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Numerical Investigations of Thin Cylindrical Panel Subjected to Mechanical Loads with different materials

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Abstract
In Present paper linear buckling analysis of Aluminum alloy 6061, Carbon epoxy fiber reinforced plastic and glass fiber epoxy reinforce plastic cylindrical panels with/ without cut-outs has been carried out using finite element software, ANSYS. The static structure analysis also carried out and compared the results of the above material. During the buckling analysis of cylindrical panels single has taken in panel modeling and compared the results. The weight reduction of the cylindrical panel can have a certain role in the general weight reduction of the vehicle and is a highly desirable goal. Substituting composite structures for conventional metallic structures has many advantages because of higher specific stiffness and strength of composite materials. In this project, Static, linear buckling & linear layer analysis to determine the deformation, stress of the thin cylindrical panel. Layer stacking method carried out on cylindrical panel for 3, 6 and 9 layers for analysis of aluminum alloy 6061, CFRP and glass fiber reinforced plastic material.

Keywords: Buckling analysis, glass fiber, carbon fiber, cylindrical panel, cut-outs Aluminium alloy

1. 0 Introduction

Various fields of engineering such as civil, mechanical, aerospace and nuclear engineering fields the thin walled cylindrical shells finds wider applications as primary structural members. The stiffened and unstiffened shells made up of metallic and laminated composite materials (large diameter to thickness ratio) are extensively used in underwater, surface, air and space vehicles as well as in construction of pressure vessels, storage vessels, storage bins and liquid storage tanks. The geometric imperfections due to manufacturing processes takes dominant role in decreasing the buckling load of cylindrical shells. Buckling is often viewed as the controlling failure mode of these structures due to its relatively small thickness of these structural members. It is therefore essential that the buckling strength of the thin shells along with knowledge of its buckling has been the subject of many researchers in both analytical and experimental investigations. Composite structures are important in different areas of industry such as aero, marine aircrafts, ships, automotive and so on. Many of the structures experience blast loading during war or terrorist attack or accidental explosions. Response of composite structures subjected to explosion has been a field of intense activity of researchers in recent decades. So composite plates and shells form one of the basic elements of the structures, therefore, studying the blast response of such structures helps understanding and improving their blast resistance.

The Eigen frequencies and Eigen modes of a thin isotropic cylindrical panel are calculated. The purpose of the analysis is to examine the performance of the MITC shell elements combined to point mass elements (PMASS). The panel is supported with four springs attached to the corners of the plate. Thus, the panel is not fully constrained and a shift of 1.0 has to be applied in order to be able to solve the eigenvalue problem. A Composite material (also called a composition material or shortened to composite, which is the common name) is a material made from two or more constituent materials with significantly different physical or chemical properties that, when combined, produce a material with characteristics different from the individual components. The individual components remain separate and distinct within the finished structure. The new material may be preferred for many reasons: common examples include materials which are stronger, lighter, or less expensive when compared to traditional materials. More recently, researchers have also begun to actively include sensing, actuation, computation and communication into composites, which are known as Robotic Materials.

2. 0 Literature Review

Reza Haghi[1] In this paper, the behavior of composite structures against the explosive phenomenon has been investigated using finite element method. Some composite shells such as composite plates and hemispheres with different layer-upping have been investigated using LS-DYNA software. The blast loading is simulated by explosion's pressure versus time curves and is directly defined in LS-DYNA software. The Tsai-Wu failure criterion is used to predict the behavior of the composite structure. In this paper, the effect of layer-upping on the blast resistance of the structure is investigated. The results show that, hemisphere composite has better performance against the blast loading than plate and failure occur under greater load. Also it is shown that angle ply composite structures have good resistance in comparison with cross plies one.

Mahmoud Shariati[2] In this paper, the effects of the length, sector angle and different boundary conditions on the buckling load and post buckling behavior of CK20 cylindrical panels have been investigated using experimental and numerical methods. The experimental tests have been performed using the INSTRON 8802 servo hydraulic machine and for numerical analysis. Abaqus finite element package has been used. The numerical results are in good agreement with the experimental tests.

