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LAMINATED COMPOSITE HYPAR SHELL ROOFS WITH STIFFENERS: FREE VIBRATION BEHAVIOR UNDER DIFFERENT BOUNDARY CONDITIONS

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ABSTRACT

An eight noded shell element combined with a three noded beam element is used to study the free vibration behaviour of laminated composite stiffened hypar shells. Benchmark problems are solved to validate the proposed approach and a variety of author's own problems are solved taking simply supported and clamped boundary conditions. Different types of laminations including symmetric and antisymmetric, cross and angle ply laminations and sixteen combination of stiffening schemes are considered for the present study. The fundamental frequencies obtained for different combinations of laminations, boundary conditions and stiffening schemed are discussed critically.

1. INTRODUCTION

Among the common civil engineering shell forms, which are used as roofing units, the skewed hypars have a special position because these architecturally pleasant forms may be cast and fabricated conveniently being doubly ruled surfaces. The hypar shells may be stiffened to have enhanced rigidity when subjected to point loads or provided with cutouts for some service requirements. A comprehensive idea about their static and free vibration characteristics is essential for a designer for successfully applying these forms. Nowadays researchers are emphasizing more on laminated composite shells realizing the strength and stiffness potentials of this advanced material.

The initial studies about vibrations of stiffened shell panels where about stiffened cylindrical shells reported from time to time by Bardell and Mead (1989), Mecito lu and D kmeci (1991), Olson (1991), Sinha and Mukhopadhyay (1994), Jiang and Olson (1994) who used different methods like collocation, finite strip and finite element. Sinha and Mukhopadhyay (1995) echoed this fact in their review paper. As the researchers became more inclined towards composite materials a number of interesting papers came up dealing with free vibrations of stiffened composite shell panels most of which used the finite element as the analytical tool. Among these papers, Goswami and Mukhopadhyay (1995, 1996), Prusty and Satsangi (2001) worked on both cylindrical shell and spherical shells while

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