Investigation of Carbon Glass Epoxy Fibre Composite Material Under Tensile Loading

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ABSTRACT - Epoxy glass fibre composites are good for structural engineering for high strength and low weight and high stiffness. Aeroplanes and space vehicles are important low weight structures in which glass composite materials are useful. The study of composite materials involves many topics for example manufacturing processes, anisotropi, elasticity strength of anisotropic materials and micromechanics. Composite material means two or more materials are combined to form a useful material. Properties are- Strength, Fatigue Life ,Stiffness, Temperature dependent, Corrosion Resistance, Thermal Insulation, Wear Resistance, Thermal Conductivity, Attractiveness, Acoustical Insulation, Weight.

In this paper, we will investigating the glass epoxy fibre composite material behaviour under tensile loading experimentally and will validate that with FEA analysis. This investigation can help in replacing the previous material used in various applications.

Keywords: Composite Material, Glass fibre, Epoxy, Araldylite, CN-89, Fibre Matrix, Aviation, Aluminium 5xxx.

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1 AIM: To study the new budding glass epoxy fibre composite material at tensile loadings.

2 OBJECTIVES:

The usual design criterion for composite material is based on trying to align the fibres with most critically loaded directions of mechanical component.

1. Study of glass epoxy fibre composite lamina experimentally.
2. Validate experimental results through finite element approach.
3. Compare experimental results with existing material.
4.

3 LITERATURE REVIEW

An advanced book on mechanics of composite material by R. Jones covers applications of composite materials and micromechanical and macro-mechanical behavior of lamina and laminates as well as the design of the composite structure. They have derived theoretical methods for the analysis of composite materials.[11] An advanced book on mechanics of composite material by Autar K. Kaw covers applications of composite materials and micromechanical and macro-mechanical behavior of lamina and laminates as well as the design of the composite structure. [12] A book on metal matrix composite by N. Chawla and K. K. Chawla has given the micromechanical analysis for the composite material. They have used some numerical methods for micromechanical analysis of the composite material.[09]

In the investigation of effects of randomness on band gap Formation in Models of Fiber-Reinforced Composite Panels Having Quasirandom Fiber Arrangements, Large-scale deterministic simulations are performed to observe the band gap formation in composite models having quasirandom fiber arrangements. [1][9]

A mechanism-based progressive failure analyses (PFA) approach is developed for fiber reinforced composite laminates. [2]. Special Features are built into a user-defined material subroutine that is implemented through the commercial finite element (FE) software ABAQUS in conjunction with classical lamination theory (CLT) that considers a laminate as a collection of perfectly bonded lamina [3]. In a study of stiffened panels subjected to shear loading a Composite Structures [4]. Experimental and analytical results are presented for a progressive failure of stiffened composite panels with and without a notch and subjected to the in-plane shear loading well into the post-buckling regime. Good agreement between experimental data and numerical results is observed for the stitched stiffened composite panels studied [5].

In the investigation of Theoretical and Experimental Dynamic Analysis of Fiber-Reinforced Composite Beams, inherent anisotropy allows the designer to tailor the material to achieve the desired performance requirements[6][10]

A simple experimental layout consisting of a shaker and a pair of miniature accelerometers was used to investigate the natural vibration modes of a cantilever sandwich beam with a transversely flexible core [7].

In literature review it is seen that composite material can be designed and manufactured according to required properties. The key material

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properties for usual engineering mechanics applications are strength and stiffness. The usual design criterion for composite material is based on trying to align the fibres with most critically loaded directions of mechanical component. Again critical percentage of volume fraction of matrix material and fibre is also considered while designing the composite material. It is very important to find out elastic constants and other mechanical properties of an orthotropic (glass epoxy) composite lamina experimentally as many times theoretical and finite element approach for these may not give true results.

1. 4 EXPERIMENTAL ANALYSIS

A specimen square rod is moulded & casted for tests. Density &Modulas of elasticity of that material is determined by these test to use these values in FEM analysis.FEM results are validated experimentally using UTM , experimental validation. Development of Suitable fixture setup is done.Selections of location of deflection measurement. Deflection measurement at predefined loading conditions.

<u>Specimen data:</u>

No. of strings of glass fibre = 21

1. Length = 260 mm
2. Area = 44 X 34 = 1496 mm2
3. Gauge length in U.T.M. = 81 mm

Machine Used: Tesla 2002 Nake 10000 KG

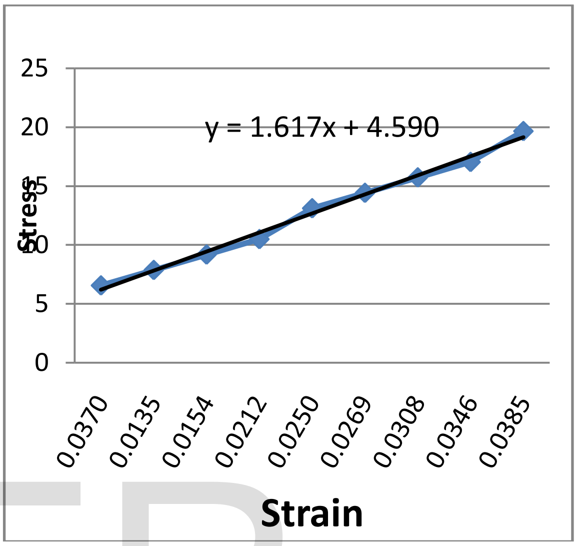
Table 4.6 Experimental Results for composite material specimen

