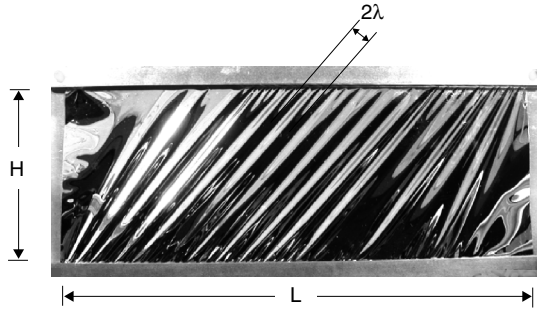
Deployable Structures Laboratory



Computation of Wrinkle Amplitudes in Thin Membrane Structues

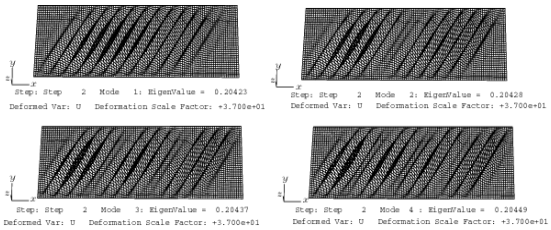
Background

Structural wrinkling is a common phenomenon found in thin membranes when subjected to different loading and boundary conditions. With increase used of prestressed membrane in space missions, it is hence importnat to know the implications of wrinkles on the structural performance and the stability of these structures.

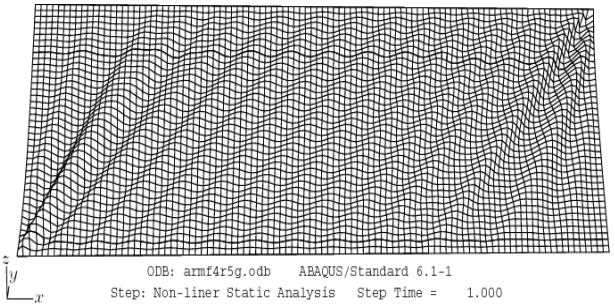
Objective

Previous studies on wrinkling have always neglected the bending stiffness of the membrane and hence details of the wrinkles can't be obtained. In present study, consideration is given to the negligibly small bending stiffness of membrane and the determination of wrinkle amplitudes.

Non-linear Finite Element Analysis - Thin Shell model



The bending of membrane is taken into account by modelling it with very thin shell element. Wrinkling modes of a membrane subjected to shear at one of its edges and clamped at the other edge is obtained by eigenvalue analysis. This imperfection is then embedded to the original mesh and a geometrical non-linear analysis is implemented



The deformed shape of the membrane after subjected to a geometric shear strain, $\gamma_g 0.0243$ is found to be same as the one observed in experiment. Details of the wrinkling parameters can also be determined.

Analytical Solution

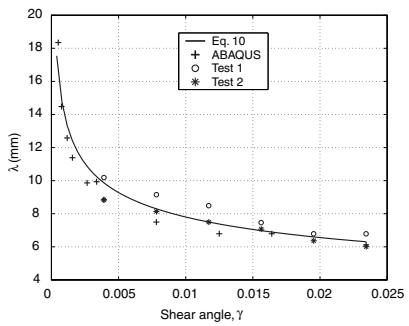
A simple analytical solution for the shearing model has been developed based on the assumption that the critical wrinkling stress, σ_{cr} is equal to the buckling stress of a plate with a width of half-wave, λ. The relationship of the wavelength and the shear displacement is then developed.

$$\lambda = \frac{\sqrt{\pi}\sqrt{Ht}}{[3(1-\nu^2)]^{\frac{1}{4}}\gamma^{\frac{1}{4}}}$$

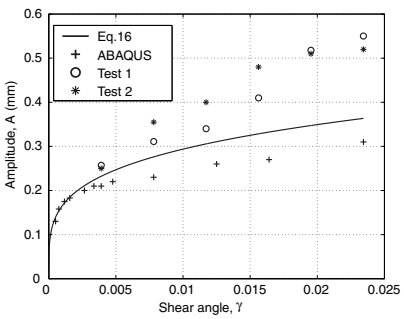
$$A = \frac{\sqrt{2(1-\nu)}}{\sqrt{\pi}[3(1-\nu)]^{\frac{1}{4}}}\sqrt{Ht}\,\gamma^{\frac{1}{4}}$$

$$\sigma_{cr} = -\frac{\pi^2}{\lambda^2}\frac{Et^2}{12(1-\nu)^2}$$

Comparison of wrinkle wavelengths for Kapton membrane



Comparison of wrinkle amplitudes for Kapton membrane



Comparison of critical stress at different shear angles, γ