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Investigations on the Flexural Strength and the Effect of b/h and l/b ratio on the Carbon Fiber Reinforced Epoxy Laminated Composites

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Abstract: In present day the use of fiber reinforced composites is increased remarkably in the various sectors of industries owing to its relative advantages especially in industries like aeronotics, automobile, ship building and in chemical industries, where the major emphasis is on weight reduction with a subtantial increase in the mechanical strength of the component with enhanced durability by having properties like corrosive resistance, anti reactive to various acidic reactions and to with stand various climatic and temperature conditions. In this context carbon fibre reinforced laminated composites exhibit excellent mechanical properties. Investigation of various properties is difficult in composite materials because of its complex behavior further it is very difficult to evaluate the behavior of fiber laminated composites because of its enhanced complexity, evaluation of properties in composites is difficult with the addition of the fiber (carbon fiber) into the matrix. in this paper an investigation on the flexural properties of the carbon fiber reinforced laminates is carried out and the effect of bredth(b) to thickness (t) and the influence of the of length (l) to breadth(b), Aspect ratio is being evaluated and appropriate conclusions are drawn.
Keywords: polymer laminate, aspect ratio, flexural properties, carbon fibre.

I. INTRODUCTION

In recent days the use of polymer laminated composites is increasing in a exhaustive manner because of its enhanced chemical and mechanical properties with increased self life. The application of fiber reinforced polymer is not just restricted to non load bearing structures but also in structures that have to carry load.The fiber reinforced laminated composites exhibits typical mechanical behaviour when loaded, which is complex in its nature to analyse, the addition of the fibers makes the composite more complex and determination of its properties will be much more complicated. In the present study carbon fiber is used as the reinforcing material, carbon fibers exhibit several important charateristic properties, such as carbon fibers has the highest strength and highest price of all reinforcement fibers used in composites the size or thickness of carbon tows is measured in terms of number of filaments.Carbon fibers exhibit substantially better strength and stiffness values than the other type of fibers used, carbon fibers exhibit outstanding temperature performance, high electrical and low thermal conductivity. Impact or damage tolerance of pure carbon composite products can be from relatively low to very poor, and greatly depends on processing method.

Bert [1] proposed beam stiffnesses for rectangular laminated beams based on an integration through the thickness of the piecewise constant lamina longitudinal and shear moduli. Vinson and Sierakowski [2] applied the above approach to develop “an advanced theory” to obtain strength and stiffness of laminated beams under flexural load. Bauld and Tzend [3] presented a novel theory for thin-walled laminated beams with open cross-section based on this criterion. Effective moduli of laminated beams under flexure were proposed by Whitney et.al [5] from the reciprocals of the corresponding laminate compliances.Barcero et.al [6] adopted the above approach in order to develop a first order shear deformation theory for laminated beams and stiffness was characterized. Wu and Sun [7] applied a combination of second and third approaches to compute the laminated beam stiffnesses depending on the element slenderness and the presence of stiffening ribs.

II. METHODOLOGY

A. Fabrication of Carbon Fiber reinforced Laminates

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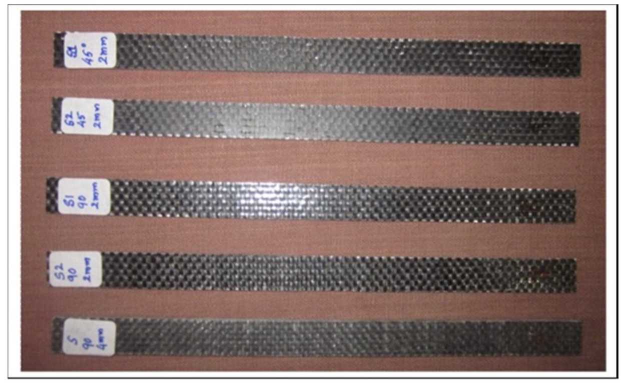

Fig 1: Hand lay up technique- Carbon Laminate Fig 2 : Standard specimen for flexural test

The fiber chosen were bi-woven carbon fibre with density 1.6 g/cc. The bi-woven carbon fabric are cut in to the required shape and is bonded using an adhesive made from a mixture of LY556 resin and HY 951 hardner in proportions of 1000:100 by weight.The surfaces are thoroughly cleaned in order to enhance proper bonding between the fiber and the matrix by removing the dirt, oil and other solid impuriyies.The adhesive acts as the matrix material and bi woven carbon fabric is used as the reinforcing material to enhance the mechanical rpoperties of the laminate.The fabrics are stacked one above the other by applying the adhesive at every layer as matrix material. The stacked fiber with adhesive is allowed to cure for about 24 hours followed by vaccum bag technique to remove entrapped air if any in the laminate.

