Experimental study of the effect of hybridization on Mechanical Behavior of Jute/Glass Fibers Reinforced Polyester Composite Material

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1. Abstract

Natural fibers are being increasingly used to substitute artificial glass and carbon fibers in polymer composites. It is important to know how the mechanical properties of these natural fiber composites compare with those of the traditional glass and carbon fiber composites. Glass and carbon fiber composites are currently being used in many applications that may not require such high-strength materials a lower strength jute fiber composite may be adequate. Natural fiber composites are currently being used in mostly non-structural applications. The present work focus on the hybridization of natural fiber (jute) and synthetic fiber (glass) with polyester resin. Hybridization of jute fiber along with glass fiber produces better tensile and flexural strength than GFRPC and JFRPC at same wt. percentage of fibers.

Keywords – FRP Composite, JFRPC, GFRPC, HFRPC, Tensile Strength, Flexural Strength.

2. Introduction

For years, composite materials have growing applications in different industries. Composite is a mixture of two or more constituents/materials (or phases) with different physical/chemical properties at the macroscopic or microscopic scale. In general composites have two or more constituents, fiber and matrix. Composites are classified by the geometry of the reinforcement: particulate, flake, and fibers or by the type of matrix: polymer, metal, ceramic, and carbon. The basic idea of the composite is to optimize material properties of the composite, i.e., the properties of the matrix are to be improved by incorporating the reinforcement phase. Fibers are the principal load-carrying constituents while the surrounding matrix helps to keep them in desired location and orientation and also act as a load transfer medium between them [1]. The effective properties of the fiber reinforced composites strongly depend upon the geometrical arrangement of the fibers within the matrix [2]. This arrangement is characterized by the volume fraction, the fiber aspect ratio, fiber spacing parameters and orientation angles of fibers. Thermoplastic composites reinforced with long fibers, short fibers and mat (fabric) of natural and synthetic fibers like hemp, jute banana, glass, carbon, Kevlar etc are used in a variety of applications such as aerospace elements, automotive parts, marine structures, structural members and antivibration applications due to their combined properties of resilience, creep resistance, high strength to weight and stiffness to weight ratios, corrosion resistance and good damping properties [3, 4, 5]. Due to inherent advantages of composites over traditional materials like metals, their utilization over the last decade increased many folds in the field of design of many engineering and structural components [6]. Many researchers have analytically and experimentally investigated [7-12] the mechanical properties (tensile, flexural, toughness, fatigue etc.) of FRP composites and other used finite element analysis [13-17] to predict the behavior of FRP and their mechanical properties.

3. Experimental Setup

3.1 Raw Material

The composite materials used in this research work were fabricated by reinforcing Jute fiber and Glass fiber in polyester resin by wt percentage of 2%, 4%, 6%, 8%.Jute fiber are natural fiber having good interfacial strength with polymer matrix while glass fiber are synthetic material having better strength than jute fiber. By taking the advantage of both fibers, Hybrid composite were manufactured.

3.2 Fabrication of composites

There are many composite manufacturing techniques available in industry [22-24]. Compression molding, vacuum molding, pultruding, and resin transfer molding [25] are few options. The hand lay-up [26] manufacturing process is one of the common techniques to combine resin and fabric components. This process allows manual insertion of fiber reinforcement into a single-sided mould, where resin is then forced through fibers into mould. A primary advantage to the hand lay-up technique is its ability to fabricate very large, complex parts with reduced manufacturing times. Additional benefits of hand lay-up process are simple equipment and tooling that are relatively less expensive than other manufacturing processes. All composite specimens were manufactured using hand lay-up process.

