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Experimental Evaluation of effect of filler on tensile behaviour of E-glass/epoxy composites

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Abstract-*The present work describes the processing and tensile characterization of polymer matrix composites (PMC). Two types of E-glass laminates namely woven and chopped are used as a reinforcing materials and epoxy resin constitutes matrix system. Several works has been carried out to prove that strength of glass fibre composites progressively increased with adding fillers. Keeping this in mind the present work successeded in using wollastonite as a filler material, tensile test samples from both woven and chopped type were prepared and tests are conducted as per ASTM standards and corresponding results are tabulated and discussed. The present work also highlights the tensile strength for both woven and chopped laminates were compared. It is observed that use of wollastonite filler influences greatly on tensile properties of polymer matrix composites. And it is also cleared that woven laminates shows higher resistance to tensile loading as compared to chopped laminates.*

Keywords: wollastonite, filler composites, polymer composites, strength of composite.

I. INTRODUCTION

Composites are combination of two materials in which one of the materials, Composite materials are formed from two or more materials producing properties that could not be obtained from any one material. One of the constituent materials acts as the matrix and at least one other constituent material act as the reinforcement in the composites. Composite materials emerge as a promising alternative to correct the deficiencies caused by steel reinforcement in concrete structures [1-5]. Composite materials have replaced metals in various engineering applications owing to their numerous advantages, like high strength/weight ratio, low cost, low density, better stealth properties, etc. Due to these advantages, there is an increasing demand for use of these materials in defense applications like naval ships, warplanes, armor vehicles and re-entry vehicles. In addition to this composites find their applications in automotive and aerospace industries such as bushes, gears, seals, cams, shafts etc. The most common types of reinforcement used in polymeric matrix composites (PMC) are strong and brittle fibres incorporated into a soft and ductile polymeric matrix. In this case, PMC are referred to as fibre reinforced plastics (FRP's). Composites in civil engineering applications have been steadily increasing. This is primarily due to the ever-increasing demand for materials, which are characterized by high strength-to-weight and stiffness-to-weight ratios at an effective installed or life cycle cost. The advantageous properties of fibre reinforced polymer (FRP) includes, high strength-to-weight ratio, and corrosion and fatigue resistance create an interest in engineers; the most economical choice depends on the cost of material, production cost, life cycle cost, and material properties. Weight savings and performance, naturally, play a major factor in the choice of materials. A combination of good mechanical properties and relatively low cost makes glass fibre attractive choice for the marine structures. The glass fabric chosen was woven roving E-glass supplied by Fibre Glass Industries' (FGI) and designated as per FGI 1854 and glass fibres had Super 317 sizing for ease of handling, fast wet out, and compatibility with a number of resins including vinylester. The glass fibres reduce the quantity of water absorbable material and thus, the water sorption of FRC should be less compared to that of the matrix polymer. In-plane shear properties of both carbon and glass fibre composites were comparable and inter laminar shear properties of E-glass composites were observed to be better than the carbon composite because of the better nesting between the E-glass fabric layers.

II. FABRICATION OF SPECIMENS

The main materials used are glass fiber with density of 360GSM and 200GSM for both woven and chopped type respectively, Epoxy resin (araldite GY250) and hardner (teta),wollastonite powder as a filler material. Glass fiber is a material consisting of numerous extremely fine fibers of glass. It is most commonly used as reinforcement material because of is exceptional properties. Although not as strong or as rigid as carbon fiber, it is much cheaper and significantly less brittle. Here type of glass fibre used is E-glass, The main compositions of E-glass (electrically conductors) are the oxides of silica, aluminium and calcium. The glass fiber is also regarded as calcium alumino borosilicate glass. Epoxy is the cured end product of epoxy resins, as well as a colloquial name for the epoxide functional group. Epoxy resin is relatively low molecular weight pre polymers capable of being processed under a variety of conditions. In this work a fine powder of calcium ino silicate mineral called wollastonite is used as a filler material. wollastonite sample collected is as shown in Fig.1. The die arrangement for preparing composites and pressing arrangements are shown in Fig 2.

