

## Simulation and Experimental Studies on Composite Beams

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### ABSTRACT

A composite beam a one dimensional structure or a rod all of them are sectional dimensions in which width and height are much smaller in comparison to the structure. In structural applications longer beams are more frequently used. In this work a composite beam is manufactured with glass and epoxy combination. And stress analysis is carried out using derived analytical expressions. This research work carried out will enable to determine the beam strength due to bending loads. The importance of fiber reinforcement in the manufacturing of the beam is studied in terms of bending strength of the beam. Mat lab codes are generated to implement analytical equations of the composite beam. The analytical results are validated by performing experiments on composite beams. In this investigation, two different composite beams have been tested and compared the experimental results with the analytical results.

**Key words:** Composite beam, glass and epoxy, stress analysis, fiber reinforcement, Mat lab.

### I. INTRODUCTION

Composite materials are one of the most favored solutions to this problem in the field. By combining the stronger properties of traditional materials and composite materials technology is providing compromising solutions and alternatives to many engineering fields. Problems born from material limitations like heavy weight, structural strength, and thermal resistance are being solved by the composite material alternatives. Composite materials, with their high strength/weight ratio are becoming popular with their increasing availability due to advancement in their manufacturing processes.

Chou and Wang<sup>1</sup> (1970) investigated a one dimensional elastic wave front in a layered medium by employing a control volume approach. By relating the in-plane averaged normal stress and strain, the stiffness terms for the layered medium can be derived. The results were shown to be identical with those from the equivalent material approach. Berthelot and Sefrani<sup>2</sup> (2005) investigates the damping of unidirectional glass fiber composites with a single or two interleaved visco-elastic layers. The experimental damping characteristics are derived from flexural vibrations of cantilever beams as a function of the fiber orientation. Narita and Leissa<sup>3</sup> (1992) presented an analytical approach and accurate numerical results for the free vibration of cantilevered, symmetrically laminated rectangular plates. The natural frequencies are calculated for a wide range of parameters: e.g., composite material constants, fiber angles and stacking sequence. .

Savoia and Tullini<sup>4</sup>(1993)analyzed the torsional response of composite beams of arbitrary cross section. The boundary value problem was formulated in terms of both warping and Prandtl's stress function.

Using the eigen function expansion method, the exact solution of rectangular multilayered orthotropic beams under uniform torsion was derived. Laila<sup>5</sup>(2008) has presented aero elastic characteristics of a cantilevered composite wing, idealized as a composite flat plate laminate. The composite laminate was made from woven glass fibers with epoxy matrix. The elastic and dynamic properties of the laminate were determined experimentally for aero-elastic calculations.

### II. PRODUCTION OF COMPOSITE BEAMS

Composite beams are combined with the matrix and fibre.Manufacture of glass/epoxy composite beams are fiber is the GLASS, matrix is the EPOXY RESIN. In this work the epoxy resin is used in grade and hardner. Material of the composite beam is,

Unidirectional glass cloth-360GSM,

Chopped strand mat-300GSM,

Wovenroving-400GSM,

Glass cloth-10mil.

The manufacture of the glass epoxy composite beams are first taken of the wax polish or PEA polish jel, layup of the under wooden table, next layer by layer like Glass, woven roving, is repeated for next two layers, Chopped strand mat woven roving, UD, Roving is layered on it. This process of layering prepared for required thickness, by the hand layup process at room temperature and it is kept idle for 24hrs then release composite from the table as shown fig3



Fig: 1 Manufacture of the glass /epoxy composite beams

From the above laminate beam prepare the test beam as per following dimensions as shown in fig.2.



Fig.2: Glass/epoxy Composite test beams

Dimensions of test beam:

- The each layer has thickness 0.42 mm,
- Length of the beam is 700 mm,
- Height of the beam is 16 mm,
- Breadth of the beam is 24 mm,
- Weight of the beam is 600 grms.

