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Author: Dr. Takashi Iwasa
Tottori University, Japan

Mr. Shintaro NAKAJIMA
Japan

SPATIAL DISTRIBUTION PROPERTY OF SURFACE DISTORTION OF SQUARE MEMBRANE WITH WRINKLES SUBJECTED TO SHEAR AND TENSION LOADS

Abstract

Object:
Large-sized membrane space structures such as solar sails, inflatable antenna reflectors, and sunshields have attractive attention for future advanced space science missions. Since the performance of these membrane structures is affected by the membrane surface configuration, it is important to estimate the membrane surface distortion appropriately in orbit. However, a full-field surface shape measurement of the membrane structures is difficult to perform due to its large-sized area, and a discrete point measurement will be an effective candidate as a practical method. In that case, the maximum membrane surface deformation is not always obtained properly, and an estimation method capable of capturing the maximum membrane surface deformation from the limited number of the measured data is demanded. In this work, to establish such a practical and simplified estimation method of the maximum membrane surface distortions, a spatial distribution property of the out-of-plane displacement on the membrane surface is studied. If the spatial distribution property is described with a certain probability distribution model, the maximum deformation of the wrinkled membrane surface can be estimated from the limited number of the measured data.

Methodology:
The square polyimide film, which held fixed at the bottom edge and subjected to in-plane shear and tension loadings at the upper edge, is treated. The size of the membrane is 0.05 m x 0.05 m and its thickness is 25 mum. The membrane deformation during the shear and tension loading is simulated using a geometrically nonlinear finite element analysis with shell theory. Based on the results, the spatial distribution property of the out-of-plane displacement on the membrane surface during the formation and dissipation process of wrinkles is discussed.

Results:
When the in-plane shear and tension loadings are applied to the membrane, wrinkles are formed and dissipated with changing the amplitude and the number of wrinkles. However, the spatial distribution of the out-of-plane displacement on the membrane surface has a similar probability distribution even if the wavelength and the amplitude of the wrinkles varies.

Conclusion:
This paper pointed out that the spatial distribution of the out-of-plane deformation of the square membrane subjected to in-plane shear and tension loadings potentially has similar probability distribution model regardless of the amplitude and the number of the wrinkles.