Calibrated modelling of form-active structures

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Abstract

The design and analysis of a bending active, thin timber shell structure using a self-written physics based structural analysis solver, K2Engineering.

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1 Introduction

Lightweight and low stiffness structures that exploit an efficiency of form to resist applied loads in mainly direct tension or compression with minimal bending of the members are often difficult to model and to analyse. Gridshell structures are an example of these, which whilst elegant are often limited in terms of design exploration by the need to incorporate a form finding step which is dictated by the force flow. Their slender nature can mean that the assumption of a linear relationship between force and deformation no longer applies due to the inherently large deformations and global/local buckling behaviour.

The steps to address both the form finding as well as the large deformations and buckling should, ideally, be highly interconnected. It would also be advantageous for any design workflow to allow an openness that allows for intervention in geometry and topography of structure in a simple and instantaneous way. Conventional structural analysis software does not offer these steps in a single platform. They are only useful for form-finding or the analysis is so cumbersome to set up that multiple design iterations become impractical. In an attempt to improve this workflow, a plug-in called "K2Engineering" has been developed for the parametric modelling environment Grasshopper. K2Engineering offers the ability to analyse form-active structures in a much more interactive environment and thereby encourages an informed exploration in the early design stage. It is an extension of the physics constraint solver "Kangaroo2" developed by Daniel Piker. The physics based underpinnings of the plug-in allow swift evaluation of bending active structures and accurate modelling of the resulting geometry caused by applied bending forces.

This paper focuses on a doubly curved gridshell using bending-active thin plywood timber laths, designed and erected by students at The University of The West of England, the structural performance of which was simulated in the K2Engineering environment.

2 Geometry modelling

A doubly curved surface to suit the site constraints was defined parametrically (using Rhino/Grasshopper) and then used to derive a set of primary laths based on geodesic lines. Secondary elements were then woven around these primaries, again by generating geodesics. Finally, splice points along the laths were located, with the final geometry the exported for detailed

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