The Timber Reciprocal Frame Designer: Free Form Design to Production

Tom S. GODTHELP*, Rinus ROELOFS[a], Arjan P.H.W. HABRAKEN[b], André J.M. JORISSEN[c]

*Graduate Student, Structural Design, Department of the Built Environment
Eindhoven University of Technology (TU/e)
t.s.godthelp@student.tue.nl

[a] Artist, Specialized in Mathematical Morphology
[b] Assistant Professor, Innovative Structural Design, TU/e
[c] Professor, Timber Structures, TU/e

Abstract

The definition 'Reciprocal Frame' (RF) applies to structures that are feasible by means of circulating compression or tension interactions between their constituent members. This relation indicates that beam depths and connections correlate to an RFs' structural geometry. Until now, a combination of RF form finding that regards both beam depths and structural design of connections has not yet been developed. Although researchers developed computational form finding methods to create geometrical solutions and described the global structural design [1], computational complexity may have prevented a direct inclusion of detailing in the overall design.

This research presents a new and direct RF form finding method that includes the structural design of beam dimensions and detailing based on the polygon modification method described by Anastas et al. [2]. A parametric model -to be referred to as 'The Timber Reciprocal Frame Designer' (RFD)- is developed to design three- and four-member RF assemblies from any arbitrary NURBS surface (Fig.1). Eccentricities between members that may result or are generated from this surface correlate to detailing and beam depth causing the need to be controlled. Therefore, a method has been established that allows this control and results in direct geometrical solutions. Among geometrical equations, fictional beam stiffnesses in combination with initial strains are here used to derive the geometrical shape.

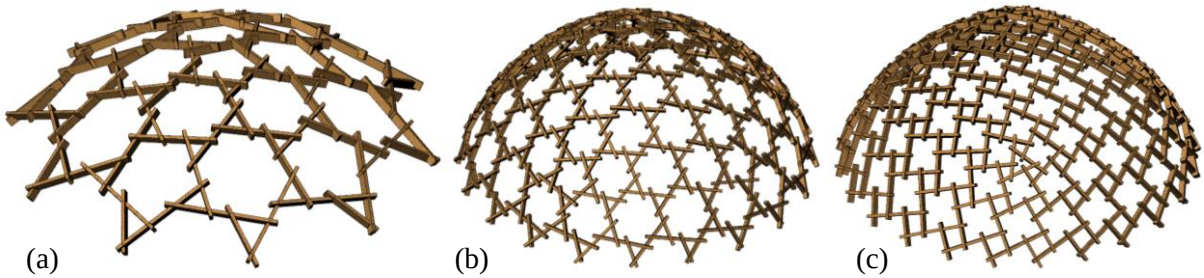

Figure 1: RF designs made with the RFD covering the same span and with equal eccentricities, (a,b) Based on three-member assemblies, (c) Based on four-member assemblies.

A geometrical shape is supplemented in the RFD with standardized detailing and beam dimensions that are checked, and if necessary adjusted to satisfy stress and deformation regulations. In conclusion, the RFD provides a tool in which designs can be produced by using industry standard machines stimulating structural designers to add RF's to their design pallet. An experimental validation of the design to production process is made by means of a full-scale model, built in cooperation with the timber industry.

References

[1] U. Thönnissen, *Hebelstabwerke / Reciprocal Frameworks Tradition und Innovation / Tradition and Innovation*, Bilingual. Zürich: gta publishers, 2015.

[2] Y. Anastas, L. Rhode-Barbarigos, and S. Adriaenssens, "Design-to-Construction Workflow for Cell-Based Pattern Reciprocal Free-Form Structures," *IASS*, vol. 57, no. 2, pp. 159–176, 2016.