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Research Article

DYNAMIC ANALYSIS OF LAMINATED COMPOSITE PLATE WITH HOLE

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ABSTRACT

Fiber reinforced composites are finding increasing applications in the aerospace, marine, transportation, electrical, chemical, construction and consumer goods industries. 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. The effects of the variations of behavior for different shape of holes by maintaining same length/height ratio and hole area ratio are studied. Scope of this paper is to find out the best location of the holes. The ANSYS software is used for analyzing the plates under different boundary conditions and different orientation of laminate. Eight-noded Shell99 is used throughout the analysis which is a linear element. Different boundary conditions are considered for CFFF-(clamped free free free) and conditions and length to height ratio considered are 50 and 200.The hole area ratio is maintained as constant throughout the analysis as 0.04.Two different layers of laminate is considered those are 4 no's and having six different orientations each. The influence of the thickness parameter is inherent at higher modes of vibration. In this report we study the dynamic behavior of various laminates with different holes.

Keywords: Finite Element Method (FEM), ANSYS software.

INTRODUCTION

Composite material are that material which are formed by putting together at least two different materials. For example a reinforced concrete and a tire of car, theses all things known as composite materials. The aim of to produce composite materials to possesses higher performance in any particular work. Some properties are like mechanical strength, corrosion and temperature resistance heat conductibility, stiffness, light weight and appearance etc. A composite material should be satisfied in several conditions. It must be manmade and comprise at least two different material of different chemical component separated by distinct layers. These materials are must be three-dimensional unity.

The material must behave like as whole, *e.g.* the material surrounding by fibers they must be perfectly bounded to each other (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. The properties that can be emphasized by lamination are strength, stiffness, low weight, corrosion resistance, thermal insulation *etc*. 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.

Importance of present study - Fiber reinforced composite are finding increasing application in marine, aerospace , chemical, construction, electrical and consumer goods industries. 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. 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 holes.

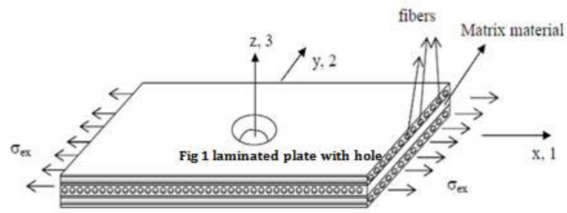

Fig 1 laminated plate with hole

FINITE ELEMENT ANALYSIS- Problems which are involving complex geometry and boundary conditions analytical methods are not easily applicable and numerical method finite element methods (fem) are preferred. the finite element formulation is developed hereby for the structural analysis of isotropic as well as composite twisted panels using a curved shear deformable shell theory.

The support condition has taken -

CFFF-Clamped on one edge and free on remaining edges.

MATERIAL PROPERTIES- Material properties considered throughout the analysis are

E_{11}=134.4Gpa, E_{22}=10.34Gpa, υ_{12}=0.33, υ_{21}=0.33, G_{12}=4.99Gpa, G_{23}=1.999 and G_{13}=4.99Gpa.

Where E_{11} is young's modulus in 1-1 axis, E_{22} is young's modulus in 2-2 axis $\upsilon_{12}$is poisons ratio in 1-2 axis, υ_{21} is poisons ration in 2-1 axis and G_{12},G_{23},G_{13} are shear stress respectively. Analyzing of plate with shell element shell99 with hole area to total area as (a/A=0.04) and total area to total thickness as (A/h=50) the total thickness will be 0.005m and (A/h=200).For the (A/h=200) the total thickness will be 0.00125m.

Model analysis

Model-I

The figure 2 shows the model-I(CFFF) which is an four layer laminated of orientation as 0/90/90/0with each layer thickness as 0.00125 considering the different location of hole as I(a) no hole,(b) hole at centre,(c) hole at edge,(d) hole at both edges,(e)hole at support(mid), (f) hole at support corner.

