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RESEARCH ARTICLE

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EFFECT OF ADDITIVES ON THE COMPRESSIVE STRENGTH OF 'GFRP' SHELL

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ABSTRACT

The axial compression of thin-walled E-glass fibre/epoxy resin reinforced (GFRP) composite cylindrical shape was carried out to study the crashworthiness of cylindrical shape. The cylindrical shape E-glass fibre reinforced polymer (GFRP) cylindrical were fabricated and oriented mats*4 layers to the required dimensions as per ASTM standards by hand layup process. The development of surface was created by using CAD tool. By using the surface development a template was prepared. With the template marked on GFRP E-glass fabric. After 24 hours the GFRP cylinder was removed from pattern. Now the sharp edge was trimmed as per the ASTM standards. Quasi-static axial compression load was applied over the small end of the cylindrical specimen with a crosshead speed of 2 mm/min using Universal Testing Machine (UTM). From the experiment results, the load deformation characteristics of thin GFRP composite cylindrical shells were analyzed and the results were validated through finite element analysis package ANSYS16.0. Further, the influence of ply orientation and the laminate wall thickness towards the energy absorbing capability of each GFRP cylinder specimen was studied. The crushing mode of collapse and the failure loads of GFRP composite cylindrical shape were also investigated to identify the crushing mechanisms involved in thin fibre/resin composite laminated cylinder specimens under quasi-static axial compression. The different apical cylinder of GFRP cylindrical shape are filed under different crushing loads. In that 15° cylinder is better compare to other cylinder was investigated.

INTRODUCTION

In its most basic form a composite material is one which is composed of at least two elements working together to produce material properties that are different to the properties of those elements on their own. In practice, most composites consist of a bulk material (the 'matrix'), and a reinforcement of some kind, added primarily to increase the strength and stiffness of the matrix. This reinforcement is usually in fiber form. Composites are combinations of two or more distinct materials and present as separate phases and combined to form structures with desired performance. They take advantage of the desirable features of each constituent phase. The manufacturing technique used to fabricate (Process) a composite structure is dependent up on the material performance requirements (Material selection), structure configuration (Design) and production rates

In its most basic form a composite material is one which is composed of at least two elements working together to produce material properties that are different to the properties of those elements on their own. In practice, most composites consist of a bulk material (the 'matrix'), and a reinforcement of some kind, added primarily to increase the strength and stiffness of the matrix. This reinforcement is usually in fiber form. Today, the most common man-made composites can be divided into three main groups:

- Polymer Matrix Composites (PMC)
- Metal Matrix Composites (MMC)
- Ceramic Matrix Composites (CMC**)**

"Science and technology, like literature and the lively arts, have their fashionable phrases and catchwords. One very much to the fore these days is 'COMPOSITE MATERIALS', which has been coined to give dignity and renewed impetus to a very old and yet simple idea: putting dissimilar materials to work in concert so as to achieve a new material whose properties are different in scale and kind from those of any of the constituents"

Composite shows advantages like low weight, low density, low cost and good specific properties like tensile, flexural and impact strengths. It may possess applications in area where weight of the total equipment is a major problem, like rocket technology, aircraft industry, marine structures etc. By combining with some insulating material, composites can also utilized as thermal and electrical insulating material. Composites are used to prepare many mechanical components like brakes, drive shafts, flywheels, pressure vessels etc.

Experimental Procedure

We need the template before fabrication for that development of the surface will need. By using AUTODESK the development will be created as per the ASTM standards. According to my project the **5%, 10%, 15%** template was prepared with drawing paper then by using the template the outer margins are marked on E-glass fabric.

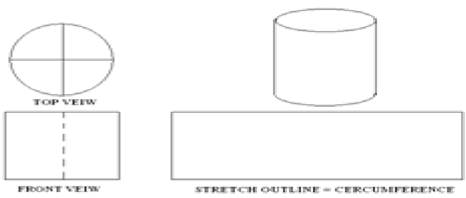

Figure 1: surface development of cylindrical shape.

ARIEL DENSITY OF FABRIC:

For the fabrication we need to find the ariel density of fabric.

A = πr^2 = 3.14 * 0.025^2 = $0.001963m^2$

E-glass ariel fabric density=456gsm

gsm=grams of squire meter

The fabric ariel density for 1 layer:

1 layer =A*gsm=0.001963*456=0.895g

4 layers=0.895*4=3.5805g

Resign = fabric weight

Hardner = 10% resign weight.

