NOVATEUR PUBLICATIONS
INTERNATIONAL JOURNAL OF INNOVATIONS IN ENGINEERING RESEARCH AND TECHNOLOGY [IJIERT]
ISSN: 2394-3696
VOLUME 2, ISSUE 8, AUG-2015

INVESTIGATION ON THE MECHANICALBEHAVIOUR OF THE GLASS/ BANANAFIBERS REINFORCED EPOXY COMPOSITE

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ABSTRACT

The composites are one of the advanced engineering materials which are commonly used in this decade in day today life. The natural fibers are used for the reinforcement in order to get higher strength, reduced density, lower weight for several applications. The hybrid composite is obtained by using two or more materials with varying properties. Hybridization is a process of incorporating synthetic fiber with the natural fiber to get the better strength, stiffness, high strength to weight ratio and improvements in the mechanical properties. In this work, an attempt is made to hybridize using Glass (synthetic) fiber as well as Banana (natural) fiber with Epoxy resin as the matrix material, such that to reduce the overall use of the synthetic reinforcement and to enhance the mechanical properties. The composites are fabricated using the Hand Lay-Up method for the different weight percentages of the reinforcements. The mechanical properties are evaluated by conducting tests such as Tensile test, Flexural test, Impact test, Hardness test, Interlaminar shear strength test, Water absorption test according to the ASTM standards. The experimental results showed that the HFREC showed better mechanical properties than the BFREC and closer to the values of the GFREC.

KEYWORDS – BFREC (Banana fiber reinforced epoxy composite), GFREC (Glass fiber reinforced epoxy composite), HFREC (Hybrid fibers reinforced epoxy composite), Hand Lay-Up.

INTRODUCTION

Over the last twenty years composite materials are one of the dominating engineered materials. Modern composite materials constitute a considerable part of the engineered materials market which is having the wide range of applications. Already composite have proven their significance as weight-saving materials, the present challenge is to make them cost saving materials.

Banana fiber (musa balbisiana or musa acuminate) is obtained from the pseudo stem of the banana plant. Bast fibers, like banana are complicated in structure. Banana fibers have been traditionally used for making paper, carpets, packing material, bags, and more recently as a textile material. Banana fiber reinforced composites have recently gained significance. Banana fibers are mainly used for making lightweight composites and in agricultural industriesBanana fibers are the waste product of the banana cultivation and these are easily available. The glass fibers are the other reinforcement (synthetic fiber) used in this workalong with the banana fibers. The commonly used is the E-glass fibers, because of their improved properties compared to others. Lapox-12 is the thermosetting epoxy resin used for as the matrix. The hybrid composite laminates are fabricated for the 35% of the weight fraction of the fibers and remaining 65% of the matrix material. The fabricated laminates are tested for the mechanical properties according to the ASTM standards.

MATERIALS AND METHODOLOGY

2.1 Reinforcement- Banana fibers and glass fibers are the two reinforcing fibers used for the fabrication. Banana fiber (musa balbisiana or musa acuminate) is obtained from the pseudo stem of the banana plant. Initially the pseudo stem is abstracted from the fully grown trunk. The stem is kept under the sunlight for 15-20 days. Then the dried fibers are soaked in water for at least 20 days. Then it is again dried under the sunlight until all the moisture is taken out. Then finally the stem is cut horizontally and then fibers are extracted. The woven banana fiber mat is used as the natural reinforcement. The E-glass fibers of 300 gsm synthetic fiber were used for the fabrication.

2.2 Matrix- The matrix will act as the binding agent for the fibers and also provides support for carrying the load. The thermosetting Epoxy resin is used as the matrix material for the composite. The epoxy resin of grade Lapox L-12 and hardener K-6 was used.

2.3 Fabrication of the composite

There are many techniques available for the fabrication of the composites such as vacuum molding, compression molding, resin transfer molding etc. One of the most commonly used methods is the land lay-up method. This is simple and cost effective method of fabrication.At the first step a sheet of releasing film is placed over the flat molding surface. Then a thin coat of epoxy resin was applied over the film using the brush as. The first layer of the glass fiber mat is placed over the resin coat and slight pressure is applied. The second coat of the epoxy resin is applied and a layer of the banana fiber is placed over the previous layer. This procedure was continued for the further layers, until desired thickness was obtained. On the top of the last layer, to get good surface finishing a layer of resin is applied. Finally a sheet of releasing film is placed on the top and light rolling was done. Then a weight of 10 to 20 kg was applied on the composite. The material is allowed to cure for about 24 hours and then the material is removed from the mold.

