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# MECHANICAL PROPERTIES OF DENSITY GRADED E-GLASS FIBER REINFORCED CARBON NANO TUBE MIXED POLYESTER RESIN COMPOSITES

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**Abstract--** The mechanical failure behavior of fiber reinforced polymer composites is extremely basic to the designing applications. The crack modes and failure modes of the components under strain must be completely comprehended with an end goal to understand the energy absorption capacity of such composites. The present study involved in the preparation of density graded E-glass fiber laminates (DGL) addition of multi walled carbon nano-tube by weight percentage and mechanical property evaluation of density graded FRP made of E-Glass fiber and polyester resin. The property evaluation involves tensile strength, flexural strength and Intra laminar strength. The obtained test results show that MWCNT content significantly affect the different properties of laminates. Tensile, and Flexural strength values of MWCNT content specimens show increasing trend compared to non MWCNT content specimens. Hence MWCNT content specimens show best results compared to non-MWCNT filler content ones.

## INTRODUCTION

As glass fiber strengthened polymer composites (FRP) present expanding significance as load bearing parts in numerous applications [3], precise prediction of quality and failure behavior turns out to be important[4]. Size and density of the component are parameter in prediction of mechanical properties of composite part. As per literature, [2] strength of the FRP increases with increasing the fiber mat density, which also affects density and thickness of overall composite [5]. This weight to strength ratio and thickness to strength ratio effect can be minimized by fabrication of composites by density grading, which increases significance for the improvement of thin-laminate for fabricating composite components.

Carbon nanotubes (CNTs) have high potential for the modification of glass-fiber strengthened polymer (GFRP) composite. This paper presents the preparation of MWCNT/GFRP composite utilizing the hand lay-up method. In the field of composite materials most of the researchers indicate enthusiasm for utilizing the nano material as a filler material. Carbon nano tubes assume an imperative job in making high performing composites which could take care of industrial requirements. Presently characteristic of CNT's places a major role in the composite material area because of its remarkable characteristic to modify the property of the polymer matrix composites [1]. Carbon blacks, Graphene and Carbon nano tubes are the fillers most generally utilized as strengthening E-glass strands in polymer network [6]. Filler materials are utilized to lessen the material expenses and to enhance mechanical properties to some extent [7]. Filler materials likewise build the properties like adhesion between matrix and fiber which acts as crack bridges and lessen shrinkage after polymerization [8].


 

Mechanical properties of E- Glass fiber Reinforced polyester resin composites are significantly impacted by the filler loading and density of the fiber mat and these overlays discover applications in the aviation, marine industry and automobile industries [9-12]. The examination was focused on preparing the density graded E-glass fiber mat strengthened polyester resin composite laminates with varying MWNCT weight concentration and the properties were examined.

## MATERIALS AND METHODS

### Materials

Density graded laminates were made from E-glass fiber mat of 300gsm,450gsm and 600 gsm, unsaturated polyester resin with hardener MEKP as matrix supplied by Fibro reinforced plastic Pvt Ltd,Bengaluru. MWCNT powder was used as filler materials supplies by Platonic Nanotech Pvt Ltd. Fabrication were done at room temperature by hand layup technique and laminates were cured at room temperature.

### Fabrication of Density graded laminates

Density graded laminates were prepared by hand layup method. The laminates are prepared with constant number of plies of E-glass fiber as shown in Figure 1. Stacking was made in the order of 2 plies of 300 gsm fiber mat + 450gsm fiber mat +600gsm fiber mat for 2 to 4 mm thickness laminate and. Density graded laminates filled with varying concentrations (0.1 and 0.2 wt. %) of MWCNT powder. The addition of MWCNT particles beyond 0.2 weight % during hand layup process of composite preparation , form a high viscose resin matrix mixture that lead to difficulty in applying the resin also decrease resin wettability which in turn weaken the bonding between matrix and reinforcement.

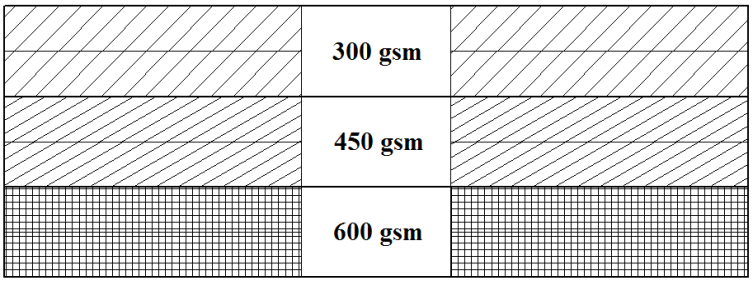


**FIGURE 1:** Configuration of lamination

### Sample preparation

The prepared density graded laminates were taken from the mould and then specimens were prepared for mechanical tests according to ASTM standards as shown in Table 1. Three identical test specimens were prepared for different tests.

