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Effect of Fiber Orientation on Strength of a Cross-Ply Composite Plate using ANSYS

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Sheik .Hyderali**

Keywords:

Flexural strength;
Laminated;
Fibre reinforced;
Glass fibre;
Graphite fibre;
Unidirectional;
Bidirectional;
Corrosion resistance.

Abstract

The objective of this paper is toSuperior mechanical properties of composite materials such as high stiffness and strength to weight ratios, corrosive resistance and low coefficients of thermal expansion, caused it to be used increasingly in many areas of technology including marine, aerospace, automotive and others. To take advantage of full potential of composite materials, accurate models and design methods are required the most common structural elements are plates and shells. Laminated composites are one of the classifications of the composites which are used in structural elements like leaf springs, automobile drive shafts, and gears, and axles.An accurate understanding of their structural behaviour is required, such as the deflections, the through thickness distributions of stresses and strains, the large deflection behaviour and, of extreme importance for obtaining strong, reliable multi-layered structures. In general, the fibres in the composite materials can be of unidirectional and bidirectional. Here the focus is on unidirectional fibre composite materials. The fibres can be oriented in many ways i.e., 0, 10, 20,30,45,90 degrees etc., but the strength in each type will be different. Using the load-deflection graphs, the maximum load and flexural strength are calculated. The attention is to note the variation of flexural strength of a composite material with the variation of fibre orientation and comparing the results with practical results. Here the modelling of composite material with different fibre orientations is done in Ansys software and simulation is done on them and those results are compared with practical results.

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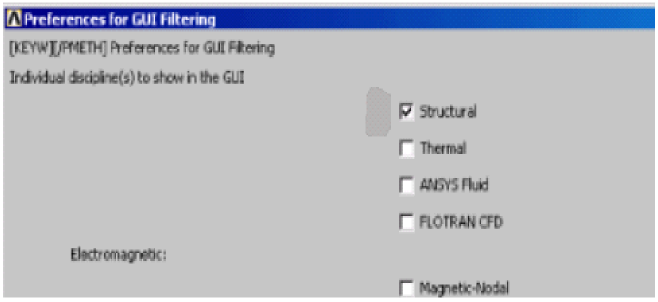
I. Introduction

A Composite material is a material system composed of two or more macro constituents that differ in shape and chemical composition and which are insoluble in each other. Composites Materials are combinations of two phases in which one of the phases, called the reinforcing phase, which is in the form of fiber sheets or particles and are embedded in the other phase called the matrix phase.

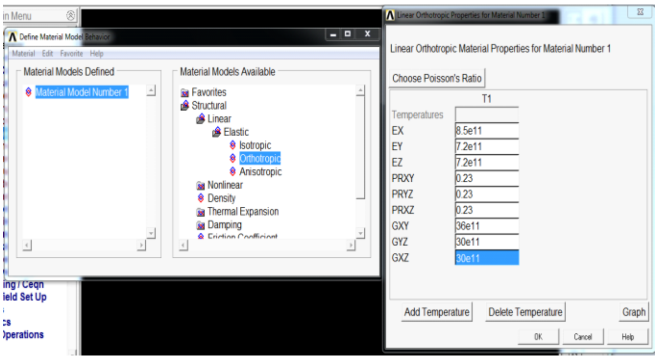
The primary functions of the matrix are to transfer stresses between the reinforcing fibers or particles and to protect them from mechanical and environmental damage whereas the presence of fibers or particles in a composite improves its mechanical properties such as strength, stiffness etc. The reasons why composites are selected for such applications are mainly due to their high strength-to-weight ratio, high tensile strength at elevated temperatures, high creep resistance and high toughness. Typically, the reinforcing materials are strong with low densities while the matrix is usually a ductile or tough material. The strength of the composites depends primarily on the amount, arrangement and type of fiber or particle reinforcement in the resin.

