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1964

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Abstract

Full Text

THEORY OF ELASTICITY

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LOSS OF STABILITY OF A CONVEX SHELL UNDER THE PRESSURE OF A TAUT STRING

Let a strictly convex shell, rigidly fixed along its edge, be subjected to the pressure of a taut string upon it (Fig. 1a). At a certain tension Q of the string, the shell loses stability with the formation of bulging regions along the line of contact of the string (Fig. 1b). This tension will be called critical. In the present note we determine the magnitude of the critical tension.

The considerations set forth in work ([1]) give a natural approximation to the form of the shell under postcritical deformation by means of "mirror bulging." In this case, for the energy of elastic deformation of the shell one obtains the expression

$$U = \pi c E (2h)^{3/2} \delta^{5/2} (k_1 + k_2).$$

Here $2h$ is the deflection of the shell at the center of the bulge; k_1 and k_2 are the principal curvatures of the shell; δ is the thickness; E is the modulus of elasticity; c is a constant. According to recent data,

$$c = \frac{0.178}{1 - \mu^2},$$

where μ is Poisson' s ratio. The work produced by the tension Q is

$$A = Q \Delta l,$$

where Δl is the total displacement of the ends of the string associated with the bulging of the shell. Assuming that there is no friction between the string and the shell and, consequently, that the string lies on the shell along a geodesic line, we readily find Δl. It is equal to the difference between the arc AB and the chord joining its ends. If the normal curvature of the shell in the direction of the string is k_n, and the deflection at the center of the bulge is $2h$, then

$$\Delta l \simeq \frac{(2h)^{3/2}}{3} \sqrt{k_n}.$$

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Consequently,

$$A = Q\frac{(2h)^{3/2}}{3}\sqrt{k_n}.$$

From the equilibrium condition for the shell

$$d(U - A) = 0,$$

where the deflection $2h$ is varied, we find the load Q borne by the shell at the moment of loss of stability:

$$Q = 3\pi cE\delta^{5/2}(k_1 + k_2)/\sqrt{k_n}.$$

In particular, for a spherical shell,

$$Q = 6\pi cE\frac{\delta^{5/2}}{R^{1/2}}.$$

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Received
2 III 1964

CITED LITERATURE

1. A. V. Pogorelov, *On the Theory of Convex Elastic Shells in the Postcritical Stage*, Kharkov, 1960.

Note: Figure translations are in progress. See original paper for figures.

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