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Finite Element Analysis of Laminated Plates with Circular Holes

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Abstract: *A composite material consists of matrix & fiber. Therefore, a component having two or more distinct constituent materials or phases can be considered as a composite material. Fiber-reinforced composites have been used more frequently in recent years due to their higher strength-to-weight ratio. The goal is to produce a material that has higher performance properties than its components. Some of these properties are mechanical strength, corrosion resistance, high temperature resistance, heat conductivity, rigidity, durability, lightness and appearance. Therefore, it is very important to study the behavior of composite materials along with the design and mechanical properties. The present study reports the finite element analysis of a laminated plate with central concentric holes under uniform pressure for stresses and deflections .Four layered rectangular cross ply and angle ply tendencies were used. Practice includes the use of Graphite / Epoxy and S-glass / Epoxy. The parameter used for the analysis is the ratio of the central hole diameter to the plate side diameter (D / W) ranging from 0.15 to 0.6. The thickness of the laminated layers in the plate is kept equal. The orientation angle of the layers varies in the study from 0 degree to 90 degree varies depending on its increase 30 degree .Stress and deflection are discussed under The boundary condition of the bus supported case and clamped Cases are drawn between all four sides. Symmetrical, antisymmetric, crossply and stress or Deflection for D / W ratio.*

Discussed the influence of fiber angle change on the maximum stress and the maximum deflection of all layers. D/W ratio 0.15 in simple supported state graphite / epoxy is maximum when compared to s- Glass / epoxy while deflection has a maximum s- Glass / epoxy compared to graphite / epoxy except at a ratio of 0.6. The finite element method is performed with the help of ANSYS 15.0 software.

INTRODUCTION:-In recent years, three fiber materials, namely glass fiber, carbon fiber and Kevlar have been increasingly used in composite materials. In the case of substrates, the most commonly used resin is polyester resin. In many engineering and civil applications, the number of vinyl resins and epoxy resins has increased, from aircraft fuselages to simple tennis racket frames. Because of their wide range of applications, and almost 50% of their structures are composed of composite materials, they are becoming more and more important in the construction of aerospace structures. The area of concern for the use of composite materials is that their bearing load parameters reach larger thresholds. The main advantages of composite materials are high strength, light weight and corrosion resistance. Fiber-reinforced composite materials have high strength and modulus. The fibers in the matrix material are the main load-bearing members, and the matrix material holds the fibers together. It acts as a load transfer medium between the fibers and protects the fibers from exposure to the environment. In composite materials, the matrix material has some important functions, such as holding the fibers together, protecting them from the environment, enhancing the lateral performance of the laminate, and performing interlayer shear. It also improves the impact resistance and fracture resistance of components, etc. In composite materials, the matrix material has some important functions, such as holding the fibers together, protecting them from the environment, enhancing the lateral performance of the laminate, and performing interlayer shear. It also improves the impact resistance and fracture resistance of components, etc. The purpose of this three-dimensional composition is to obtain property that the voter does not have. The goal is to form materials with higher performance to achieve specific goals. Some of these properties-mechanical strength, corrosion resistance, high temperature resistance, thermal conductivity, stiffness, brightness and appearance. According to this definition, the material must meet several conditions. It must have at least two different materials with different chemical compositions. The material must behave as an entity, for example the fiber and the matrix material (the material surrounding the fiber) must be perfectly bonded.

Literature Review:-

Literature (Bibliographic) reviews explain the various aspects of the dishes and their applications in various fields of expertise The talk area in this place is on the plate with holes and how holes in the plate can have an effect on stress the plate under load. Slabs with holes with different for analysis, shape and orientations. The the expected result is the reduction of stress with the introduction the holes in the slabs.

Kam, T.Y. and Chang, R.R (1993):-Study explained Effect of physical properties, length Thickness Ratio, plate aspect ratio, Number of Layers and Laminate Angle on The mechanical behavior of laminated composite plate is Investigated. Best arrangement of layers for laminate composite plates were found. Study found optimal Angles and number of layers to maximize buckling Weight of symmetrically laminated plates with different Material properties, aspect ratio by design technique Kam and Snyman.

Tenchev, R.T et. al. (1995):- proposed the procedure to decrease the stress concentration factor by increasing the thickness of the plate. The study guided the procedure based on the analytical solution of the stress concentration factors in the laminate and the reinforcing ring provided both with infinite dimensions with a correction factor for finite reinforced ring. The study generated the empirical formula by the large number of results of finite element analysis.

Sayman, O. and Aksoy, S. (2001):- calculated an elastic plastic analysis on simply supported and clamped cross-ply and angle-ply aluminum metal matrix composite laminated plates with a circular hole. The formation of the plate was a done a specific manner of stainless-steel reinforced aluminum metal matrix laminated plates of constant thickness stacking four layers about the middle surfaces of the plate symmetrically or unsymmetrically .The expansions in the plastic region found to be different for symmetrically and asymmetrically laminated plates due to different orientations. The magnitude of the residual stresses found to be higher for cross- ply. The expansion in the simply supported plates was more than the clamped. The yield point for the simply supported plates was higher than the clamped plates except for the cross-ply case.