3.3 Test specimens

The composite specimens were produced in rectangular size as per ASTM standards, ASTM D638 (160x19x4.5 mm) for tensile tests and ASTM D790 (130x12x4 mm) for flexural tests as shown in Figure:

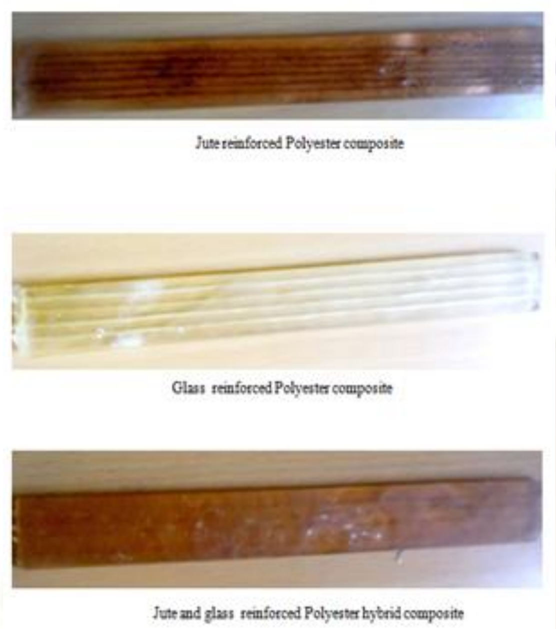

Fig. 1: Test Specimen

4. Test Apparatus and Procedure

All experimental tests were carried out at central institute of plastic engineering and technology (CIPET) Panipat, Haryana.

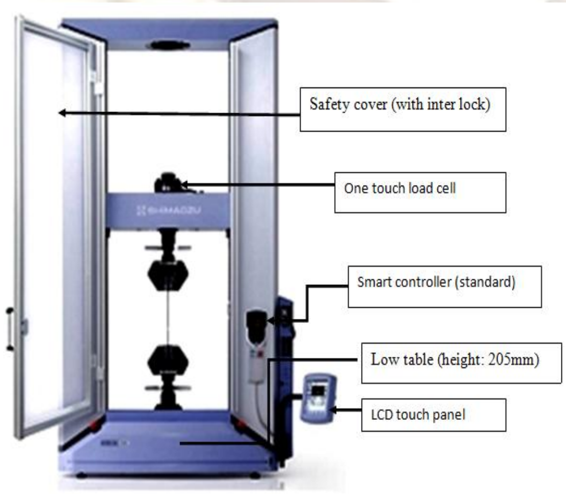

Fig. 2: Autograph Machine

4.1 Tensile test

The tensile tests were conducted on Autograph Machine. These tests were carried out on rectangular specimens (160x19x4.5 mm) at room temperature. Specimens were placed in the grips and were and pulled until failure. The test speed was 5mm/min as per ASTM D638 and an extensometer/strain gauge was used to determine the elongation and tensile modulus. Fig. 3 shows the tensile testing apparatus for the various composites.

Fig. 3: Tensile Test

4.2 Flexural test

Flexural testing was carried on rectangular specimens (130x12x4 mm) of composite using Autograph Machine at ambient temperature according to the procedure described in ASTM D-790. The test was initiated by applying the load on the specimen at the specified rate. The deflection was measured by a gauge under the specimen in contact with it in the center of the support span. Fig.4 shows the flexural testing apparatus for the various composites.

Fig. 4: Flexural Test

5. Experimental Results

The tensile strength and bending strength of FRP having different wt. % of jute fiber and glass fiber is shown in table. The experimental results shows that tensile strength of polyester resin increases with increasing wt. % of reinforced fiber also the tensile strength of GFRPC is much more than the tensile strength of JFRPC.

Table 1: Strengths of FRP Composites

Composite	Tensile Strength (N/mm^2)	Flexural Strength (N/mm^2)
PP	20.82	30.46
2% JFRPC	30.5	42.16
4% JFRPC	36.4	64.3
6% JFRPC	41.2	71.1
8% JFRPC	45.96	82
2% GFRPC	48.68	61.49
4% GFRPC	62.6	68.95
6% GFRPC	68.8	82.98
8% GFRPC	85.69	86.64
4% HFRPC(2%J+2%G)	63.35	71.32
6% HFRPC(4%J+2%G)	43.84	90
6% HFRPC(2%J+4%G)	74.59	95
8% HFRPC(6%J+2%G)	59.02	84
8% HFRPC(2%J+6%G)	78.95	102.83

