

Experimental Determination of Flexural Strength of Glass Fiber Reinforced Composite Laminates

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Abstract— Aerospace industry is in need of material which has high strength to weight ratio. Before using a material for aerospace application it is necessary to test that material as per ASTM standard. The continuous and chopped fiber composite beam was fabricated at various thicknesses (3 and 4 mm) by using the Hand lay-up technique. Many structures are often prone to bending loads, which can result in serious damage. Therefore, for structural integrity, structures must be efficient to resist bending. Flexural loading causes stresses in the composites, which vary through the thickness according to fibers so determine the flexural strength of glass-epoxy composite beam. The glass epoxy beams are cut as per the ASTM D7264 for flexural test. The structural parts subjected to bending loads causing flexural stress. The present study aims at investigating the flexural parameters of Glass-Epoxy composite beam when subjected to static flexural loading. The flexural parameters are determined by flexural test on in specimen. The loads Vs deflection graphs are plotted from which flexural strength for glass - epoxy composite beam is determined.

Key words: ASTM D7264, Flexural loading, Glass Fiber Reinforced Composite Laminates

I. INTRODUCTION

Composite materials are a blend of two or more components one of which is made up of stiff, long fibers and the other is a matrix, which holds the fibers in a place. Such combination exhibits the best properties of the individual materials and includes other qualities that none of the individual material possesses. Thus composite materials are macroscopic combination of two or more distinct materials having discrete and recognizable interface separating them. Composites like laminated plywood, reinforced concrete, etc.

The narrower definition of composites, therefore, becomes more specific and can be restricted to those combinations of materials that contain high strength, stiffness fiber reinforced supported by a high performance matrix material. It is a truism that technological development depends on advances in the field of materials. One does not have to be an expert to realize that the most advanced turbine or aircraft design is of no use if adequate materials to bear the service loads and conditions are not available. In aerospace application the term 'composite structure' refers to fiber /resin combination where in the fiber is embedded in the resin called matrix but retain its identity.

The resulting composites will generally be composed of layers of the fibers and matrix stacked to achieve desired properties in one or more directions. The major disadvantage of composite materialism airplane conditions is, however, their relatively high cost. The fiber filaments which provide strength and stiffness carry the

tension load, and the matrix provides support for the fibers and assists the fibers in carrying the compression load. Flexural loading causes stresses in the composites, which vary through the thickness. Flexural stresses are the maximum at the outer surfaces and zero in the middle at the neutral axis [1]. The maximum fibre stress at failure on the tension side of the flexural specimen is considered the flexural strength of the material [3]. Three point bending method provides a better estimates of the material behavior under flexural loading [2].

II. COMPOSITE FABRICATION

The choice of fabrication process is strongly influenced by chemical nature of the matrix and the temperature required to form, melt or cure the matrix with fiber orientation.

Two different glass fibres are fabricated. One with chopped fibre and the other with bidirectional glass fibre for two different thickness 3mm and 4 mm for each. The epoxy used is Polyvinyl chloride.



Fig. 1: Chopped and Contineous glass fibre

III. EXPERIMENTAL TESTING

A. Flexural Test:

Many structures are used in aerospace, automobile naval and other transportation vehicle structural parts are subjected to different kindings of loads. These structures are further subjected to bending loads causing flexural stress in the structures. The structures subjected to bending loads are borne to catastrophic failure. Therefore the structural integrity of structure is a must to overcome bending. The flexural parameters are determined by conducting the three point bend test on composite specimen as per ASTM D 7264 standards. The composite laminate specimens are subjected to three point bending test. The load vs. deflection and stress vs. strain graphs are plotted and flexural properties like flexural strength and stiffness for glass laminated composites are evaluated.



Fig. 2: Flexural testing

B. Three Point Flexural (Bending) Test:

A bar of rectangular cross section, supported as a beam, is deflected at a constant rate as follows, The bar rests on two supports and isolated by means of a loading nose midway between the supports. The bar rests on two supports and isolated at two points (by means of two loading noses), each an equal distance from the adjacent support point and the load is acting on the center of the bar. The major difference between four-point and three-point loading configurations is the location of maximum bending moment and maximum flexural stress. Consequently, the maximum flexural stress is uniform between the central force application members. In the three-point configuration, the maximum flexural stress is located directly under the center.

