A new approach to free form wooden shell structures using helical cuts

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Abstract

The paper gives a comprehensive review of wooden shell structures beginning from the twenties of the last century. It presents a typology by focussing on design aspects like shapes, textures, connections, executions and materials. Based on this typology advantages and disadvantages of different designs are being discussed.

The main emphasis lays on the design of an innovative free form wood structure that uses traditional joining techniques with compressed wood dowels instead of adhesives and metals.

This approach results from the research project "adhesive free timber buildings (AFTB)" financed by the European Commission within the Interreg framework.

The concept is part of AFTB and consists in cutting helical lamellas from a tree stem. In this way a stack of twisted boards can be bent in any direction to form a grid-like shell structure.

The form finding process of the structure begins with an artistic artwork from thin cardboard strips, digitalized by means of photogrammetry, then turned into a parametric model and scaled up thereafter. This parameterization has two objectives: The first is to retrieve the spatial target shape from a straight cylinder (stem); a deployment function is therefore introduced enabling the target spline to unfold progressively, so that it can be rectified. The second is to control the critical curvature which is limited by two factors: first the strength reduction across the grain due to the helical cut and second the mechanical stresses due to the subsequent bending of the twisted board into the spatial target shape. In this case a genetic algorithm in Python and Grasshopper is implemented, to determine the critical curvature.

In addition, bending tests on helical cut lumbers and connections are carried out. The minimum radius is compared with the critical radius and, if necessary, the shape may be adjusted and corrected. Final goal is the realization of an innovative demonstrator by September 2019 and its exhibition in a representative building on the campus.

References

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