Sr. No.	Load (Kg)	Stress (N/mm^2)	Deformation (mm)	Strain
	1000	6.5575	3	0.0370
	1250	8.1969	3.5	0.037037
	1500	9.8362	4	0.04321
	1750	11.4756	5.5	0.049383
	2000	13.1150	6.5	0.067901
	2250	14.7543	7	0.080247
	2500	16.3937	8	0.08642
	2750	18.0331	9	0.098765
	3000	19.6725	10	0.111111

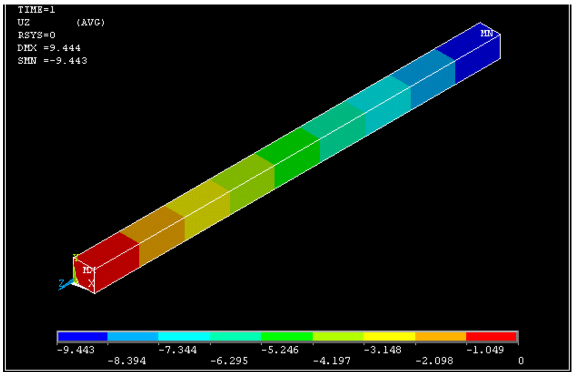
The value of modulus of lasticity from experimental data is **454.85 N/mm²**

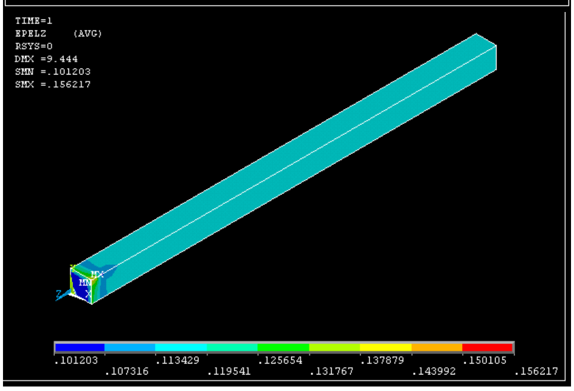
Finite Element Analysis by Using Analyse

Define material properties: Material no.1 (Epoxy) Modulus of elasticity 65 ,Poisons ratio-0.2 , Material no.2 (glass fiber) ,Modulus of elasticity -953 .Poisons ratio- 0.2.



To support our observations we also done with the FEA using Ansys. Results are as follows.





