Enhancing Design and Production in Modular Timber Architecture with Computational Design

Degree programme: Master of Science in Wood Technology
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This research integrates computational design tools to enhance modular timber architecture by improving decision-making and automating the modeling, analysis, and CNC fabrication of design variations. These tools increase quality and productivity while enabling unique architectural solutions. The àDisposition project exemplifies this approach with a modular timber construction kit optimized for easy transport and temporary use, showcased through a user-friendly configurator.

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Complex Timber Structures

1 – INTRODUCTION

Off-site construction and modular building systems both lead to fast production, economic solutions regarding material and processes, more accuracy and higher overall quality. This research investigates the integration of computational design tools to enhance both design process and production methods within the context of modular timber architecture.
The focus is specifically on two aspects. Firstly, the integration of various existing analysis tools into the design process to achieve a more informed design. Secondly, automating the modelling, analysis, and CNC fabrication of different architectural design variations (geometry, shape, materials, etc) using a range of bespoke computational tools.

2 – PROJECT DESCRIPTION

The utilization of computational design tools in modular timber construction has the potential to enhance both quality and productivity without sacrificing architectural uniqueness. The resultant flexibility achieved by such computational methods enables the creation of distinctive and unique solutions with the same level of effort required for standardized, repetitive ones. This represents a paradigm shift in modular architecture transitioning from mass production to mass customization of buildings or building components. To achieve these goals, this research has developed bespoke computational tools. All these tools have been integrated into a parametric planning platform that has been iteratively improved and extended by the learning-by-doing design process and validated by different series of 1:1 prototypes.

The parametric planning platform that allows for a complete design-to-production approach using a full digital chain consists of the following parts:
1) Algorithm Modeling and Visualization Tool: Models, informs, and exports geometric data for modular system variations and generates abstract base models for performance analysis.
2) Performance Analysis Tool: Evaluates modular systems based on weight, cost, embedded CO^2 emissions, structural compliance, and energy performance, also exporting a Bill of Quantity.
3) Design-to-Production Integration Tool: Automatically generates manufacturing instructions from geometric models, quickly bridging the CAD/CAM link for any modular design variant.
4) Configurator: A web-based tool for end-users to visualize, measure, and adapt modular system variations according to their needs.

3 – CONCLUSIONS

All the findings are exemplified by the research project "àDisposition" (Innosuisse, 59217.1 IP-SBM) led by the Bern University of Applied Sciences with the goal to develop a modular timber construction kit optimized for easy transport, assembly, adjustment, and dismantling, particularly for the temporary use of vacant buildings and sites. Finally, research outcomes are showcased by a configurator, designed to be used at an end-user level, that allows to plan, visualize, analyze, and prepare production files for various proposals utilizing the above-mentioned modular kit.

Structure of the second round of prototypes: defining a minimal 3x3 walls room at DISPO hall, Nidau.