FEA & EXPERIMENTAL ANALYSIS OF THREE POINT BENDING TEST OF THIN WALLED CIRCULAR STRUCTURES WITH ALUMINIUM HONEYCOMB

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Abstract - *Now a days, Aluminium honeycomb filled carbon fiber reinforced plastic (CFRP) thin walled square type of beams are used as it has the high energy absorption capacity. CFRP thin walled structures are considered exceptionally efficient energy-absorbing components for aerospace and automotive engineering applications. So, in this project we will take the circular specimen which is filled with aluminium honey comb material. The 3 D model will be drawn with the help of CATIA software. The three point bending experimental testing will be carried out. The analysis will be carried out with the help of ANSYS software. The experimental and FEA results will be compared. The result and conclusion will be drawn & the suitable future scope will be suggested.*

Key Words: FEA, THREE POINT BENDING TEST, CFRP.

1.INTRODUCTION

It has been proven that Carbon Fibre Reinforced Plastic (CFRP) is an effective energy-absorbing material. CFRP thin-walled structures are considered exceptionally efficient energy-absorbing components for aerospace and automotive engineering applications. However, the issue as to how to decide the best possible structural configuration still presents a challenge. Composite structures filled with lightweight materials have also attracted considerable interest due to their potential to enhance the energy-absorbing capability of composite structures. Moreover, honeycomb filling has been shown to be efficient in improving the energy absorption and specific energy absorption of composite structures. It should be noted that aluminum honeycomb filled CFRP thin-walled circular beams have not been studied in depth. As such, understanding their mechanical behaviour and crashworthiness would be of critical importance to more extensive and reliable application of such composites. Extensive studies have been made on the crashworthiness characteristics of composite structures with lightweight filler. Aluminum honeycomb has attracted much attention as a typical cellular material due to its excellent mechanical and energy absorption property, and specific strength-to-weight ratio. Honeycomb structures are natural or man-made structures that have the geometry of a honeycomb to allow the minimization of the amount of used material to reach minimal weight and minimal material cost. The geometry of honeycomb structures can vary widely but the common feature of all such structures is an array of hollow cells formed between thin vertical walls. The cells are often columnar and hexagonal in shape. A honeycomb shaped structure provides a material with minimal density and relative high out-of-plane compression properties and out-of-plane shear properties. Man-made honeycomb structural materials are commonly made by layering a honeycomb material between two thin layers that provide strength in tension. This forms a plate-like assembly. Honeycomb materials are widely used where flat or slightly curved surfaces are needed and their high Specific strength is valuable. They are widely used in the aerospace industry for this reason, and honeycomb materials in aluminum, fibreglass and advanced composite materials have been featured in aircraft and rockets since the 1950s. They can also be found in many other fields, from packaging materials in the form of paper-based honeycomb cardboard, to sporting goods like skies and snowboards. Man-made honeycomb structures include sandwich-structured composites with honeycomb cores.

2. LITERATURE REVIEW

A. *Literature Survey*

et al [1], Experimental and numerical investigations of steel-polymer hybrid floor panels subjected to three-point bendingJaeho Ryua, Yong Yeal Kimb, Man Woo Parkc, Sung-Won Yoond, Chang- Hwan Leee, Young K. Ju

A new floor system for steel buildings was developed that can replace conventional concrete deck slab systems. The floor system is designed with a new type of composite panel with a polymeric material filling between the top and bottom steel plates. Its salient features are its light weight and simple installation that reduce structural materials and shorten the construction period. Experiments with various independent variables were performed to evaluate the flexural capacity of the proposed composite panel, and a finite element analysis was also conducted to examine the state of the stresses generated between the steel plate and the polymeric core. The test results showed that the proposed panel exhibited very ductile behavior and maintained its structural integrity even after a maximum load. No other failure mode than the face yielding of the top and bottom steel plates was observed. The bond strength between the polymeric material and the steel plates was confirmed to be sufficient, even without any special surface treatment or any additional shear connectors, to maintain the stability of the proposed panel and to resist the forces generated at the interface between the two materials. Design equations for predicting the flexural strength and stiffness of the proposed panel were proposed, and its suitability was verified. Additionally, the experimentally tested efficient methods for field applications of the proposed panel regarding cutting and joining were presented in this paper.

et al [2], Mathematical Simulation of Nonlinear Problem of Three-Point Composite Sample Bending Test, I.B. Badriev, M.V. Makarov, V.N. Paimushin

