EXPERIMENTAL VERIFICATION AND VALIDATION OF STRESS DISTRIBUTION OF METAL BEAM WITH COMPOSITE BEAM FOR DIFFERENT SUPPORT CONDITIONS

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Abstract: The evolution of composite materials has given an opportunity to various designers to use new and better materials resulting in cost reduction, better utilization of available resources and increase in efficiency. Composite materials have large areas of applications in aerospace industry, automobile sector, manufacturing industries, chemical industries, in sports, in electrical field etc A composite material is a mixture of two or more materials (fillers, reinforcement and binder) different in composition. Composite materials also called composition materials.. The delivered work presents experimental analysis as well as FEA analysis of metal and composite beam for different supporting loading condition, finally comparative analysis of the FEA results and experimental results. The result concludes that as the weights of the composite beam are compared with mild steel beam weights which are calculated analytically. The percentage difference between weights was about 50%. This shows the great weight reduction

***Index Terms*- Composite material, Glass fibre, ANSYS**

I. INTRODUCTION

The composite materials are having excellent combination of high structural stiffness and low weight. The behaviours (Mechanical) of fibre reinforced composites are dependent on their inherent abilities to enable stress transfer which is depends on the fibre strength and matrix strength. Glass fibres have been employed in various forms such as distinct fibre and longitudinal and. The properties of such composites is dependent on the nature and orientation of the fibres laid during composite preparation. Glass fibres are one of the most commonly and widely used polymer reinforcements with nearly 90% of all FRPs made of glass fibres. The most popular and oldest form is the E-glass or electrical grade glass. Other types of glass fibres include C-glass or chemical resistant glass, A-glass or alkali glass, , and the high strength R-glass or S-glass. The advantage of Glass fibre is its low cost. It has high chemical resistance and good insulating properties and high strength. In this work behaviour of components manufacturing from fibre reinforced composite materials are considered.

II. PROBLEM DEFINITION

The composite materials are well known by their excellent combination of high stiffness and low weight as compared to mild steel. The study of strength, properties and factors associated with composite material. The delivered work presents experimental analysis as well as FEA analysis of metal and composite beam for different supporting loading condition, finally comparative analysis of the FEA results and experimental results. The result concludes that as the weights of the composite beam are compared with mild steel beam weights which are calculated analytically. The percentage difference between weights was about 50%. This shows the great weight reduction.

III. ANALYSIS USING ANSYS

The Finite Element Method (FEM) of analysis was chosen. Geometrically linear static structural analysis was conducted with personal computer based ANSYS R15.0, an advanced finite element code.

Preference:-Structural.

Ansys methodology*:*

The finite element analysis consists of three main steps such as Pre-processing, solution and post processing.

Preprocessing:

For linear beam under investigation the Table gives the preprocessor data.

Table No 1 Preprocessor data

Element Type	Solid -Brick8 node185	Solid -Brick8 node185
Material	Mild steel	Composite glass fiber
Young’s modulus (E)	205Gpa	85Gpa
Poisson’s ratio	0.29	0.23

Software used: ANSYS R15.0

Post procedure:

In the first step the FE model is developed by model geometry, choosing element type, and material properties. FEA software element library consists of various types of elements such as structural, thermal, fluid etc. Under structural type beam, plane, solid, shell etc. elements are available which are to be selected depending upon analysis type and geometry. Rectangular beam are longer in length compared to thickness. Throughout the geometry thickness is uniform and case becomes a problem of plane stress theory, so element solid (brick 8 node 185) is selected. In Ansys solid (brick 8 node 185) plane stress element.

Solution:

In this step analysis type and options are defined, loads and boundary conditions are applied, load step options are specified. Matrix methods are to be used to solve the structural matrix equation to get primary variables at nodes. Secondary variables or any other relevant derived terms, from primary variables may be found.

Post processing:

In the last step, the results are reviewed and extracted in order to be processed in more useful forms such as contour plots of stress, strain, principal stress etc. The results can also be plotted in tabular and graphical forms. This facilitates to interpolate the quantities at any point within the domain.

3.1 FEA of Cantilever Plates

The rectangular beams are first analyzed in the ANSYS. The dimensions of the beam are 25.4x10x300mm. The following figure shows the model of plate designed in the ANSYS. The values of Young's modulus and Poisson's ratio are given below. The element used for this analysis is Solid Brick8 node 185.