### III. STRESS EVALUATION OF COMPOSITE BEAMS

#### ANALYTICAL METHOD:

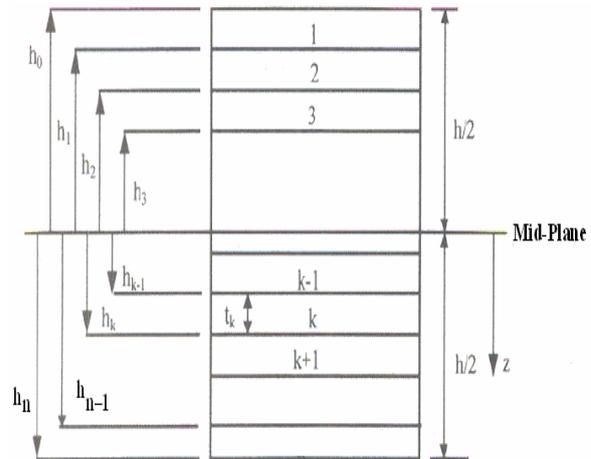


Fig: 3 Coordinate locations of plies in a beam laminate.

The above figure shows that coordinate locations of plies in a laminate to the h is the height of the beam, the layers are 1,2,3,....., k-1, k, k+1, thickness of the each layer is, the each layer of the heights is the the .....the mid plane to the last layer of the beam distance is the z.

$E_1$  = Longitudinal stiffness

$E_2$  = Transverse stiffness

$G_{12}$  = Shear stiffness

$\nu_{12}$  = Poisson's ratio

The stiffness in terms of engineering constants along the principal material axis are:

$$Q_{11} = E_1 / (1 - \nu_{12}\nu_{21})$$

$$Q_{22} = E_2 / (1 - \nu_{12}\nu_{21})$$

$$Q_{12} = (\nu_{12}E_2) / (1 - \nu_{12}\nu_{21})$$

$$Q_{12} = Q_{21},$$

$$Q_{33} = G_{12}$$

$$\nu_{21} = (\nu_{12}E_2) / E_1$$

$$m = \cos\theta$$

$$n = \sin\theta$$

To calculate of the reduced stiffness matrix [Q] values :

$$Q_{xx} = m^4 Q_{11} + n^4 Q_{22} + 2 m^2 n^2 Q_{12} + 4 m^2 n^2 Q_{33}$$

$$Q_{yy} = n^4 Q_{11} + m^4 Q_{22} + 2 m^2 n^2 Q_{12} + 4 m^2 n^2 Q_{33}$$

$$Q_{xy} = m^2 n^2 Q_{11} + m^2 n^2 Q_{22} + (m^4 + n^4) Q_{12} - 4 m^2 n^2 Q_{33}$$

$$Q_{xs} = m^3 n Q_{11} - m n^3 Q_{22} + (m n^3 - m^3 n) Q_{12} + 2 (m n^3 - m^3 n) Q_{33}$$

$$Q_{ys} = mn^3Q_{11} - m^3nQ_{22} + (m^3n - mn^3)Q_{12} + 2(m^3n - mn^3)Q_{33}$$

$$Q_{ss} = m^2n^2Q_{11} + m^2n^2Q_{22} - 2m^2n^2Q_{12} + (m^2 - n^2)^2Q_{33}$$

$$Q_{xys} = \begin{bmatrix} Q_{xx} & Q_{xy} & Q_{xs} \\ Q_{xy} & Q_{yy} & Q_{ys} \\ Q_{xs} & Q_{ys} & Q_{ss} \end{bmatrix}$$

To find out the Inplane stiffness matrix [A], Coupling stiffness matrix [B], and Bending stiffness matrix [D].