This study is devoted to numerical analysis of the geometrically and physically nonlinear problem of three-point bending test of laminated fiber-reinforced composite samples with rectangular crosssection. The problem is formulated by using relationships based on describing the displacement vector for an arbitrary point on the beam (Timoshenko model). For numerical solution of the problem, the finite sums method is used. In accordance with this method, the initial equations are reduced to integro-algebraic equations, which are then approximated by a collocation method using Gauss nodes. Implemented numerical enables a very accurate description of solution having large gradients change at very short sections. Buckling of the beam under transverse load has been studied by altering the loading parameter.

et al [3], Considering damages to open-holed composite laminates modified by nanofibers under the three-point bending test A. Gholizadeha, M. Ahmadi Najafabadia,H. Saghafib, R. Mohammadi

Nowadays, many components are made of composite laminates assembly by bolted or riveted joints. Thus, the drilling of laminates is a usual machining operation in many industries. Due to the stress concentration around the hole, different damage modes can occur during the service. In this study, the effect of interleaving Nylon 66 nanofibers between glass/epoxy laminate on decreasing damage under the three-point bending test is considered. The results showed that applying nanofibers caused a 57% decrease in the delaminated area. On the other hand, the Acoustic Emission (AE) technique was used to consider the effect of Nylon 66 nano fiber on other damage modes, matrix cracking, fiber/matrix debonding, and fiber breakage. AE signals were analyzed with three different methods, the outcomes showing that these damages significantly decreased.

et al [4], Three-point bending collapse of thin-walled rectangular beams Zhixin Huanga, Xiong Zhang

Three-point bending collapse is an important energy absorption mechanism of thin-walled beams subjected to crash loads. However, currently, there are still no theoretical methods available to predict the response of the beams under such load condition due to the complicated deformation features and influencing factors. In this paper, a detailed investigation on the three-point bending collapse of rectangular beams is performed. Quasi-static three-point bending tests are conducted first for thin-walled rectangular tubes. Numerical simulations are then performed by nonlinear finite element code LS-DYNA to investigate the bending responses. Parametric studies are carried out for thin-walled rectangular beams to investigate the influences of the span, the cross-sectional geometrical configurations and the diameter of the punch on bending responses. Results show that the geometrical parameters have great influence on the deformed shapes, force and moment responses of the beams. Finally, the bending responses of rectangular beams in experiment and simulation are compared with Kecman's model, which is proposed for pure bending. Big deviations are observed and hence a theoretical method basing on Kecman's model is proposed to predict their bending responses under three-point bending. Comparisons show that the proposed theoretical method can well predict the moment response of thin-walled rectangular beams under three-point bending.

et al [5], Thermal-stress analysis of beam loaded by 3-point bending Milan Sapietaa, Vladimír Dekýša, Alžbeta Sapietová

This paper describes investigation of experimental thermal stress analysis of stainless steel which was loaded by three-point bending. Loading took place cyclically with constant amplitude. The measurements were performed using as contactless scanning of infrared radiation emitted during loading from the face of specimen. The results were evaluated according to the theory of thermos elasticity. After evaluation of the results we get stress distribution of first invariant on the front face of the specimen.

B. Closure of the review

Literature review shows following research areas to be addressed for improving Bending behaviour and energyabsorption characteristics.

- Square tubes have a strong tendency to undergo tearing of the tube corners, which is inefficient and difficult to control. Therefore, for practical purposes, the circular tubes are strongly recommended.
- It is suggested to further study on the design optimization of the tube filling structures for more efficient and reliable energy absorbing components.

C. Problem Statement

To investigate the Bending response and energy absorption characteristics of the circular aluminium column with and without honeycomb structure to reduce injury to the passengers and damage to the vehicle.

D. Objectives

1. A non-linear finite element analysis of aluminium Specimen (With and Without Honeycomb)
2. Experimental study of aluminium specimen (With and Without Honeycomb) by using UTM
3. To validate the FEA and Experimental results.

E. Methodology

• CAD model generation (CATIA-V5)
• Finite Element Analysis (ANSYS)
• Manufacturing Stage
• Fabrication of Assembly
• Compression Testing (UTM)

Using the knowledge from literature review, we know how the 3D CAD model is to be prepared. The conditions required for applying various constraints will be decided based on literature review.

