once again obvious when comparing the average annual incomes. The heterogeneity of relative incomes (prior to taxation) in different countries reflects many factors, including the demand after work skills on the labour market, legislation, scope of collective agreements, structure of employees with different level of attained education, extent of professional experiences of employees for individual occupations.

The data show that in many countries the decrease of proportion of people in the lower income categories is related to attaining higher levels of education. This result thus points at the correlation of incomes and the level of attained education. However, at the same time,

there are people recruiting from the lower income categories, who have higher education. These people experience a relatively lower rate of return on their investments in education.

Individual countries also differ very significantly from one another in the variance of incomes. In majority of OECD countries the majority of population has incomes exceeding the half of the median of incomes, however, lower than 1.5 of the median. The percentage varies from 45% of the population in Canada, through 51% in the United States, to 79% in the Czech Republic. Countries such as the Czech Republic, Belgium, France, and Luxembourg have relatively few people with low incomes, which are lower than half of the median. On the other hand, the average proportion of people of 25 - 64 years of age with an income exceeding 1.5 median amounts to 21% across the range of countries, low proportion of people with such incomes can be seen in Sweden (15%).

Countries also differ significantly in the representation of men and women in the group of low-income population. Hungary is, for example, the only country, where the percentage of women in the low-income group is lower than the percentage of men. The other end of the spectrum is occupied by Switzerland – with 44% of all women and only 16% of all men within the low-income group.

The extensive area of factors – from various institutional decisions to different personal capabilities – is very likely decisive for the scope of dispersion of incomes of individuals with similar level of education. On the institutional level, countries, for which the salary assessment is more centralized, tend to have a lower variance of incomes, and a resulting convergence of the work status and education attained. In broader terms, the dispersion of incomes also reflects the fact that the education attained does not always fully correspond to the skills and capabilities of an individual. The differences in the comprehension and execution of programs for adults also affect the national model of income distribution. Also other factors not related to expertise affect the income distribution – e.g. discrimination based on gender, race, or age.

At the same time, it is becoming more evident that the dispersion between incomes is decreasing in all countries with an increasing level of education attained. This trend can also be interpreted in such a way that higher level of education brings more information about the skills and capabilities of the potential employee, which results in the narrow correlation between education and salary.

It is generally possible to say that there is an attempt to understand the determination of income distribution. The research carried out in the United States showed that more than half of income differences of individuals of the same race and gender are not affected by qualification factors, e.g. years of school attendance, age, work experience, education, or occupation and income of parents. The research on determinants of income threw some light on the importance of so called non-cognitive skills – e.g. perseverance, reliability, responsibility – which leads to a greater number of questions asked with regard to the role of an educational system and namely with regard to education during early childhood stages, which is developing the above mentioned skills.

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Utility Maximization of Particular Engineering Constructions for Individual Users

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The utility of particular engineering constructions depends on utility definition. How to set definition is exposed in many papers [1-4]. Description of any building is specified on several levels. Model accuracy rises with quality of entry parameters. The quality of parameters gives a higher difficulty for their obtaining and their entering to the model. Each user has to determine for a rate of result accuracy. The user verdict has to impeach how much time and effort user is disposed to invest in this step. The programme application allows create object model only on several entered data. The created model will contain supposed list with structural elements on basic level. User will have a possibility to more specify parameters of each element in the model. This step will adjust the model to concrete object. Mentioned system of data entry allows full improvement of all module extensions in case user sets only a few description parameters. But the possibility to model adjust will be preserve.

The utility optimization of particular engineering constructions requires good knowledge in part technical and technological element parameters of object. But this knowledge is not sufficient only on particular elements. The analysis requires reflection of all elements in context with whole object. The next step is economical-administrative layer. This step involves economic-analyses, law relations and standard specifications. The base platform of model comes out from element description and relations among them. The utility rate is subsequently optimized for concrete user.

On the market is a presence of software products with different sight on the presented theme. Products differ in externalization to two directions. The first sight is based on connection with CAD system programs. The content is more aimed to the project area and economic parameters are considered as description data. The second sight goes out from accounting and there is an absence of technical object description. Several products take a view to both areas. But they have a lack of optimisation methods for presented model. Users miss solution suggestion for minimalization of cost trusteeship and cost services.

The base platform of application will be set on the database of construction elements. The system creates a proposed list of construction elements with their quantity. Calculations consist on the rate cost of construction elements and cost of whole object. This method is removing necessity of price level actualization on construction elements that is necessary in case database contain unit prices for concrete construction elements. The list of proposed construction elements responds to building type. Elements will imply in recalculation to financial sums. Economical data about "object life" will be linked to previews platform. Economical data present operating expenses, services cost and trusteeships. A registration covers all contracting relations with tenants, back payments, revisions etc. Additionally optimisation modules will suggest to the user steps in the area of building renovation and modernization considering utility maximalization for a concrete user.

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What an executive has to know about project management

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This paper is addressed not only to top-level executives who must provide their continuous support for all projects, but also to those project managers, project team members, and functional managers who must interact with top-level management during the execution of a project. The majority of the textual material are actual situations taken from the author's consulting practice and the seminars and lectures the author has conducted through the Czech republic. Executives are facing increasingly complex challenges. These challenges are the result of high escalation factors. These conditions have existed before, but not to the degree that they do today. As jobs become vacant, executives pressure line managers to accomplish the same amount of work with fewer resources, either by improving efficiency or by upgrading performance requirements to a higher position on the learning curve.

Because people costs are more inflationary than the cost of equipment or facilities, executives are funding more and more capital equipment projects in an attempt to increase or improve productivity without increasing labor. Unfortunately, the modern executive is somewhat limited in how far he can go to reduce manpower without running a high risk to corporate profitability. Capital equipment projects are not always the answer. Thus, executive have been forced to look elsewhere for the solutions to their problems. Almost all of today's executives are in agreement that the solution to the majority of corporate problems involves obtaining better control and use of existing corporate resources. Emphasis is being placed on looking internally rather than externally for the solution to these problems. As part of the attempt to achieve an internal solution, executives are taking a hard look at the ways corporate activities are being managed. Project management is one of the techniques now under consideration.

Project management is characterized by new methods of restructuring management and adapting special management techniques, with the purpose of obtaining better control and use of existing resources. The rapid rate of change in both technology and the marketplace has created enormous strains upon existing organizational forms. The traditional structure is highly bureaucratic and experience has shown that it cannot respond rapidly enough to a changing environment. Thus, the traditional structure must be replaced by project management, or other temporary management structures which are highly organic and can respond very rapidly as situations develop inside and outside the company.

The project manager's job is not an easy one. Managers may have increased authority and responsibility, but very little power. This lack of power can force them to "negotiate" with upper-level management as well as functional management for control of company resources. They may often be treated as outsiders by the formal organization. To be effective as a project manager, an individual must have management as well as technical skills. Unfortunately, businessmen sometimes find it difficult to think as engineers, and engineers find it difficult at times to think as businessmen. Executives have found that it is usually easier to train engineers rather than businessmen to fill project management positions. The average age of project managers in industry is between thirty-two and thirty-eight.

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within the UW project management framework. Learning objectives include developing clear project charters and goals, accurately estimating project time and cost, eliminating scope creep, dealing with labor- or material-related resource shortages and establishing feedback systems to ensure project control. Project management answers all your questions about:

- Use project tools such as Gantt charts, critical path method (CPM), and program evaluation and review technique (PERT) charts.
- Describe the purpose and benefit of project risk analysis. Develop a control plan to document and hold the gains, and implement control and monitoring systems.
- Identify and help resolve negative dynamics such as dominant or reluctant participants, groupthink, feuding, the rush to accomplishment and digressions.
- Select the proper vehicle for presenting project documentation (e.g., spreadsheet output, storyboards, etc.) at phase reviews, management reviews and other presentations.

During the past ten years there has been a so-called hidden revolution in the introduction and development of new organizational structures. Management has come to realize that organizations must be dynamic in nature. That is, they must be capable of rapid restructuring should environmental conditions dictate. These environmental factors evolved from the increasing competitiveness of the market, changes in technology, and a requirement for better control of resources for multiproduct firms.

