EXPERIMENTAL STUDY ON ARAMID FIBER REINFORCED POLYMER COMPOSITES

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Abstract

A great deal of research is currently being conducted concerning the use of the fiber reinforced plastic wraps, laminates and sheets in strengthening the reinforced concrete members. The aim of the resent work is to investigate the hybridization of aramid fibers with cotton fibers for the applications in civil industry. Mechanical properties such as tensile, impact and flexural test of aramid/cotton fiber reinforced epoxy polymer in the form of composites were determined. The tests were carried based on ASTM D-38 standards. The composites prepared with cotton fiber shows the lower mechanical properties compared to laminas with aramid fiber. For this reason it is proposed to use a hybrid design for the various applications which makes use of cotton fiber and aramid woven fabrics. Composites are fabricated by hand layup technique in a mould and cured under light pressure for 1h, followed by curing at room temperature for 48hrs. Non-hybrid composites are tested to determine the tensile strength of individual laminas of both cotton and aramid for the selection of fabrication to be used in hybridisation. Hybrid laminas are tested to determine the maximum tensile strength of the hybrid laminates which is to be used for strengthening the slabs. Flexural strength and impact strength for the non-hybrid and hybrid laminates are also found.

Key Words: *Cotton fiber, Epoxy resin, Aramid fiber and FRP*

1. Introduction

In many buildings reinforced concrete structures were tend to fail due to inadequate maintenance, excessive loading or exposed to adverse environmental conditions . Therefore strengthening or repairing should be done for that structures to bring back to its original service condition. Some of the strengthening techniques used are steel plate bonding, external prestressing, section enlargement, and reinforced concrete jacketing. These techniques although increase the load carrying capacity it leads to corrosion resulting in failure of strengthening system. To overcome these a new strengthening technique of fiber reinforced polymer (FRP) composites were used. Nowadays, hybrid fiber reinforced polymer composites were mostly used due to their ability to increase the service life of structures and also reduces the maintenance costs. Hybrid fiber reinforced composite structures have different characteristics like easy to apply, resistance to corrosion, high strength etc.

Synthetic Fiber

Synthetic fibers are made from synthesized polymers of small molecules. The compounds that are used to make these fibers come from raw materials such as petroleum based chemicals or petrochemicals. These materials are polymerized into a long, linear chemical that bond two adjacent carbon atoms. Differing chemical compounds will be used to produce different types of synthetic fibers. Synthetic fibers account for about half of all fiber usage, with applications in every field of fiber and textile technology. Although many classes of fiber based on synthetic polymers have been evaluated as potentially valuable commercial products, four of them nylon, polyester, acrylic and polyolefin - dominate the market. These four account for approximately 98 percent by volume of synthetic fiber production, with polyester alone accounting for around 60 per cent.

Plant Fibers

Around the world, plants are one of the most common sources of fibers. Many plants get their structure from fibers, so we have many to choose from. Some come from the bast, or inner stem of a plant, like flax or hemp. Bast fibers tend to be soft and flexible. Flax fibers, for example, are used to make linen. Fibers can also be found in the seed or fruit. We pick and use cotton because the fibers used to make cloths are in the seedpods. Finally, plant fibers can come from leaves. Leaf fibers, such as those from the sisal plant, are hard and durable, but much less comfortable. Sisal fibers are most often used for rugs or rope.

2. Materials

Cotton fiber

Cotton are soft made from a boll of seeds around the cotton plants. The cotton are made into yarn or thread which makes it soft. The cotton fiber is the most widely used natural fiber in making cloths in textile industry. The cotton fiber is made up of many concentric layers. The fiber requires adequate moisture and warmer climate. Cotton fiber is more comfort, hydrophilic and has a good conductivity of heat.

Aramid fiber

Aramid fibers are the most commonly used synthetic fiber. These fibers are used in aerospace, military applications. Aramid fibers have High strength, Good resistance to abrasion, Good resistance to organic solvents, Non-conductive, No melting point, Low flammability and Good fabric integrity at elevated temperatures.