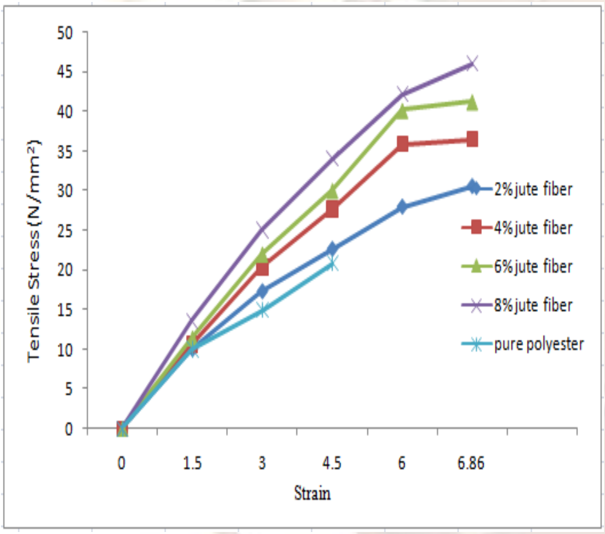

Fig. 5: Stress v/s Strain for Tensile Strength of JFRPC

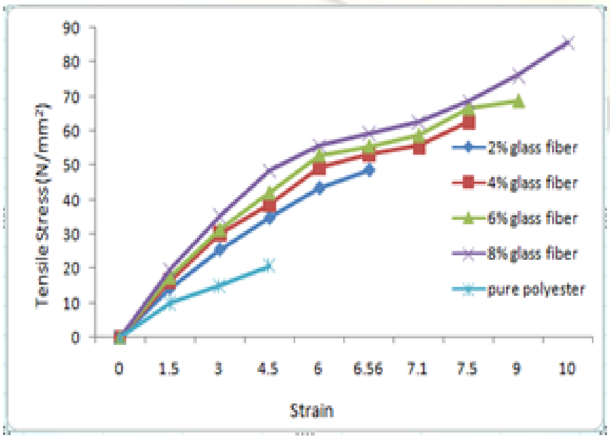

Fig. 6: Stress v/s Strain for Tensile Strength of GFRPC

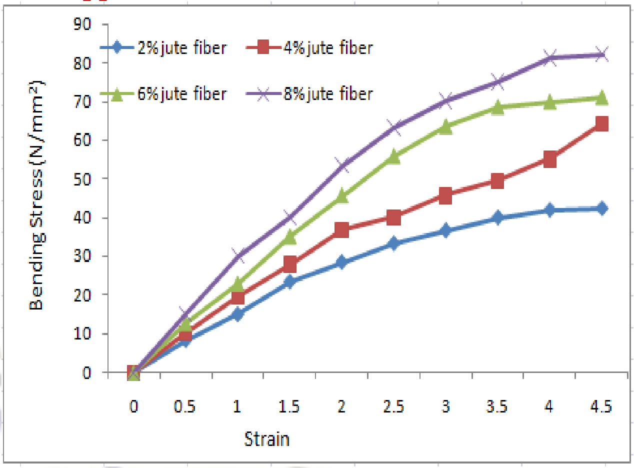

Fig. 7: Stress v/s Strain for Flexural Strength of JFRPC

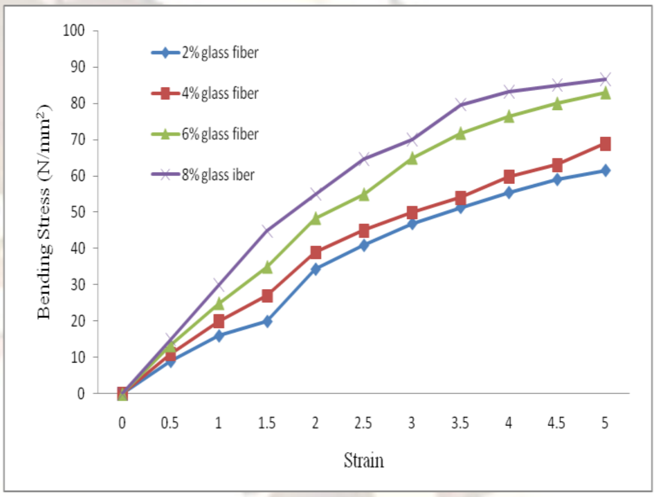

Fig. 8: Stress v/s Strain for Flexural Strength of GFRPC

6. Comparison between JFRPC, GFRPC and HFRPC

In the present research work comparison b/w the tensile and flexural strength of JFRPC, GFRPC and HFRPC having 4%, 6% and 8% wt percentage of reinforced fiber is done.