Muhsin, I.S. et. al. (2006):-examined a numerical investigation onto the behavior of a plate with hole or number of holes by finite element method.The study proved that maximum stresses decreasing as we moved away from the holes. The observation found for number of holes at the uniform stress distribution, themaximum stress was slightly larger than the average stress. The diameter of holes showed the effect on maximum stresses in smallest area. The relation between maximum stress and number of holes were proved. The stress concentration factor was effected by the diameter of hole (0.015 m to 0.035) and number of holes, having variation in values of 2.79 to 2.54 and 2.79 to 2.72.

Akbarov, S.D. et. al (2010):- derived the forced vibration of an initially statically stressed rectangular plate made of an orthotropic material is studied. The focus was on the effect of initial stresses, geometrical and material properties on the stress distribution due to additional dynamic forces. The natural frequency(squared) increased with initial stretching force but decreased with size of hole (volume). The concentration of stress increased with size of hole and decreased with applied stretching force, also increased with the frequency of external forces, also increased as the hole approaches to the upper surface of the plate.

Manoharan, R. and Jeevanantham, A. K (2011):- Discussed the stress strain and displacement for the compressive load on the fibre reinforced composite laminates.

Nagpal, S. (2013):- explained the influence of structural dimension D/A ratio upon stress concentration factor for different cases. The study proposed that the auxiliary holes have a significant effect on shear stresses and deflection in the plate. Deflection in x-direction increases with the auxiliary holes. The significant value of SCF mitigation is reported after the auxiliary holes.

Rathi, S. et al. (2017):-presented the behavior of a rectangular laminated composite plate with a central circular hole and without holes under transverse loading. The results based on the variation of D/H versus stress and D/H versus deflection were discussed critically.

The conclusion drawn from the above research is that different analysis panel technologies have been studied. Different parameters have been studied for plates with square, rectangular, and circular holes. For example, compared with different types of material laminates, the deflection and stress under concentrated load affect the characteristics of the plate. However, the comparison of the concentric hole behavior of s-glass/epoxy and graphite/epoxy plates under uniform pressure has not been studied.

Therefore, it has been decided to use FEM to compare and analyze the concentric hole behavior of s glass/epoxy and graphite/epoxy plates under uniform pressure.

METHODOLOGY

The method used in this study includes comparing the concentric holes of s-glass/epoxy and graphite/epoxy panels in terms of maximum stress and deflection. FEM is used to analyze the anti-symmetric, symmetric, and cross layers with various boundary conditions under uniform pressure to study the changes in stress and deflection that occur by changing the D/W ratio. ANSYS has been used to perform the analysis. The results obtained are plotted in a table and graphed to compare the stress and deflection at different D/W ratios. The focus of the research is:-

- A four-layer rectangular laminate (+θ/-θ/-θ/+θ) in a symmetrical arrangement, (+θ/-θ/+θ/-θ) in antisymmetrical, (00/900/900/00) in symmetrical crossply and (00/900/00/900) in antisymmetricalcrossply stacking sequence has been analysed. Thickness of each layer of the laminate is taken as uniform.

- Boundary conditions considered are all sides clamped and all sides simply supported.

- A uniform pressure of magnitude 50 Kn/mm2 has been analysed through software ANSYS 15.0.

- Material taken are s-glass/epoxy and graphite/epoxy its properties are defined as linear orthotropic as stated in th table below.

PARAMETER USED

S-glass/epoxy properties	
E1	55×10^{6} kN/m^{2}
E2	16×10^{6} kN/m^{2}
E3	16×10^{6} kN/m^{2}
G12	7.6×10^{6} kN/m^{2}
G23	7.6×10^{6} kN/m^{2}
G13	7.6×10^{6} kN/m^{2}
μ12	0.28
μ23	0.28
μ13	0.28
ρ	2 kN/m2
Graphite/epoxy properties	
E1	145×10^{6} kN/m^{2}
E2	10×10^{6} kN/m^{2}
E3	10×10^{6} kN/m^{2}
G12	4.8×10^{6} kN/m^{2}
G23	4.8×10^{6} kN/m^{2}
G13	4.8×10^{6} kN/m^{2}
μ12	0.25
μ23	0.25
μ13	0.25
ρ	1.58 kN/m^{3}
P (Uniform pressure)	50 kN/m^{2}
h (thickness of each layer)	5 mm
t (overall thickness)	20 mm

- The of D/W ratio varying from 0.15 to 0.6 with an increment of 0.15 has been studied on maximum stresses (σx,σy,τxy,τyz,τxz) and maximum deflection (Uz) for θ varying from 00 to 900 with an increment of 300 for all layers.

- A four noded structural shell element (SHELL181) has been selected.

- Each node has six degrees of freedom which are three translations in x, y, and z axes respectively, and three rotations about x, y, and z respectively.

Plate selected for the study with the dimension as shown in Table.

