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Testing of Mechanical Properties of E- Glass Fiber and A-R Glass fiber Reinforced Epoxy Polymer Composites

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Abstract

Composite can be defined as "A material composed of two or more different materials, with the properties of the resultant material being superior to the properties of the individual materials that make up the composite". In past years there is a intense try for substituting the inert structural materials with the newly developed composite materials with advance desirable properties of high strength, better durability than conventional materials, good surface quality and cost efficiency. The fiber reinforced polymer is composite materials made from fibers, such as glass, carbon, vinyl and aramid fibers in a resin matrix, such as epoxy, vinyl ester, polyester, or phenolic resin. The most used type of FRP is GFRP (Glass fiber reinforced polymer) as Glass fibers has properties like greater strength, flexibility, and offers a better resistance to chemical reactions where ever it is used. The glass fibers are available in various forms of roving's, chopped strand, yarns, fabrics and mats. In the present work, two types of GFRP samples have been prepared using chopped strand E glass fiber and A-R glass fiber mesh as the reinforcement and the mixture of epoxy resin and hardener as the matrix and the composite is tested for its tensile strength property.

Keywords; *GFRP, epoxy resin, E-Glass fiber, A-R glass fiber mesh.*

I. INTRODUCTION

Composite can be defined as a material made up of different materials (more than one material), which results to give a new material with superior properties to that of the individual materials properties that make up the composite. The composite materials are replacing the old materials, because of its superior properties such as low thermal expansion, high strength to weight ratio, light weight and thin [2]. The fiber reinforced polymer (FRP) is composite materials made from fibers, such as glass, carbon, vinyl and aramid fibers in a resin matrix, such as epoxy, vinyl ester, polyester, or phenolic resin. Some of the advantages of such fiber reinforced polymer are:

1. FRPs have greater resistance against corrosion when used along with concrete or to chloride exposure.
2. The FRP materials made from glass fiber or aramid fiber has much lesser unit weight than that of steel, nearly 6 to 7 times less.
3. The FRP materials have greater stiffness to weight ratio.
4. These composite have a easy manufacturing, cutting and transferring process than any other construction materials.
5. Such type of polymer composites are not affected by affects of magnetic fields and are also electrically non-conductive.

GFRP refers to Glass Fiber Reinforced Plastic which is a composite with Glass fibers as the reinforcement in the composite and epoxy resin as the matrix

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material. The mechanical properties, bonding and load transfer mechanism of GFRP depends on properties of fibers used [5] The application of GFRP composites are into the field of aerospace and aviation especially in making ground level infrastructures, in making home decors and other home furniture, vastly used in making electronic items including X-ray beds for medical utility in making the body parts of automobiles, etc [8]. The fiber which acts as the reinforcement are responsible for providing strength and stiffness to the composite and the matrix acts as the binding material and helps to transfer the load uniformly throughout the fibers in the composite. The aspect ratio(length/diameter) of the fibers has an important role like for continuous fiber the aspect ratio is long and for chopped fibers the aspect ratio is short[5], [7]. Continuous reinforcements include, woven cloth, and helical winding, etcwhere as discontinuous reinforcements are chopped fibres and random mat. The resultant properties of the composite depend on the type of fibres or reinforcement used and the amount of fibres used in making the composite. Theoretically the higher strength and higher modulus are obtained with composites made using continues type fibre.

II. EXPERIMENTAL DETAILS

A. Materials for making the composite

The materials used for making the reinforced polymer composite are as below:

B. Thermosetting resin and the hardener

Thermosetting resins have the best adhesives and bonding properties. Mostly the Epoxy resin is used as the polymer in the composite. Epoxy resins are much more costlier than polyester resins but have the property of good strength and ductility.For the Glass Fiber Reinforced Plastic, the matrix used is the ARALDITE LY556 Epoxy resin along with the ARADUR HY951 hardener in the Ratio of 10:1.

Fig. 3. Epoxy resin and the hardener

C. Glass fiber

Glass fibers can be categorized into 2 classes:

1. Low cost general purpose fibers
2. Premium special purpose fibers

Most of the glass fibers falls into the category of general purpose fibers like the E glass fibers which represents the low electrical conductivity glass fibers and the other glass fibers like the S- glass fiber which denoted high strength glass fiber, A-R glass fiber representing alkali resistance, ECR glass fiber which has a property of high chemical durability, etc comes under the special purpose glass fibers.

Two types of composite samples were prepared. Chopped strand E glass fiber of length of the fiber is 12 mm confirming to the specifications of ASTM C1666/C1666M is used for making the composite. The specific gravity of the chopped strand glass fiber is 2.70. The color of the glass fiber is brilliant white.

The A-R glass fiber mesh is used for making the other type composite.

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Fig. 1. Chopped strand E-glass

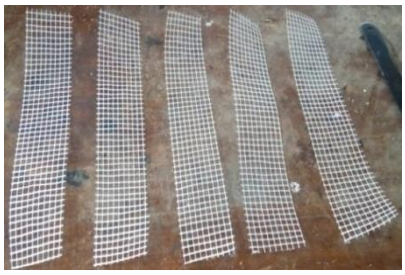

Fig. 2. A-R Glass fiber mesh

D. Releasing agent

Grease or oil is used as a releasing agent. The grease is applied in the mould before the casting of the sample which ensures easy removal of the sample after drying of the sample for testing.