**TABLE 1**: *ASTM Standards*

| Test | ASTM Standards |
|---|---|
| *Tensile* | *ASTM-D3039* |
| *Flexural* | *ASTM-D790* |

Mechanical testing

### Tensile test

Three samples from each variation of the specimen were tested, the tensile behavior of prepared samples was determined at room temperature using Universal testing machine**.** The tensile test was carried out according to ASTM-D 3039. A displacement controlled cross head speed of 1mm/min was used; the specimen dimension was 250 mm x 25 mm x 4 mm. Three identical specimens of each type were tested and Load –Displacement curve were recorded. Details of Universal testing machine: FIE make displacement controlled; computerized UTM machine, digital extensometer attachment was used to find the Young's modulus of the material.

### Flexural test

The flexural test was carried out according to ASTM-D 790. The specimen dimension was 130 mm x 25 mm x 3 mm with a support span length of 100 mm. The flexural test was performed using a three point bending for the laminates. The loading was done on the specimen, loaded from low density fiber mat side. Details of Universal testing machine: FIE make displacement controlled, computerized UTM machine.



 

## RESULTS AND DISCUSSIONS

Experiments have been conducted to estimate the mechanical properties and characterization of density graded fiber mat composite material under various loading conditions and with various MWCNT percentage. The outcome of investigations and the impact of different parameters on the properties are presented in the following sections. The tensile strength, flexural strength, intra laminar strength for different MWCNT content of density graded mat laminates are presented in Table 2 and their variations shown in the Figures 3a and Figures 5a respectively.

### Tensile strength

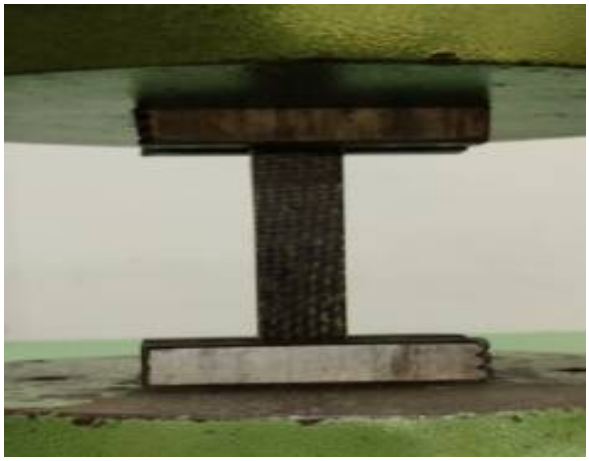

**FIGURE 2.**Tensile testing of the specimen

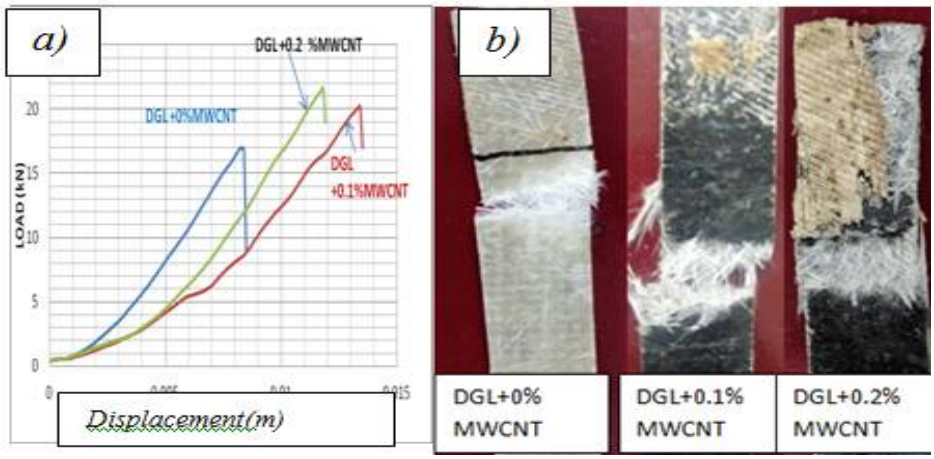


**FIGURE 3.** Representative Load –Displacement curves (a) and tested specimen photographs obtained in tensile testing.

The longitudinal young's modulus for different MWCNT content of density graded mat laminates are presented in Table 2.

