Digital Solutions in Architecture and Timber Construction

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Overview

An inspiration for the creation of innovative and interesting structures have always been nature with its flowing, organic forms, which have evolved for maximum optimization and efficiency. Organic architecture is based on studies of these nature-based forms, which as a rule, are almost never straight. The design and implementation of such flowing shapes is more complex than working with orthogonal shapes and requires a good spatial performance, knowledge of geometry and use of suitable design tools and techniques. Digitalization has facilitated the development of complex geometric and free-form shapes that were not manageable before with simple design tools. Thanks to the broadened potential of computing, parametric design, and digital manufacturing, it is now possible to design structural elements and structures that deviate from orthogonal practices and form complex shapes. Architects and engineers consider the use of computers and computation techniques for planning and looking for solutions to a given design problem. They are provided with powerful analytical tools to create new designs, predict their behaviour, and formulate effective production strategies. The materials that have been typically used are now combined with new engineered wood products (EWPs), which have the advantage of high load-bearing capacity, good dimensional stability, and flexibility in large dimensions. EWPs also offer greater design freedom for ambitious constructions and advanced manufacturing processes.

Fig. 1. Engineered wood products EWPs

The classic construction methods are joined with a novel 3D printing technology, including 3D printing with wood filaments combined with PLA material. 3D printing already allow the creation of large and advance building structures. Digitalization solutions in architecture will be presented with examples of recently realized projects and their involvement in different design stages. Examples of educational programs and student outputs dealing with digitalization processes will be also featured.

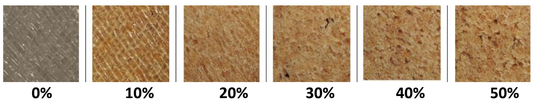

Fig. 2 Wood - PLA filament - wood share from 0-50%. Appearance of the product surface printed with filaments with different wood contents ((20x magnification) (photo: Žigon, J.)

Recent innovations in computational techniques, material systems and fabrication processes have revolutionized the design and construction of surface structures. Powerful analysis tools now enable architects and engineers to create new surface forms, predict their behavior and devise efficient manufacturing strategies. Digitally supported design and fabrication technology has unfolded new potential to realize complex structural surface shapes.
Innovative surface structure methods provides techniques necessary to design folded plates, shells and tensile membranes in a broad variety of materials. Some of these technologies demonstrating use of wood based materials in creating successful surface architecture are shown in case studies. Some of these methods are also applied in teaching of wood products design classes by instructors and their students. Below are examples from the US and Slovenia.

Case Studies

Fig.3. An adaptive robotic fabrication process makes possible a necessary scaling-up and handling of complex interrelations between the pattern shapes and the behaviour of novel materials. In contrast to repetitive manufacturing processes where automation relies on the execution of predetermined and fully defined steps, sensing technology is employed to enable a workflow that synthesizes material computation and robotic fabrication in real time. In this process, the shape of the tailored work piece is repetitively scanned.

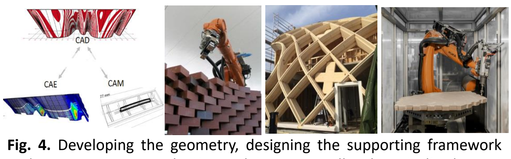

Fig. 4. Developing the geometry, designing the supporting framework and generating production data are all decentralized, yet interconnected, processes. An integrated exchange of data with clearly defined interfaces makes seamless project management possible.

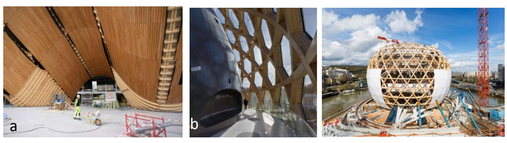

Fig. 5. a-**Kilden Performing Arts Center,** Kristiansand, Norvay and b-**La Seine Musicale** in Boulogne-Billancourt, France.

Fig. 6. Bowooss Bionic Inspired Research Pavilion - parametric design, School of Architecture, Saarland University, Germany.

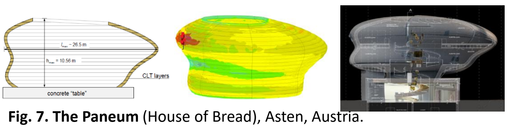

Fig. 7. The Paneum (House of Bread), Asten, Austria.

Fig. 8. BUGA Wood Pavilion / ICD/ITKE University of Stuttgart, Germany.

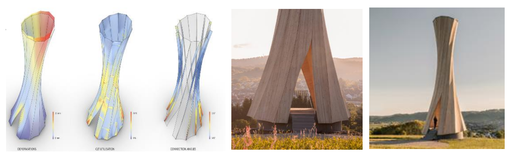

Fig. 9. Urbach Tower - tall experimental structure, Urbach, Germany.

Fig. 10. 3D printed earthen house, enhancing the design opportunities of on-site 3D printing towards the achievement of multi-purpose architectural systems. Institut d'Arquitectura Avançada de Catalunya, Spain.

Fig. 11. 3D printed buildigs / innovative construction solutions - Urban Cabin, Amsterdam, Nederland, and Office of the Future, Dubai.

Digital Solutions in Teaching

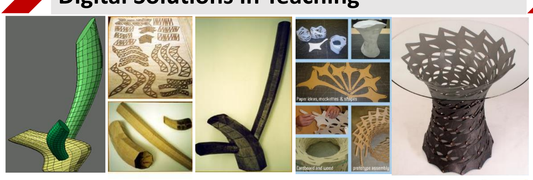

Fig. 12. Students designs examples: Created in the CNC Manufacturing class at Purdue University, Department of Forestry and Natural Resources, where variety of digital methods are learned and then applied in products design and its fabrication.

3D Printing Sustainable Solutions in Teaching

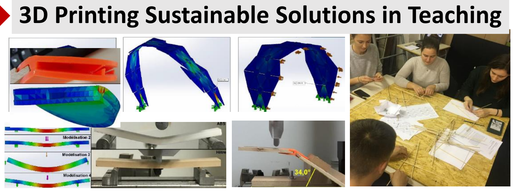

Fig. 13. Students designs examples: Construction and design class at University of Ljubljana, Department of Wood Science and Technology, BF, where nature-inspired sustainable solutions for an architectonic environment are teaching learning by doing.