$$A_{ij} = \sum Q_{ij}^k (z_k - z_{k-1})$$

$$B_{ij} = \frac{1}{2} \sum Q_{ij}^k (z_k^2 - z_{k-1}^2)$$

$$D_{ij} = \frac{1}{3} \sum Q_{ij}^k (z_k^3 - z_{k-1}^3)$$

$$m = D_{ij} - B_{ij} \text{inv}(A_{ij}) B_{ij}$$

$$e = \text{inv}(m)$$

The procedure of the glass/epoxy cantilever beam to calculate stresses to different loads in the follow as

$$f_1 = (Q_{xx}e_{xx} + Q_{xy}e_{xy} + Q_{xs}e_{xs}) \frac{h^3}{12}$$

$$f_2 = (Q_{xy}e_{xx} + Q_{yy}e_{xy} + Q_{ys}e_{xs}) \frac{h^3}{12}$$

$$f_3 = (Q_{xs}e_{xx} + Q_{ys}e_{xy} + Q_{ss}e_{xs}) \frac{h^3}{12}$$

$$\sigma_x = z_0 f_1 \frac{12PL}{bh^3}$$

$$\sigma_y = z_0 f_2 \frac{12PL}{bh^3}$$

$$\sigma_s = z_0 f_3 \frac{12PL}{bh^3}$$

#### IV. MAT LAB FOR ANALYTICAL SOLUTIONS

The deflection and stresses under different load conditions are determined by using matlab. The steps in matlab for analytical solution as follows

**STEP 1: To find the reduced stiffness matrix [Qxys]:**

$$Q_{11} = E1 / (1 - \nu_{12}\nu_{21});$$

$$Q_{22} = E2 / (1 - \nu_{12}\nu_{21});$$

$$Q_{12} = (\nu_{12}E2) / (1 - \nu_{12}\nu_{21});$$

$$Q_{33} = G12;$$

$$Q_{xx} = Q_{11}m^4 + Q_{22}n^4 + 2Q_{12}m^2n^2 + 4Q_{33}m^2n^2;$$

$$Q_{yy} = Q_{11}n^4 + Q_{22}m^4 + 2Q_{12}m^2n^2 + 4Q_{33}m^2n^2;$$

$$Q_{xy} = Q_{11}m^2n^2 + Q_{22}m^2n^2 + Q_{12}m^2n^2 + (m^4 + n^4) - 4Q_{33}m^2n^2;$$

$$Q_{ss} = Q_{11}m^2n^2 + Q_{22}m^2n^2 + 2Q_{12}m^2n^2 + Q_{12} + (m^2 - n^2)^2Q_{33};$$

$$Q_{xs} = Q_{11}m^3n - Q_{22}m^3n + Q_{12}(m^3n - m^3n) + 2Q_{33}(m^3n - m^3n);$$

$$Q_{ys} = Q_{11}m^3n - Q_{22}m^3n + Q_{12}(m^3n - m^3n) + 2Q_{33}(m^3n - m^3n);$$

**STEP 2 : To find the each layer thickness**

d = To distance between the reference line to the last layer to the no of layers.

z = Distance between to the reference line to the last layer.

$$d = - (8/19); \quad z_0 = - 8; \quad z_1 = (z_0 - d); \quad z_2 = (z_1 - d);$$

$$z_3 = (z_2 - d); \quad z_4 = (z_3 - d); \quad z_5 = (z_4 - d);$$

$$z_6 = (z_5 - d); \quad z_7 = (z_6 - d);$$

$$z_8 = (z_7 - d);$$

$$z_9 = (z_8 - d); \quad z_{10} = (z_9 - d); \quad z_{11} = (z_{10} - d);$$

$$z_{12} = (z_{11} - d); \quad z_{13} = (z_{12} - d); \quad z_{14} = (z_{13} - d);$$

$$z_{15} = (z_{14} - d); \quad z_{16} = (z_{15} - d); \quad z_{17} = (z_{16} - d);$$

$$z_{18} = (z_{17} - d); \quad z_{19} = (z_{18} - d); \quad z_{20} = (-d);$$

$$z_{21} = (z_{20} - d); \quad z_{22} = (z_{21} - d); \quad z_{23} = (z_{22} - d);$$

$$z_{24} = (z_{23} - d); \quad z_{25} = (z_{24} - d); \quad z_{26} = (z_{25} - d);$$

$$z_{27} = (z_{26} - d); \quad z_{28} = (z_{27} - d); \quad z_{29} = (z_{28} - d);$$

$$z_{30} = (z_{29} - d); \quad z_{31} = (z_{30} - d); \quad z_{32} = (z_{31} - d);$$

$$z_{33} = (z_{32} - d); \quad z_{34} = (z_{33} - d); \quad z_{35} = (z_{34} - d);$$

$$z_{36} = (z_{35} - d); \quad z_{37} = (z_{36} - d); \quad z_{38} = (z_{37} - d);$$