Model-II

The figure 3 shows the model-II(CFFF) which is an four layer laminated oforientation as0/45/45/0 with each layer thickness as 0.00125 considering the different location of hole as I(a) no hole,(b) hole at centre,(c) hole at edge,(d) hole at both edges,(e) hole at support(mid), (f) hole at support corner.

Model-III

The figure 4 shows the model-I(CFFF) which is an four layer laminated of orientation as0/60/60/0with each layer thickness as 0.00125 considering the different location of hole as I(a) no hole,(b) hole at centre,(c) hole at edge,(d) hole at both edges,(e) hole at support(mid), (f) hole at support corner.

Model-IV

The figure 5 shows the model-I(CFFF) which is an four layer laminated of orientation as 0/30/30/0with each layer thickness as 0.00125 considering the different location of hole as I(a) no hole,(b) hole at centre,(c) hole at edge,(d) hole at both edges,(e) hole at support(mid), (f) hole at support corner.

Model-V

The figure 6 shows the model-I(CFFF) which is an four layer laminated of orientation as 0/30/60/90with each layer thickness as 0.00125 considering the different location of hole as I(a) no hole,(b) hole at centre,(c) hole at edge,(d) hole at both edges,(e) hole at support(mid), (f) hole at support corner.

Model-VI

The figure 7 shows the model-I(CFFF) which is an four layer laminated of orientation as 0/30/60/90with each layer thickness as 0.00125 considering the different location of hole as I(a) no hole,(b) hole at centre,(c) hole at edge,(d) hole at both edges,(e) hole at support(mid), (f) hole at support corner

Table I: Effects of fibre orientations for frequencies having 4 layers of laminated composite with cfff

ORIENTATION OF LAYERS	0/90/90/0	0/60/60/0	0/45/45/0	0/30/30/0	0/15/30/45	0/30/6/90
NO HOLES	3.2613	2.7042	2.3654	2.1597	2.4963	3.4613
HOLE AT CENTRE	4.8181	4.2868	4.0573	4.1669	3.5474	3.9797
HOLE AT EDGE	5.4711	5.0201	4.8379	4.7009	4.0333	4.293
HOLE AT BOTH EDGE	6.0083	5.6605	5.4805	5.1	4.4366	4.6083
HOLE AT SUPPORT(MID)	4.2278	3.9208	3.7355	3.2309	3.3158	3.8556
HOLE AT SUPPORT(CORNER)	4.5695	4.5176	4.3615	4.1714	3.5848	3.7501

