

Shell Structure Design And Shape Optimization As A Model For Material Behavior Of Bamboo

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Abstract

The purpose of the study is to develop an integrated design approach to shell structure with natural material properties by utilizing material behavior and computational design tools. The study focuses on the analysis and outcomes obtained from optimal form finding in Voronoi shell structure. A design process has been accomplished by incorporating the constraints of the forces acting on the material and the parameters of the mechanical properties by taking into consideration in the early stages. The process is inspired by the formation of natural structures and abstractions from selected natural properties have been transferred to the digital design environment. In this respect, underlying motivation to translate natural systems, behavior and processes into design principles, minimizing energy and material usage that promises more sustainable structures to generate a robust, efficient, lightweight, rigid structures also by considering constraints on early stages thereby saving time and cost. Moreover, locate the designer to be in a decision-making position from the beginning to the end of the design process.

Natural analogies formulated to digital design parameters of the material behavior determined by bamboo mechanical properties, which defines structural behavior of the shell. The different fiber distributions according to self-weight and the external forces acting on bamboo, can serve as a model for the distribution of structural elements to form the shell. Shell is a special structure that its structural behavior directly determined by the mechanical properties of the material and it is crucial to provide force equilibrium. Hollow tube form of bamboo provides material minimum usage at the same time rigid, stiff structure and high buckling resistance. Abstraction of these natural properties of bamboo, are translated into principles as the thickness and the density of the structural geometry determined by the loads on it that provide structural efficiency of the shell. The study conducted by structural shape optimization to evaluate different design alternatives and digital simulations to analyze material behavior. The results obtained from the form-finding process by mechanical properties on shell structure have the potential to contribute to a better understanding of the material behavior effects on the structural efficiency and material-environment relation. The study will discuss how to adapt the findings from the optimization process to the future design problems.

Key words: Material behavior, structural behavior, shell structure, form finding, bio-inspiration, natural materials, biomimicry.

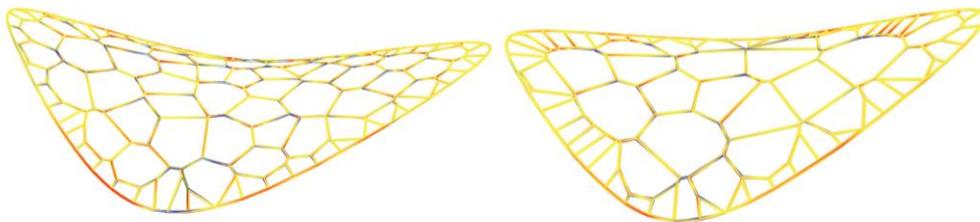


Figure 1: Comparing the models before and after optimization.