➢ 3D CAD Model Generation
• Getting input data on dimensions aluminium column
• Creating 3D model in CATIA-V5
➢ Determination of boundary conditions
• Determination of different loads and boundary condition acting on the component by studying various ref papers, and different resources available
➢ Testing and Analysis
• Using the best suitable material for the application referring different literatures
• Meshing the CAD model and applying the boundary conditions
• Solve for the solution of meshed model using ANSYS
➢ Fabrication, Experimental validation and Result
• Fabrication of specimens
• Suitable experimentation (UTM)
• Validation of result by comparing with software results.

3. DESIGN

A. Cad

The CAD or the computer aided design process is the enrichment of the traditional manual design process by using computer software and hardware extensively. The whole design process becomes much faster, robust and reliable by using computers. The output of a computer aided design process typically is 2D drawings and/or 3D parts/components like curves, surfaces and solids. The output of CAD process also contains data like material properties, dimensions, tolerance and manufacturing process specific information. The flexibility to draft and design in a digital sphere is provided by CAD, which were previously done manually. The output of CAD process makes data handling easier, safer, and quicker because these are in digital format. Prior it was very cumbersome and time-consuming activity to scan hand drawn blueprints and then expand upon digitally. Now days three-dimensional drawings are created using CAD software to maximize productivity and provide quicker, better product results, allowing for the development of the tiniest details.

B. Cad Models

Fig.1 Aluminium Circular Structure

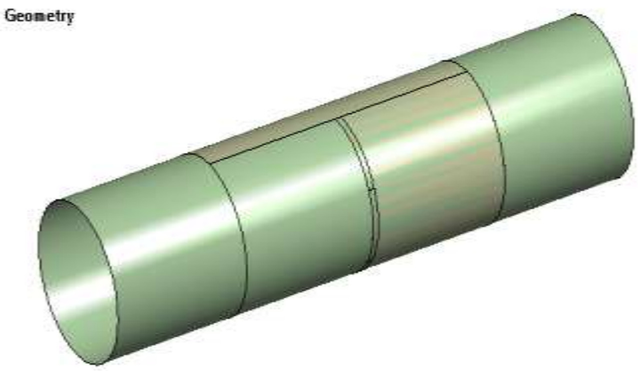
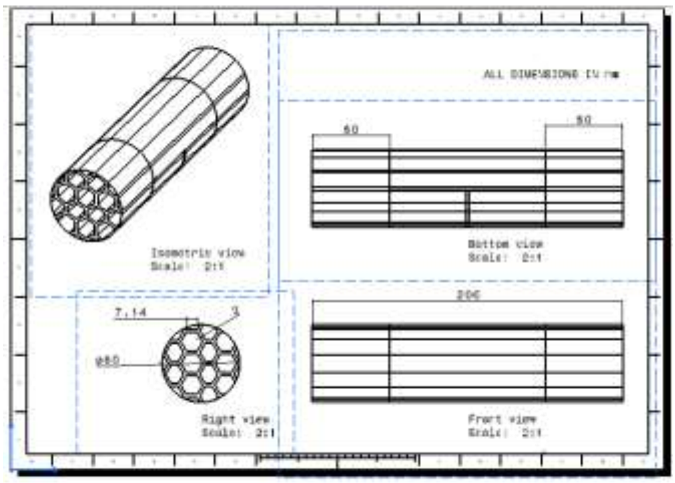


Fig.2 Aluminium +Carbon Fibre Circular Structure



CAD GENERATION DRAFTING OF HONEYCOMB STRUCTURE

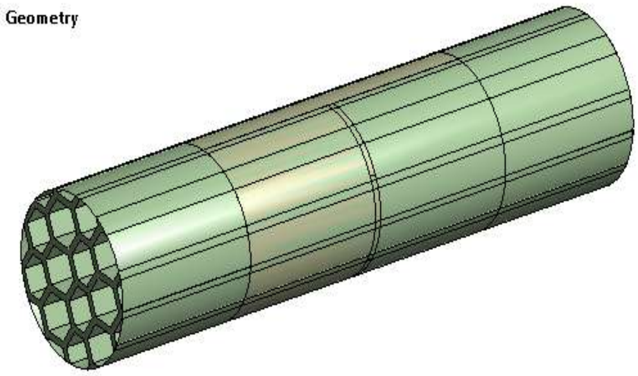


Fig.3 Aluminium +Carbon Fibre+Honeycomb Circular Structure

4. ANALYSIS

We will perform the analysis on the software Ansys. As we don't have a specified parameter on which we will compare the FEA results with the experimental results, we will Consider "DISPLACEMENT" as the specified parameter through which we can conclude the end results.

