Experimental and Numerical Study of the Influence of Volume Fraction on Tensile and Flexural Strength of E-Glass Epoxy Cross Ply Laminates

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Abstract: **In this study, the e-glass epoxy laminates are manufactured and fabricated as per ASTM standard 300x300x4mm. Tensile, flexural strength specimens of E-glass epoxy laminated composite are examined experimentally. Clamped-free boundary conditions are considered for all iterations. Experiments have been carried out on these laminated composite specimens to find the tensile & flexural strength. Same models are modelled in hyper mesh and run with the Abaqus software to validate the experimental results. After the validation different configuration laminates are modelled and solved numerically using Abaqus to identify the best material having the highest tensile and flexural strengths. Percentage error computed between the validated experimental and numerical results is applied on the results of all the iterations involved in the work. The buckling strength of the panel is computed for panel selected from the study.**

Keyword: **Fiber orientation, Epoxy resin composites, Glass fiber, laminated polymer composites.**

I. INTRODUCTION

A composite is a combination of two or more materials in which one of the materials is called the reinforcing phase which is in the form of fibres, sheets, or particles, and is embedded in the other materials called the matrix phase. The reinforcing material and the matrix material can be metal, ceramic or polymer. Composites typically have a fibre or particle phase that is stiffer and stronger than the continuous matrix phase and serve as the principal load carrying members. The matrix acts as a load transfer medium between fibres and in less ideal cases where the loads are complex, the matrix may even have to bear loads transverse to the fibre axis. The matrix is more ductile than the fibres and thus acts as a source of composite toughness. The matrix also serves to protect the fibres from environmental damage before, during and after composite processing. When designed properly, the new combined material exhibits better strength than would each individual material. Composites are used not only for their structural properties, but also for electrical, thermal, tribological and environmental applications.

II. EXPERIENTAL DETAILS

A. Materials

The matrix material used was medium Epoxy resin widely used in industries due to their strong adhesive properties, chemical resistance and toughness. The reinforcement material employed was E-glass which is a popular fiber. The matrix materials are epoxy resin LY556 and hardener HY951 mixed in appropriate ratio1:10 with room temperature curing cycle of 48 hours duration.

Instrumental: The composite laminates were subjected to various loads and computer controlled UTM as shown in fig1. The specimens were clamped and tests were performed. The tests were closely monitored and conducted at room temperature. The load at which the completed fracture of the specimen occurred has been accepted as breakage load.

Fabrication: The glass/Epoxy composite is fabricated using simple hand layup technique. The procedure consists of placing the glass fibers, layer by layer and applying liquid epoxy mixed with hardener on the glass fibers in order to form a solid network cross-linked polymer. The layup assembly is pressed with the help of roller so that excess air between the layers is expelled out. The laminate is cured at ambient conditions for a period of about 24hrs. The laminate is prepared for three different compositions of E-glass/Epoxy with a size of 300mm×300mm×4mm.

Experimentation: The fabrication involves three different compositions of composites where the composite plates are cut down according to the ASTM standards in order to carry out tensile, flexural on each specimen.

Plan of Experiments for conducting tests: Tensile test &3-point bending test ASTM D3039, ASTM D790 standards. ASTM standards for the above stated tests are given in Fig 2 and Fig 3 respectively.

Material properties for different volume fraction: Bending test and tensile test is carried out for different volume percentage of E-glass/Epoxy composites. For three different series of E-glass/epoxy: Series 1- 50:50% by volume of E-glass/Epoxy, Series2- 40:60% by volume of E-glass/Epoxy, Series3- 35:65% by volume of E-glass/Epoxy. As shown in table :1

B. Figures, Graphs and Tables

Fig.1: Computer controlled UTM

Tensile test and3-point bending tests are carried out in accordance with ASTM D3039 and ASTM D790 standards respectively under displacement control using an UTM/E-40 with resolution of the piston movement of 0.01mm.

