IOP Conf. Series: Materials Science and Engineering **438** (2018) 012005 doi:10.1088/1757-899X/438/1/012005

Flexural Property Enhancement of Jute Polyester Composite

S.Z. Ali, M.K. Nahian and M.A. Islam

Department of Materials and Metallurgical Engineering, Bangladesh University of Engineering and Technology, Dhaka 1000, Bangladesh

Abstract. Jute fiber is used as a reinforcement material for its availability, lightweight, non-toxicity, biodegradability, low cost, renewable source and moderate mechanical properties. In addition, jute fiber has longer continuous length. In this study, 10 and 15 wt% jute fiber reinforced polymer matrix composites were fabricated by hand lay-up method using polyester resin. The jute composites were developed with and without compression stress. To understand the effects of compression stress levels 2.5, 5 and 10 kPa were used. The jute fibers used here were in untreated condition (raw jute fiber). Developed composites were then characterized by three-point flexural test. Experimental results revealed that compression stress significantly enhanced the flexural properties (flexural strength and flexural modulus) of the composites. In this regard, 15 wt% jute fiber reinforced composite showed greater flexural properties.
Keywords: Jute fiber composite, Polyester, Compression stress, Flexural strength.

1. Introduction:

The burgeoning demand for a clean environment has led the innovation of green materials and utilization of natural materials. Thus, the urge for the production of high-performance engineering products from natural renewable resource is growing day by day. Natural fiber reinforced composites are among those versatile, high-performance materials which combine the unique mechanical and thermal properties that cannot be achieved in a single material. Jute fiber is one of the most common natural fiber since it is produced on a large scale in the Indian sub-continent, especially in Bangladesh, and has a minimal effect on the environment because of its biodegradable properties [1,2]. Jute is the cheapest lignocellulosic long vegetable bast fiber and abundantly available in South Asia. But Jute has an affinity towards moisture. Due to its hygroscopic nature, dimensions of the filament, as well as its mechanical and electrical properties, are changed [3]. So proper wetting of the two phases is naturally poor which does not conduct the desired properties in composite materials.

Normally thermoplastic composites are fabricated under pressure in the hot pressing machine. To carry a higher amount of applied load modulus transfer is important. Modulus transfer mainly depends on the fiber matrix bonding. Due to applied pressure, pores are also eliminated from the resin. A highly compact product can be obtained by applying molding pressure. Because of this, mechanical properties are reported to improve [4].

In hand lay-up method for thermoset composites fabrication, usually, no load or stress is applied. However, in this research work thermoset composites were made under applied stress. This was done by applying a certain amount of weight when the resin started to coagulate during the composite fabrication process. The aim of this project was to compare the enhancement in flexural properties due to compression stress for various amounts of jute fiber reinforced polymer matrix composites.

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2. Experimental

2.1 Materials and methods

In this research raw jute fiber was collected from local market of Bangladesh and then it was washed and dried in sun. The middle portion of every jute fiber was selected so that they have same diameter and possess similar properties. The polyester resin was used as matrix material and Methyl Ethyl Ketone Peroxide was used as a hardener.

The required amount of continuous and aligned jute fibers (10 &15 percent by weight) were placed on the lower part of the mold and then the upper part was closed. Resin with 2% hardener was poured into the mold and after 7-10 minutes, when the resin starts to coagulate, various compression stresses (2.5, 5 and 10 kPa) were applied. To apply compression stress, various amounts of load were imposed on the composite casting so that the whole composite solidifies under this stress. The pure polyester sample was also fabricated.

Figure 1. Jute-polyester composite.

2.2 Three-point flexural test

Three-point flexural test was carried out for each type of sample using a Universal Testing Machine of model number INSTRON 3369. Flexural test specimens were prepared according to ASTM D 790-00 standard.

