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Model analysis of Centre circular laminated composite plate with circular cutout

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Abstract ***— This work provides an assessment of Model analysis of Centre circular laminated composite plate with circular cutout. The Various sizes of centrally located circular cutouts are considered in order to examine the effect of cutout size and boundary condition on the fundamental natural frequency of the square graphite epoxy laminate. The Natural frequencies of the finite element (FE) were analyzed by the ANSYS software, which was found by analysis.***

Keywords*- Circular Cutout; Model Analysis; Boundary Condition; Finite Element Analysis;*

I. INTRODUCTION

Composite materials are various types of application such as fuselage panels, turbine blades, automobile body panels, floor cryogenic fuel tank etc. They siding, cladding, roofing, woven fabrics of textile composites as a class wide application in various fields including various architectural applications have excellent integrity and conformability for advanced structural composite applications that provide a fully integrated, continuous spatial network with fiber composite materials. The composite structure is high performance continuous fiber reinforcement and typically it also determines the mechanical properties such as stiffness and strength in the direction of the fiber. Phase matrix provides protection to the fiber sticking the support and the transfer of a fiber local constraint to another. Laminated composite structures are increasingly used in many industries such as aerospace, marine and automotive industries due to their high strength to weight ratio, high stiffness to weight ratio, low weight and resistance to electrochemical corrosion, good electrical and thermal conductivity and aesthetics.

Kant and Swaminathan [1] analyzed analytically the free vibration responses of laminated composite and sandwich plates based on a higher order refined theory and used Navier's technique to obtain the solution in closed form. Khdeir and Reddy[2] studied free vibration behavior of laminated composite plates using second order shear deformation theory and a generalized Levy type solution in conjunction with the state space concept. Thai and Kim [3] examined the free vibration responses of laminated composite plates using two variables refined plate theory. Reddy and Liu [4] presented Navier type exact solutions for bending and natural vibrations of laminated elastic cylindrical and spherical shells based on the HSDT. Luccioni and Dong [5] reported Levy type semi analytical solutions of free vibration and stability behavior of thin and thick laminated composite rectangular plates based on the CLPT and the FSDT. Reddy [6] studied the free vibration of anti-symmetric angle ply laminated plates including transverse shear deformation using FEM. Ganapathi et al. [7] analyzed the free vibration analysis of simply supported composite laminated panels in the framework of FSDT and obtained governing equations using energy method. Reddy and Phan [8] reported exact solutions of stability and vibration responses of isotropic and orthotropic simply supported plates according to the HSDT. Khdeir [9] Investigated the free vibration of anti-symmetric angle ply laminated plates based on a generalized Levy type solution. This theory is a generalization of Mindlin's theory for isotropic plates to laminated anisotropic plates. Reddy and Kuppusamy [10] reported 3-D elasticity solutions natural vibrations of laminated anisotropic plates. Reddy [11] studied the large amplitude flexural vibration of layered composite plates with cutout based on a Reissner-Mindlin type of a shear deformable theory and employed the nonlinear strain displacement relations of the von-Karman theory. Kumar and Shrivastava [12] employed a finite element formulation based on HSDT and Hamilton's principle to study the free vibration responses of thick square composite plates having a central rectangular cutout, with and without the presence of a delamination around the cutout. Pandit et al. [13] studied the free undamped vibration of isotropic and fibre reinforced laminated composite plates in the frame work of FSDT and recommended an effective mass lumping scheme with rotary inertia.

II. PRESENT GEOMETRY ANASYS

Cutout Size on natural frequencies for square laminated plate with circular cutout

Various sizes of centrally located circular cutouts are considered in order to examine the effect of cutout size on the natural frequency of the square graphite epoxy laminate. The laminate has side to thickness ratio (a/h) of 100, lay-up sequence (0/90)s. The properties of each lamina are given in Table 1. The cutout ratio (i.e. d/a) along x-axis and y-axis is varied from 0.0 to 0.6 in steps of 0.2. Plate geometries for plates with cutout ratio 0.0, 0.2, 0.4, 0.6 are shown in Fig 1.