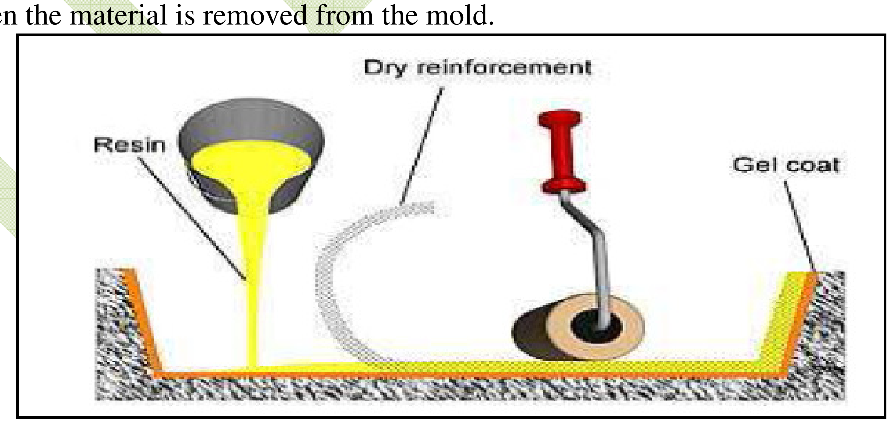

Figure 1: Hand lay-up technique

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TESTING OF THE COMPOSITE

3.1 Tensile test: The tensile test was conducted in universal testing machine (UTM). The test specimen was cut according to the ASTM D-638 standard. The test specimen of dimension 165x 19mm is prepared as in figure. The test specimen is enclosed between the grippers of the universal testing machine. The load is applied gradually until deformation of the specimen is observed. The corresponding value of the load is noted down for the deformation of the specimen. The stress, strain for the corresponding load and deformations are calculated.

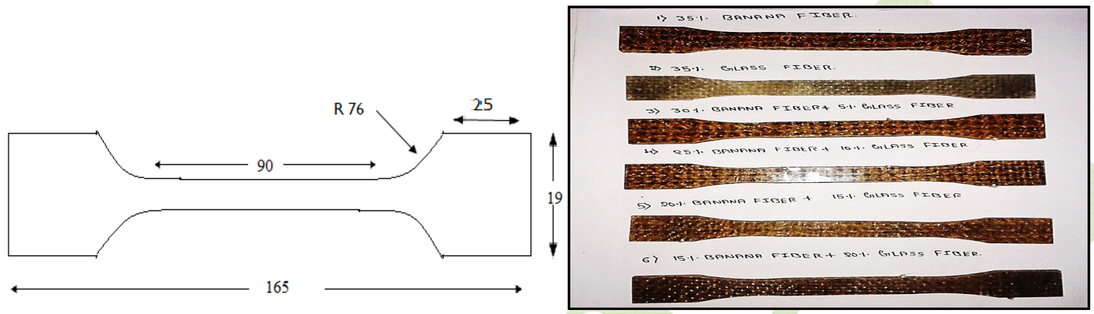

Figure 2: Tensile test specimens

3.2 Flexural test: Flexural test was conducted in the three point bending test arrangement in a UTM machine.Specimen is cut according to ASTM D-790 standard. The test specimen of the dimension 70x19 mm is prepared as shown in figure. The test specimen is placed on the roller supports at both the ends.The load is gradually applied from the top roller until the deformation is observed.The load value at the maximum deformation is noted down.