3. Development of FRC Laminates

This chapter deals with the fabrication stages carried out to obtain the composite material. The steps involved in Hand –Lay –Up Method for the development of fiber reinforced Composite is same for both the plant (cotton) and synthetic (AFRP) fibres.

Materials used

The materials used in our fabrication process are as follows

1. Cotton fiber
2. Matrix (Epoxy LY 556 and Hardener HY 951)
3. OHB Sheet
4. Roller

Steps in Hand –Lay –Up Method (Cotton Fiber)

Hand –Lay-Up method is also called as manual method. The following are the steps involved in the preparation of cotton lamina (FRC laminates).

Step 1: Cut the cotton fibre into 190 mm X 140 mm size

Step 2 : Preparation of the mould is done by using the thermacol, of size suitable for placing the cotton fibre (200 mm X 150 mm) and thickness of the base plate of the mould is about 150 mm.

Step 3: Then, prepare the matrix by mixing of epoxy LY556 and hardener in the ratio of 1:10.

Step 4: The OHB sheet is placed in the prepared mould

Step 5: After placing the OHB sheet in the mould, the matrix is placed above OHB sheet in the mould and spread evenly..

Step 6: Once the Epoxy is placed, the cotton fibre is placed above the OHB sheet with Epoxy.

Step 7: After placing the cotton fibre in the mould, the epoxy should be poured on the cotton fibre in the mould and the fibre should be immersed in the epoxy resin.

Step 8: OHB sheet is placed over the immersed cotton fibre and it should be free of voids otherwise the desired strength should not be achieved.

Step 9: The laminate is allowed for curing in atmospheric condition for 2 days.

Step 10: After 2 days, the specimen should be taken out from the mould and the OHB should be removed from the lamina (specimen).

Steps in Hand –Lay –Up Method (AFRP)

The steps followed in the development of cotton fiber laminates have to be follows for

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the development of AFRP laminates of woven roving.


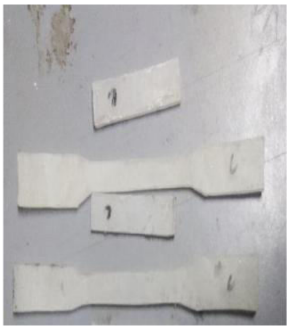

Fig 1 FRC Laminates

Development of HFRC

Laminates Materials Used

The materials which are all used in the development of FRC laminates are used for the development of HFRC laminates.

Steps Involved

Hand –Lay- Up method is used to prepare the HFRC laminates. The steps involved in the preparation of FRC plates are followed here but only up to step 7.

(For step 1 to 7 refer Cotton Fiber)

Step 1: The Aramid fibre reinforced Polymer (AFRP) of Woven roving type is place above epoxy which is placed above the cotton fibre. The AFRP mat is pressed against the cotton fibre with for the perfect bonding and to achieve greater interlayer locking between to mats.

Step 2: The epoxy is poured over these mats and both mats should be immersed in resin.

The remaining steps are as same as the steps followed in the development of FRC laminates. The other HFRC laminates are developed by following the above steps by keeping the cotton fibre as a base for AFRP.

Fig 2 HFRC Laminates

4. Testing

The testing of FRC and HFRC laminates are done with the help of ASTM-Universal Testing Machine. Before testing the laminates, the sample should be prepared from the prepared laminates of both FRC and HFRC laminates.

Tensile Test

The laminates removed from the mould should be cleaned and free from dust. Marking should be done for the size of 165 mm X 19 mm x 13 mm (ASTM size) with the help of ruler and marker. Cut down the marked size. The edges of the sample should be angular and free from extra small pieces at the sides.

