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Mineral Filler Effect on Tensile Parameters of Randomly Oriented and Woven Fabric Plastic Laminates

Lokesh KS
Assistant Professor, Department of Mechanical Engineering & Faculty of Nano Technology, Srinivas Institute of Technology, Karnataka, India

ABSTRACT

Use of mineral fillers draws researchers attention to retain the commercial qualities of fibre reinforced light weight structures. This work signifies the use of two types of E-glass fibres namely woven fabric and randomly oriented fibres are used as a reinforcing materials and epoxy resin constitutes matrix system. Several studies proved that the strength of GFRP composites progressively increased with adding fillers. Keeping this in mind the present work highlights the utilization of mineral filler called calcium ino silicate powder having the composition of CaSio3 as a filler material. By employing hand layup technique samples have been prepared from both woven and chopped type and tensile test is conducted as per ASTM standards and corresponding results are tabulated and recorded. The present work also highlights the comparison of tensile strength for both woven and chopped laminates. It is observed that use of mineral filler influences greatly on tensile properties of polymer matrix composite and it is also cleared that woven laminates shows greater resistance to tensile loading as compared to randomly oriented fibre.

Keywords : Mineral Fillers, Axial Loading, Lightweight Materials

I. INTRODUCTION

Composites are the combination of two or more materials combined in the macro scale to get the integrated properties of individual 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[6-7]. Due to these advantages, there is an increasing demand for use of these materials in defence applications like naval ships, warplanes, armour 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)[8].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 [9]. 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 [10]. 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 vinyl ester [11]. 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

E-glass fibre of woven fabric type and chopped strand mat type with corresponding densities of 360GSM and 200GSM are used respectively along with epoxy resin (araldite GY250) and hardner (teta),mineral powder of 80 microns size 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 [12]. The glass fiber is also called 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. Filler sample collected is as shown in Fig.1.

Fig.1:Calciumino-silicate

Based on the thickness required, number of layers are calculated with 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 hardener 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 of samples are shown in figure .2

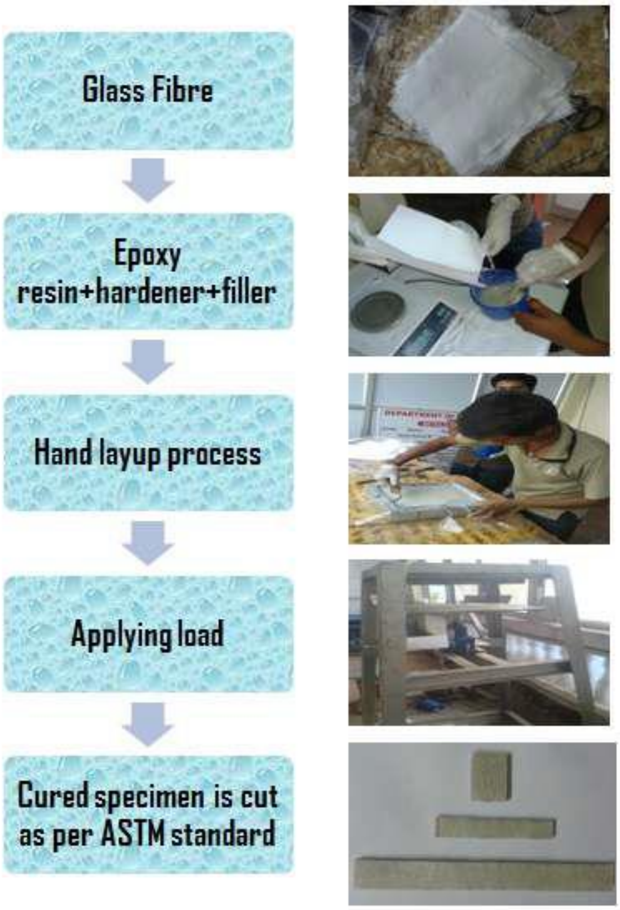

Figure 2:- Specimen preparation

III. EXPERIMENTAL METHOD

The tensile test is generally performed on flat specimens. The commonly used specimens for tensile test are the straight side type. The tensile experiments were performed according to ASTM standard. The specimens that were produced from glass fibre reinforced epoxy with the layup. A universal testing machine was used for the tests. 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 th 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 of 5mm/min until the failure of the specimen. 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. Testing setup is as show in figure 4. 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 4: UTM machine (for tensile test)

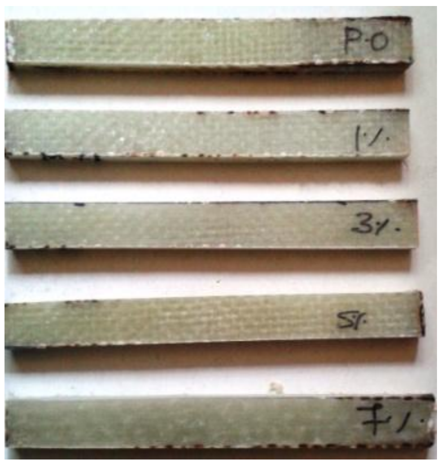

Fig.5: WF Samples for testing.

Fig.6: CSM Samples for testing

IV. RESULTS & DISCUSSIONS

Mineral filler is added by varying the percentage by 1,3,5,7% with epoxy matrix to form the two types of fibres namely woven and chopped samples are prepared successfully by employing manual hand layup technique. 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. Fig 8 and 9describes 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 behaviour 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% filler 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.

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

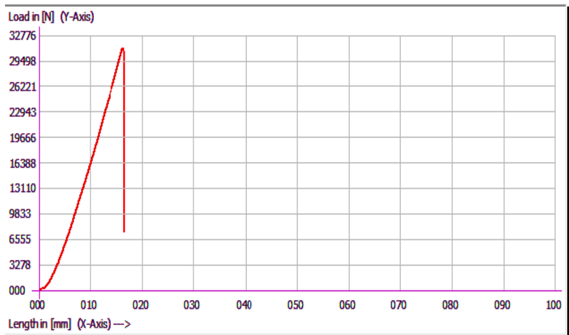

Fig.8: Shows load v/s length for woven (1% filler)

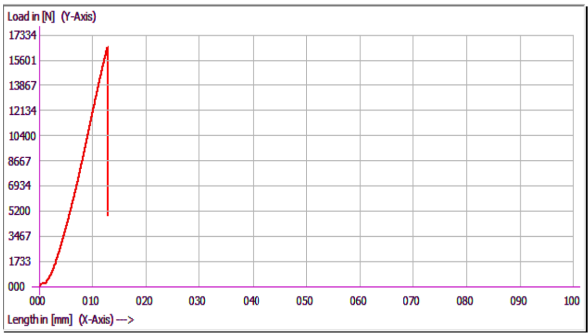

Fig.9: Shows load v/s length for chopped (1% filler).

V. CONCLUSION

Effect of calcium ino silicate mineral filler content in GFRP composites significantly directs the material behaviour in tensile loading conditions. Test is conducted and compared for the two set of samples prepared with varied filler percentage. The load-deflection curve and corresponding stress strain values are recorded . addition to reduction in weight of the sample which concludes the woven samples are comparatively lighter than chopped samples due to over consumption of resin. Experiments were conducted on Glass/Epoxy laminate composite specimens with varying fiber orientation to evaluate the tensile properties. It was observed clearly that woven fabric glass fibre laminates with 1%of calcium-ino silicate mineral filler composites yields' better ultimate tensile strength when compare to the rest of the samples. Compared to the chopped fibres e-glass woven fabric laminates exhibits greater resistance to tensile loading which emphasize the better symmetry of fibre alignment with matrix bonding.

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