3. Results and Discussion

3.1 Flexural strength

3.1.1 Pure polyester sample

Three-point flexural test was conducted for the pure polyester sample. According to the composition of their main chain polyester can be of different types and their flexural strength also varies with their composition. In our research, the average flexural strength of pure polyester is 51.86MPa. Ratna and Mohana also reported the same flexural strength for pure polyester [5].

3.1.2 Jute polyester composite (10 wt% jute fiber)

Flexural strength of sample without any compression stress is 57.98 MPa which is greater than pure polyester. Normally flexural strength of the composite is higher than pure polymer [6]. When this same composite is fabricated under 2.5, 5 and 10 kPa compression stresses, it is observed that flexural strength increases with increasing compression stress (table 1). Without any compression stress, jute polyester composite with 10 wt% jute fiber has a flexural strength of 57.98 MPa and flexural strength increases to 83.99 MPa for the same composite fabricated under 10 kPa compression stress. It has been seen that when pressure is applied during fabrication of coir fiber/polyester, flexural strength increases with increasing molding pressure [7].

Table 1. Flexural strength of 10 wt% jute polyester composite for different compression stresses.

Compression stress (kPa)	Average Flexural Strength (MPa)
0	57.98
2.5	65.01
5.0	76.57
10.0	83.99

Stress vs. strain curve for 10 wt% jute fiber reinforced polyester fabricated under different compression stresses is plotted along with the stress vs. strain curve of pure polyester in figure 2. Changes in flexural property can be easily identified from this graph.

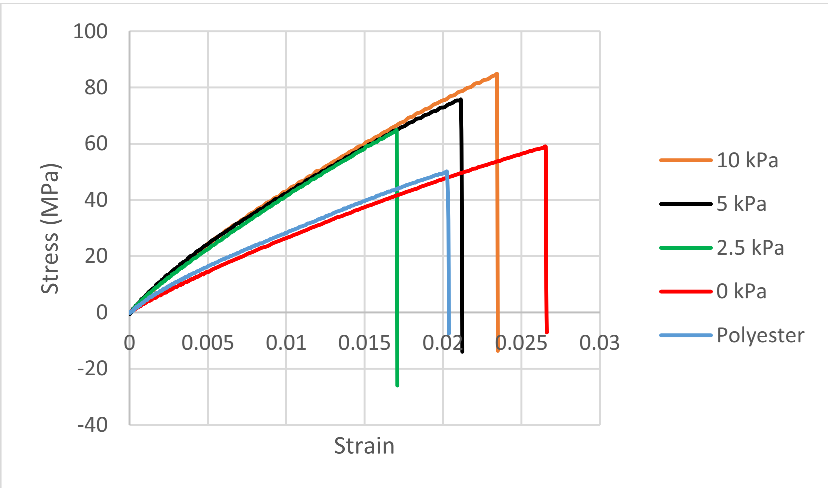

Figure 2. Stress vs. Strain curve for 10 wt% jute polyester composite fabricated under different compression stresses.

3.1.3 Jute polyester composite (15 wt% jute fiber)

Flexural strength of 15 wt% jute fiber reinforced polyester sample without any compression stress is higher than the previous sample fabricated under no compression stress, which is quite expected. It was reported that flexural strength of composite increases with increasing jute fiber loading up to 40 wt% [8,9]. At normal condition that means for no compression stress, 15 wt% jute fiber reinforced polyester composite has a flexural strength of 63.29MPa. When compression stress is applied, flexural strength also increases in this case and for 10kPa compression stress it becomes 114.38MPa which is almost double than the sample fabricated without any compression stress. For both fiber content used, there is a tendency for composites cured under higher compression stress to present corresponding higher flexural strength values. This is due to the more effective impregnation of the fibers by the resin, which certainly occurred as a higher pressure is applied during the matrix setting. Table 2 and figure 3 show the strength variation with different compression stress. From the figure, it is clear that the increase in flexural strength with increasing compression stresses is more pronounced for 15 wt% jute fiber sample than 10 wt% jute fiber reinforced polyester sample. Figure 4 shows the increase in flexural strength with compression stress for two different fiber contents. It is clear from the plot that the increase in flexural strength with compression stress is not actually linear. So compression stress applied during the fabrication has just a tendency to increase the flexural strength of composite. Still one cannot be sure that compression stress have any direct influence. Because, for both piassava–polyester composites [10] and chopped bagasse–polyester composites [11] the molding pressure was observed to have only a secondary effect on the flexural behavior. Their mechanical performance doesn't improve until the threshold molding pressure in overcome.