Here in all the three models we will consider displacement as 1mm throughout.

Also each model is 2mm in thickness.

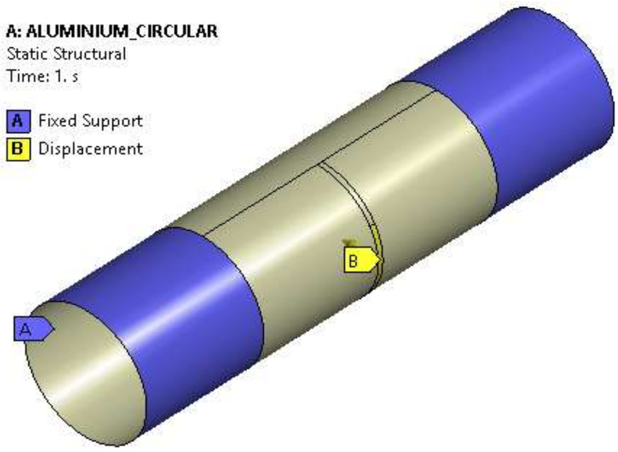


Fig.4 Aluminium circular structure **Geometric Model**

Statistics	
Nodes	21745
Elements	21596

Fig.5 Aluminium circular structure **Meshed Model**

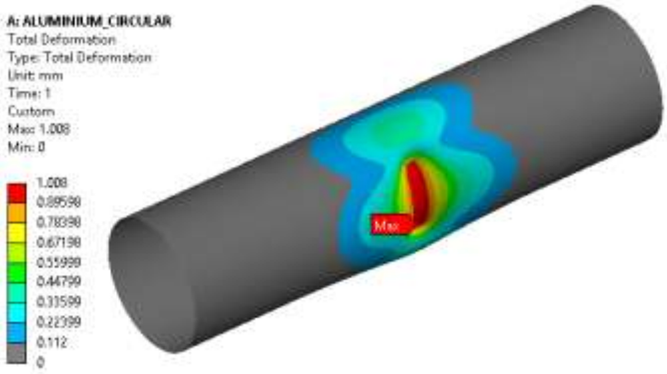


Fig.6 Aluminium circular structure **Total Deformation**

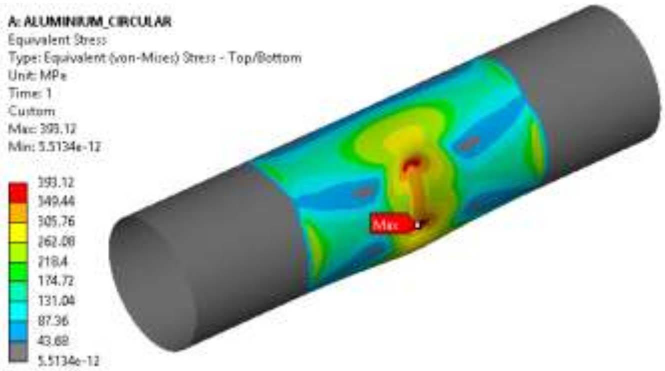
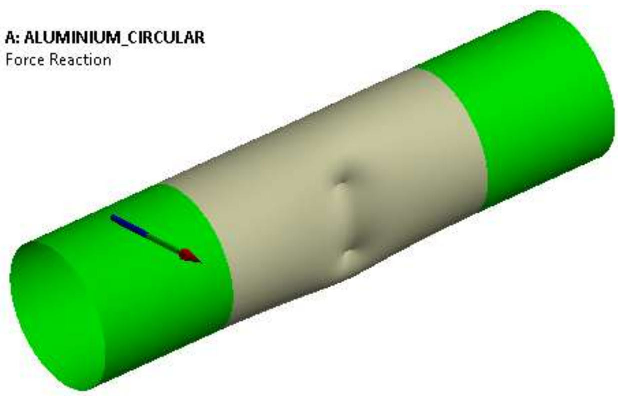