C. Machine Specifications:

The 3-point bending tests were performed in a servo controlled UTM machine according to the procedure outlined in ASTM 7264. At least 3 specimens were tested for each thickness of laminate. The crosshead speed was maintained at 2mm/minutes tested specimens were examined using through visual inspection for failure of fibers and matrix.



Fig. 3: Three point bending

IV. RESULTS AND DISCUSSION

We find out the flexural strength of our material at different loads. We get the result for different graphs (i.e.) load vs. deflection and stress vs. strain. Thus the graphs are plotted below.

A. For Specimen 1 (Chopped Fibre- 4mm):

The specimen bending at (Ultimate / Break load) 0.525 KN, displacement at flexural maximum is 4.600mm, maximum

displacement is 6.200mm, bending area is 69.020mm² and the ultimate stress is 8 N/mm²

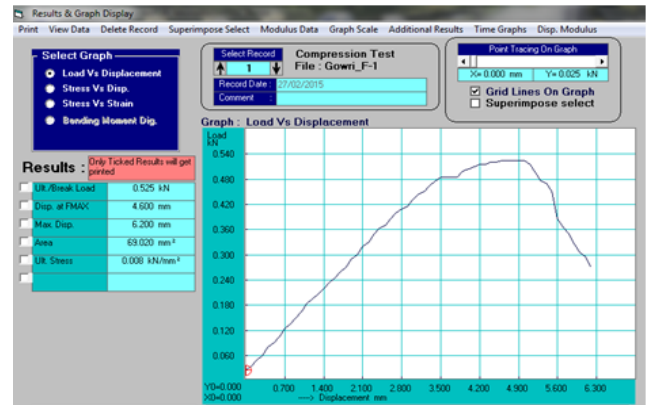


Fig. 4: Load vs. deflection

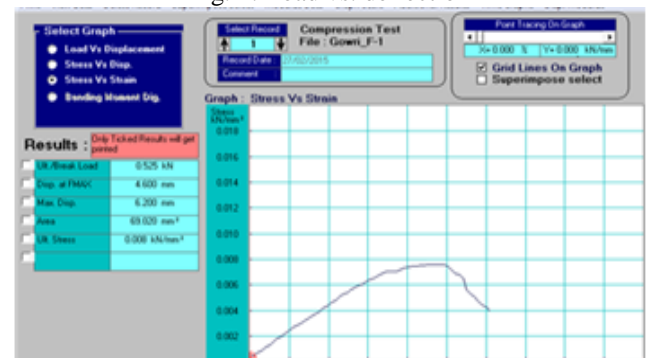


Fig. 5: Stress vs. Strain

B. For Specimen 2 :(Chopped Fiber- 4mm):

The specimen bending at (Ultimate / Break load) 0.805 KN, displacement at flexural maximum is 4.300mm, maximum displacement is 5.200mm, bending area is 85.748mm² and the ultimate stress is 9 N/mm².

