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# "BUCKLING ANALYSIS OF SHELL PANEL COMPONENTS"

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## ABSTRACT
The cylindrical components generally are subjected to buckling load in many of the applications. The shear stresses and the deformation of the material play key role in the life of the component. The present research involves the evaluation of such cylindrical component made of epoxy material, subjected to compressive load. The cylinders are made in two types, without and with reinforcement of fibres, with 0, 1, 2 and 4 holes equally spaced around the lateral surface. The system is simulated using ANSYS. The results obtained from the experimentation are analysed.

## I. INTRODUCTION
A composite material means, the material is prepared by a combination of two different materials but it acts as a single material and providesa unique properties which are differentcompared to their parent materials.It maintains a special features like high strength with low weight, so that it is commonly considered in differentindustrieslike Aerospace, Automobile, etc., It also exhibits high thermal conductivity, and some other mechanical properties like fatigue, stiffness, temperature dependent behaviour, corrosion resistance, thermal insulation, wear resistance. These thin-walled cylindrical shells have much importance in aerospace structural applications due to better loading capacity and less structural weight. These aerospace shell structures have various shaped openings used as doors, windows, etc.,In general, any cylindrical component which has openings often require some type of reinforcing structure to control the internal structural deformations and stresses which shows the initiation of cracks and flaws at openings under loading conditions.Their buckling response characteristics play a key role and should be accurately predicted in order to make effective designs and to specify safe operating conditions for these structures. In the present work, an attempt is made to analysethe deformations occurred during compressive load on a cylindrical shell

with the presence and absence of openings by using the finite elementanalysis. On shell the load was applied as compressive load and parameters like Interlaminar, Intra-laminar stresses, buckling factor and deformation under with and without reinforcement of Graphite /Epoxy composite laminate material was studied.

## II. LITERATURE REVIEW

A critical load is applied which leads the material to failure under compressive when it is applied on cylindrical shells to find the buckling factor of shell[1].To reduce the overall weight ,these shells are made of composite materials which exhibits different properties other than its parent material and are dependent upon different factors like interlaminar structures, types of fibres filled ,procedure of lamination ,composition of material etc.,[2].Theses shells are maintained by small openings which acts as doors and windows ,but when the shell undergoes a compressive load , these openings should be supported with a reinforcement to avoid the initiation of cracks. The failures and responses in these shells when they are taken as quasi static isotropic laminated under compressive load was numerically studied.[3].The cracks are initiated may be due to degradation of material at laminated panels which occurs due to both inter and intra laminar failures and also due to shear mode and failure mode of fibre matrix [4,5]. By preference, a flat plate under linear analysis by its preliminary design wit square shaped opening was analyses by standard method and a curved panel was tested under axial compression load which shows a geometrically nonlinear response and failure [6,7]. The effects of initial geometrical imperfections was accurately predicts the shell under buckling analysis due to compressive load [8]. A high feasibility analysis was applied successfully on other similar compression loaded shells which has openings of circular holes and are verified comparing with weak sections of circular holes [9, 10]. The stability of cylindrical shells with different shaped cut-outs like circular and rectangular cutouts are demonstrated [11]. The theoretical and experimental investigations are carried out on local inter laminar axisymmetric imperfections under different axial loads [12].

## III. 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

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- 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) upto the limit point load by using the NewtonRaphson 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 hyperelastic 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. [10] 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.

## IV.MEHANICAL PROPERTIES OF MATERIALS:

| **Materials** | **Young's modulus(Mpa)** | **Tensile strength(Mpa)** | **Poisson's ratio** | **Density(kg/mm3)** |
|---|---|---|---|---|
| **AISI 1050 steel** | 205000 | 690 | 0.29 | 0.00000785 |
| **Carbon fiber** | 228000 | 3900 | 0.30 | 0.00000020 |
| **E-Glass fiber** | 72000 | 3441 | 0.21 | 0.0000024 |

**AISI 1050 STEEL**

Carbon steels contain carbon as the main alloying element. They are designated by AISI four-digit numbers, and contain 0.4% of silicon and 1.2% of manganese. Molybdenum, chromium, nickel, copper, and aluminum are present in small quantities.

**CARBON FIBER**

In fiber reinforced composites, fiberglass is the "workhorse" of the industry. It is used in many applications and is very competitive with traditional materials such as wood, metal, and concrete. Fiberglass products are strong, lightweight, non-conductive, and the raw material costs of fiberglass are very low.

In applications where there is a premium for increased strength, lower weight, or for cosmetics, then other more expensive reinforcing fibers are used in the FRP composite.

**E- Glass fiber**

Glass fiber has roughly comparable mechanical properties to other fibers such as polymers and carbon fiber. Although not as rigid as carbon fiber, it is much cheaper and significantly less brittle when used in composites. Glass fibers are therefore used as a reinforcing agent for many polymer products; to form a very strong and relatively lightweight fiber-reinforced polymer (FRP) composite material called glass-reinforced plastic (GRP), also popularly known as "fiberglass". This material contains little or no air or gas, is more dense, and is a much poorer thermal insulator than is glass wool.

