Comparison of Mechanical and Water absorption characteristics of natural fillers on Glass Fiber Reinforced Polymers

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***Abstract*—Due to ill-health arise from asbestos, It has been replaced by glass-fiber in many application Since 1950, further glass fiber have been replaced by Glass Fiber Reinforced Polymers (GFRP) in recent years. But further research has been happening to obtain cost effective composite material with better mechanical and water resistant characteristics. In this research , Effect of various Natural filler on GFRP were studied . Natural filler selected for study are Egg shell, Prosposis Julifora, Sugarcane bagasse (SCB), Water Hyacinth, Human hair. Laminates were prepared with epoxy resins, hardener to bind Natural filler to GFRP , machined to ASTM required dimensions for various testing to study relevant mechanical properties and water absorption characteristics.**

***Key words*— GFRP, Natural Filler,Egg shell, Prosposis Julifora, Sugarcane bagasse (SCB), Water Hyacinth, Human hair , tensile strength test, compression test, Charpy impact test, Water absorption test.**

I. INTRODUCTION

The world always needs eco-friendly and waste managing strategy to overcome pollution and well-being of human being. Asbestos being threat to workers for over half a century as it causes pleural thickening , asbestosis and also lung cancer at severe stage. There's always need of finding a material which outruns other material by cost, method of preparation. So, In order to eliminate the problem by usage of asbestos, glass fiber and GFRP usage increased after 1950, Even then cost involved in manufacturing the material method with which it can be transported was not so commercially viable, much eco-friendly as it causes some respiratory ailments.The methology starts with problem identification and followed by extensive investigation on literature related to asbestos, glass fiber, GFRP,GFRP+Natural fillers. Literature survey was followed by comparative study of mechanical properties and water absorption properties of various materials under study and selecting the best material.

II. POWEDER SYNTHESIS

Egg shell, Sugarcane bagasse[1], Human hair, Water Hyacinth (Eichhornea crassipes)[2], Proposis Juliflora were collected from various sources, cleaned and dried to get rid of impurities and moisture. After that materials were grind properly to make it into fine powder which can act as filler for making GFRP laminate.

Fig.1: Powder Synthesis - Natural filler

III. MATERIAL AND METHOD

Hand lay-up is desirable for making GFRP-Natural Filler laminate since it is simple, easy to use procedure and also cost effective.Usually in hand-lay-up technique, Resins are impregnated by hand into fibres which are in the form of woven, knitted, stitched or bonded fabrics. This is usually accomplished by rollers or brushes, with an increasing use of nip-roller type impregnators for forcing resin into the fabrics by means of rotating rollers and a bath of resin. Laminates are left to cure under Standard atmospheric conditions.

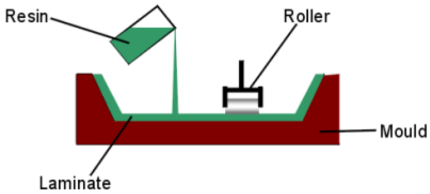

Fig.2: hand lay up technique

Reinforcement ,matrix, filler had been set correctly and hand lay-up technique[3] was carried out to ensure proper curing and setting.

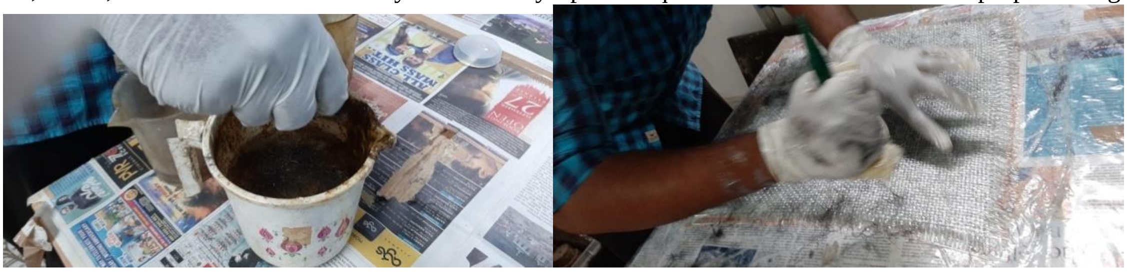

Fig.3: Mixing Hardener – Epoxy Resin – Natural Filler, and applying it over woven glass fabric