Unfortunately many companies do not realize the necessity for organizational change until it is too late. Management continually looks externally for solutions to problems rather than internally. A typical example would be that new product costs are continually rising while the product life cycle may be decreasing. Should emphasis be placed on lowering costs or developing new products? Even the simplest type of organizational change can induce major conflicts. The creation of a new position, the need for better planning, the lengthening or shortening of the span of control, the need for additional technology (knowledge), and centralization or decentralization can result in major changes in the sociotechnical subsystem. We can define conditions that form the basis for organizational change requirements:

- Discuss project and business drivers and how a project integrates into the overall organizational goals.
- ↓ Identify key metrics that predict or track project success.
- **↓** Define processes and determine their interrelationships across the organization.

Quite often project problems are kept well hidden and never come to the surface. How should executives and managers get their people to escalate the problems to the surface instead of hiding them? Therapy sessions, group discussions or individual counseling appears to be the best method. Many times employees are more open with outside consultants than with internal management.

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Marketing Management of a Technical University

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Success today in the competitive battle between universities to attract students depends greatly on the ability to collect information on the future goals and plans of students as well as information regarding the needs of companies, industry, and other employers. The methods and principles of marketing-oriented management play a vital role in this competitive battle. The strategic decisions of technical universities must be comprehensive and must lead to taking full advantage of the strategic possibilities in creating programmes of study that reflect the needs of society. The subsequent success of technical university students in the job market increases the attractiveness of these schools.

Despite the fact that there are substantial differences in the process of establishing priorities, it is clear that the basic requirement is a continual dialogue between the university and its clients (students) on the basis of the use of all relevant data. With respect to the demographic, social-cultural, and economic development of the Czech Republic as a country with advanced engineering industry it is possible to find methods and tools for increasing the competitive ability and attractiveness of Czech technical universities.

The creation of a marketing study was commenced during the 2005/2006 academic year with the goal of measuring the appeal of the Faculty of Mechanical Engineering at the Czech Technical University in Prague to secondary technical school and high school graduates.

In order to conduct a marketing study it was necessary to create a relevant questionnaire to gauge the position of the Faculty of Mechanical Engineering at the Czech Technical University in Prague among graduating classes in high schools and secondary technical schools. It was necessary to draw up a questionnaire that would provide information for introducing principles and methods of marketing-oriented management at the faculty level as well as at the level of individual departments.

The marketing study is composed of an analysis of the current marketing aimed at applicants, an assessment of research methods for determining the expectations and the knowledge of applicants to the Faculty of Mechanical Engineering, an assessment of methods for collecting information on applicants, students, and graduates, and a definition of tools for effective marketing management.

The marketing study is focussed on getting to know potential students before they send in their school applications. A questionnaire was chosen as the method for determining secondary technical school and high school students' perceptions of the Faculty of Mechanical Engineering at the CTU in Prague.

The results of the research clearly indicate that the further progression of a student from a secondary school to a university depends on the type of the secondary school and the field of study the student had already chosen in the ninth class of elementary school. Students at secondary industrial schools have excellent regard for the Faculty of Mechanical Engineering and in the majority of cases submit applications. High school students lean toward study programmes they regard as easier, such as economic and humanity oriented universities, and their knowledge of the Faculty of Mechanical Engineering is minimal.
In order to attract new students it is necessary to focus not only on the promotion of the Faculty of Mechanical Engineering but above all on the promotion of the education programmes the faculty offers.

It is important to create a clear, comprehensible, and complete presentation of the faculty for the marketing oriented management of the CTU in Prague. It is necessary to concentrate increased attention on high school students, who should be better equipped to manage the computationally demanding subjects and would be less inclined to drop out after the first years of study. The faculty must also focus on secondary technical school students and convince them that they will be able to manage the first years at university, in which they will mainly cover general information, thanks to preparatory courses and free seminars organized in the framework of the study programmes. The success of the information campaign likewise depends on the selection of employees who will make presentations at schools. These people must be able to captivate potential students and attract them to the faculty.

For successful marketing in the conditions facing Czech technical universities it is not enough to merely define and describe the mix of marketing tools that must be used; it is also necessary to define a strategy for the recruitment of new applicants in future years with respect to the needs of the job market. Research results are already being used to create promotional events in the 2006/2007 academic year.

The decline in interest in technical schools involves not only universities, but also secondary schools. During the marketing study the administration of the pilot technical school where the research was conducted on the graduating class requested that we create a similar questionnaire for ninth year elementary school students.

This research work was conducted by the Department of Enterprise Management and Economics of the Czech Technical University in Prague for the marketing needs of the faculty.

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Databases for the Calculation of Indirect Benefits of Transport Infrastructure

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In order to determine indirect benefits, i.e. for the inhabitants of the serviced territory, the following four assessment factors have been devised:

- increased number of job opportunities
- the effect of mobility on economic growth
- increased value of the territory
- environmental effects on the territory and inhabitants

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 territory, based on the description and calculation of difference consequences between the state unaffected by the new road and the state after its construction, a corresponding database must be obtained to serve for the calculation of the respective assessment criteria [1].

The basic data source – given by the need for territorial coverage of the whole of the Czech Republic – is the Czech Statistical Office or its respective publications or databases. Additionally, other sources may be used, both of application nature (e.g. intentions incorporated in territorial planning documents), research (monitoring the use of space by means of land use) or primary sources (own limited-scope investigation).

The overall analysis should not omit the effect of socioeconomic development up-todate, i.e. evaluation of potential prolongation of identified tendencies in time. The calculation itself applies data obtained by comparing the development on the territories affected by the infrastructure implementation against a "background" territory unaffected by such influence.

While monitoring the development aspect, analyses can be made at different periods, the ideal approach being uninterrupted (continuous) monitoring whose implementation, however, is unsuitable for many reasons (e.g. too much detail). For solution purposes, a yearly periodicity has been applied starting from 1990, with potential links to the sections under completion. The second approach is represented by one-purpose monitoring whose typical example is the census of population, houses and flats (SLDB) carried out in our country on a 10-year basis (the latest at 1.3.2001). Here, the wide scope of monitored data and sufficient territorial detail, in particular, contribute to the fact that the information coming from SLDB forms the basis of the developed methodology.

The selection of assessment indicators of indirect benefits of transport infrastructure must necessarily be preceded by discussions on the impacts resulting from such structures. For the sake of simplicity, our considerations will involve a higher order transport structure, i.e. a motorway.

Within the basic thematic spheres, the proposed database to be obtained for the purposes of performing the considered calculations contains the following:

a) Changes in labour market

The following indicators have been recommended for the assessment of changes in the affected regions:

- the number and sector structure of jobs in municipalities and its changes
- main directions and intensity of job-related travel from municipalities and its changes
- changes in unemployment rate
- qualification index

b) Transport situation

The principal assessment indicators of indirect benefits of transport infrastructure designed are:

- changes in the volume and composition of road traffic (based on the results of Traffic count by ŘSD ČR)
- changes in the number of cars owned by households/municipalities (SLDB, CRV MV ČR)
- changes in time-related accessibility of municipalities to major centres before and after motorway construction

c) Environment

In relation to the effects on the surrounding environment and inhabitants (including road safety) the following has been designed [2]:

- monitoring the number of inhabitants in a strip along high-capacity roads (100 and 500m) in comparison with the situation before implementation (mainly the effect of noise and air pollution)
- evaluation of the exposure of the respective territory based on land use records (types of land use)

d) Local development

The monitoring of local development will be based on the following indicators:

- the structure and amounts of budgets in municipalities
- monitoring of building activity in the vicinity of motorways
- technical infrastructure and services available in municipalities
- questionnaire-based surveys and controlled interviews with inhabitants, key entrepreneurs and representatives of municipalities
- other site investigations situation mapping, aerial photogrammetric campaigns

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Data Sources for Comparing Road Constructions with a View to Technical and Economic Aspects

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This contribution deals with data sources and models, which could be used for the life cycle cost analysis of road constructions. The main goal of this work is a proposal of a suitable model for comparing road constructions. Creating such a model comes from the need of society to increase the quality of road infrastructure, which is one of the most important factors for a harmonic and balanced regional development. Furthermore, in practice the selection process is often based only on finding the alternative with the lowest purchase costs, but this kind of selection falsifies the benefits of the other alternatives and seems to be insufficient. Repair, reconstruction and maintenance costs during their life cycles make a significant part of the total costs and that is why they have to be considered in a proposal or a selection of construction alternatives. This means that the optimum proposal of the road constructions' life cycle could significantly help to decrease construction, operation and time costs [1].