**STEP 3 : To calculate of the In plane stiffness matrix [A] Coupling stiffness matrix [B] ,and Bending stiffness matrix [D].**

$$A = Q_{xys}*(z_1 - z_0) + Q_{xys}*(z_2 - z_1) + Q_{xys}*(z_3 - z_2) + Q_{xys}*(z_4 - z_3) + Q_{xys}*(z_5 - z_4) + Q_{xys}*(z_6 - z_5) + Q_{xys}*(z_7 - z_6) + Q_{xys}*(z_8 - z_7) + Q_{xys}*(z_9 - z_8) + Q_{xys}*(z_{10} - z_9) + Q_{xys}*(z_{11} - z_{10}) + Q_{xys}*(z_{12} - z_{11}) + Q_{xys}*(z_{13} - z_{12}) + Q_{xys}*(z_{14} - z_{13}) + Q_{xys}*(z_{15} - z_{14}) + Q_{xys}*(z_{16} - z_{15}) + Q_{xys}*(z_{17} - z_{16}) + Q_{xys}*(z_{18} - z_{17}) + Q_{xys}*(z_{19} - z_{18}) + Q_{xys}*(z_{20} - z_{19}) + Q_{xys}*(z_{21} - z_{20}) + Q_{xys}*(z_{22} - z_{21}) + Q_{xys}*(z_{23} - z_{22}) + Q_{xys}*(z_{24} - z_{23}) + Q_{xys}*(z_{25} - z_{24}) + Q_{xys}*(z_{26} - z_{25}) + Q_{xys}*(z_{27} - z_{26}) + Q_{xys}*(z_{28} - z_{27}) + Q_{xys}*(z_{29} - z_{28}) + Q_{xys}*(z_{30} - z_{29}) + Q_{xys}*(z_{31} - z_{30}) + Q_{xys}*(z_{32} - z_{31}) + Q_{xys}*(z_{33} - z_{32}) + Q_{xys}*(z_{34} - z_{33}) + Q_{xys}*(z_{35} - z_{34}) + Q_{xys}*(z_{36} - z_{35}) + Q_{xys}*(z_{37} - z_{36}) + Q_{xys}*(z_{38} - z_{37});$$

$$B = 0.5*Q_{xys}*(z_1^2 - z_0^2) + 0.5*Q_{xys}*(z_2^2 - z_1^2) + 0.5*Q_{xys}*(z_3^2 - z_2^2) + 0.5*Q_{xys}*(z_4^2 - z_3^2) + 0.5*Q_{xys}*(z_5^2 - z_4^2) + 0.5*Q_{xys}*(z_6^2 - z_5^2) + 0.5*Q_{xys}*(z_7^2 - z_6^2) + 0.5*Q_{xys}*(z_8^2 - z_7^2) + 0.5*Q_{xys}*(z_9^2 - z_8^2) + 0.5*Q_{xys}*(z_{10}^2 - z_9^2) + 0.5*Q_{xys}*(z_{11}^2 - z_{10}^2) + 0.5*Q_{xys}*(z_{12}^2 - z_{11}^2) + 0.5*Q_{xys}*(z_{13}^2 - z_{12}^2) + 0.5*Q_{xys}*(z_{14}^2 - z_{13}^2) + 0.5*Q_{xys}*(z_{15}^2 - z_{14}^2) + 0.5*Q_{xys}*(z_{16}^2 - z_{15}^2) + 0.5*Q_{xys}*(z_{17}^2 - z_{16}^2) + 0.5*Q_{xys}*(z_{18}^2 - z_{17}^2) + 0.5*Q_{xys}*(z_{19}^2 - z_{18}^2) + 0.5*Q_{xys}*(z_{20}^2 - z_{19}^2) + 0.5*Q_{xys}*(z_{21}^2 - z_{20}^2) + 0.5*Q_{xys}*(z_{22}^2 - z_{21}^2) + 0.5*Q_{xys}*(z_{23}^2 - z_{22}^2) + 0.5*Q_{xys}*(z_{24}^2 - z_{23}^2) + 0.5*Q_{xys}*(z_{25}^2 - z_{24}^2)$$