- Area of fabric for **5%:**

5% = A*gsm*5/100 = 3.5805*0.05= 0.1790 m^2

- Area of fabric for **10%:**

10% = A*gsm*10/100= 3.5805*0.1= 0.3580 m^2

- Area of fabric for 1**5:**

15% = A*gsm*15/100= 3.5805*0.15=0.5340 m^2

The fabric ariel density for 1 layer:

- For **5%:**456*0.1790=81.62g,
- For **10%:**456*0.3580=163.24g,
- For **15%:**456*0.5370=244.87g

WEIGHT COMPOSITION OF FABRIC, RESIN, HARDNER:

For **5%:**

- Fabric Ariel density=81.62g,
- Resin weight=Fabric Ariel density=81.62g,
- Hardener=10% of resin weight=8.162g.

For **10%:**

- Fabric Ariel density=163.24g,
- Resin weight=Fabric Ariel density=163.24g,
- Hardener=10% of resin weight=16.32g.

For **15%:**

- Fabric Ariel density=244.87g,
- Resin weight=Fabric Ariel density=244.87g,
- Hardener=10% of resin weight=24.48g.

Fig.2: Front view of specimens after extracting from patterns

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Fig.3: Top view of specimens after extracting from patterns.

ANSYS

ANSYS is a general purpose finite element modeling package for numerically solving a wide variety of mechanical problems. These problems include: static/dynamic structural analysis (both linear &non linear), heat transfer& fluid problems, as well as acoustic and electromagnetic problems. It enables engineers to perform the following tasks build computer moulds or transfer cad models of structures, products, components or system, apply operating loads or other design performance conditions, study physical responses .

ANALYSIS TYPES AVAILABLE

- Structural static analysis
- Structural dynamic analysis
- Thermal analysis
- Structural buckling analysis
- Nonlinear buckling analysis
- Thermal analysis.

STRUCTURALANALYSIS

Structural analysis is most commonly application of finite elemental model. The term structural not only civil engineering structures but also mechanical members such as ship hulls, aircraft bodies, machine housing, mechanical components like pistons, machine parts and tools.

TYPE OF STRUCTURAL ANALYSIS

- Static analysis
- Model analysis
- Dynamic analysis

Static analysis:

Static analysis all so called static code analysis In Computer terminology static means fix. This method of computer programming debugging is done by examining code without executing Programming. Automated tools can assist programmers and developers in carrying out static analysis. Static analysis is only a first step in a comprehensive software quality-control Regime.

Material Properties:

Type of Property	E-Glass
Density (g/cm^3)	2.60
Young's Modulus (GPa)	72
Tensile Strength (GPa)	1.72
Tensile Elongation (%)	2.4

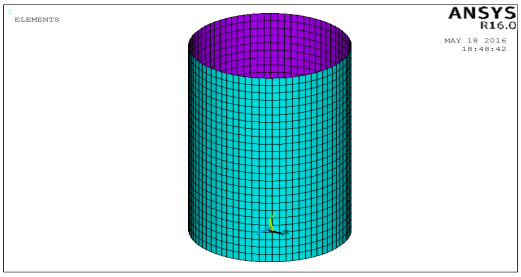

Fig 3: Meshing of specimen with 8noded281 mesh

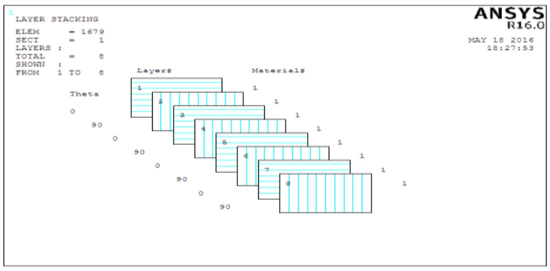

Fig 4: Meshing of specimen with 8noded281 mesh

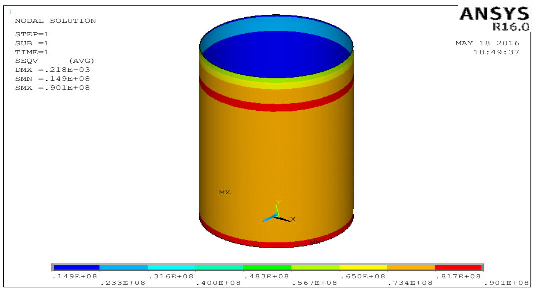

Fig 5: Behavior of First layer of laminate with compression loading at 5% of matrix distribution.