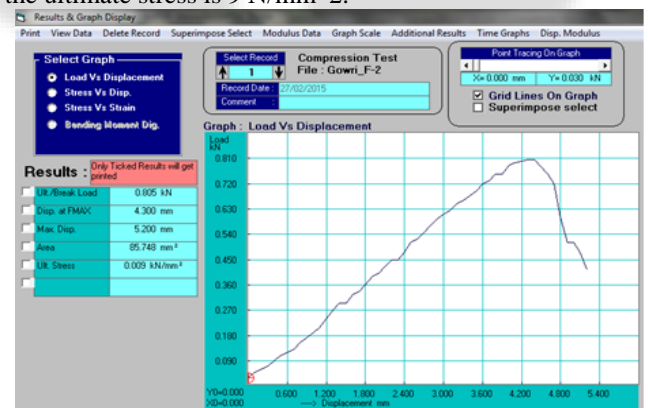


Fig. 6: Load vs. deflection

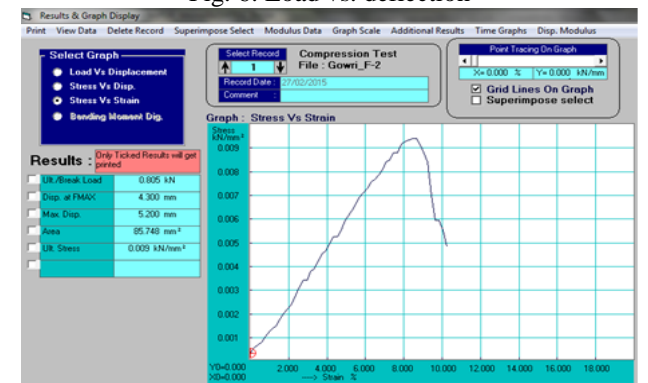


Fig. 7: Stress vs. Strain

C. For Specimen 3 :(Chopped Fiber- 4mm):

The specimen bending at (Ultimate / Break load) 0.580 KN, displacement at flexural maximum is 4.000mm,maximum displacement is 6.500mm,bending area is 79.080mm²and the ultimate stress is 7 N/mm².

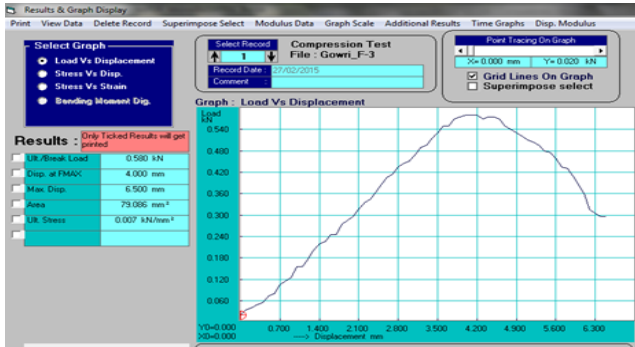


Fig. 8: Load vs. Deflection

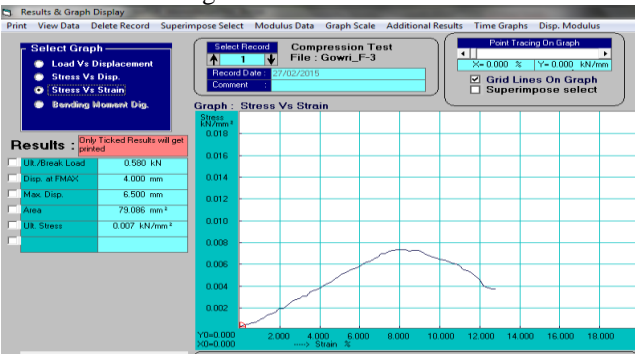


Fig. 9: Stress vs. Strain

D. For Specimen 4 :(Chopped Fiber- 3mm):

The specimen bending at (Ultimate / Break load) 0.290 KN, displacement at flexural maximum is 5.700mm,maximum displacement is 12.600mm,bending area is 51.748mm²and the ultimate stress is 6 N/mm².

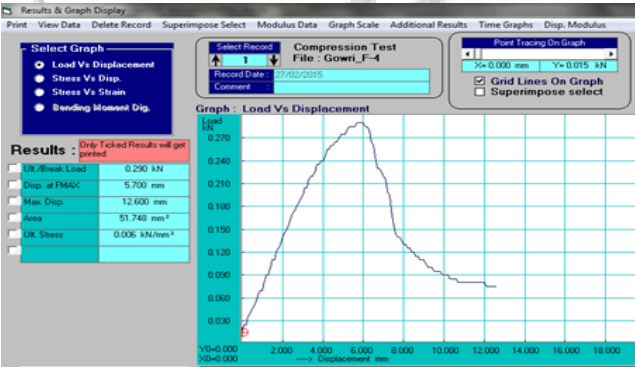


Fig. 10: Load vs. Deflection

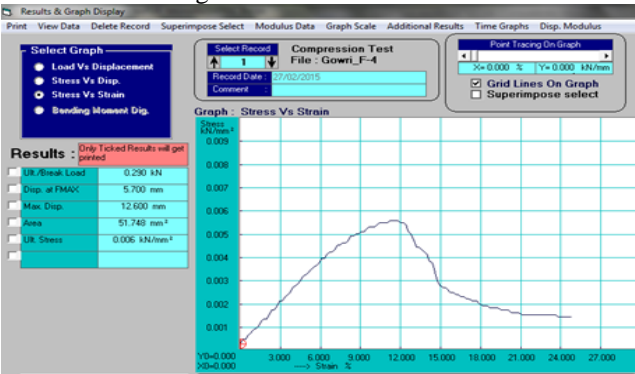


Fig. 11: Stress vs. Strain

E. For Specimen 5 :(Chopped Fiber- 3mm):

The specimen bending at (Ultimate / Break load) 0.315 KN, displacement at flexural maximum is 6.000mm,maximum displacement is 9.900mm,bending area is 53.199mm²and the ultimate stress is 6 N/mm².

