International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

Available online: www.ijmrset.com

e-ISSN: 2394-8752, p-ISSN: 2394-8791

Volume-02, Issue-11, November 2015

A Study on Effect of Filler on Mechanical Properties of GFRP Composites

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ABSTRACT: Fiber reinforced plastics are been used for this specific properties and advantages such as weight to strength ratio, tailoring design properties and ease of manufacturing. The complex material behaviour of GFRP composites depends on the properties of the building materials used for. Along with the fiber, reinforcement and voids the addition of the filler would affect the mechanical properties of the composite. The present study is focused on studying the effect of filler material on the mechanical properties of the GFRP composites. Glass/Polyester laminates with different size of fillers (in µmm) and with different weight proportions are prepared for the study. Glass particulates with 106 µmm and 125 µmm are prepared using a ball-mill. Compression molding technique is used to prepare the samples and where subjected to uniaxial tension and bending test. An attempt to study inter-laminar shear behaviour for the laminates with different filler size was also done. The test results showed that there is a considerable effect of the filler size and the quantity of the filler on the mechanical properties of the GFRP laminates.

KEYWORDS: GFRP Composites, Mechanical Properties, Fillers, Inter-laminar shear stress, glass/ polyester.

I. Introduction

Fabric reinforced polymeric composites have gained acceptance for use in many industries including aerospace, automotive, marine, infrastructure, and recently oil and gas. Polymers and their composites are being increasingly employed in view of their good strengths and low densities. Besides, a wider choice of materials and ease of manufacturing make them ideal for many engineering applications. On account of their good combination of properties, fibre reinforced polymer composites are used particularly in the automotive and aircraft industries, the manufacturing of spaceships and sea vehicles. There are two main characteristics which make these materials attractive compared with conventional metallic systems. They are relatively low density and ability to be tailored to have stacking sequences that provide high strength and stiffness in directions of high loading.

Composite materials consist of resin and a reinforcement chosen according to the desired mechanical properties and the application. Many studies reported that the wear resistance with polymer sliding against steel improved when the polymers are reinforced with glass or aramid fibres. However, the behaviour is affected by factors, such as the type, amount, size, shape and orientation of the fibres, the matrix composition and the test conditions, such as load, speed and temperature. Reports of application of polymer and its composites in mechanical components such as gears, cams, wheels, impellers are cited in literature. The applications on these materials, to meet the present demands can be achieved by the introduction of fillers into these polymeric systems having fibrous reinforcement. The filler materials include organic, inorganic, and metallic particulate materials in both macro and nano sizes. However, the use of these filler based materials in actual service requires a careful cataloguing of the processing conditions employed and the attendant structure that follows. Keeping these aspects in mind, it was decided to investigate the characteristics of a glass-polyester composite, filled with particulate glass particles with different grain size.

II. MATERIALS AND METHODS

E-Glass woven rowing of 800 GSM was used as the reinforcement, commercial grade polyester resin as the matrix material and glass particulates as the filler. The filler glass particulates are prepared in the laboratory using the conventional glass in plate form. The Glass plates are broken into small pieces which are then introduced into the ball mill so that these are crushed to fine size. The ball mill is kept running for 2-3 hours at a constant speed of 60rpm. These glass particulates are then sieved using different grades of sieve jar available, say 125 micron sieves. Some

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amount of it is collected as a sample and is weighed later. The glass particulates of two different grades i.e., 106, 125 micron particulates are collected using the similar sieve grades. These particulates of different grades are collected individually is weighed ratio of 1:3:5 total weights of least weight particulates. (i.e. 106microns) So that a sample of 1.8, 2.7 and 4.5 gms of each grades are collected and the reaming 125micron particulates 10, 20, 30 and 40 gms are collected. The laminates with different weight quantity of filler as mentioned above were maintained and compression mould technique was used to prepare the laminates. Eleven different lamanates are prepared using the same technique.

(a) (b)

Fig. 2: (a) Hand layup of resin (b) placing the upper mold

III. EXPERIMENTATION

The laminates which are removed from the mould after curing are collected and are then cut into required shape rectangular strips of 280mm length and 28mm width made each of 3 from a laminate. Three different tests are conducted on the samples prepared and the results of which are presented in the section 4.