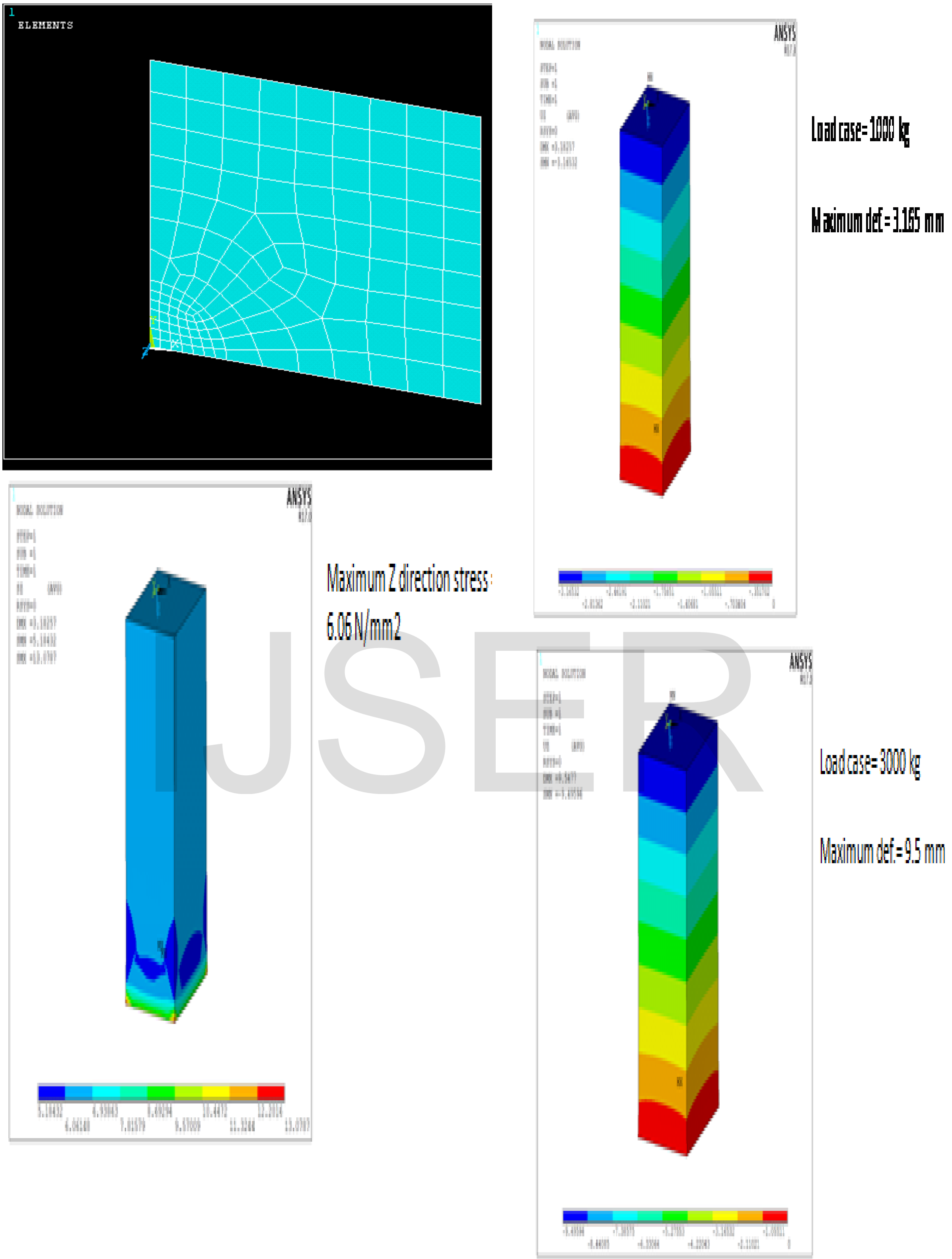


Fig. 5.2. Meshing of area

2. 5 RESULTS AND DISCUSSION

Table 6.1 Comparative table of Stress and deformation with experiment and FEA .

Sr. No.	Load Kg	Stress N/mm^2		Deformation	
		Experimental	FEA	Experimental	FEA
	1000	6.55	6.06	3	3.165
	2000	13.11	12.12	6.5	6.33
	3000	19.67	18.18	10	9.5
	4000	26.22	24.5	13.5	12.8
	5000	32.78	30.3	17	15.9

Table 6.2 Comparative table of modulus of elasticity

Material	Gauge Length of specimen mm.	Cross sectional area mm^2	% Volume fraction of fibre	% Volume fraction of matrix	No. of fibres	Modulus of elasticity experimental N/mm^2
Fibre string	195	3.141	100	00	1	1156.721
Carbon epoxy material	120	1496	00	100	-----	32.51
Glass fibre Composite specimen	81	1496	13	87	21	454.85

In this dissertation glass fibre string is made from fibre strand and it is tested for finding modulus of elasticity. Modulus of elasticity is found from experimental results by plotting stress strain graph..

Epoxy model is prepared from the solution of CY-230 and HY-951 and it is tested in universal testing machine. From these experimental results modulus of elasticity for matrix material is calculated. Also modulus of elasticity is found from stress strain graph.

Composite material is prepared by using constituent materials as glass fibre and epoxy. Glass epoxy composite is tested in universal testing machine to find experimental modulus of elasticity. Then finite element analysis of composite specimen is made and results obtained by these two methods are compared.

Again modulus of elasticity for fibre string varies from string to string it is not constant. In this dissertation modulus of elasticity experimentally obtained for glass fibre string is 1156.721 N/mm2 while that of glass fibre composite material is 454.85 N/mm2

Modulus of elasticity for composite material specimens by using twomethods, experimental and finite element analyses are calculated as shown in table 6.2.

Table 6.1 represents the comparison between two methods viz as experimentally and FEA, used to find out stress and deformation in material under different tensile loading.

The error between two methods is comes as 12% which could be caused due to testing environment, faulty testing machine, improper testing by operator. Also the composite material used for experimentation is also has limitation of fibre insertion.

3. 6 CONCLUSION

Attempts have been made to fabricate a composite material made of glass fibre and epoxy material. Stress-strain curve for fibre, epoxy and composite material have been found out. Two specimens have been tested in U.T.M. and stress-strain curve for each specimen is plotted. Modulus of elasticity for glass fibre string, epoxy and composite specimens found by experimentally. Result analysis of composite specimen is made by considering experimental values of modulus of elasticity are calculated from ANSYS results.

Stress strain curve is drawn from experimental results to calculate modulus of elasticity. modulus of elasticity by using micromechanics approach. From that it is observed that there is slight difference because of following reasons.

1. In experimental analysis glass fibres are in the form of string and modulus of elasticity may change from string to string.

2. In finite element analysis by using ANSYS plane stress condition assumed but thickness of composite specimens is slightly more and axis symmetry is considered but specimens are not exact symmetric. From experimental data and stress strain diagram it is seen that composite specimen behaves elastically up to point of failure and is subjected to brittle fracture.

The fibres, epoxy and the composite material when loaded in tension are very much sensitive to strain rate and this is the reason for deviation between ansys and experimental values.

The fibre volume fractions of the specimens are near about 13 percent . This work is restricted up to determination of tensile properties for fibre glass epoxy resin composite material.

Considering this results, one can conducts their own application experimentation as we found out relationship between stress and strain between the new budding glass fibre composite material.

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