Dimensions of plates

Length (a)	1800 mm
Breadth (b)	600 mm
Thickness (t)	20 mm

FEM and its importance

FEM is a numerically based approach which is utilized in solving many engineering problems such as structural analysis, heat transfer, fluid flow, mass transport and electromagnetic potential. The finite element detailing of the problem results in the arrangement of synchronous algebraic equations for a solution instead of requiring the result of differential equations. In the finite element method, instead of solving the problem for the whole body in a single operation, we form the equations for every finite element and combine them to get the solution of the entire body. There are three types of finite elements:

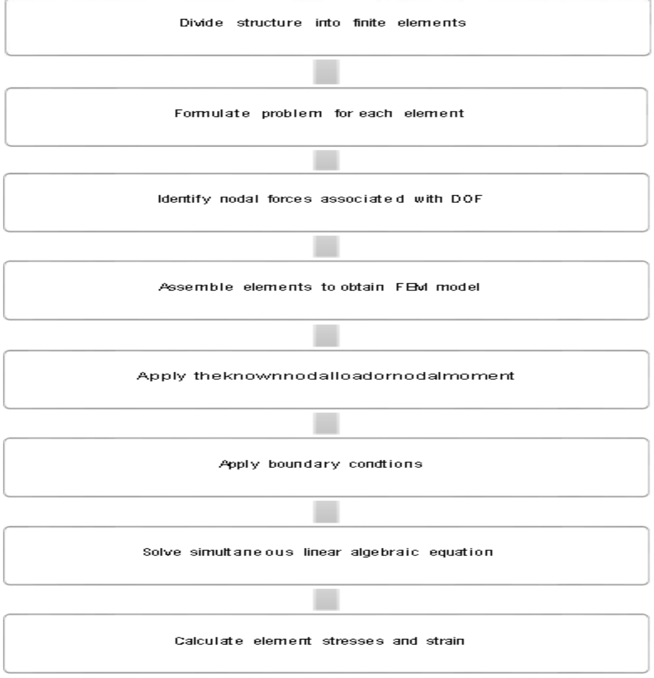
1. One-dimensional element
2. Two-dimensional element

3. Three-dimensional element

Various steps involved in solving problems using FEM are as under:

Various Shell elements used to analyse plate and shells

- SHELL 61 = 2-node, axisymmetric shell – 4 DOF/node (3 translations and one rotation)
- SHELL 208 = like 61, but finite strain
- SHELL 209 = like 208, but with midside node (3-node element)
- SHELL 28= shear twist panel – 3 DOF/node (3 translation or 3 rotation)
- SHELL 41 = 3-D quad or triangle with membrane only
- SHELL 43 = 4-node shell with 6 DOF/node (plastic)
- SHELL 63=4-node shell with 6 DOF/node(elastic only)

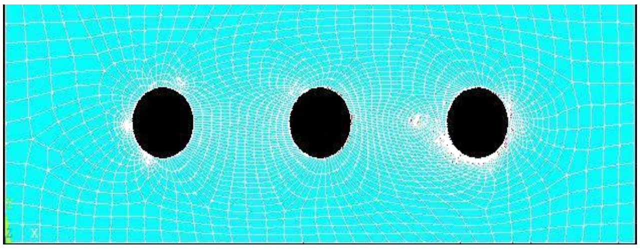


- SHELL 93 = Like 63, but with midside nodes
- SHELL 150 = 8-node p-element
- SHELL 181 = 4-node, finite strain SHELL 281 = 8-node, finite strain

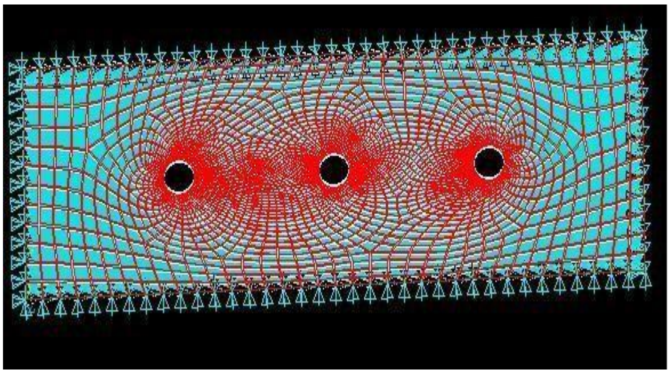
Modeling in ANSYS

ANSYS is a finite element analysis tool for structural analysis, including linear, nonlinear and dynamic studies. It enables us to solve complex engineering problems and make better faster design decisions. ANSYS is a very useful and widely accepted engineering tool which is used to solve many problems involving electronics aviation atomic and automobile. ANSYS is one of the best finite element computer software which includes all the aspects of FEM. It is capable of performing static, fluid flow dynamic and electromagnetism and heat transfer analysis. It is used throughout the industry to enable engineers to optimise their product designs and reduce the costs of physical testing.