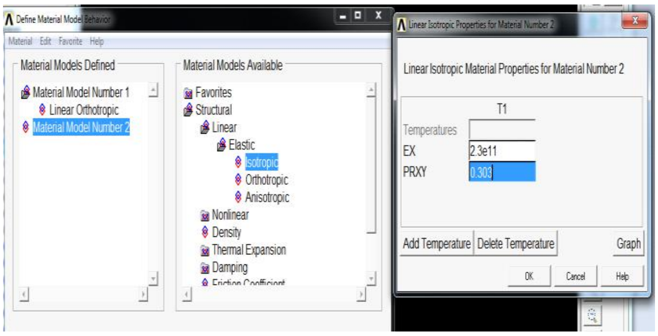
II. Modelling Illustration

Step 1: Define Problem Type

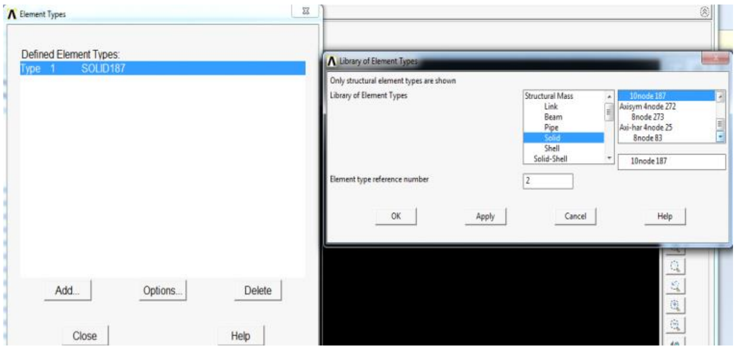


Step 2: Define Multiple Material (Material 1=glass fiber; Material 2=epoxy resin):

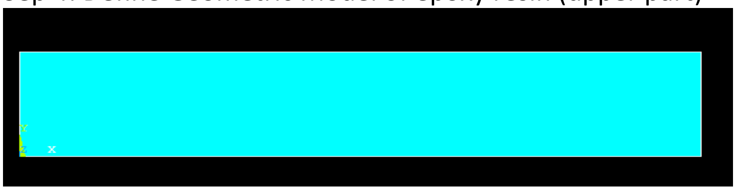


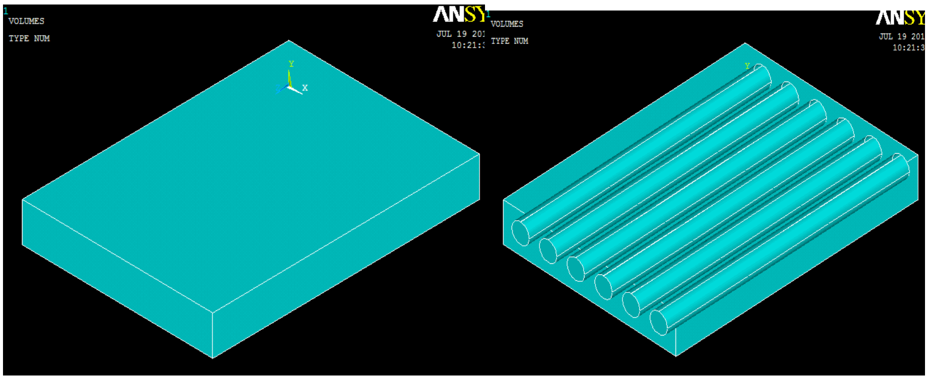


Step 3: Define element type

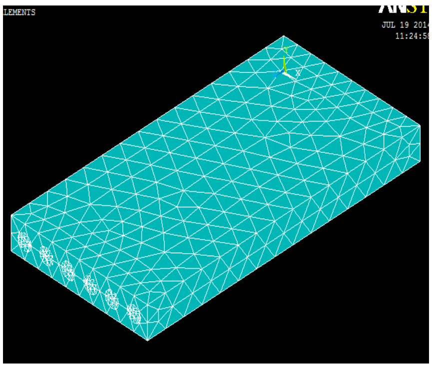


Sep 4: Define Geometric Model of epoxy resin (upper part)

