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# Mechanical Characterization of GFRP Hybrid Composite with Nano Filler

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**ABSTRACT:** Nano-particles when used as reinforcement in polymer matrix leads to very good mechanical and other physical properties. When these mixture of nano-particle and polymer are used in Fabricating Reinforced Polymer (FRP) there is significant improvement in tensile strength and bending strength. These hybrid FRP is also referred as multi functional composites. In this method of experimental work three different types of nano-particles namely carbon nanotube, nano silica and iron oxide are used as filler in the epoxy resin polymer with different weight percentages to enhance their tensile strength, bending strength.

**KEYWORDS:** Tensile strength, bending strength, carbon nano-tube, nano silica, iron xide and resin polymer.

### I. INTRODUCTION

Polymer composites have more complicated properties as they display elastic and viscous responses at different strain rates and temperatures [1–3]. Young's modulus can be improved by adding inorganic fillers since it generally has a much higher stiffness than polymer matrices [4]. The two main forms of iron oxide are magnetite ( $\text{Fe}_3\text{O}_4$ ) and its oxidized form magnetite ( $\text{Fe}_2\text{O}_3$ ). They have attracted extensive interest due to their super paramagnetic properties and their potential applications in many fields hence it is being used in the research. The nano silica currently cannot attain the mobility that poly-Si can, it has the advantage over poly-Si that it is easier to fabricate, as it can be deposited using conventional low temperature amorphous silica deposition techniques. However, there is an increasing awareness of possibilities to simultaneously improve a broad range of mechanical properties and reduce costs by incorporating nanometer-sized particles [5–8]. The filler of carbon nanotubes (CNTs) have shown major attention in last decade, mainly because they possess extraordinary properties and therefore, have many potential applications [9]. For example, they have high stiffness [10–15], strength [16–17], thermal conductivity [18,19], electrical capacity [20] and thermal stability [21]. To obtain suitable dispersion of MWCNT in epoxy, the highest filler ratio (1 wt.%) was chosen. The sonication durations were kept constant for one hour.

The aim of this work is to study the influence of polymer based nanoparticles of silica, cabontube and iron oxides with different ratios in PVC host on the mechanical properties such as tensile strength and bending strength.

### II. . MATERIALS AND METHODS

The nano polymer composite was prepared from 66% of unidirectional glass fibre and 34% of chopped stand on weight basis having 600 GSM thick size. Lapox L12 resin is used as polymer with K6 as hardner. The fillers of nano particles were used in this experimental work are nano silica, multi wall carbon nano tube(MWCNT) and nano iron oxide .

The outer diameter of MWCNT is 30-50 nm and inner wall is 15-20 nm. The length of MWCNT was found to be 10-15  $\mu\text{m}$ . The bulk density and specific area of MWCNT are 0.21  $\text{g}/\text{cm}^3$  and 110  $\text{m}^2/\text{g}$ . MWCNT used were 99.8% pure. Nano silica used is of 50 nm size and spherical in shape. Nano silica has a specific surface area of 110-120  $\text{m}^2/\text{g}$

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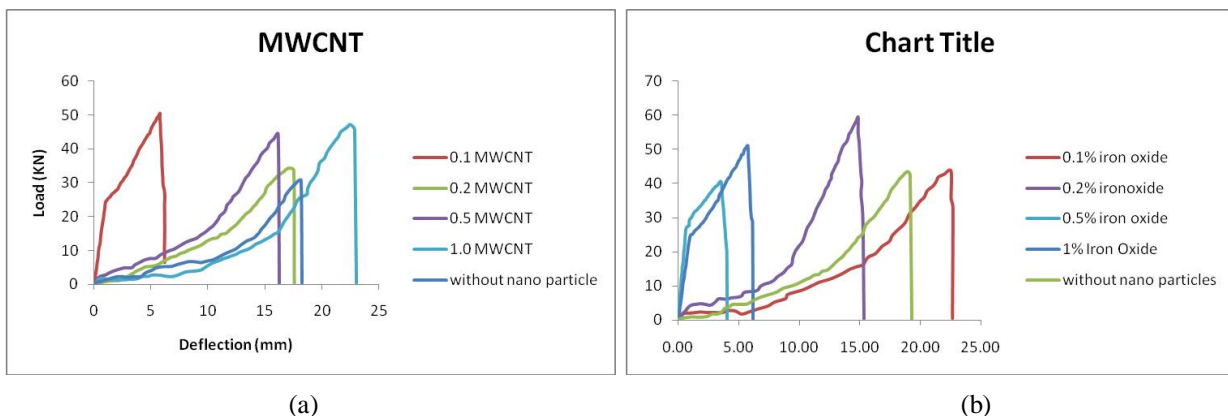
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and bulk density of  $2.4 \text{ g/cm}^3$  which has purity of 99.9%. Iron oxide used is also of 50 nm size, and has specific surface area of  $30 \text{ m}^2/\text{g}$  and bulk density of  $5.242 \text{ g/cm}^3$  with a purity of 99.9%.

