

Properties investigations on metallic fiber reinforced sandwich composites

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Abstract: The present study deals with the usage of two types of metallic reinforcements namely bronze and steel, one natural reinforcement namely jute and an artificial reinforcement namely glass for preparation of composite laminates. The study investigates the mechanical behaviour of prepared samples and concludes with the selection of best samples. Four composite laminates were prepared by changing the compositions of reinforcements in polyester resin. Tensile, compressive, flexural and impact tests were carried out on the developed samples and it was found that the inclusion of jute and metallic reinforcements improved the compressive and impact strengths of the composite whereas inclusion of jute and glass improved the tensile and flexural strengths of the composite.

Introduction

Studies on the mechanical properties of fiber reinforced plastics were carried out in the recent past by considering natural fibers as reinforcements. In a study, vetiveria zizanioides were used as reinforcements in vinyl ester resin and mechanical properties were investigated. The study revealed that by proper selection of fiber composition, natural fibers could be used as a replacement for synthetic fibers [1]. A study on jute and glass fiber reinforced epoxy laminates reported that the tensile and flexural strength of composites were enhanced when glass fibers are used as extreme plies during fabrication [2]. A research on kenaf fiber reinforced polypropylene plastic reported that the inclusion of kenaf fiber in polypropylene matrix improved the mechanical properties like young's modulus, failure strain and impact resistance [3]. Investigations on maize fiber reinforced epoxy composites reported that alkali treatment to maize fibers removed the excess lignin and improved the water absorption characteristics of the composites [4].

In a study typha domingensis leaves were used as reinforcements in polyester resin to form composite plates. The study reported that mechanical properties increases with increase in fiber volume fraction and these composites could be used as insulating boards, electronic packages and construction industries [5]. Metallic fibers were used as reinforcements by only few researchers. In a study on steel fibers were used as reinforcements in glass matrix and impact strength was investigated. The study concluded that the toughness improved due to the presence of metallic fibers [6]. The present study investigates the mechanical properties of newly developed natural hybrid composites samples. Composite samples are prepared by using fibres namely jute, steel, bronze and E-glass reinforced in polyester resin. Four composite samples were prepared by varying the composition of fibres. The laminates were tested for tensile, compressive, flexural and impact strengths. The results were compared and the influence of each fibre on the mechanical properties was analysed.

Materials and methods

Four hybrid composite laminates were prepared using hand lay-up method with varying proportions of reinforcements and constant proportion of matrix. During this preparation methyl ethyl ketone peroxide was used as a catalyst and cobalt octoate was used as an accelerator [1]. The

fiber proportions in each laminate were presented in Table 1. Tensile and compression testing was done by using a universal testing machine according to ASTM D638 and ASTM D695 respectively. A three point bending test was done for calculating the flexural strength of the composites by using ASTM D790 and Charpy impact test was done to measure the impact strength of composites by using ASTM D256. Mechanical testing methods are presented in Fig.1.