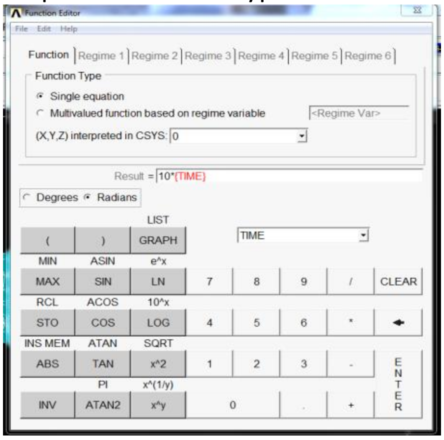




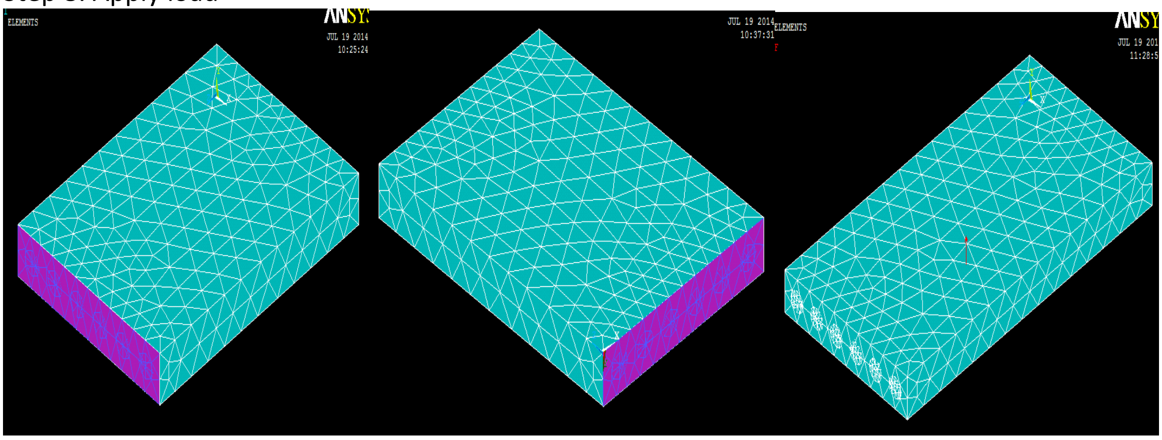
Step 5: Generate meshing in the model



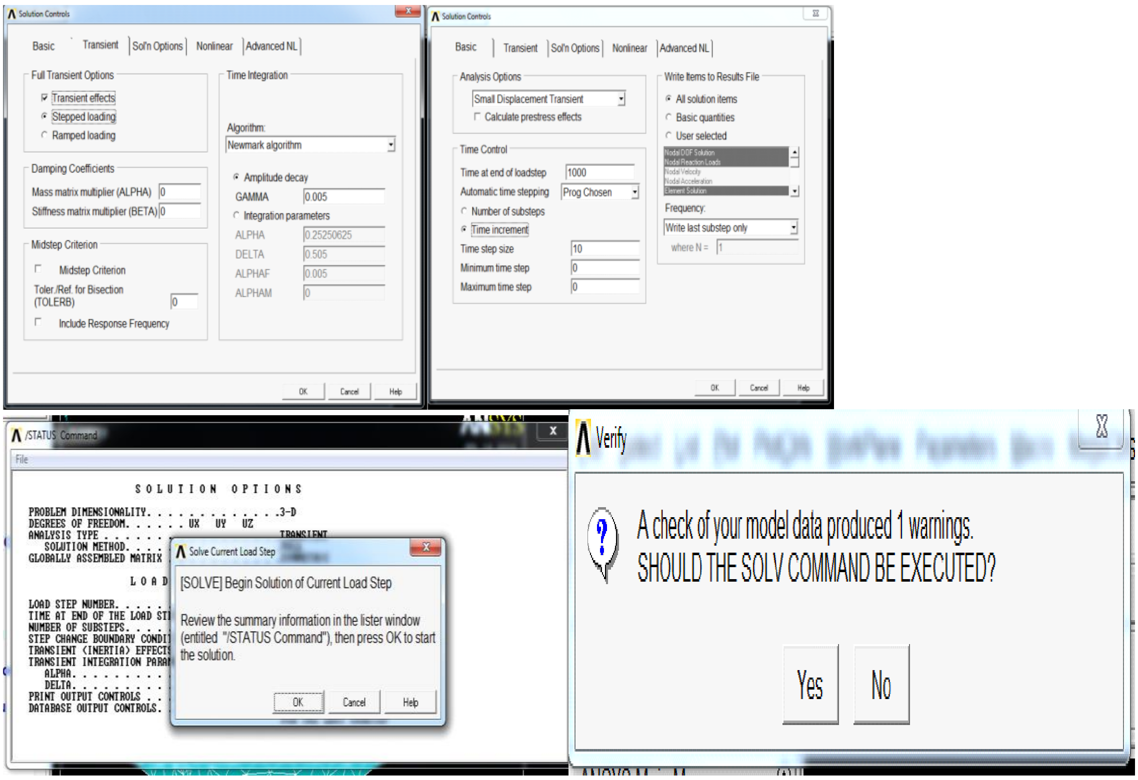
Step 6: Define load type

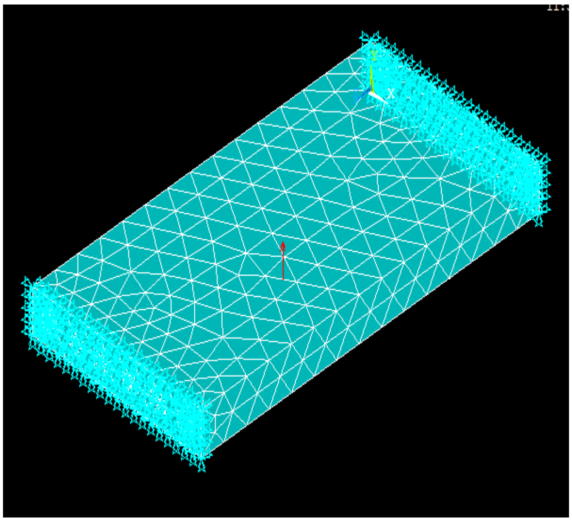


Step 8: Apply load

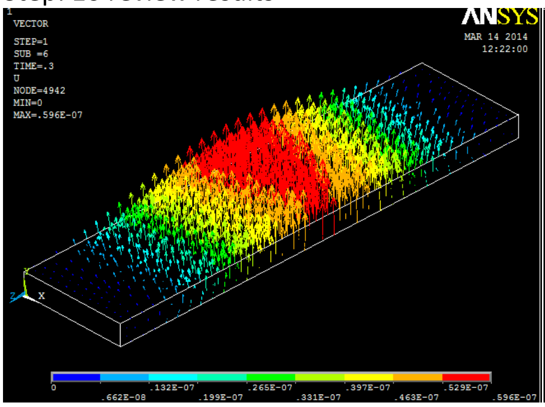


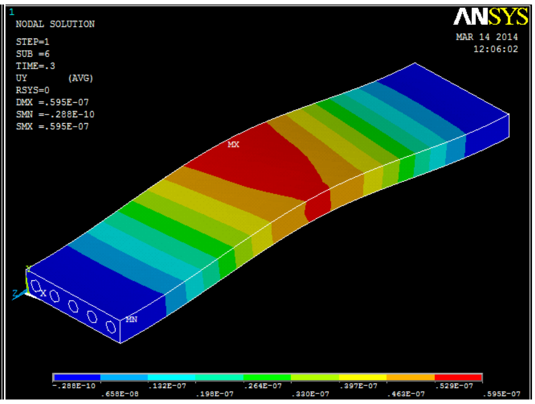
Step 9: Solution

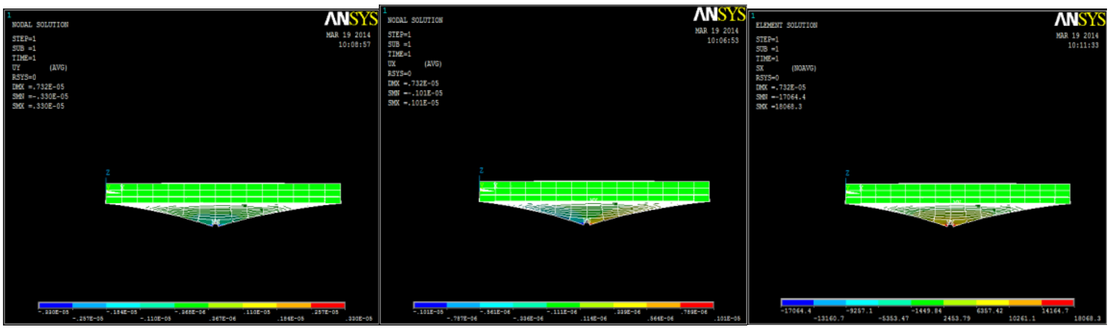




Step: 10 review results

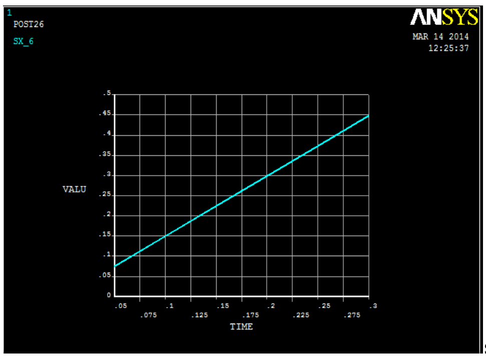




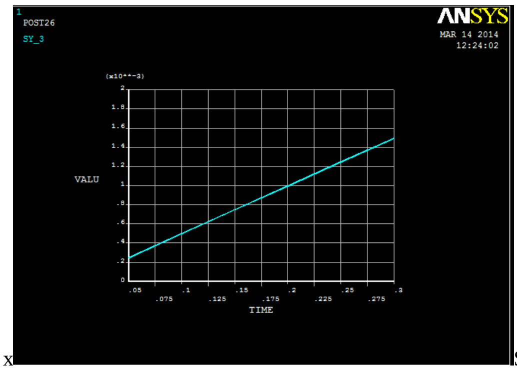


You can also produce an animated version of the deformed shape:

Step: 11 plot the stress corresponding axis



stress in x



Stress in y

III.Different Angle Orientation Models:

The strength and stiffness of a composite buildup depends on the orientation sequence of the plies. The practical range of strength and stiffness of carbon fiber extends from values as low as those provided by fiberglass to as high as those provided by titanium. This range of values is determined by the orientation of the plies to the applied load. Proper selection of ply orientation in advanced composite materials is necessary to provide a structurally efficient design. The part might require 0° plies to react to axial loads, ±45° plies to react to shear loads, and 90° plies to react to side loads. Because the strength design requirements are a function of the applied load direction, ply orientation and ply sequence have to be correct. It is critical during a repair to replace each damaged ply with a ply of the same material and ply orientation. The fibers in a unidirectional material run in one direction and the strength and stiffness is only in the direction of the fiber.