Fig.1: wollastonite sample

Fig.2: Die arrangement

As per the calculations 16 no. of layers of 250x250 sized glass fiber was cut. The required amount of Epoxy resin was weighed. Calculated amount of powdered filler was added. The different percentages of wollastonite used are: 1%, 3%, 5%, 7%. The resin hardner proportion ratio of 10:1 was mixed and thoroughly stirred. The laminate surfaces will be cleaned thoroughly to make sure that they were free from oil, dirt. etc., this process could be done before bonding takes place between the laminates at room temperature and pressure. By using Hand layup technique the glass fiber along with resin was compressed and cured in the die for 24hours. The constant thicknesses of 4 mm are maintained for all specimens prepared. The fabricated and cured samples of both woven and chopped specimens are shown in fig 3 and 4 respectively.

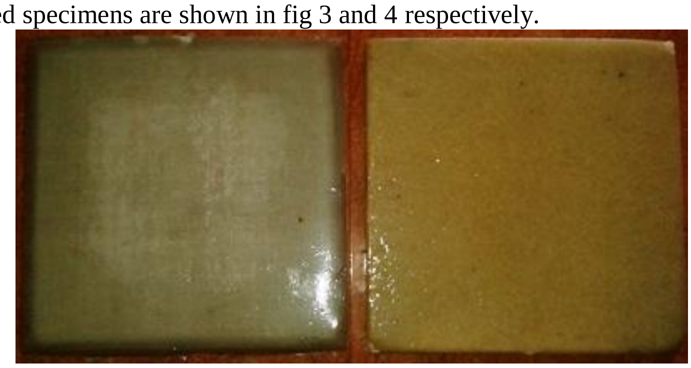


Fig.3: woven sample Fig.4: chopped sample.

III. EXPERIMENTAL METHOD

The tensile test is generally performed on flat specimens. The commonly used specimens for tensile test are the dog-bone type and the straight side type with 14 end tabs. The tensile experiments were performed according to ASTM standard D3039 [6-12th in phase1 rep]. The tensile test specimens of 200*15 dimensions were prepared after resizing of the samples from 250*250mm dimensions in which it is derived from cured glass fibre epoxy reinforced laminates of both woven and chopped strand mats. The grip length at both ends of the specimens for tensile test is allowed to ensure proper breaking of the specimens. A universal testing machine was used for tensile test. The top end of the specimen was fixed by the grips on the top cross-head of the machine while the bottom end was not fixed before applying the load. A slotted steel plate was placed between the top of the bottom anchor and the bottom of the middle cross-head. When the specimen was loaded, this plate engaged the bottom anchor: The load was applied at a constant speed until the failure of the specimen. The tensile test specimens prepared in the order of filler percentage (i.e 1%,3%,5%,7%) for both woven and chopped type is as shown in fig.5 and fig.6 respectively.

Fig 5: UTM MACHINE (for tensile test)

Fig.5: Test Samples of woven fibre with different filler percentage.

Fig.6: Test Samples of chopped fibre with different filler percentage.