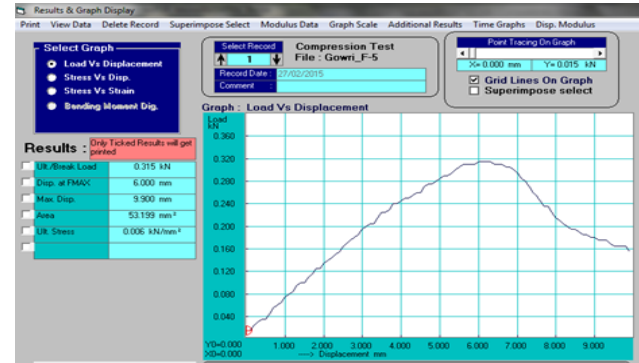


Fig. 12: Load vs. Deflection

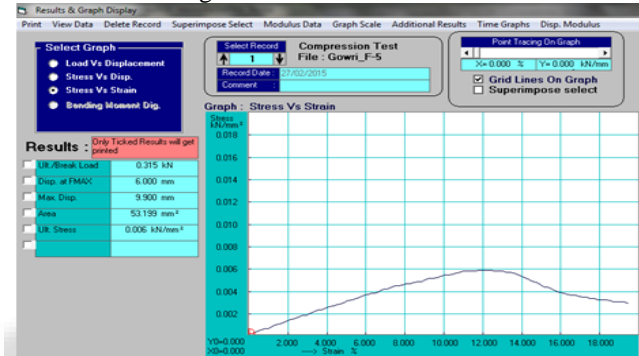


Fig. 13: Stress vs. Strain

F. For Specimen 6 :(Chopped Fiber- 3mm):

The specimen bending at (Ultimate / Break load) 0.405 KN, displacement at flexural maximum is 5.400mm,maximum displacement is 6.700mm,bending area is 55.497mm²and the ultimate stress is 7 N/mm².

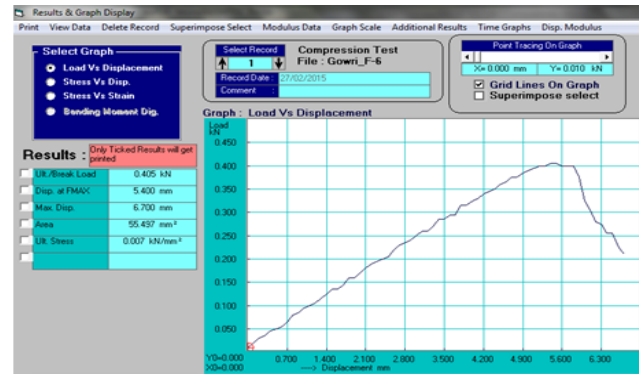


Fig. 14: Load vs. Deflection

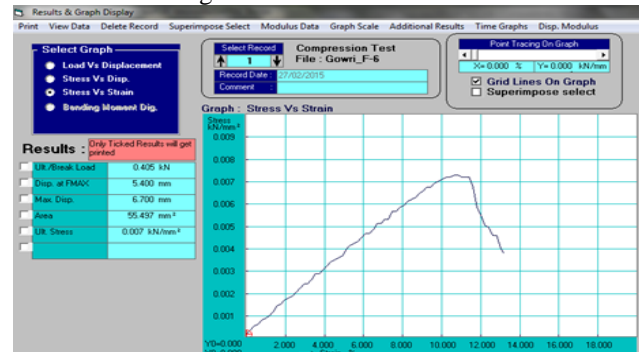


Fig. 15: Stress vs. Strain

G. For Specimen 7 :(Continuous Fiber- 3mm):

The specimen bending at (Ultimate / Break load) 0.280 KN, displacement at flexural maximum is 5.000mm,maximum displacement is 11.200mm,bending area is 44.269mm²and the ultimate stress is 6 N/mm².