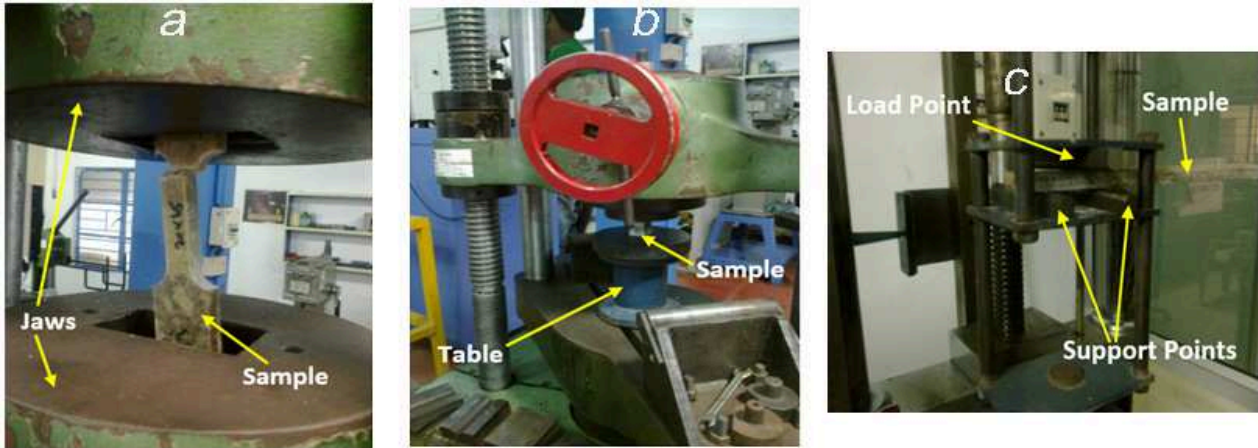


Figure 1. (a) Tensile test (b) Compression test (c) Flexural test

Table 1. Composition of laminates

Sample number	Sample Identity	Jute Wt %	E-Glass Wt %	Bronze Wt %	Steel Wt %	Polyester Resin Wt %
1	JP	30	0	0	0	70
2	JGP	20	10	0	0	70
3	JBP	20	0	10	0	70
4	JSP	20	0	0	10	70

Tensile strength analysis

The tensile strength plot for developed samples was presented in Fig. 2(a). A maximum tensile strength was shown by laminate JGP and this followed by laminate JP. Comparing these two samples it was observed that a 10 % inclusion of glass fibers improved the tensile strength. This shows that inclusion of multiple fibers improves the tensile strength [7]. Laminates JBP and JSP presented very low tensile strength in comparison with the other two laminates. This clearly shows that the inclusion of metallic fibers namely steel and jute does not produce high tensile strength. Comparing samples JP and JGP, it would be concluded that the presence of glass fibers is very important to achieve good tensile properties. Also, comparing laminate JP with laminates JBP and JSP, it could be concluded that natural jute reinforcement produce better tensile strength than the metallic fibers namely steel and bronze.

