Experimental Investigation on Mechanical Properties of Glass and Jute Reinforced Composite

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ABSTRACT

Nowadays composite materials are mostly preferred due to good mechanical properties and light weight nature than conventional materials. In composite material matrix and reinforcement play important role; as load is taken by matrix and transmitted to the reinforcement. Reinforcement can be either synthetic fiber or natural fiber. Manufacturing of synthetic fibers is harmful from environment point of view; hence recent research work is focused on use of natural fiber as reinforcement. In this research work Jute natural fiber is taken into account for reinforcement along with Synthetic glass fiber. Epoxy resin is used. Three types of composites are prepared X-321, X-322 and X-323. X-321 has only glass reinforcement which is 68 percent with 12 glass layers. X-322 has glass reinforcement (43 percentages) and jute reinforcement (7 percentages) with G/G/J/G/G layers arrangement. Two glass layers followed by one jute layer and two glass layers. While X-323 has glass reinforcement (31 percentages) and jute reinforcement (14 percentages) with G/J/G/J/G layers arrangement. Mechanical properties of prepared composites are tested according to ASTM standards. It is observed that with decrease in total reinforcement mechanical properties are also decreasing. Compressive strength of X-321 and X-322 is almost same. Short beam shear strength of X-322 and X-323 is same.

Keywords*: composite, Jute, reinforcement.*

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1. INTRODUCTION

Composite materials are mostly preferred due to good mechanical properties and light weight nature than conventional materials. In composite material; matrix and reinforcement play important role; as load is taken by matrix and transmitted to the reinforcement. Reinforcement can be either synthetic fiber or natural fiber. Natural fiber reinforced composites are environment friendly than synthetic fiber composite due to following reasons: (1) Production of natural fiber has less environmental impacts than production of synthetic fiber. (2) Natural fiber composites have higher fiber contents to have similar performance to synthetic fiber composite; which in turn also reduces polluting base polymer content. (3) Improvement in fuel efficiency and reduction in emission during useful phase of component due to light weight nature of natural fiber composites; particularly in automobile application. (4) Recovered energy and carbon credits due to end of life incineration of natural fibers [1]. Natural fibers are broadly classified based on their source as Animal fibers and Plant fibers. Wool, silk etc are animal fibers. Jute, sisal, flax, banana etc are plant fibers which are obtained either from leaf, stalk or seed. Use of natural fiber either as total reinforcement or partial reinforcement in composite is good step from environment point of view along with other advantages.

2. COMPOSITE MATERIAL PREPERATION AND TESTING

2.1 Selection of Natural Fiber and Synthetic Fiber

In our surrounding large variety of flora and fauna are available. Jute Natural fiber which is within range is taken into account for research work. Jute fiber canvas sheet with 240 GSM (Grams per Square Meter) & Glass synthetic fiber sheet with 360 GSM are used for further work.

2.2 Chemical Treatment of Natural Fiber

Poor compatibility or adhesion between the hydrophilic fibers and hydrophobic matrix materials can reduce mechanical properties in Natural fiber reinforced composite. Researchers are finding treatments to improve the surface properties of fibers to enhance compatibility and adhesion. Mechanical interlocking, molecular attractive forces and chemical bonds are factors which affect bond between two materials. In ideal situation hydroxyl groups in natural fibers would bond with hydroxyl groups in resin & creates hydrogen bonds. Due to presence of moisture the bond strength between natural fibers and resin significantly decreases while curing; as H_2O molecules will bond with available hydroxyl groups on surface of fiber and reduces connections available for matrix bonding. After evaporation of water; voids will remain in cured composite. If fibers are dried properly before use then proper bond will form & future moisture uptake will be limited due to absence of hydroxyl bonding sites. Process of alkalization is the common method to reduce the moisture absorption tendency of Natural fibers. Alkali treatment with NaOH or KOH reduces hydrogen bonding capacity of cellulose by eliminating open hydroxyl groups which tend to bond with water molecules. Hemicellulose is also dissolved due to alkalization. Hemicellulose is the most hydrophilic part of natural fiber structure and its removal will reduce the ability of fibers to absorb moisture [2].

Use of 5 percent NaOH treated Jute fiber in composite shows better mechanical properties than 10 percent NaOH treated Jute fiber[3]. Washing after alkalization is necessary. If washing is not done after alkalization then alkali will continue its reaction with fiber and after long exposure it will degrade the fiber which eventually will lead to significant fiber swelling & breakdown [2]. Jute fiber canvas sheet is treated with 5 percent NaOH solution for 24 hours; followed by washing and drying in sunlight.