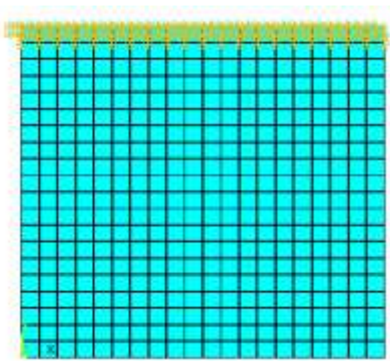

Fig 2

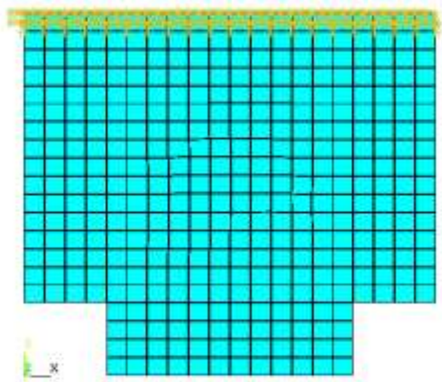

Fig 4

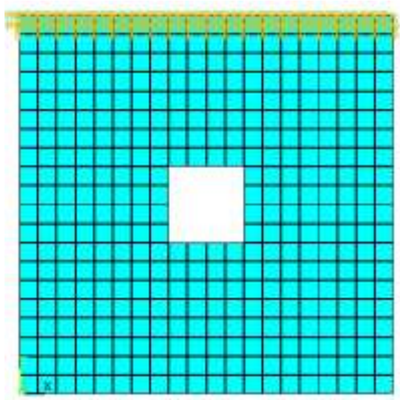

Fig 3

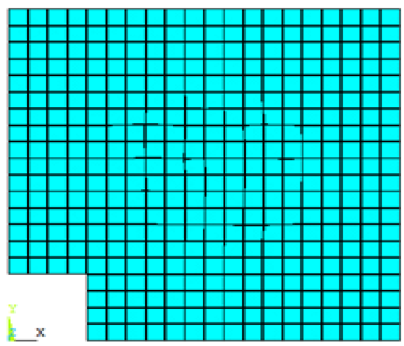

Fig 5

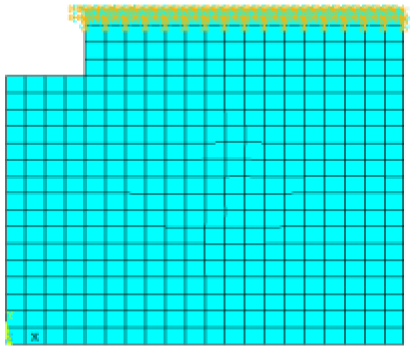

Fig 6

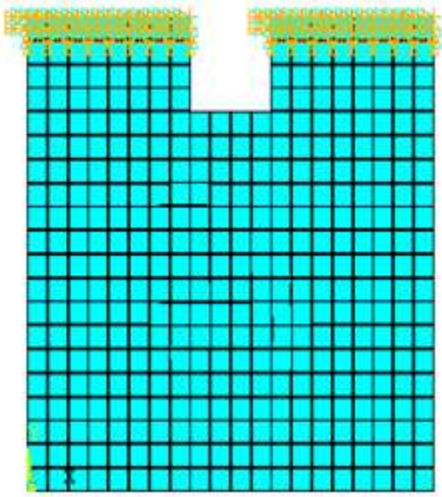

Fig 7

Modal analysis is done having 4 layers of composite having CFFF condition with six different orientations are considered, 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

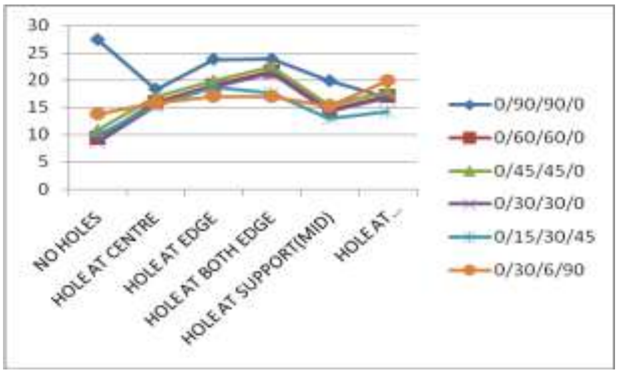

Fig.8 Effect of fibre orientations for frequencies having 4 layersof laminated composite with cfff

The increase in frequency in any case is due to the increase in stiffness of the plate and/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. It is observed that there is no significant variation of frequency in various modes.

CONCLUSION

In the present work, the conventional finite element method using ANSYS is used 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:

When there is no hole in the plate with ply orientation of (0/30/60/90) shows highest frequency vibration when a/h ratio is equal to 200 for CFFF and CFCF boundary conditions.

We conclude that the SHELL 99 element for meshing the carbon composite specimens yielded results with good accuracy. Hence, we recommend the use of SHELL 99 for Modal Analysis of carbon fiber composite specimens.

From the present studies, it is concluded that the best location for hole at a/h ratios for cantilever, hole at the extreme edges.

Future scope-The present investigation can be extended to dynamic stability of laminated plates and shells subjected to hydrothermal condition. Material and geometry nonlinearity may be taken into account in the formulation for further extension of the dynamic stability of plates. The effects of damping on instability regions of plates can be studied

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