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Ultra lightweight construction is based on hydraulics Press Release I 16 April 2012

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Adaptive structures: Revolution for sustainable construction

Stuttgart, 16 April 2012. Maximum load capacity with minimal consumption of materials – this is how supporting structures for constructions should be today. Researchers from the University of Stuttgart together with Bosch Rexroth have now come a great deal closer to achieving this goal. They have constructed a wooden shell which is much thinner than anything deemed possible up to now. With a mere four centimetre thickness the shell spans a surface of over 100 square metres. The construction stands on Vaihingen Campus of the University of Stuttgart and was presented to the public for the first time today. The extreme slimness of the shell becomes possible through the use of an adaptive structure.

Up to now constructions have always been designed for an exact maximum stress; this type of stress, however, generally only occurs very rarely and then only for a short period. A large part of the building materials used today therefore serves these extremely seldom peak loads and is effectively seldom used. The aim of the ultra lightweight construction developed at the University of Stuttgart is therefore to achieve a drastic saving of materials and a better reaction to dynamic loads through an active manipulation of the structure. In the case of the Stuttgart wooden shell this manipulation is achieved through hydraulic drives: these drives rest on the points of support of the shell and generate movements that compensate in a targeted way for deformations and material stresses caused by wind, snow and other loads.

Institute for Lightweight Structures and Conceptual Design (ILEK) and Institute for System Dynamics (ISYS) of the University of Stuttgart in cooperation with Bosch Rexroth have realised an adaptive structure on a large scale for the first time. The shell made of wood is mounted on four points. Three of the points of support can be moved individually by hydraulic cylinders and freely positioned in space. Sensors record the load status at numerous points on the supporting structure. Targeted movements of the points of support counteract variable loads (for example through snow or wind) and thus reduce deformations and material tensions. Compared to conventional, passive constructions this considerably reduces the use of materials for the shell construction. The load balancing takes place through a Rexroth control which was especially developed for hydraulic drives. The core task of the control is to implement the complex hydraulic control tasks of the shell structure. In this way the supporting structure can react to a change in the load status within milliseconds.

An active vibration dampening and the adaptation to changing loads can be applied in many areas of construction, for example in stadium roofs, in high-rise buildings, in wide-spanning façade constructions or in bridges. The results of the research project at the University of Stuttgart thus enable a completely new construction method which not only saves resources but at the same time also considerably increases the performance of supporting constructions. The active dampening of dynamic loads (for example from the effects of wind, earthquake or explosions) namely enables not only a drastic reduction in weight but furthermore also reduces material fatigue and damage to the structure.

In order to be able to actively compensate loads and vibrations, these influencing factors initially have to be precisely recorded resp. predicted; a second step would be to calculate the necessary counter-movements in real time (and likewise promptly to implement them). Researchers from the University of Stuttgart developed simulation models for this purpose, enabling an exact prediction of the behaviour of the structure. The material stress as well as the vibration behaviour under static and dynamic exposure is thereby taken into account. These simulation models serve as a basis for the development of control concepts which calculate the necessary counter movements on load and vibration compensation depending on the recorded measured values. These movements are then precisely implemented through the hydraulics.

The scientific foundations for the project were laid in recent years at ILEK and at ISYS. Bosch Rexroth supplied the active elements of the prototype. In close cooperation with the University of Stuttgart the company took over the project management, selection and design of the hydraulics as well as their commissioning. Institut für Leichtbau Entwerfen und Konstruieren (ILEK) is a pioneer in researching adaptive systems in the field of construction; a first prototype was already created on a small scale with the responsible Stuttgart body several years ago. The core competence of Institut für Systemdynamik (ISYS) lies in the analysis of dynamic systems and their targeted influence. For this purpose the institute developed control structures creating coordinated movements of the structure. Bosch Rexroth is one of the world's leading specialists for drive and control technologies. The company is a partner for mobile applications, machinery applications and engineering, factory automation as well as renewable energies. As the drive & control company Bosch Rexroth develops, produces and distributes its components and systems in over 80 countries.

The project is integrated as an evaluation model in the group of researchers ‚Hybride Intelligente Konstruktionselemente', supported by Deutsche Forschungsgemeinschaft (DFG). This group of researchers brings together experts from mechanical engineering, aerospace technology, civil engineering and process engineering. Moreover, the project received scientific support from Prof. Leander Bathon (Institut für Baustoffe und Konstruktion of the University of RheinMain Wiesbaden) and from Prof. Uwe Heisel (Institut für Werkzeugmaschinen of the University of Stuttgart).

Furthermore, the project was supported by the following industrial partners: Sensor-Technik Wiedemann GmbH, Eschenbach Zeltbau GmbH & Co. KG, Wilhelm Gerüstbau GmbH, Ulrich Lübbert Warenhandel GmbH & Co. KG, Friedrich Wahl GmbH & Co. KG, Leitz GmbH & Co. KG and Rütgers Organics GmbH.

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