6.1 Comparison of Tensile Strength of JFRPC, GFRPC and HFRPC

The comparison of tensile strength of hybrid composite with different wt percentage of jute fiber and glass fiber with jute fiber FRP and with glass fiber FRP were shown in the figures.

It was found that hybridization of FRP results in increasing the tensile strength of FRP at relatively lower cost than glass fiber reinforced polyester composite. It was concluded that just by reinforcing 2% jute fiber in glass fiber reinforced polyester composite the tensile strength of composite increase as comparison to the pure glass fiber reinforced composite.

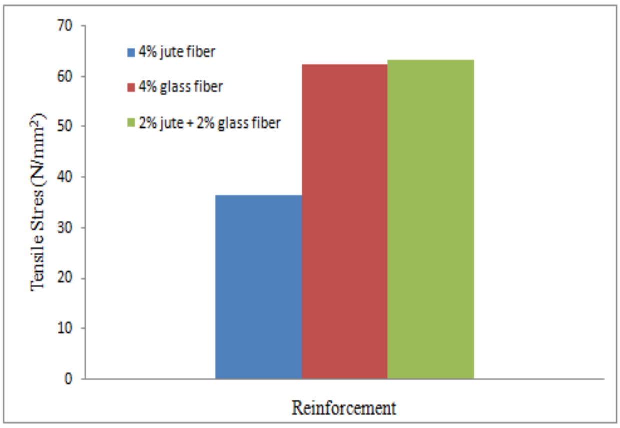

Fig. 9: Comparison of Tensile Strength of FRP at 4% reinforcement

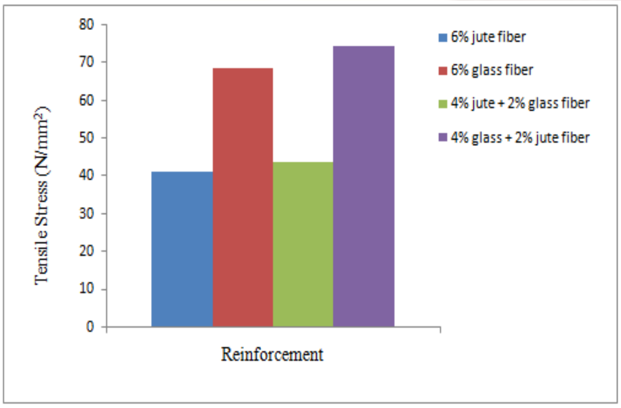

Fig. 10: Comparison of Tensile Strength of FRP at 6% reinforcement

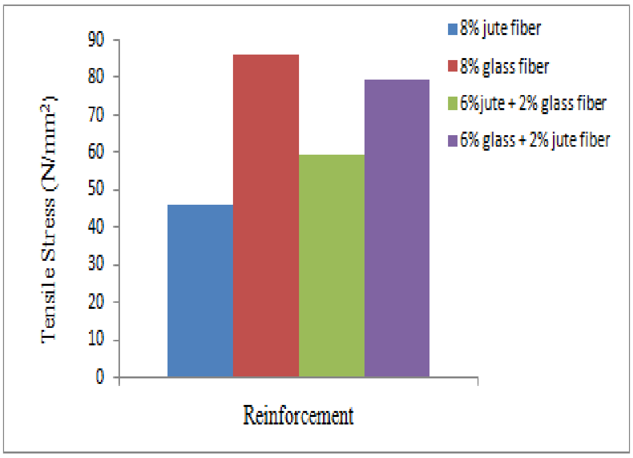

Fig. 11: Comparison of Tensile Strength of FRP at 8% reinforcement

6.2 Comparison of Flexural Strength of JFRPC, GFRPC and HFRPC:

The comparison of flexural strength of hybrid composite with different wt percentage of jute fiber and glass fiber with jute fiber FRP and with glass fiber FRP were shown in the figures.
The experimental results represent that flexural strength can be improved by hybridization of glass fiber and jute fiber with polyester matrix as comparison to single fiber reinforced polyester composite (JFRPC and GFRPC). It may be due to the collective effect of properties of jute fiber and glass fiber with polyester matrix. The results obtained exclaim that Flexural Strength can be improved by reinforcement of biodegradable jute fiber along with glass fiber in polyester matrix.

