Collaborative workflow for the design, structural analysis and fabrication of a strip-based segmented complex structure

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Abstract

The authors present state-of-art computational design workflows for strip-based segmented structures, as well as a strategy for the structural analysis of such structures.

In the Architecture, Engineering and Construction (AEC) industry, an increasing interest is given to collaborative design workflows between different software tools among multiple trades and stakeholders. Despite an effort made to enhance interoperability through Building Information Modelling (BIM) and its corresponding Industry Foundation Classes (IFC), a lack of cross-software communication persists within digital design and parametric modelling tools, such as Rhino3D and Grasshopper. Therefore, the present research **investigates a custom collaborative workflow that enable seamless data communication between distributed files during the design, fabrication and structural analysis of a strip-based segmented complex structure**. This paper reports on a computational design modelling and fabrication workshop conducted by the authors at the Centro de Estudios Superiores de Diseño de Monterrey (CEDIM) in November-December 2018. The workshop aimed at introducing computational design tools to undergraduate students in architecture, through the design and fabrication of a complex structure made of laser-cut polypropylene plastic strips. The strip-based discretization of the structure is inspired by the work of THEVERYMANY and precedent research on graph-based computational design tools developed by Nejur and Steinfeld [1]. One of the main goals of this workshop was to establish a seamless collaborative design workflow using the Rhino-Grasshopper environment as the main modelling platform. The workflow was distributed among multiple modelling pipelines shared between students. Those pipelines could be gathered at any time in the design process through the open source AEC communication platform Speckle, from initial conception to the final construction and assembly of the final architectural design installation.

Although the recent development of digital tools and fabrication methods allows for cost-effective production of such complex shapes, the mechanical validation of a discretized shell structure is under minor research. An attempt has been made by Schönbrunner *et al.* [2] to simulate a similar segmented shell structure with assembled bending-active plates. When the scale of the structure is increased to the architectural scale, the challenge lies in the evaluation of the joints between discrete segments such that the membrane action is guaranteed. Therefore, the second part of the paper presents the structural analysis of a scaled-up structure that consists of two layers of strip segments in metal sheets. **A structural analysis is made for both local and global verification of the structure, including stresses at the joint conditions and the effect of bending during the assembly.**

References

[1] A. Nejur and K. Steinfeld, "Ivy - Bringing a Weighted-Mesh Representation to Bear on Generative Architectural Design Application," in *ACADIA/2016: POSTHUMAN FRONTIERS: Data, Designers, and Cognitive Machines*, Proceedings of the 36th Annual Conference of the Association for Computer Aided Design in Architecture (ACADIA), 2016, pp. 140-151.

[2] A. Schönbrunner, N. Haberbosch, R. La Magna, S. Schleicher, J. Lienhard and J. Knippers "Design strategies for bending-active plate structures out of multiple cross-connected layers" in *Proceedings of the IASS Symposium*, 2015.