Dynamic Analysis of Laminated Carbon Composite

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Abstract: ***Laminated composites are finding increasing applications in the civil engineering, aerospace, marine, transportation fields. In some of these applications the composites are subjected to dynamic loads. The composite structures may sometimes be provided with different types of holes for the purpose of assembling the components and units inside the structure, for passing the cables and control mechanisms, for inspection, maintenance and attachment to other units. Scope of this project is to find out the best shape of the holes. The ANSYS software is used for analyzing the plates.***

Keywords: composite laminated plate, orthotropic plate, free vibration

1. Introduction

Composite materials constitute a group of materials formed by putting together at least two different materials. The aim of this is to acquire good properties like mechanical strength, corrosion resistance, high temperature resistance, heat conductibility, stiffness, lightness, and appearance. The material must behave as a whole, e.g. the fiber and the matrix material (material surrounding the fibers) must be perfectly bonded (Classical Lamination Theory-CLT).Lamination is used to combine the best aspect of the constituent layers and bonding material in order to achieve a more useful material. Laminates, as with many other structures, could have holes to serve various purposes. An obvious purpose is to accommodate a bolt. Considering two different materials that are reinforcing bars (fibers) and surrounding materials (matrix material), mechanical properties of each layer are given in two directions.

The needs of the high rise building and aerospace industry led to the development and application of composite materials. Advances in the manufacturing process and technology of laminated composites have changed the use of the composites from secondary structural components to the primary ones. Fiber reinforced composites are finding increasing applications in the aerospace, marine, transportation, electrical and chemical fields. In some of these applications the composites are subjected to dynamic loads. The composite structures may sometimes be provided with different types of holes for the purpose of assembling the components and units inside the structure, for passing the cables, for inspection, maintenance and attachment to other units. The stresses and deformations of steep gradient are induced around these cutouts. The influence of the thickness parameter is inherent at higher modes of vibration. In this paper we study the dynamic behavior of laminates with different shapes of holes.

2. Objective of the Study

- The main aim of the research is that we can study the variations in behaviour of plates for different shape of holes by maintaining same length/height ratio and hole area ratio.
- A study on the dynamic behaviour of plate under different boundary conditions and different orientation of laminate is done.

3. Methodology

3.1 Modelling was done using ANSYS software

Table 1: Geometric Properties

Dimension	No of Layers	Stacking sequence
Length = 0.5m Width = 0.5m Thickness = 0.005m	4	0/90/90/0 0/60/60/0 0/45/45/0 0/30/30/0 0/30/60/90 0/15/30/45

Table 2: Material properties

E11=134.4Gpa, E22=10.34Gpa, υ12=0.33, υ21=0.33, G12=4.99Gpa, G23=1.999Gpa, G13=4.99Gpa.

3.2 Boundary conditoins

The support conditions are
1)CFFF-Clamped on one edge and free on remaining edges.
2)CFCF-Clamped on opposite edges and free on other opposite edges.

3.3 Analysis

Analysis was done using ANSYS software.

