Point load Actuated, Adaptive Elastic Gridshells:
Methods for initial design and modeling

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Abstract

This paper presents a series of physical and digital experiments concerning the design of multiple-equilibrium, adaptive gridshells actuated by strategically applied point loads. Therefore, an unrestrained elastic gridshell is made to buckle through point loads in the direction of gravity at different positions. This results in an adaptive structure that is stable yet capable of transforming into multiple shapes. Such an approach may be useful as a form of temporary architecture that is able to change itself significantly to suit users' spatial needs.

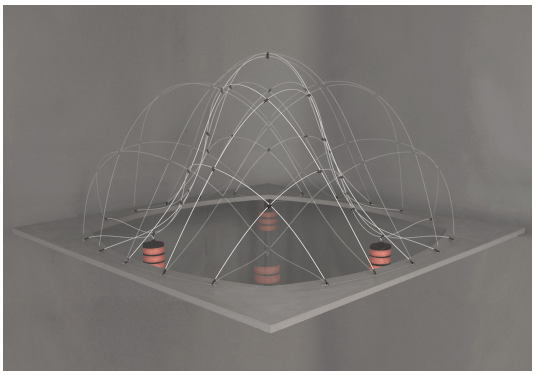

Figure 1: Two superimposed states of GFRP gridshell prototype at different actuator configurations

Elastic gridshells are typically used for the ease with which they can be constructed on site. Once erected, the gridshell is usually locked into shape immediately and secured into a static form that corresponds with the intended design, preventing any additional transformation of the flexible bending-active elements. Building upon the topic of lightweight, material based adaptive architecture [1] the presented research investigates the adaptive potential on such bending active gridshells made of glass fiber reinforced plastic (GFRP) rods.

The main focus of this research is to establish an understanding of how to control the elastic deformation and stability of an adaptive gridshell, actuated by point loads. The positioning, sequence and magnitude of applied load is investigated and evaluated in terms of resulting displacement and motion behavior in digital and physical models. A record of possible states was initially collated through carefully photographed physical prototypes, showing how single or dual point loads at specific positions influence the gridshell geometry. Subsequently, the results from physical experiments where used to calibrate a particle spring based simulation model. The digital model was used to iterate fast through variations in the positioning and sequence of the applied loads, to gain understanding of their effect on the resulting shapes. The results show that this actuation approach can produce a significant number of equilibrium states. Notably, the applied loads do not only influence the shape, but also the geometric stiffness of the gridshell. Thus, certain configurations could only be achieved by temporarily increasing the geometric stiffness and carefully considering the sequence in which the point loads are applied. This study can eventually lead to the definition of actuator paths for the purpose of producing many desired geometries without compromising stability.

References

[1] Sparmann, Matthews et. al, *Large-Scale Lightweight Transformable Structures,* ACADIA 2017: DISCIPLINES & DISRUPTION Proceedings of the 37th Annual Conference of the Association for Computer Aided Design in Architecture (ACADIA), Cambridge, MA 2-4 November, 2017