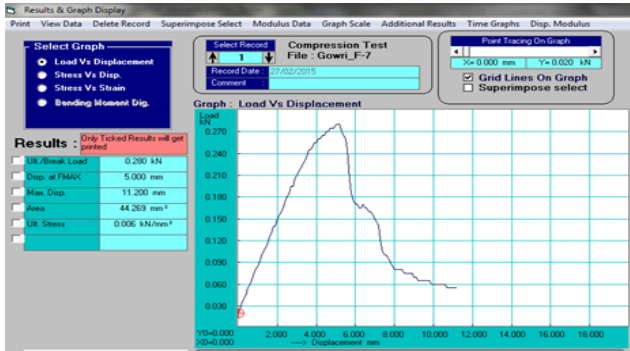


Fig. 16: Load vs. Deflection

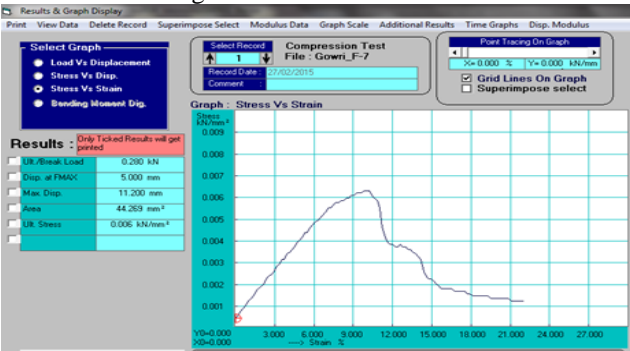


Fig. 17: Stress vs. Strain

H. For Specimen 8 :(Continuous Fiber- 3mm):

The specimen bending at (Ultimate / Break load) 0.315 KN, displacement at flexural maximum is 5.200mm,maximum displacement is 7.100mm,bending area is 48.476mm²and the ultimate stress is 6 N/mm².

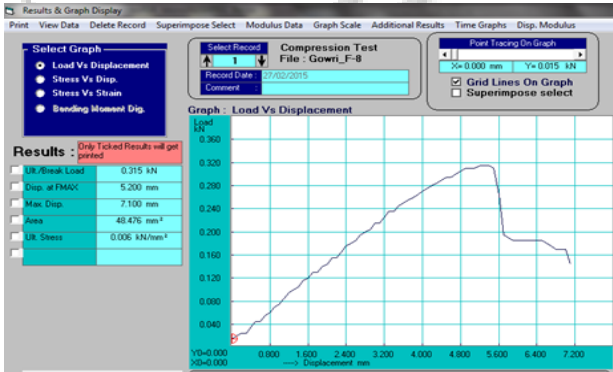


Fig. 18: Load vs. Deflection

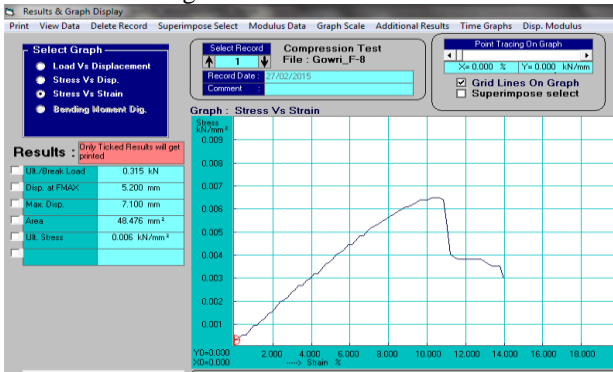


Fig. 19: Stress vs. Strain

I. For Specimen 9 :(Continuous Fiber- 3mm):

The specimen bending at (Ultimate / Break load) 0.210 KN, displacement at flexural maximum is 5.300mm,maximum displacement is 9.700mm,bending area is 40.605mm²and the ultimate stress is 5 N/mm².