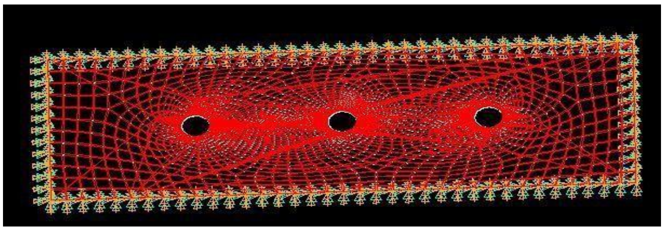
Model of Plate

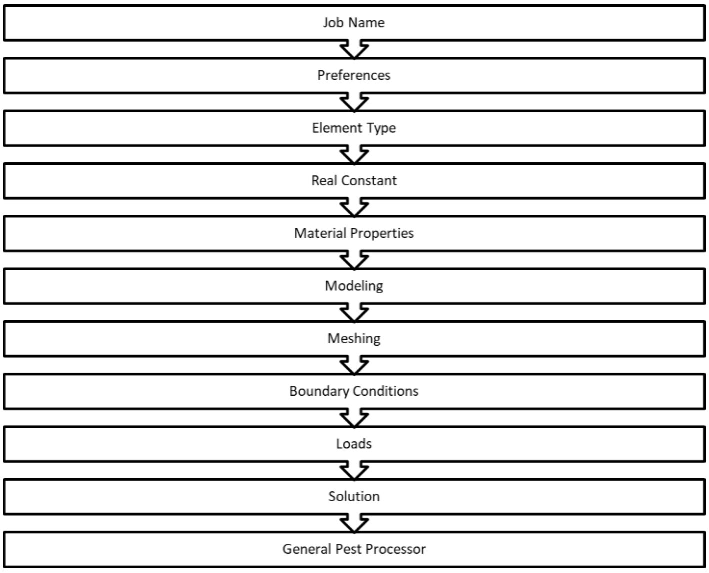


Rectangular laminate with boundary conditions all four sides



Rectangular laminate with clamped boundary conditions on all four sides





RESULTS AND DISCUSSION

1) Clamped boundary condition

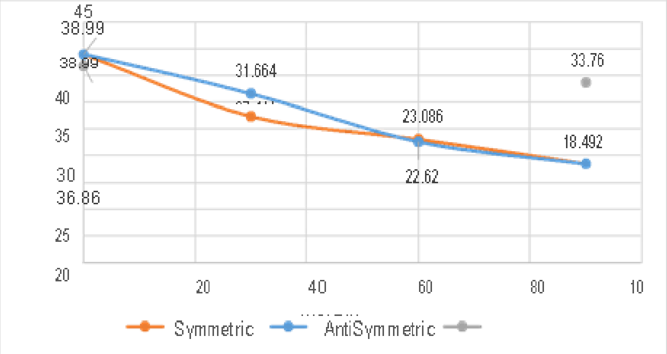
For this condition, the result of s-glass/epoxy and graphite/epoxy finite element analysis are discussed below.

2) Clamped rectangular s-glass/epoxy laminate with concentric circular hole ratio d/w 0.15 under transverse uniform pressure load

For this case, the maximum stresses (+θ/-θ/-θ/+θ) in a symmetrical arrangement, (+θ/-θ/+θ/-θ) in antisymmetrical, (00/900/90 0/00) in symmetrical crossply and (00/900/00/900) in anti-symmetrical crossply stacking sequence are listed in Tables.

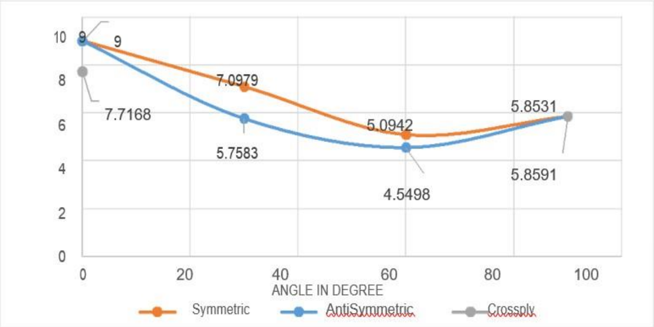
Max. Stresses (σx) in clamped rectangular laminate

Angle	0	30	60	90
Symmetric	38.99	27.411	23.086	18.492
AntiSymmetric	38.99	31.664	22.62	18.492
Crossply	36.86			33.76



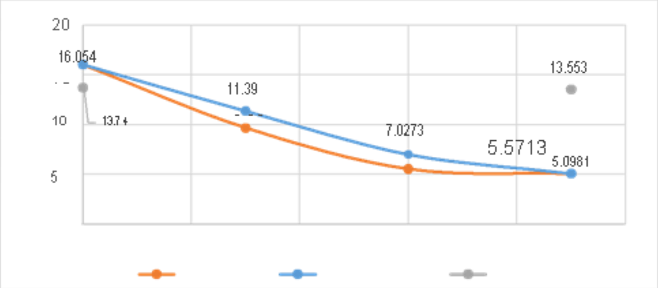
Max. Stresses (σy) in clamped rectangular laminate

Angle	0	30	60	90
Symmetric	9	7.0979	5.0942	5.8535
AntiSymmetric	9	5.7583	4.5498	5.8531
Crossply	7.7168			5.8591