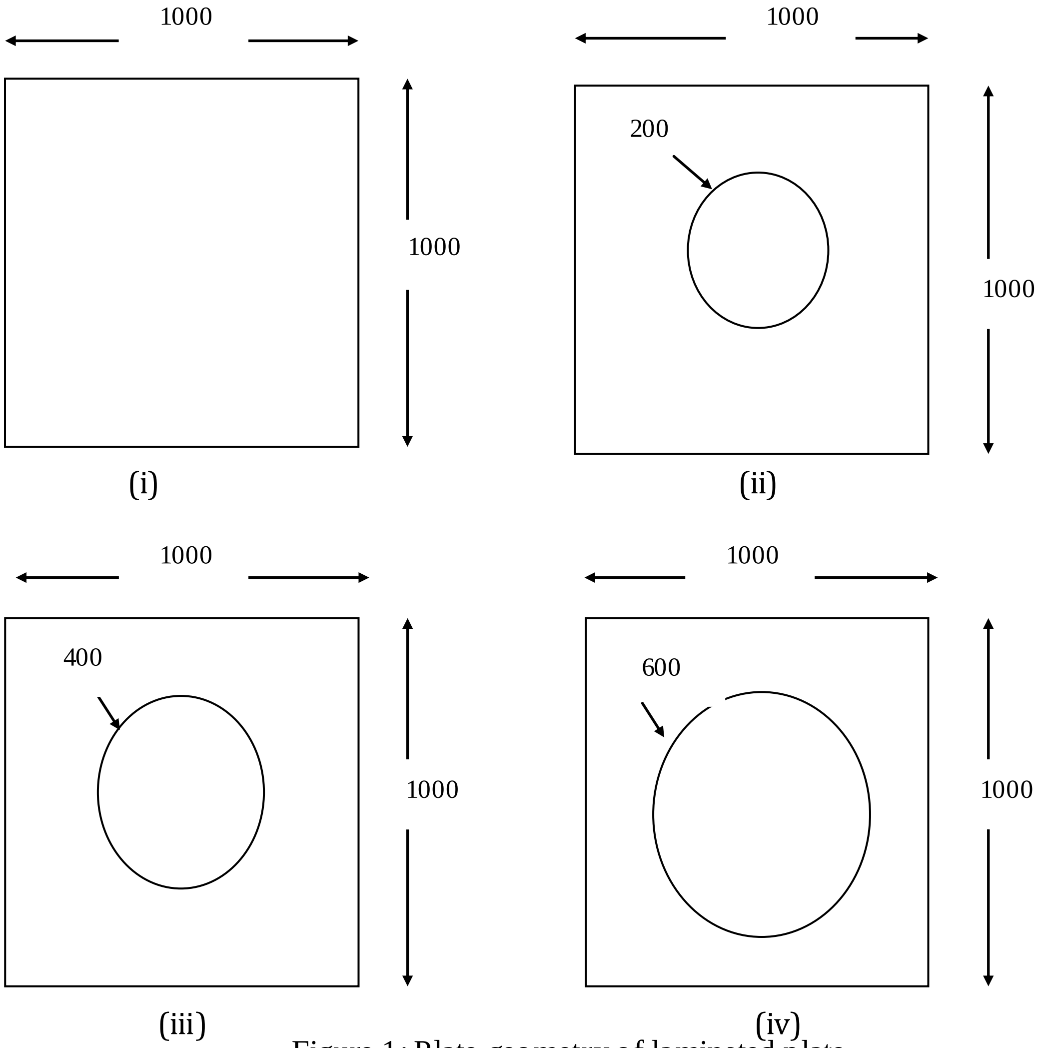

Figure 1: Plate geometry of laminated plate

(i) Plate geometry with cutout ratio 0.
(ii) Plate geometry with cutout ratio 0.2.
(iii) Plate geometry with cutout ratio 0.4.
(iv) Plate geometry with cutout ratio 0.6.