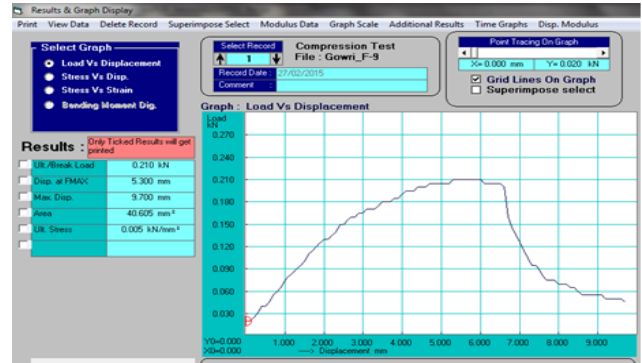


Fig. 20: Load vs. Deflection

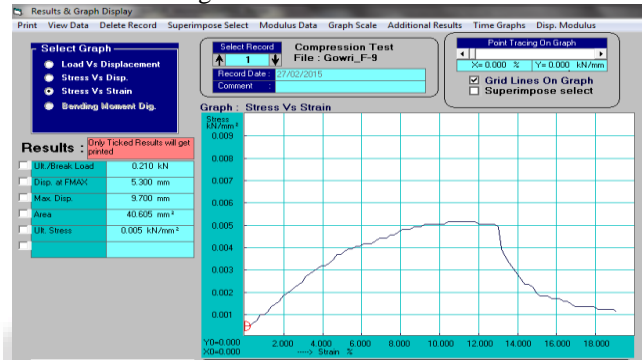


Fig. 21: Stress vs. Strain

J. For Specimen 10 :(Continuous Fiber- 4mm):

The specimen bending at (Ultimate / Break load) 0.565 KN, displacement at flexural maximum is 4.00mm,maximum displacement is 5.200mm,bending area is 59.684mm²and the ultimate stress is 9 N/mm².

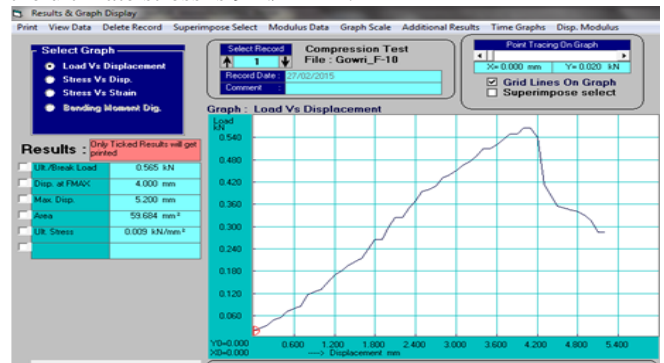


Fig. 22: Load vs. Deflection

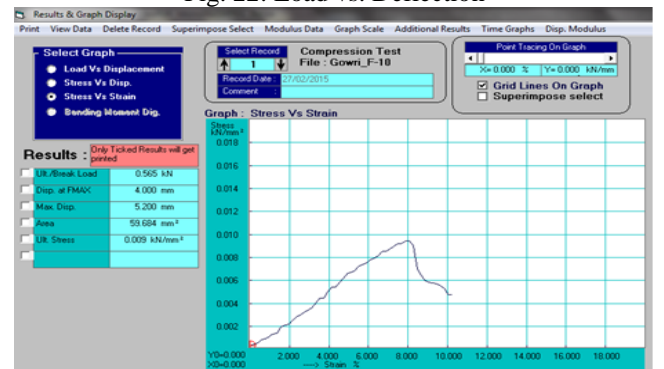


Fig. 23: Stress vs. Strain

K. For Specimen 11 :(Continuous Fiber- 4mm):

The specimen bending at (Ultimate / Break load) 0.605KN, displacement at flexural maximum is 5.00mm, maximum displacement is 5.500mm, bending area is 60.720mm²and the ultimate stress is 7 N/mm².

