Strip-Based Double-Layered Lightweight Timber Structure

Djordje STANOJEVIC*, Kenryo. TAKAHASHI[a]

*Centro de Estudios Superiores de Diseño de Monterrey CEDIM
Antiguo Camino a la Huasteca 360, Mirador de la Huasteca, 66354 Santa Catarina, N.L. México
djordjes@cedim.edu.mx

[a] Ney & Partners Brussels, Belgium
Chaussée de la Hulpe 181 /Ter Hulpsesteenweg 181, 1170 Brussels, Belgium
kta@ney.be

Abstract

In the current paper, the authors present the Bending Bridges project as part of an ongoing academic research on strip-based geometries and their applications for lightweight timber structures carried during the last three years. Within the context of double-layered shells in architecture there is a relevant research developed at the Institute for Computational Design and Construction ICD, the Institute of Building Structures and Structural Design ITKE and the Centre for Information Technology and Architecture CITA, demonstrating the potential of active-bending and double-layer principles for pavilion scale structures [1], however not applied yet on large span with high load bearing cases.

The project focuses on the development of a double-layer construction system for a free-standing load bearing lightweight wooden structure. The system explores hygroscopic material enhancement and active bending principle where the aim is the design and construction of a pedestrian bridge exploiting the elastic bending capacity of standard thin plywood.

The design explores geometrically complex curved forms that fulfills both architectural and structural constraints. The global shape of the structure is designed through a computational modelling tool, such that the structure behaves as an arch while satisfying required geometric criteria. The foundation in concrete has been constructed to transfer the horizontal reaction force to the ground. The double curvature of the bridge surface has been chosen to cover several architectural requirements, and at the same time to withstand the weight of five people crossing the bridge while guaranteeing structural integrity with minimum displacement.

Strip patterns were introduced from the beginning of the design process, generating series of unique curvy-linear developable segments. The segmentation strategy adopted is intrinsically connected to the assembly sequence of the bridge, which is built section by section from two sides towards the centre. The double-layer system, integrated in the structure through U-shaped components, allows to fix in place the curvature of each section without springback. The local load transfer between the segments is secured by shear bolt connections, while globally, structural analyses have been made with accurate detailed model to estimate the structural displacement with the previously mentioned load, and to foresee the torsional buckling due to excessive additional weight.

The paper concludes with the shortcomings of the construction system and the structural issues due to imprecise assembly strategy and the lack of an internal substructure. Furthermore, the collapsing of the structure is shown after testing its load bearing limits and featuring ductility on global level.

[1] J. Lienhard, S. Schleicher, and J. Knippers, Bending-active Structures – Research Pavilion ICD/ITKE, *Proceedings of the International Symposium of the IABSE-IASS Symposium*, 2011.