newsletter

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CET IN NUMBERS

Czech Academy of Sciences

ITAM ARCCHIP
INSTITUTE OF THEORETICAL AND APPLIED MECHANICS

Centre of Excellence Telč

1 / 2018

SCOLA TELCZ 2018

The interdisciplinary workshop Scola Telcz 2018 was held in Telč from the 5th to the 9th of February in 2018. Students from three universities in the Czech Republic and from Austria attended the workshop. The main topic was conducting case studies of the renewal and further use of a former synagogue.

The "winter school" program consisted of lectures by experts, fieldwork demonstrations and, in particular, independent creative work of student teams. The program also included a detailed introduction to the historic center of Telč, the town where the investigated object is located. Participants had a unique opportunity to access otherwise inaccessible places and to closely cooperate with specialists from various fields such as conservationists, architects and representatives of the disciplines of science and historical art. The student teams were diverse, enabling participants to try out the interdisciplinary cooperation typical of work in the field of heritage care. However, the assignment was the same for all teams – to prepare an initial study for the reconstruction of the Telč synagogue building. The week-long event culminated on Friday with a public presentation of the results of the individual teams directly on the premises of the former synagogue.

Scola Telcz 2018 was organized by the CTU in Prague, Masaryk University in Brno, Danube University in Krems, the Center of Excellence Telč of the ITAM CAS and the Telč department of the National Heritage Institute. Scola Telcz is one of the results of their long-term cooperation in the field of heritage science.

J. Novotný

EDITORIAL

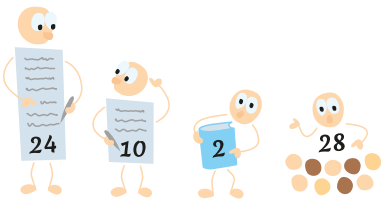
Dear readers, You are now holding another Newsletter of the Institute of Theoretical and Applied Mechanics of the CAS and the Centre of Excellence Telč. ITAM's employees can again boast of many scientific findings, and it is especially encouraging when some are even recognised by the management of the Academy. Their visit on February 8th was the first visit to the Institute from the first scientific area. The members of the CAS' management heard the Activity Report and the future conception of ITAM and CET. A lively debate about basic and applied research ensued. Judging both from their immediate and subsequent reactions the visit was a success.

Some of our most interesting research projects are presented here. One of them is the research of a team specializing in analysis of wooden structures from the point of view of both traditional technologies and new scientific findings. Another topic, successfully researched over a long period, is the study of the deformation of bone scaffoldings using 3D dynamic radiography. Also, there is an article about a study on wind turbines, which is an interesting subject from an aerodynamics point of view. Researchers at the wind tunnel at CET have managed to develop and test a relatively reliable model of a wind turbine scaled 1:385, from which, among other things, the acting forces on a prototype and its effectivity can be predicted.

The results of our work are presented mainly in journals, at conferences and in workshops. One of the last meetings took place in March in Montagnana, Italy, as part of the project RUINS. Another source of inspiration for scientific work are the so-called "mobilities" of researchers, about which we've also written. In short, there is no shortage of interest in the cooperation, internships and scientific work at ITAM and CET. I wish you an amusing read.

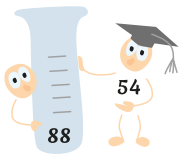
Stanislav Pospíšil, director of ITAM

CET 2017 IN NUMBERS



24 articles in peer-reviewed impact journals
10 articles in other peer-reviewed journals
2 chapters in books
28 papers at international conferences
1 patent & 1 utility model
6 functional samples
25 research projects

Use of CET infrastructure:



88 researchers from the Czech Republic and abroad
54 students in master's or doctoral programs from the Czech Republic and abroad

WHAT IS NEW IN WOOD RESEARCH?

