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Investigation of Mechanical Properties of Polymer Composites using Glass and Flax Fiber Reinforcement

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ABSTRACT

Recently there has been rapid growth in research related to the natural fibre composites, due to advantage of these material compared to synthetic fibre composites. As these material possesses properties such as a low cost, low weight, low environmental impact and ability to use wide range of application. Properties of these materials depends on several factors; and orientation of fibre is one of them. The objective of this work is to know whether bidirectional flax fibre mat properties can be achieved by using unidirectional flax fibre mat arranged such that flax fibres are perpendicular to each other. Similarly can chop strand mat (CSM) glass fibre mat give the similar properties like bidirectional glass fibre mat. In order to reduce the material cost general purpose polyester resin is used. Then laminates has been prepared and their mechanical properties like tensile strength and flexural strength are studied. Tensile test and flexural test are conducted according to ASTM standards. According to Test results percentage difference between Bidirectional and unidirectional flax fibre mat was 14.95% and the flexural test result shows CSM glass fibre polyester composite shows higher strength than bidirectional glass fibre polymer composite.

Keywords: Glass fibre, Flax fibre, Bidirectional and unidirectional mat

1. INTRODUCTION

In recent years use of composite materials has grown extensively in Engineering and non-Engineering applications. Composite material consist of two components, fibre and matrix. In which fibre is material with possesses high strength and bonded to matrix at distinct interface between them. In this form both fibre and matrix continue to contribute their physical and chemical indentities, to achieve combinational properties that cannot be attained by either one of them solely [1]. The Fibres are segregated as Natural and Synthetic fibres. Natural fibres are obtained from plants, animals and minerals. The plants fibres are hemp, flax, jute, sisal, kenaf, banana and many more [2]. These fibres have mechanical properties like flexibility and stiffness, it contains advantageous characteristics such as low density, low cost, comparable specific tensile properties, non-irritating to skin, renewability and biodegradability in nature [3], While common Synthetic fibres are glass, carbon and aramid, the synthetic fibre possesses good tensile, compressive and stiffness such as E-glass[4,5]. These synthetics fibres are bonded with polymer matrix materials to form fibre Reinforced Polymer Composites (FRP). FRP includes set of properties such design flexibility, Non – Corrosiveness and it is lightweight in nature [1]. When synthetic fibre such as E glass is combined with polyester resin, it gives properties like good corrosion resistance, good temperature tolerance, ease of manufacturing and good mechanical properties at low cost. According to Mohan Kumar S, Raghavendra Ravikiran K, Govindaraju H K [5] 85% of FRP components of cars, aircrafts and boats are manufactured

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using polyester. Now a days environmental impact is major concern due to increase rate of greenhouse emission .the traditional material such as metal, metal based alloys or synthetic material are responsible for emission of carbon dioxide produce due to their processing and usage. Hence Researchers are finding the interest in environmentally materials like bio-composite, while this material considered as possible replacement for metal based alloy and synthetic fibre components. This bio-composite process satisfactory mechanical characteristics while being inexpensive, light weight, structurally efficient materials [6].This development of this new class materials came out of environmental concern while they own attractive mechanical properties. This material have high specific mechanical properties due to contribution of good mechanical properties and low density due to natural fibre. The prime area of application for this material are automotive body parts hence automotive engineering industry has provided path for further work and improvement of their properties and performance[7]. Life Cycle Assessment (LCA) was carried out for under floor panels, fabricated for Mercedes A-Class made with Glass fibre and Polypropylene, and another with flax Fibre and Polypropylene. From LCA it is found that Flax reinforced panels is better for all environmental impacts over Glass Fibre reinforced Polypropylene. Flax Fibre mats require comparatively very less energy than Glass fibre which is nearly 80%. Energy saving and also, it reduces environmental impact such as Global Warming (GW), Acidification (AP), Eutrophication (EP), Emission Ozone Precursors, Toxication of Air & Water. The environmental impact is reduced by 20%, But polypropylene is an unavoidable component which is to be used to manufacture component so total energy saving come up to 40% [8]. Natural fibre composites gaining the attention as viable and eco-friendly substitute for mineral and synthetic fibre based composite. The fact that, Mechanical properties possessed by Natural fibre composite are poorer than synthetic fibre composites but these natural fibre composite possesses several advantages to overcome this lacking. Natural fibre composites are Carbon Dioxide Neutral, less expensive, recyclable, bio-degradable, Non-abrasive to machinery and impose little health risk when inhaled. With these advantages Natural fibre composites hold upper hand synthetic composites. While considering these advantages the research is directed to achieve their use in optimal designing and manufacturing of product which is environmentally safe, durable and of high performance [9].