$$+ 0.5 * Q_{xys} * (z_{26}^2 - z_{25}^2) + 0.5 * Q_{xys} * (z_{27}^2 - z_{26}^2) + 0.5 * Q_{xys} * (z_{28}^2 - z_{27}^2) + 0.5 * Q_{xys} * (z_{29}^2 - z_{28}^2) + 0.5 * Q_{xys} * (z_{30}^2 - z_{29}^2) + 0.5 * Q_{xys} * (z_{31}^2 - z_{30}^2) + 0.5 * Q_{xys} * (z_{32}^2 - z_{31}^2) + 0.5 * Q_{xys} * (z_{33}^2 - z_{32}^2) + 0.5 * Q_{xys} * (z_{34}^2 - z_{33}^2) + 0.5 * Q_{xys} * (z_{35}^2 - z_{34}^2) + 0.5 * Q_{xys} * (z_{36}^2 - z_{35}^2) + 0.5 * Q_{xys} * (z_{37}^2 - z_{36}^2) + 0.5 * Q_{xys} * (z_{38}^2 - z_{37}^2);$$

$$d1 = 0.33 * Q_{xys} * (z_1^3 - z_0^3) + 0.33 * Q_{xys} * (z_2^3 - z_1^3) + 0.33 * Q_{xys} * (z_3^3 - z_2^3) + 0.33 * Q_{xys} * (z_4^3 - z_3^3) + 0.33 * Q_{xys} * (z_5^3 - z_4^3) + 0.33 * Q_{xys} * (z_6^3 - z_5^3) + 0.33 * Q_{xys} * (z_7^3 - z_6^3) + 0.33 * Q_{xys} * (z_8^3 - z_7^3) + 0.33 * Q_{xys} * (z_9^3 - z_8^3) + 0.33 * Q_{xys} * (z_{10}^3 - z_9^3);$$

$$d2 = 0.33 * Q_{xys} * (z_{11}^3 - z_{10}^3) + 0.33 * Q_{xys} * (z_{12}^3 - z_{11}^3) + 0.33 * Q_{xys} * (z_{13}^3 - z_{12}^3) + 0.33 * Q_{xys} * (z_{14}^3 - z_{13}^3) + 0.33 * Q_{xys} * (z_{15}^3 - z_{14}^3) + 0.33 * Q_{xys} * (z_{16}^3 - z_{15}^3) + 0.33 * Q_{xys} * (z_{17}^3 - z_{16}^3) + 0.33 * Q_{xys} * (z_{18}^3 - z_{17}^3) + 0.33 * Q_{xys} * (z_{19}^3 - z_{18}^3) + 0.33 * Q_{xys} * (z_{20}^3 - z_{19}^3);$$

$$d3 = 0.33 * Q_{xys} * (z_{21}^3 - z_{20}^3) + 0.33 * Q_{xys} * (z_{22}^3 - z_{21}^3) + 0.33 * Q_{xys} * (z_{23}^3 - z_{22}^3) + 0.33 * Q_{xys} * (z_{24}^3 - z_{23}^3) + 0.33 * Q_{xys} * (z_{25}^3 - z_{24}^3) + 0.33 * Q_{xys} * (z_{26}^3 - z_{25}^3) + 0.33 * Q_{xys} * (z_{27}^3 - z_{26}^3) + 0.33 * Q_{xys} * (z_{28}^3 - z_{27}^3) + 0.33 * Q_{xys} * (z_{29}^3 - z_{28}^3) + 0.33 * Q_{xys} * (z_{30}^3 - z_{29}^3);$$

