Behavior of Modular Components in a Funicular Glass Bridge

Mohammad BOLHASSANI[*,a,b], Cory BYRNES[c], Joseph Robert YOST[c], Masoud AKBARZADEH[a], Jens SCHNEIDER[d], Andrei NEJUR[a]

[*,a] Polyhedral Structures Laboratory, Department of Architecture, School of Design, University of Pennsylvania, Pennovation Center 3401 Grays Ferry ave. Philadelphia, PA, 19146

[b] The Bernard and Anne Spitzer School of Architecture, The City College of New York, 141 Convent Avenue, New York, NY, 10031, mbolhassani@ccny.cuny.edu

[c] Structural Engineering Teaching and Research Laboratory (SETRL), Villanova University

[d] Institute for Structural Mechanics and Design, Technical University of Darmstadt

Abstract

The recent evolution of two-dimensional graphic statics (2DGS) into the third dimension (3DGS) has broadened the opportunity for extensive exploration into design of efficient funicular structural systems [1]. Furthermore, the design and use of structural glass has expanded significantly in recent years [2]. This research exploits the current potential to which 3DGS and computational form finding can be used to extend the boundaries of optimization in the design of glass structures. The ultimate research objective is construction of a fully-transparent, high performance pedestrian bridge composed entirely of glass plates, which are oriented in a double layer, funicular, compression-dominating configuration. The funicular form of the bridge, developed using 3DGS, maximizes structural performance and minimizes the use of materials and resources: making it both architecturally unique and structurally efficient [3].
Unique to this structure is a modular approach to construction, where the bridge is built using a collection of inter-connected polyhedral hollow glass units (HGU). The proposed modular approach simplifies construction, improves quality control and allows for removal and replacement of an individual HGU in the event of damage. The research will initially involve the study of a single HGU. Behavior of an individual HGU will be related to plan and edge geometry of the glass plates, the connection detail between glass plates, and the collective interaction between glass and connection. The initial study will involve fabrication methodology, finite element modeling, and experimental testing. Following the single HGU study, will be investigation of a reduced scale bridge for the purpose of understanding the inter-HGU connection behavior. Finally, a full-scale bridge will be built, modeled and tested. This paper will present the overall research methodology with emphasis on construction, analysis, and experimental testing of an individual HGU.

References

[1] M. Akbarzadeh, *3D Graphic Statics Using Polyhedral Reciprocal Diagrams*. PhD thesis, ETH Zürich, Zürich, Switzerland, 2016.

[2] H. Schober and J. Schneider, "Developments in structural glass and glass structures," *Structural Engineering International*, vol. 14, no. 2, pp. 84–87, 2004.

[3] M. Akbarzadeh, M. Bolhassani, A. Nejur, J. R. Yost, C. Byrnes, J. Schneider, U. Knaack, and C. Borg Costanzi, "The design of an ultra-transparent funicular glass structure," in *Structures Congress 2019*, (Orlando, Florida), April 24-27 2019.