DYNAMIC ANALYSIS OF LAMINATED COMPOSITIE PLATES WITH HOLES

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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. Scope of this project 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. Two different boundary conditions are considered those are CFFF-(clamped free free free) and CFCF-(clamped free clamped free) 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 8 no's having six different orientations each.

Keywords: *ANSYS Software, Composites, Fibre*.

Introduction

Composite materials constitute a group of materials formed by putting together at least two different materials. A reinforced concrete beam and a car tire are examples of such materials. The aim of this three-dimensional composition is to acquire a property which none of the constituents possesses: In other words, the target is to produce a material that possesses higher performance properties for a particular purpose than its constituent parts. Some of these properties are mechanical strength, corrosion resistance, high temperature resistance, heat conductibility, stiffness, lightness, and appearance. In accordance with this definition, there are several conditions that must be satisfied by the composite material. It must be man-made and not natural. It must comprise at least two different materials with different chemical components separated by distinct interfaces. 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 some times 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.

Methods and Materials

LAMINATED COMPOSITE PLATES

The stress-strain relation for a three-dimensional linear, elastic, anisotropic material is given as

$$\{\sigma\} = [C]\{\varepsilon\}$$

which is also known as Hooke's law. {ζ } and {ε } are stress and strain vectors respectively. The [*C*] matrix is called material stiffness matrix, which has 21 independent material constants. For plane stress problems, where the external stresses are in the plane of plate, Hooke's law could be simplified to

$$\underbrace{\begin{Bmatrix} \sigma_1 \\ \sigma_2 \\ \tau_{12} \end{Bmatrix}}_{\{\sigma\}} = \underbrace{\begin{bmatrix} Q_{11} & Q_{12} & 0 \\ Q_{21} & Q_{22} & 0 \\ 0 & 0 & Q_{66} \end{bmatrix}}_{[Q]} \underbrace{\begin{Bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \gamma_{12} \end{Bmatrix}}_{\{\varepsilon\}}$$

in which [*Q*] is the reduced material stiffness matrix, having elements as

$$Q_{11} = \frac{E_1}{1-\nu_{12}\nu_{21}}$$

$$Q_{12} = Q_{21} = \frac{\nu_{21}E_1}{1-\nu_{12}\nu_{21}} = \frac{\nu_{12}E_2}{1-\nu_{12}\nu_{21}}$$

$$Q_{22} = \frac{E_2}{1-\nu_{12}\nu_{21}}$$

$$Q_{66} = G_{12}$$

Here, E1 is the elasticity modulus in the fiber direction, E2 is the elasticity modulus in the transverse direction, ν12 and ν 21 are the Poisson's ratio, and G12 is the shear modulus. For a unidirectional fiber reinforced layer there are two principal material directions.

When these material directions are oriented by the angle α from the plate direction (Figure 2), the stress strain relation is given as

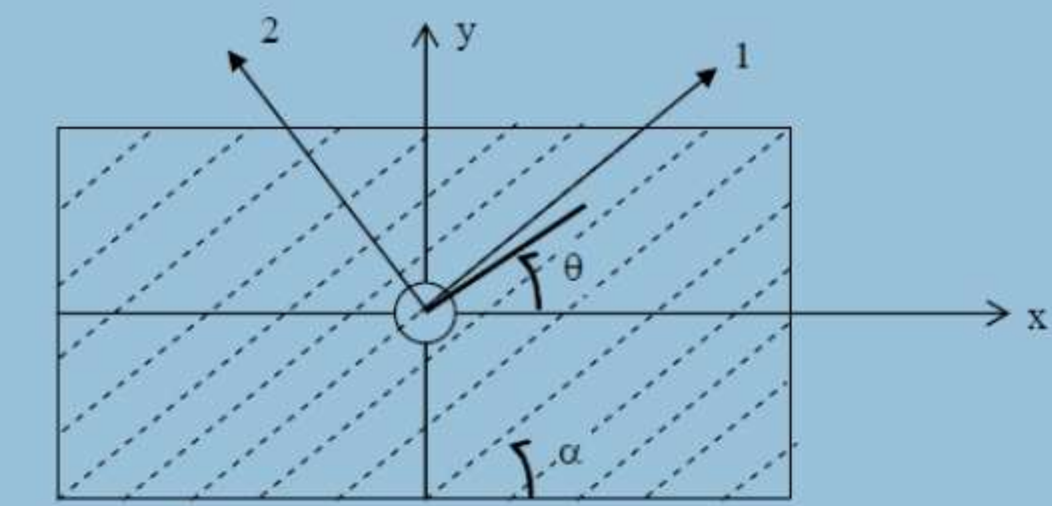


Figure 2. Orthotropic layer with a circular hole

FINITE ELEMENT FORMULATION

For problems involving complex geometrical and boundary conditions, analytical methods are not easily adaptable and numerical methods like 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.