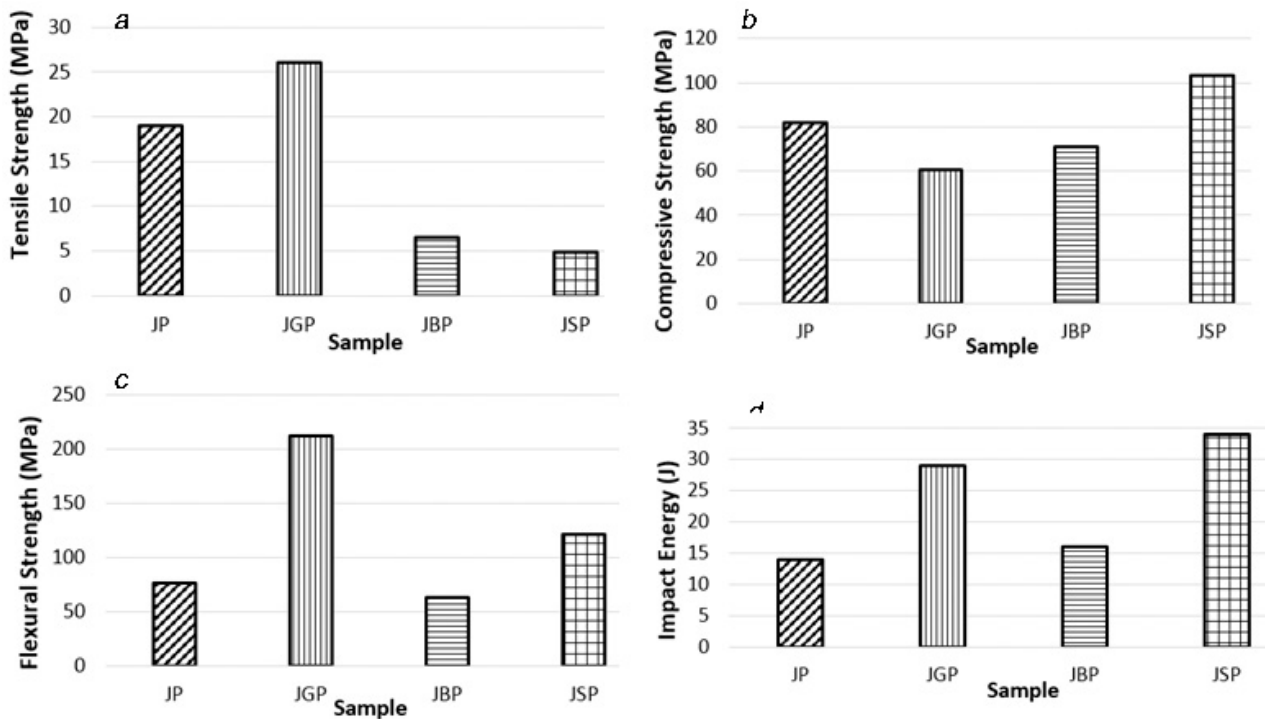


Figure 2. (a) Tensile strength plot (b) Compressive strength plot (c) Flexural strength plot (d) Impact strength plot

Compressive strength analysis

The compressive strength of all samples were presented in Fig. 2(b). A maximum compressive strength was shown by laminate JSP followed by laminate JP. This shows that steel fibers offer more resistance to compressive loads than jute, bronze and glass fibers. A minimum compressive strength was shown by laminate JGP. This indicates that glass fibers are not suitable to bear more compressive load when compared to jute, bronze and steel fibers. Comparing laminate JP with laminates JGP and JBP clearly indicates that jute fibers have more capability to bear compressive load than the glass and bronze fiber. Comparing laminates JGP and JBP shows that bronze fiber could be substituted for glass fibers in order to achieve better compression strength.

Flexural strength analysis

Flexural strength is a measure of resistance offered by the material against bending loads. During this test, the top and bottom layers of the laminates were subjected to bending and shear respectively. Hence the failure would be due to a combination of bending and shear. The flexural strength plot for developed laminates were presented in Fig. 2(c). A maximum flexural strength was shown by laminate JGP which is followed by JSP. Comparing laminates JP with laminate JGP and JSP, it was observed that composites made in sandwich form improves the strength considerably [8]. A minimum flexural strength was shown by laminate JBP. This shows that bronze fibers does not bear high bending loads when compared to jute, glass and steel fibers.

Impact strength analysis

Impact strength is the measure of energy absorbed by the material at the time of fracture or it is the toughness of the material. The impact strength of all samples were presented in Fig. 2(d). A maximum impact strength was shown by laminate JSP followed by laminate JGP. A minimum impact strength was shown by laminate JP. This clearly shows that inclusion of steel fibers and glass fibers along with jute fibers improved the impact strength considerably. Earlier researches in impact strengths showed that the presence of glass fibers are vital to improve the impact properties

of composites [1, 9]. In the present study, it was observed that steel fibers absorb more energy than glass fibers and hence steel fibers could be substituted in place of glass fibers.

Microstructure analysis

Microstructural images of tested laminates were presented in Fig. 3. These images are used to visualize the defects like matrix cracking, cavities, micro holes and fibre pull-outs in fractured samples. Laminate JP presents uniform distribution of resin with only few micro cavities. When compared to laminate JP, laminate JGP shows more cracks and few micro-holes. These cracks are formed due to low stress transfer capability of glass fibers. Microstructure of laminate JBP shows more cracks and cavities. This clearly shows that the bonding between the bronze fiber and matrix was poor than between other fibers and matrix. Microstructure of laminate JSP shows few fiber pull outs. Increase in fiber pull out increases the impact strength of composite. Hence, these fiber pull outs are responsible increased impact strength of laminate JSP.

