

Comparative Study on the Mechanical Properties of Composite Panels Made with Natural and Synthetic Fibers

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ABSTRACT:The objective of this study is to find the mechanical properties of vinylester based jute and glass fiber based composite material. The composite materials were replacing the traditional materials, because of its superior properties such as high tensile strength, low thermal expansion, high strength to weight ratio. Natural fiber like jute became more attractive due to their high specific strength, light weight and biodegradability. Mixing of natural fibers with Glass-Fiber Reinforced Polymers (GFRPs) was finding increased applications. In this study, vinyl ester based jute and glass fiber composite materials with varying proportions of vinyl ester were developed and their mechanical properties such as tensile strength and flexural strength are evaluated. Vinyl ester proportion varies from 90% to 70%. Totally 18 number of composite panels were prepared and they are jute-vinylester, GFRP-vinylester and jute-GFRP-vinylester panels. The results indicated that the incorporation of jute fiber can increase the tensile strength and GFRP can improve the flexural strength properties and can be used as wall panels, roofing sheets or as false ceiling due to its strength and high temperature withstanding capacity.

KEYWORDS: Biodegradability, Reinforced, Polymers

I. INTRODUCTION

The design of durable and low cost fibre materials for building construction is a technological challenge in developing countries. The type of fibres currently been used include glass, polymers, carbon and natural fibre. Considerable researches are being done for use of reinforcing fibre like jute, bamboo, sisal, akwara, coconut husk, sugarcane bagasse in epoxy resins mostly in case of roofing construction. The availability of natural fibre is abundance and also they are very inexpensive when compared to other advanced man made fibre. These natural fibre are used as a suitable reinforcing material environmental concern and they are now emerging as a potential alternative for glass fibre in engineering composite. Natural Fibre, isolated from plants, is classified into three categories, depending upon the part of the plant they are extracted from. Economic and other related factors in many developing countries where natural fibre are abundant demand that scientists and engineers apply appropriate technology to utilize these natural fibre as effectively and economically.

Paper is organized as follows. Section II describes the methodology of study. Section III represents experiments performed for each specimen. Finally, Section IV presents conclusion.

II. METHODOLOGY

2.1 Fibre collection

Jute Fibre

Jute is known as the 'Golden Fibre' due to its golden brown color and its importance. In terms of usage, production and global consumption, jute is second only to cotton. Jute is environmentally friendly as well as being one of the most affordable fibre.



Fig 2.1: jute fiber

They are white, yellow or brown in color. It becomes golden colour as a layer of lignin is deposited on their walls. Each cell is about 0.0015 to 0.020 millimeter average diameter. A better understanding of the chemical composition and surface adhesive bonding of natural fiber is necessary for developing natural fiber-reinforced composites. The components of natural fibers include cellulose, hemicelluloses, lignin, pectin, waxes and water soluble substances. It has an average tensile strength of about 393 N/mm². Density is about having 1.46 g/cc and a specific gravity of about 1.5.

Glass fiber

Glass-Fibre reinforced plastic, or GFRP is a fibre reinforced polymer made of a plastic matrix reinforced by fine fibre of glass. Fibreglass is a light weight, extremely strong, robust material. Glass fibre is used as a reinforcing agent for many polymer products; to form a very strong and relatively lightweight fibre-reinforced polymer (FRP) composite material called glass-reinforced plastic (GRP), also popularly known as "fibreglass". (Typically 5–25 micrometres in diameter for E-Glass, 9 micrometres for S-Glass).



Fig 2.2 Glass fiber

Vinyl ester

Vinyl Ester is a resin produced by the esterification of an epoxy resin with an unsaturated monocarboxylic acid. The reaction product is then dissolved in a reactive solvent, such as styrene, to 35 - 45 percentage content by weight. Vinyl tarps look similar to polyester tarps. However, vinyl, made from salt and ethylene, is stronger, sturdier and more water-resistant than polyester. In fact, it yields highly rigid products with a low heat resistance property.