In order to devise the optimum construction alternatives we have to know all the information about their qualities and features. This kind of information can be divided into two basic groups – technical and economic data.

• Technical data include especially technologies, materials and their basic characteristics. The useful sources of technical and technological data could be the catalogue of road constructions' failures, standards and regulations concerning testing and designing road materials, technologies and constructions [2].

• Economic data have to do with the prices of construction materials, technologies and processes. The main data sources of this kind of information could be intradepartmental price lists of construction processes of some construction companies or standardized prices of construction processes.

For the comparison of solid or non-solid pavements several computer models can be used. All these models usually work on the same principle. They enable comparing purchase, maintenance, repair and reconstruction costs of selected constructions, considering various factors. The level of analysis details divides the models into simple and complex ones. The suitable computer model selection depends on the project purpose and entry data accessibility. The methodology is not unified in the Czech Republic and so it is necessary to find out the most suitable method how to solve this problem from miscellaneous alternatives [3].

The final outcome of this work should be a design of a model for comparing road alternatives, which could be used not only by investors, but also by contractors and road providers. The selection of the optimum road construction could lead to benefit maximization from the investors', road users' and affected regions inhabitants' points of view.

One of the possible solutions is using the "HDM4" program. It is an English computer model for road development and management, which is used in developed countries for technical and economic comparisons of road projects and for road investment programs 736

preparations. This model is quite exacting concerning entry data quality, but it provides a complex road management analysis. HDM4 is a world-wide reputable method and could be one of the main road projects decision-making instruments [4].

A suitable instrument for setting up the life cycle cost analysis could also be the "Pavement Management System". This model was developed more than 15 years ago to determine the pavement deterioration course during the life cycle and to select suitable maintenance, repair and reconstruction strategies.

The results of the analysis could include not only the selection of the optimum alternative from the existing constructions, but also the design of a brand new "superconstruction", which would have ideal qualities and features with a view to the whole life cycle. One of the assessment criteria for the comparison could be the requirement for decreasing the total time necessary for partial or full road blocks during the maintenance, repair or reconstruction processes. A special attention should be also paid to the use of recycled materials, which is advantageous for the environment, and so for the sustainable growth of the construction's life cycle as well.

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Curriculum Development with the Involvement of Industry

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Department of Management and Economics, Faculty of Mechanical Engineering, CTU in Prague together with Centre for Higher Education Studies are partners of international project titled "Development of Elements for Quality Assurance within practice oriented Higher Education (DEQU)". This project is funded by the Leonardo da Vinci program. The main objective of this international project consists in improving the QA processes at HEI with regard to the collaboration with enterprises emphasising involvement of industry in curriculum design. Five Higher Education institutions from different European countries (Austria, Czech Republic, Finland, Spain and the UK) take part in this project.

Within the frame of the project the pilot study was carried out serving as the first step for the creation of the mechanism of university – industry cooperation at regular and systematic basis. The purpose is to integrate the requirements and the suggestions of the industry representatives to innovate study programs especially bachelors study program.

To establish the mechanism of such cooperation, the university:

- should to know the employers and careers of graduates (information about the fields, about the companies where graduates work)
- should create the working group (Advisory Board) which is composed of members of university and representatives of companies which are employing graduates. The main activities of this group would be: the evaluation of existing study programs and courses, the recommendations and the proposals aimed at modification of existing study programs and at developing new one. This form of collaboration with industry could be important for accreditation process.

Overall pilot study includes following phases: Inquiry of graduates (questionnaire sending by electronic mail), Inquiry of employers (qualitative interviews), Establishment of Advisory Board, Review of study program.

Inquiry of graduates aimed at gaining feedback on the study programme content (Is the study programme in accordance with business needs?) at getting the suggestions (What could be involve in bachelor study programme to reflect requirements of business environment?), at finding out the companies where graduates work (to make the mechanism of industry-university cooperation more systematic and effective), at creating network of graduates contacts, closer relation with graduates. We have sent 120 questionnaires by email with cover letter and we have processed 55 received questionnaires. The questionnaire was composed from 22 questions and its length was 5 pages. Respondents of this inquiry were graduates which graduated between 2003-2006 (i.e. 3,5 - 0,5 after graduation).

Main topics of the inquiry: employers characteristics of graduates (name of company, branch of industry, position, character of work, satisfaction with actual work), graduates' evaluation of compliance of graduate skills and knowledge with requirements of business (professional knowledge, soft skills, languages), graduates' suggestions for improving actual

study program to meet actual business needs, graduates interest in collaboration with our department, graduates' interest in meetings organized by faculty. To obtain graduates' suggestions for improving actual study program we asked these questions: Could you evaluate the content of study programme provided by our department as a whole? And give the reason for it? In your opinion, what should be involved in this study programme to better fulfil the needs of industry, needs of business? In your opinion, what and in which way should be changed the process of teaching (delivery phase) to better fulfil the needs of industry, needs of business? Informally said: what do you appreciate and what could be better in your study?

We have obtained wide range of common and particular suggestions what could be improved. Moreover graduates expressed their interest in cooperation with the department in future (on different project, diploma works), interest to take part in meetings organized by faculty (possibility to create alumni club). Communication with graduates in the frame of the inquiry led to two perspective collaboration with companies. Names of companies serve also as database for choosing the respondents of qualitative in-depths interviews.

Centre for Higher Education Studies realised 9 in-depths interviews with chosen employers of graduates of Czech Technical University, field of study: management and economy of enterprise. There were small, middle and big companies employed about 10 % of graduates from 4 regions of Czech Republic. Respondents were directors of business, financial, control and personnel from mechanical, chemical and financial industry.

There were 6 main topics: skills of graduates, career of graduates, work experience, cooperation with HEI, bachelor study programme, rank of HEI in Czech Republic.

Employers expressed the weaknesses and strong characteristics of graduates. Strong characteristics: analytical thinking, high creativity, high adaptability. Weaknesses: capability to self expression (minimally one foreign language), capability to act, capability to present results of projects, lack of self-confidence. These findings were also confirmed by the results of graduate inquiry.

Employers and graduates mentioned the need of deeper connection between theory and practice. But not all of employers provide work experience, only 4 companies asked providing it – in most cases in the form of diploma work. All companies were pleased by those in-depth interviews, they wanted extend cooperation, they embraced memberships in Advisory Board. Bachelor study programme is necessary for them and he expressed the opinion that HEI in Czech Republic is comparable with foreign countries.

Both inquiries appeared to be useful for our intention to design study programme in cooperation with industry. Employers and graduates were pleased by the interest of our department. Collaboration with employers is beginning to develop based on these inquires. In next phase of this project we would like to create an active Advisory Board which should contribute to enhance cooperation between HEI and the employers.

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HONEYWELL OPERATING SYSTEM

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The Honeywell Operating System (HOS) is based on the Toyota Production System (TPS).

The Toyota Production System has long been hailed as the source of Toyota's outstanding performance as a manufacturer. The system's distinctive practices its kanban cards and quality circles, for instance have been widely introduced elsewhere. Indeed, following their own internal efforts to benchmark the world's best manufacturing companies, GM, Ford, and Chrysler have independently created major initiatives to develop Toyota-like production systems. Companies that have tried to adopt the system can be found in fields as diverse as aerospace, consumer products, metals processing, and industrial products.

The tactical knowledge that underlies the TPS can be captured in four basic rules. These rules guide the design, operation, and improvement of every activity, connection, and pathway for every product and service. The rules are as follows:

Rule 1:	All work shall be highly specified as to content, sequence, timing, and outcome.		
Rule 2:	Every customer-supplier connection must be direct, and there must be an		
	unambiguous yes-or-no way to send requests and receive responses.		
Rule 3:	The pathway for every product and service must be simple and direct.		
Rule 4:	Any improvement must be made in accordance with the scientific method, under		
	the guidance of a teacher, at the lowest possible level in the organization.		