The orientation of fibre also affects the strength and stiffness of composite. The reinforcement fibres are introduced in matrix in various orientations. The short randomly orientated fibre with small aspect ratio (L/D) can be introduced into matrix which will provide relatively good isotropic properties to composite. The fibre with long or even continues unidirectional arrangement will produce anisotropic behaviour particularly good strength and stiffness in direction parallel to fibres. This fibres generally designated as 0° (This indicates that all fibres are in alignment with applied force). However unidirectional orientation shows poor behaviour if applied load is perpendicular directions to the orientation. The orientation of fibre also affects the Young's modulus [10]. The objective of this work is bidirectional mat properties can be achieved by using unidirectional mat layers when laid perpendicular to each other and similarly can CSM gives the same properties like bidirectional glass fibre mat. Accordingly laminates were prepared. And mechanical properties such as tensile and flexural strength were investigated and compared to a previous study [13].

2. FABRICATION OF TEST SPECIMEN

Manufacturing method used for composite laminates under study was hand lay-up Method. Manufacturing has been needed to be done under same environmental condition for Glass and flax fibre polyester composite. Matrix material used for composite is Polyester along with hardener and the accelerator. The hardener were Methyl Ethyl Ketone Peroxide (MEKP). Accelerator used during manufacturing is Cobalt Naphthenate. Glass fibre Chop Strand Mat (CSM) were used for manufacturing while Flax fibre mat was with orientation of 0°.Thickness of CSM mat is 0.6 mm and thickness of Flax mat is 0.4 mm. The size of each fabricated laminate was 300×300×3 mm. Fabricated laminates were cut into different specimen sizes according to ASTM standards.

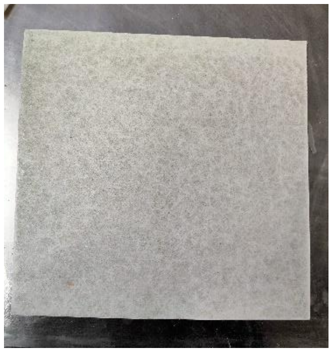

Fig. 1 Glass Fibre Polyester Composite Laminate

Fig. 2 Flax Polyester Composite Laminate

2.1 Tensile Test: The tensile test conduction was done by following ASTM standard D 638:2014. Specimen used with dimension

Overall Length 165±5 mm, Width 13±0.5 mm, overall width 25±0.5 mm, thickness 3 mm. overall dimensions including tolerances are (165×5×3) mm. The tensile test was conducted on universal tensile machine with maximum capacity of 1 Ton. Temperature and Relative humidity at the time of test is noted to be 23±2°C and 50±5% respectively. Test Setup and Specimen before testing are shown in fig.

Fig. 3 Test Setup for Tensile Test

Fig .4 Glass Fibre Specimen before testing

Fig. 5 Glass Fibre Specimens after testing

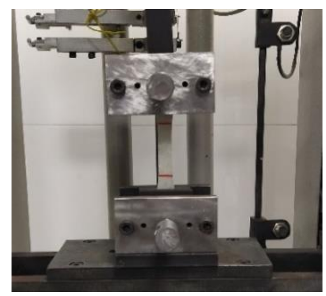

Fig. 6 Flax after testing

2.2 Flexural Test: The test method implemented for flexural performance of composite is according to the ASTM standard D 790:2017. Specimen size was (127×12.7×3) mm. Load applied on the specimen was in upward direction. Temperature and Relative humidity at the time of test is noted to be 23±2°C and 50±5% respectively. Test Setup and Specimen before testing are shown in fig.

