Free vibration of laminated composite folded sandwich plate with cutout

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1. INTRODUCTION & OBJECTIVE

Laminated Composite (LC) is one of the very popular composites in engineering applications worldwide. Due to its excellent properties of high stiffness to weight ratio and low maintenance cost, it is used in many engineering fields like aerospace, civil, automotive, naval etc. It comprises of different laminas or plies formed by matrix and fiber oriented in different angles as required. On the other hand, the sandwich materials are very light in weight. It consists of face sheets, core and adhesive interface layers. The face sheets resist in-plane and bending loads whereas the core prevents shear loads. The core material taken is generally low or moderately stiff. These materials are considered as a good thermal and acoustical insulator.

Sandwich plates, when folded, find huge applications in roofing and cladding industry. Due to direct exposure of the roof to heat, folded sandwich plates, being heat resistant, are extremely useful as roofing and cladding material. The folds, when properly applied, also increase the plate stiffness significantly. Due to multiple uses of folded sandwich plates, it has become important to investigate the vibration behaviour. Since presence of cutouts alter the vibration behaviour significantly, it is necessary to analyze folded plate with cutouts.

The main objective of this study is to perform the free vibration analysis of laminated composite folded sandwich plate structures with cutouts at different locations to show the effect of crank angles, fibre angles, core to skin thickness, overall thickness and boundary conditions on the natural frequencies and mode shapes.

2. RESULTS & HIGHLIGHTS OF IMPOINTANT POINTS

The natural frequency of cantilever square LC folded sandwich plate with cutouts at different positions as shown in Fig: 1 and Fig:2, is tabulated for varying crank angles. The plate is of size 1m x 1m. Fibre angle used is 0/45/core/45/0.

Thickness of plate is taken as 10 mm, and core to skin thickness ratio (t_c/t_f) is taken as 10. Material properties used are E-glass Epoxy as surface material and Polyurethane as core material as given below. [1]

$E_{2f}/E_{1c} = E_{2f}/E_{2c} = E_{2f}/G_{12c} = E_{2f}/G_{23c} = E_{2f}/E_{13c} = 27.7$, $\upsilon_{12}=\upsilon_{21}=0.35$ $\rho_c=121.874$ Kg m^{-3}, ρ_f=1300Kg m-3

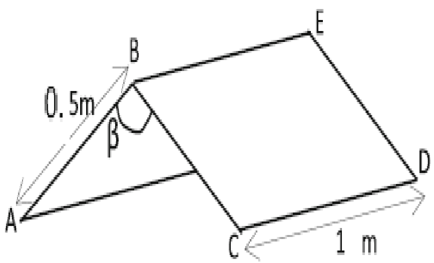

Figure 1. Folded Square Sandwich plate

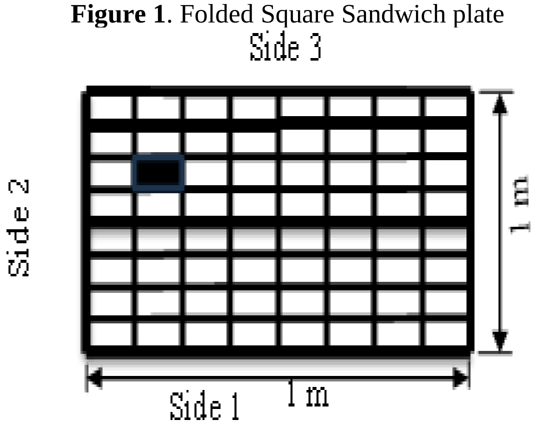

Figure 2. Folded Sandwich plate with cutout at position 1

Table 1. Natural frequencies in Hz of laminated composite folded sandwich square cantilever plate with Side 1 clamped for different crank angles, and 10 mm plate thickness

		Natural Frequency (Hz)
Position of cutout	**Orientations**	**0/45/core/45/0**
	Mode	**Crank Angle (β)**
		90 °
Without Cutout	1	14.37
	2	24.51
	3	39.32
Cutout position 1	1	14.51
	2	24.62
	3	39.01

From Table 1, it is seen that fundamental frequency increases marginally with presence of cutout. Here the mass has been reduced slightly (1.5%) whereas the stiffness reduction is insignificant due to fixity at the extreme end near cutout. This in turn increases the natural frequency.

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