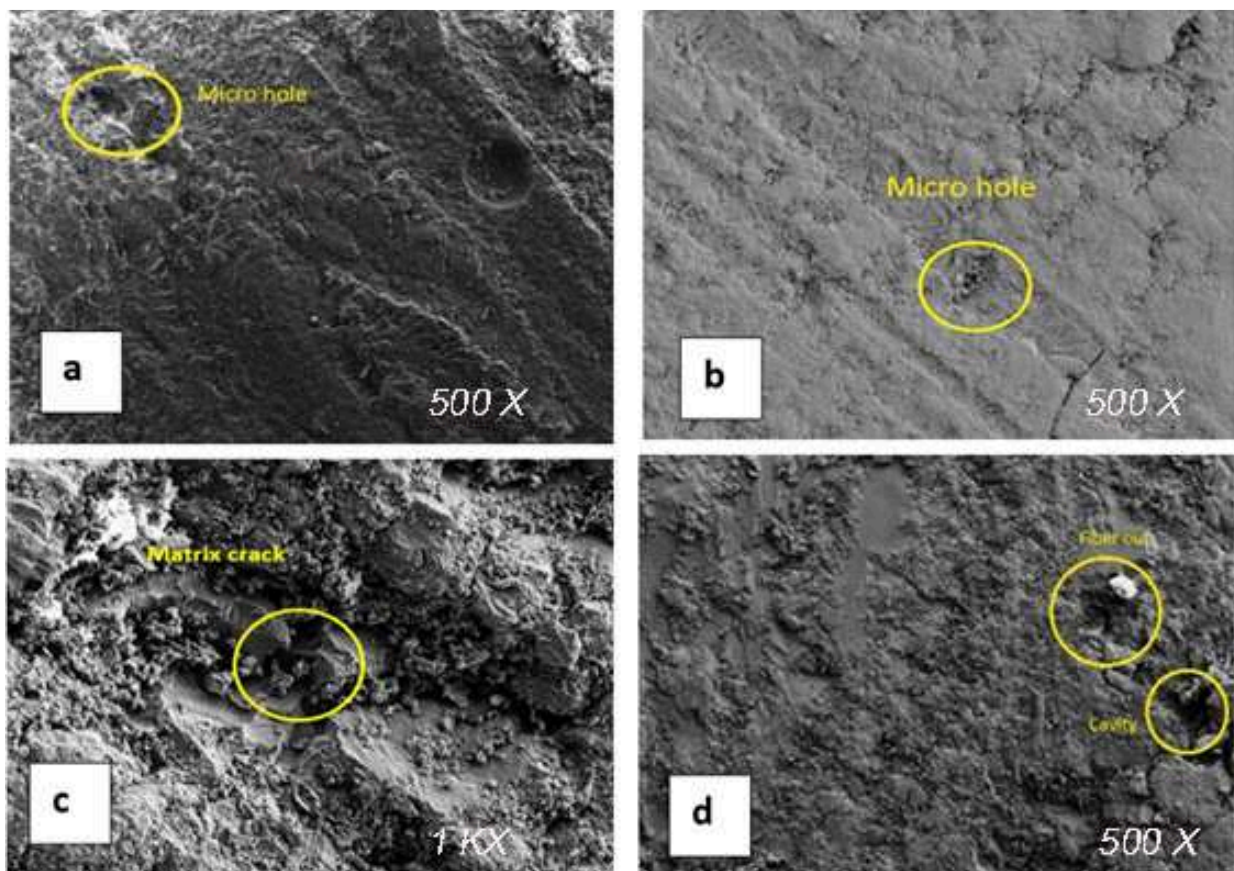


Figure 3. Microstructure of (a) laminate JP (b) laminate JGP (c) laminate JBP and (d) laminate JSP

Conclusion

This study analyzed the properties of composite samples developed under varying proportions of jute, glass, bronze and steel fibers and the conclusions obtained are as follows:

- High tensile and flexural strength were shown by jute/glass/polyester sample. The presence of glass is very important as far as tensile and flexural strengths are concerned.

- High compressive and impact strength were shown by jute/steel/polyester sample. The presence of steel enhanced the compressive and impact behavior of samples. Hence steel fibers could be substituted for glass without losing the composite properties.
- Inclusion of Bronze fibers does not improved any of the properties of composite .Hence Bronze fibers are suitable for usage as reinforcements in fiber-reinforced composites.
- Investigations on Jute/polyester composites revealed that they could be supported in place of Bronze during tensile and compressive loading.
- Hence by appropriate selection of natural and metallic fibers, mechanical properties could be decided well in advance for composite materials.

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