Material properties of composite material

1. Modulus of Elasticity =210000 Mpa
2. Poisson's ratio =0.29

Material properties of composite material

1. Modulus of Elasticity =85000 Mpa
2. Poisson's ratio =0.23

The mild steel beam and composite beam analysis is done using Finite Element Method. Following steps are followed for stress analysis:

1. CAD model of beam is prepared by using dimensions.
2. Apply element type and different material properties on model by using software ANSYS.
3. Finite element mesh is generated.
4. Define the loads by using software ANSYS.
5. Analysis of model is done in solution step.

The following figures show the models of beam prepared in the Ansys. The fig No 1. is the CAD model of rectangular beam and Fig No 2 shows the meshed model of the rectangular beam . Both modeling and meshing is carried out in Ansys.

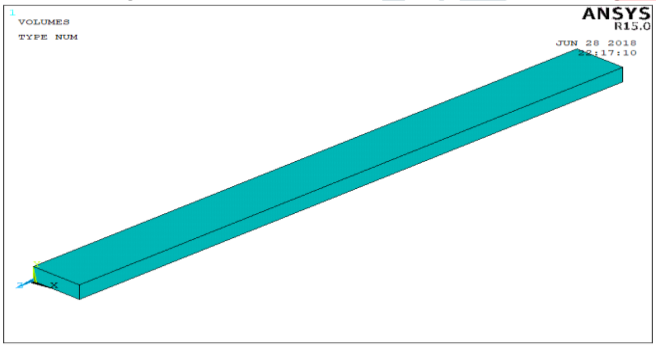