$$d4 = 0.33 * Q_{xys} * (z_{31}^3 - z_{30}^3) + 0.33 * Q_{xys} * (z_{32}^3 - z_{31}^3) + 0.33 * Q_{xys} * (z_{33}^3 - z_{32}^3) + 0.33 * Q_{xys} * (z_{34}^3 - z_{33}^3) + 0.33 * Q_{xys} * (z_{35}^3 - z_{34}^3) + 0.33 * Q_{xys} * (z_{36}^3 - z_{35}^3) + 0.33 * Q_{xys} * (z_{37}^3 - z_{36}^3) + 0.33 * Q_{xys} * (z_{38}^3 - z_{37}^3);$$

$$D = d1 + d2 + d3 + d4;$$

**STEP 4 : To findout the forces;**

$$m = (D) - B * \text{inv} (A) * B;$$

$$e = \text{inv} (m); h = 8; Q_{xs} = 0; Q_{ys} = 0;$$

$$f1 = (Q_{xx} * e (1,1) + Q_{xy} * e (1,2) + Q_{xs} * e (1,3)) * (h^3 / 12);$$

$$f2 = (Q_{xy} * e (1,1) + Q_{yy} * e (1,2) + Q_{ys} * e (1,3)) * (h^3 / 12);$$

$$f3 = (Q_{xs} * e (1,1) + Q_{ys} * e (1,2) + Q_{ss} * e (1,3)) * (h^3 / 12);$$

**STEP 5: To calculate of the different loads in the find the stresses and deflections**

P = 25; L = 700; B = 24; H = 16;  
I = (b \* H<sup>3</sup>) / 12;  
s1 = z0 \* f1 \* (12 \* P \* L) / (b \* h<sup>3</sup>);  
s2 = z0 \* f2 \* (12 \* P \* L) / (b \* h<sup>3</sup>);  
s3 = z0 \* f3 \* (12 \* P \* L) / (b \* h<sup>3</sup>);  
m1 = (s1 + s2 / 2) - sqrt ((s1 - s2 / 2)<sup>2</sup> + ((s3)<sup>2</sup>);  
K1 = (P \* L<sup>3</sup>) / (3 \* E1 \* I);  
P = 15;  
s1 = z0 \* f1 \* (12 \* P \* L) / (b \* h<sup>3</sup>);  
s2 = z0 \* f2 \* (12 \* P \* L) / (b \* h<sup>3</sup>);  
s3 = z0 \* f3 \* (12 \* P \* L) / (b \* h<sup>3</sup>);  
m2 = (s1 + s2 / 2) - sqrt ((s1 - s2 / 2)<sup>2</sup> + ((s3)<sup>2</sup>);  
K2 = (P \* L<sup>3</sup>) / (3 \* E1 \* I);  
P = 20;  
s1 = z0 \* f1 \* (12 \* P \* L) / (b \* h<sup>3</sup>);  
s2 = z0 \* f2 \* (12 \* P \* L) / (b \* h<sup>3</sup>);  
s3 = z0 \* f3 \* (12 \* P \* L) / (b \* h<sup>3</sup>);  
m3 = (s1 + s2 / 2) - sqrt ((s1 - s2 / 2)<sup>2</sup> + ((s3)<sup>2</sup>);  
K3 = (P \* L<sup>3</sup>) / (3 \* E1 \* I);  
P = 10;  
s1 = z0 \* f1 \* (12 \* P \* L) / (b \* h<sup>3</sup>);  
s2 = z0 \* f2 \* (12 \* P \* L) / (b \* h<sup>3</sup>);  
s3 = z0 \* f3 \* (12 \* P \* L) / (b \* h<sup>3</sup>);  
m4 = (s1 + s2 / 2) - sqrt ((s1 - s2 / 2)<sup>2</sup> + ((s3)<sup>2</sup>);  
K4 = (P \* L<sup>3</sup>) / (3 \* E1 \* I);  
P = 5;  
s1 = z0 \* f1 \* (12 \* P \* L) / (b \* h<sup>3</sup>);  
s2 = z0 \* f2 \* (12 \* P \* L) / (b \* h<sup>3</sup>);  
s3 = z0 \* f3 \* (12 \* P \* L) / (b \* h<sup>3</sup>);  
m5 = (s1 + s2 / 2) - sqrt ((s1 - s2 / 2)<sup>2</sup> + ((s3)<sup>2</sup>);  
K5 = (P \* L<sup>3</sup>) / (3 \* E1 \* I);  
Load= P=5N; Distance= z0=8mm; Length=L=700mm; Breadth= b=24mm; Height =h=16mm; Moment of inertia =I=8192mm<sup>4</sup>.  
Force f1=0.1263;  
Young's modulus E=0.53 \* [(10)<sup>5</sup> N / (mm)<sup>2</sup>]  
Deflection δ=[PL]<sup>3</sup> / 12EI =1.2997 ;  
Stress σ=z0 \* f1 \* 12PL / (bh)<sup>3</sup> =3.4525N / (mm)<sup>2</sup>.