Table 2. Flexural strength of 15 wt% jute polyester composite for different compression stresses.

Compression stress (kPa)	Average Flexural Strength (MPa)
0.0	63.29
2.5	80.49
5.0	86.59
10.0	114.38

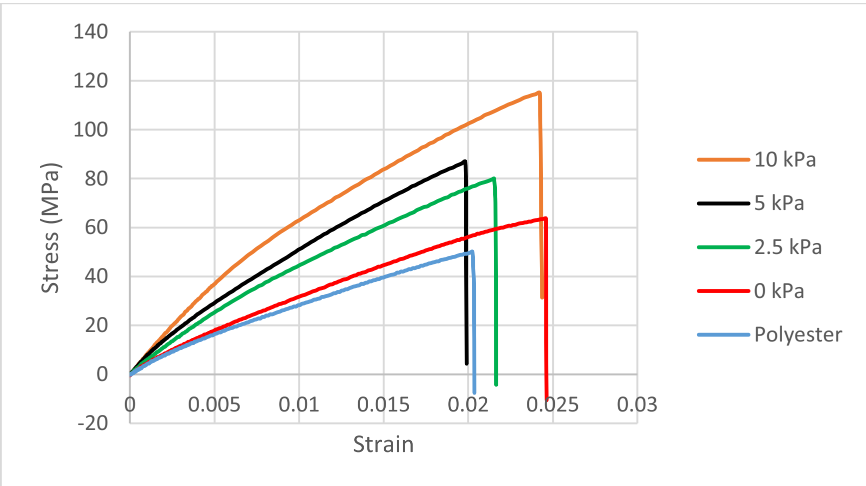

Figure 3. Stress vs. Strain curve for 15 wt% jute polyester composite fabricated under different compression stresses.

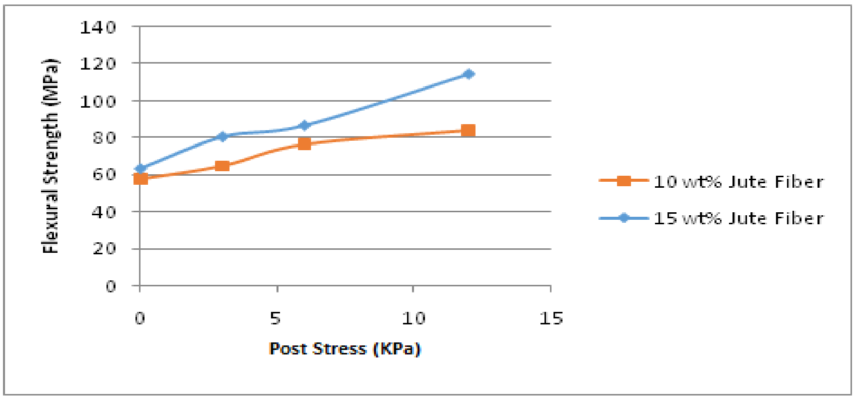

Figure 4. Relationship between flexural strength and compression stress for two different fiber contents.