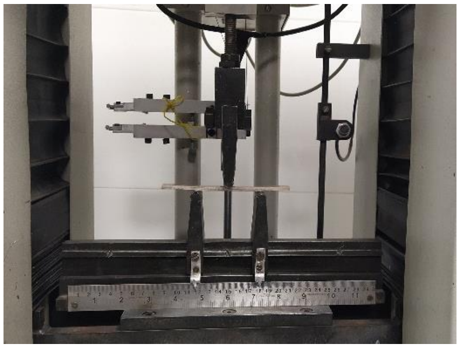

Fig. 7 Flexural testing

Fig.8 Flax polyester Specimen

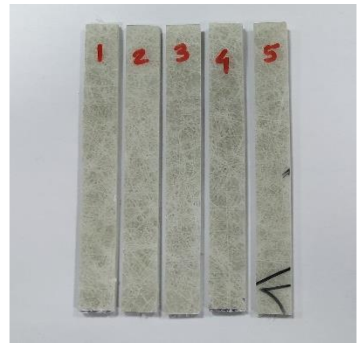

Fig. 9 Glass Fibre polyester Specimen

Fig. 10 Glass Fibre Specimen after Flexural Testing

Fig. 11 Flax Fibre Specimens after Flexural Testing

3. RESULT AND DISCUSSION:

Work done by C. M. Meenakshi and A. Krishnamoorthy [10] with flax and glass fibre composite fabricated using hand lay-up method for developing bi-directional mat of glass fibre and flax fibre reported results shown in table no. 1 and table no. 2.

As composite exhibits the properties dependent on the orientation of the fibre introduced as reinforcement, inspiring from this fact following experiment was conducted to find out whether the bi-directional mat composite properties can be achieved from the uni-directional mat composite by laying the mats perpendicular to each other in case of Flax fibre polyester composite. Similarly following study follows wether CSM glass fibre can exhibits the properties of Bi-directional Glass Fibre Polyester composites and also providing an alternative which is cost effective in case of materials. Results are tabulated in the table no. 1 [13].

Table No. 1 Overall Performance of Tensile Test

Sr. No	Composite	Tensile strength(N/mm^2)	Percentage Difference (%)
1	Glass Fibre polyester Composite (Bidirectional)	92.57	7.70
2	Glass Fibre polyester Composite(CSM)	85.44	
3	Flax Fibre Polyester Composite (Bidirectional)	44.68	14.95
4	Flax Fibre Polyester Composite (Unidirectional)	38	

Table No. 2 Overall Performance of Flexural Test

Sr. No	Composite	Flexural strength(N/mm^2)	Percentage Difference (%)
1	Glass Fibre polyester Composite (Bidirectional)	125.54	32.68
2	Glass Fibre polyester Composite(CSM)	186.35	
3	Flax Fibre Polyester Composite (Bidirectional)	61.49	1.08
4	Flax Fibre Polyester Composite (Unidirectional)	60.82	

From data listed in Table No. 1 The percentage difference between bidirectional and unidirectional flax fibre polyester composite were 14.95%. For Flax fibre the interfacial bonding is equal or greater important in predicting the tensile strength of composite. The performance of the flax fibre composite can be improved by appropriate chemical treatment (like silane treatment on flax fibre) [8].

The Flexural test result shows that the CSM fibre polyester composite has higher flexural strength than the bidirectional glass fibre polyester composite. Whereas flax unidirectional polyester composite has almost same result as that of flax bidirectional polymer composite.

4. CONCLUSION

Based on study presented in paper following conclusions and remedies are stated below. As all the tests were conducted according to ASTM standards.

- Flexural strength shown by glass fiber in CSM form with polyester resin composite are much promising than the glass fiber in Bi-directional form.
- Similarly the flax fiber unidirectional mat composites shows similar results like bi-directional flax composites, the unidirectional composite is manufactured by placing fibers in perpendicular direction to each other forming bi-directional mat structure.
- Tensile strength of shown by both unidirectional flax composite and CSM glass fiber composite was less than both bi-directional composites.

- The tensile strength of the flax fiber composite can be enhanced by several chemical treatments which will promote interfacial bonding or adhesion between fiber and matrix leading to increase in tensile strength.
- The use of Flax fibre unidirectional composite instead of their bi-directional counter parts is suggested for economic savings. Also similar economic advantage is expected with the use of CSM glass fibre polyester laminate instead of their bi-directional counter parts.

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