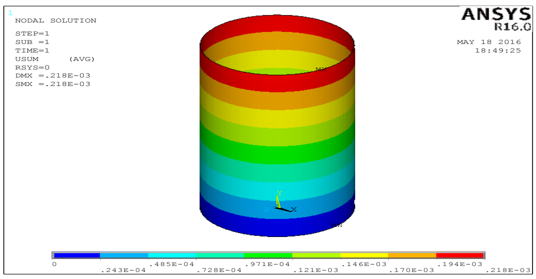

Fig 6: Behavior of second layer of laminate with compression loading at 5% of matrix distribution.

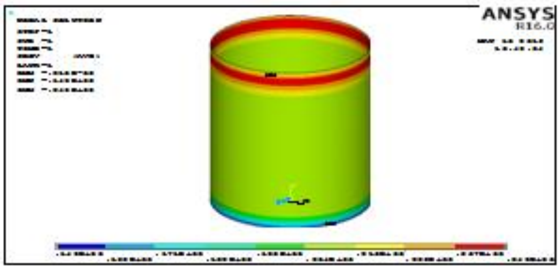

Fig 7: Behavior of Third layer of laminate with compression loading at 5% of matrix distribution

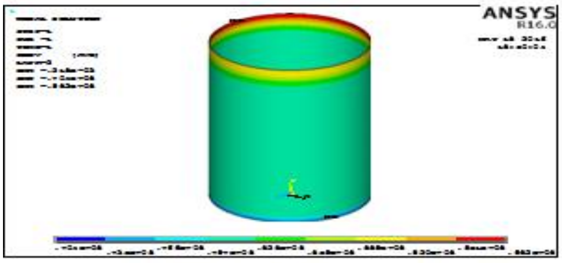

Fig 8: Behavior of fourth layer of laminate with compression loading at 5% of matrix distribution

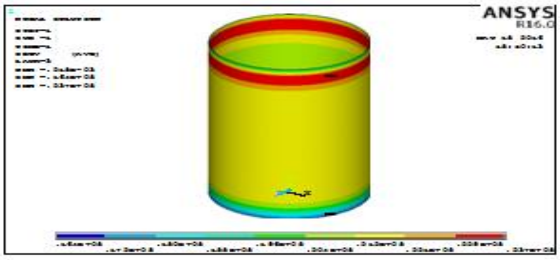

Fig 9: Behavior of Fifth layer of laminate with compression loading at 5% of matrix distribution

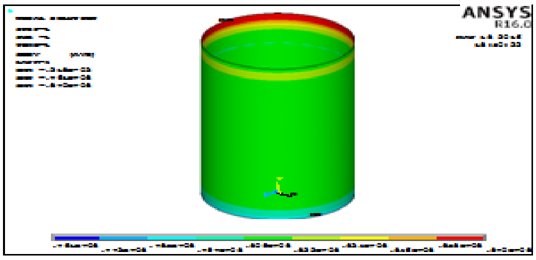

Fig 10: Behavior of Sixth layer of laminate with compression loading at 5% of matrix distribution

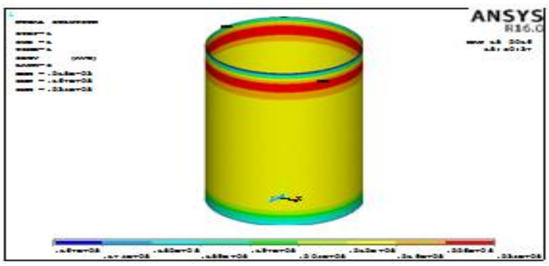

Fig 11: Behavior of Seventh layer of laminate with compression loading at 5% of matrix distribution

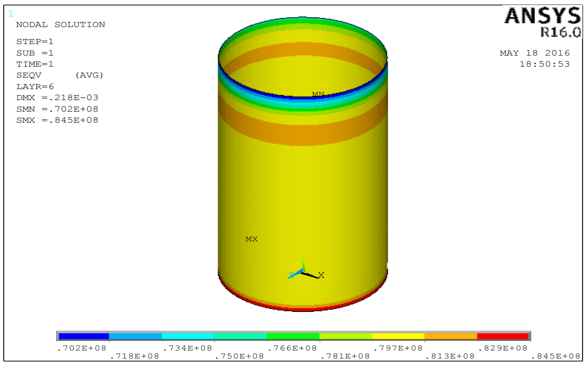

Fig 12: Behavior of Eighth layer of laminate with compression loading at 5% of matrix distribution