Fig 2.3 Vinyl Ester

2.2 Preparation of mould

The mould is made by using plywood. Plywood is made of three or more thin layers of wood bonded together with an adhesive. Plywood is cut into required size and is joined by using nails and glue. Hacksaw is used to cut the plywood. Length of mould = 304.8 mm, Breadth = 304.8 mm, Depth of mould = 5m

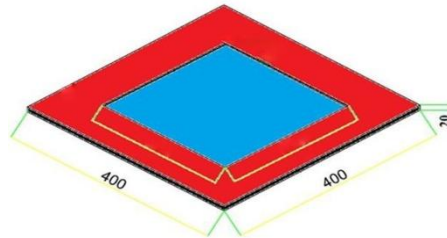


Fig 2.4 Mould (All dimensions are in mm)

2.3 Preparation of composite panels

We have used a conventional moulding method such as Hand lay-up. Hand lay-up is a simple method for composite production. A mould must be used for hand lay-up parts unless the composite is to be joined directly to another structure. The mould can be as simple as a flat sheet or have infinite curves and edges. Jute fibres are used in a mesh manner for the specimen. Glass fibres are used as sheets for the specimen. The composite specimen consists of total two layers. Ester and jute mesh and another consist of ester and glass fibre. The layers of fibres are fabricated by adding the required amount of vinyl ester resin. Initially the glass fibre polymer, jute fibre are dried in sunlight to remove the moisture. The glass fibre reinforced polymer is then completely filled with resin. The resin got mixed with glass fibre reinforced polymer. The vinyl ester resin applied is distributed to the entire surface.



Fig 2.5 Hand Layup Mould and specimen

Fabrication details

- Glass fibre = 1500 gm.
- Jute fibre = 1000 gm.
- Vinyl Ester resin = 4000 ml.



- Total number of specimen = 18

III. EXPERIMENTAL RESULT AND DISCUSSIONS

Mechanical Characterization

3.1 Tensile Strength Test

Tensile test is the most common mechanical test for determining the mechanical properties of materials such as strength, ductility, toughness, elastic modulus, etc. The samples are taken for testing, and the corresponding values obtained from those samples were observed. The tensile test specimen is prepared according to the ASTM D3039 standard. The dimensions, gauge length and cross-head speeds are chosen according to the ASTM D3039 standard. A tensile test involves mounting the specimen in a machine and subjecting it to the tension. The testing process involves placing the test specimen in the testing machine and applying tension to it until it fractures during the application of tension, the elongation of the gauge section is recorded against the applied force.

Tensile strength can be calculated by the equation,

$$\text{Tensile Strength} = \frac{P}{A}$$

Length=250mm, Width= 25mm, Thickness = 5 mm

Table 3.1 a) Jute – Vinyl Ester composite panel

SI No	Specimen	Specimen size (mm)	Load (KN)	Tensile strength (N/mm ²)
1	70% Resin & 30% jute	250×25×5	6.72	53.76
2	80% Resin & 20% jute	250×25×5	6.25	50
3	90% Resin & 10% jute	250×25×5	6.10	48.8

Table 3.1 b) Glass Fibre – Vinyl Ester composite panel

SI No	Specimen	Specimen size (mm)	Load (KN)	Tensile strength (N/mm ²)
1	70% Resin & 30% Glass fibre	250×25×5	5.60	47.6
2	80% Resin & 20% glass fibre	250×25×5	5.82	46.56
3	90% Resin & 10% glass fibre	250×25×5	5.95	44.8

Table 3.1 c) Jute - glass fibre – vinyl ester panel

SI No	Specimen	Specimen size (mm)	Load (KN)	Tensile strength (N/mm ²)
1	70% Resin & 15% Glass fibre & 15% jute	250×25×5	5.98	47.85
2	80% Resin & 10% glass fibre & 10 %jute	250×25×5	5.90	47.2
3	90% Resin & 5% glass fibre & 5% jute	250×25×5	5.83	46.64