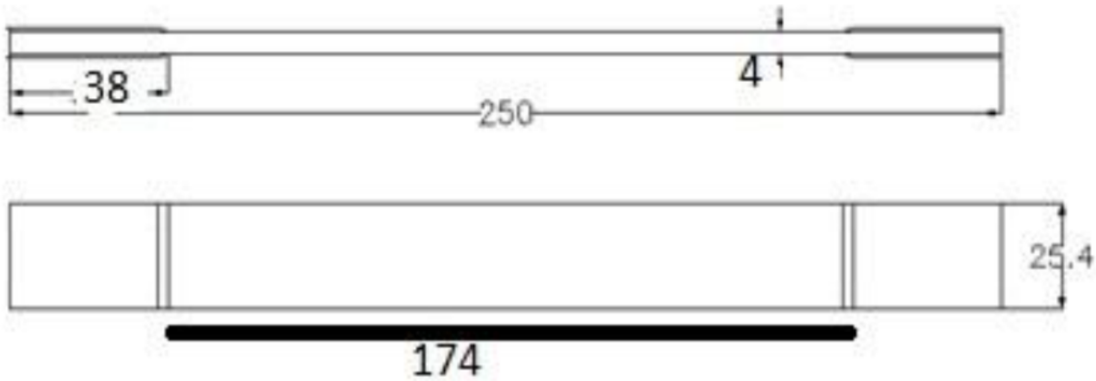

Fig.2: Tensile test specimen as per ASTM D3039 standards**.** All Dimensions are in mm

International Journal of Mechanical and Industrial Technology ISSN 2348-7593 (Online)
Vol. 2, Issue 1, pp: (39-44), Month: April 2014 - September 2014, Available at: www.researchpublish.com

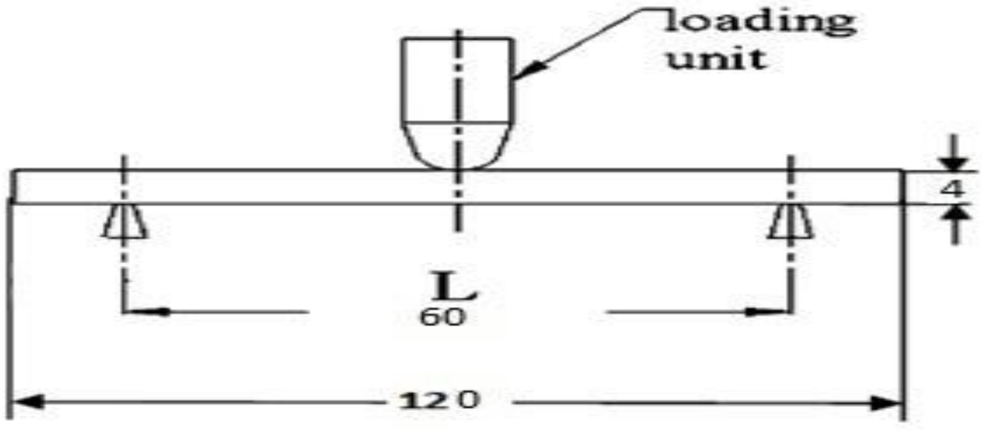

Fig.3: Flexural test specimen as per ASTM D790 standards. All Dimensions are in mm