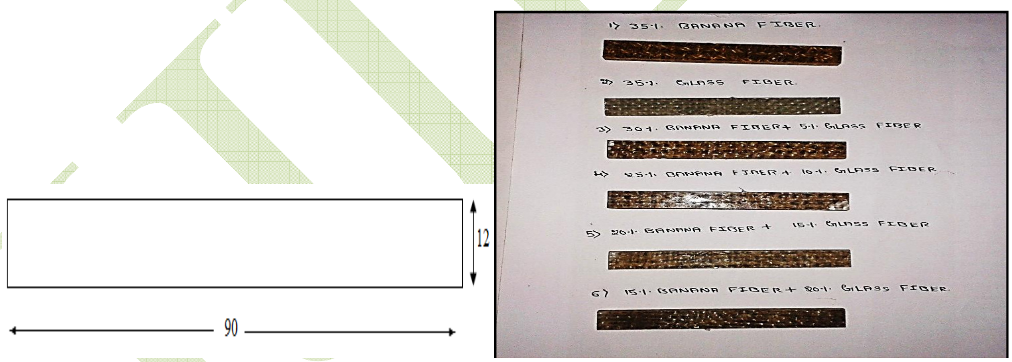

Figure 3: Flexural test specimens

3.3 Impact test: The impact test was conducted in the charpy impact test machine.The test specimen was cut according to the ASTM D-256 standards. The test specimens of the dimension 60x12 mm are prepared as in the figure. The specimen was fixed on the slot.Then the impact load is applied by releasing the swinging pendulum.The pendulum hits the specimen placed in the slot.The load absorbed for the breakage of the specimen is noted down.

ISSN: 2394-3696
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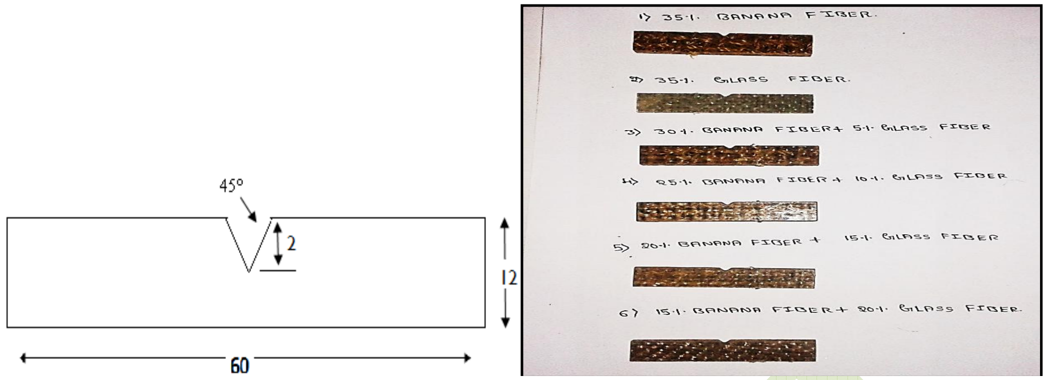

Figure 4: Impact test specimens

3.4 Hardness test: The hardness test was conducted in the Rockwell hardness test machine.The test specimen was cut according to ASTM D-785 standard.The specimen is placed on the anvil.At first the minor load is applied to cause the penetration.Then the major load is applied.The Rockwell hardness number is noted down.

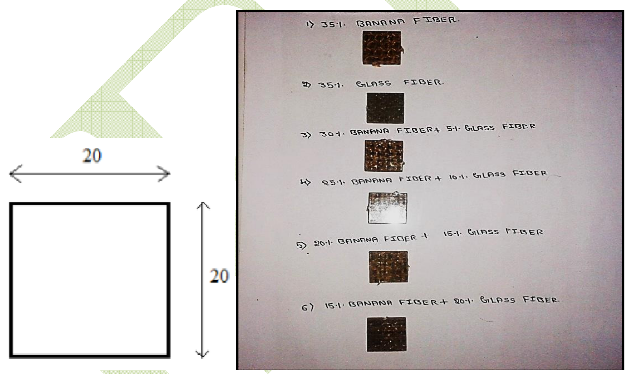

Figure 5: Hardness test specimen

3.5 Interlaminar shear strength test: The ILSS test was conducted in the UTM machine.The specimens were prepared according to the ASTM D 2344 standard.The specimen was placed on the bottom support rollers for the span length.The load is applied from the top roller until deformation is observed.The load value at maximum deformation is noted down.