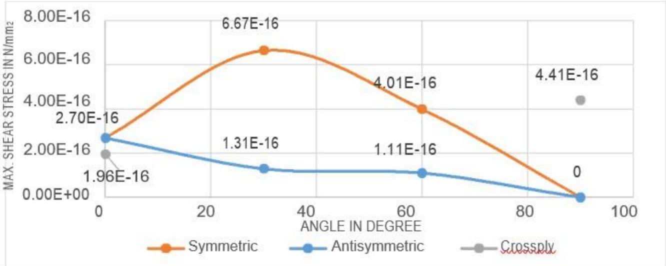
Max.in plane shear stresses (τxy) in clamped rectangular laminate

Angle	0	30	60	90
Symmetric	16.054	9.69	5.5713	5.0981
Antisymmetric	16.054	11.39	7.0273	5.0981
Crossply	13.74			13.553



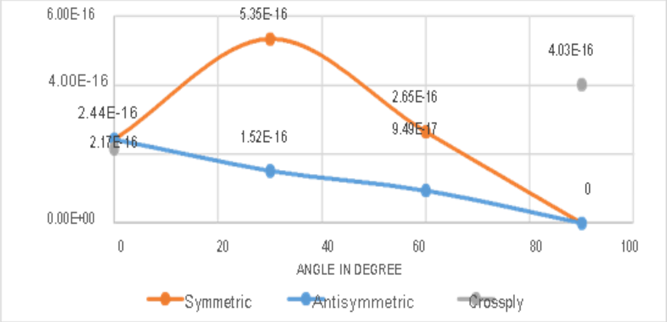
Max. in plane transverse shear stresses (τyz,) in clamped rectangular laminate

Angle	0	30	60	90
Symmetric	0.26975E-15	0.66748E-15	0.40086E-15	0
Antisymmetric	0.26975E-15	0.13074E-15	0.11087E-15	0
Crossply	0.19597E-15			0.44106E-15



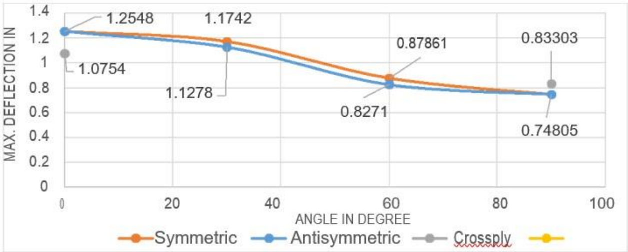
Max.in plane transverse shear stresses (τxz) in clamped rectangular laminate

Angle	0	30	60	90
Symmetric	0.24364E-15	0.53451E-15	0.26505E-15	0
Antisymmetric	0.24364E-15	0.15226E-15	0.94881E-16	0
Crossply	0.21672E-15			0.40278E-15



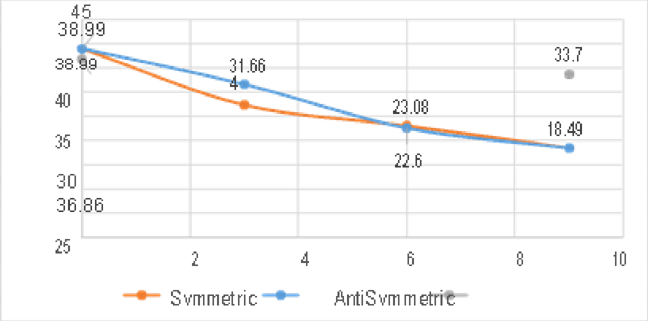
Max deflection (Uz) in clamped rectangular laminate

Angle	0	30	60	90
Symmetric	1.2548	1.1742	0.87861	0.74805
Antisymmetric	1.2548	1.1278	0.8271	0.74805
Crossply	1.0754			0.83303



3) Maximum normal stress (σx)

The variation of maximum normal stress (σx) with respect orientation of fiber with constant D/W ratio 0.15 is shown in following graph:



Clampped when ratio is 0.15

1. The stresses in x direction in s-glass/epoxy antisymmetric case vary from 38.99 Mpa to 18.492 Mpa and stresses in graphite/epoxy antisymmetric case varies from 75.956 Mpa to 22.22 Mpa. Mainly the stresses in x direction in graphite/epoxy antisymmetric case is more than the s-glass/epoxy antisymmetric case.

2. The stresses in y direction s-glass/epoxy symmetric case varies from 9 Mpa to 5.8535 Mpa and stresses in Graphite/epoxy symmetric case varies from 19.624 Mpa to 8.3477 Mpa. Mainly the stresses in y direction in graphite/epoxy symmetric case is more than sglass/epoxy symmetric case.

3. The shear stresses in xy plane in s-glass/epoxy antisymmetric case varies from 16.054 Mpa to 5.0981 Mpa and stresses in Graphite/epoxy antisymmetric case varies from 35.544 Mpa to 9.1972 Mpa. Mainly the stresses in xy plane in graphite/epoxy antisymmetric case is more than the s-glass/epoxy antisymmetric case.

4. The deflection in z direction in s-glass/epoxy symmetric case varies from 1.2548 mm to 0.74805 mm and deflection in graphite/epoxy symmetric case varies from 1.5204 mm to 0.5451 mm. Mainly the deflection in z direction in s-glass/epoxy symmetric case is more than the graphite/epoxy symmetric case except for 0^{0}case.