2.3 Plan of Preparation

Three types of composites are prepared X-321, X-322 and X-323. X-321 has only glass reinforcement with 12 glass layers. X-322 has glass reinforcement and jute reinforcement with G/G/J/G/G layers arrangement. Two glass fiber sheet layers followed by one Jute fiber sheet layer and two glass fiber sheet layers. While X-323 has glass reinforcement and jute reinforcement with G/J/G/J/G layers arrangement.

2.4 Manufacturing of Composite

Three types of laminated Composites X-321, X-322 and X-323 are manufactured by Hand layup method. 5 percent NaOH treated Jute fiber canvas sheet with 240 GSM (Grams per Square Meter) and Glass synthetic fiber sheet with 360 GSM are taken as reinforcement. Epoxy resin (MY 740) is used with hardener (HY-918) & accelerator (DY 062) in proportion of 100:90:2 by weight. By hand layup method reinforcement sheets of Jute & Glass are laminated in desired sequence with epoxy resin in between successive laminates. Prepared composites were pressed under press machine for 2 hours at 120 degree Celsius followed by room temperature curing for one day. Once again prepared composites were pressed under press machine for 2 hours at 120 degree Celsius followed by natural cooling to room temperature.

2.5 Calculation of Percentage Reinforcement

Prepared composite X-321 has dimensions as (420 X 430 X 3.2) mm and mass is 1.14 kg. It has 12 layers of Glass fiber sheet of 360 GSM.

Area for one Glass fiber sheet layer = (420 X 430) mm^2; which is equal to 0.1806 m^2. Mass of one glass fiber sheet = Area X GSM= 0.1806 X 360 = 65.016 gm. X-321 is having 12 such layers; Hence total mass of Glass fiber sheet reinforcement = 12 X 65.016 = 780.192 gm.

% Reinforcement of Glass in X-321 = $\frac{780.192}{1140} \approx 68$ %. Similarly percentage reinforcement of Glass and Jute are obtained for X-322 and X-323. Percentage reinforcement in X-321, X-322 and X-323 is shown in Table- 1.

Composite Material →	**X-321**	**X-322**	**X-323**
Size of Sheet (mm)	420X430X3.2	330X370X2.7	350X390X2.76
Mass of Sheet (kg)	1.14	0.41	0.47
GSM of Glass sheet	360	360	360
GSM of Jute sheet	-	240	240
Percentage (%) Glass reinforcement	68	43	31
Percentage (%) Jute reinforcement	-	7	14
Total percentage (%) reinforcement	68	50	45

Table-1: Percentage reinforcement

2.6 Testing of Prepared Composites

Prepared composites X-321, X-322 and X-323 are tested according to ASTM standards. Tensile test is done according to ASTM D-3039 standard. For compression test ASTM D-3410 standard is used. Flexural strength is obtained by ASTM D-790 standard. ASTM D-2344 standard is used for determination of short beam shear strength. Density is determined by using ASTM D-792.

Fig-1 shows Tensile Test specimens of X-321, X-322 and X-323 after testing.

Fig-1: Tensile test specimens after testing

Fig-2 shows Compression Test specimens of X-321, X-322 and X-323 after testing.

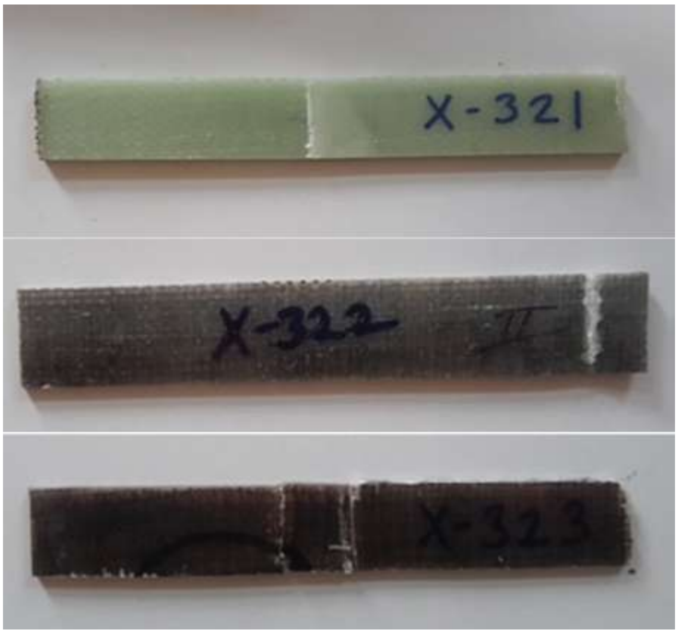

Fig-2: Compression test specimens after testing

ISSN: 2321-8169
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Fig. 3 shows Flexural Test specimens of X-321, X-322 and X-323 after testing.