3.1 Tensile Test

The Tensile test is conducted on all the samples as per ASTM D3039 test standards. Specimens are positioned in the grips of universal testing machine and a uniaxial load is applied through both the ends until it gets failure. During the test, the crosshead speed is taken as 2 mm/min as per ASTM standards, specimens of rectangular cross-sections having length and width of 280 mm and 28 mm respectively are used.

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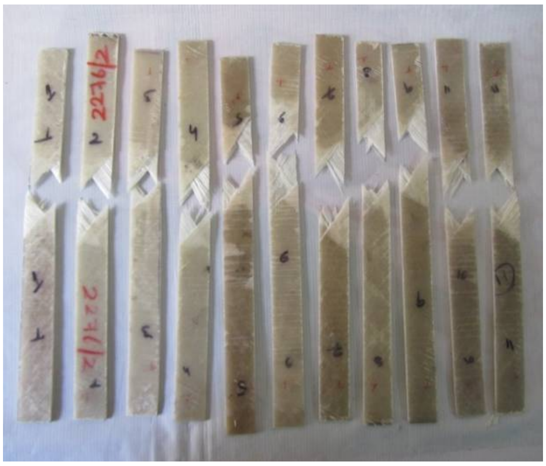
(a)

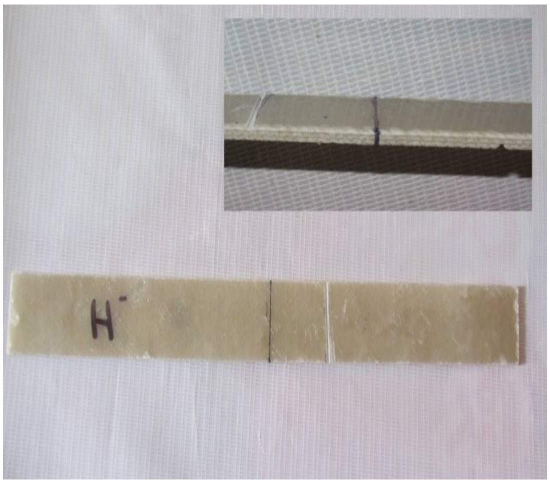


(b)

Fig 3.1: (a) Universal testing machine for tensile test (b) Samples after Tensile test

3.2 Inter Laminar Shear Stress Test

The Inter laminar shear stress test is conducted on all the samples as per ASTM D3518 and ISO 14129 test standards. Specimens are positioned in the grips of universal testing machine and a uniaxial load is applied through both the ends until it gets failure. During the test, the crosshead speed is taken as 2 mm/min as per ASTM standards, specimens of rectangular cross-sections having length and width of 280 mm and 28 mm respectively are used.



(a)

(b)

Fig 3.2: Sample for Inter laminar shear stress (b) samples after Inter laminar shear stress test

3.3 Bending Test**:**

The Bending test is conducted on all the samples as per ASTM D6272 test standards. To determine the flexural strength of composites it is performed on UTM (universal testing machine). Specimens of rectangular cross-sections having length and width of 280 mm and 28 mm respectively are used. Samples were placed horizontally upon two points and midpoint is perpendicular to loading nose. The crosshead speed for test is maintained at 2 mm/min.

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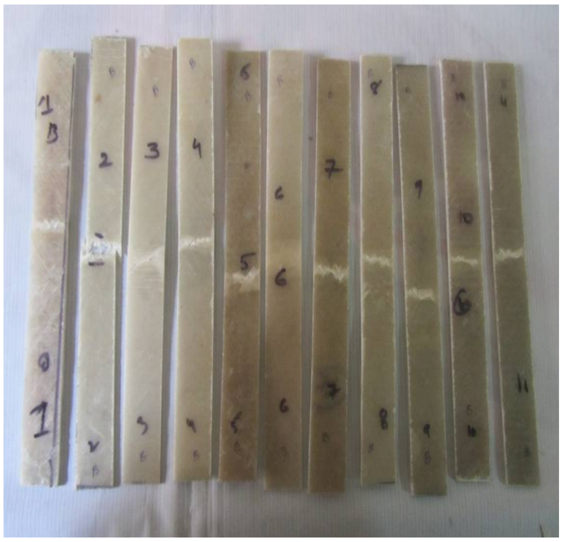
(a)

