Bi-layer Thick Rigid Origami Vault

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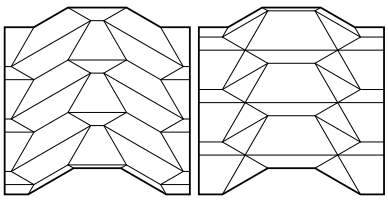
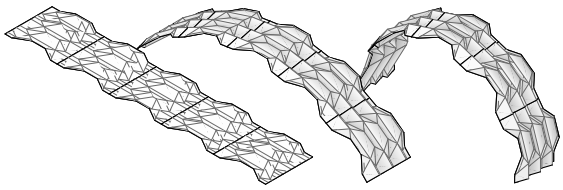
Abstract

Recent studies [1, 2] reveal that combining multiple sheets of rigidly foldable origami create extremely stiff yet deployable structures. Our goal is to apply such ideal structures for temporary structures such as emergency shelters and pavilions; to achieve this goal, there are two crucial structural problems needed to be tackled, namely, curvature creation and thickness accommodation. In this presentation, we show a design that succeeds in solving both problems, i.e., a rigidly foldable vault structure composed of two surfaces of thick folded panels. Coupling of two sheets of Miura-ori forms a thick sheet structure stiff in out-of-plane and soft in in-plane deformation [2]. A geometric construction from a curve [3] easily generalizes this structure to create a curvature in the soft direction but not in the stiff direction. However, to apply the curvature for creating a vault, the opposite property is required, i.e., the structure needs to be curved in the stiff direction. We solve this problem by creating different patterns for the bottom and top structures generated from zig-zag curves having carefully selected alternating torsion along the curve. This enables a pair of mutually compatible mechanisms of corrugated rigid origami that forms a curvature in the stiff, out-of-plane direction. The thickness issue, i.e., the existing thickening techniques of rigid origami only apply to single sheet geometry, can be solved by carefully placing the hinge locations on the interface of two thick panels using volume trimming method. In the pavilion design, we used two plies of 10mm polypropylene sandwich boards (Plapearl) and applied hinges using CNC V-cut patterns.





References

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