Development of Novel Standardized Structural Timber Elements Using Wood-Wood Connections

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	Wood-Wood Connections
	Bending Test
	Bending Stiffness
	Numerical Model
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Summary:

Traditional wood-wood connections, widely used in the past, have been progressively replaced by steel fasteners and bonding processes in modern timber constructions. However, the emergence of digital fabrication and innovative engineered timber products have offered new design possibilities for wood-wood connections. The design-to-production workflow has evolved considerably over the last few decades, such that a large number of connections with various geometries can now be easily produced. These connections have become a cost-competitive alternative for the edgewise connection of thin timber panels. Several challenges remain in order to broaden the use of this specific joining technique into common timber construction practice: (1) prove the applicability at the building scale, (2) propose a standardized construction system, (3) develop a convenient calculation model for practice, and (4) investigate the mechanical behavior of wood-wood connections. The first building implementation of digitally produced through-tenon connections for a folded-plate structure is presented in this work. Specific computational tools for the design and manufacture of more than 300 different plates were efficiently applied in a multi-stakeholder project environment. Cross-laminated timber panels were investigated for the first time, and the potential of such connections was demonstrated for different engineered timber products. Moreover, this work demonstrated the feasibility of this construction system at the building scale. For a more resilient and locally distributed construction process, a standardized system using through-tenon connections and commonly available small panels was developed to reconstitute basic housing components. Based on a case-study with industry partners, the fabrication and assembly processes were validated with prototypes made of oriented strand board. Their structural performance was investigated by means of a numerical model and a comparison with glued and nailed assemblies. The results showed that through-tenon connections are a viable alternative to commonly used mechanical fasteners. So far, the structural analysis of such construction systems has been mainly achieved with complex finite element models, not in line with the simplicity of basic housing elements. A convenient calculation model for practice, which can capture the semi-rigid behavior of the connections and predict the effective bending stiffness, was thus introduced and subjected to large-scale bending tests. The proposed model was in good agreement with the experimental results, highlighting the importance of the connection behavior. The in-plane behavior of through-tenon connections for several timber panel materials was characterized through an experimental campaign to determine the load-carrying capacity and slip modulus required for calculation models. Based on the test results, existing guidelines were evaluated to safely apply these connections in structural elements while a finite element model was developed to approximate their performance. This work constitutes a firm basis for the optimization of design guidelines and the creation of an extensive database on digitally produced wood-wood connections. Finally, this thesis provides a convenient design framework for the newly developed standardized timber construction system and a solid foundation for research into digitally produced wood-wood connections.

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