Use of all-wooden joint during reconstruction of rafters in Bratronice castle

Wood and timber structure research has been a long-term topic at ITAM CAS. Thanks to efforts to reconstruct historical buildings using traditional technologies and new scientific knowledge, carpentry and traditional woodworking have become popular again in recent years. The research on all-wooden joint behaviour, supported by NAKI run by the Czech Ministry of Culture (CMC) from 2012 to 2015, was concluded with the publication of a certified handbook about the static design of the joints. The relatively successful implementation of the handbook into practice has stimulated further research and led to the handbook being revised and supplemented so that it can be used in more cases. Currently, experimental testing is being done on a large series of specimens of 1:1-scale four-doweled joints (see Fig. 1), which should serve as verification of the part of the design diagram corresponding to the combination of bending and compression loading. It will influence joint design for repairing rafters (a combination of higher compression and lower bending). The greatest ambition of the current experimental research is to design a joint that will be more efficient under high tension loads (e.g. tie beams). Optimally, it should combine the functions of a peg (docking and tightening the joint faces) and a dowel (clasping the laps, easily defining their manufacture). The joint will be tested in the following months at the real dimensions (cross-section 200×240 mm, length 6 m) in tension and bending until rupture (the load-bearing capacity is estimated to be about 80 kN).

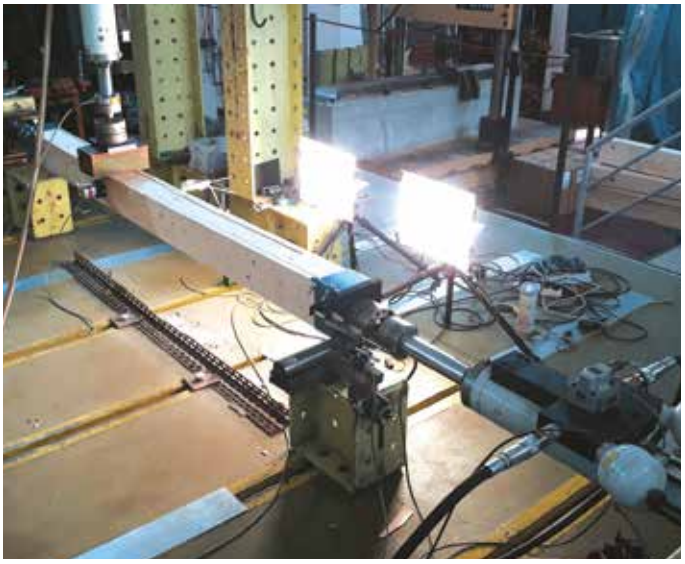


Fig. 1 Testing of all-wooden joints for use while repairing rafters in historically valuable structures

Mathematical modelling is part of the research. The question of practice – How will the application of the joint during a repair influence the distribution of forces in the structure? – led to an interesting numerical simulation. The change in the structure's stiffness was studied on a set of rafters of a simple collar-beam construction. The middle rafter was repaired "virtually". The joint in the element was loaded with a combination of normal compression force N and bending moment M. The construction was loaded in three steps while the lathing and sheathing was added gradually. The model and bending moment distribution after final loading are shown in fig. 2. The length of the rafters was 3.6 m and their cross-section was 140×180 mm. The results show that repairs always increase the strain on adjacent elements and other structural elements are also influenced. A harmonious effect is present in the surrounding elements when the load is alternately increased and decreased.

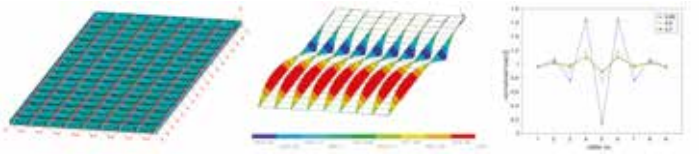


Fig. 2 a) Model of rafter set created by ANSYS software, b) distribution of bending moment, c) influence of all-wooden joint application (position no. 5) on strain distribution in the other structural elements after being fully loaded (values of model bending stiffness kmodel – missing element kmodel = 0,05, joint positioned in the third of element kmodel = 0,5, joint close to element end kmodel = 0,7).