Clampped when ratio is 0.3

1. The stresses in x direction in s-glass/epoxy antisymmetriccrossply case is 45.86 Mpa and stresses in graphite/epoxy antisymmetriccrossply case is 53.66 Mpa. Mainly the stresses in x direction in graphite/epoxy antisymmetriccrossply case is more than the s-glass/epoxy antisymmetriccrossply case.

2. The stresses in y direction in s-glass/epoxy antisymmetric case varies from 8.1146 Mpa to 12.555 Mpa and stresses in graphite/epoxy symmetric case varies from 10.354 Mpa to 10.933 Mpa. Mainly the stresses in y direction in s-glass/epoxy antisymmetric case is more than the graphite/epoxy symmetric case
except at 0^{0}and 60^0.

3. The shear stress in xy plane in s-glass/epoxy symmetric case varies from 15.016 Mpa to 4.6674 Mpa and stresses in graphite/epoxy symmetric case varies from 17.555 Mpa to 7.824 Mpa. Mainly the stress in xy plane in graphite/epoxy symmetric case is more than the s-glass/epoxy symmetric case.

4. The deflections in z direction in s-glass/epoxy symmetric case varies from 1.0241 mm to 1.267 mm and deflection in graphite/epoxy symmetric case varies from 0.58033 mm to 1.0332 mm. Mainly the deflection in z direction in glass/epoxy symmetric case is more than the graphite/epoxy symmetric case.

Clampped when ratio is 0.45

1. The stresses in x direction in s-glass/epoxy antisymmetric case varies from 40.002 Mpa to 15.094 Mpa and stresses in graphite/epoxy antisymmetric

case varies from 56.27 Mpa to 18.669 Mpa. Mainly the stresses in x direction in graphite/epoxy antisymmetric case is more than the s-glass/epoxy antisymmetric case.

2. The stresses in y direction in s-glass/epoxy symmetric case varies from 7.8521 Mpa to 6.4707 Mpa and stresses in graphite/epoxy antisymmetric case varies from 9.0929 Mpa to 4.6886 Mpa. Mainly the stresses in y direction in s-glass/epoxy symmetric case is more than the graphite/epoxy antisymmetric case except in case of 0^0 .

3. The shear stresses in xy plane in s-glass/epoxy antisymmetriccrossply case is 13.11 Mpa and stresses in graphite/epoxy antisymmetriccrossply case 16.498 Mpa. Mainly the stresses in xy plane in graphite/epoxy antisymmetriccrossply case is more than the s-glass/epoxy antisymmetriccrossply case.

4. The deflection in z direction s-glass/epoxy symmetric case varies from 1.1284 mm to 0.95296 mm and deflection in graphite/epoxy symmetric case varies from 0.96011 mm to 0.63758 mm.
   Mainly the deflection in z direction in s-glass/epoxy symmetric case is more than the graphite/epoxy symmetric case.

Clampped when ratio is 0.6

1. The stresses in x direction in s-glass/epoxy antisymmetric case varies from 18.298 Mpa to 12.674 Mpa and stresses in graphite/epoxy antisymmetric case varies from 36.558 Mpa to 15.893 Mpa. Mainly the stresses in x direction in graphite/epoxy antisymmetric case is more than sglass/epoxy antisymmetric case.

2. The stresses in y direction in s-glass/epoxy symmetric case varies from 3.3388 Mpa to 3.1765 Mpa and stresses in graphite/epoxy symmetric case varies from 5.2905 Mpa to 3.1765 Mpa. Mainly the stresses in y direction in graphite/epoxy symmetric case is more than s-glass/epoxy symmetric case except in case of 60^0.

3. The shear stresses in xy plane in s-glass/epoxy symmetric case varies from 6.2393 Mpa to 2.9237 Mpa and stresses in graphite/epoxy symmetric case varies from 14.385Mpa to3.7131 Mpa. Mainly the stresses in xy plane in graphite/epoxy symmetric case is more than s- glass/epoxy Symmetric case.

4. The deflection in z direction in s-glass/epoxy symmetric case varies from 0.74386 mm to 0.61214 mm and deflection in graphite/epoxy symmetric case varies from 0.80432 mm to 0.56424 mm. Mainly the deflection in z direction in s-glass/epoxy symmetric case is more than graphite/epoxy symmetric case except for 0^0case.

Simply supported when ratio is 0.15

1. The stresses in x direction in s-glass/epoxy antisymmetriccrossply case is 103.10 Mpa and stresses in graphite/epoxy antisymmetriccrossply case is 172.87 Mpa. Mainly the stresses in x direction in graphite/epoxy antisymmetriccrossply case is more than s-glass/epoxy antisymmetriccrossply case.

2. The stresses in y direction in s-glass/epoxy symmetric case varies from 25.18 Mpa to 19.91 Mpa and stresses in graphite/epoxy symmetric case varies from 45.706 Mpa to 36.105 Mpa. Mainly the stresses in y direction in graphite/epoxy symmetric case is more than sglass/epoxy symmetric case.

