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EFFECTS OF STRUCTURAL CONFIGURATIONS ON DEPLOYMENT BEHAVIOR OF TWO-DIMENSIONAL SELF-DEPLOYABLE STRUCTURE WITH CORRUGATED PANELS

Abstract

Deployable structures can greatly expand the range of space utilization. They are very useful not only for large structures but also for micro-satellites. We have proposed a concept of two-dimensional self-deployable structure in which corrugated panels are arranged based on origami folding, rotationally skew fold, and connected them by elastomer film. Since this structure can be deployed without spring hinges and has higher rigidity than a flat panel of the same thickness, it can achieve both lightness and rigidity at a high level. This feature provides a possibility for mounting solar cells and antennas on micro-satellites, which have strict requirements for mass and size.

This study focuses on the qualitative properties for the self-deployable structures composed corrugated panel elements. We evaluate the relationships between the panel size, the connection conditions between panels versus the deployment characteristics, which have not been clarified so far, experimentally and numerically.

First, we experimentally clarify the similarity law concerning the deployment characteristics of this structure by comparing some conceptual models with different numbers of panels made of the same material and with same dimensions. This experiment shows that this scalable deployment is possible even when the number of panels is increased. This result can be attributed to the fact that the deployment forces are distributed throughout the structure.

Next, we compare the two-dimensional deployment behaviors of some models with different types of films connecting the panels. It is shown that the two-dimensional deployment behaviors are very different due to the elasticity, viscoelasticity, and thickness of films. This result suggests that it is possible to adjust the deployment speed of panels by selecting the films well.

Finally, we formulate the equations of motion for each panel and solve them in the manner of multi body dynamics to derive the two-dimensional deployment behavior numerically. In this calculation, the deployment torque and viscous force acting on each panel are given by experimentally evaluating the deployment of one-dimensionally connected panels. The experimental result and numerical result confirm the approximate agreement.

The results of this study will provide important suggestions for the design of actual two-dimensional deployment panels. Also, it will be possible to evaluate the two-dimensional deployment characteristics of them by evaluating the deployment characteristics of only a one-dimensional model experimentally, without an actual 2D model, which will be helpful to reduce the manufacturing costs.