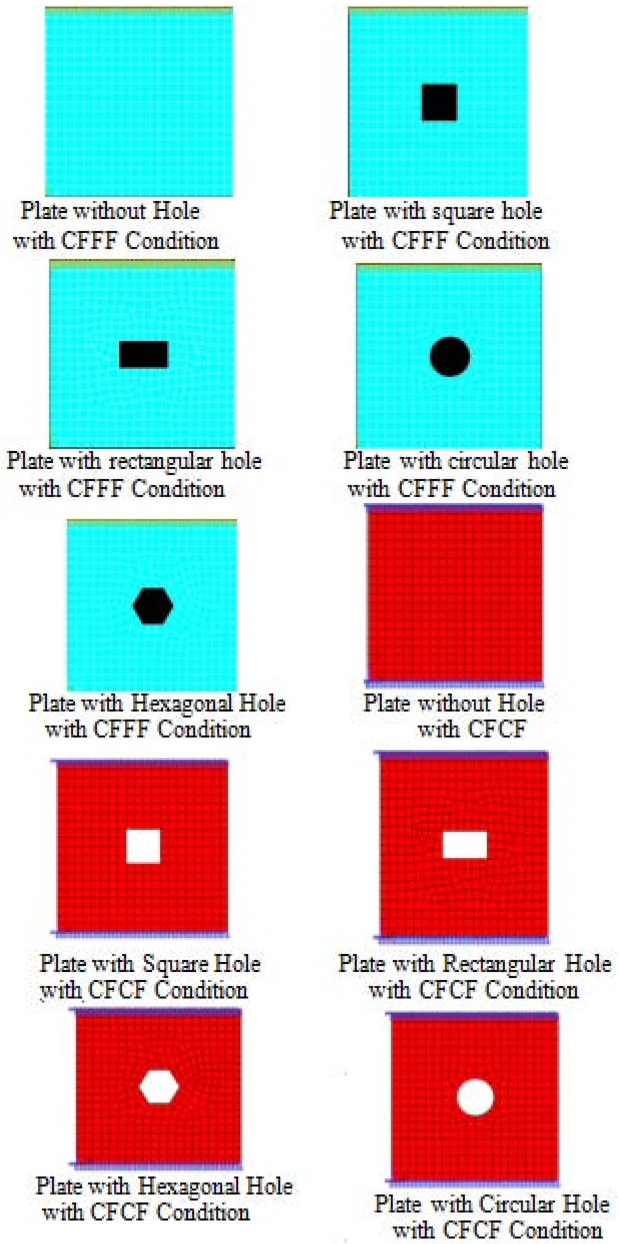
4. Modeling Phase

ANSYS software is used for the dynamic analysis. Shell 281 is used as the element. It can be used for analysis of layered plates. The element is defined by eight nodes, average or corner layer thicknesses, layer material direction angles, and orthotropic material properties. The plate is analyzed for different orientations and boundary conditions as specified above..Six models for each support condition and six different orientations are considered in the analysis.

Throughout the analysis total area as (a/A=0.04) and total area to total thickness as (A/h=50) was considered.

4.1 Analysis

Analysis of the laminated plate is done using ANSYS software. The analysis results are tabulated.



5. Results and Discussions

The increase in frequency in any case is due to the increase in stiffness of the plate or due to the decrease in mass of the plate for any change in the geometry of the plate. The decrease in frequency at any position is due to the decrease in stiffness of the plate. In some of the modes it is observed that there is no significant variation in frequency.

Modal analysis is done having 4 layers of composite having CFFF condition with Six different orientations, by keeping a/h ratio as constant which is equal to 0.04. In case 1 (no holes in plate) (0/30/30/0) orientation gives the better results as compared with the other orientations. Similarly all others cases are summarizes in the Tables and the Figure shows the plot of 4 layers of laminated composite with CFFF conditions. From model analysis frequency for different orientations and boundary conditions were obtained and the result was obtained. The results are tabulated.

Table 3: Effect of Fibre Orientations for Frequencies Having 4Layers of Laminated Composite with CFFF Condition

	0/90/90/0	0/60/60/0	0/45/45/0	0/30/30/0	0/15/30/45	0/30/60/90
No holes	16.12	13.28	11.59	10.59	12.16	17.003
Square hole	22.96	20.59	19.325	18.601	16.559	19.273
Rectangle hole	22.972	20.019	18.764	17.887	16.419	18.823
Circular hole	22.800	20.483	19.17	18.341	16.897	18.899
Hexagonal hole	33.623	33.112	32.990	33.167	27.382	32.820

Table 4: Effect of Fibre Orientations for Frequencies Having 4Layers of Laminated Composite with CFCF

	0/90/90/0	0/60/60/0	0/45/45/0	0/30/30/0	0/15/30/45	0/30/60/90
No holes	99.83	85.103	73.902	66.600	77.485	102.73
Square hole	144.29	139.34	135.52	131.25	108.58	122.03
Rectangle hole	145.26	140.26	136.05	131.95	108.69	119.73
Circular hole	143.31	137.85	133.80	129.82	108.88	123.97
Hexagonal hole	192.77	190.52	190.40	191.72	157.76	189.09

Linear Dynamic analysis is done having 4 layers of composite having CFCF condition with Six different orientations, by keeping a/h ratio as constant which is equal to 0.04. In case 1 (no holes in plate) (0/90/90/0) orientation gives the better results as compared with the other orientations. Similarly all others cases are summarizes in the table 4 and the figure no. shows the plot of 4 layers of laminated composite with CFCF conditions. For all others case (0/30/60/90) gives good results as compared with other. But plate is affected less when Hole is circular.

6. Conclusion

In the present work, the conventional finite element method using ANSYS is done to study the dynamic behavior of laminated composite plates with and without holes for the effects on the free vibration of plates. The numerical results are presented and discussed in above. The broad conclusions that can be made from the present study are summarized as follows:

1) When there is no hole in the plate with ply orientation of (0/30/60/90) shows highest frequency vibration for CFFF and CFCF boundary conditions.
2) When there is square hole in the plate with ply orientation of (0/90/90/0) shows highest frequency vibration when a/h ratio is equal to 50 for CFFF and CFCF boundary conditions.
3) When there is rectangular hole in the plate with ply orientation of (0/90/90/0) shows highest frequency vibration when a/h ratio is equal to 50 for CFFF and CFCF boundary conditions.

4) When there is circular hole in the plate with ply orientation of (0/90/90/0)s shows highest frequency vibration when a/h ratio is equal to 50 for CFFF and CFCF boundary conditions.
5) When there is hexagonal hole in the plate with ply orientation of (0/90/90/0) shows highest frequency vibration when a/h ratio is equal to 50 for CFFF and CFCF boundary conditions.
6) The natural frequency of carbon composite is less than graphite/epoxy material.
7) The natural frequency for composite laminated plate in simply supported boundary condition is more than in clamped boundary condition.
8) Plates with hexagonal hole have highest natural frequency than any other shapes both CFFF and CFCF condition.
9) Diagrid structure system having vertical geometric irregularity shows less top storey displacement and inter-storey drift than that of vertically irregular tubular structure.
10) Diagrid structural system provides better flexibility in interior space planning and façade of the structure. So the diagrid system is more efficient in case of vertical geometric irregular tall building system under wind loading.

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