SHELL ELEMENT

The plate is made up of perfectly bonded layers. Each lamina is considered to be homogeneous and orthotropic and made of unidirectional fiber-reinforced material. The orthotropic axes of symmetry in each lamina are oriented at an arbitrary angle to the plate axes. An eight-nodded isoperimetric quadratic shell element is employed in the present analysis with five degrees of freedom u, v, w, θx and θy per node as shown in Figure. But the in-plane deformations u and v are considered for the initial plane stress analysis.

CFCF CONDITION

MODEL-VII

The model-VII (CFCF) which is a four layer laminate of orientation as 0/90/90/0 with each layer thickness as 0.00125 considering all the above conditions.

MODEL-VIII

The model-VIII (CFCF) which is a four layer laminate of orientation as 0/45/45/0 with each layer thickness as 0.00125 considering all the above conditions.

MODEL-IX

The model-IX (CFCF) which is a four layer laminate of orientation as 0/60/60/0 with each layer thickness as 0.00125 considering all the above conditions.

MODEL-X

The model-X (CFCF) which is a four layer laminate of orientation as 0/30/30/0 with each layer thickness as 0.00125 considering all the above conditions.

MODEL-XI

The model-XI (CFCF) which is a four layer laminate of orientation as 0/30/60/90 with each layer thickness as 0.00125 considering all the above conditions.

MODEL-XI

The model-XII (CFCF) which is a four layer laminate of orientation as 0/15/30/45 with each layer thickness as 0.00125 considering all the above conditions and for 8Layers.

Comparison

The composites plates with arbitrary geometries and boundary conditions subjected to various loading got important roles to play as the structural elements in aerospace and other engineering structures. The plate and shell structures subjected to dynamic loading cause non-uniform stress field which greatly affects the stability and dynamic behavior of structures.

Validation

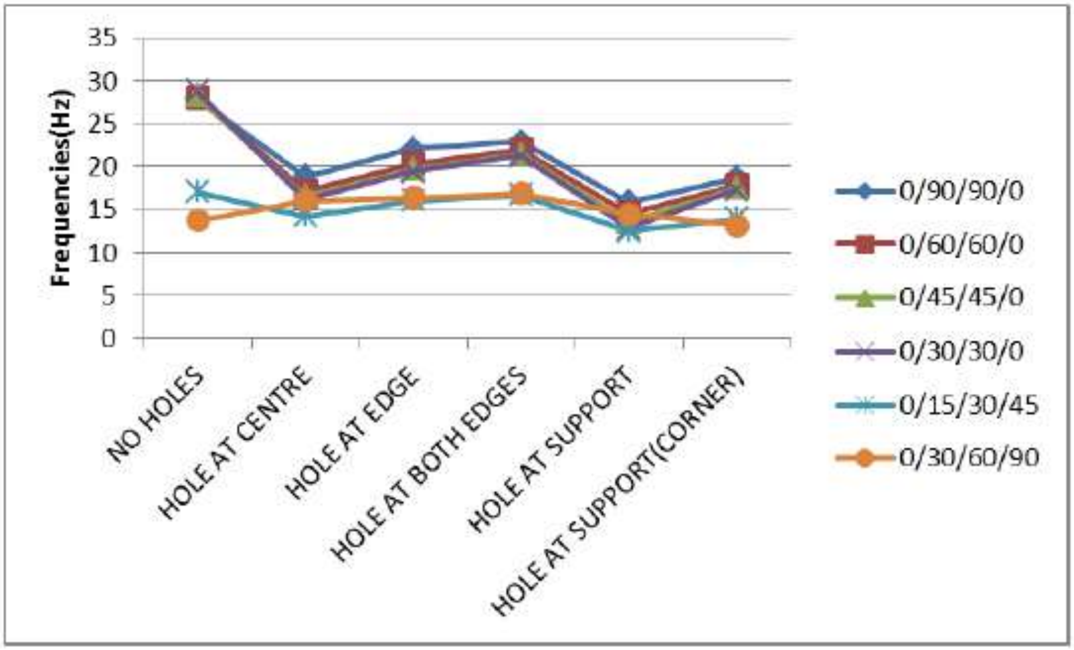
Comparison of free vibration frequencies for CFFF and CFCF (0/90)10 square plate Carbon Fiber specimen with 4 mm thickness 150mm X 150mm size.

TABLE NO.1 SHOWING VALIDATION OF RESULTS FOR CFFF AND CFCF CONDITIONS

CFFF			CFCF		
mode no	Dutt et al.[26]	present	mode no	Dutt et al.[26]	present
1	37.98	37.74	1	152.96	152.47
2	47.65	47.44	2	223.76	223.36
3	63.65	63.53	3	345.98	345.48
4	89.12	88.54	4	435.29	434.78
5	103.86	103.45	5	587.76	587.25

RESULTS

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. In some of the modes it is observed that there is no significant variation in frequency. Similarly all others cases are summarizes in the table 1 and the figure no. shows the plot of 4 layers of laminated composite with CFFF conditions. For all others a case (0/90/90/0) gives the good results as compared with other. But plate is affected less when Hole is at the center of the plate.



FURTHER SCOPE

Buckling analysis can be included

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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