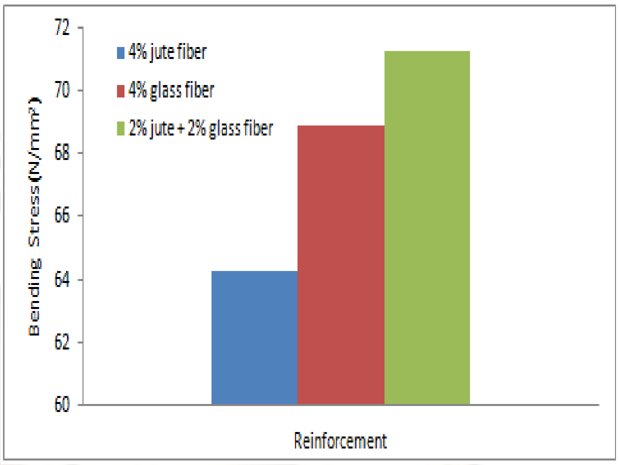

Fig. 12: Comparison of Flexural Strength of FRP at 4% reinforcement

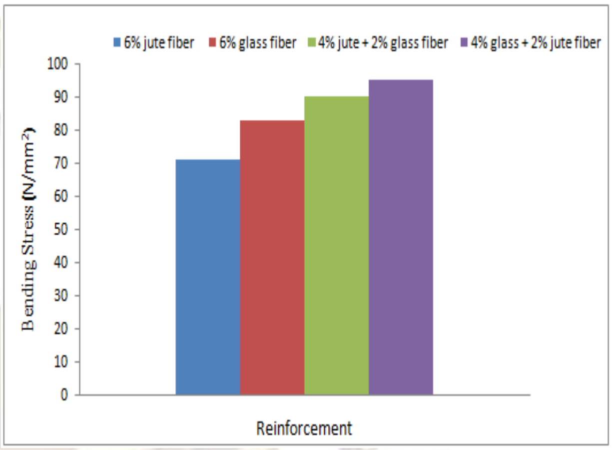

Fig. 13: Comparison of Flexural Strength of FRP at 6% reinforcement

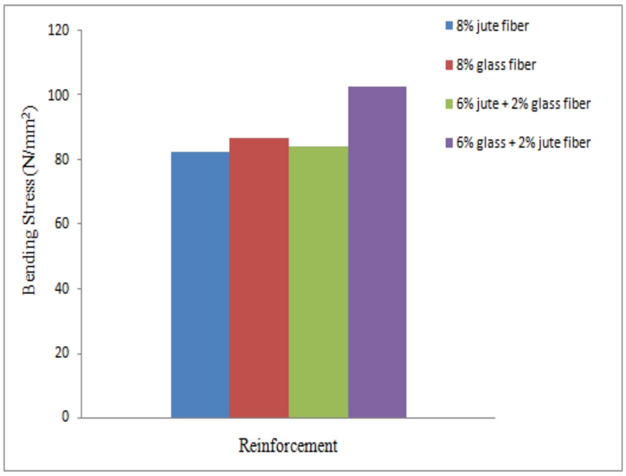

Fig. 14: Comparison of Tensile Strength of FRP at 8% reinforcement

7. Conclusions

The result shows that with the increase in wt. percentage of fiber reinforcement the tensile and flexural strength of FRP composites increases also the strength of GFRPC is more than the strength of JFRPC. The combination of both jute fiber and glass fiber as reinforcement produces better results than singe fiber reinforced composites. The HFRPC have high tensile and flexural strength as comparison to JFRPC and GFRPC. It may be because of high interfacial strength of jute fiber with matrix and high strength of glass fiber. Due to the reinforcement of both fibers the HFRPC have high tensile and flexural strength. It is observed that by reinforcement of jute fiber by an amount of 2% by wt in polyester matrix along with glass fiber reinforcement produces good and comparable strength as that of JFRPC and GFRPC. The benefit of reinforcement of 2% jute fiber in polyester matrix along with glass fiber reinforcement is that the FRP becomes economical, biodegradable and environment friendly.

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