B. Vacuum bag technique

A process for molding reinforced plastics in which a sheet of flexible transparent material such as nylon plastics is placed over the lay-up on the mold and sealed. Vacuum is applied between the sheet and the lay-up. The entrapped air is removed by the vacuum and the part is placed in an oven or autoclave. Addition of pressure further results in higher fiber concentration and provides better adhesion between layers of composite construction. The entrapped air is removed by the vacuum and the part is placed in an oven or autoclave. The addition of pressure further results in higher fiber concentration and provides better adhesion between layers of laminate construction. Figure above depicts vacuum bag technique set up.

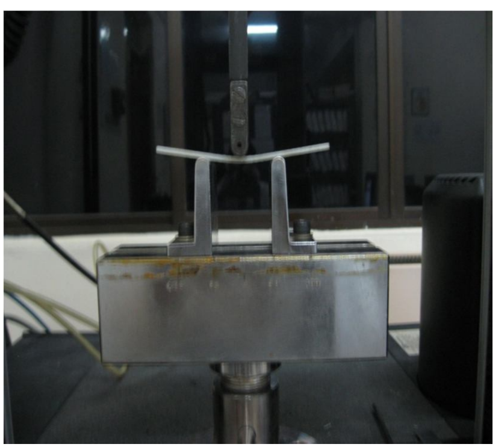

Fig 3: Closer look Flexural loading **Fig 4: Specimen Under Flexural loading**

III. RESULTS AND DISCUSSION

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Table 1: CFRP specimen Details

Material	Fiber (%)	Resin (%)
FRP (2 mm)	54 (Carbon)	46 (Epoxy)

C. Flexural test on Carbon fiber composite Panels

Table 2: Geometric dimensions of Specimen:

Specimen	CFRP 1	CFRP 2	CFRP 3
b (mm)	12.75	13.5	20
h (mm)	2.05	2.12	2.2
b/h	6.22	6.36	9.09

