Fabrication and testing of Fibre-reinforced Glass-epoxy composite with Seashell as a filler Material

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Abstract: In this study mechanical properties of a Polymer Matrix Composite i.e. mixing E-glass fibre (synthetic fibre) with seashell as filler material and using Lapox L-12 as the epoxy resin with K-6 hardener are tested. The constituents used in this composite are cheaper when compared to other composites and it showcases properties like higher strength, higher stiffness, chemically resistant, good insulation to electricity and light weight too. Three components are fabricated with ratio of sea shell powder varying from 5% to 15% in a total amount of 70:30 (Volume Fraction) fibre to resin ratio. Properties of different ratios of the composite material are determined using various tests like Tensile strength, Three-point bending & Natural frequency is found by FFT analyser. As this composite is light weight and durable, it is can be used in helmets, karts, and auto body parts.

1. Introduction
In recent years, Composite materials have expanded more hugeness in various fields. The extension being utilized of composite materials can be cleared up by better and more data of the essential properties of composites and their long organization life. This has achieved the extension of Composite materials starting late.

A Composite material can be characterized as a mix of two or more materials that results in preferable properties over those of the individual parts utilized alone. As opposed to metallic compounds, every material holds different physical, chemical and mechanical properties. The Reinforcement and Matrix are the two constituents of Composites. The essential central purposes of composite materials are their high quality and firmness, combined with low thickness when contrasted and mass materials, considering a weight diminish in the finished part. The Reinforcing phase is said to be made either of fibres, particles, or flakes and the Matrix phase in Composite is said to be continuous. Generally, Composites are known to be Heterogeneous.

The part of reinforcement in composite materials is fundamentally to add mechanical properties to the material, for example, strength and stiffness. The reinforcement in composite material assumes an imperative part and it influences the mechanical properties of the composite. By and large, the reinforcement is harder, more grounded, and stiffer than the matrix. The reinforcement is normally a fibre or a particulate. The reinforcement serves as spine of the composite.

The matrix phase in a composite also holds the important role and its main function is to keep or bind the reinforcement together and position it correctly with respect to cross sectional area in order to use mechanical properties of the material optimally. Matrix phase in a composite is known as continuous
phase and it can be metallic, ceramic, or polymeric. The matrix in a composite is also used to transfer shear and it gives the composite surface appearance and shape. The classification of composites is based on geometry of reinforcement and on the type of matrix. Based on geometry of reinforcement composites are classified as particulate, fibre and flake. Based on type of matrix composites it can be classified as polymer matrix composite (PMC), ceramic matrix composite (CMC), metal matrix composite (MMC). At the point when assembling procedure is viewed as the PMC’s are much less demanding to fabricate as a result of need of low temperature contrasted with MMC and CMC.

2. Literature Review
R. Karthikeya et. Al [1] (2014), carried out a work on Bio Composites made of PMMA Sea Shell base for Dental application and studied their Tribological and Mechanical properties. They used sea shell powder varying in weight from 2%-20% and studied their properties by testing the specimens for Hardness and Wear. They concluded that the composites with 12% of sea shell powder would yield better results i.e., Hardness and Low Frictional Force followed by 8% composition material. Gajendra Mundel et. Al [2] (2014), carried out a work on Bio Composites made of Sea Shell in combination with Linear Low Density Poly Ethylene (LLDPE). The LLDPE was used as a base and the sea shell powder as reinforcement. The weight% of sea shell powder varied as 5, 10, 20, 30 and 40. The size of the sea shell used was averaged to be 75microns. The pin on disc test was carried out for Tribological properties and water absorption test was also conducted. They concluded that COF and wear decreased with increase in reinforcement and the capacity of water absorption increased with increased in reinforcement volume.
V. Manohara et. Al [3] (2014), carried out a work on Sea Shell Jute Fabric composite and studied the Tensile properties of it. In this study the sea shell powder was used as filler material. The weight% of sea shell powder used as filler material was varied. By this study they concluded that the composite with 5% of filler material showed better Tensile Characteristics.
Abiodum Ademola Odusanya et. Al [4] (2014), carried out a work on Unsaturated Polyster Composite which used sea shell as filler material. The filler material used was of size 250 microns. They studied the properties for different compositions of sea shell powder and concluded that the composite with 10% of filler material yielded better results.
Ban Bakir et. Al [5] (2013), studied the effect of Fibre Orientation on Fibre Glass Composite material. They studied the effect of orientation of these fibres on Mechanical properties. This study showed the fibres oriented at 45degree gave better results and this was achieved when volume of fibres exceeded 30% in total volume. The experiment was carried out for 45degree orientation of fibres for Continuous and Discontinuous fibres.
Sandeep M. B. et. Al [6] (2014), carried out an work on Glass/Epoxy composite to study the effect of Orientation of fibres and how it effects the flexural strength of the material. In this study they used glass fibre as reinforcement and epoxy was used as resin and the material was prepared by hand layup process. This study showed that the flexural strength in -45+45 orientation fibres is more than that of 0,90 oriented ones.

3. Fabrication Methodology
There are assortments of techniques for manufacturing composite segments. A few strategies have been received for instance infusion forming, yet numerous were produced to satisfy the particular plan or assembling challenges. Each of these procedures offers certain points of interest and particular advantages which might be actualized to the creating of composites. Hand lay-up and shower lay-up are two crucial embellishment forms. The Hand lay-up procedure is the soonest, uncomplicated and most work extraordinary creation technique. It normally comprises of laying dry fabric layers/handles/pre-peg utilizes by hand on a pass on to frame laminates. Once layup is completed the Resin is applied on Plies.

