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Clamped Saddle Shells of Laminated Composites: Effect of Cutout on Natural Frequency and Mode Shapes

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Abstract

Clamped saddle shells made of laminated composite materials in presence of stiffeners and cutouts are analyzed employing the eight-noded curved quadratic isoparametric element for shell with a three noded beam element for stiffener formulation. Free vibration problem of stiffened saddle shells with different size and position of the cutouts with respect to the shell centre are examined to find natural frequency and mode shapes of stiffened shells and arrive at some conclusions useful to the designers. The results are further analyzed to suggest guidelines to select optimum size and position of the cutout with respect to shell centre.

Keywords

Clamped Saddle Shell, Laminated Composite, Cutout, Natural Frequency, Mode Shape

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1. Introduction

Laminated composites are increasingly being used nowadays in aerospace, civil, marine and other related weight-sensitive engineering applications requiring high strength-to-weight and stiffness-to weight ratios. Among the different shell forms, saddle shells are one of them. Cutouts are provided in shell panels to save weight and also to provide a facility for inspection. In practice the margin of the cutouts are stiffened to take account of stress concentration effects. Also, there can be some instruments directly fixed on these panels, and the safety of these instruments can be dependent on the vibration characteristics of the panels. Hence free vibration studies on saddle shell panels with cutouts are of interest to structural engineers.

Dynamic analysis of shell structures having complex geometry, loading and boundary conditions can be solved efficiently by finite element method. Different computational models for laminated composites were proposed by researchers. Chao and Tung [1] presented an investigation on the dynamic response of axisymmetric polar orthotropic hemispherical shells. Later free vibration study of doubly curved shells was done by Liew and Lim [2], Chakravorty et al. [3]. Sathyamoorthy [4] considered the nonlinear vibration of moderately thick orthotropic spherical shells. Gautham and Ganesan [5] considered free vibration characteristics of isotropic and laminated orthotropic spherical caps. Wang et al [6] studied wave propagation of stresses in orthotropic thick-walled spherical shells. Lellep and Hein [7] did an optimization study on shallow spherical shells under impact loading. Dai and Wang [8] analyzed stress wave propagation in laminated piezoelectric spherical shells under thermal shock and electric excitation. Dynamic stability of spherical shells was studied by Ganapathi [9] and Park and Lee [10]. Qatu et al [11] reviewed the work done on the vibration aspects of composite shells between 2000-2009 and observed that most of the researchers dealt with closed cylindrical shells. But, saddle shells on rectangular planform with cutout (stiffened along the margin) are far from the existing literature.

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