3.2 Flexural modulus

Figures 5 & figure 6 show the change in flexural modulus with compression stress for both 10 wt% and 15 wt% jute fiber content. For jute-polyester composite flexural modulus was reported to increase with increasing fiber content [12]. Pure polyester has a lower flexural modulus of 1711MPa but for 10 wt% fiber content it increases to 3279MPa and for 15 wt% fiber content it increases to 5743MPa. For both amounts of fiber content, a further increase in flexural modulus is observed with increasing compression stresses. G Francucci and his co-workers observed the similar affect for flax fiber/epoxy laminates. [13]

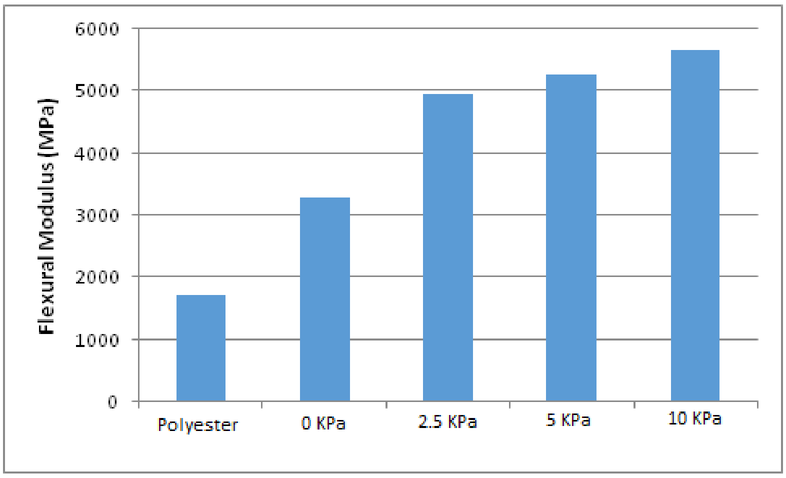

Figure 5. Relation between flexural modulus and compression stress for 10 wt% jute fiber reinforced polyester.

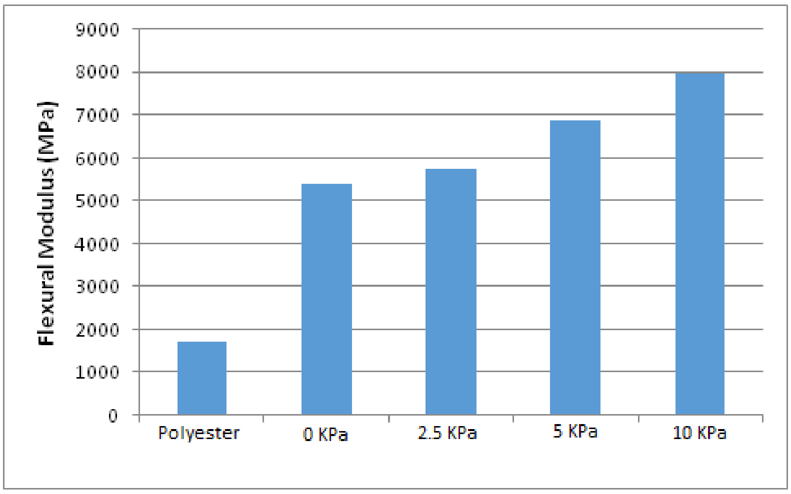

Figure 6. Relation between flexural modulus and compression stress for 15 wt% jute fiber reinforced polyester.

4. Conclusion

In this research work, different amount of compression stresses (2.5, 5 and 10 kPa) were applied to various percentages (10%, 15%) of fiber loading to fabricate composites. Following conclusions are made from this research work.

- Flexural properties (flexural strength and flexural modulus) of the composite sample without any compression stress were significantly lower than composite samples fabricated by applying compression stress. Flexural strength and flexural modulus increased with increasing compression stress.
- Higher flexural properties for increasing compression stress were due to better impregnation of the fibers by the resin, which certainly occurred as a higher pressure is applied during the matrix setting.
- Flexural properties of composites with 10 wt% and 15 wt% are higher than the pure polyester sample. Flexural properties of 15 wt% jute fiber composite are also higher than 10 wt% composite for the same amount of applied compression stress.

5. References

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Acknowledgments
The authors are grateful for a research grant in the course of this investigation to the authority of BUET as well as Department of Materials and Metallurgical Engineering, Bangladesh University of Engineering and Technology (BUET), Dhaka-1000, Bangladesh.