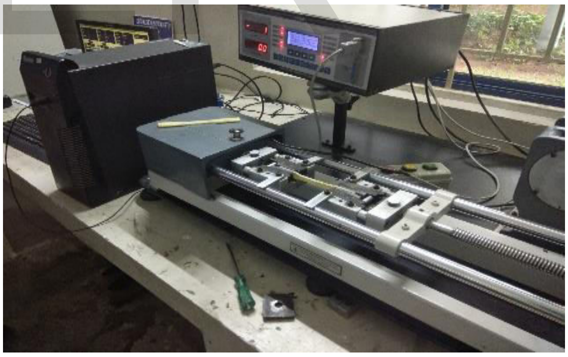

Fig 3 Tensile Test

Flexural & impact test

The laminates removed from the mould should be cleaned and free from dust. Marking should be done for the size of 60 mm X 13 mm x 3 mm (ASTM size) with the help of ruler and marker. Cut down the marked size.

Fig 4 Flexural Test

Fig 5 Impact Test

5. Result Tensile

Strength

The tensile strength of polymer composite was tested by using the Strain controlled UTM based on ASTM D638. Here, the comparative analysis was done to identify the tensile strength of low modulus fiber Cotton and high modulus fiber (Aramid).

Tensile strength = Yield force / Area

Table 1 Tensile properties of fiber reinforced polymer composites

Sl. no	Description	Aramid	Cotton	Aramid + cotton
1.	Area (mm^2)	39	39	39
2.	Yield force (N)	1250	405	720
3.	Yield elongation (mm)	5.1	4.1	2.8
4.	Break force (N)	1400	450	825
5.	Break elongation (mm)	5.5	4.8	3.3
6.	Tensile strength at yield (N/mm^2)	32	10.38	18.46
7.	Tensile strength at break (N/mm^2)	35.89	11.53	21.15
8.	Max force (N)	1400	450	825
9.	Max elongation (mm)	5.7	8	5

Flexural Strength

The flexural behaviour of fiber reinforced polymer composite was investigated under strain controlled UTM.

Flexural strength (or) modulus for a three point bending = $3FL/2bd^2$

Where,

F= load at the fracture point (N)

L= length of support span

b= width (mm) & d= thickness (mm)

Table 2 Flexural properties of fiber reinforced polymer composites

Fiber composite	Area (mm^2)	Force at fracture (N)	Elongation (mm)	Flexural modulus (N/mm^2)
Aramid	39	14.2	2.25	9.1
Cotton	39	3.2	6	2.05
Aramid + Cotton	39	16	4.2	10.25

The flexural modulus of hybrid composites of aramid and cotton possess the higher value than that of non-hybrid composites. It shows that hybrid composites have good flexural modulus than that of non-hybrid composites.

Impact test

Table 3 Impact value of fiber reinforced polymer composites

Fiber composites	Impact value (Joule)
Aramid	1.293
Cotton	0.083
Aramid + cotton	0.945

The impact value for aramid is found to be higher than that of the cotton fiber and hybrid fiber composites as that the impact value for cotton is only 0.083 joule it found to be minimum so when it is hybrided with it shows some impact value.

Thus, the hybrid composites of aramid and cotton possess good flexural strength than the non-hybrid composites this is due to flexural behaviour of aramid fibers. Impact value for the hybrid composites also shows the impact resistance as cotton possess very minimum impact value but when it is hybrid with aramid it shows better impact value as aramid has better impact value. Though the fiber material does not possess an impact resistance as like as epoxy resin composites. When incorporating the fiber into composite, volume of epoxy resin get reduced by restricting the quantity. Here the above results show the equivalent amount of impact resistance of aramid compared to aramid cotton composites.

6. Conclusion

The present study explored the load carrying capacity of fiber reinforced polymer composite by incorporating the aramid and cotton fiber into epoxy resin matrix. In particular, incorporated FRP composites subjected to tensile, flexure and impact loadings were evaluated by monitoring the stress – strain relationship. The main conclusions pinched from this work can be summarized as follows:

Experimental results show that the increase level of load carrying capacity was found in AFRP composite than HFRP composite, but HFRP composite will be economical when compared to AFRP composite matrix.

Plastic deformation was found on Cotton FRP composite, so these cotton fiber can't be introduced individually on polymer matrix.

Effectiveness of bond between the fiber and epoxy was good.

This investigation gives clear idea about FRP composite, which can be suitable for strengthening of Reinforced Concrete slab.

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