A Method for Flat-pack Origami Construction of Spatial Structures

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Abstract

This project investigates origami as a means to construct 3-dimensional spatial structures in situ from pre-cut and pre-scribed flat sheet material composed of Aluminum. The approach relies on rationalizing a structure to origami node connectors connecting origami members. The method is intended to allow for efficient prefabricated construction of light-weight spatial structures.

The buckling resistance and stiffness of the member is proportional to the fold angle. Through a digital optimization process, selection of member size/fold angle and position of the member is achieved based on the internal forces obtained from a structural Finite Element Model (FEM) (Figure 2). Optimization for light open fold members where axial load is small versus closed fold members where axial is high is achieved. The length of the origami members is optimized based on degree of curvature of form to be constructed, and maximum effective buckling lengths. The intended application of the approach is to arrive at the "massing" shown in the tri branch structure below. The form has been optimized to maximize axial compression forces and minimize flexural forces (Figure 1). The form is divided into the origami nodes and branches. Branches consist of simple triangular closed prisms, or open angles if loads allow. Nodes consist of curved-folded faces with some of the vertices cut out to allow for geometric flexibility (Figure 3 & 4).

The pieces will be digitally fabricated from aluminum sheets unfolded from the design model. Current estimated surface area of the material in the constructed state is around 14m² and the weight is estimated to be around 180kg, well within the allowed maximum.

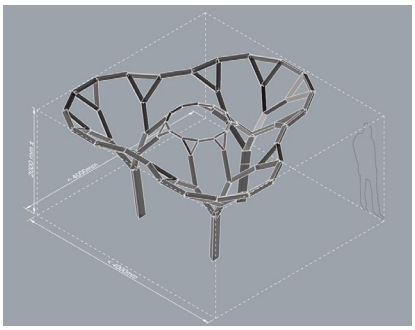

Figure 1: Design Model

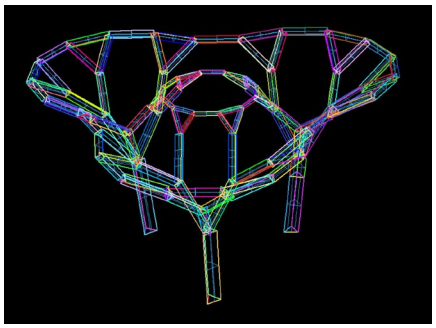

Figure 2: Finite Element Model

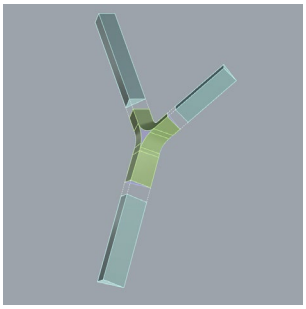

Figure 3: Origami Node

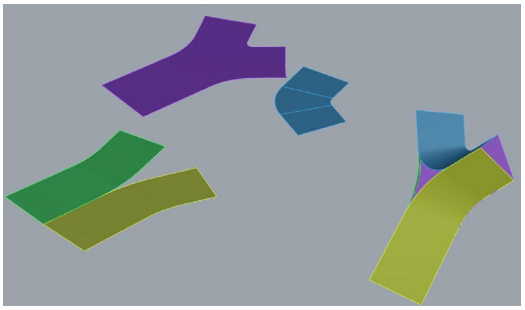

Figure 4. Unfolded Origami Node Member