Fig No 1 CAD Model of Rectangular Beam

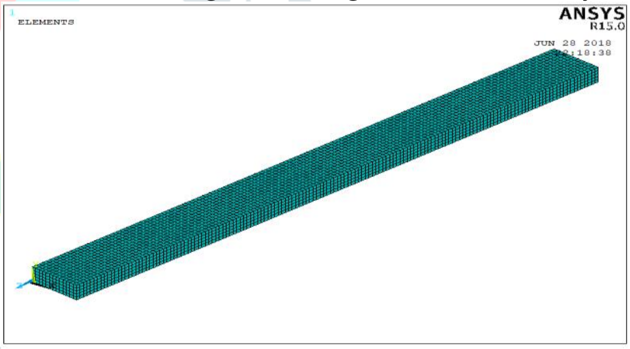


Fig No 2 Meshed model of Rectangular Beam

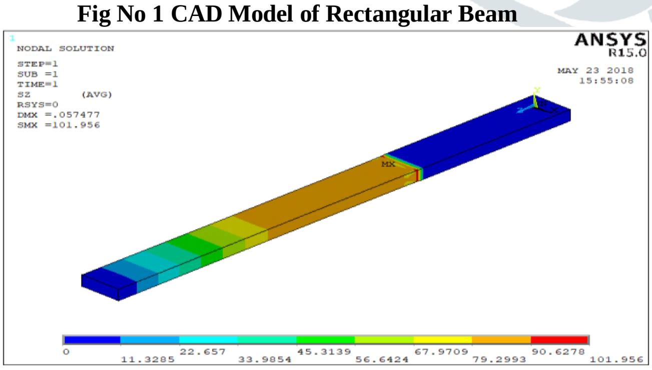


Fig No 3 Tensile test for cantilever mild steel beam

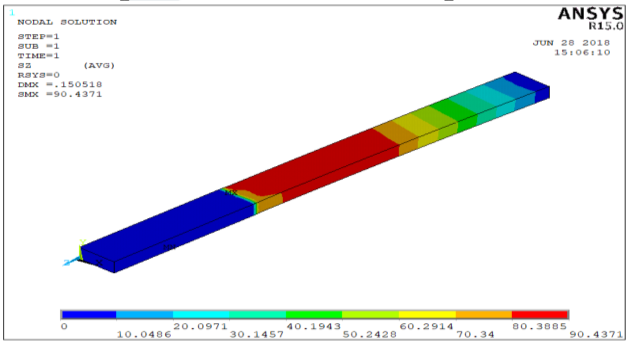


Fig No 4 Tensile test for cantilever composite beam

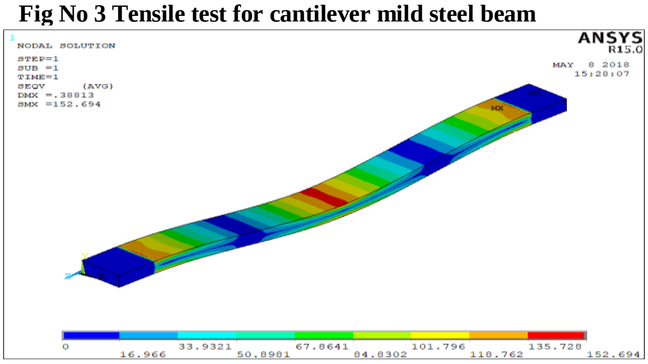


Fig No 5 Bending test for simply supported mild steel beam

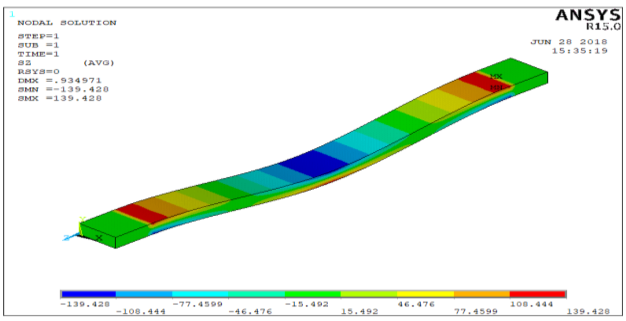


Fig No 6 Bending test for simply supported composite beam

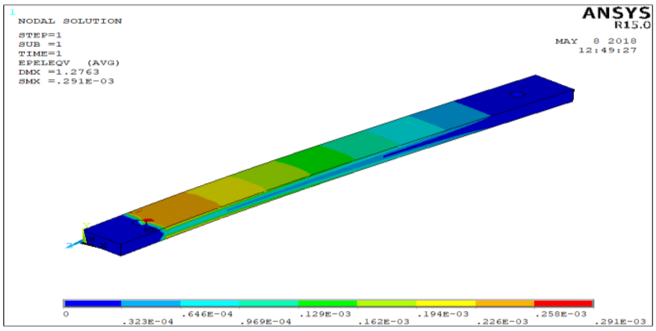


Fig No 7 Bending test for cantilever mild steel beam (Strain test)

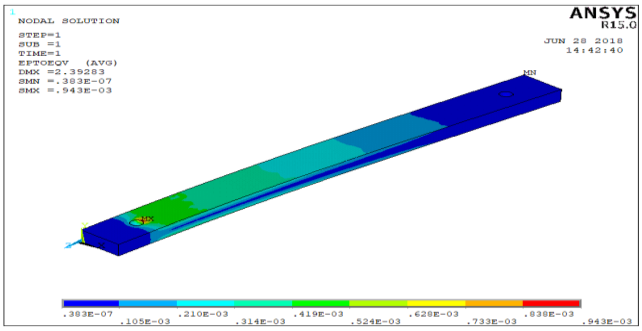


Fig No 8 Bending test for cantilever composite beam (Strain test)

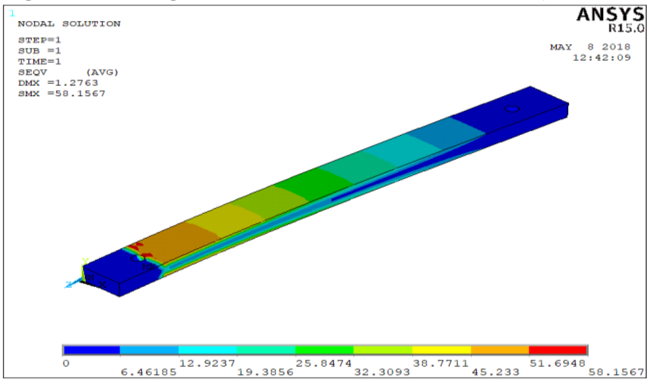


Fig No 9 Bending test for cantilever mild steel beam (stress test)