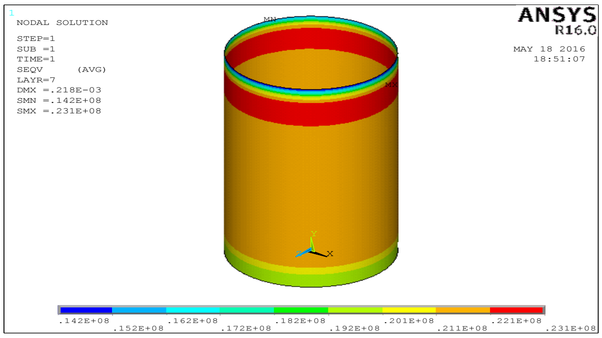

Fig 13: Displacement behavior laminated cylinder at 5% of matrix distribution

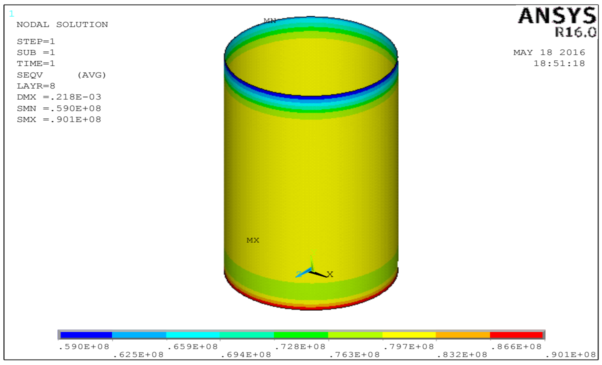

Fig 14: Equivalent stress distribution in laminated cylinder at 5% of matrix material

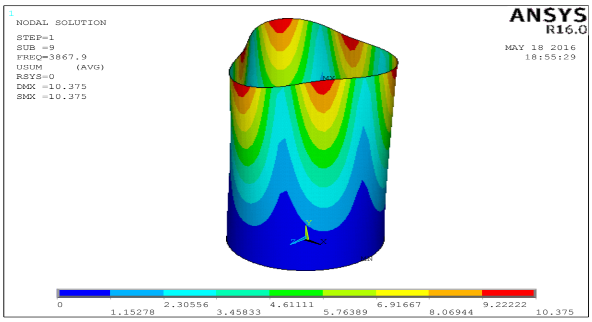

Fig 15: displacement behavior of the laminated cylinder at 10% of matrix distribution

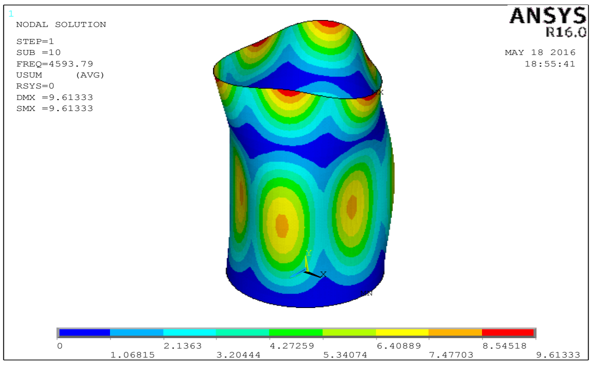

Fig 16: Equivalent stress distribution in the laminated cylinder at 10% of matrix distribution.