**V. ANALYTICAL RESULTS OF MATLAB**

Table 1 Numerical values of the deflection and Stress with respect to loads for beam one.

Numerical values			
S.NO	LOADS(P) (N)	DEFLECCTION (δ)	STRESS (σ) (N/mm <sup>2</sup> )
1	5	1.2997	3.4525
2	10	2.5994	6.9050
3	15	3.8991	10.3575
4	20	5.1988	13.8100
5	25	6.4985	17.2625

Table 2: Numerical values of the Deflection and Stress with respect to Loads in another beam two.

MAT LAB Results of the another composite beam			
S.N O	LOAD S (P) (N)	DEFLECTION ( $\delta$ )	STRESS ( $\sigma$ ) ( $\frac{N}{mm^2}$ )
1	5	0.9279	3.5245
2	10	2.2276	6.9770
3	15	3.5273	10.4295
4	20	4.8270	13.8820
5	25	6.1267	17.3345

Table 3: MAT-Lab results of the different orientations

MATLAB Results of the different orientations( $0^0, 30^0, 45^0$ )			
S.N O	LOADS(P) (N)	DEFLECCTION( $\delta$ )	STRESS ( $\sigma$ ) ( $\frac{N}{mm^2}$ )
1	5	1.3887	3.2524
2	10	2.6884	6.7024
3	15	3.9881	10.1524
4	20	5.2878	13.6024
5	25	6.5875	17.0524

### VI. EXPERIMENTAL SETUP

In the composite beam as shown in fig.3, the main analysis carried out are bending stress, bending deflection values. In this work glass/epoxy composite beam is evaluated for experimental and analytical.



Fig: 3 Glass epoxy composite beam

The experimental method of the composite beam procedure to find the deflections. Clamp the beam horizontally on the clamping support at one end, Measure the length of cantilever L distance from clamp end to loading point, Fix the dial gauge under the beam at the loading point to read downward moment and set to zero, Hang the loading pan at the free end of the cantilever, Load the cantilever with different loads and note the dial gauge readings. And next find moment of inertia I to calculate of the

different weights to the different stress values as shown in fig.4

The deflection and moment of inertia of cantilever beam calculated and presented in table.4 using the formula as follow:

$$\text{DEFLECTION}=\delta = WL^3/3EI$$

$$\text{MOMENT OF INERTIA } =I =bh^3/12$$

$$\text{STRESS}=\sigma=MY/I$$

Where M is the bending moment, Y is distance from the reference line to the last layer, I is the moment of inertia.