There are two other projects in the field of wood nowadays. The project Historical timber structures: Typology, diagnostics and traditional woodworking, supported by CMC, is a critical analysis of the processes used in woodworking and the following specific proposals for optimizing the restoration, conservation, repairs and maintenance of historical wooden constructions. The partial aims are the systematization of roof structures based on design-typological classification, the application of advanced methods in the diagnostics and monitoring of physic-mechanical behaviour of timber structures and the design of construction and remediation measures suitable for the restoration of monuments on the basis of the traditional craft of woodworking (including correct log selection in the woods, the felling period, the elimination of growth stress during machining, wood response to different machining methods).
The last project is Oak fastener in timber structures: Materials for normative anchorage, which is financially supported by TAČR due to the possibility of wider application in practice. Mendel University in Brno and the University Centre for Energy Efficient Buildings CTU are participating in the project. The research has been divided into three parts (load-bearing capacity of the fastener related to its material and geometry, behaviour and load-bearing capacity of the surrounding mass, long-term behaviour of the loaded fastener in various humidity conditions).

Related new publication
Kunecký Jiří, Hasníková Hana, Kloiber Michal, Milch Jaromír, Sebera Václav a Tippner Jan, 2018. Structural assessment of a lapped scarf joint applied to historical timber constructions in central Europe. International Journal of Architectural Heritage (Conservation, Analysis, and Restoration). 18, 1-17. ISSN: 15583058.

The certified handbook Lapped Scarf Joints for Repairs of Historical Structures is available along with other information at www.itam.cas.cz/spoje.

Questions can be sent to spoje@itam.cas.cz.

H. Hasníková, M. Kloiber, J. Kunecký

MEASUREMENTS OF AERODYNAMIC FORCES ON WIND TURBINES

Under the ongoing project WESLO (Wind and Sea Loads on Energy Structures), the team from the Department of Dynamics and Stochastic Mechanics started experiments on wind power turbines with horizontal rotation axes. Classical, mainly three-bladed, wind power turbines are being analysed. They can achieve, using the most recent technologies and knowledge, a maximum power of 9 MW. The diameters of the propellers reach dimensions of over 170 m and the heights of the shafts up to 220 m. The flow of wind on a structure of these dimensions constitutes a heavy load. Moreover, the rotation of the propeller creates additional gyroscopic and centrifugal forces that have to be taken into account when making the design. A detailed knowledge of all the forces at work make it possible to propose larger, and therefore more efficient, wind turbines. Our team is currently working on analysing the effects of wind load on wind turbines using scaled models in the Aerodynamic climatic tunnel at the Centre of Excellence Telč. Using a scaled model of the wind turbine, we are able to predict the expected load intensity on real-life structures for the wind turbine's different modes of operation and the different flow conditions influenced by, i.e., the location in the terrain, intensity of the wind turbulence, and incident angle of the wind flow with respect to the propeller plane. The model was made on a 3D printer. A small three-phase outrunner brushless motor was used in place of a real generator, thanks to which very precise measurements can be made and the rate-of-turn can be changed smoothly. As we know how much energy the experimental model of the wind turbine produces, we can deduce the generator's braking forces and therefore the torque of the propeller at different speeds. The forces in the base of the tower are measured with a dynamometer, which makes it possible to measure 3 force components and 3 bending moments.
Future experiments will be focused on aerodynamic and aeroelastic force application in the context of the location of the wind turbine in more complex terrain.

M. Macháček

NEW INSTRUMENTS AT CET

New isocalorimeter

The materials research team at CET has a new instrument called isothermal conduction calorimeter. It can monitor the thermal activity and heat flow of chemical, physical and biological processes. The information provided cannot be obtained using other techniques. It is particularly useful when investigating hydration processes in cements, concrete and mortars and when determining the heat of hydration or studying the effects of components added to retard reactions or improve material performance. It can also be applied to monitor the stability of drugs, like antibiotics, or the self-discharge of batteries, to determine their shelf-life.
The sample is placed in an ampoule that is in contact with a heat flow sensor that is also in contact with a heat sink. When heat is produced or consumed by any process, a temperature gradient is developed across the sensor. This generates a voltage which is measured. Up to 8 samples can be accommodated, and they can be measured simultaneously and independently of each other.