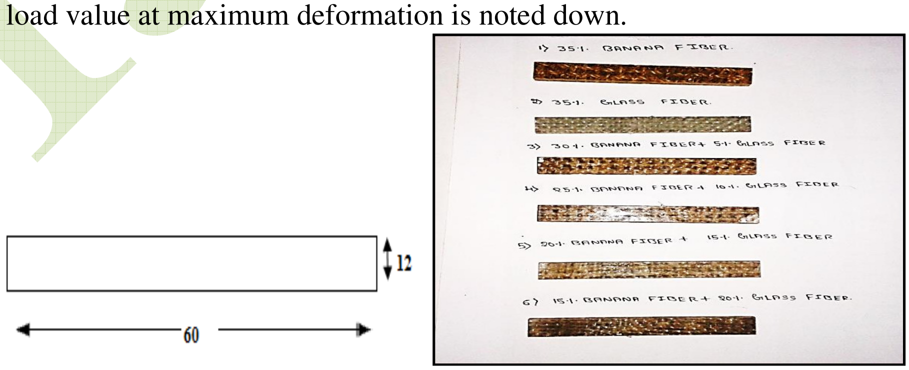

Figure 6: ILSS test specimen

3.6 Water absorption test: The test is conducted according to ASTM D 570 standard.The weight of the specimens is measured before the test.The specimens were then submersed in the water for 24 hours.Then again the weight of the specimens is measured after the test.The percentage amount of water absorbed is calculated using the formula

$$\mathbf{W\ (\%) = (W_f - W_i) / (W_i) \times 100}$$

Where W_i= Dry weight of specimen, W_f= wet weight of specimen, W= percent of water absorbed by the specimens.

Figure 7: Specimens immersed in water

RESULTS AND DISCUSSION

4.1 Tensile test

Table 1. Tensile test results

Materials	**UTS (N/mm^2)**	**Young's modulus (N/mm^2)**
35% banana fiber	26.89	523.81
30% banana fiber + 5% glass fiber	30.27	617.75
25% banana fiber + 10% glass fiber	25.359	513.12
20% banana fiber + 15% glass fiber	68.74	897.91
15% banana fiber + 20% glass fiber	71.06	1080.30
35% glass fiber	73.71	1124.38

From the table it is observed that the banana fiber reinforced composite has the least strength of 26.89 Mpa compared to other combinations. Since the synthetic fibers have the superior strength compared to the natural fibers, the result showed the maximum tensile strength of 73.71 Mpa. The comparison of UTS of various compositions is shown in the figure8. The 15% banana reinforced hybrid composite showed the maximum strength of 73.71 Mpa, only 3.6% lesser than the GFREC. The reason for increase in tensile strength of HFREC is that the glass fibers have the highest strength compared to the banana fibers.The reason for increasein tensile strength in hybrid fiber reinforced composite is that natural fibers have higher interfacial strength with the matrix than synthetic fibers.

4.2 Flexural test

Table 2. Flexural test results

Material	Flexural modulus (N/mm^2)	Flexural strength (N/mm^2)
35% banana fiber	1309.10	55.45
30% banana fiber + 5% glass fiber	1587.56	59.83
25% banana fiber + 10% glass fiber	1794.83	62.68
20% banana fiber + 15% glass fiber	2554.78	69.435
15% banana fiber + 20% glass fiber	2984.96	74.138
35% glass fiber	3421.48	75.575

The above result shows the flexural strength of the different composites. From the result it is observed that the 15% banana fiber reinforced hybrid composite showed the maximum bending strength compared to the BFREC and HFREC. The strength is only 1.9% lower than the glass fiber reinforced epoxy composite. The glass fiber reinforced composites show the superior flexural strength than the banana fiber reinforced composites. The reason is that the glass fiber can take more bending loads than the banana fibers. The reason for increase in the strength of HFREC may be the combined effect of the properties like high stiffness and the capability to take high bending forces by both banana fibers and glass fibers.

4.3 Impact test

Table 3. Impact test results

SL. no	Material	Charpy impact strength (Kj/ m^2)
1	35% banana fiber	22.09
2	30% banana fiber + 5% glass fiber	66.6
3	25% banana fiber + 10% glass fiber	62.68
4	20% banana fiber + 15% glass fiber	70.56
5	15% banana fiber + 20% glass fiber	72.59
6	35% glass fiber	76.44

The above table shows the results of the impact strength of the different composite. This test is conducted to study the toughness of the material.The experimental result showed that 15% banana reinforced composite exhibit better strength compared to the BFREC and HFREC. The strength value is only 5.3% lesser than the glass fiber reinforced composite. The reason for increase in impact strength of HFREC is the high interfacial strength of banana fiber with matrix and ability of glass fiber to withstand against impact loading.