Fig-3: Flexural test specimens after testing

3. RESULTS & DISCUSSION

Mechanical properties obtained after testing, arrangement of layers and details about percentage reinforcement for X-321, X-322 and X-323 are tabulated in Table 2. From Table 2 and Fig. 4 to 7; it is clear that Mechanical properties are also decreasing with decrease in total percentage reinforcement and percentage glass reinforcement. Fig. 4 to 7 indicates that in X-322 and X-323 with increase in percentage Jute reinforcement Tensile strength, Compressive strength and Flexural strength are reduced but Short beam shear strength is same. From Table 2 and Fig.5 it is observed that for X-321 and X-322 Compressive strength is 100.59 N/mm^2 and 90.69 N/mm^2 respectively; which is almost same.

Composite Material →	**X-321**	**X-322**	**X-323**
Nature of Composite (Arrangement of layers)	All Glass layers (12 number of Glass layers)	G/G/J/G/G	G/J/G/J/G
Percentage Glass reinforcement	68	43	31
Percentage Jute reinforcement	-	7	14
Percentage Total reinforcement	68	50	45
Ultimate Tensile Strength (N/mm^2) (ASTM D-3039)	335.09	122.07	62.76
Compressive Strength (N/mm^2) (ASTM D-3410)	100.59	90.69	46.28
Flexural Strength (N/mm^2) (ASTM D-790)	545.4	197.3	109.2
Short beam Shear Strength (N/mm^2) (ASTM D-2344)	61.88	8.07	8.07
Density (gm/cc) (ASTM D-792)	1.91	1.3	1.34

Table-2: Details of Composite Material

X-321 has 12 glass layers while X-322 has just 4 glass layers and 1 Jute layer (G/G/J/G/G); it means by using X-322 instead of X-321 for almost same compressive strength 12 glass layers will be replaced by just 4 glass layers and 1 Jute layer which will be good from environment point of view.