Fig.7 Aluminium circular structure **Equivalent stress**



Total	11782 N

Fig.7 Aluminium circular structure **Reaction Force**

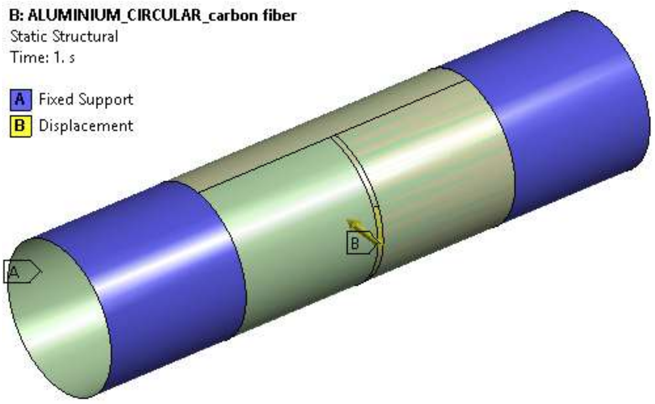


Fig.8 Aluminium circular+Carbon Fibre structure **Geometric Model**

Statistics	
Nodes	43056
Elements	42744

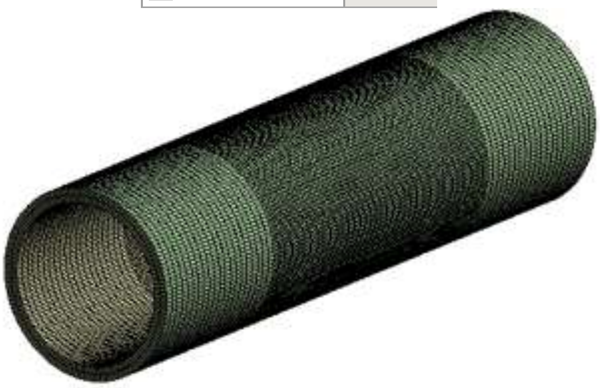


Fig.9 Aluminium circular+carbon fibre structure **Meshed Model**

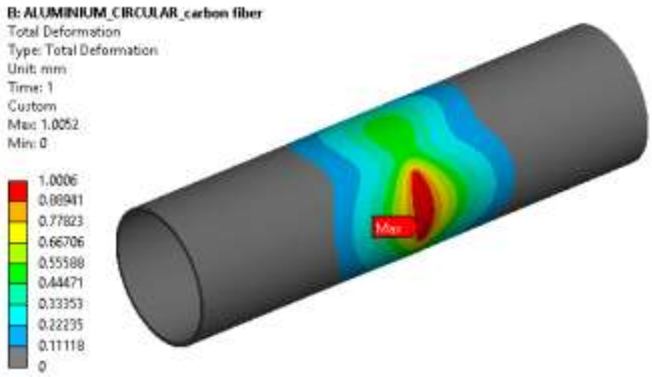


Fig.10 Aluminium circular+carbon fibre structure **Total Deformation**

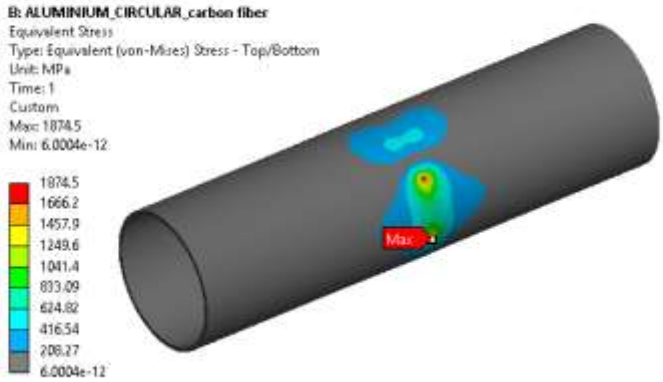


Fig.11 Aluminium circular + carbon fibre structure **Equivalent stress**

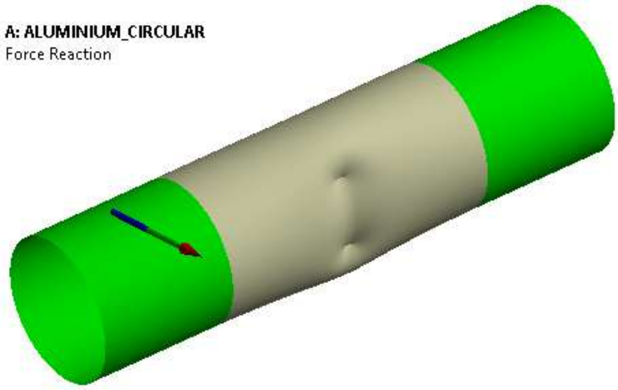


Fig.12 Aluminium +Carbon fibre circular structure **Reaction Force**

Total	32068 N

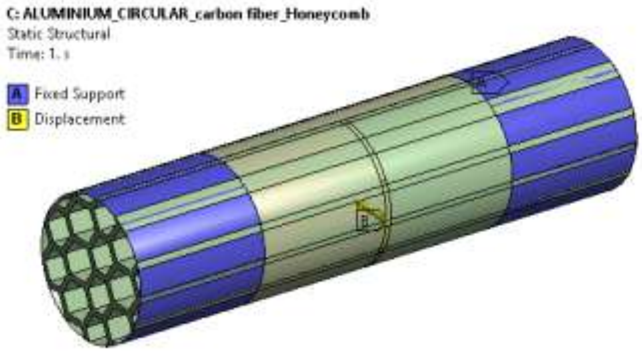


Fig.13 Aluminium circular + Carbon Fibre + Honeycomb structure **Geometric Model**

Statistics	
Nodes	73936
Elements	47840

Fig.14 Aluminium circular + Carbon Fibre + Honeycomb structure **Meshed Model**

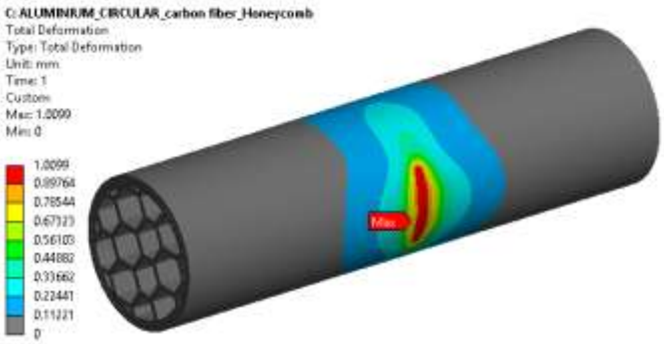


Fig.14 Aluminium circular + Carbon Fibre + Honeycomb structure **Total Deformation**

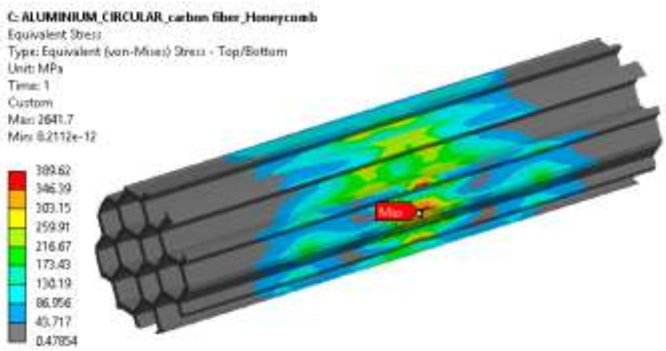
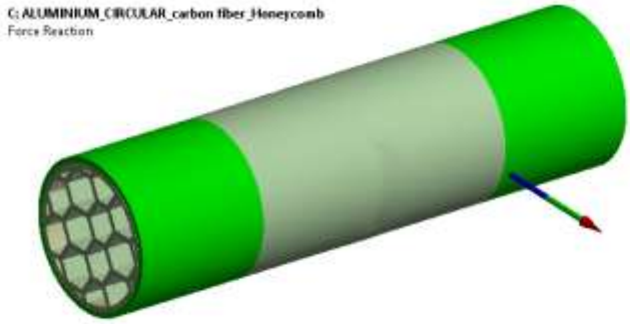


Fig.15 Aluminium circular + Carbon Fibre + Honeycomb structure **Equivalent Stress**



Total	69234 N

Fig.16 Aluminium circular + Carbon Fibre + Honeycomb structure **Reaction Force.**

5. Results & Discussions

From the above analysis it is simple to conclude that the Structure with Carbon fibre and Honeycomb has more Reaction force than the other two models, Hence it can resist more stress in conditions than the other two models.

Hence we can say that the strength of the Structure having Carbon Fibre with honeycomb is highly recommended for light weight with hight strength applications.

Characteristics	Aluminium Specimen	Aluminium Carbon Fibre Specimen	Aluminium Carbon Fibre Honeycomb Specime
Reaction Force (N)	11782	32068	69234
Equivalent Stress (MPa)	393.12	1874.5	2641.7

The Experimental Validation is under process. Here in the FEA we have taken 1mm displacement throughout and have proceeded with the analysis part, but for actual experimentation we will consider Force as per the study.

Once the force is decided then after the experimentation we can technically compare the outcome of FEA results Vs Experimental Result.

6. REFERENCES

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[4]Three-point bending collapse of thin-walled rectangular beams
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[5]Thermal-stress analysis of beam loaded by 3-point bending
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