The glass fibre is a bi-directional mat with 0/90° introduction having a mass of 204 gsm. The glass
fibre is supplied from Marktech Private Limited, Bangalore. The epoxy is LAPOX 12 and the hardener is polyamine hardener (K6) which is supplied by Yuje Enterprises, Bangalore. The Mother of shell powder commonly known as sea shell powder was prepared from collecting the sea shells from the shore and powdering them. The powdered sea shell was further sieved in sieving machine for the size of 450microns. This powdered sea shell was further utilized for preparation of composite by altering the volume% of sea shell powder. The mould is made of plywood having measurements of 300×300×3 mm. A plastic sheet is put in the mould and a thin film of petroleum jam and coconut oil is connected over it. A sheet of glass fibre having proper measurements is set over it and epoxy is connected over the sheet of glass fibre. Epoxy is blended with 10% hardener and additionally figured measure of ocean shell filler material. Same method is taken after for more layers of glass fibre until the required layers are fulfilled for the given structure. The abundance epoxy and air crevices are evacuated utilizing a roller. At that point a plastic sheet connected with a flimsy film of petroleum jam and coconut oil is set over it and secured. The Hand Lay-Up technique is appeared in figure 3.1. A substantial level inflexible metal stage is put over the mould for compressive reason. Curing is accomplished for 1 day and the specimens are kept in the sun for the following 3 days for drying. Material is cut according to required shapes for testing reason.

4. Results and Discussion
4.1 Tensile Test
Tensile test is a basic test method where sample undergoes controlled tension till specimen fails. This test results in choosing appropriate material for particular application, controlling the quality and how specimen behaves for different kind of loads acting on it. The properties like Young's modulus, Poisson's ratio and yield strength can be determined using tension test. Uniaxial test method is used for isotropic materials and anisotropic materials like composites undergo bi axial testing. For this particular test Instron 3366 machine was used. The specimen used satisfied ASTM 638 standards. The Testing results showed that the Composite with 5%, 10% and 15% of Filler material carried a load of 10.5KN, 10.1KN and 9.82KN respectively. The Young's modulus achieved for 5%, 10% and 15% of Filler material were 7.6GPa, 7.7GPa and 7.4GPa respectively.

![Figure 1. Instron 3366 Tensile Test](image-url)
4.2 Three Point Bending Test

The Flexural test is also known as Three point Bending test. By this test we can obtain the values for stress, strain and modulus of elasticity.

The test is conducted by placing the specimen on specified test fixture. The test specimen is placed between two supports which are separated by some distance and the load acting pin acts at the centre of the test specimen until the specimen fails. The machine used for testing is Instron 3366 and the specimen satisfies ASTM D 790 standards.

From above plots of Flexural Test we can note that the Composite with 5% Filler bears a maximum load of 304.45N, where as the Composite with 10% Filler withstands a load of 313.14N and the composite with 15% Filler can bear a load of 322.68N. The Young’s modulus for the composites with 5%, 10% and 15% filler material were found to be 60.56GPa, 61.5241GPa and 59.92GPa respectively.

Figure 2. Combined Tensile Test Results

Figure 3. Instron 3366 Flexural Test
4.3 Vibration Test

Vibration can be defined as oscillations in the body which is at equilibrium. These vibrations sets disturbance in the system and may affect the performance of the system in large scale. To know vibration parameters the FFT test was carried out using LAB view software. This set up consists of modal hammer, accelerometer and analyser. The specimen is supported like a cantilever beam and for vibrations to occur an impact hammer is used. The free end of the test specimen is connected to accelerometer with the help of wax glue. The hammer used consists of force transducer which measures input signals. The output signals are obtained by the help of the analyser. The test specimen with dimensions 200*20*3mm is used and when it supported like a cantilever beam its effective length turns out to be 180mm.

The graph shows variation in amplitude for different frequencies for Glass/Epoxy Composite with 5%, 10% and 15% of Filler material. The material with 5% of filler material has greater frequencies when compared to 10% and 15% compositions

![Figure 4. Combined Bending Test Results](image)

![Figure 5. Combined Vibration Tensile Test Results](image)
Table 1 Comparison of Frequencies obtained by Numerical, Experimental and Analysis method

| Filler % | Numerical Value (Hz) | Experimental Value (Hz) | FeMap Value (Hz) |
|----------|----------------------|-------------------------|-----------------|
| 5%       | 37.152               | 37                      | 37.9            |
| 10%      | 37.38                | 38                      | 38.14           |
| 15%      | 37.45                | 38.5                    | 38.23           |

5. Conclusion
The tests conducted on the Composite showed that the Filler material affected the properties of Composite Material. The Material with 5% of filler material showed better strength for Tension followed by 10% and 15% filler material which means minimum % filler material composition yields better Tensile properties.
The tests were also carried out for bending and it was found that the composite with 15% Filler material gave better strengths for rupture where as 5% and 10% were comparatively low. The bending strengths were found to be optimum at 15%.
The tests for Vibration gave better results for 15% which gave lower logarithmic decrement than 5% and 10% compositions. As the logarithmic decrement was found to be lower it means the material can withstand vibrations better than that of 5% and 10% composition materials.

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