III. FABRICATION OF THE COMPOSITE

For GFRP the epoxy resin and the hardener is mixed together in the ratio of 10:1 by weight and casted by hand lay-up technique as per IS 14856:2000 and ASTM D3039 and the samples were de-molded after 3 days. The moulds are the iron moulds with bolting connections forming a rectangular cavity and consisting of a bottom and top plates and can be opened by all four sides. The casting of the samples were done carefully to filling the glass fibers and epoxy + hardener mixture layer by layer followed by proper leveling the layers properly and then storing and testing of the GFRP was carried out at the room temperature of 27˚C. After curing the mould was opened and the samples were taken out of the mould and cleaned properly from the excess grease or oil on the surface.. Before testing the specimens dimensions i.e. the length, width and thickness was measured by using a vernier caliper and the area of the specimen is calculated as

Area = Width × Thickness (1)

Fig. 4. Mixing of Epoxy and the hardener

Fig. 5. Casted A-R glass fiber mesh GFRP

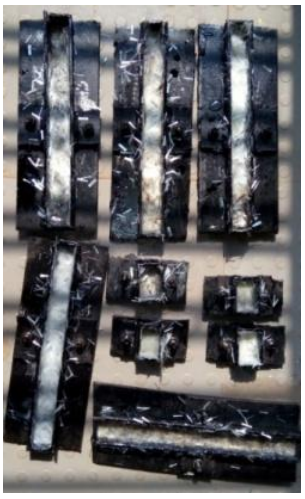

Fig. 6. Casted chopped E glass fiber GFRP

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Table-I : Test Specimen size details for GFRP

Tests	Sample size	Number
GFRP		
3 days tensile strength test for E- GF GFRP	(250 X 25 X 4) mm	5
3 days tensile strength test for A-R GF mesh-GFRP	(250 X 25 X 4) mm	5

IV. TESTING OF COMPOSITE

A. Tensile strength Test

The tensile test on the casted GFRP specimens was carried out according to ASTM D3039 in the universal testing machine (UTM). For the GFRP composite, two types of samples were casted. One with chopped strand E-glass fiber as the reinforcing material and epoxy resin and other with A-R glass fiber mesh as the reinforcing material and the epoxy resin. Five numbers of specimens were casted for each type. The casted Glass Fiber Reinforced Plastic (GFRP) specimens of size 250×25×4 mm were tested in the UTM.

Fig. 4. Testing of GFRP samples

The tensile load is applied till the specimen fails and the tensile strength value is calculated.

The results thus obtained are tabulated in table 2. and the comparison is also done and by plotting the graphs of the results obtained of the tensile strength, ultimate force.

Table- II: Tensile strength test results

Composite type	GFRP	
Types of Fiber	E-glass Fiber	A-R glass Fiber mesh
Area of specimen (mm^2)	100	100
Loading (KN)	2.608	3.256
Tensile strength (MPa)	26.08	32.56

V. RESULT AND DISCUSSION

The tensile force at which the specimen breaks is noted and the tensile strength (TS) of the GFRP specimen is calculated as

$$TS = \frac{P}{A}$$

Where, TS = tensile strength in MPa

P = load at break in N

A = original cross sectional area

The failure point and the load at failure were marked and the tensile strength is calculated and compared with the code specifications.

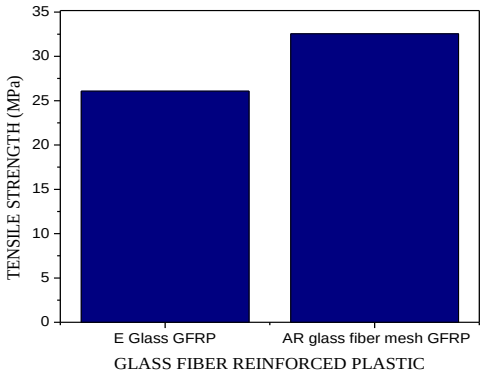

Fig. 6. Tensile strength test results

Fig 6.shows the tensile strength test results, one with GFRP with E-glass fiber and other with A-R glass fiber mesh. Table 8 shows the tensile strength of the GFRP composite with A-R glass fiber mesh is more

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than the GFRP composite with E-glass fibers by 24.84%. This is because of the composite with A-R glass fiber mesh has better interfacial bonding and due to the uniform cross section the load distribution was even in the whole composite unlike the composite with E-glass fiber in which the fiber distribution was random distribution and it was difficult to maintain a uniform thickness with good finish surface condition and also the casting of the GFRP composite with A-R glass fiber mesh was easier than the casting of GFRP with E-glass fiber.

CONCLUSION

From the tensile strength test performed on the GFRP samples using chopped strand e glass fiber and A-R glass fiber mesh, we can draw the conclusion that, the tensile strength of the Glass Fiber Reinforced Plastic (GFRP) with A-R glass fiber mesh is found to be 24.84% more than the tensile strength of GFRP composite with E-glass fiber due to its better interfacial bonding and even distribution of reinforcing fibers.

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