Investigation on multi-stable behaviors of star-shaped tensegrity structures with dihedral symmetry

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Abstract

In this study, we investigate multi-stable behavior of the star-shaped tensegrity structures, which are of dihedral symmetry $\mathbf{D}_4$. A multi-stable structure can have two or more stable configurations, in the sense of having locally minimum potential energy; moreover, the structure can be switched from one stable configuration to another one by application of external forces [1].

Figure 1 shows two of the stable configurations of a star-shaped tensegrity structure. This structure is not super-stable, because there exist negative eigenvalues in its geometrical stiffness matrix [2]. The original stable configuration of the structure as shown in Figure 1(a) is of high 4-fold dihedral symmetry $\mathbf{D}_4$. It has another stable configuration with much lower symmetry as shown in Figure 1(b). Both of the configurations are stable, in the sense that they will recover the original configuration after release of small enforced deformations. The two stable states can be switched to each other by applying a large enforced deformation.

The multi-stable behaviors of the structure are investigated by changing three parameters: (1) level of prestress, (2) (relative) stiffness of cables, and (3) the ratio of height to radius. It is demonstrated by parametric studies that the level of prestress is the most important factor on the multi-stable behavior.

(a) initial stable configuration (b) another stable configuration

Figure 1. Two stable configurations of the star-shaped tensegrity structure with four struts.

References

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