Experimental result in tensile &flexural specimens

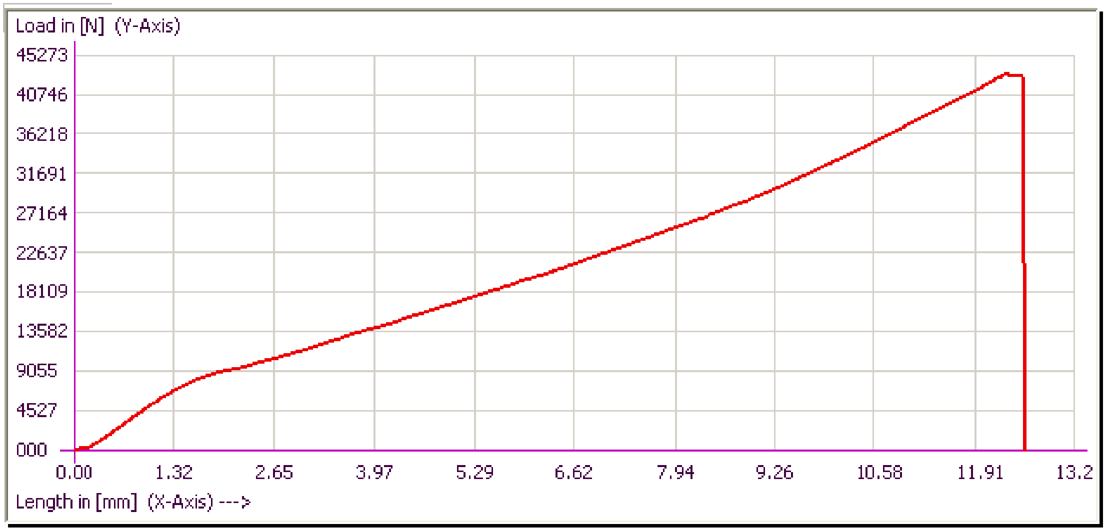

Fig.4: tensile load v/s deflection graph for E-glass epoxy specimen

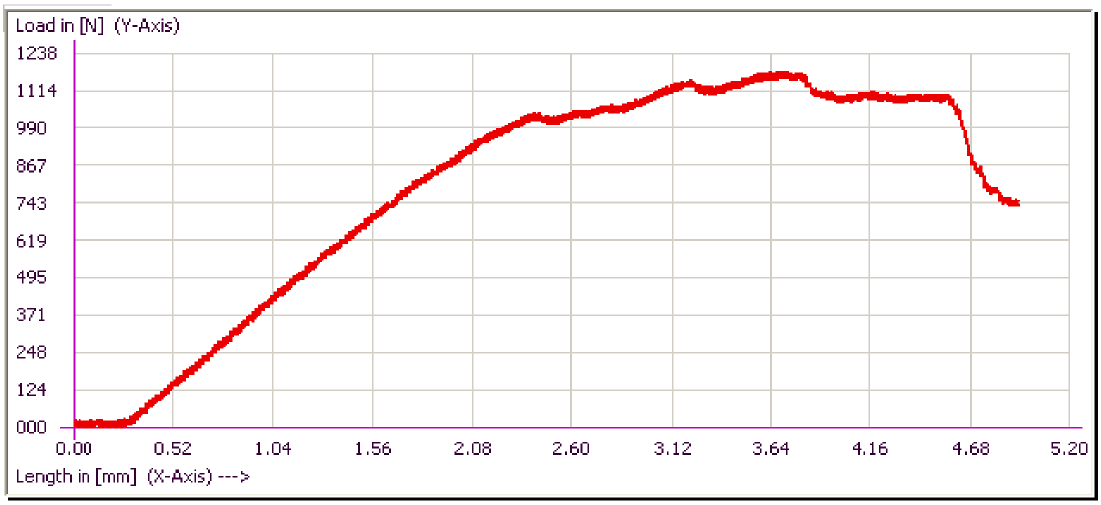

Fig.5: Flexural load v/s deflection graph for E-glass epoxy specimens

FIINITE ELEMENT ANALYSIS RESULT FOR BOTH TENSILE &FLEXURAL SPECIMENS

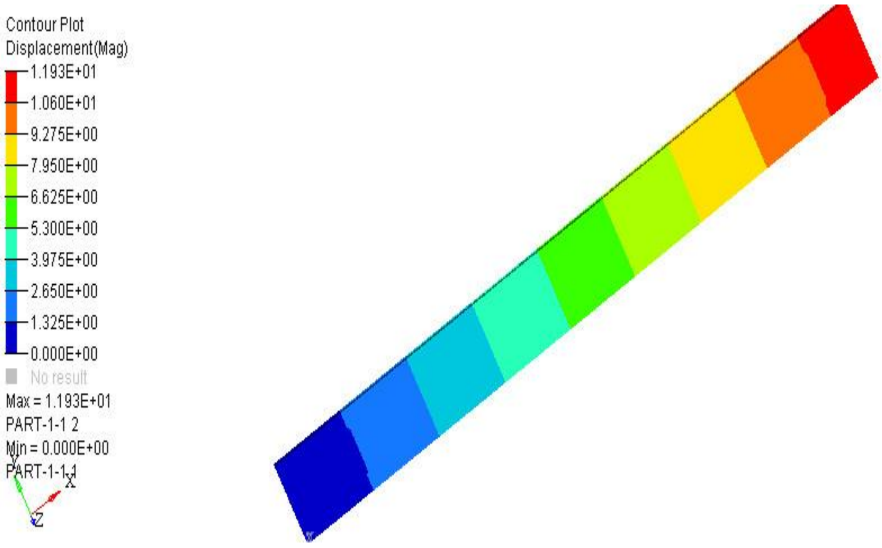

Fig.6: Displacement contour plot of the tensile specimen

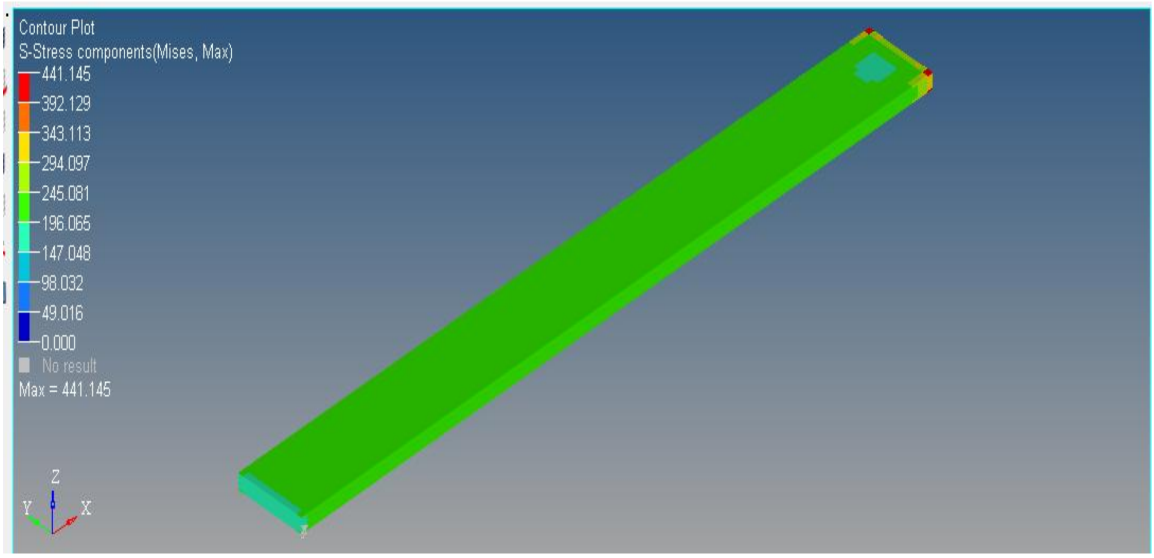