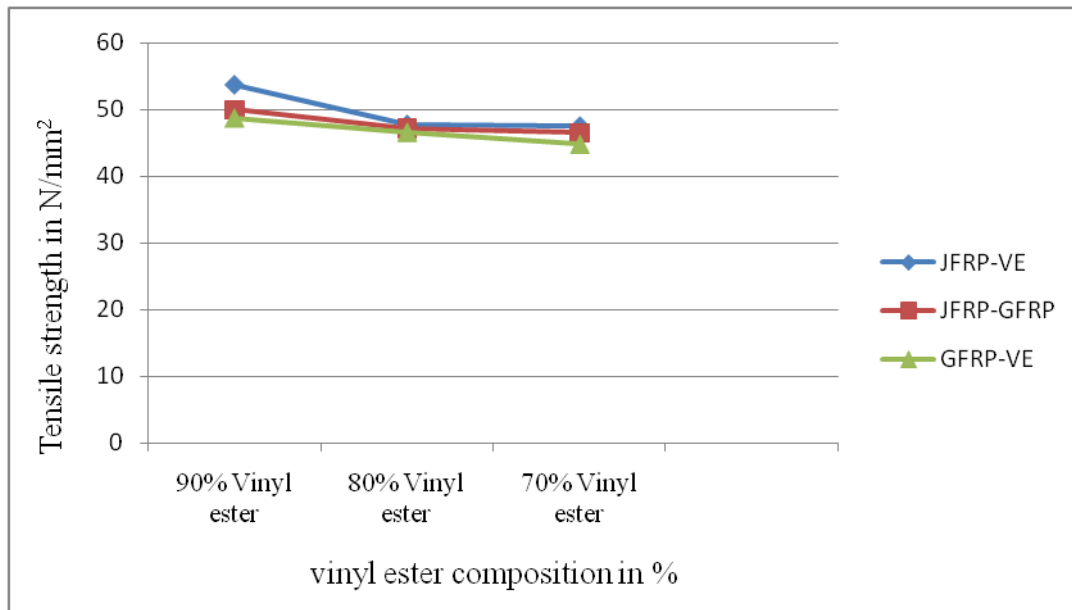


Fig 3.1:Tensile Strength variation curve for different composite materials with varying Percentage of vinyl ester.

Fig 3.1 shows a comparison of the tensile strengths of the composites using various loads of treated glassfibrereinforced with jute fibre and Vinyl ester resin. The horizontal axis shows vinyl ester composition with varying percentage. Vertical axis represents the tensile strength for varying percentage of vinyl ester and its unit is N/mm².From the observations of tensile strength test of jute – vinyl ester composite panelit is found that, the specimen with 70% vinyl ester and 30 % jute is having high tensile strength of 53.76N/mm², when compared to other composites.The tensile strength test of glass – vinyl ester composite panelshows that, the specimen with 70% vinyl ester and 30 % glass fibreis having high tensile strength of 47.6N/mm²when compared to other composites. The tensile strength test of jute - glass – vinyl ester composite panelshowsthat, the specimen with 70%vinyl ester, 15% jute and 15 % glass fibre is having high tensile strength when compared to other composites, which is having a tensile strength of 47.85 N/mm².

3.2 Flexural Strength Test

The flexural specimens are prepared as per the ASTM D790 standards. The 3-point flexure test is the most common flexural test for composite materials. Specimen deflection is measured by the crosshead position. Test results include flexural strength and displacement. The testing process involves placing the test specimen in the universal testing machine and applying force to it until it fractures and breaks. In three point Bending test, the outer rollers are and the samples were tested at a strain rate of 2mm/min.A three point bend is chosen because it requires less material for each test and eliminates the need to accurately determine center point deflections with test equipment. Flexural test properties are the major parameter used in assessing the suitability of composite materials for structural applications.

$$\text{Flexural strength} = \frac{3FL}{2bd^2}$$

Where L is the support span, b is the width and d is the thickness, F is the maximum load and m is the slope of the initial straight line portion of the load deflection curve. . The sample specimens after bending test are shown.

Table 3.2 a) Jute – Vinyl Ester composite panel

Sl. No	Specimen	Specimen size (mm)	Load (KN)	Flexural strength (N/mm ²)
1	70% Resin & 30% jute	250×25×5	0.60	288
2	80% Resin & 20% jute	250×25×5	0.75	360
3	90% Resin & 10% jute	250×25×5	0.90	432



Table 3.2 b) Glass Fibre – Vinyl Ester composite panel

Sl. No	Specimen	Specimen size (mm)	Load (KN)	Flexural strength (N/mm ²)
1	70% Resin & 30% glassfiber	250×25×5	0.85	408
2	80% Resin & 20% glassfiber	250×25×5	1.10	528
3	90% Resin & 10% glassfiber	250×25×5	1.25	600

Table 3.2 c) Jute - glass fibre – vinyl ester panel

Sl. No	Specimen	Specimen size (mm)	Load (KN)	Tensile strength (N/mm ²)
1	70% Resin & 15% Glass fibre & 15% jute	250×25×5	0.70	336
2	80% Resin & 10% glass fibre& 10 %jute	250×25×5	0.90	432
3	90% Resin & 5% glass fibre & 5% jute	250×25×5	1	480