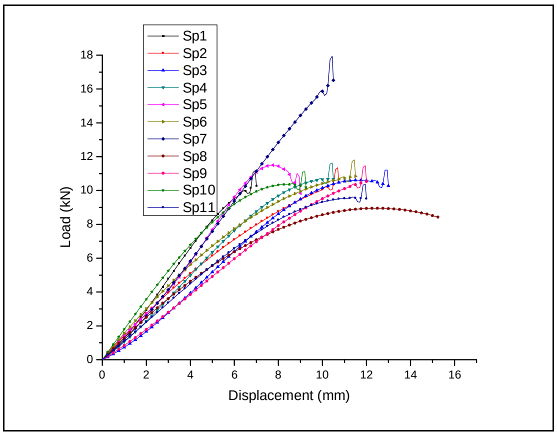


(b)

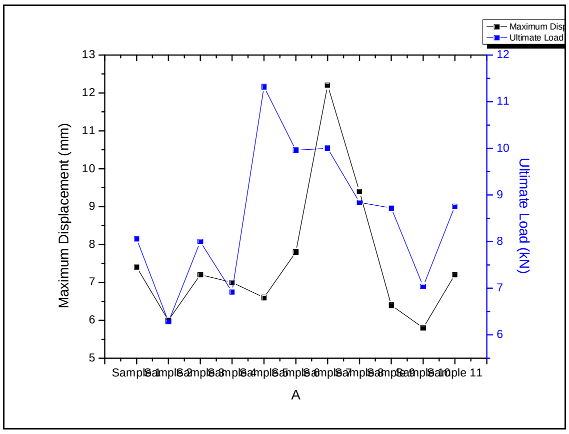
Fig 3.3: Universal testing machine for bending test (b) samples after Bending test

IV. RESULTS

The mechanical test results of E-glass/polyester composites with different filler ratios and filler sizes prepared for present investigation are presented. Details of processing of these composites and the tests conducted on them have been discussed in the previous sessions. The results of various tests are reported here. This includes evaluation and comparisons of tensile strength, flexural strength, inter laminar shear strength of laminates.



(a)



(b)

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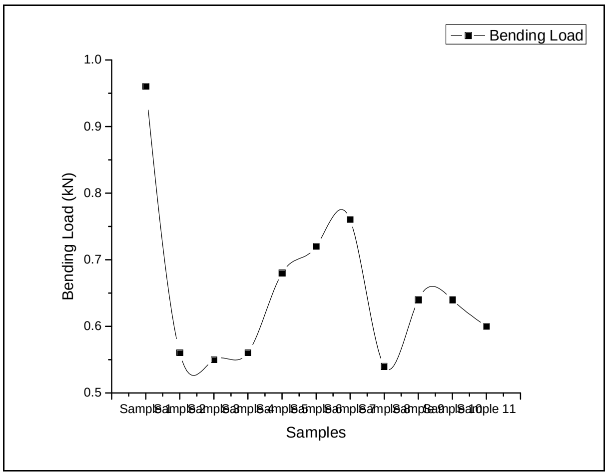

(c)

Fig 4: (a) Load v/s displacement for all the samples (b) Variation of maximum deflection and ultimate loading shear (c) Variation of Maximum bending stress

The experimental results lead to understand the behaviour of failure in Glass/Polymer composites with different filler concentration. The effect of addition of fillers shows a considerable influence on the failure of pattern of Glass/Polymer composites subjected to mechanical testing.

V. CONCLUSION

1. There is considering effect on loading bearing capacity of the compressive with the addition of filler.
2. The size of the filler being added is even affecting the material property.
3. As the quantity of the filler is increment from 1.8 to 40 grams the effect in load bearing property of the base material is being varied.
4. An increase in tensile behaviour was observed but showed a decrement in the bending.
5. An increase in inter laminar shear strength was observed due to addition of filler, this is due to the filler particulates occupying the void between the fiber and the matrix.
6. A brittle behaviour was observed due to the addition of the filler material.

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