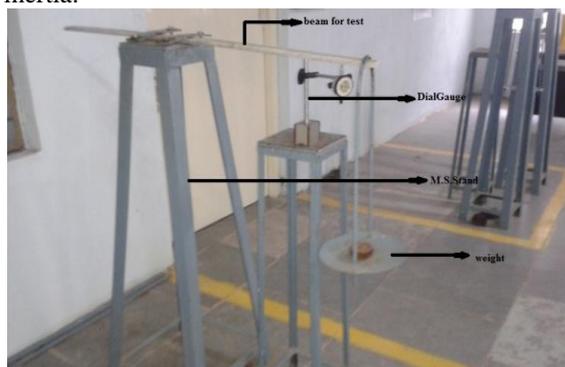


Fig: 4. Experimental setup of cantilever in the glass epoxy composite beam

### VII. RESULTS AND DISCUSSION

The different experiments are carried out with help of the experimental set up at different loads and noted results. From the results calculated the deflection and stresses and tabulated in a table 4. The errors in deflections and bending stress are evaluated by the difference between experimental value and numerical value.

Table 4 : Experimental Stress in Composite Beam in Comparison of Results with Analytical Solutions:

Comparison of Experimental and Numerical Results					
S. NO	Different loads (N)	Deflection of Experimental (mm)	Numerical Deflection (mm)	Stresses of Experimental ( $N/mm^2$ )	Numerical Stresses ( $N/mm^2$ )
1	5	1.3166	1.2997	3.4179	3.4525
2	10	2.6333	2.5994	6.8359	6.9050
3	15	3.9500	3.8991	10.2539	0.3575
4	20	5.2666	5.1988	13.6718	3.8100
5	25	6.5833	6.4985	17.0898	17.2625

Fig: 5 show the variation in the deflection error as load increases on the beam. The error is increases

in gradually from 0.015mm to 0.085mm as load changes 5N to 25N.

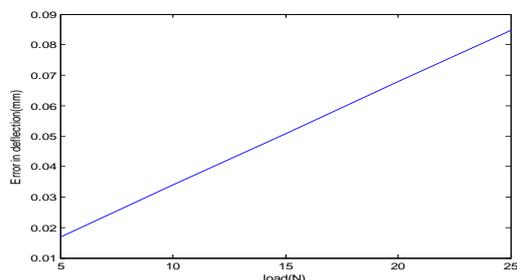


Fig:5 The variation of error in deflection with respect to load

Fig 6. Show the error is decrease as load increasing on the beam. The developed analytical model can be utilizes bending stress and deflections instead of checking beam for higher loads. The braking loads in the evaluated easily by considering the composite beam strength and moment of inertia of cross section of the beam. The braking of load is 3703N in cantilever beam.

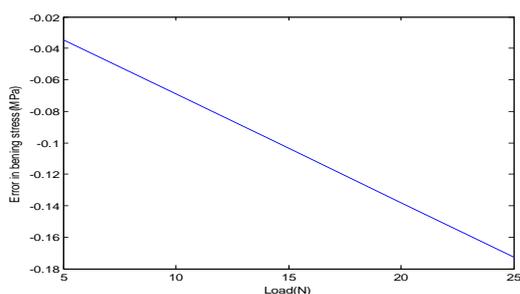


Fig:6. the variation of error in stress with respect to load

## VIII. CONCLUSIONS

In this work the experimental setup is prepared and evaluated the experimental values of stress and deflections of composite beam with cantilever arrangement. MATLAB CODES are used to implement the analytical expressions that are derived for numerical values.

Bending tests are conducted with a load range from 5-25N. The experimental values of deflection and bending stress are compared with the numerical values obtained by Mat lab codes and observed good agreement between them.

Simulation studies also carried out on beams having different orientations like like  $(0^0, 30^0, 45^0)$ . It is found that unidirectional fibers  $(\theta = 0^0)$  contributing less deflections and less bending stresses in the glass/epoxy composite beam. It is found that increasing number of layers in beam with overall same cross-section dimensions, same increases bending stresses and decreases deflections.

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