All the rules require that activities, connections, and flow paths have built-in tests to signal problems automatically. It is the continual response to problems that makes this seemingly rigid system so flexible and adaptable to changing circumstances.

The rules of the TPS aren't explicit. So, how are they transmitted? Toyota's managers don't tell workers and supervisors how to do their work. Rather, they use a teaching and learning approach that allows their workers to discover the rules as a consequence of solving problems. For example, the supervisor teaching a person the principles of the first rule will come to the work site and, while the person is doing his or her job, ask a series of questions:

- How do you do this work?
- How do you know you are doing this work correctly?
- How do you know that the outcome is free of defects?
- What do you do if you have a problem?
- Which support do you need of your team or supervisors?

This continuing process gives the person increasingly deeper insights into his or her own specific work. From many experiences of this sort, the person gradually learns to generalize how to design all activities according to the principles embodied in rule 1.

All the rules are taught in a similar Socratic fashion of interactive questioning and problem solving. Although this method is particularly effective for teaching, it leads to 740

knowledge that is implicit. Consequently, the TPS has so far been transferred successfully only when managers have been able and willing to engage in a similar process of questioning to facilitate learning by doing.

It is obvious that the high production of quality vehicles with successful feedback from satisfied clients brought Toyota cars to the top of the world's manufacturers. In the year 2005 - 2006 the number of cars produced by Toyota surpassed Chrysler and Ford. The prognosis for the year 2007 is that Toyota will surpass GM and will be the world's number one supplier of automobiles.

The basic company philosophy is that any operating system can be improved if enough people at every level are looking and experimenting closely enough.

Honeywell

Since it was first introduced to Honeywell in 1995, Six Sigma Plus has been a key driver of productivity and profitable growth.

Formerly, the Kaizen system was used. This system had positive aspects which are still applied in some aspects of manufacturing and managerial processes. It is based on continual improvement. At all levels, employees with high initiatives are rewarded and sometimes even required to present proposals leading to better results.

The redeployment of Six Sigma Plus (Six Sigma and Lean Manufacturing) resources to the company's major initiatives the Honeywell Operating System, Functional Transformation, Velocity Product Development and Commercial Excellence speaks to the ongoing maturity of Six Sigma Plus within Honeywell and its ability to help drive what matters most to our business performance. The regular use by employees of Six Sigma Plus tools in their day-today work continues to accelerate, leading to stronger results and an inherent commitment to process improvement. Today, the tools and methodologies of Six Sigma Plus remain a significant source of competitive advantage for Honeywell.

From 2006 it was discovered that we had the tools necessary; however, something was missing. Many companies had copied the TPS, so they had tools such as Six Sigma and Lean Manufacturing. Still, these companies didn't reach the some success as Toyota. The problem was that TPM is not only a tool it is a way of how to think. One of the key factors is that at Toyota every operation and every step is standardized. You can have the tool to cut back the waste, but you will still have variance in the process. This means that every worker will do his or her work differently. There is no quality when variance is present.

We still have to learn from the Toyota Production System. At Honeywell Brno we have a mission statement part of which says *Better Every Day*.

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Dangerous Information Sharing in Business Clusters

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Czech Republic turned to market mechanism in 1989. Czech economy has changed from directive economy to functional market mechanism of valid EU member in the last 15 years. Competition and especially its protection is dynamic sector with very quickly changing conditions.

This abstract points out possible problems of sharing and gathering information in group of firms, especially in business clusters (business cluster has to be understood as a group of firms, individuals, universities and other institutions connected to each other in some particular specialization or cross specializations, vertically or horizontally, sharing information, costs of development, marketing etc. in order to development of each member). On the one hand clusters gain massive support from government (CzechInvest Agency), on the other hand Office for the Protection of competition (the Office) in Brno (www.compet.cz) judges clusters as any other deals so there must be the same respect of the competition law. It doesn't dispute competitors' right to fuse for purpose of effective cooperation, but the competition must not be harmed or at least, moderate disturbance must be equilibrated with advantage for the other participants of competition, especially for customers(if a smaller number of small competitors starts cooperate to compete transnational company, it is possible to consider such a cooperation even useful. For such cases exists rule called *de minimis*).

In the case of clusters it is clear that cooperation is between competitors (rivals in horizontal relationship and suppliers in vertical relationship) and the risk of breaking the competition rule can be very serious. It is strictly forbidden among the other things collectively gather information concerning of prices, planned sales volume and other sensitive or strategical data, which use could lead to direct or indirect fixing the prices, sales volume control, dividing of markect etc.

How to share information?

The way how to share information is different in group of firms and individual company. There must be rules for gathering and sharing information in such a group not to harm competition law. Gathering information should always be done outside of cluster by the third person, not connected with cluster with some security standards. It is possible to have a manager of cluster doing this kind of job, but the risk is higher. There should be absolutely independent specialist doing it to be sure the risk is low. There should always be the reason well defined for gathering information and the compliance with the competition law evaluated. It is not possible to gather information, which general helpfulness cannot be properly claimed.

Only historical data should be collected and the participants of cluster should get such information in aggregated and anonymous form in which wouldn't be possible their next individualization.

Collective gathering of data by authority of cluster concerning of e. g. prices, sales volume, purchase, export, import, investment, research, know-how and specialization is problematic, especially if happens in individual form for each member of cluster and if uses present or supposed future data. From many decisions of the Office and European commission results that discussion between competitors concerning of intended market behavior of individuals, e. g. intended price making steps, marketing, business strategies, 742

contracts, capacity utilization etc. can be, especially on concentrated markets with smaller number of competitors as anti-competitiveness behavior.

The discussion of survey results should be in the similar way, thus general, harmless information. It is highly appropriate this harmless data equalize to the third person on demand or publish them.[1]

Up to now survey results

How is mentioned above in consciousness of cluster members is currently being part of my survey. I have drawn conclusions from the preparatory questionnaire and consultations with specialists from the Office:

- 1) There really is some danger of breaking the competition rules in the field of gathering and use of information
- The Office hasn't solved any problem of breaking the rules yet and it doesn't have high priority nowadays
- Cluster members have some notion of competition rules, but are not systematically interested in it
- 4) Even if companies are fully responsible for their behavior, field of competition law is not being considered as a basic manager knowledge.

Conclusion

The all problematics looks like not very important object of interest of companies or government from my survey. The possibility of braking the competition rules in clusters are underestimated because nowadays is being "in" to support clusters as a very important part of economics of the Czech Republic. We all are equal before the law and if not today, one day it may cause serious problems to clusters not respecting this basic rules.

List of seven advices for business cluster members:

- 1) Cluster has to be open to everyone. It is not elite club.
- 2) Do not talk about prices, markets and customers
- 3) Have exact, generally respected rules for cooperation
- 4) Evaluate regularly if there is no possibility of braking the competition rules
- 5) Declare the equality of members
- 6) Remember, that the Office for Protection of Competition is watching you

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Technical-Financial Integration in Enterprise Control System

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For each element of ECS is possible to define its technical and financial characteristics. Technical characteristics are possible to measure by technical indicators and financial characteristics are possible to measure by financial characteristics. If we change technical characteristics of a certain process (change in technical solution, technology etc.) it will change financial characteristics of process (costs). Between technical and financial characteristics is actually a causal relationship. Finding out of efficient level of integration is looking for links between basic elements of ECS. Only quantification of these links is not enough. Only existing of these links is not guarantee for functional relationship between investigated elements of ECS. It is necessary these links in detail characterize.

From T-F integration point of view basic elements are:

Outputs

Outputs are products or services, which an enterprise produces or provides. By selling products or services an enterprise earns money. It is actually the primary interest of an enterprise. From managerial reasons, it is possible to aggregate outputs into products sets or products groups.

In T-F integration context is supposed that output is product respective product group, which has technical characteristics and financial characteristics.

Technical characteristics of product respective product group are: construct solution of product, time consumptions of product, used material, used manufacturing technology, kind of packaging etc.

Financial characteristics of product respective product group are mainly costs (costs per unit respective costs per product group). It is possible to work also with contribution margin generated by product respective product group.