M. Shariati [3] The effects of the length, sector angle and different boundary conditions on the buckling load and post buckling behavior of cylindrical panels have been investigated using experimental and numerical methods. The experimental tests have been performed using a servo hydraulic machine and for numerical analysis, Abacus finite element package has been used. The numerical results are in good agreement with the experimental tests

Y. Venkata Narayana [4] The Laminated cylindrical shells are being used in submarine, underground mines, aerospace applications and other civil engineering applications. Thin cylindrical shells and panels are more prone to fail in buckling rather than material failure. In this present study linear and non-linear buckling analysis of GFRP cylindrical shells under axial compression is carried out using general purpose finite element program (ANSYS). Nonlinear buckling analysis involves the determination of the equilibrium path (or load-deflection curve) up to the limit point load by using the Newton Raphson approach. Limit point loads evaluated for geometric imperfection magnitudes shows an excellent agreement with experimental results [25]. The influence of composite cylindrical shell thickness, radius variation on buckling load and buckling mode has also investigated. Present study finds direct application to investigate the effect of geometric imperfections on other advanced grid stiffened structures.

Farbod Alijani [5] the present literature review focuses on geometrically non linear free and forced vibrations of shells made of traditional and advanced materials. Flat and imperfect plates and membranes are excluded. Closed shells and curved panels made of isotropic, laminated composite, piezoelectric, functionally graded and hyper elastic materials are reviewed and great attention is given to non linear vibrations of shells subjected to normal and in plane excitations. Theoretical, numerical and experimental studies dealing with particular dynamical problems involving parametric vibrations, stability, dynamic buckling, non stationary vibrations and chaotic vibrations are also addressed. Moreover, several original aspects of non linear vibrations of shells and panels.

Dr. Adnan N. Jamel[6] The present work is an attempt to investigate the vibrations characteristics and effect of static stresses and deformation in partially pressurized thick cylindrical shells, such as the gun barrels. The method used cover analytical investigation developed to determine static stresses and deformation along the thick cylindrical shell using LAME'S equation. The numerical investigation is developed using the finite element method with axisymmetric element (Plane 42) four nodes to determine the static response and solid element (Solid 45) eight nodes for vibration analysis by using the ANSYS package. The obtained results show a good agreement with the other investigators. It's found that the natural frequency of the selected models almost equal (150. Hz) and these results indicate that the frequency of powder gasses pressure more than (150 Hz) to be far away from resonance phenomena.

Khamlichi et al. [7] studied analytically, about the effect of localized axisymmetric initial imperfections on the critical load of thin elastic cylindrical shell subjected to axial compression. Schneider (2006) discussed about the effect of local axisymmetric concave and convex axisymmetric ring shaped imperfection patterns on buckling strength of cylindrical shell under axial compression and one of the conclusion was that as width of imperfection increases buckling strength increases whereas as depth of imperfection increases buckling strength decreases.

Prabu.et al. [8] carried out parametric study about the effect of dent dimensions and its orientations on the buckling strength of short stainless steel cylindrical shells under uniform axial compressive force load condition and it was concluded that circumferential dents have more dominant effect than longitudinal dents in reducing the buckling strength of cylindrical shells.

Prabu et al. [9] studied about the nearness effect of two circumferential short dents on buckling strength of cylindrical shell by modeling two short dents at half the height of the perfect cylindrical shell model with varying the centre distance between the dents.

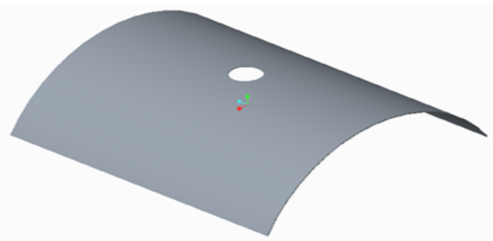
Prabu et al. [9] also studied about the buckling behavior of short carbon steel cylindrical shells under uniform displacement controlled axial compression and it was concluded that effect of dent dimensions and orientations on buckling strength of cylindrical shells decreases with a decrease in R/t ratio.

3.0 Materials and Methods

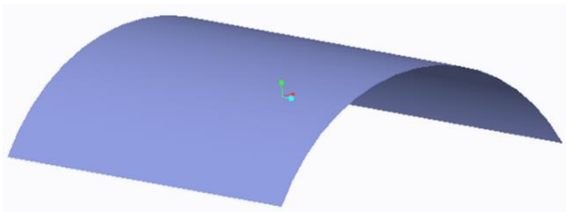
The Materials used for analysis of cylindrical panel are Aluminum alloy 6061, Carbon fiber and glass fiber. The material properties for the above material are shown in Table 1.

