MECHANICAL CHARACTERISATION OF FLAX/EPOXY COMPOSITE MATERIAL EMBEDDED WITH GRAPHENE

Murugan R [1], Amith Raj R R[2], Charanraj A[3], Chandru T[4], Dharneesh N[5], N. Nithyanandan[6]

[1,6] Professor, Department of Mechanical Engineering, Panimalar Institute of Technology, Chennai, India.

[2,3,4,5] UG scholar, Department of Mechanical Engineering, Panimalar Institute of Technology, India.

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Abstract - Fibre reinforced polymer (FRP) composite laminates are widely used for making structural components in automobile, aircraft, marine, and machine tool applications due to their appreciable strength to weight ratio. To promote environment friendly materials in structural applications nowadays natural fibers are preferred in place of synthetic fibers. Many researchers have nowadays been using Nano filler materials with synthetic resin to improve the mechanical properties of the FRP laminates. In the present study, unidirectional flax fibre and epoxy resin embedded with grapheme are considered for preparing the composite laminates. Fibre in woven fabric form to promote balanced mechanical properties in the fabric plane and thickness direction. Three layered flax fibre composite laminate were prepared by hand layup technique. The fabricated laminates were tested for mechanical properties such us critical buckling load, compressive load and flexural strength as per ASTM standards. The effect of graphene filled epoxy matrix on mechanical properties of flax fibre composite laminates was discussed in detail.

Key Words: FRP, flax fibre, graphene, buckling load, bending load.

1. INTRODUCTION

FRP composite materials consist of high modulus fibres embedded in a low modulus matrix with distinct interfaces between them. They show their dominance because high strength to weight ratio and high stiffness to weight ratio. In this form, both fibres and matrix retains their physical and chemical identities, yet they produce combination of properties that cannot be achieved with either of the constituents acting alone. Because of their low density, very high strength-weight ratios and modulus-weight ratio, the fibre reinforced polymer materials are markedly superior to those of metallic materials [1]. Increase in demand for environment friendly materials promote the natural fibers in place of synthetic fibers for structural applications [2]. M. the properties of flax fabric reinforced epoxy composite for the improvement of several properties of flax/epoxy composite. The authors found that flax/epoxy composites are performing better in tensile load condition and flax/epoxy composites performing better in flexural loading and buckling effect. FatmaOmraniet al [4] evaluated the mechanical properties of flax fiber reinforced performs and composites. Kamrajet al[3] studied the effect of graphene on the properties of flax fabric reinforced epoxy composites for improvement of several properties of flax/epoxy composites. The authors' in order to improve the understanding of the mechanical properties of flax fibre, a multi-scale characterization was carried out to analyze tensile properties of flax fibre yarns, fabrics and composites. Tensile tests are performed at each scale to study the effect on the properties of yarn such as the twist level. Saidulu et al [5] worked on the influence of angle ply orientation on mechanical properties of hybrid composite materials. They concluded that only 0°/90° angle ply orientation offer better mechanical properties than the other orientations. HomNathDhakal and MohiniSain[6] said that the experimental results showed that the carbon/flax fibre hybrid system exhibited significantly improved tensile properties over plain flax fibre composites, increasing the tensile strength from 68.12 MPa for plain flax/epoxy composite to 517.66 MPa and tensile modulus from 4.67 GPa for flax/epoxy to 18.91 GPa for carbon/flax hybrid composite. The objective of the present work is to investigate the effect of the stacking sequence on mechanical properties of natural hybrid composite laminates.

2. FABRICATION OF FLAX/EPOXY WITH GRAPHENE HYBRID COMPOSITE LAMINATES

Three layered flax/epoxy composite laminates are made by vacuum bag moulding [7, 8]. Epoxy resin along with graphene is used as matrix. Flax fabric of 300 gsm is selected for the fabrication. Before fabrication, flax fibre is subjected to alkaline treatment to increase the bonding strength of the natural fibre. The purpose of the alkaline treatment is to reduce the unwanted cellulose present in the jute fibre and thereby to increase the load withstanding ability of the natural fibre.

2.1 Alkaline treatment

Alkaline treatment is done by treating jute fibre with 5% NaOH solution [9]. Alkaline solution is prepared by mixing 50 gof NaOH pellets in 10lof distilled water. Flax fibres are soaked completely into the alkaline solutionfor 2 hours. Then flax fibre is thoroughly washed with distilled water to remove the base elements and sticky nature of the surface of fibres. Flax fibres are completely drained and dried in the sunlight for one day and followed by oven drying at 100^{o}C for 2 hours.

2.2 Vacuum Bag Moulding method

The vacuum consolidation method produces high-quality mouldings, with complete exclusion of air bubbles and improvement to the inner surface of the moulding, which is not in contact with the mould. The controlled curing conditions also improve quality and consistency and allow superior resin systems to be used, while opening the way to a more rapid cure with faster turn round of moulds. Vacuum bag moulding is a modification of hand lay-up, in which the lay-up is completed and placed inside a bag made of flexible film and all edges are sealed.