A. Viani

DEFORMATION ANALYSIS OF ARTIFICIAL BONE SCAFFOLD USING ON-THE-FLY TOMOGRAPHY

In bone tissue engineering, the accurate description of deformation behaviour in both original bone and artificial replacements is one of the most important prerequisites for the assessment of biocompatibility and bone-integration characteristics of a proposed structure intended for use as a bone scaffold. A newly synthesized hydrogel-based bone scaffold was subjected to compressive loading to obtain its deformation characteristics. Its very soft nature and high porosity together with the low X-ray attenuation of the material required the development of an experimental method employing an in-house designed micro-loading device and a CT device operating in on-the-fly mode. The sample was compressed at a loading rate of 0.4 microns per second.
To evaluate the displacements and strains on the deforming microstructure, the digital volume correlation method was employed on the reconstructed tomographical images. In total, 34 CT scans were acquired using a single photon counting detector during the loading procedure. Individual tomographies were acquired within 120 seconds with a sample compression corresponding to 48 microns. The task was solved with the support of the Competence Center for High-Resolution 3D X-ray Imaging (ATCZ38) and Kompetenzzentrum MechanoBiologie in Regenerativer Medizin (ATCZ133) in cooperation with the Ludwig Boltzmann Gesellschaft - Institut für experimentelle und klinische Traumatologie and the University of Applied Sciences Upper Austria.

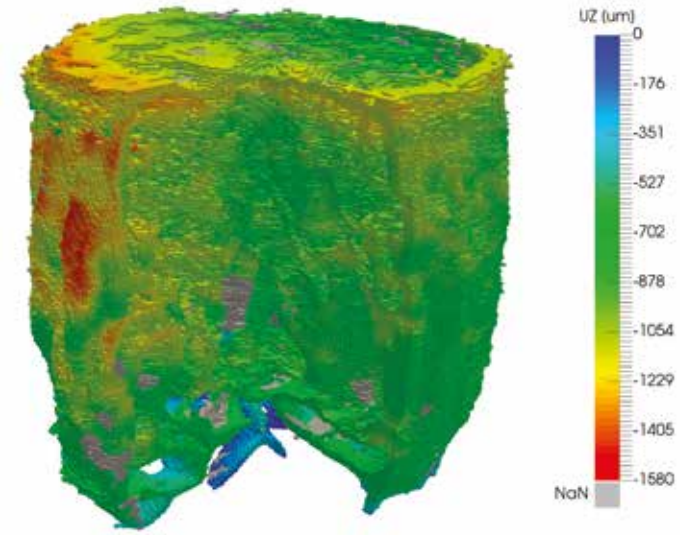


Figure: Visualisation of a deformed full-scale voxel model of the scaffold's microstructure showing displacements at the last load step

D. Kytýř, P. Zlámal

TOP MANAGEMENT OF THE CZECH ACADEMY OF SCIENCES VISITED ITAM

On Monday the 8th of February 2018, the president of the CAS, Prof. Eva Zažímalová, began her round of visits of the institutes of the CAS at ITAM. She had visited ITAM before, and this time she came with the vice-president, Prof. Jan Řídký, and two of the academy's board members, Lenka Vostrá and Pavel Krejčí. The visit started with a discussion with the management of ITAM, followed by tours of the Central Laboratory of Experimental Mechanics (CLEM), the Laboratory of Particular Media and the Laboratory of Biomechanics. At the end, the guests visited the newly built and inspected part of the institute.

