

Analytical Geometrical Responses in Large Deflection of Elastically-Bossed Sensor Plate under Initial Tension

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Abstract

The linear problem of large deflection of a pre-stressed layered plate with an elastic boss due to lateral pressure is studied analytically. The nonlinear governing equations were developed, first, based on von-Karman plate theory for large deflection, which are further formulated in terms of lateral slope and radial force resultant via a non-dimensional and equation merging scheme. Following the consideration of a small deflection, the thus derived nonlinear governing equations were simplified, by neglecting the arising nonlinear terms, yielding a linear problem and thus a modified Bessel equation for the lateral slope. Analytical solutions were then developed which were expressed in terms of modified Bessel functions by considering the continuity at the interface between the boss and the annular plate as well as the boundary condition along the clamped edge. For a nearly monolithic plate with a thin boss, the solutions correlate very well with those of a single-layered plate available in literature, thus validates the present approach. Emphasis is placed upon the exploration of the influences due to various parameters including the magnitudes of lateral pressure, the initial tension, and also the geometry of the center boss upon the geometrical response (lateral deflection, slope, and curvature) of symmetrically-layered plates made of typical silicon-based materials. Following the obtained results, it is seen, the boss size and the modulus ratio between the layers of the annular plate can influence the geometrical behavior of the bossed plate significantly. In addition to the severe edge behavior around the clamped end, substantial edge effect may also appear at the interface between the center boss and the annular plate, i. e., the plate behavior may prevail around these regions. For a relatively large initial tension, however, the pretension effect dominates, yielding a total membrane behavior for

the bossed plate, regardless of the size of the center boss, except in the very vicinity of the clamped edge.

Keyword : Elastic Boss, von-Karman Large Deflection Plate Theory, Modified Bessel Function, Pre-stress