Fig -1: Fabrication of hybrid laminates by vacuum bag mould method

Aluminium dam of size 300mm×300mm is used for this purpose. Initially, dam edges are cleaned for removing dust and dirt. After cleaning, the dam is covered with polythene sheet. Then the silicone spray is sprayed over the polythene sheet. A layer of peel ply is applied for surface roughness and easy to peel. The composite matrix material is prepared by using epoxy resin LY556 and hardener HY951 and graphene (TYPE 1) in the ratio of 500:1(in gms). Sonication process is used for better mixing of epoxy and hardener. The matrix material is applied over the polythene sheet using soft brush. According to the preferred stacking sequence layers of flax fabrics are arranged one by one. Between those fabric layers epoxy resin is applied and finally on top of the final layer also. After every fabric layer is laid, steel roller is used to roll over the fibre surface in order to remove the entrapped air between the layers three respective layers are stacked along with matrix and placed in a breeder. The bag is then evacuated, so that the pressure eliminates voids in the laminate, forcing excess air and resin from the mould. By increasing external pressure, a higher glass concentration can be obtained, as well as better adhesion between the layers/plies of laminate. After the proper curing process the laminates are cut into standard ASTM size.

In the present study, single type of composite laminate is considered. They are prepared by stacking 3 layers of fabric in a unidirectional manner. Flax composite hybrid laminates are preferred to study the effect of stacking sequence on mechanical properties. In making the hybrid laminate, flax fibers are kept as one above the other (FFF). The stacking sequences are preferred in such a way that they should have balanced properties both in longitudinal and transverse direction.

3. EVALUATION OF MECHANICAL PROPERTIES

The evaluation of the engineering properties of the FRP composite materials are complex due to their anisotropy and inhomogeneity nature [9, 10]. ASTM is known as American Society for Testing and Materials is an international standards organization that develops a standard for testing of wide range of system services and materials. The specimens are cut into standard ASTM size. In this study, mechanical testing such as critical buckling load and flexural test are conducted as per the ASTM standards [11, 12].

3.1 Critical Buckling test

According to ASTM standards, the composite material is cut into standard size and kept for the mechanical loading.

Fig – 2: Fabricated Composite material

Test trials are carried out for each type of composite laminate. The tests were conducted on a universal testing machine. Fig.3 shows the critical buckling effect on laminates carried out in testing equipment. Thin flat strips of composite laminate are mounted in the grips of a mechanical testing machine and loaded in buckling mode. Then the response is periodically recorded by using strain transducers

Fig -3: Image showing Buckling test of flax composite

Fig - 4: Image showing material after Critical Buckling load

3.2 Flexural test

ASTM standard testing procedure is followed for evaluating flexural strength of FRP composite laminates. After proper curing of composite laminates, the specimens were cut according to the ASTM D790 standard size [13,14].

Fig – 5: Three point loading condition

Test trials are done for flax composite laminate. The flexural test was conducted on a standard machine with feed rate of 1.2 mm/min. Fig.6 shows the flexural test conducted on dedicated flax laminates in universal testing equipment.

Fig - 6: Image showing Maximum Bending load of composite specimen

This Bending test method includes provisions for measuring maximum bending load, flexural strength, and flexural modulus. The test method consist of three point loading condition which simply supporting a straight-sided, rectangular cross-section specimen on two supports symmetrically placed about the transverse centreline and loading in flexure with a third point placed on the transverse centreline. The load application and the two supports make up the three point test condition.

4. RESULTS AND DISCUSSION

The composite laminates are fabricated by vacuum bag moulding method with uniform fiber volume fraction and tested for critical buckling and maximum bending load condition according to the ASTM standards. The experimental results with suitable graphs and tables for flexural and buckling properties are reported and discussed.

4.1 Buckling strength

Table 1 shows the result of Critical Buckling effect on the composite material. From this table, it is evident that flax/epoxy laminate with graphene shows a good improvement in load bearing capacity and thus a change in mechanical property.

Table - 1: Results of Buckling Analysis

Description	Value
Maximum Force	17.35kN
Maximum Displacement	10mm
Compressive Strength	0.029kg/mm^2

4.2 Flexural test

The comparison of flexural test results for laminates is shown in Table 2. From Table 2 it is found that the flexural property of hybrid composite laminates shows better than flax/epoxy composite material. During transverse loading condition, outer layer fiber plays important role in withstanding the bending load.

Table - 2: Result of flexural Test

Description	Value
Maximum Force	117.2
Maximum Displacement	29.9
Compressive Strength	106

5. COMPARISON OF RESULTS OF ORDINARY FLAX/EPOXY COMPOSITE

Experimentally evaluated mechanical properties of flax/epoxy laminate embedded with graphene are compared with properties of pure flax/epoxy laminates collected from earlier literature and shown in Table 3. The bending load and the buckling load have increased that made the material more stable than the normal composite material.

Table - 2: Comparison with the published result

Description	Flax/Epoxy Composite[15]	Flax/Epoxy Composite with Graphene
Maximum Bending Load	0.2kN	15.2kN
Critical Buckling Load	0.556kN	17.35kN

6. CONCLUSION

The effect of embedded graphene on mechanical properties of the Flax/epoxy composite laminate is experimentally investigated. To promote the environment friendly materials, natural flax fiber is considered for this study. FRP composite laminate is made by vacuum bag moulding method using the natural flax fibre as reinforcement and epoxy resin embedded with graphene as matrix. The flexural and buckling load is evaluated experimentally and the results are compared with the flax/epoxy composite material taken from literature. From the experimental result, it is found that flax/epoxy laminate embedded with graphene shows better mechanical properties than the pure flax/epoxy composite material.

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