FABRICATION AND COMPARISON OF MECHANICAL PROPERTIES OF HYBRID GFRP USING EPOXY MODIFIERS

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Abstract - Fiber reinforced polymer composite is an important material for structural application. The diversified application of FRP composite has taken centre of attraction for interdisciplinary research. However, improvements on mechanical properties of this class of materials are still under research for different applications. In this thesis work, hybrids GFRPs were fabricated using epoxy modifiers (Al_2O_3, $SiO_2$and TiO_2) using Hand Lay Up technique. Epoxy modifiers were used individually and in various combinations. All GFRPs were subjected to tensile strength test and flexural strength test. Results were analyzed and compared with the results for GFRP fabricated without using any modifier .While the use of single modifier shows significant increase in the Tensile Strength for the hybrids fabricated with TiO_2 and Al_2O_3, flexural strength is increased in hybrid fabricated with silica when compared to standard GFRP. When all the three modifiers were used Flexural strength and Tensile strength is lesser when compared to standard GFRP. When hybrids were fabricated with 2 modifiers only Hybrid fabricated with TiO_2 and SiO_2 increased the tensile strength and flexural strength of the standard GFRP.

Key Words: GFRP, HAND LAY UP TECHNIQUE, TENSILE STRENGTH TEST, FLEXURAL STRENGTH TEST , EPOXY MODIFIERS

1.INTRODUCTION

In the last few decades composite materials have emerged as an important player in the fields ranging from automotive industry to aerospace industry to sporting goods and every other industry where primary requirements are long term properties. Because of their wide applications various researches had been done to develop new composites or to modify the existing ones. Epoxy based composites have the potential to replace the conventional metallic materials. One of the approaches while developing a new kind of polymer structural material is polymer matrix modification. This modification can be achieved by adding various ceramic powders of various sizes in the polymer matrix to obtain the desired mechanical properties. Ramesh K. Nayak et.al (2014) studied the effects of silica, alumina and TiO_2 micro powders in the polymer matrix. They found that (I) Mechanical properties like ILSS, flexural strength and flexural modulus are more in case of SiO2 modified epoxy composite compare to other fillers Improvement of mechanical properties increases with decrease in ceramic particle size (II) Alumina modified epoxy composite increases the hardness and impact energy compare to other modifiers.(III) Agglomeration of Al2O3 micro particles in the matrix is observed. Amar Patnaik et al. (2008) has reported the effect of different ceramic fillers on the solid particle erosion characteristics of glass-polyester composites. Two industrial wastes (fly ash and cement by-pass dust) rich in metal oxides and two conventional ceramic powders (Al2O3 and SiC) have been used as the filler materials. The unfilled glass polyester composite has a strength of 349.6 MPa in tension and that this value drops to 304.5 MPa and 279.4 MPa with addition of 10 wt% and 20 wt% of fly ash respectively. Among the four fillers taken in this study, the inclusion of alumina causes maximum reduction in the composite strength. Jin Zhang et al. (2012) investigate the influences of stacking sequence of on the strength of hybrid composites comprising materials with differing stiffness and strength. Hybrid composite laminates were manufactured using varying ratio of glass woven fabric and carbon woven fabric in an epoxy matrix. Static tests including tension, compression and three-point-bending were carried out to composite coupons containing various ratios of carbon fibres to glass fibres. The results show that hybrid composite laminates with 50% carbon fibre reinforcement provide the best flexural properties when the carbon layers are at the exterior, while the alternating carbon/glass lay-up provides the highest compressive strength. Yongli Zhang et al (2013) studied the mechanical behaviors of unidirectional flax and glass fiber reinforced hybrid composites with the aim of investigation on the hybrid effects of the composites made by natural and synthetic fibers. The tensile properties of the hybrid composites were improved with the increasing of glass fiber content. The fracture toughness and inter laminar shear strength of the hybrid composites were even higher than those of glass fiber reinforced composites due to the excellent hybrid performance of the hybrid interface. These macro-scale results have been correlated with the twist flax yarn structure, rough surface of flax fiber and fiber bridging between flax fiber layers and glass fiber layers. Chensong Dong, and Ian J. Davies (2014) study on the flexural and tensile moduli of S-2 glass and T700S carbon fibre reinforced hybrid epoxy composites in intra-ply configurations is presented in this paper. Finite element analysis (FEA) and Classic Lamination Theory (CLT) were employed to model the flexural behavior of hybrid composites, which was obtained from the three point bend test in accordance with ASTM: D790-10 at various span-to-depth ratios. The flexural moduli were obtained from the load–displacement curves. The models were validated against the experimental results from a previous study.

From the literature review it can be observed that with the addition of modifiers like Al_2O_3, SiO_2 and TiO_2 significant improvement in the mechanical properties of FRPs has been achieved. These modifiers are used individually with equal weight percentage, however effects on mechanical properties while using them together and in various weight percentages has not been studied. Therefore in this paper effects on the mechanical properties of GFRPs while using epoxy modifiers in various combinations has been studied.