Processes

Processes are timely sorted activities organized in order to make outputs or to support making outputs. From this point of view is possible to divided processes into:

- production processes these processes directly make outputs (products, product groups),
- □ support processes these processes prepare conditions for production processes

In T-F integration context is possible to identify in processes technical characteristics and financial characteristics.

Technical characteristics of processes are: process capacity, technology solution of process, organization solution of process (which centers and how take part in process, which activities and how take part in process), time consumption of product within process, etc.

Financial characteristics of processes are mainly costs on partial process (also in time expression)

Activities

Activities are partial elements of processes, but their sense within T-F integration is crucial, therefore in the context of this dissertation activities are independent elements in ECS. Accordingly, every activity belongs to certain process (production or support) and belongs to

certain center. Every activity belongs only to one center, in this context it is very important assumption.

In T-F integration context is possible to identify in activities technical characteristics and financial characteristics.

Technical characteristics of activities are: organization solution of activities (on which processes activities take part), consumption of activities on certain output, etc.

Financial characteristics of activities are mainly costs on partial activities (also in time expression).

Centers

Centers are determined by organizational solution of an enterprise. In spite of sense of process control is increasing, the traditional sections (centers) still have sense. In centers all enterprise resources are allocated. Thanks to existing of centers these resources are controllable. Enterprise resources allocated in centers:

- □ tangible resources
- □ intangible resources
- □ human resources
- financial resources

Financial resources mean allocated financial resources into centers regardless of kind of resources (shareholder's capital or foreign capital). Tangible, intangible and financial resources are evidenced in company's balanced sheets. Only human resources are not evidenced in these balanced sheets, although they have crucial sense for whole company.

In T-F integration context is possible to identify in sections (centers) technical characteristics and financial characteristics.

Technical characteristics of sections are: section capacity, technological equipment of section, etc.

Financial characteristics of activities are mainly costs (budget of section, costsin time expression – hour overhead tariff etc.).

Resources

Resources (tangible, intangible, human and financial) has already mentioned previous article about sections. For decision making about processes is important to measure how processes contribute to economic value added of enterprise, therefore it is crucial to know origin of capital (shareholder's capital or foreign capital).

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The attractiveness study of selected industrial sectors

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This study has been elaborated within the scope of finding alternative manufacturing programme in order to utilise unoccupied production capacity of important domestic engineering enterprise. Due to request of the enterprise, its name is not mentioned.

The enterprise is focused in custom-made and small batch production with superior quality. It faces the problem of idle capacity on a long-term basis, especially in the field of large-area moulding, cutting operation, heat treatment and surface finishing of parts made of alluminium alloys, high-strenght and stainless steels and in the field of preparation and tool manufacturing. The study serves as a basis for attractiveness evaluation of selected industrial sectors.

For purposes of attractiveness evaluation, several statistics published by the Ministry of Industry and Trade of the Czech Republic have been used. These studies make use of processing industry classification in accordance with OKEČ - Industrial Classification of Economic Activities. On a basis of depth inner background analysis and manufacturing capabilities of the enterprise, six industrial sectors have been selected. Manufacture of food products, beverages and tobacco (OKEČ 15), Manufacture of chemicals, chemical products and man-made fibres (OKEČ 24), Manufacture of steel constructions and metalworking products (OKEČ 28), Manufacture of machinery and equipment n.e.c. (OKEČ 29), Manufacture of self-propelled motor vehicles, trailers and semi-trailers (OKEČ 34) and Manufacture of other transport equipment (OKEČ 35). Within the scope of these economic activities, economics characteristics such as revenues from sales, costs, value added, productivity of labour, number of employees and exports were monitored, including its progress between years 2000 and 2005. Further, the interannual revenues rates of growth in industrial sectors were evaluated. Growth ratio CAGR (Compound Annual Grow Rate) for years 2000 - 2005 has been used as a long-term characteristic. The result of this analysis is briefly summarized below.

As a whole, processing industry significantly participates in generation of GDP (25,5%) and its interannual rate of growth exceeds the value of 8% (GDP growth ratio 6%). This positive dynamism is mainly caused by foreign capital inflow and easier access to the European market associated with admission of Czech Republic into the European Union.

Within industrial sector Manufacture of food products, beverages and tobacco (OKEČ 15), use can be found mainly in the area of tank and container manufacture, other parts of production lines and its surface finishing. The revenues rate of growth is significantly lower (2%) inferior to that in whole processing industry, especially due to oversaturated European market. Even in a medium-term horizon, noticeable reviviscence cannot be expected. Manufacturers of food products are forced to increase the production quality in order to become able to compete with European producers. With regard to this fact, extensive investments have to be made, and this is the situation, where the enterprise can assert.

Revenues rate of growth in sector Manufacture of chemicals, chemical products and man-made fibres (OKEČ 24) is substandard (5%), mainly due to the high oil and energy prices. It is also affected by tight legislature in the European Union. In 2005, this led to greatest efflux of capital among all processing industry sectors. Attractiveness of this sector is contingent on renovation of obsolete domestic production units, which is held off on a long-term basis.

Between years 2000 and 2005, sector Manufacture of steel constructions and metalworking products (OKEČ 28) noted positive progress, CAGR (Compound Annual Grow Rate) reached 10 % value. Significant growth has been reported in following sections of this sector – Surface finishing and heat treatment (OKEČ 28.5) and Tools and ironwork products (OKEČ 28.6). This growth has especially been caused by considerable proliferation in automotive industry, which is closely linked to this processing industry sector.

Situation in Manufacture of machinery and equipment n.e.c. (OKEČ 29) can also be regarded as good, between years 2000 and 2005, CAGR reached almost 12 % value. Positive turnaround has been noticed in Manufacture of agricultural forest and machines (OKEČ 29.3), first of all due to traditional tractors manufacturer Zetor Brno, which has succesfully restructured, asserts oneself on markets lost in the past and constantly raises production. Positive progress can be assumed in manufacturing of lifts and escalators. Approximately 80 000 lifts are to be replaced due to the fact that they are nonconforming to valid regulations. On the contrary, only small growth is anticipated in manufacturing of machine and moulding tools.

Manufacture of self-propelled motor vehicles, trailers and semi-trailers (OKEČ 34) comes through a period of rapid growth. Especially thanks to long tradition of automotive industry in our country, lots of capital investments flow in. Even progress in the future is predicted to be positive. Increased production has been announced by both major motor car companies (Škoda Auto, TPCA) and bus manufacturers (Karosa, SOR Libchavy). Further development of this sector will be affected by completion of car manufacturing plant by Hyundai. In 2010, the production will reach full capacity of 300 000 cars per year.

In comparison with processing industry, Manufacture of other transport equipment (OKEČ 35) records lower growth rate (5,3%). Positive advancement is anticipated in dominant section Manufacture of rail vehicles (OKEČ 35.2), where demand of both domestic and foreign (Italy, USA) customers is expected to rise. Auspicious lookout is assumed in section of ultralight planes, where sharp raise of demand is expected, mainly due to liberalization of legislature in the United States of America. Demand is estimated to approximately 11 000 new ultralight planes per one year.

Generally, within the frame of Czech Republic, the most attractive sector is automotive industry. Basic barrier for analyzed enterprise to entry is a high level of productivity and seriality in this sector. For these reasons, it is necessary to focus on activities with high rate of value added, such as manufacturing tools and preparations. However, opportunities for utilising unoccupied production capacity have to be looked for in other perspective sectors too.

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Application Conditions of Vertical Alternative of Hour Overhead Tariffs Method

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The major aim is to describe under which conditions the *Vertical alternative of Hour Overhead Tariffs (HOT) Method* can be beneficial in application and which benefit can be taken from its application.

The Hour Overhead Tariffs (HOT) Method is based on this simple fraction:

$$HOT = \frac{OC[CZK, \$]}{CAP[hours]}$$

which links overhead costs with in hours expressed capacity.

Overhead Costs (OC) are the center's costs, departmental costs, process costs, activity costs, workplace costs, etc., which are caused by installed capacity of tangible, intangible, human and financial sources in particular centers, process, activity, etc., responding to expected (actual) scope of capacity utilization and are budgeted (recorded) for given time period (year, month). *Capacity (CAP)* is a capacity expressed in hours expected (actual) to be utilized in particular center, process, activity, workplace, etc. (entity), responding to expected (actual) size of overhead costs and are planned (recorded) for given time period.