Four types of boundary condition namely FFFC, FCFC, CCCC and SSSS (where F, C and S stand, respectively, for a free, a clamped, a simply supported edge) are considered in order to examine the effect of boundary condition on the fundamental natural frequency of a square graphite epoxy laminate with a centrally located circular cutout.

III. MATERIAL PROPERTIES

Table 1: Material properties of each lamina

Material Constant	E_x	E_y	E_z	G_{xy}	G_{yz}	G_{xz}	ν_{xy}	ν_{yz}	ν_{xz}	**ρ**
Values	137.90 GPa	14.48 GPa	14.48 GPa	5.86 GPa	5.86 GPa	5.86 GPa	0.21	0.21	0.21	1500 kg/m^3

IV. RESULTS

The FFFC, FFCC, FCFC, CCCC and SSSS stand for five types of boundary conditions as given below.

Cutout ratio is varied from 0.0 to 0.6 in steps of 0.2. Plate geometries for plates with cutout ratio 0.0, 0.2, 0.4, 0.6, are shown in Figure 1. The laminate has side to thickness ratio of 100, and the properties of each lamina are given in Table 1. The lay-up sequence namely (0/90)s, is considered. Results are summarized in Table 2.

Table 2: Frequencies (Hz) for varying cutout size under different boundary conditions for square laminated plate with circular cutout and lay-up-sequence (0/90)s

Conditions	**Modes**	**d/a Ratio**			
		0	**0.2**	**0.4**	**0.6**
FFFC	1	14.631	9.5138	8.7034	7.2117
	2	19.54	9.5138	11.759	16.103
	3	54.766	48.595	47.921	45.34
	4	92.916	59.314	57.976	60.251
	5	98.873	62.318	61.215	64.197
FCFC	1	94.601	69.191	71.286	68.24
	2	96.795	71.835	72.54	69.17
	3	113.83	99.296	117.72	171.02
	4	174.73	168.57	145.09	171.54
	5	268.91	180.12	164.53	176.67
CCCC	1	108.16	111.87	147.59	263.64
	2	170.03	194.98	175.73	269.94
	3	276.28	202.9	185.67	271.34
	4	299.66	310.63	257.25	281.46
	5	311.28	362.78	304.97	385.14
SSSS	1	50.279	41.285	42.427	54.293
	2	101.68	115.79	89.662	88.57
	3	174.84	119.97	91.437	89.481
	4	204.05	190.5	166.1	145.29
	5	209.82	252.95	214.2	191.81