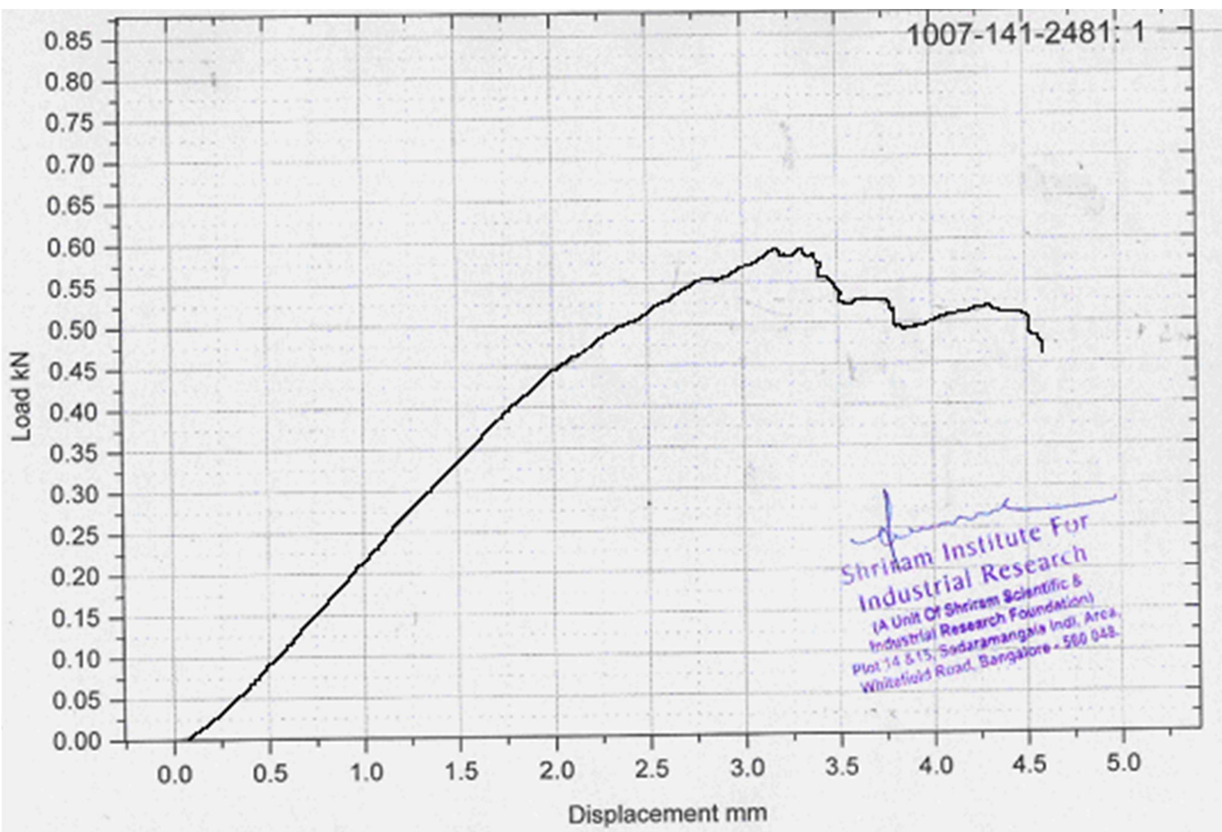

Fig 5: Graph showing Load Vs displacement Carbon fiber with 2 mm thick – CFRP 1

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Table 3: Length-to-width aspect ratio of beam specimens:

L (mm)	L/b		
	CFRP 1	CFRP 2	CFRP 3
128	10.03	9.48	6.4
180	14.11	13.33	9.0
235	18.43	17.4	11.75

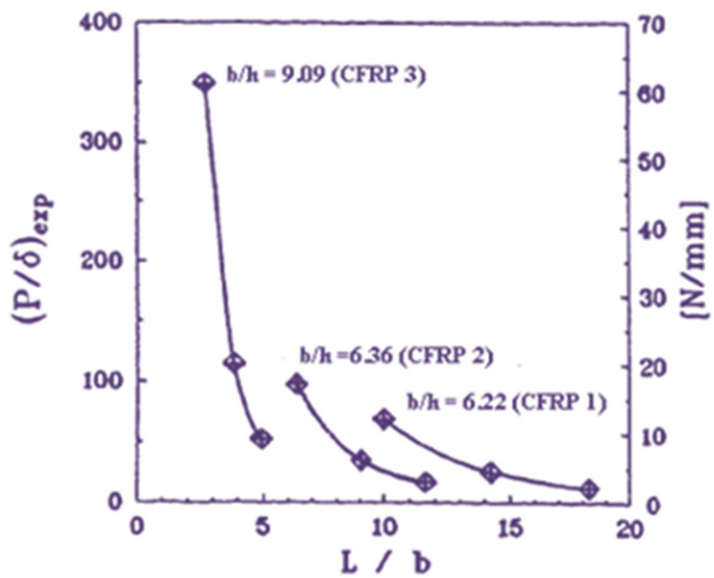

Fig.6 Graph of Load – Deflection coefficients versus aspect ratio

D. Calculation of beam Stiffness:

From the above fig; the slope of the graph provides the stiffness of the laminates for various L/b ratios. Similarly, stiffness values for other specimens are calculated and results recorded.

It is observed that for L/b ratio of 6.4 (CFRP 3) Specimen the stiffness value appeared large as compared to other laminates. The results of the computed stiffness values are recorded in the table.

Table 4: Stiffness values

	δ (Displacement) mm		
P (Load) KN	**CFRP 1**	**CFRP 2**	**CFRP 1**
0.10	0.5	0.32	0.21
0.20	1.0	0.68	0.4
0.30	1.51	1.01	0.62
0.40	1.78	1.38	1.22

The Moduli E_x and G_x will be expressed in terms of lamina stiffness components. The effective moduli of a laminated beam are the corresponding engineering constants of the laminate.Hence, the effective beam moduli are obtained from the reciprocals of the components of the laminate compliance matrix.Equation used to evaluate moduli is given below.

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$$\delta = \frac{PL^3}{48\,(E_x)_{anal} I_y}$$

P – Load in N; L – span length (mm)
E_x – Moduli; I_y – M.I of beam cross section

IV. CONCLUSIONS

The fabrication of laminated Composite specimens with three different L/b ratios & with 2mm thickness using bi-woven carbon cloth has been successfully carried out. A simple Digital Flexural Test System has been utilized to determine Flexural parameters such as Flexural stiffness, & Moduli for composites panels of three different L/b ratios. Physical and mechanical properties of carbon matrix composite specimens have been evaluated as per the relevant ASTM standards.