2. Experimental details

2.1 Materials

In this study micro powders of Al_2O_3 (<200 micron), SiO_2 (<10micron), TiO_2 (<300micron) were used as epoxy modifiers. Commercially available woven fabric roving E-Glass fiber of 45^0 orientations was used as re-enforcement. Unsaturated polyester resin was used as epoxy

2.2 Fabrication of Hybrid GFRP

Table -1: DESIGNATIONS AND COMPOSITION OF HYBRID GFRPs

GFRP	EPOXY%	GLASS FIBRE%	AL_2O_3%	SiO_2%	TiO_2%
A	100	60	10	NIL	NIL
T	100	60	NIL	NIL	10
S	100	60	NIL	10	NIL
AT	100	60	5	NIL	5
AS	100	60	5	5	NIL
TS	100	60	NIL	5	5

There were total of 6 types of hybrid composites with various combinations of epoxy modifiers which were fabricated using hand lay-up method. Initially the micro alumina/silica/titania powders were dried at 600 C for 3 hours before mixing with unsaturated polyester resin. The fillers were mixed with neat unsaturated polyester resin and stirred manually using glass rod for a time period of 1hour before hardener addition. In each layer of the composite, mild steel (MS) roller was used to remove air entrapped and maintain uniform thickness. Laminates are cured at room temperature for 72 hours before characterization.

3. Results and Discussions

3.1 Tensile Test

Test Method - IS: 1608:2005
Instrument Used- UTE100
Capacity – 100 KN
Resolution-0.01 KN
Make- FIE
Temp. Range- 22^0C-28^0C
Relative Humidity- 40-60 %

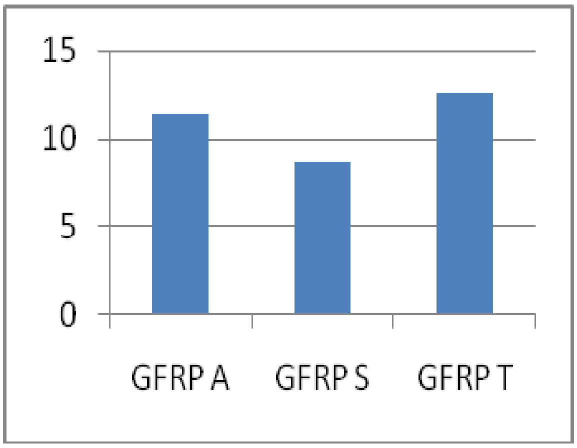

FIG.1-TENSILE STRENGTHS FOR HYBRIDS REINFORCED WITH SINGLE MODIFIER

Fig.1 represents the graphical representation of investigated results of Tensile strength by performing test on hybrid GFRP A, S and T. It is clear from Figure 5.1 that tensile strength of GFRP (T) is considerably higher than that of A and S. This indicates that adding TiO_2 has highest positive impact on tensile strength when used as epoxy modifier. Tensile strength is least in the GFRP in which SiO_2 is used as Epoxy modifier. Results for GFRP T shows the increase in tensile strength by 37% which is the highest, GFRP A has also increased the strength of standard GFRP by 25%. Addition of Silica resulted in the decrease of tensile strength by 5%.

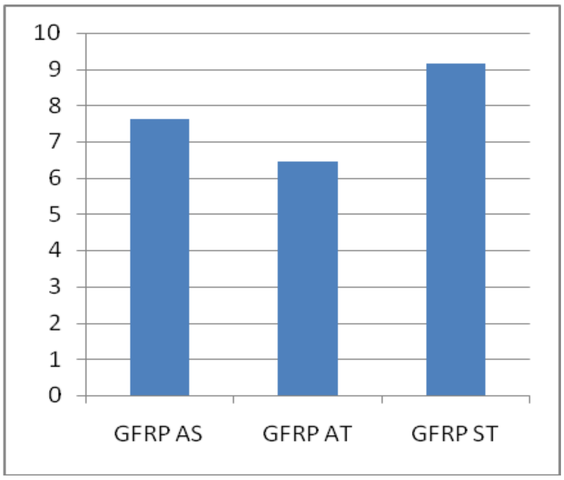

FIG.2-TENSILE STRENGTHS FOR HYBRIDS REINFORCED WITH TWO MODIFIERS

Fig.2 represents the graphical representation of investigated results of Tensile strength by performing test on hybrid GFRP AS AT and ST. From Fig. 5.2 it is clear that tensile strength of ST is more than that of AS and AT. Tensile strength is least in GFRP AT. Tensile strength of both AS and AT is lower than the standard GFRP. Results for GFRP ST shows the increase in tensile strength by .38%, GFRP AS decreased the strength of standard GFRP by 16%. GFRP AT shows the decrease in tensile strength by 30%.