3. The shear stresses in xy plane in s-glass/epoxy antisymmetriccrossply case is 40.301 Mpa and stresses in graphite/epoxy antisymmetric case varies from 77.198 Mpa to 36.499 Mpa. Mainly the stresses in xy plane in sglass/epoxy antisymmetriccrossply case is more than graphite/epoxy antisymmetric case.

4. The deflection in z direction in s-glass/epoxy symmetric case varies from 5.0207 mm to 4.6921 mm and deflection in graphite/epoxy symmetric case varies from 6.2986 mm to 4.6334 mm. Mainly the deflection in z direction in s-glass/epoxy symmetric case is more than the graphite/epoxy symmetric case except for 0^0case.

Simply supported when ratio is 0.3

1. The stresses in x direction in s-glass/epoxy antisymmetriccrossply case is 171.84 Mpa and stresses in graphite/epoxy antisymmetriccrossply case is 197.38 Mpa. Mainly the stresses in x direction in graphite/epoxy antisymmetriccrossply case is more than s-glass/epoxy antisymmetriccrossply case.

2. The stresses in y direction in s-glass/epoxy symmetric case varies from 29.465 Mpa to 43.585 Mpa and stresses in graphite/epoxy antisymmetric case varies from 32.99 Mpa to 37.399 Mpa. Mainly the stresses in y direction in graphite/epoxy antisymmetric case is more than the s-glass/epoxy symmetric case except for 60^0 and 90^0.

3. The shear stresses in xy plane in s-glass/epoxy antisymmetriccrossply case varies is 58.21 Mpa and stresses in graphite/epoxy antisymmetriccrossply caseis 66.623 Mpa. Mainly the stresses in xy plane in graphite/epoxy antisymmetriccrossply case is more than the s- glass/epoxy antisymmetriccrossply case.

4. The deflection in z direction in s-glass/epoxy symmetric case varies from 5.673 mm to 8.0272 mm and deflection in graphite/epoxy symmetric case varies from 4.2141 mm to 6.7739 mm. Mainly the deflection in z direction in s-glass/epoxy symmetric case is more than graphite/epoxy symmetric case.

Simply supported when ratio is 0.45

1. The stresses in x direction in s-glass/epoxy antisymmetriccrossply case is 187.37 Mpa and stresses in graphite/epoxy antisymmetriccrossply case is 215.58 Mpa. Mainly the stresses in x direction in graphite/epoxy antisymmetriccrossply case is more than s-glass/epoxy antisymmetriccrossply case.

2. The stresses in y direction in s-glass/epoxy symmetric case varies from 28.286 Mpa to 42.012 Mpa and stresses in graphite/epoxy antisymmetric case varies from 23.884 Mpa to 31.388 Mpa. Mainly the stresses in y direction in s-glass/epoxy symmetric case is more than the graphite/epoxy antisymmetric case.

3. The shear stresses in xy plane are shown in sglass/epoxy antisymmetriccrossply case is 63.78 Mpa and stresses in graphite/epoxy antisymmetriccrossply case is 75.661 Mpa. Mainly the stresses in xy plane in graphite/epoxy antisymmetriccrossply case is more than s-glass/epoxy antisymmetriccrossply case.

4. The deflection in z direction in s-glass/epoxy symmetric case varies from 6.3873 mm to 8.5082 mm and deflection in graphite/epoxy symmetric case varies from 3.8954 mm to 6.9442 mm. Mainly the deflection in z direction in s-glass/epoxy symmetric case is more than the Graphite/epoxy symmetric case except for 0^0case.

Simply supported when ratio is 0.6

1. The stresses in x direction in s-glass/epoxy antisymmetriccrossply case is 90.411 Mpa and stresses in graphite/epoxy antisymmetriccrossply case varies from 134.07 Mpa to 127.67 Mpa. Mainly the stresses in x direction in graphite/epoxy antisymmetric case is more than s- glass/epoxy antisymmetriccrossply case.

2. The stresses in y direction in s-glass/epoxy symmetric case varies from 10.356 Mpa to 10.601 Mpa and stresses in graphite/epoxy symmetric case varies from 19.624 Mpa to 8.3477 Mpa. Mainly the stresses in y direction in graphite/epoxy symmetric case is more than sglass/epoxy symmetric case.

3. The shear stresses in xy plane in s-glass/epoxy antisymmetriccrossply case varies is 26.206 Mpa and stresses in graphite/epoxy antisymmetriccrossply case is 56.137 Mpa. Mainly the stresses in xy plane in graphite/epoxy antisymmetriccrossply case is more than s-glass/epoxy antisymmetriccrossply case.

The deflection in z direction in s-glass/epoxy symmetric case varies from 5.9776 mm to 6.8959 mm and deflection in graphite/epoxy symmetric case varies from 6.0981 mm to 8.5929 mm. Mainly the deflection in z direction in graphite/epoxy symmetric case is more thans-glass/epoxy symmetric case except for 30^0 case.

Outcome of result and discussion

For clamped when D/W ratio is 0.15, we observe that

i. σx s-glass is maximum for θ = 0^0, 30^0, $60^0$and 90^0 antisymmetricangleply respectively.

