Design and Construction of an Asymptotic Geodesic Timber Gridshell

Eike Schling*, Zongshuai Wan* and Pierluigi D'Acunto†

* The University of Hong Kong (HKU)
Department of Architecture, Pokfulam Road,
Hong Kong SAR
schling@hku.hk - www.eikeschling.com

† Technical University of Munich (TUM)
Arcisstr. 21, 80333 Munich, Germany
pierluigi.dacunto@tum.de -
www.arc.ed.tum.de/en/sd/structural-design/

ABSTRACT

The responsible use of natural resources is driving innovations in the building industry. Material efficiency and high load-bearing capacity can be reached through the design of doubly curved shells, which utilize the spatial curvature of the structure to generate stiffness. Fabrication and assembly of freeform gridshells can be simplified significantly when controlling the curvature of structural elements [1]. This research presents a strategy to design and build strained timber gridshells from repetitive straight timber slats, which are interwoven and bent into the design shape. The slender slats are combined in two orientations, upright and flat, to create robust and versatile triangulated grids. For this purpose, we digitally generate hybrid webs of asymptotic and geodesic curves on freeform surfaces [2]. The research combines computational geometry with architectural building practice. The paper summarizes the geometrical background of geodesic (G) and asymptotic (A) curves and present a digital method to design and optimize AAG-webs including their developable panelizations. The paper gives a comprehensive overview of this new construction system, which benefits from the targeted use of the two differing bending axes of timber slats for flexibility and rigidity. A large-scale timber gridshell covering an area of 60m² was designed and built at the Design Factory 1:1 of the Technical University of Munich. We document the construction process of manufacturing, prefabrication, elastic formation, on-site assembly, and installation of the polycarbonate cover, to verify constructive tolerances and feasibility. By interlacing the flat, geodesic slats at the midpoint of the asymptotic beams, a tri-hex pattern is created, which lowers the buckling length and decisively increases the overall stiffness. Physical testing with up to 26 kN asymmetric load and 54kN distributed load will confirm the structural performance, with deflections below 20mm.

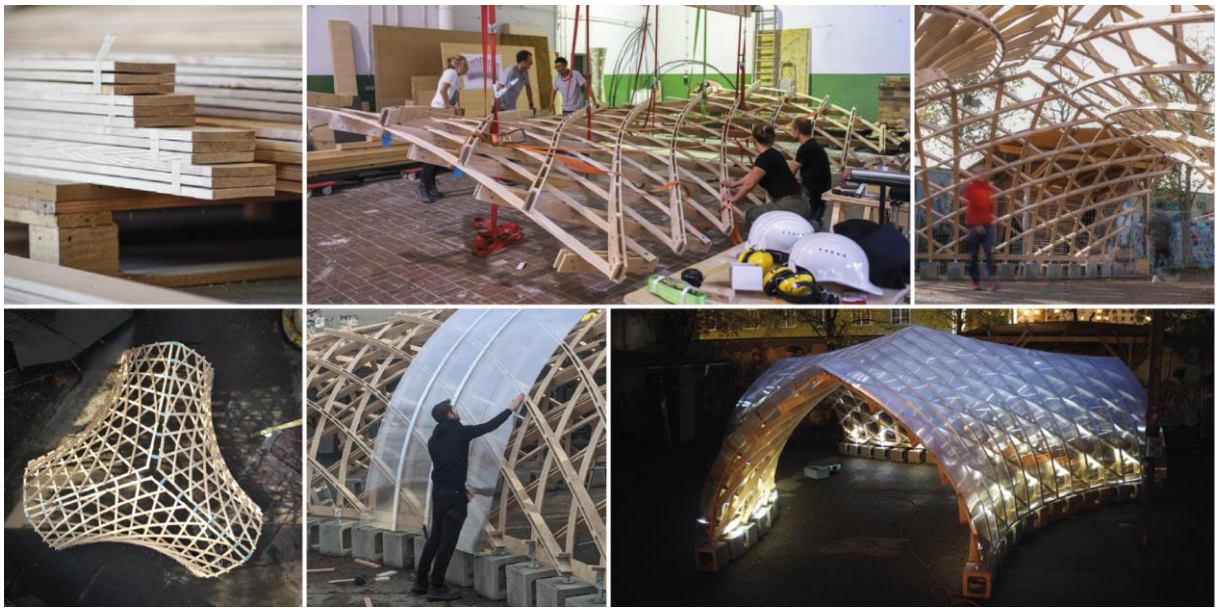

Fig.1: Construction process of the AAG-Timber Vault.

REFERENCES

[1] Tang, Chengcheng; Kilian, Martin; Bo, Pengbo; Wallner, Johannes; Pottmann, Helmut (2016): Analysis and design of curved support structures. In: Advances in Architectural Geometry 2016. ETH. 1. Auflage. Zürich: vdf Hochschulverlag, pp. 8–23.

[2] Schling, Eike; Wang, Hui; Hoyer, Sebastian; Pottmann, Helmut (2022): Designing asymptotic geodesic hybrid gridshells. In Computer-Aided Design 152 (0010-4485), p. 103378.