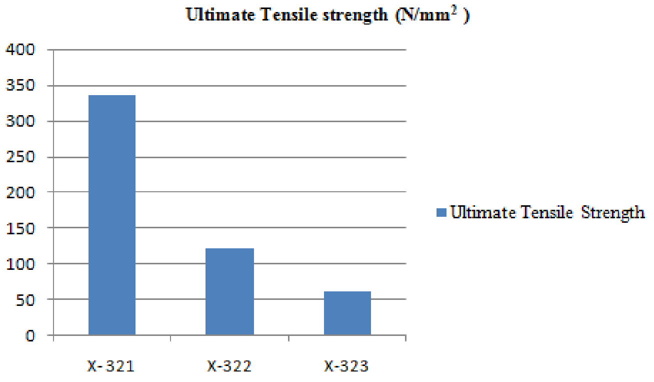

Fig-4: Variation in Ultimate Tensile Strength

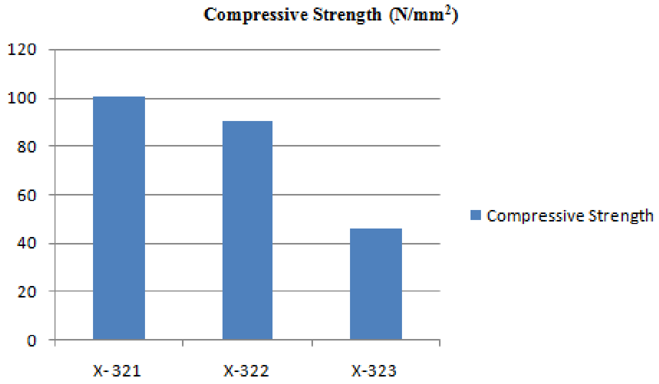

Fig.5. Variation in Compressive Strength

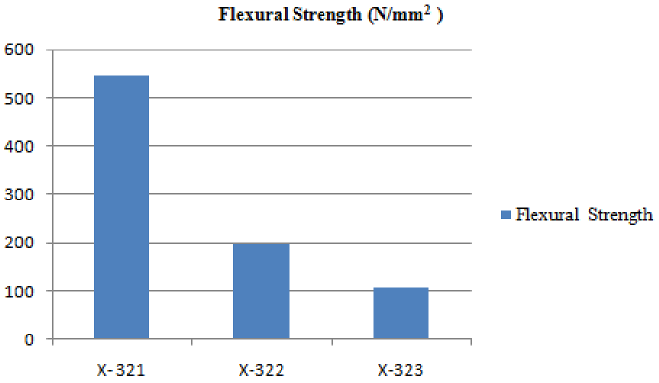

Fig.6. Variation in Flexural Strength

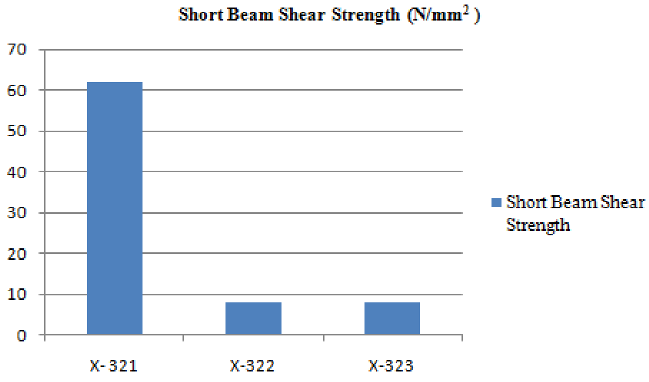

Fig.7. Variation in Short Beam Shear Strength

From Fig. 8 it is very clear that X-322 is having lowest density. Density of X-323 is also close to density of X-322. It means components made by using X-322 and X-323 will have less weight than components made by X-321.

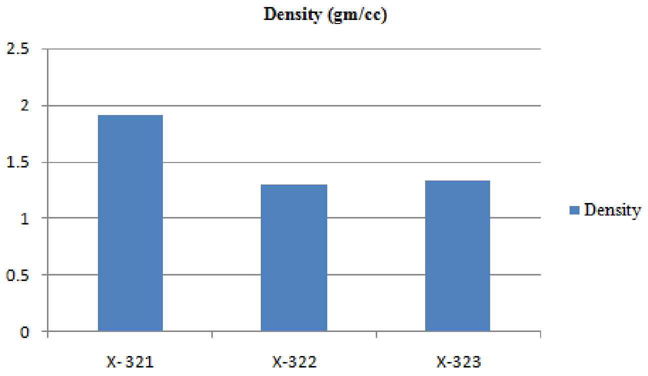

Fig-8: Variation in Density

Natural fibers are having potential to emulate with synthetic fiber as reinforcement in composite material. Natural fiber reinforced composite are somewhat inferior to synthetic fiber reinforced composite. So to have properties comparable and equivalent with synthetic fiber reinforced composite two options are available. One option is to use more percentage of Natural fibers for equivalent strength; as synthetic fibers have better mechanical properties than natural fibers. Another option is simultaneous use of both type of fibers i.e. Natural & Synthetic as reinforcement; such composites are also known as Hybrid Composites. Use of natural fiber along with synthetic fiber will replace synthetic fiber to some extent; which in turn will also result in reduction in environmental impacts due to synthetic fibers.

4. CONCLUSION

Three types of composites are prepared X-321, X-322 and X-323. X-321 has only glass reinforcement which is 68 percent with 12 glass layers. X-322 has glass reinforcement (43 percentages) and jute reinforcement (7 percentages) with G/G/J/G/G layers arrangement. Two glass layers followed by one jute layer and two glass layers. While X-323 has glass reinforcement (31 percentages) and jute reinforcement (14 percentages) with G/J/G/J/G layers arrangement. 5 percent NaOH treated Jute fiber canvas sheet with 240 GSM (Grams per Square Meter) and Glass synthetic fiber sheet with 360 GSM are taken as reinforcement. Epoxy resin (MY 740) is used with hardener (HY-918) & accelerator (DY 062) in proportion of 100:90:2 by weight. Prepared composites were tested according to ASTM standard. Mechanical properties like Ultimate tensile strength, Compressive strength, Flexural strength, Short beam shear strength are also decreasing with decrease in total percentage reinforcement and percentage glass reinforcement. In X-322 and X-323 with increase in percentage Jute reinforcement Tensile strength, Compressive strength and Flexural strength are reduced but Short beam shear strength is same. For X-321 and X-322 Compressive strength is 100.59 N/mm^2 and 90.69 N/mm^2 respectively; which is almost same. Use of X-322 for same Compressive strength will be in favor of environment as it is having less number of glass layers and one jute layer. X-322 is having lowest density.

In future work X-322 can be used in some application as it is having equivalent compressive strength to X-321 and lowest density as compare to X-321 and X-323. As in our surrounding large variety of flora & fauna is there; one can consider Natural fiber which is within range & study its use as reinforcement in composite materials.

ACKNOWLEDGMENT

Authors would like to thank Mr. Pradeep Pingale of Om Industries; Nashik for making tailor made composites and Mr. Parijat Bhase of FAN services laboratory, Nashik for testing of prepared composite according to ASTM standards.

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