Table 1 Mechanical Property of Materials:

Materials	**Young's modulus(Mpa)**	**Tensile strength(Mpa)**	**Poisson's ratio**	**Density(kg/m3)**
Aluminum alloy 6061	68900	480	0.29	0.0000027
CFRP	Ex=2.07E5MPa, Ey=5200MPa,Gxy=2600 MPa, νxy =0.25,	3900	0.25	0.00000020
E-Glass fiber	Ex=1.64E5MPa, Ey=1.27MPa,Gxy=0.310MPa, νxy =0.20	3441	0.21	0.0000024



a)



b)

Fig.1 Cylindrical Panels a) With Hole and b) Without Hole

The length to width ratio of the plate and cylindrical panels were kept 1.0(a/b = 1). And also the straight edge length (a) and curved length (b) are equals to 250 mm. The angle of curvatures is kept constant $\phi = 116^0$ for the cylindrical panels while buckling. The circular hole having 20 mm diameter is taken for plate and cylindrical panels. The thickness of the panel was kept constant (t= 1.0) throughout the buckling analysis

4.0 Linear-Buckling Analysis of Thin Cylindrical Panel

First, consider a linear-buckling analysis (also called eigenvalue-based buckling analysis), which is in many ways similar to modal analysis. Linear buckling is the most common type of analysis and is easy to execute, but it is limited in the results it can provide. Linear-buckling analysis calculates buckling load magnitudes that cause buckling and associated buckling modes. FEA programs provide calculations of a large number of buckling modes and the associated buckling-load factors (BLF). The BLF is expressed by a number which the applied load must be multiplied by (or divided — depending on the particular FEA package) to obtain the buckling-load magnitude.

The buckling mode presents the shape the structure assumes when it buckles in a particular mode, but says nothing about the numerical values of the displacements or stresses. The numerical values can be displayed, but are merely relative. This is in close analogy to modal analysis, which calculates the natural frequency and provides qualitative information on the modes of vibration (modal shapes), but not on the actual magnitude of displacements.

5.0 Results and Discussions:

The buckling analysis of cylindrical panel with simply supported boundary conditions subjected to axial compressive load was carried out with different materials and for given geometry mentioned. Induced axial stress for carbon fiber reinforced plastic (epoxy) laminated cylindrical panel without hole is more compared to other two materials whereas for glass fiber reinforced plastic(epoxy) cylindrical panel with hole is high as shown in Table 2.

Table: 2 Static Analysis Results

Cases	Material	Displacement (mm)	Stress(Mpa)	Strain
Without hole	Aluminum alloy (6061)	0.007007	1.592	0.23e-04
	Carbon fiber	0.0211	1.613	0.71e-04
	E-glass fiber	0.006761	1.560	0.21e-04
With hole	Aluminum alloy(6061)	0.01596	6.274	0.911e-04
	Carbon fiber	0.004515	6.342	0.27e-04
	E-glass fiber	0.01527	6.272	0.87e-04

It is evident in Table 3 that the maximum buckling factor/load obtained for carbon fiber reinforced plastic (epoxy) laminated cylindrical panel without hole/without hole whereas BLF for Aluminum alloy 6061 cylindrical panel with hole/without hole is observed to be less compared to two other materials as shown in Table 2.

Table: 3 Buckling analysis results

Material	Without hole			With hole		
	Modes	BLF	Displacement (mm)	Modes	BLF	Displacement (mm)
Aluminum alloy 6061	1	35.20	0.28	1	26.06	0.27
Carbon fiber	1	116.517	0.15	1	120.10	0.15
E-glass fiber	1	35.9037	0.77	1	36.47	0.27

The linear buckling analysis of GFRP and CFRP cylindrical panels is extended with 3 layer 6 layer and 9 layer with the same boundary conditions subjected to axial compressive load and observed that as the number of layers increase the buckling load is increasing as it is evident in Table 4.

Table: 4 Linear layer analysis results

Layers	Without hole			With hole		
	Modes	BLF	Displacement (mm)	Modes	BLF	Displacement (mm)
3	1	33.90	0.25	1	40.985	0.3104
6	1	37.012	0.29	1	35.452	0.279
9	1	44.38	0.28	1	51.844	0.351