From *the basic alternative*, which has one hour tariff for each entity, were derived three other specific alternatives according to the practical request of the managerial needs: *Items alternative, Vertical alternative* and *Controlling alternative*.

Concerning *on the vertical alternative of the HOT-Method* these characteristics from the application point of view are decisive: The major areas of the application are two: expensive *manufacturing* centers or processes and *research and developmental* centers and processes. Generally expressed: The major benefit can be expected in these applications, where within one bigger entity (center, process) are smaller entities (workplaces, machines, staffers) with either significantly different costs or capacity utilization or with both of them and these single entities can be applied also for another processes or independently from the particular process. The main feature is that one value of the HOT for particular entity is split into mostly two HOTs, each of which describes particular entity.

In the *manufacturing center or process* one HOT is linked with the particular workplace or machine. *The other HOT* is linked with the rest of the center or process, which serves to all the workplaces or machines. That means that each particular workplace or machine in the center has its own HOT which is determined by its costs, which can be allocated to the particular workplace or machine, and by its capacity. Then exists one HOT of the common utilities of the center, which is determined by the size of costs, which cannot be allocated to the particular workplace or machine, and by the common center's capacity. The application in the manufacturing center or process is reasonable, if there are specific and expensive workplaces (machines) in the centre or in the process or in the particular activity, if the costs of the single workplaces (machines) in the center differ significantly or if some workplaces

(machines) are used in a different mode then others - mostly in a higher or in a lower capacity utilization.

In the *development, research, design or consultancy department or process:* Instead of the workplaces the groups of the staff are considered (senior consultant, junior consultant, assistant consultant) according to which size of cost and how much capacity for productive activities is linked with them. The application is reasonable if there are significant differences in the personal and the equipment costs and in the capacity on disposal.

The vertical alternative offers a very truthful overhead cost calculation. It uses the hour overhead tariffs, which are created as a result of strict allocation of the costs and capacity to the particular entities (subjects) - in this case to the workplace and to the center - according to the real conditions. On the other hand this alternative is more laborious, proportionally to the number of subjects, which each has its own HOT.

For product costing this relation can be used:

Overhead costs allocated to the k-th product:

$$OC_{k} = \sum_{i=1}^{n} \sum_{j=1}^{m} (t_{kij} \cdot HOT_{WKPj}) + \sum_{i=1}^{n} (HOT_{CTRi} \cdot \sum_{j=1}^{m} t_{kij})$$

where:

$\overline{OC_k}$	calculated overhead	cost to <i>the k-th</i> product				
t _{kij}	time consumption preparation, etc.) of	(laboriousness + other needed time, like workplace <i>the k-th</i> product at <i>the j-th</i> workplace in <i>the i-th</i> center				
HOT _{WKPi}	hour overhead tariff of <i>a j-th</i> workplace					
HOT _{CTRi}	hour overhead tariff of the common overhead costs in the i-th center					
Indexes:						
icenter		n = number of the centers				
jworkplace (machine)		m = number of the workplaces in the particular center				

<u>Conclusion:</u> Laborious but very precise method for integrated capacity-cost assessment of the entities like centers, processes, activities, workplaces, staffers, etc. and for an exact approach to product costing in highly expensive processes.

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Renovation and Maintenance Processes during Building Life Cycles

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This contribution gives publicity and supplements the poster presentation at 3^{rd} International Conference on Project Management (ProMAC2006) which was held in Sydney on $27^{th} - 29^{th}$ September 2006. The poster presentation was discussing about the model of the interdependencies in renovation and maintenance processes during building life cycles.

The LCC analysis can provide important inputs in the decision making process in the building planning. An important component of the life cycle costs (LCC) of buildings are the costs for renovation and maintenance. The model is possible to determine these costs for the entire life of a building. The information system is based on the principle of a fixed algorithm and reference databases of buildings and constructional elements between which are established mutually dependent links.

The created information system allows owners of buildings, even when knowing only basic or incomplete data on a building with various degrees of accuracy and reliability, to optimize the financial management of one or more buildings regardless of their type, age and quality of maintenance.

The benefit of using LCC in the building practice is the possibility of determining annual costs of a building or engineering work already in the planning phase as well as providing minimal annual costs in the selected quality or optimalization between costs and quality.

Within contemporary public procurement there are often left out criteria connected with the life cycle costs of buildings. Public competitions are often based only on the principle of lowest price quotation without considering if costs of improvement, maintenance and demolition in future will be more than average or not. Nevertheless, it is necessary to consider all costs that are connected with the project life cycle of a building when looking at submitted offers.

There is a lot of known or ascertainable information about technical and economic condition of the building objects. These inputs spring from more or less reliable sources, they have various significances, various exactness and they are variable at the time. Responsible decision about business financing (especially a maintenance and repair) based on this casual mixture of information is very difficult, as we did not know the inaccuracy rate of our decision.

It is possible to create the information system by the assembly and layout of all relevant data on the technical and economic condition of a building object valid to the fixed date into the unified input data scheme. This information system described by author in [1] will allow building object owners (managers) expertly and effectively to take control of the object costs and revenues and its method of utilization.

The model of LCC analysis of building objects is based on the principle of fixed algorithm input data processing by means of a building production reference database. An

essential part of this model is also the assessment of mutually interacting relationships between particular construction elements and works, more in [2].

The result of the project in 2006 is the basis of a model for the technical and economic analysis of buildings. The basis databases of buildings and construction elements have been created. The database of buildings is broken down into 7 categories of building with each category containing a clearly defined group of buildings. The database has a total of 102 defined model buildings. Each of them has an assigned structure of elements from the database of construction elements with their volume and service life with the aid of the conversion matrix. The service life of individual constructions and work is set such that the functionality of the elements is preserved; it also takes into account obsolescence due to technical progress.

The basic links between the performance of the renovation and maintenance of individual construction elements have been defined. 3 types of link have been identified – fully dependent, dependent with optional scope (%), recommended with optional scope.

This model is the first module of a tool for determining the total life cycle costs and their analysis.

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Structural equation modeling as a tool for evaluation of strategic investment into modern technologies

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Present theoretical and practical approach for investment' evaluation into modern produce technologies are built mostly on evaluation of technical parameters and financial effects of investments. Another evaluation of contributions of Non-financial (quality) character is still out of attention for the most part. In the area of appreciation qualitative effects and its following implementation into the complex model of evaluation is being opened wide free area for research. New Structural equation model (only SEM) of evaluation of investments is discovering macroeconomic view on complexion of investment evaluation with other advantages, which are very difficulty for quantification. For example: increasement of produce flexibility, short delivery time and increasement of produce quality.

Main aim of this work was creating SEM model, which could help with complexion investment evaluation into modern produce technologies. SEM model is solving shortness of present particular approach for evaluation of investment. They lead to non-objective evaluation investments variants and also for failed result. Necessarily correlation analysis with the software support made it possible effective application in concrete industry practice condition. For application of concrete data has been knowledge from association of car industry in the Czech Republic from 1995 – 2004. During the research has been used correlation analysis, which has showed relative fixed connection: A firm's innovativeness mediates the relationship between quality and growth. Correlation coefficients for line $r_{Zu} = 0,1584$. Correlation coefficients for parabola $r_{ZII} = 0,4681$.

Technological development is bringing new constructive and technological results of suggested machines. In the process of appreciation contributions of modern technologies in impossible miss out effects in the area of the most important and competitive factors of success, for example: flexibility, quality, fast of innovation and so on. Evaluation of these strategic effects involves specifically access.

This designed access for evaluation of investments is to considerable measure original. It is coming from research of wide spectrum of foreign literature. They are focusing on technical, economical and market aspects of modern produce technologies. Into this result belongs creating of system of effects, investment and methodology for their evaluation. Original rates as in particular creating of metric for strategic measure, respective qualitative effects of modern produce technologies. New SEM model for evaluation of investment into modern technologies overreach with its complex scope of traditional accesses for evaluation of investment. You can observe them in special literature and company practice. Above standard it is possible to consider also creating of software support of SEM model, which could help with simulation and effective implementation of model in company practice. Creating of SEM model for completive investment evaluation into the modern produce technologies take out particular research of complex potential of technical, financial and qualitative effects of these technologies. For every effect, respective for every area of effects were created metric, which could help with appreciated concrete effects.