The fabrication was done by hand layup method. The size of the mould used is  $325 \times 300 \text{ mm}^2$ . The mould is of two part and made up of mild steel for good thermal conductivity and to avoid deformation under thermal loads due to exothermic reaction of resin. The inner surface of mould that is both top and bottom moulds are well coated with wax polish which act as releasing agent. Four layers of E-glass fibers are used and each layer is of size  $250 \text{ mm} \times 250 \text{ mm}$ . With each nano particles four sample are fabricated by varying their weight percentage with respect to resin as 0.1%, 0.2%, 0.5% and 1%. For good improvement in strength even dispersion of nano particles is necessary. To achieve this nano particles were stirred and mixed with mechanical stirrer and ultrasonic bath. The nano-particles and resin was stirred mechanically and then this mixture was kept in ultrasonic bath for 1 hour. Using this mixture laminates were fabricated. The thirteen laminates were fabricated using polyester resin. The content of glass fiber is maintained constant. The four different weight percentage of samples with each nano-particle and one with neat resin (without nano particles). These laminates samples were cut for tensile and bending as per ASTM standards of D-3039 and D-790.

### III. RESULTS AND DISCUSSIONS

Fig. 1(a) shows the variation in tensile load with respect to displacement for different weight percentage of MWCNT. It has been observed that with the addition of MWCNT in glass-polyester composite there is increase in tensile load carrying capacity. Also there is increase in ductility of laminate as the break point is continuously increasing with 0.1% to 0.5% of MWCNT, with the addition of 1% MWCNT brittleness is observed due to agglomeration of MWCNT in resin. According to (M.M. Shokrieh et al) results, the tensile strength did not show any significant improvement by adding MWNTs [22]. But for 0.1% of MWCNT by weight, its tensile strength increased for about 95% in our experimental result. From fig. 1(b), it is evident that the tensile load carrying capacity of specimen is more for 0.2% iron oxide mixed laminate. There is no much change with addition of nano iron oxide in different percent breaking point which indicates the material does not change in its behavior. And by adding nano silica as filler the maximum tensile load was also observed at 0.2% and 0.5% and there is a slight variation in breaking point which is shown in fig. 1(c).

