Smart Manufacturing of Curved Mass Timber Components by Self-shaping

https://research.thinkwood.com/en/permalink/catalogue2379

Author:	Grönquist, Philippe
Publisher:	ETH Zurich
Year of Publication:	2020
Country of Publication:	Switzerland
Format:	Thesis
Application:	Wood Building Systems
Topic:	Design and Systems
Keywords:	Manufacturing
	Mass Timber
	Up-scaling
	Form-stable Curved Elements
	Self-Shaping
Language:	English
Research Status:	Complete
Notes:	DOI link: https://doi.org/10.3929/ethz-b-000405617

Summary:

With the rise of complex and free-form timber architecture enabled by digital design and fabrication, timber manufacturing companies increasingly need to produce curved components. In this thesis, a novel approach for the manufacturing of curved timber building components is proposed and analyzed. Following biological role models such as the bending of pine cone scales, a smart way to curve wood at large-scale is given by the biomimetic concept of bi-layered laminated wood. This principle enables large programmed material deformations upon controlled moisture content change. The main objectives of this thesis are the in-depth understanding of the mechanics of self-shaping wood bilayers and the up-scaling of the already known principle from the laboratory to the industrial scale in order to enable an application as form-stable curved elements in architecture. Hereby, the main challenges addressed are the accurate prediction of shape-change in terms of the natural variability in wood material parameters, the scale-dependent impact of moisture gradients on mechanical behavior, and the influence of wood-specific time- and moisture-dependent deformation mechanisms such as creep or mechano-sorption in the shaping process. Major impacts of these aspects on the shaping behavior could be demonstrated by the use of continuum-mechanical material models adapted to wood, both in the form of analytical and numerical models. Based on the gained insight, the up-scaling process to industrial manufacturing was successfully made possible. A collaborative project realized in 2019, the 14 m high Urbach tower, is presented as a proof of concept for application and competitiveness of the novel biomimetic method for production of curved mass timber components. Furthermore, next to self-shaping by bending to single-curved components, possibilities and limitations for achieving double-curved structures using wood bilayers in a gridshell configuration are analyzed and discussed.

Online Access: Free

Resource Link

https://www.research-collection.ethz.ch/handle/20.500.11850/405617