Especially in the area of quality are effects opened free for original suggestion and results. In the next process of research there will focus on creating of SEM model, which is concerning only on one investment and its relevant evaluation. After process of correlation analysis is necessary to set up the main figures like ROA, ROE, ROI etc. They can show the secondary results after correlation analysis, which can verify our results and inspire managers for substantial resolution. Main aim will be also creating of informative support of SEM model for investment evaluation into the modern technologies.

SEM model will supply by software support with right simulation and analysis of feeling. Process of creating of SEM model is necessary to use direct contacts with domestic or international companies for better validity of SEM model and to analyze critical places in the process of its implementation. It could be supported by question-form. These kinds of questions are helpful for customers, but as well for investors (managers, owners of companies). They should show, how investment affects our investment and then Growth or Quality of product or service.

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Problems of Old Ecological Burdens at Brownfield Redevelopment

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The primary goals of brownfield redevelopment are to reduce public and environmental hazards on existing commercial and industrial sites that are abandoned or underused due to these hazards. On that score it is necessary to create financial and regulatory incentives to encourage voluntary cleanup and redevelopment of sites and derive cleanup target levels.

The initial step before starting remediation is ecological audit which is based on the assessment of productions, which were used in the given grounds in the past and evaluates an amount of used dangerous substances. The next very important step in verifying contamination range is ecological risk assessment. This is a total evaluation of the rate of ecological and health risks that are or may be caused by chemical burden of rock environment, groundwater contamination, hazardous waste dumps or by building structures.

Contaminant	Occurrence	Contamination	Health risks
		source	
Arsenic	The most at the city	Vehicles, industrial	Harmful to central nervous
	centre, otherwise	technologies, fossil	system, cancer effects air
	everywhere	fuels combustion	passages
Cadmium	Importantly around	Processing of non-	Cumulates in livers with
	Pal Kbely, otherwise	ferrous metals, fossil	retention more that 10 years,
	irregularly	fuels and waste	violate Ca, P and vitamin D
		combustion	metabolism, causes bones
			softening
Nickel	Irregular band from	Anticorrosion alloys	Harmful to air passages,
	SW to NE	production, batteries,	internal organs (brain, livers,
		aircraft industry	kidneys)
Lead	The most at the city	Vehicles, coagulates	Harmful to central nervous
	centre, along the	and creates very mobile	system, dangerous for pre-natal
	main vehicle routes	powder aerosol	humans and babies
Mercury	The central part of,	Atmospheric emissions	All forms are toxic, in
	Holešovice, Libeň,	arising from the fossil	particular organic compounds
	Vysočany	fuels combustion,	
		sewerage sludge	
Organic	The most at the city	Incomplete combustion	Toxic effects on human
contaminants	centre, along the	of engine fuels,	organism, threat to the
(PAU, PCB)	main vehicle routes	evaporation from	environment
		supply fuel tanks	

Table 1: Distribution of major contaminants in surface layers of Prague's agglomeration soils

In this distribution I present results of surveying the contamination in the surface layers of Prague's agglomeration soils for the purpose of founding out distribution of major contaminants and evaluation of health risks for inhabitants (Tab. 1). The investigation of soil contamination proved that the main sources of contamination are except for prevailing vehicle transport also industrial emissions caused by out-of-date industrial technologies, fossil fuels combustion and hazardous waste dumps.

As results from the Table 1 the most risky elements are arsenic and lead both being harmful to the central nervous system and air passages. The lead is also hazardous for the groundwater, because creates very mobile powder aerosol lasting 7-30 days. The mercury contaminates soil around the manufacturing works and its danger lies in the accumulation in vegetable and animal organisms.

Remediation of contaminated land depends on the evaluation of ecological risk assessment. Commonly the simplest and the most widely used remediation technique is covering the contaminated soil with uncontaminated. But this method is only effective where contamination is not mobilisable. Excavation and disposal in an engineering landfill is another widely used technique. More sophisticated, potentially more effective remediation techniques include for example physical treatment (vertical barriers, liners), hydraulic methods or bioremediation methods.

Remediation is contracted out by the new potential owner. It is suitable to have a few variant solutions and to choose an optimum variant including financial estimation. New constructions which have been constructed so far on the former brownfields in our country usually use the simplest technique of remediation, i.e. removal from the land. Some of them, i.e. KBP project applied barriers and pocketing and obviously groundwater remediation by means of boreholes.

Brownfield sites have become a persisted problem which cannot be alleviated by the normal process of modernising the built environment in cities. Brownfield redevelopment can assist in achieving the objective of integrated and sustainable land management. The positive outcomes of the redevelopment of brownfield sited include:

- remediation of many thousands of sites;
- the physical, social and economic regeneration of cities and regions;
- significant levels of private sector investment;
- dynamic partnership within cities.

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VBA Procedures Used in the Decision Supporting Tool in Expert Judgments

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Expert judgments (EJ) applied in decision support significantly reduce the time needed for the mathematical modeling. On the other hand the expert judgments always influence the final result by certain level of subjectivity. The classification of the methods for elimination the subjectivity from EJ is obsolete and the methods are often inapplicable in current modern world.

Decision strategy depends mostly on the accessible information; the problem doesn't exist when the decision maker doesn't have the choice at least from two alternatives. Decision tasks can be generally categorized as the *holistic* problems or the *experimental criteria selection*, problems what can be again sorted as the *repeatable* problems or the *unique* problems.

The holistic problems must be perceived intuitively by the decision maker and the decisions must be made according to this perceiving. The decision maker must be capable to identify these holistic problems and must be capable to form the decisions without braking down the problems to the elementary units (sub-problems).

Experimental criteria selection problems are more structured and usually very complex for being solved just by the intuition. Therefore the decision maker can not be capable to make the decisions himself and the problem must be analyzed and re-structured with the application of the expert judgment, than it must be sliced to the elementary units (sub-problems). The decision criteria for each sub-problem must be set and the information from the current status of the system must be gathered.

Typical attributes for the unique experimental criteria selection problems are:

- lack or complete absence of the objective quantitative information;
- poor possibility or impossibility to formalize the problem;
- uniqueness of the problem (no experiences with similar problems)

- complexity;

- insufficient structuring or integrity.

Critical tasks for solving complex problems are:

- identification of the problem (consists of analysis, determination of the possible solutions set, determination of the characteristics of the alternatives);

- measurement and calculation (assignment of numeric or similar values to the characteristic alternatives, setting of the relative weights for each alternative);

- interpreting and the decision forming (selection of the best alternative or elimination of the inefficient alternatives or re-sorting the set of alternatives);

- realization of the decision (realization of the best alternative).

Unfortunately there always exists a certain level of the primary information 'subjectification'. This is the tax for the expert judgments used for the re-structuring of the complex problem. Numerous methods for elimination of the subjective information $(^{[1,3]}$ e.g. the method of the subjects evaluation, the subjects sequence sorting method or the pair comparison method) can be used. The question of computer automatization becomes frequently discussed. The VBA (Visual Basic for Applications) is a capable tool for such tasks. One of the most important phases of the expert judgment method application is the establishing of the expert team. Therefore the development of the VBA tool, what should assist for the efficient expert team selection and the minimization of the subjective information, was started.

Basic requirement of the expert judgment is that the team should assure the efficient and effective solution of the complex problem. The efficiency is defined as the possibility to achieve the predefined requirements; the effectiveness is defined as the possibility to achieve the requirements at the highest reliability and with the lowest costs necessary to be invested into the solution of the problem.

The developed ExJ VBA tool is capable to recognize easily the unusual or suspicious choices from the experts (overestimating, underestimating or the fault) and the fast identification of the suspicious choices could help the decision maker to filter-out the mistaken expert evaluations. Later the automated tools can easily perform numerous calculations from embedded expert evaluations (e.g. sorting, reforming, pair comparisons etc.).