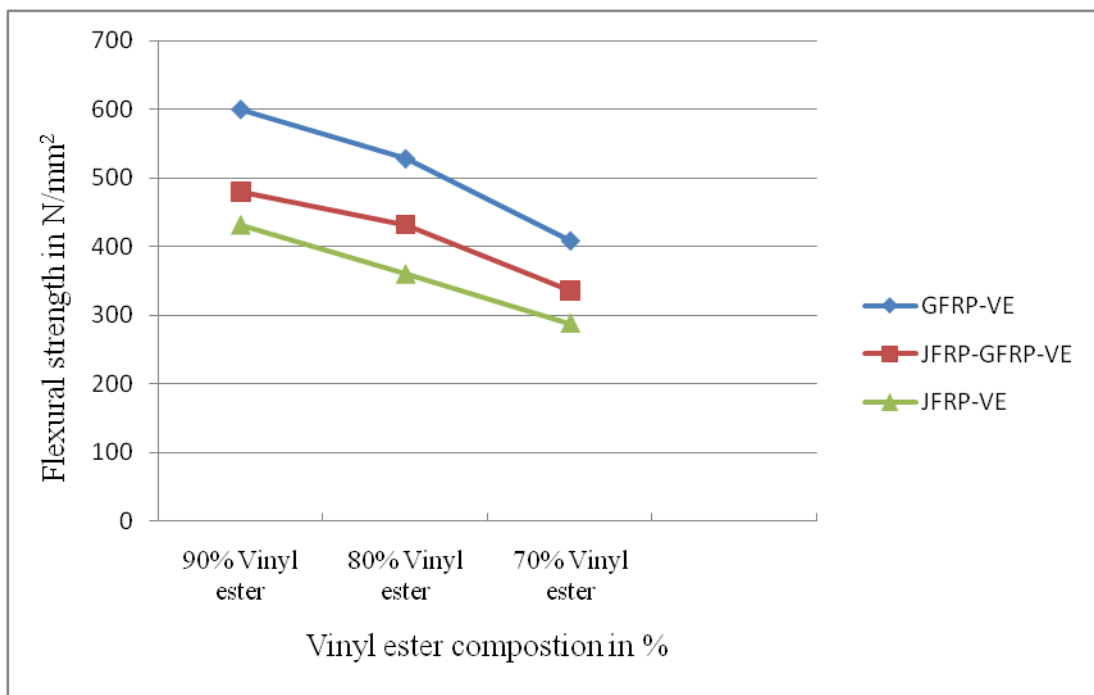


Fig 3.2: Flexural Strength variation curve for different composite materials with varying Percentage of vinyl ester

The strength of a material in bending is expressed as the stress on the outermost fibres of a bent test specimen, at the instant of failure. The horizontal axis shows vinyl ester composition with varying percentage. Vertical axis represents the flexural strength for varying percentage of vinyl ester and its unit is N/mm². From the observations of flexural strength test of jute – vinyl ester composite panel it is found that the specimens with 90% vinyl ester and 10% jute is having high flexural strength of 432N/mm² when compared to other composites. The flexural strength test of glass fibre – vinyl ester composite panel shows that, the specimen with 90% vinyl ester and 10% glass fibre is having high flexural strength of 600 N/mm² when compared to other composites. The flexural strength test of jute – glass fibre – vinyl ester composite panel shows that, the specimen with 90% vinyl ester, 5% jute and 5% glass fibre is having high flexural strength when compared to other composites, which is having a flexural strength of 480 N/mm².

IV. CONCLUSION

The composite material which is made by using fibres and vinyl ester can be used as a partial replacement of concrete structures. Vinyl ester at different dosage of 70%, 80% and 90% were added and necessary tests were conducted. The following conclusions were presented based on results from our project on the addition of different proportions of fibre and vinyl ester.

- The results indicate that Jute –Vinyl ester specimen of 70% vinyl ester and 30% jute gives higher tensile strength. The Maximum tensile Strength obtained for the Jute–VE composite is 53.76 N/mm^2 . GFRP-VE specimen gives low tensile strength. The Maximum tensile strength obtained for the GFRP-VE composite is 47.6 N/mm^2 .
- The results indicated that the glass composite material shows maximum flexural strength and can hold the strength up to 600 N/mm^2 . The sample that is made with 90% vinyl ester and 10% glass fibre is having high flexural strength.
- By incorporation of natural fibres and synthetic fibres into the polymer, mechanical properties almost enhanced to greater extent. It can thus be inferred that jute fibre can be a very potential candidate in making of composites, especially for partial replacement of high-cost glass fibres of low load bearing applications.
- It was attributed that advanced hybrid composites have a better prospective in the fabrication of automotive parts and in the construction and building industries compared to single fibre-reinforced polymer composites. It is understood that the hybrid composites developed by a combination of natural and natural/synthetic fibres are environmentally friendly, cost effective and have comparable mechanical properties to glass fibre-reinforced polymers.
- Few researchers have reported investigations on the thermal analysis of hybrid composites, therefore further studies are required in order to understand the effects of hybridisation on the thermal properties of hybrid Composites.

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