Materials used for making the laminate , condition, specitic ASTM Standards are tabulated below:

Reinforcement	**GFRP(Bi-directional type.E-glass)**
Matrix	Epoxy resin
Ratio of Glass fiber : Natural Filler	10:1
Resin	Araldite® LY 556
Hardener	Aradur® HY951
Curing period	24-48 hours
ASTM Standard for Tensile Test	D 3039/D 3039M
ASTM Standard for Compression Test	D695
ASTM Standard for Charpy Impact Test	D6110
ASTM Standard for Water Absorption test	D570

Table 1: Materials and conditions for Laminate preparation and testing

Laminates were created for Regular GFRP, GFRP with Egg shell[4], Prosposis Julifora, Sugarcane bagasse (SCB), Water Hyacinth, Human hair then following mechanical tests (tensile strength test, compression test,charpy V-Notch test) and water absorption test were conducted ,results are tabulated.

IV. Testings and Result

(1) Tensile strength test :

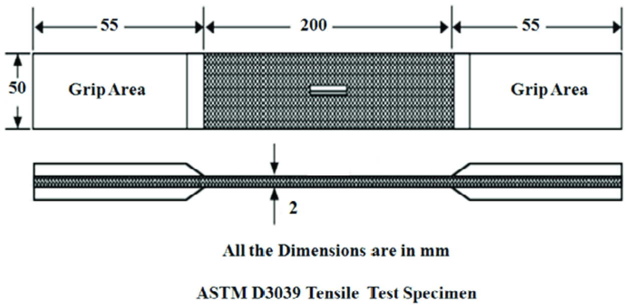

Fig.4:ASTM Tensile Test Specimen

One of the most important properties we can determine about a material is its ultimate tensile strength (UTS). This is the maximum stress that a specimen sustains during the test. The UTS may or may not equate to the specimen's strength at break, depending on whether the material is brittle, ductile, or exhibits properties of both. Sometimes a material may be ductile when tested in a lab, but, when placed in service and exposed to extreme cold temperatures; it may transition to brittle behavior. Tensile strength test was carried out based ASTM D 3039/D 3039M: "Standard Test Method for Tensile Properties of Polymer Matrix Composite Materials" on all GFRP Material combinations mentioned above. Specimens are placed in the grips of Universal Testing Machine at a specified grip separation and pulled until failure. The ultimate tensile strength is the maximum amount of stress a material can withstand before failure. This is the maximum value on the stress-strain curve. For most materials, the initial portion of the test will exhibit a linear relationship between the applied force or load and the elongation exhibited by the specimen. In this linear region, the line obeys the relationship defined as "Hooke's Law". where the ratio of stress to strain is a constant, or $\frac{\sigma}{\varepsilon} = E$. Where E is the slope of the line in this region where stress (σ) is proportional to strain (ε) and is called the "Modulus of Elasticity" or "Young's Modulus."For each GFRP Specimen, 3 trails were conducted and average values are tabulated as follows:

Test Material	Tensile Strength value (in MPa)
GFRP	396
GFRP +Egg Shell	343
GFRP +Prosopis Julifora	271
GFRP + SCB	277
GFRP + Water hyacinth	252.5
GFRP + Human Hair	428

Table 2: Test materials and their Tensile Strength values (in MPa)

(2) COMPRESSION TEST :

Compression test has been carried out based on ASTM D695. With this ASTM Testing procedure and result, we can understand compression strength and modulus of plastics materials used in various engineering applications. Compressive properties describe the behavior of a material when it is subjected to a compressive load. Loading is at a relatively low and uniform rate. Compressive strength and modulus are two common values generated by the test. The specimen is placed between compressive plates parallel to the surface. The specimen is then compressed at a uniform rate. The maximum load is recorded along with stress-strain data. An extensometer attached to the front of the fixture is used to determine modulus. Specimens can either be blocks or cylinders. For ASTM D695, the typical blocks are 12.7 x 12.7 x 25.4mm (½ by ½ by 1 in). and the cylinders are 12.7mm (½ in) in diameter and 25.4mm (1 in) long. For ISO, the preferred specimens are 50 x 10 x 4mm for modulus and 10 x 10 x 4mm for strength.