4.4 Hardness test

Table 4. Hardness test results

Sl. no	Material	RHN
1	35% banana fiber	63
2	30% banana fiber + 5% glass fiber	64
3	25% banana fiber + 10% glass fiber	67
4	20% banana fiber + 15% glass fiber	68
5	15% banana fiber + 20% glass fiber	70
6	35% glass fiber	72

The Rockwell hardness number shows the depth to which an indenter is driven by the major load beyond the depth of previously applied minor load. From the result we can observe that the highest value of the hardness number is obtained for the 15% banana fiber reinforced hybrid composite compared to the BFREC and other HFREC.The greater value of the hardness number is obtained from the hard materials with a shallow indentation and lower values are obtained for the softer material with a deep indentation.

4.5 Interlaminar shear strength test

Table 5. ILSS test results

SL. no	Material	Inter laminar shear strength (N/mm^2)
1	35% banana fiber	6.43
2	30% banana fiber + 5% glass fiber	9.88
3	25% banana fiber + 10% glass fiber	10.36
4	20% banana fiber + 15% glass fiber	8.31
5	15% banana fiber + 20% glass fiber	18.10
6	35% glass fiber	22.7

The above table shows the experimental result of the ILSS test. The test is conducted in a UTM machine with three point bending arrangement, by keeping the s/t ratio 4:1. The figure shows the comparison of the ILSS strength for different composites. The maximum value of the strength is observed for the 15% banana fiber reinforced epoxy composite compared to BFREC and HFREC.

4.6 Water absorption test

Table 6. Water absorption test results

Material	Weight before the test (W_i) in grams	Weight after the test (W_f) in grams	Percent gain in weight (W %)
35% banana fiber	5.28	5.54	4.926
30% banana fiber + 5% glass fiber	5.60	5.85	4.462
25% banana fiber + 10% glass fiber	6.23	6.47	3.851
20% banana fiber + 15% glass fiber	3.70	3.81	2.982
15% banana fiber + 20% glass fiber	4.67	4.75	1.713
35% glass fiber	3.77	3.82	1.32

The result of the test for the different specimens is as shown in the table. The results showed that the water absorbed by a specimen depends on the weight percentage of the banana fibers in the composite. The total weight percent of the water absorbed in the 15% banana fiber reinforced hybrid composite is almost same to that of the 35% glass reinforced epoxy composite. The amount of the water absorbed in the specimen increases when the weight percent of the banana fiber in the composite is more. This increased absorption of water by banana fiber is due to its greater affinity towards the water.

