Design of Freeform Timber Gridshells: Problems and Methods

Degree programme: Master of Science in Wood Technology | Specialisation: Complex Timber Structures
Thesis advisors: Prof. Katharina Lindenberg, Prof. Dr. Christophe Sigrist
Expert: Fabian Scheurer (Design-to-Production)

Given the recent technological developments concerning form-finding, architects and engineers have experimented with more challenging design solutions for freeform structures. The challenge that recently emerged focuses on the assembly of prefabricated timber pieces with curvature and torsion, since the on-site constructive method considers each building block as a rigid body.

Main Objective

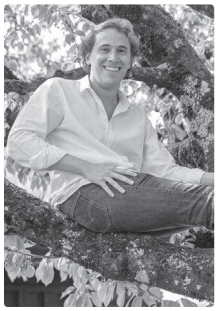
The main objective of this work is to establish a comprehensive geometrical basis and understanding for the design of lap joints in two-way timber gridshells, taking in consideration the overall shape of the master surface and the placement of vertically-projected or geodesic grids.

Methods

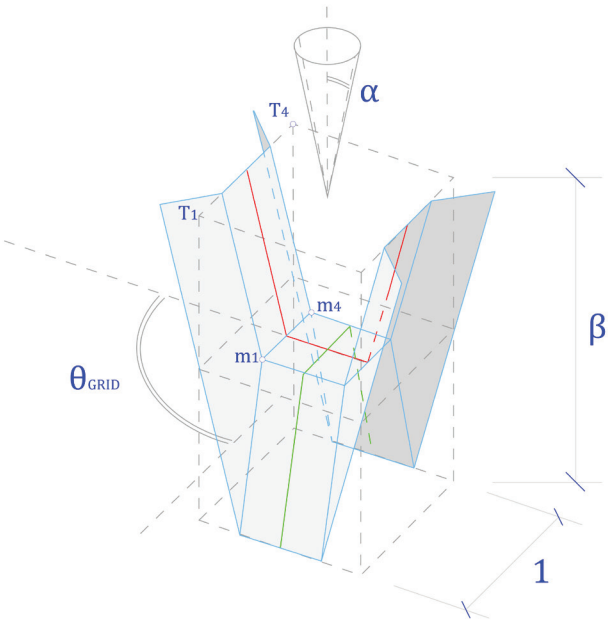
The starting point was an overview of the five geometrical instances occurring on smooth surfaces when evaluating the two main curvatures and their intrinsic torsions. This introduction served as a basis for the further evaluation of grid lines constructed directly on these surfaces via projection or through geodesic curves. From the construction of the grid lines, the discussion presented the two possible orientations for the beam profiles, vertical or normal-to-surface, explaining the circumstances for choosing the appropriate one depending on the design goals at hand. Afterwards, an analytic geometrical deduction followed from a few basic assumptions, where a few features have been discovered – the openness factor and its relation to the cross-section ratio and the intersection angle . Finally, the research arrives at a thorough mathematical description of the influence of these features in the geometry of contact joints.

Results & Further Research

To conclude, the geometry of lap joints plays a major role in the segmentation of members, and it is exclusively a result of three variables which can readily be manipulated by architects and engineers for an optimized solution for the prefabrication of beams with double curvatures and torsion that allow the



Tomaz Alves De Souza Scheliga



$$\gamma = \frac{\overline{T_1T_4} - \overline{m_1m_4}}{\overline{T_1T_4}}$$

$$\alpha = \cos^{-1}\sqrt{\frac{1+\cos\theta}{1+\cos\theta+\frac{\gamma^2}{2\beta^2}}}$$