Here we can observe the displacement variations and stress variations of different fiber orientations (alignment) of unidirectional glass-epoxy composite and their graphs. Strength of the unidirectional fibers is changing as the orientation of the fibers changes. For zero (0) degree of unidirectional composite strength is more compared with the other fiber orientations. Strength of the unidirectional composite will decrease as the angle of orientation goes from 0, 10, 20…90.

1. **Zero degrees fiber orientation:**

Stress in X, Y, Z respectively…

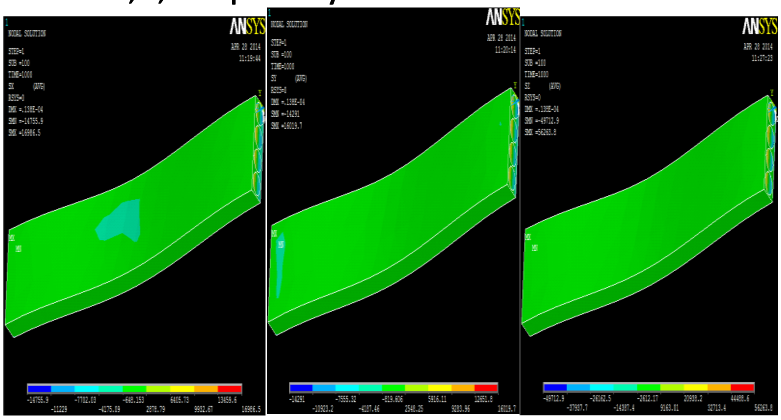


Fig.3.1. stress results of zero degree fiber orientation

2. **10 degrees:**

Stress in X, Y, Z respectively…

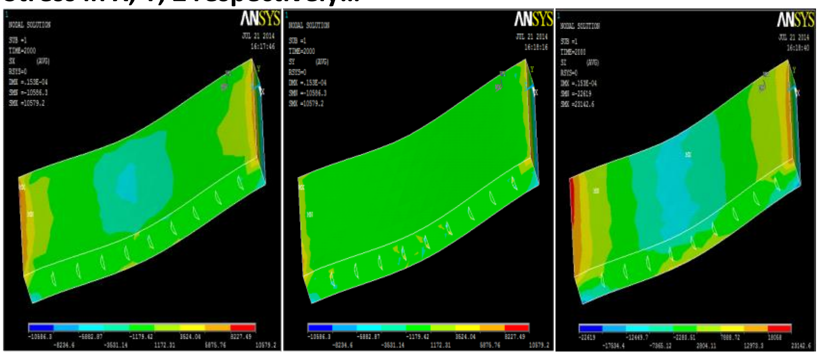


Fig.3.2. Stress results of 10 degree fiber orientation

3. **20 degrees**

Stress in X,Y, Z respectively…

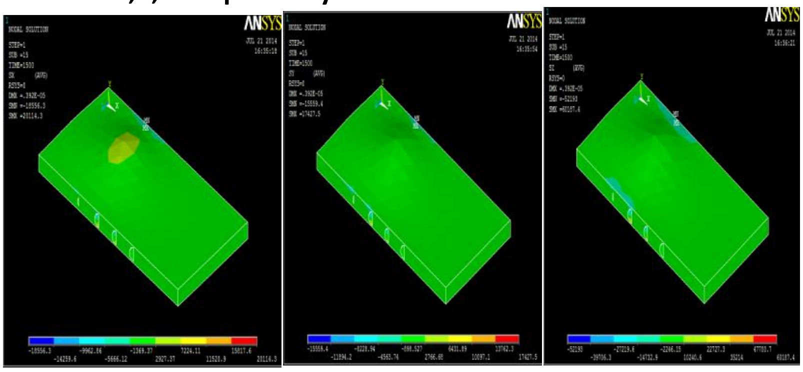


Fig.3.3. Stress results of 20 degree fiber orientation

4. 90 degrees

Stress in Y, X, Z

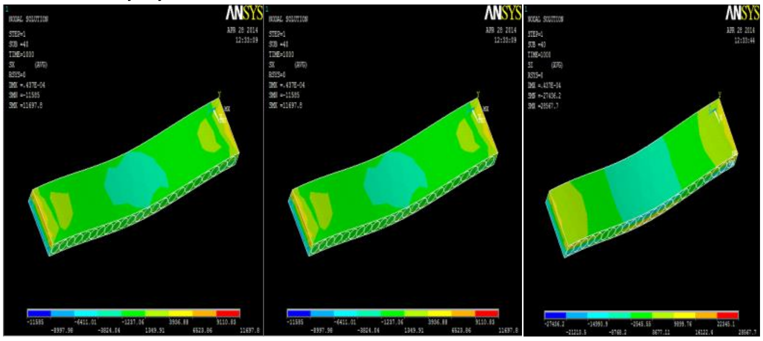


Fig.3.4. Stress results of 90 degree fiber orientation

5. 0-90 degrees fiber orientation:

Stress in Y, X, Z

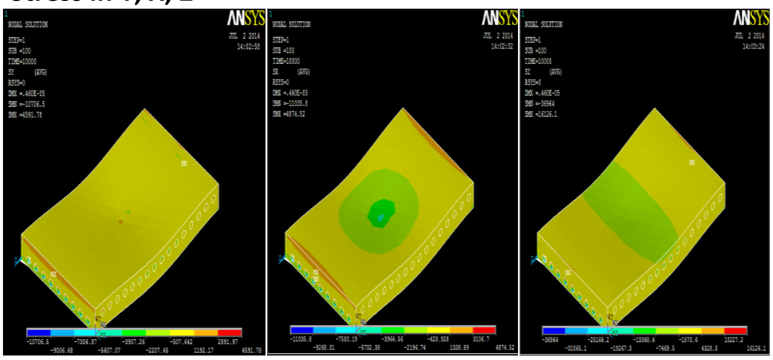


Fig. 3.5.Stress results of 0-90 degree fiber orientation

6. 0-90-0 degrees fiber orientation(3 dimensional):

Stress in Y, X, Z

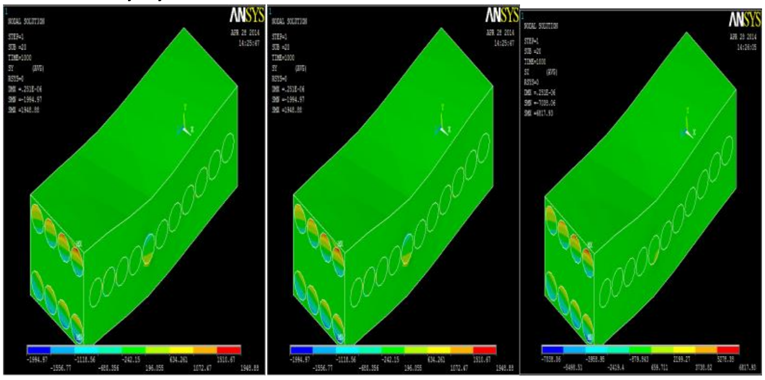


Fig.3.6.Stress results of 0-90-0 degree fiber orientation

IV.Experimental Results:

The Standard test method, ASTM D790M-86, for bending properties of plastics has been used to test the unidirectional composite specimens. The composite materials used in the current study comprise of Glass fiber and Epoxy Resin. The specimen is prepared by hand layup process in the form of a rectangular strip of 100x25x3 mm thick.

Method of testing for properties:

Standard test method, ASTM D790M-86 for bending properties of fiber reinforced composite has been used to test the unidirectional composite specimens. The standard specimen size required is adopted for the present study.

The tensometer is fitted with a fixed self-aligned quick grip chuck and other movable self-aligned quick grip chuck to accommodate 25mm wide and 3mm thick specimen. The specimen was held in fixed grip and the movable grip is manually moved until the specimen is held firmly without slackness. The power supply is switched on to measure the load and deflection of the specimen. The movable chuck is further moved such that the load indicator just starts giving indication of loading on the specimen. At that instant, the deflection meter is adjusted to read zero, when the load on the specimen is zero. The speed reduction pulleys are chosen such that a crosshead speed of 2mm/min. is applied on movable grip. Then the electric motor fitted to tensometer is started. Starting from zero, at every 0.2 mm extension the load indicated is noted until the specimen breaks. At the end of the test, the final load and deflection are also noted from the electronic indicator display. For each specimen the type of failure and any other such observations pertaining to failure are noted. The tests are conducted at 28^0 c and 50 % relative humidity in the laboratory atmosphere.

On doing the experiments the following results are obtained i.e., Load vs deflection and there by stress and strain values are derived.

Load vs Elongation:

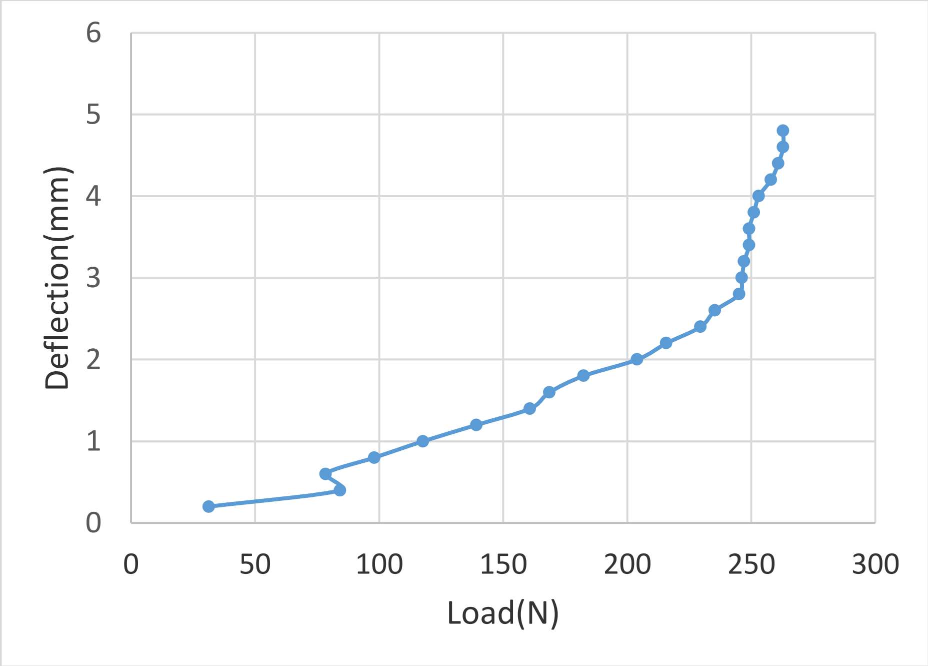


Fig.4.1.Load vs Elongation graph of specimen

Stress vs strain:

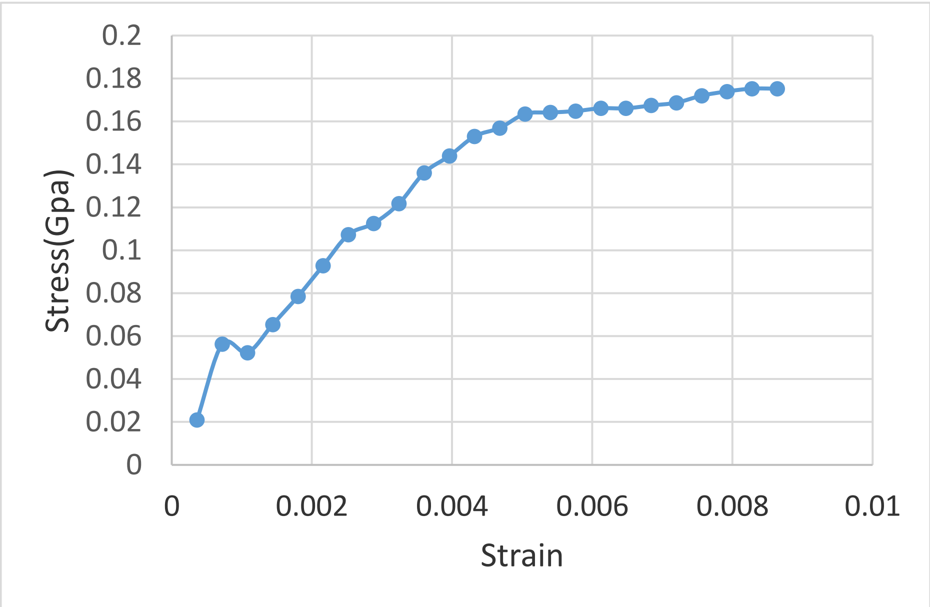


Fig.4.2. Stress vs strain graph of specimen

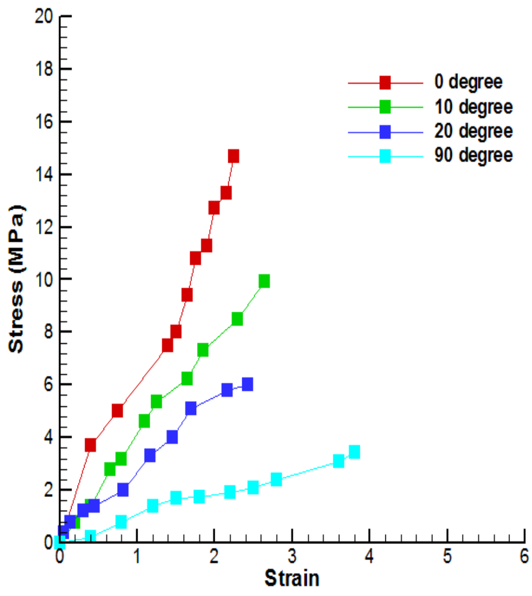


Fig.4.3. Stress-strain graph of Ansys results

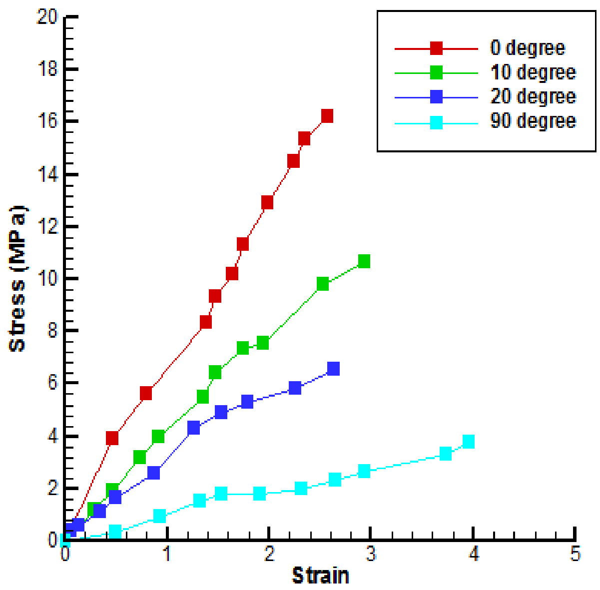


Fig. 4.4 stress-strain graphs of experimental results

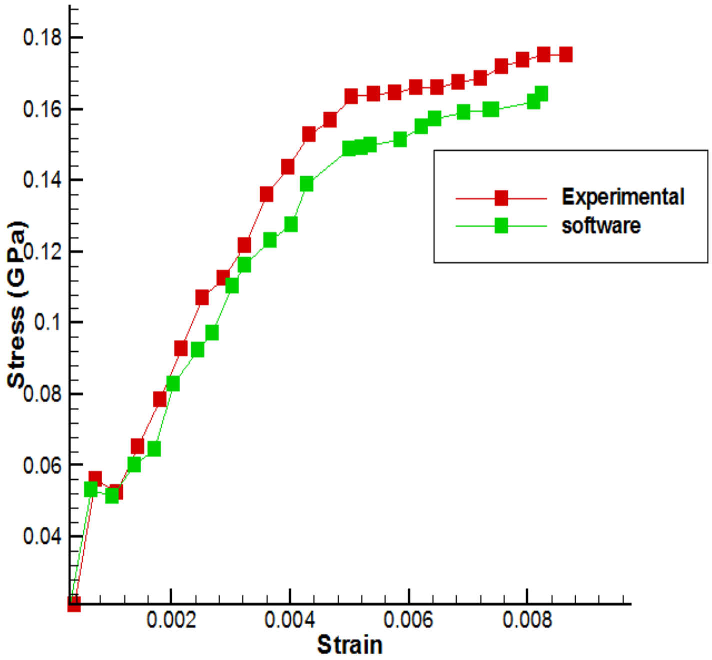


Fig 4.5 stress – strain graph of 0/90 orientation

V. Calculations:

Young's modulus = $\frac{\text{stress}}{\text{strain}}$

$$E = \frac{\sigma}{\varepsilon}$$

= (0.092868-0.0654) / (0.00216-0.00144)

= **38.15 GPa.**

From the analytical point of view,

$E = f*E_f + (1-f)*E_m$

E = (0.45*85) + (0.55*3) = 39.9 GPa.

VI.Results:

orientation	Experimental Ultimate Stress N/mm^2	Analytical Ultimate Stress(MPa)	Error %
$0^0/90^0$	175.272	164.217	6.30
0^0	16.20	14.7	9.25
10^0	10.67	9.94	6.84
20^0	6.57	6	8.67
90^0	3.80	3.43	9.73

Table 6.1 Experimental vs Analytical results

VII.Conclusions

The experimental investigations used for the analysis of flexural behavior of glass fiber reinforced epoxy laminates leads to the following conclusions. In this study Glass/Epoxy laminates with different fiber orientations are subjected to bending test. Above practical results clearly showed that stress-strain variation is linear. The practical results and the results obtained by the modeling are almost matching. And the above results also showed that if the angle of orientation of fibers changes, the stress-strain variation is linear but strength of the composite varies. For zero degree fiber orientation the stiffness and strength of the material is high compared to other orientation of fibers. As the angle orientation increases the strength of the composite decreases. This stress-strain behavior is used to analyze the material before using in practical applications like constructions. That means how effectively it will work and for which application the material is suitable, these things we can easily identify.

VIII. References:

- Robert M. Jones, "Mechanics of Composite Materials", Second Edition, April 1998.
- Mechanics of composite materials, Second Edition, KAW.
- Advanced Mechanics of Solids, L.S.Srinath.
- **K. Vasantha Kumar, P. Ram Reddy, D. V. Ravi Shankar**, "Influence of Angle Ply Orientation of Stacking On Mechanical Properties of Glass-Polyester Composite Laminate "(ISSN: 2249 – 8958, Volume-3, Issue-1, and October 2013).
- **G. Ratnakar and Dr. H.K. Shivanand, "**Fiber Orientation and Its Influence on the Flexural Strength of Glass fiber and Graphite fiber reinforced polymer composites", International journal of innovative research in science, engineering and technology, (ISSN: 2319-8753, vol-2, issue-3, March 2013).