B. Přechová

CET TEAM INVESTIGATES THE USE OF MEDIEVAL RUINS

In June of last year, the RUINS project supported by Interreg Central Europe was launched, with the CET team being one of 10 partners in an international consortium of 6 European countries. The aims of the project are to bring medieval ruins back to life using modern technical and economic approaches and to find ways to use them in contemporary societies while preserving their historical value. The project's output leads to these goals: the creation and distribution of internationally applicable manuals and procedures, including procedures for the modern administration and management of medieval ruins, particularly in Central Europe.

The project's activities also include surveys and case studies of six selected ruins. Immediately after the project was launched in June of last year, a field survey of Janowiec Castle in Poland was carried out, and then in August field surveys of the ruins of St. Stošije in Zadar (Croatia) and Šalek Castle in Velenje (Slovenia) followed. Since October, the CET team has been preparing for and securing research activities in the ruins of the fortified Bzovik Monastery in Slovakia and has conducted a technological workshop focused on in-situ diagnostic methods for historical wooden structures that took place in one of the monastery's bastions. In March of this year, a study visit was made to the city fortifications in Montagnana, Italy, and the Beatrice d'Este Villa with the remains of a medieval monastery. The output of study visits are always detailed reports mapping the history, current technical condition, conservation interventions and economic use of the given torsional objects. In the next phase of the project, the work will focus on creating manuals and implementing pilots on the selected ruins in Poland, Italy, Croatia, Slovenia and Slovakia.

More information about the project can be found at: http://www.interreg-central.eu/Content.Node/RUINS.html

The ruins of the fortified Bzovik Monastery in Slovakia

The ruins of St. Stošije in Zadar (Croatia)

J. Novotný

JIŘÍ NÁPRSTEK ELECTED CHAIRMAN OF THE CZECH SOCIETY OF MECHANICS

Ing. Jiří Náprstek, DrSc.

A secret election in January 2018 resulted in the appointment of a new committee head of the Czech Society of Mechanics (CSM). During a meeting on 7 February 2018, the new functionaries of the CSM were elected. Based on this vote, Ing. Jiří Náprstek, DrSc. from the Institute of Theoretical and Applied Mechanics of CAS was named the new chairman for the next four years.

More information about the domestic and international activities, management and history of the CSM can be found at: https://www.csm.cz.

MOBILITY OF RESEARCHERS AT CET

Each year the Center of Excellence Telč hosts several foreign researchers for short and long-term research stays. The year 2017 was not an exception. In March, Professor Rajesh Goyal head of the Institute of Engineering and Technology (India) came to work at the Climate Wind Tunnel Laboratory. In April, Karim Zara Zefreh from Antwerp University in Belgium participated in experiments in the Laboratory of X-ray Tomography. In the same laboratory, during two research stays, a metrology specialist from Belgium, Massimiliano Ferrucci, was involved in refining the setup of the unique Telč equipment. Yasemin Didem Aktas from University College London came to prepare larger future experiments in the climatic wind tunnel in May. In June, the Laboratory of Material Analysis and Microscopy hosted Professor Helois Nunes Bordall of the Danish University of Copenhagen. From late August to early September, Professor Piotr Gorski and his doctoral student, Marcin Tatara, conducted experiments in the climatic wind tunnel (both from the Opole University of Technology in Poland). In September and October, Dr. Andriy Buljac from the Croatian University of Zagreb co-operated on some other experiments.

Professor Bordall and Professor Goyal, in addition to conducting collaborative research, orally presented the results of their research to the staff of the Institute.

Four CET Ph.D. students were sent abroad for internships in 2017.

- Dita Machová studied at the University of Ljubljana from February to May 2017.
- Riccardo Cacciotti completed his internship in March and April 2017 at the International Center for the Study of the Preservation and Restoration of Cultural Property (ICCROM), Rome (Italy).
- Dita Frankeová did a month long internship (September - October) at the University of Padua (Italy).
- Klára Nedvědová started an internship at Donau University Krems (Austria) in December 2017.

J. Novotný

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