Glass fiber is formed when thin strands of silica-based or other formulation glass are extruded into many fibers with small diameters suitable for textile processing. The technique of heating and drawing glass into fine fibers has been known for millennia; however, the use of these fibers for textile applications is more recent. Until this time, all glass fiber had been manufactured as staple (that is, clusters of short lengths of fiber).

## V.METHODOLOGY

The analysis is done in various steps. At first a composite shell is modelled in ANSYS workbench considering an element of SHELL-99 with desired dimensions. A square shaped cut-out is made with 1 mm size, with reinforcement and without reinforcement was modelled. The compressive load of 2KN was applied to find out the buckling factor, deformation and inter-laminar shear stress occurred in the composite shell. The deformation, buckling factor of the shell is determined by providing one hole, two holesand at four holes.

## RESULTS AND DISCUSSIONS

## TABLE 1: STATIC ANALYSIS RESULTS:

| Material | Deformation (mm) | Stress (N/mm$^2$) | Circumferential stress(N/mm$^2$) | Longitudinal stress(N/mm$^2$) | Strain |
|---|---|---|---|---|---|
| **AISI 1050 steel** | 0.0033485 | 35.307 | 21.12 | 48.327 | 0.00017295 |
| **Carbon fiber** | 0.027914 | 33.406 | 20.675 | 44.969 | 0.00014559 |
| **E glass fiber** | 0.086815 | 33.269 | 11.368 | 43.286 | 0.00046207 |

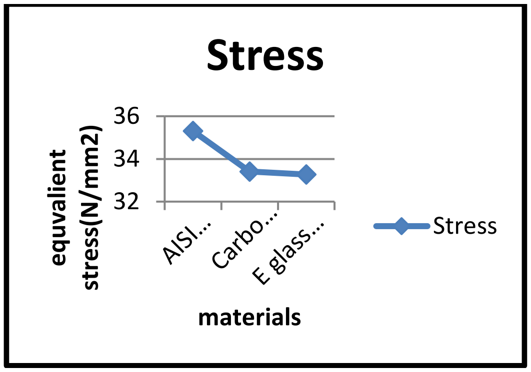


**Figure 1: Graph between Static analysis Stress and Materials**

Static analysis results were shown in Table 1 and Figure 1. In point of equivalent Stress minimization results, carbon fiber has major contribution followed by EN32 Steel and E –glass fiber. Deformation is low at EN32 Steel followed by E-Glass fiber and Carbon fiber.

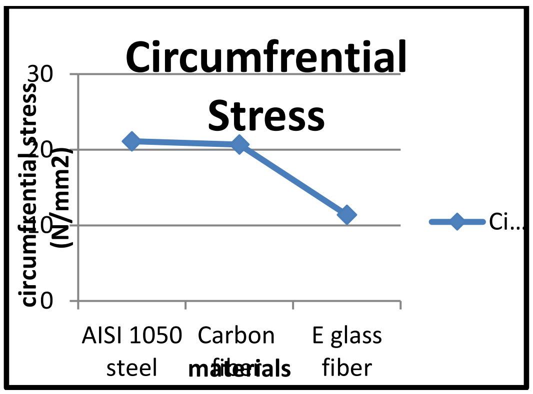


**Figure 2: Graph between Static analysis circumferential stress and Materials**

According to above plot, the circumferential stress minimization results, E glass fiber has major contribution followed by EN32 Steel and carbon fiber.

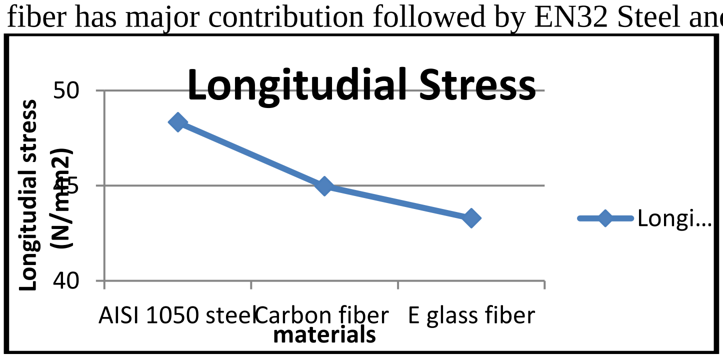


**Figure 3: Graph between Static analysis longitudinal stress and Materials**

According to above plot, the longitudinal stress minimization results, E glass fiber has major contribution followed by EN32 Steel and carbon fiber.

**CONCLUSION:**

In this project, Static, buckling & linear layer analysis to determine the deformation, stress of the cylindrical shell. Layer stacking method carried out on cylindrical panel for 3, 6 and 9 layers for analysis of steel, carbon fibre and glass fibre reinforced plastic material. 3Dmodeling done by the parametric software CATIA and analysis done in ANSYS software. By observing the static analysis the deformation, stress and strain values are increases by increasing the loads. The circumferential and longitudinal stress values are less for E glass fiber material when we compare the AISI 1050 steel and carbon fiber materials. By observing the buckling analysis the load multiplier values are less at glass fiber when we compared to the other two materials. By observing the linear layer analysis the stress values are less for 6 layers compared to other layer stacking. So it can be concluded that E glass fiber material and 6 layer stacking suitable for cylindrical shell panel component.

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