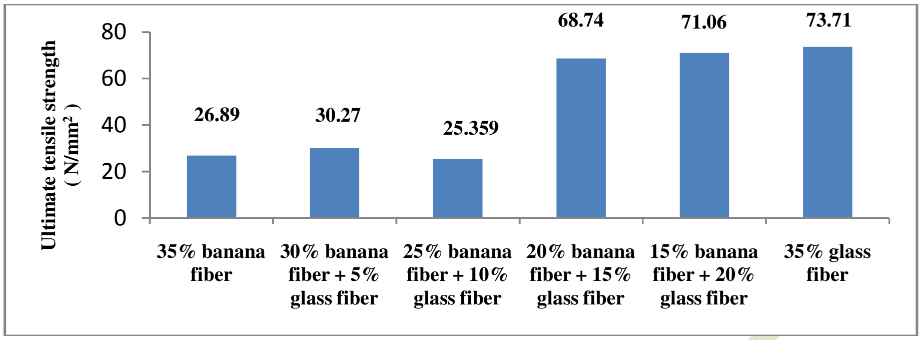

Figure 8: Comparison of UTS in Tensile test

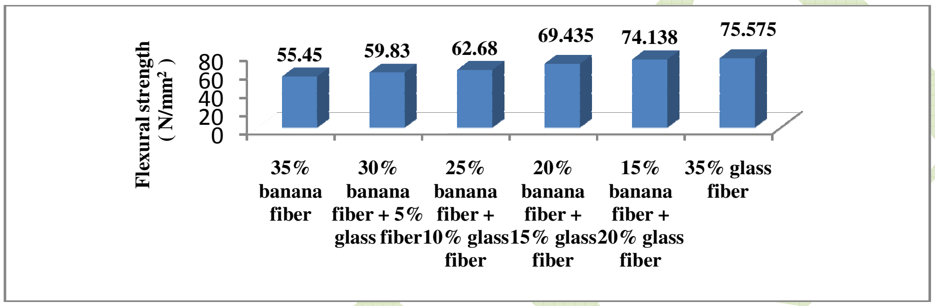

Figure 9: Comparison of Flexural strength

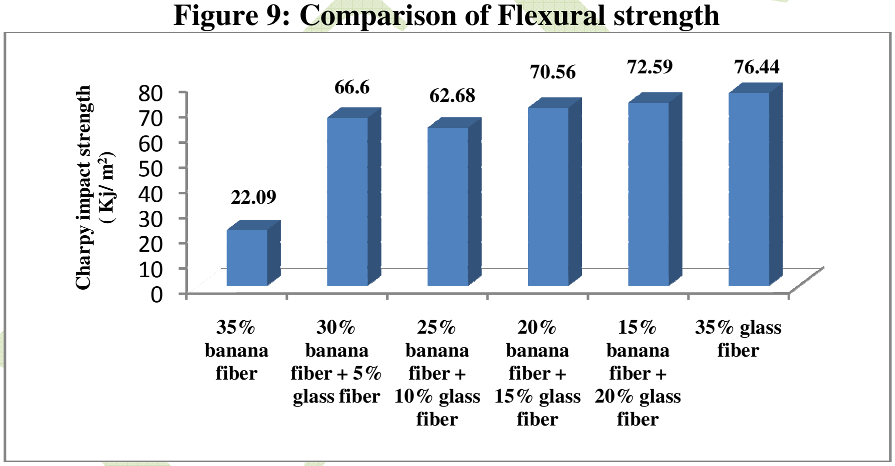

Figure 10: Comparison of Impact strength

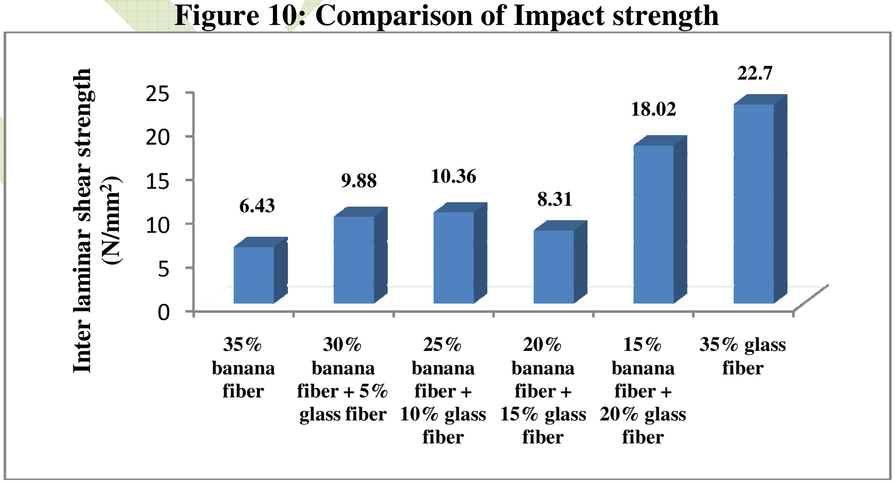

Figure 11: Comparison of Interlaminar shear strength

CONCLUSIONS

The hybrid composite with glass and banana fibers as the reinforcements were successfully fabricated by hand lay-up method.These composite laminates were subjected to the mechanical tests as mentioned above according to the ASTM standards. From the experimental results it is observed that the GFREC has better mechanical properties compared to the BFREC. The hybridization of Glass fibers and Banana fibers at varying weight fraction with the matrix had greater strengths than the BFREC. The HFREC composite strengths were closer to the strength of the GFREC. It has been noticed that by the hybridization of Banana fiber and Glass fibers enhances the properties to a greater extent, and make it eco-friendly composite.

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