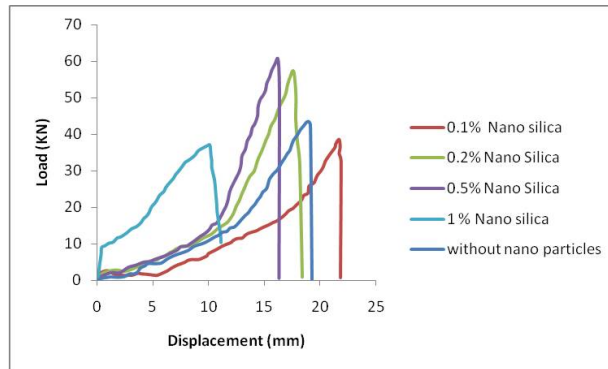


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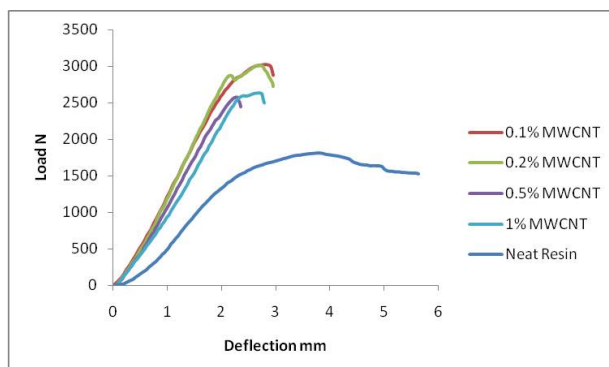
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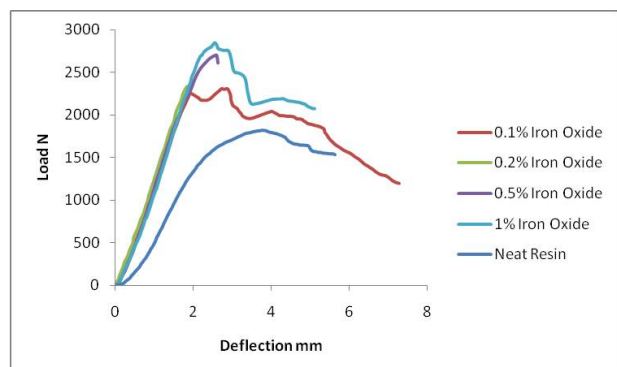
(c)

Fig. 1: Displacement versus tensile load in different weight percentage for (a)MWCNT (b) Nano iron oxide (c) silica nano particles

The figure 4 shows the variation of load in Newton with respect to deflection in mm for the nano particles of MWCNT. It is clear that there is similar variation in deflection with the addition of different percentage of MWCNT nano particle up to the elastic limit. For all hybrid composite of MWCNT the braking take place immediately after elastic limit. Where as for with out nano particles composite of a non linear behavior is absorbed. According to (M.M. Shokrieh etal) at only 0.05 wt.% MWNT, the flexural strength was increased by 45% [22] and for 0.5 wt.% of MWCNT our result has shown 39% . From figure 5 the maximum bending strength was observed for 1% of Nano Iron oxide, and and the flexural strength goes on increasing with the addition of nano particles. The material is getting deformed more before breaking in higher percentage of nano iron oxide. There is variation of slope occurs in all nano added laminates. Due to the addition of nano silica there is an increase in breaking load under bending for all the weight percentages. Non linear behavior is not observed with nano silica as filler and breaking takes place just after elastic points as shown in Figure 6. According to (Vijay Chaudhary etal) the reduction in the flexural strength of the composites with filler of silica nano particles content is probably caused by an incompatibility of the particulates and the epoxy matrix, leading to poor interfacial bonding[23]. And as per graphs it clears that the bending strength of hybrid composite with nano silica increased up to 92 % with the addition of 1% by weight.



(a)



(b)

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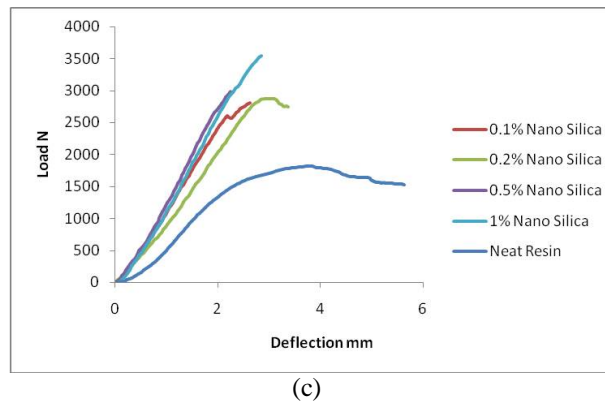


Fig. 2: Deflection versus Bending load in different weight percentage for (a)MWCNT (b) Nano iron oxide (c) silica nano particles

## IV. CONCLUSION

Glass fibre reinforced composite material with unsaturated epoxy as matrix were fabricated using hand lay up method and three different nano particles namely nano silica, nano iron oxide and MWCNT with different weight percentages has shown good mechanical properties. The tensile strength of hybrid composite with nano silica increased up to 100% when 0.1% MWCNT was added by weight, its value increased for about 104% when 1% Nano silica was added, and 100% for 1% of nano iron oxide. In bending the strength increased for specimen upto 52% for 1% weight of nano silica, for MWCNT the enhancement is 63% for 0.5% weight and in nano iron oxide the improvement is was about 55% for 1% weighth. From tensile test it can be concluded that material is behaving more as ductile with the addition of MWCNT, and it behavior is not changing much for other nano particles.

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