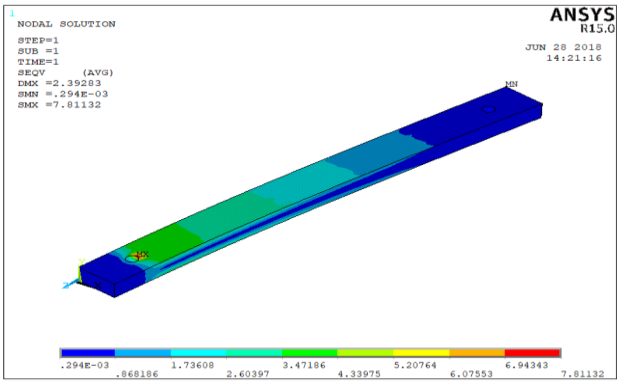


Fig No 10 Bending test for cantilever composite beam (stress tes

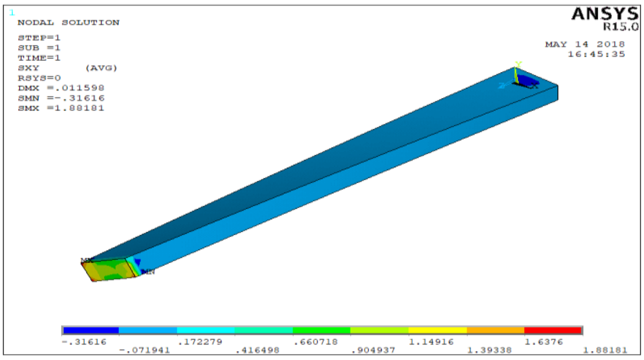


Fig No 11 Torsion test for cantilever mild steel beam

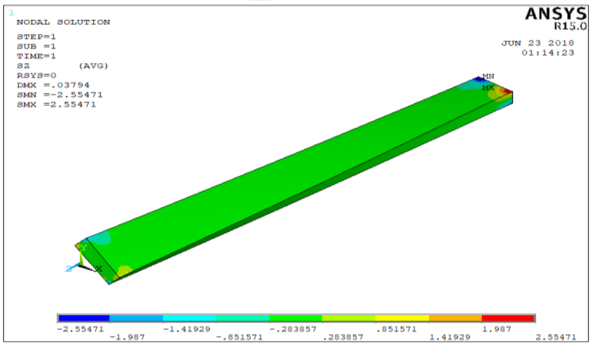


Fig No 12 Torsion test for cantilever Composite beam

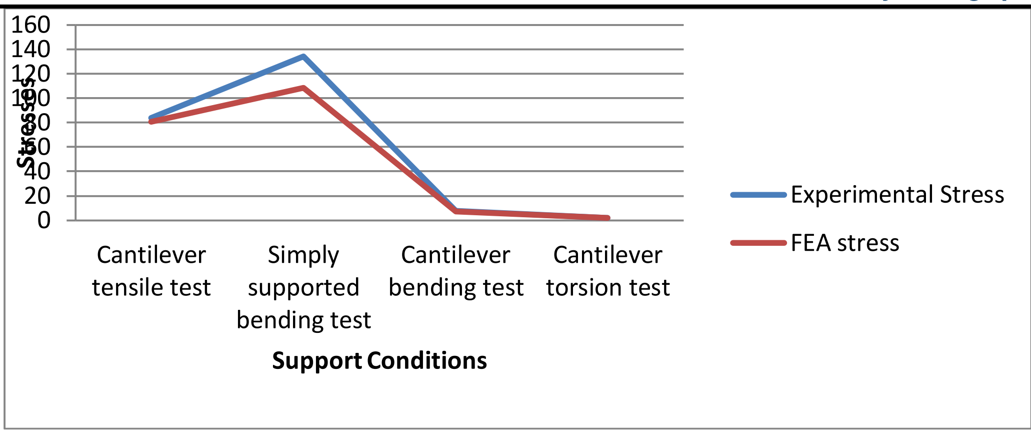
IV RESULTS AND DISCUSSION

4.1 Comparison of results:

Comparison of different stress distributions for rectangular mild steel and composite beam for different tests and supporting conditions are as follows:

Table No.2 Comparison of Theoretical stress, Experimental Stress And FEA stress mild steel beam

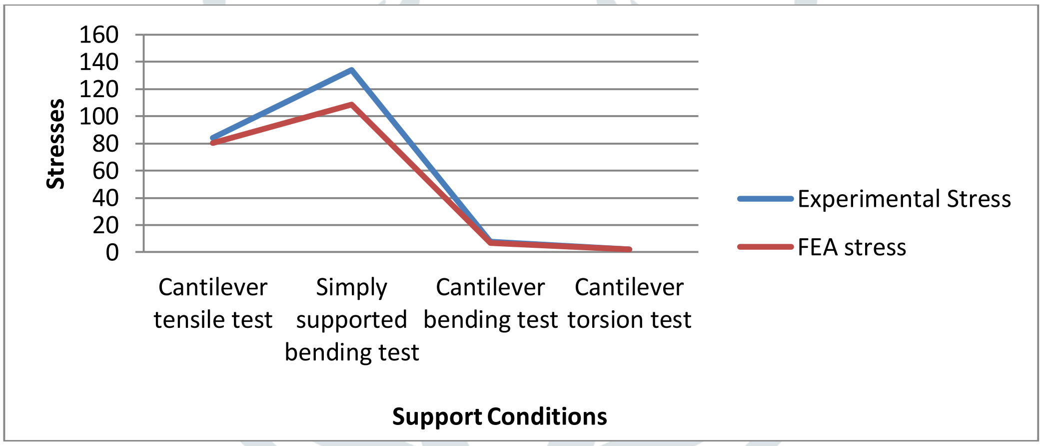
Supporting conditions	Stress	
	Experimental Stress $(\sigma_{max})_{Ex}$ in $\frac{N}{mm^2}$	FEA stress σ_{max} in $\frac{N}{mm^2}$
Cantilever tensile test	84	90.6278
Simply supported bending test	134.17	135.728
Cantilever bending test	28.95	51.6948
Cantilever torsion test	2	1.6376