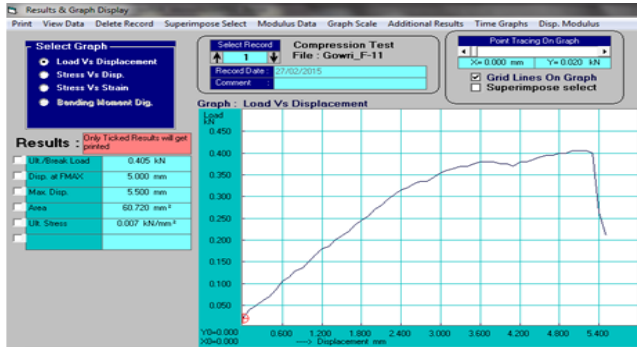


Fig. 24: Load vs. Deflection

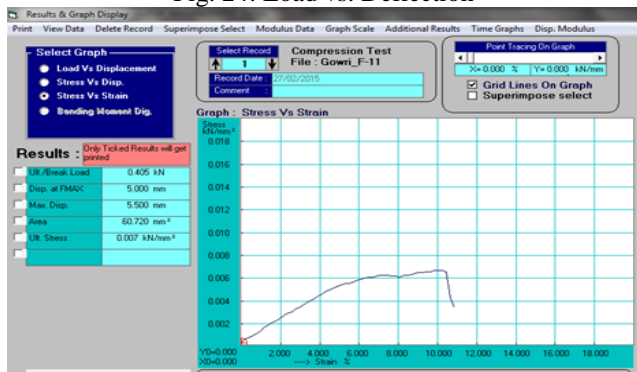


Fig.25. Stress vs. Deflection

L. For Specimen 12 :(Continuous Fiber- 4mm):

The specimen bending at (Ultimate / Break load) 0.790KN, displacement at flexural maximum is 3.800mm, maximum displacement is 4.200mm, bending area is 56.133mm²and the ultimate stress is 11 N/mm².

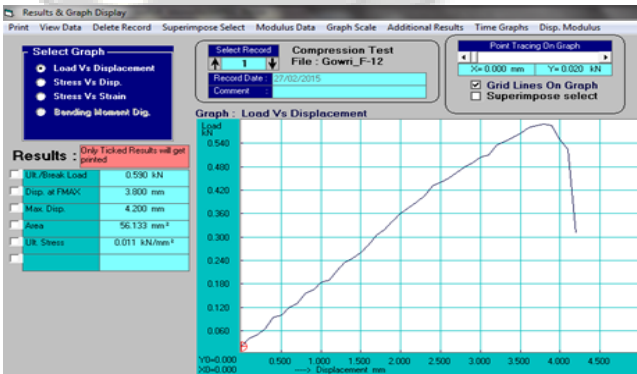


Fig. 26: Load vs. Deflection

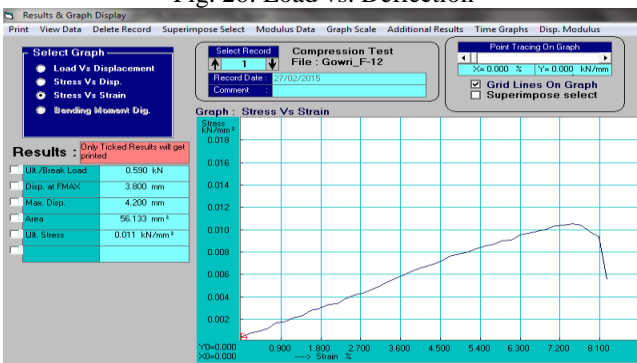


Fig. 27: Stress vs. Strain

V. CONCLUSION

The composite materials were fabricated by using hand layup method. The fabricated material was cut as per the ASTM standard D 7264 for flexural test. Three point bending tests were performed on continuous fiber and chopped fiber composite specimens. The load vs. deflection and stress vs. Strain graphs were plotted. Two types of laminates were tested with two different thicknesses (3mm and 4mm) As a result, by analyzing the load vs. deflection and stress vs. strain graphs; it is shown that the flexural strength is greater for continuous fiber than chopped fiber. For 3 mm thickness, flexural strength of chopped fiber variation is in smaller amount, whereas for 4mm thickness, flexural strength variation is more significant. The main findings of the present investigation are as follows:

- Three point bending method is more suitable to determine the flexural strength.
- There is a significant improvement in strength for continuous fibre laminates as compared to chopped for same thicknesses under test. This may be due to good adhesion between glass fiber and epoxy resin.
- Effect of thickness on flexural strength seems to play a vital role in assessing material behavior under flexural loading conditions.

VI. ACKNOWLEDGMENT

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