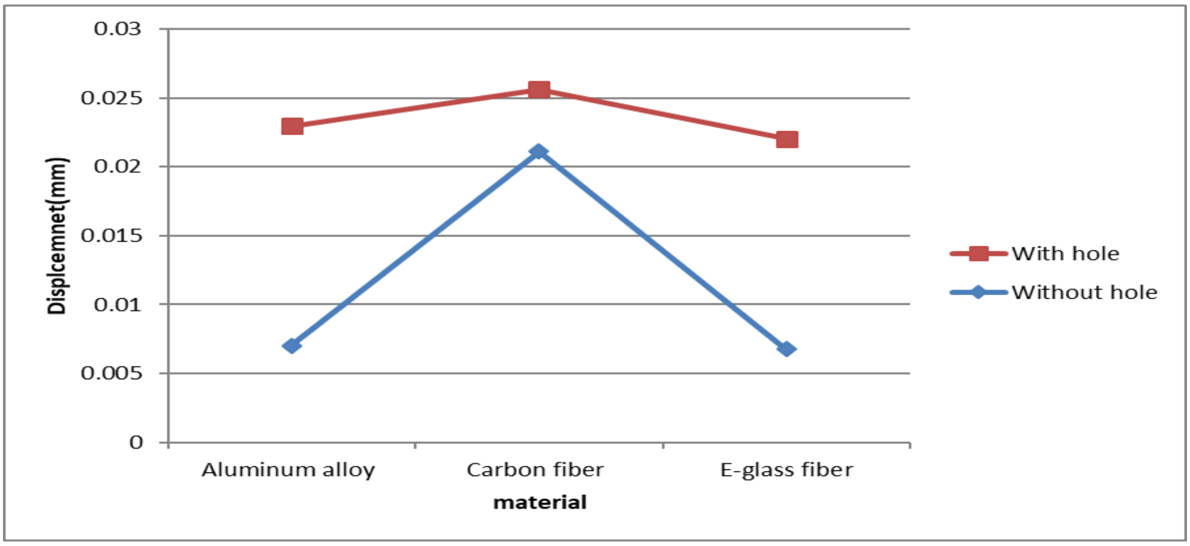


Fig.2 Graphs Materials and cases Vs displacement

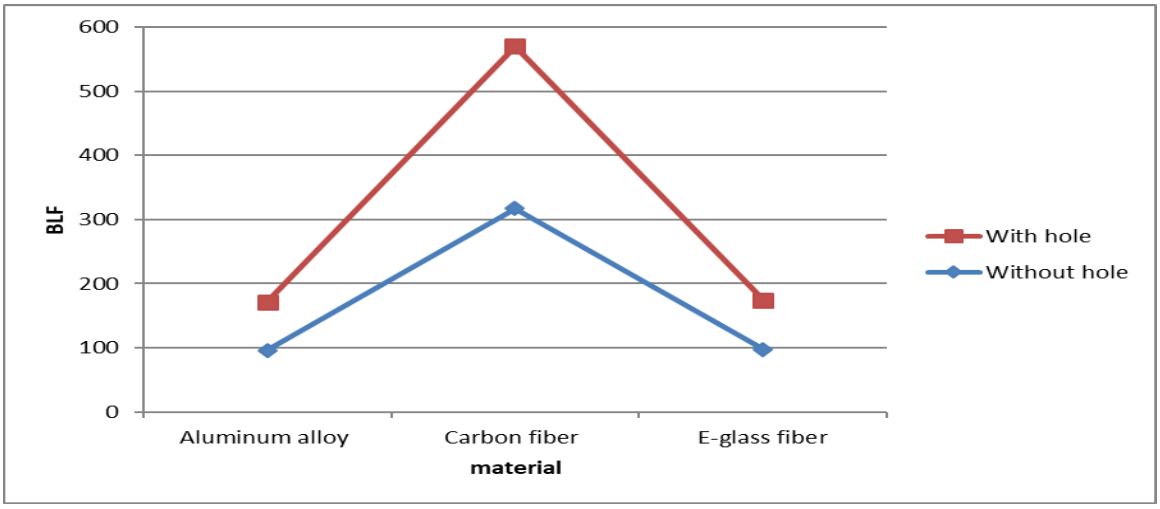


Fig.3 Graphs Materials and cases Vs Buckling Load Factor(BLF)

Conclusion

In this process Static, buckling & linear layer analysis to determine the deformation, stress of the cylindrical shell has been carried out using finite element software. Layer stacking method carried out on cylindrical panel for 3, 6 and 9 layers for analysis of aluminium alloy 6061, carbon fibre and glass fibre reinforced plastic material at different case (with and without hole). By observing the static analysis, the deformation, stress and strain values are increases by increasing the loads. The stress values are less for E-glass fibre material when we compare the aluminium alloy 6061 and carbon fibre reinforced plastic material. By observing the buckling analysis, the buckling factor more at carbon fiber material when we compare the aluminium alloy 6061 and glass fibre reinforced plastic material. By observing the linear layer buckling analysis, the buckling factor more at 3 layers when we compare the 6 and 9 layers

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