Flexural parameters of laminated Composites were tested and results tabulated for various combinations of L/b aspect ratio of the specimens as per tests recommended by ASTM standards. The values obtained have been analyzed from available literature & an excellent agreement between test results has been observed.The influence of L/b ratio on the static flexural behavior of composite panels has been examined.Substantial increase (15%) in flexural stiffness can be observed in case of CFRP – 3 laminate without any appreciable increase in weight of the Composite panel.

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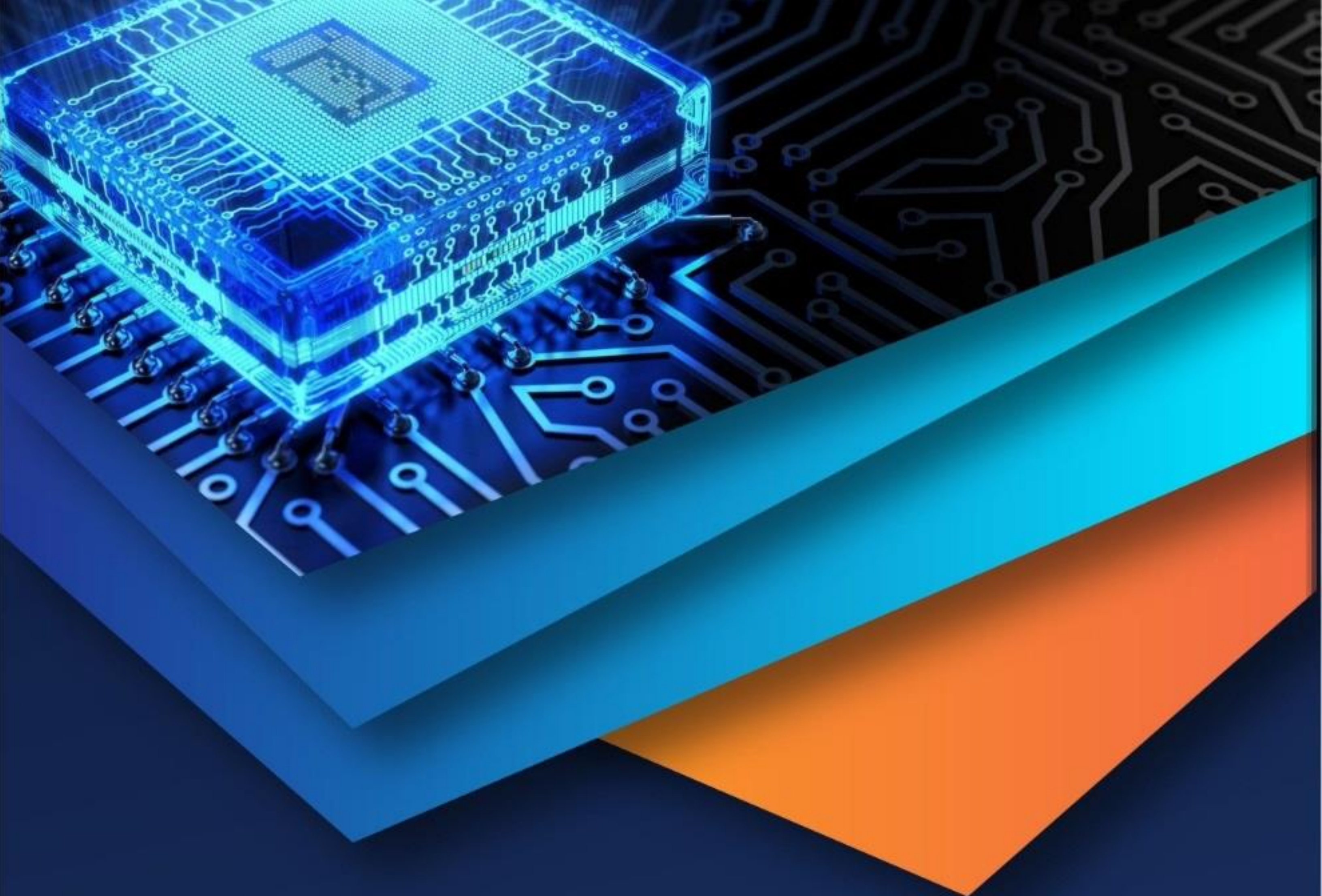

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