Fig.5:Specimen – Before compression and after compression

For each GFRP Specimen, 3 trails were conducted and average values are tabulated as follows:

Test Material	Compression Strength value (in MPa)
GFRP	13.5
GFRP +Egg Shell	14
GFRP +Prosopis Julifora	23
GFRP + SCB	19
GFRP + Water hyacinth	24.5
GFRP + Human Hair	**22**

Table 3: Test materials and their CompressionStrength values (in MPa)

(3) CHARPY IMPACT TEST :

Charpy Impact test has been carried out based on ASTM D6110. In the metal industry, resilience is an essential feature because it measures the brittleness of the material. The Charpy impact test or resilience test involves breaking a notched reference specimen on a pendulum machine, and measuring the impact energy. Manufacturers must test their raw materials with certified pendulum impact machine using Charpy V. The Charpy V-Notch test is a mechanical method of testing specimens used to determine the impact strength or notch toughness value of the specimen. The Charpy impact test, also known as the Charpy V-notch test, is a standardized high strain-rate test which determines the amount of energy absorbed by a material during fracture. Absorbed energy[5] is a measure of the material's notch toughness. It is widely used in industry, since it is easy to prepare and conduct and results can be obtained quickly and cheaply. For each GFRP Specimen, 3 trails were conducted and average values are tabulated as follows:

Test Material	Absorbed Energy (in Joules)
GFRP	12.67
GFRP +Egg Shell	8.67
GFRP +Prosopis Julifora	14
GFRP + SCB	20
GFRP + Water hyacinth	10
GFRP + Human Hair	18

Table 4: Test materials and absorbed energy (in Joules)

(4) WATER ABSORPTION TEST :

Water absorption was done based on ASTM D570.This test method for rate of water absorption has two chief functions: first, as a guide to the proportion of water absorbed by a material and consequently, in those cases where the relationships between moisture and electrical or mechanical properties, dimensions, or appearance have been determined, as a guide to the effects of exposure to water or humid conditions on such properties; and second, as a control test on the uniformity of a product. This second function is particularly applicable to sheet, rod, and tube arms when the test is made on the finished product.

Fig.6: Test specimen for water absorption test

For each GFRP Specimen, 3 trails were conducted and average values are tabulated as follows:

Test Material	Water absorption (%)
GFRP	0.58
GFRP +Egg Shell	0.82
GFRP +Prosopis Julifora	0.51
GFRP + SCB	0.69
GFRP + Water hyacinth	0.62
GFRP + Human Hair	0.49

Table 5: Test materials and their water absorption (in percentage)

From the tabulation, It is evident that only GFRP + Human Hair[6] shows less resistance to water below 0.50% i.e, It absorb less water (0.49%).Water absorption test for all GFRP Combination was carried out based on ASTM D570.Water absorption is used to determine the amount of water absorbed under specified conditions. Factors affecting water absorption include: type of plastic, additives used, temperature and length of exposure. The data sheds light on the performance of the materials in water or humid environments. For the water absorption test, the specimens are dried in an oven for a specified time and temperature and then placed in a desiccator to cool. Immediately upon cooling the specimens are weighed. The material is then emerged in water at agreed upon conditions, often 23°C for 24 hours or until equilibrium. Specimens are removed, patted dry with a lint free cloth, and weighed. Specimen size is Two inch diameter disks, 0.125" or 0.250" thick. Water absorption[7] is expressed as increase in weight percent. The weight of the specimen was first measured in air ($W1$), and then the specimen was immersed in distilled water for a period of 24 ± 1 hour. On removal from water, the specimen was wiped properly and was weighed within two minutes of its removal from water. This weight was recorded as $W2$.

Water Absorption (%)

= [(Wet weight - Dry weight)/ Dry weight] x 100.

Mettler balance is the equipment used in water absorption test for measuring water weight before and after absorption. The main objective of these test is to,To measure the strength or quality of the material and To determine the water absorption of aggregates.

