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Performance Evaluation of Free Vibration of Laminated Composite Stiffened Hyperbolic Paraboloid Shell Panel with Cutout

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Abstract. The paper considers free vibration characteristics of stiffened composite hyperbolic paraboloid shell panel with cutout in terms of natural frequency and mode shapes. A finite element code is developed for the purpose by combining an eight noded curved shell element with a three noded curved beam element. The size of the cutouts and their positions with respect to the shell centre are varied for different edge conditions of cross-ply and angle-ply laminated shells. The effects of these parametric variations on the fundamental frequencies and mode shapes are considered in details to conclude a set of inferences of practical engineering significance.

Notations

a ,b	length and width of shell in plan
$a^{/}$,$b^{/}$	length and width of cutout in plan
b_{st}	width of stiffener in general
b_{sx}, b_{sy}	width of x and y stiffeners respectively
B_{sx}, B_{sy}	strain displacement matrix of stiffener elements
d_{st}	depth of stiffener in general
d_{sx}, d_{sy}	depth of x and y stiffeners respectively
$\{d_e\}$	element displacement
e_{sx}, e_{sy}	eccentricities of x and y -stiffeners with respect to shell mid-surface respectively
E_{11}, E_{22}	elastic moduli
G_{12}, G_{13}, G_{23}	shear moduli of a lamina with respect to 1, 2 and 3 axes of fibre
h	shell thickness
M_x, M_y	moment resultants
M_{xy}	torsion resultant
np	number of plies in a laminate
N_1-N_8	shape functions
N_x, N_y	inplane force resultants
N_{xy}	inplane shear resultant
Q_x, Q_y	transverse shear resultant
R_{xx}, R_{yy}, R_{xy}	radii of curvature and cross curvature of shell respectively
u, v, w	translational degrees of freedom
x, y, z	local co-ordinate axes
X, Y, Z	global co-ordinate axes
z_k	distance of bottom of the kth ply from mid-surface of a laminate
α,β	rotational degrees of freedom
ε_x, ε_y	inplane strain component
γ_{xy} ,γ_{xz}, γ_{yz}	shearing strain components
ν_{12}, ν_{21}	Poisson's ratios
ξ, η, τ	isoparametric co-ordinates
ρ	density of material