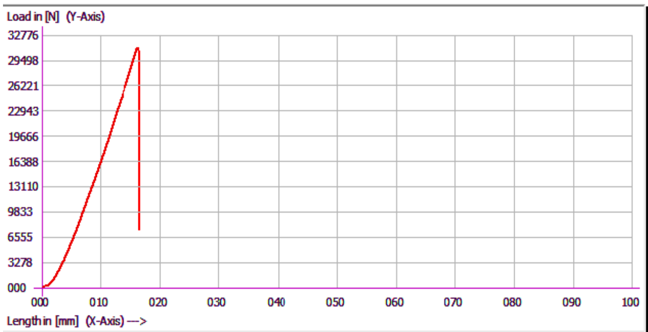
IV. RESULTS & DISCUSSIONS

The fabrication of woven and chopped test samples with different percentage of filler such as 1%,3%,5%,7% are carried out successfully. In order to predict tensile parameters such as ultimate tensile strength, peak load and modulus of tested specimens, simple digital tensile test System is employed. Tensile parameters for fabricated specimens were tested as according to ASTM standards and the results are tabulated. Graph 1 and 2 describes typical tensile load vs. deflection of both woven and chopped specimens of having 1% filler (only 2 sample graphs have been indicated). Curves for both specimens show linear behavior until failure. Curves show inflection at the point of yielding in both cases; tensile strength and tensile stiffness have been recorded. It can be observed from table 1, the effect of filler addition which directly influence on tensile strength of glass fibre composites, for woven fabric laminates, addition of 1% wollastonite material shows that the material is able to withstand maximum load as well as it bears higher values of ultimate tensile strength as compared to the unfilled(without filler) tested samples, this behaviour is continued for the samples containing 3% filler which shows better performance compared to unfilled samples but it lags behind the 1% filled samples in showing greater tensile test results, further increase in adding filler percentage shows least tensile test results. In case of chopped samples, it is observed that effect of filler content influences greatly on tensile parameters, it is cleared that samples congaing higher percentage of filler(i.e 7%)shows maximum resistance to bending load and also bears maximum tensile strength. However, the increase in strength and stiffness in case of woven seems to be more significant as compared to chopped fibers. Finally we observed that, glass/epoxy (woven) with 1% filler have higher strength, stiffness and load carrying capacity than the rest of the samples. Hence, it is suggested that woven fiber is preferred for designing of structures like which is more beneficial for sectors like, Aerospace, auto motives, marine, space etc.

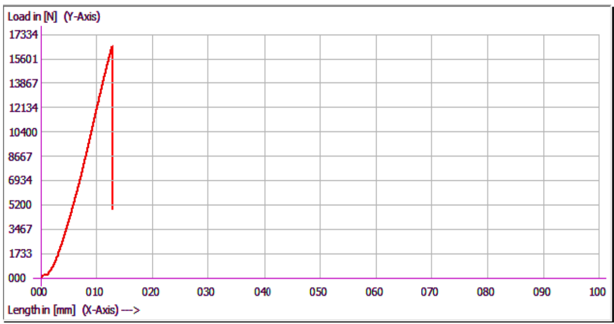
Table 1: Indicates the details of breaking load, ultimate tensile strength.

Details	**Woven sample with different filler in (%)**					**Chopped sample with different filler in(%)**				
	0	**1**	**3**	**5**	**7**	**0**	**1**	**3**	**5**	**7**
Max load (N)	**28795.666**	**31215.234**	**29229.474**	**28742.28**	**26985.387**	**15518.871**	**16508.709**	**16738.948**	**16916.095**	**17447.811**
UTS in N/mm^2	**479.925**	**520.254**	**487.155**	**479.042**	**449.759**	**258.65**	**260.427**	**262.319**	**275.605**	**290.798**
Max. displcmnt(mm)	**16.35**	**16.10**	**17.12**	**14.15**	**14.95**	**12.01**	**12.5**	**12.25**	**13.15**	**12.15**

Fig.7: Failure of test specimens under tensile loading (both woven and chopped type with 3% filler)



Graph 1: shows load v/s length for woven(1% filler)



Graph 2: shows load v/s length for chopped(1% filler).

V. CONCLUSION

Tensile tests were performed on Glass fiber (360 GSM woven & 200 GSM chopped) composite specimens. The load-deflection curve was evaluated. Two types of laminates were tested varying filler percentages. The main outcome of the present investigation are as follows:

1. Effect of filler content in glass fibre composites seems to play significant role in assessing material behaviour under tensile loading conditions.
2. Experiments were conducted on Glass/Epoxy laminate composite specimens with varying fiber orientation to evaluate the tensile properties.
3. It is observed from the result that glass/Epoxy with woven fibre with 1% filler yields' high strength when compare to the remaining alternatives.
4. It is observed from the results, compare to chopped fibre woven glass fibre/Epoxy composites yields high strength.

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