3.2 Flexural Strength Test

Test Method - IS: 1608:2005
Instrument Used- UTE100
Capacity – 100 KN
Resolution-0.01 KN
Make- FIE
Temp. Range- 22^0C-28^0C
Relative Humidity- 40-60 %

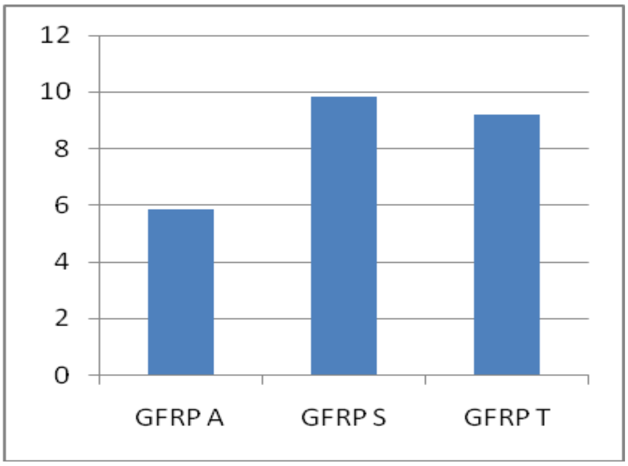

FIG.4 FLEXURAL STRENGTHS FOR HYBRIDS REINFORCED WITH SINGLE MODIFIER

Fig.4 represents the graphical representation of investigated results of Flexural strength by performing test on hybrid GFRP A, S and T. It is clear from Figure 5.4 that flexural strength of GFRP (S) is considerably higher than that of A and standard GFRP. This indicates that adding SiO_2 has highest positive impact on flexural strength when used as epoxy modifier. Flexural strength is least in the GFRP in which Al_2O_3 is used as Epoxy modifier among all the three modifiers used. While it's worth noting that every modifier used has enhanced the flexural strength of the standard GFRP. Results for GFRP T shows the increase in tensile strength by 85% which is the highest, GFRP A has also increased the strength of standard GFRP by 17%. Addition of Silica resulted in the increase of tensile strength by 98%.

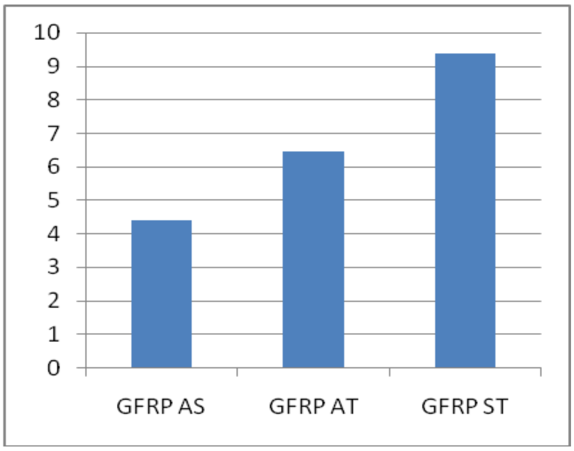

FIG.5. FLEXURAL STRENGTHS FOR HYBRIDS REINFORCED WITH TWO MODIFIERS

Fig.5 represents the graphical representation of investigated results of Flexural strength by performing test on hybrid GFRP AS AT and ST. It is clear that flexural strength of ST is more than that of AS and AT. Flexural strength of GFRP S is considerably higher than standard GFRP. As can be interoperated from the fig. flexural strength of AS and AT have negative impact on flexural strength of standard GFRP. Comparing AS and AT it can be stated that AS has more flexural strength than AT. Results for GFRP ST shows the increase in tensile strength by 89%, GFRP AS decreased the strength of standard GFRP by 11%. GFRP AT shows the decrease in tensile strength by 20%.

3. CONCLUSIONS

1. The successful fabrications of a new class of epoxy based hybrid composites reinforced with glass fiber have been done. The present investigation revealed that epoxy modifier significantly influences the different properties of composites.
2. The maximum Flexural strength i.e. 9.845 kgf/mm^2 is obtained for hybrid prepared with the addition of 10 wt % of silica in the epoxy. It has increased the Flexural strength of GFRP by 98% .
3. However, the maximum Tensile strength i.e. 12.576 kgf/mm^2 is obtained for hybrid prepared with the addition of 10 wt % of Al_2O_3 in the epoxy. It increases the tensile strength of GFRP by 37%.
4. Hybrid having 5 wt% of both TiO_2 and SiO_2 has the maximum Flexural strength and Tensile strength among the hybrids composed using 2 modifiers in equal proportions , its impact on tensile strength the GFRP is increase of tensile strength by .38% however it increases the flexural strength of the GFRP by 89%.
5. While the use of single modifier shows significant increase in Tensile Strength in case of TiO_2 and Al_2O_3, flexural strength is increased in the case of the silica hybrid when compared to standard GFRP.

6. Only Hybrid prepared using TiO_2 and SiO_2 has increased the tensile strength and flexural strength of the standard GFRP where combination of two modifiers is used.

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BIOGRAPHIES

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