**TABLE 2.** Tensile properties of DGL laminate.

| Density Graded Laminates (DGL) | Longitudinal Young's modulus (GPa) |
|---|---|
| *DGL+0% MWCNT* | *25.516* |
| *DGL+0.1%MWCNT* | *32.915* |
| *DGL+0.2%MWCNT* | *36.156* |

Figure 3 (a) indicates that in respect of tensile strength, among all the laminates, laminates with 0.2% MWCNT content having higher values when compared with unfilled laminate. The increase in the tensile strength of density graded laminates may be due to the restriction of the mobility of the matrix. A maximum tensile strength was observed in laminates with 0.2% MWCNT content when compared with the other laminates, which is due to good bonding between matrix and reinforcement material.



 

**Flexural strength**

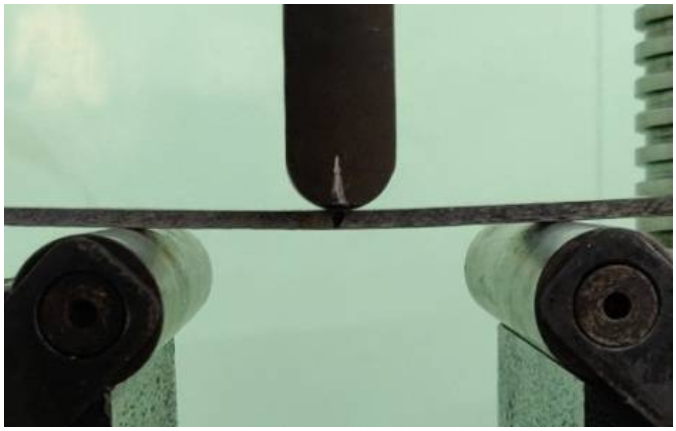

**FIGURE 4.**Flexural testing of the specimen

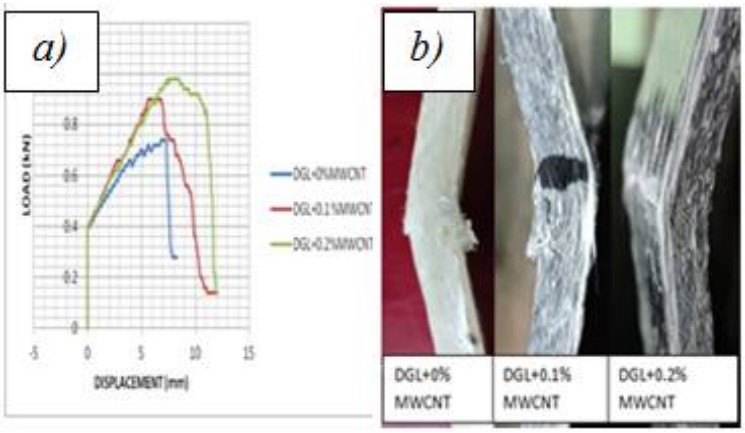


**FIGURE 5.** Representative Load –Displacement curves (a) and tested specimen photographs obtained in 3-Point bending test.

The flexural strength (S) in the units of MPa was calculated using the following equation;

$$S = \frac{3PL}{2bd^2}$$

Where P is the applied load at the deflection point, L is the span length; d and b are the thickness and the width of the specimen, respectively.

**TABLE 3.** Flexural properties of DGL laminate.

| Density Graded Laminates (DGL) | Flexural strength (MPa) |
|---|---|
| *DGL+0% MWCNT* | *218.75* |
| *DGL+0.1%MWCNT* | *281.25* |
| *DGL+0.2%MWCNT* | *309.375* |

Figure 5 indicates the load displacement curve of flexural specimens, the result shows that flexural strength of specimen with 0.2%MWCNT content having higher value of strength among all the laminates, laminates without MWCNT content failed due to fiber failure at the tensile side (bottom layer) and also delamination between the laminates can be observed. Laminates with MWCNT content failed purely by fiber failure at tensile side due to good bonding between matrix and reinforcement material.



 

## CONCLUSIONS

In the present work, the test results on the effect of MWCNT content on mechanical properties of density graded laminates shows the following conclusions

- The present study shows that MWCNT content has significant effect on the different mechanical properties of laminates.
- The tensile, flexural and intra laminar strength of laminates increase with increase in MWCNT content. Laminate with 0.2% (Weight percentage) having maximum tensile strength and flexural strength .
- The experimental observation during tensile test shows that laminate with 0.2% MWCNT takes maximum load with minimum elongation which concludes that higher content of MWCNT content decreases the elongation of the specimen.
- The experimental observation during flexural test shows that laminate without MWCNT content fails due to fiber fracture and also delaminating between the laminates. But in case of laminate with MWCNT content failed due to pure fiber fracture. It can conclude that MWCNT gives good adhesion between the laminates.

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