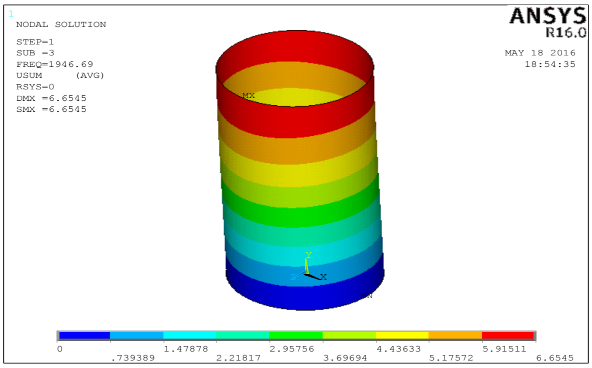

Fig 17: displacement in the laminated cylinder at 15% of matrix distribution

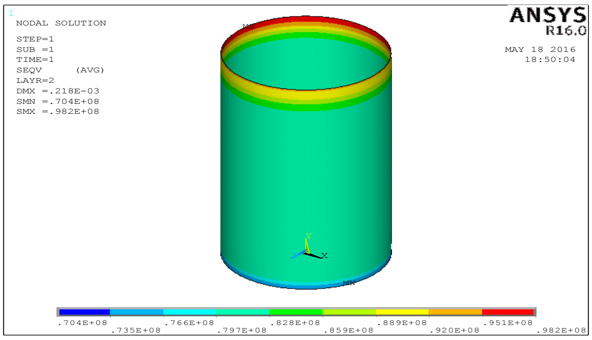

Fig 18: Equivalent stress distribution in the laminated cylinder at 15% matrix distribution.

DISCUSSION OF RESULTS

The energy absorption capability of the specimen is depending on many factors. One of them is the type of material used to fabricate the specimens. Here, cylindrical shape were considered to fabricate .Composite over wrapped Wooden and the fabricated cylindrical shell specimens were designated with GFRP specimens respectively. The dimensional details of GFRP composite &their experimental test results were retrieved from the corresponding experimental results of each specimen were compared with the present work to identify the influence of change of cylindrical specimen materials towards level of energy absorption capacity. It is clear that the GFRP cylinder have gained higher load resistance capacity than GFRP shells, and the GFRP cylindrical shells also offer higher load resistance as compared with GFR. The comparison of energy absorption levels of the corresponding specimens. It was observed that the energy absorption capacity of GFRP15% specimen is better when com-pared with the performance level of GFRP.

The crushed zones of GFRP cylindrical shells were examined to understand the collapse mechanisms involved during axial crush event. It was identified that most of the GFRP composite laminate exhibit multi-failure mode of collapse along with local buckling which are initiated due to matrix failure. Similar kind of failure was observed in GFRP composite laminate. During axial compression of GFRP cylindrical shell, the collapse begins from top end of the cylinder.

The compressed laminas are bent towards the axis of loading. During this stage of collapse, the internal layers of laminate would be in compression and the outer layer would be in tension. Due to this kind of tensile and compressive action, the intra and inter-laminar shear stresses exhibited within the laminate result End-crushing mode failure the micro-fragmentation of the composite material associated with large amounts of crush energy is mainly characterized by progressive stable collapse in top end of the cylindrical shell that leads to the formation of continuous fronds and/or a pulverized triangular wedge over the crushed region.

Transition mode of failure was characterized by the appearance of rapid crack propagation from top end of the shell, leading to an unstable global rupture of the frustum. Similar types of failure modes were observed in the present study, and one of the damaged GFRP specimens is:

By Conducting Crushing Test & Analysis on E-Glass Fiber Reinforced Polymer cylindrical shape with different**.**

- For**5%**failure occurs at 26.84KN,
- For**10%** failure occurs at 18.62KN,

- For **15%** failure occurs at 14.23KN.

S.No.	Crushing failure Load obtained by UTM	
	% of resin	**Failure load (KN)**
1	5	26.84
2	10	18.62
3	15	14.23

Conclusions

The crashworthiness analysis was carried out on GFRP cylindrical shells with varying , thickness and ply orientation. Each category of specimens was tested experimentally and the same was simulated numerically using ANSYS software under axial compression loading condition. The crash-worthiness characteristics such as energy absorption, first peak load, maximum peak load, load uniformity index and specific energy absorption of the specimens were calculated from the load–deformation characteristics curve of each specimen The four-layered composite cylinder specimen having shown maximum energy absorption capacity. The experimental and FEA results show that the average energy absorption capacity of specimen, respectively. Detailed study was made to find the critical cylindrical shape, which offers the best crashworthiness capacity. From the study, it was observed that the specimen having gains higher energy absorption capacity and the lower angled specimen offer higher first peak load.

By the Results obtained it can be concluded that the crushing stresses induced in all are within their allowable limits. And it also can be observed that which develops less vonmises stress exhibit compare to total deformation analysis.

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