Changi Jewel: Pushing the limits on shell design

Craig SCHWITTER*[a], Cristobal CORREA*[b]

*BuroHappold Engineering, New York, NY USA
[a] Columbia University Graduate School of Architecture, Planning and Preservation, New York, NY USA
[b] Pratt Institute Graduate Architecture and Urban Design, Brooklyn, NY USA
Craig.Schwitter@BuroHappold.com
Cristobal.Correa@BuroHappold.com

Abstract

In 1959 Heinz Isler challenged the world of IASS by proposing a series of shapes for shells that were very different from what most designers thought were logical or appropriate forms. These geometries were the result of experimentation and form finding methods that creatively explored form in shells beyond strict geometry and into a world of structural expression. In a similar way contemporary engineers are encountering forms for shells that are going well beyond established notions of geometrical optimization, pushed by extreme architectural programs and client demands. To realize these structures, engineers are creatively developing methodologies that meet the challenges of a new generation of shell projects – structures that previously would be have been unbuildable without the use of computational engineering and fabrications methods available today.

This paper will look at one such project, Singapore Jewel, a unique grid shell designed by Moshe Safdie Architects and BuroHappold Engineering. The single layer grid shell roof was completed in 2018 and is located at Changi Airport in Singapore. The project creates a new traveler destination for the region including a large mixed use development and garden space. The main grid shell roof covers an area of 25,000m² with interior supports creating spans of approximately 110m. The center of the shell is unsupported and hangs in tension to develop a large water feature, creating a 40m waterfall in the center of the roof. Four primary entry gateways, also formed of gridshells, provide clear views into the heart of the project.

The engineering team was challenged from the early stages of the project with a restrictive site geometry, including a working train running underneath the site of where the shell would be constructed. The geometry of the shell structure was ultimately driven not by repeatability of elements, but methodologies that created a simple hierarchy of computationally fabricated elements. Ultimately the roof had 15,000 beams, 5,000 nodes and 13,000 glass panels. The roof is comprised of a single layer of varying depth fabricated box beams. Beam depths have been optimized to address critical buckling, bending and axial conditions throughout the shell surface, driven in part by the complex forces in the built form. Nodes are comprised of solid steel elements fabricated with precision for bolting and welding on site. Glass panels are approximately 2m in height, with varying shapes.

The paper will examine the development of the structural shell form as well as its element discretization in light of the new paradigms driving construction of surface stressed structural systems. We will show how the work of Heinz Isler is very much alive today, pushing the next generation of engineers to solve new and exciting challenges in structural shell design today.


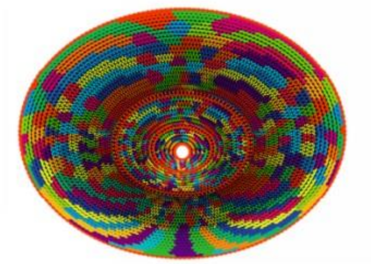

Figure 1: Image of Jewel on left, mathematical modelling of nodal families in gridshell on right