σx graphite is maximum for θ = 0^0 , 30^0 , $60^0$and 90^0antisymmetricangleply respectively. σx graphite >σx s-glass

ii. σy s-glass is maximum for θ = 0^0, 30^0, $90^0$and 60^0 symmetric angleply respectively.

σy graphite is maximum for θ = 0^0, 30^0, $90^0$and 60^0 symmetric angleply respectively. σy graphite >σy s-glass .

iii. τxy s-glass is maximum τyz graphite is maximum for θ = 30^0, 90^0, $0^0$$60^0$ symmetric angleply respectively. for θ = 0^0, 30^0, 60^0 and 90^0antisymmetricangleply respectively.

τxy graphite is maximum for θ = 0^0, 30^0, $60^0$and 90^0antisymmetricangleply respectively. τxy graphite >τxy s-glass

iv. τyz s-glass is maximum for θ = 30^0, 60^0,$0^0$and 90^0symmetric angleply respectively.

τyz graphite >τyz s-glass

v. τxzs glass is maximum for θ = 30^0, 60^0,$0^0$and 90^0symmetric angleply respectively.

τxzgraphiteis maximum for θ = 0^0 , 90^0,$60^0$and 30^0antisymmetricangleply respectively.

τxz graphite >τxzs glass

vi. Uzs-glass is for θ = 0^0, 30^0, $60^0$and 90^0symmetric angleply respectively.

Uzgraphite is for θ = 0^0 , 30^0 , 60^0 and90^0symmetric angleply respectively.

Uz s-glass >Uz graphite

Similarly it can analysed for

For clamped when D/W ratio is 0.3,
For clamped when D/W ratio is 0.45
For clamped when D/W ratio is 0.6
For simply supported when D/W ratio is 0.15
For simply supported when D/W ratio is 0.3
For simply supported when D/W ratio is 0.45
For simply supported when D/W ratio is 0.6

CONCLUSION AND FUTURE SCOPE

In the present work, finite element analysis of four layered rectangular symmetric (+θ/-θ/-θ/+θ) and antisymmetric (+θ/-θ/+θ/-θ) laminate with equal thickness of layer, clamped and simply supported on all the four sides under transverse uniform pressure load of 50 kN/mm^2 have been analysed using software ANSYS 15.0. The effect of D/W ratio varying from 0.15 to 0.6 with increment of 0.15 has been studied on maximum stresses (σx,σy,τxy,τyz,τxz) and maximum deflection (Uz) for θ varying from $0^0$to $90^0$with increment of $30^0$for all layers.

Conclusions

The maximum σx, max.σy and max. τxy occurs at top and bottom surface of the laminate; max. τyz and max. τxz occurs at middle surface of the laminate; max. Uz occurs at different locations along the periphery of the circular hole depending upon the D/W ratio. For both the laminates, the following conclusions have been observed:-

For Simply supported:

- Stresses in x directions is mostly maximum in antisymmetriccrossply in both the laminate and is always maximum for graphite/epoxy laminate than sglass/epoxy laminate.
- Stresses in y directions in graphite/epoxy is only greater when the D/W ratio is 0.15 and 0.6 otherwise its value is less.
- The shear stresses in xy plane is maximum in antisymmetriccrossply and shear stresses in xy plane in graphite/ epoxy laminate is more than s-glass/epoxy laminate except when the ratio is 0.15.
- The shear stresses in yz plane is maximum in sglass/epoxy laminate than graphite /epoxy laminate except when the ratio is 0.15.
- The shear stresses in zx plane is maximum in graphite/ epoxy laminate than s-glass/epoxy laminate
- The deflection in z direction is maximum in sglass/epoxy laminate than graphite /epoxy laminate except when the ratio is 0.6.

For Clamped edges:

- Stresses in x directions is maximum for graphite/epoxy laminate than s- glass/epoxy laminate.
- Stresses in y directions in graphite/epoxy is greater than s-glass/epoxy laminate except when the D/W ratio is 0.3.
- The shear stresses in xy plane is maximum in graphite/ epoxy laminate than s-glass/epoxy laminate.
- The shear stresses in yz plane is maximum in sglass/epoxy laminate than graphite /epoxy laminate except when the ratio is 0.3and 0.45.
- The shear stresses in zx plane is maximum in graphite/ epoxy laminate than s-glass/epoxy laminate except when ratio is 0.45
- The deflection in z direction is maximum in sglass/epoxy laminate than graphite /epoxy laminate except when ratio is 0.6.

Thus from the above results, we can say that graphite/epoxy plate with D/W ratio upto 0.45 and all sides clamped is best suited for application because small deflections and stresses are observed in this case. It is suitable to use at the places where such type of assembly is required. Thus, plate can be used in the places such as aeroplane, car body, space station, subjected to high pressure.

Scope for future

The suggestions for the extension of present work are as follows:

1. It can analyze cyclic load, impact load, point load, axial load.
2. The analysis may be carried out for plates with different size.
3. The laminates with holes of square, rectangular shapes can beanalyse.
4. The laminates withothermaterial can be analyse.
5. Laminates with arbitrary boundary conditions can be analyzed.

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