# PARAMETRIC STRUCTURAL EVALUATION OF BENDING-ACTIVE BAMBOO SHELL STRUCTURES: Tools for Conceptual Architectural Design Performance Evaluation

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## Abstract

Combining digital design technology with vernacular bamboo craftsmanship enables radically unique and spatially versatile architectural solutions that remain rooted in local culture and sustainable building practices.

This paper discusses a series of research actions taken as part of a project on the architectural design and implementation of bending-active bamboo shell structures in Hong Kong. The project combines research in 1) design with digital physics-simulation engines, 2) light-weight construction systems and 3) low-tech, vernacular bamboo building traditions. It builds on earlier fundamental topical research and works towards developing 'Guidelines for Best Practice' for their computation-driven architectural design and construction. The aspects discussed in this paper cover the development of a user-friendly parametric engineering software setup that provides the architectural designer real-time structural performance evaluation feedback during a project's conceptual architectural design stages.

This paper firstly discusses the further development of the real-time physics simulation setup and its parametric structural engineering analysis. The imposition of initial strain on the material related to the curvature radius found in specific segments has been introduced to the load analysis setup. In combination with the geometry capabilities of the procedural modeller and its physics simulation engine add-ons, this enables one to investigate a pre-bent structure where only an approximate geometry is known. Due to the principle of minimum potential energy, the structures deflect towards their most relaxed - thus physically correct - state. This approach avoids the problem of doing time-consuming non-linear large displacement calculations. Secondly, this expanded tool's applicability is tested by using the "ZCB Bamboo Pavilion" as a case-study to further evaluate its structural viability as well as the safety margins employed in its original structural design. Thirdly, the tool is used to simulate the extent to which the project's building typology could be scaled or altered before structural stability is compromised. In doing so, the extent of the new typology's solution space is assessed – knowledge which had not been tested thus far, since the project directly responded to its site restrictions.

The expanded parametric engineering software setup increases designer access to a spatially versatile and eco-friendly tectonic system, suitable for the low-tech, labour-driven, onsite construction contexts found in most rapidly developing parts of the world. It enabled the illustration of the theoretical extent to which this material and tectonic system could technically be applied in professional practice.

## References

[3] J. Lienhard and J. Knippers, "Considerations on the Scaling of Bending-Active Structures," *International Journal of Space Structures*, Vol. 28, Issue 3-4, pp. 137-148, 2013.

[2] C. Preisinger and M. Heimrath, "Karamba—A Toolkit for Parametric Structural Design." *Structural Engineering International*, 24:2, pp. 217-221, 2014.

[1] D. Rockwood, *Bamboo Gridshells*, New York: Routledge, 2015.