Fig.7: Stress contour plot of the tensile specimen

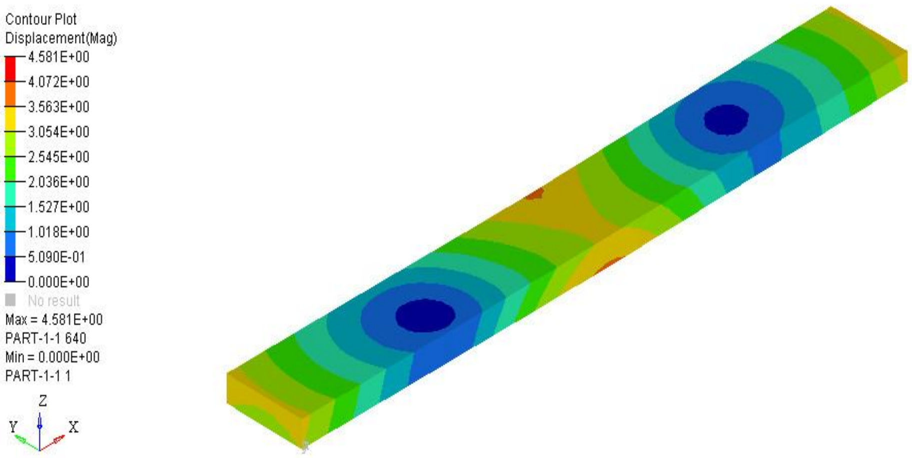

Fig.8: Displacement contour plot of the flexural specimen

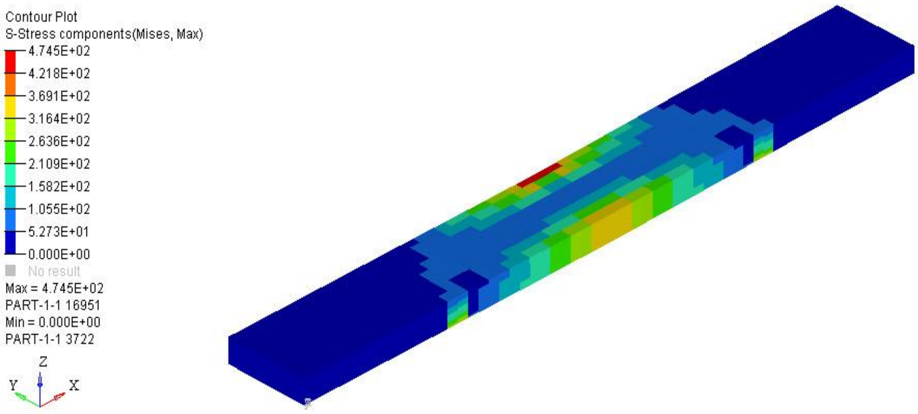

Fig.9: Stress contour plot of the Flexural specimen sample 1

Table 1: Material Property

VOLUME FRACTION	E1 IN GPA	E2 IN GPA	ν_{12}	ν_{21}	G_{12} IN GPA
50:50	38.06	7.076	0.25	0.046	3.57
40:60	31.192	5.99	0.26	0.049	2.92
35:65	27.758	5.56	0.265	0.053	2.568