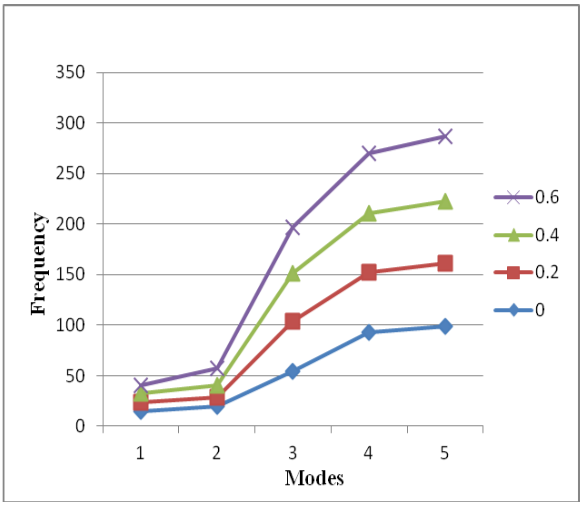

Figure 2.1: Graph between Frequency and Modes under FFFC boundary Conditions

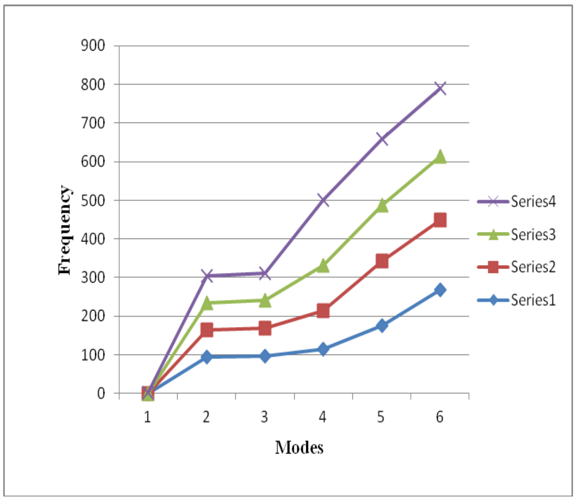

Figure 2.2: Graph between Frequency and Modes under FCFC boundary Conditions

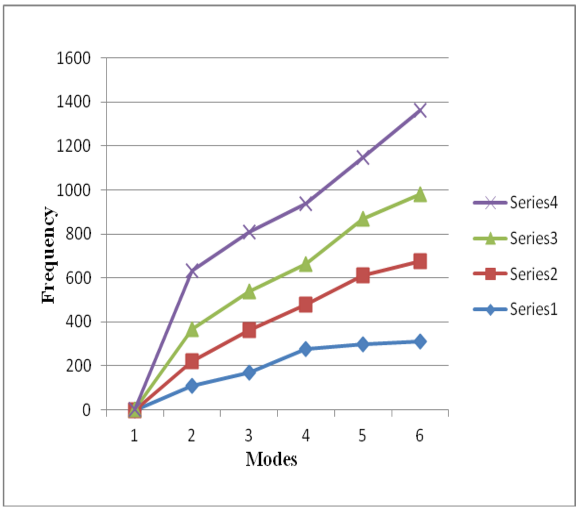

Figure 2.3: Graph between Frequency and Modes under CCCC boundary Conditions

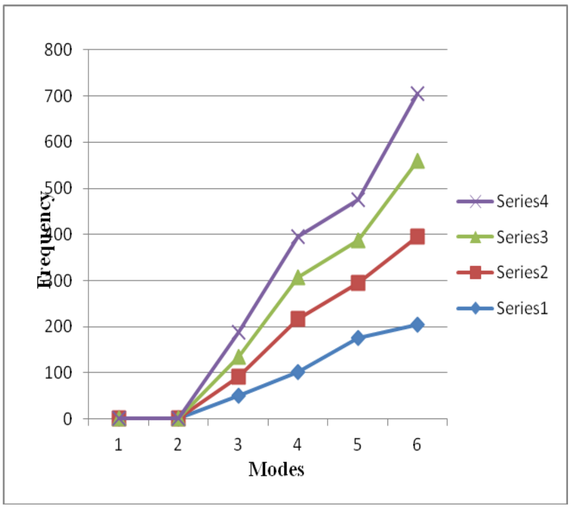

Figure 2.4: Graph between Frequency and Modes under SSSS boundary Conditions

V. CONCLUSION

Laminated composite plate in ANSYS APDL code vibration behavior carried out using available published and validated with results. The current parametric analysis the following conclusions are made:

- The fundamental natural frequency changes only marginally if a small cutout (either of the two cutout ratios being small) is made in the plate. However, for intermediate and large size cutouts, the fundamental natural frequency increases rapidly; the amount of increase depends on cutout ratios in two directions.
- For square laminate with circular cutout, the natural frequency increases with the increasing constraint at the boundary irrespective of the size of the cutout. However, this increase is not uniform; it is also dependent on the particular mode of vibration.
- For square laminate with circular cutout, an increase in cutout size does not always result in an increase in the natural frequency. Besides depending on the cutout size, the increase or decrease also depends on the boundary condition.

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