In our case we created semi-automated VBA tool to provide re-sorting and graphical evaluating of the embedded expert evaluations. The tool helps also to re-calibrate the embedded interventions into pre-defined numerical scales (e.g. cardinal, ordinal or absolute scales, relative, interval, differential or nominal scales). The scales must be still predefined by the leader of the team since the current version of the ExJ VBA tool is not capable to estimate the scales automatically.

Further development of the tool is necessary; the possibility to implement more detailed estimations and improve the graphical interface for the user is challenging. Decision makers would also appreciate the automated pre-definition of the evaluative scales, in order to eliminate the still lasting subjective information from the expert team leader.

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Concept of Product Life Cycle Costing

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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 [lit. 1]. Manufacturers will have to assume a larger degree of responsibility for activities related to the life cycle of their products after the purchasing and installation stage. [lit. 3].

Life cycle management is an approach supporting sustainable development and the most efficient possible use of resources. Based on the life cycle concept the costs and benefits of strategic aims and choices can be understood and justified in a comprehensive manner. Life cycle management covers the entire life cycle of a product with a view to maximising value along the life cycle while meeting cost and environmental requirements. Integral components of this value are, for example, reliability, costs, manufacturability, operational capacity, usefulness, usability, recycling capacity and other environmental aspects [lit. 2].

One important part of life cycle management is life cycle costing. The objective of this calculation is to optimise the manufacturing, maintenance and operation of a product (e.g. manufacturing equipment) for the period of its usability based on establishing all the important cost items over this period. This facilitates a quantified assessment of various product design alternatives, comparison of cost items at various stages of the product life cycle and comparison between the stages with a view to choosing the optimal alternative.

The life cycle costing process includes identification of items to be monitored, identification of the cost structure, definition of links to estimate costs and establishing a method for formulating life cycle costs [lit. 4].

The cost items monitored include all costs incurred in relation to manufacturing of a product until its disposal at the end of its life cycle. The items should be structured so as to allow for identification of potential links between various items with a view to establishing optimal life cycle costs. The structure of cost items will always depend on the nature of the product and it should always facilitate life cycle cost analysis. The purpose of estimating cost links is to express cost items as a function of one or more independent variables. The final stage of the calculation process is determination of a method for formulating life cycle costs.

As regards manufacturing facilities, the calculation of life cycle costs is a means of achieving an informed and effective decision based on combination of initial manufacturing costs and operational costs. Here the life cycle costs concept entails considerations over all relevant costs and benefits related to the acquisition and use of the facility.

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Despite businesses' growing awareness of aspects related to life cycle costing the use of this method in corporate practice is still insufficient. There is a number of reasons for the generally lower level of acceptance of the life cycle costing method. One of major reasons is lack of motivation resulting, above all, from insufficient trust in the outcomes and achievements of the methodology. It is important to overcome the current situation where preference is given to assessing products based on manufacturing costs, and to short-term effects, where the link between manufacturing and future costs is ignored and where there is a lack of knowledge of the life cycle costing methods and their use. A wider implementation of the life cycle costing methodology is still being hampered by a lack of reliable information. Data on life cycle performance are often missing for many components and systems (data on maintenance, lifespan, replacement regimes, performance and time aspects of operation, etc.).

There are three major drivers behind the costs of a product life cycle from its initiation until its termination: business costs, user costs and social costs [lit. 2]. The objective of the life cycle concept is to maximise the value of the product while keeping the manufacturer, user and social costs. Manufacturer costs include those related to various corporate activities, for example during planning, design, development, manufacturing, assembly, distribution and servicing of products. These are all costs incurred from the moment when a demand for delivery arises until dispatching the product to the customer. User costs are those related to activities carried out by the user. They cover the period from product delivery to its disposal where the ownership of the product ends. These costs may also include recycling and disposal at the expense of the user. Social costs are those which burden the society when the product is being used and, in particular, those related to its safe recycling or disposal.

The pressure for implementation of principles of sustainable development in corporate decision-making processes is increasing continuously. Other aspects concerning product life cycle management are also subject to this pressure. Life cycle cost management appears to be a useful approach to a comprehensive assessment of economic, environmental and social impacts of the life cycle of a product. It is necessary to realise the importance of costs throughout the full life cycle of a product in order to adopt measures to optimise the product value in relation to the financial resources used.

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Influence of Energy Prices on Building Energy Conservation Market

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The evaluation of energy saving arrangements in buildings includes same uncertainties. The main parameter is an energy price. The prediction of the next development of the unit energy price is the difficult task. This parameter is influenced by the strategy of energy producers or energy raw material producers, where the main goal is a maximum profit. The final price includes also taxes that are influenced by the state interests. Another factor is the state concern in energy companies. The calculation of the project effectiveness in the single building is known, see [1, 2]. Wider problem is the prediction of the market with energy saving projects. The understanding of the future development is important for the building construction companies.

Methodology:

The main used methodology is system dynamics [3, 4]. The dynamic model is built as a system including stocks, flows and converters.

Model description:

The model includes the subsystems that are connected with main stakeholders of the described problem. These stakeholders are investors, building construction companies, state institutions, the owners of the energy resources and their national distributors. Their interests and strategies influence main output parameters of the model:

Price of the energy in world market. The price of producers depends on the demand and rate of delivering energy raws to the stock. The demand is influenced by an economic growth in the world and in the model it is predicted as a growing parameter. The supply is derived from the level of existing resources and from the goal of the producers to keep the price on the desired level. If the price goes down they decrease the raw supply to the inventory. The price means the price of oil, because the prices of other energies are interconnected with this parameter and they copy the changes of the oil price.

Oil inventory. The reasons for the changes in the inventory is described in above paragraph.

Distributor price of the energy. The basis is world price that is increased by distributor costs and the profit.

Final unit price of the energy for customers. It is influenced by the government strategy concerning an energy conservation and an environment protection. Unit price can be increased by value added taxes and "green" taxes. Taxes also serve as a switch among different energies because the final price influences the consumer decision what energy to use.

Energy consumption. The consumption of the energy in the buildings. Energy saving projects influence part of this consumption.

Direct costs and cumulative value for time period. The costs are derived from the energy consumption in the buildings for one year. The cumulative value is the sum for certain time period when we perform the simulation.

Energy savings as a financial parameter and cumulative value. The value is calculated from the costs for the energy in the case of an implementation of energy saving projects and the costs for the standard solution or the costs in existing buildings.

Number of energy conservation projects. The value is derived from the evaluation of the project. The ratio between the cost savings and the investment costs influences the willingness of the investors to spend money for decreasing energy consumption. Higher financial output means better evaluation of projects. This decision is based on the *rationality* in the decision making process. In real life, real estate owners can behave on the different basis, e.g. they want to increase the market price of the house or, on the contrary, they do not want to save energy because their living standard is high and they are able to pay more.

Investment costs for one project. This cost is derived from the inflation rate and from the demand for the implementation of the projects.

Described parameters are endogenous parameters, it means, they can be calculated by means of the model. Exogenous parameters are an economic growth, an inflation rate for the investment costs and the changes of the unit energy price by the state (taxes).

Main loops in the model:

Unit price of the energy for customers \rightarrow Direct costs \rightarrow Energy savings \rightarrow Project evaluation \rightarrow Number of projects \rightarrow Distributor price of the energy \rightarrow Unit price of the energy for customers

Project evaluation \rightarrow Number projects \rightarrow Investment costs \rightarrow Project evaluation Oil inventory \rightarrow Price of the energy in world market \rightarrow Supply of oil \rightarrow Oil inventory The final behavior of the system is calculated as the influence of all feedback loops.

Results from the simulation:

The results calculated in the described model are influenced by the driving force of the economic growth in the world and concurrently by the negative loop that keeps the energy price low in the case of energy consumption decreasing. The external factors (producer price) outweigh the internal factors. It means, the price will increase and consequently, the market will grow.

The model includes main elements, but this year, the model will be completed by elements representing the quality of the projects and the support for the implementation of higher number of the projects (state and EU interests).

Users of the finished model are building construction companies (e.g. design of capacities), state institutions (strategy of the state in the field of energy savings). Results help to design the policies for ensuring the low energy consumption and the energy security.

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