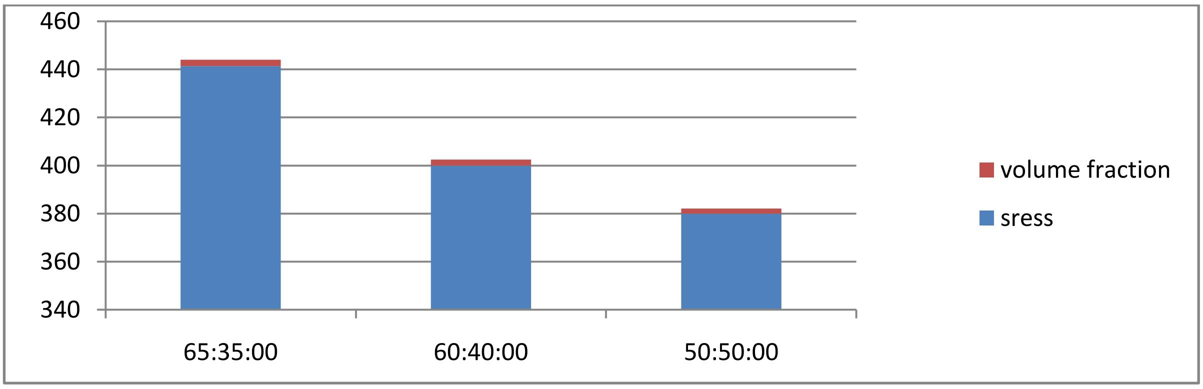

Fig.10: stress v/s volume fraction

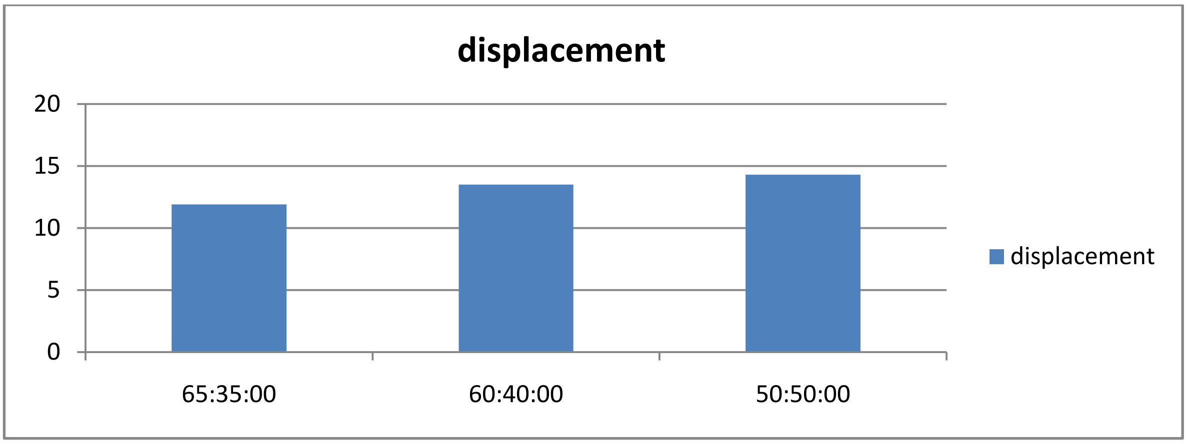

Fig.11: displacement v/s volume fraction

C. Conclusion Acknowledgement and Appendix

Conclusion section is mandatory and contains advantages, disadvantages, review the main part of research paper and use of research work. If author want to acknowledge someone, then acknowledgement section should include in research paper after conclusion. Appendix section (if required) appears before acknowledgement section.

III. CONCLUSION

From the above figure :10 &figure :11.it can be concluded that the volume fraction 65:35 is found to be the optimum and best among the iterations considered in the study, the stress found for 65:35 specimen in both tensile and flexural strength are greater than the stress found for other cases, and also the displacement is minmum for 65:35specimen.This indicate that the 65:35 specimen is more stiffer and recomonded.

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