Graph No 1 Comparison of experimental and FEA stress of mild steel beam

Table No 3 Comparison of Experimental Stress And FEA stress composite beam

Supporting conditions	Stress	
	Experimental Stress $(\sigma_{max})_{Ex}$ in $\frac{N}{mm^2}$	FEA stress σ_{max} in $\frac{N}{mm^2}$
Cantilever tensile test	84	80.3885
Simply supported bending test	134.17	108.444
Cantilever bending test	7.76	6.94343
Cantilever torsion test	1.9630	1.987



Graph No 2. Comparison of experimental and FEA stress of composite beam

V. TESTS

5.1 Tensile test for cantilever beam:

Tensile strength of mild steel is 534.449 $\frac{N}{mm^2}$

Tensile strength of composite epoxy (GFRP) is 84.173 $\frac{N}{mm^2}$

As compare to tensile strength of mild steel, the tensile strength of composite material is 4.50% less so, the forces required to failure the mild steel is 4.50% greater than the composite material in case of tensile test.

5.2 Bending test for simply supported beam:

Bending strength of mild steel is 18.756 $\frac{N}{mm^2}$

Bending strength of composite epoxy (GFRP) is 17.638 $\frac{N}{mm^2}$

As compare to bending strength of mild steel, the bending strength of composite epoxy (GFRP) is 1.118

5.3 Bending test for cantilever beam:

In case of bending test for cantilever beam, of mild steel

Equivalent von misses strain is 0.00025

Equivalent von misses stress is 28. 95

In case of bending test for cantilever beam, of composite beam

Equivalent von misses strain is 0.0001004

Equivalent von misses stress is 7.76

As compare to equivalent von misses strain of mild steel, the equivalent von misses strain in composite beam is 0.00015less so at that point. And as compare to equivalent von misses stress of mild steel, the equivalent von misses stress in composite beam is 21.19% less so, the forces required to failure the mild steel is 21.19% greater than the composite beam in case of bending test for cantilever beam.

5.4 Torsion test for cantilever beam:

In case of torsion test for cantilever beam Max. shear stress for mild steel beam $\tau_{max} = 2 \frac{N}{mm^2}$

In case of torsion test for cantilever beam Max. shear stress for composite beam $\tau_{max} = 1.930 \frac{N}{mm^2}$

5.5 Composite Beam:

The composite beam used for this experimental analysis. The plates are made up of the glass fiber material. The specifications of the plates are 25.4x10x300mm. The weights of the beam are 0.1kg . The weights of the composite glass fiber beam can be compared with the mild steel beam.

Table No 4 Comparison of weights of composite beam and mild steel beam

Sr. No.	Beam dimension	Composite plate weight (kg)	Mild steel plate weight (kg)	% difference of weights
1	25.4x10x300mm	0.1	0.6	50%

VI. CONCLUSION

1.The weights of the composite beam are compared with mild steel beam weights which are calculated analytically. The percentage difference between weights was about 50%. This shows the great weight reduction.

2. The FEA results have been validated by equivalent von Mises stress and von Mises strain. This validation was carried out using UTM, strain gauge technique and rectangular strain gauge rosette and strain indicator. Dynamic testing for strain measurement in the beam is carried out using rectangular strain gauge rosette. Close agreement between FEA-based analytical predictions and experimental measurements has been obtained.

3. By comparing the FEA results with ESA results, there is close agreement between these results. It has error in percentage up to 12-15%

4. Composite epoxy (GFRP) beam are required large in size(Length, Width, Height) compared to mild steel beam because it has very low stress and strain carrying capacity as compare to mild steel beam at same sizes.

VII. REFERENCES

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