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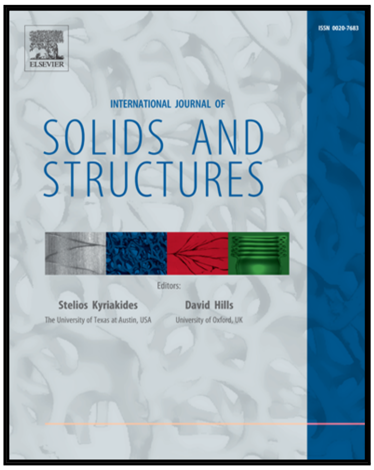

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Experimental Verification on Wrinkling Behavior Given by Wrinkling Analysis Using the Tension Field Theory

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ABSTRACT

This study investigates the physical meaning of membrane surface features given by a wrinkling analysis based on tension field theory and wrinkle strain, which releases the compressive stress in membranes in tension field theory. A rectangular membrane was subjected to shear loading, and the wrinkle geometry and strain field were measured by photogrammetry using a direct linear transformation method. The experimental model was then subjected to a wrinkling analysis based on tension field theory, and the calculated wrinkled membrane behavior was quantitatively compared to the measured results. The analyzed membrane surface features approximately represented the neutral curved surface bisecting the actual wrinkle geometry (the difference was approximately 10% of the maximum wrinkle amplitude), even when the membrane surface feature was not initially flat. The wrinkle strain, defining an in-plane shrinkage strain that releases compressive stress on the membrane in tension field theory, agreed with the experimentally observed in-plane shrinkage strain regardless of the formation process of the wrinkles. The relation between the in-plane shrinkage strain and ratio of the wrinkle amplitude to the half-wavelength of the wrinkles was then derived from inextensional theory. This relation appropriately described the relation measured in the experiment, confirming that inextensional theory describes the wrinkle formation. The results of this study will assist the evaluation of the simulation results using tension field theory for the development of future lightweight, membrane-based space structures such as sunshields and solar sails.

Keywords: Experimental Verification, Membrane Surface Feature, Wrinkle Strain, Tension Field Theory, Photogrammetry

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