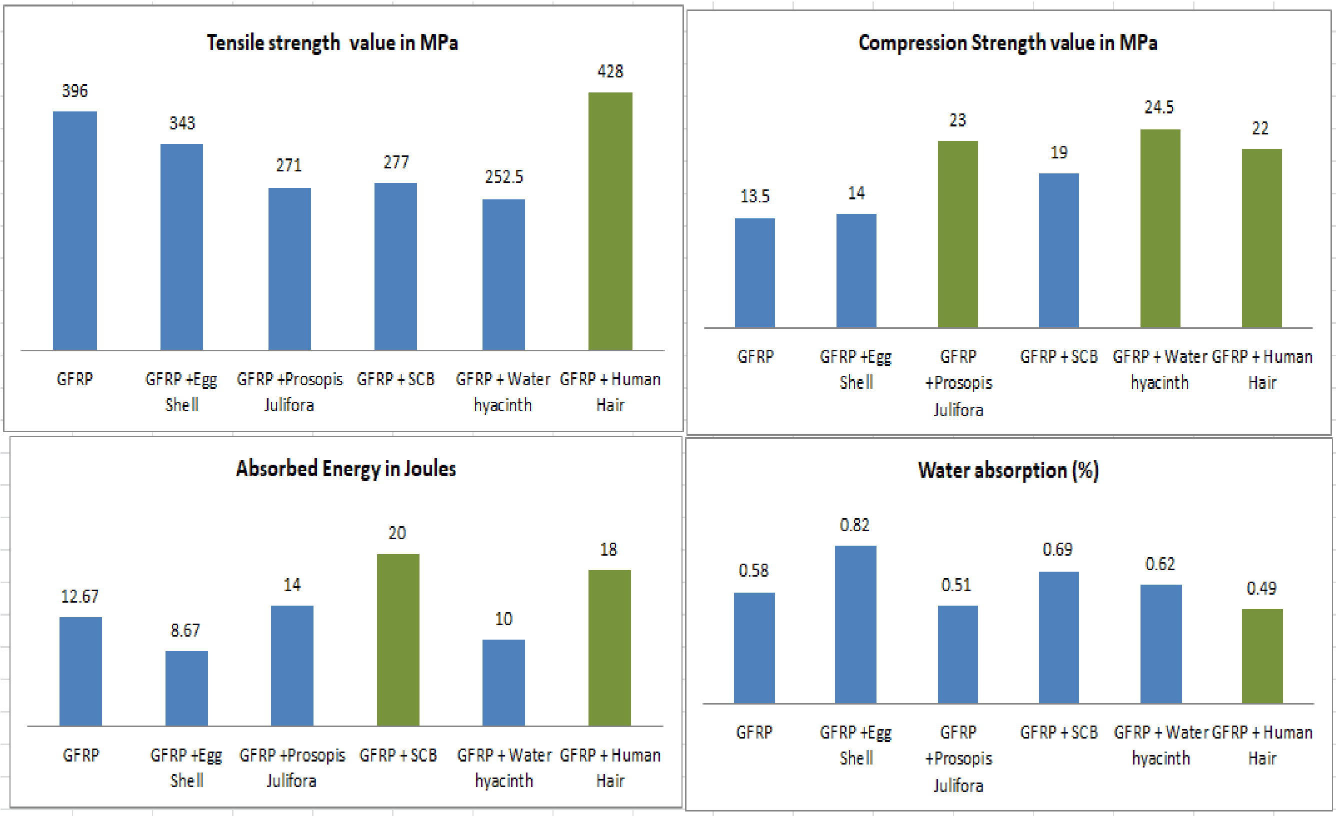

Fig.7: Comparison of mechanical and water absorption properties of GFRP with other GFRP + Natural filler.

GRFP Specimen	Tensile (MPa)	Compression (MPa)	Charpy Impact (Joules)	Water absorption(%)
GFRP	396	13.5	12.67	0.58
GFRP +Egg Shell	343	14	8.67	0.82
GFRP +Prosopis Julifora	271	23	14	0.51
GFRP + SCB	277	19	20	0.69
GFRP + Water hyacinth	252.5	24.5	10	0.62
GFRP + Human Hair	428	22	18	0.49

Table 6: Comparison of mechanical and water absorption test values - GFRP + Natural fillers

GFRP + Human hair is the only composite material which satisfies all the below conditions :

- Tensile Strength above 400MPa
- Compression strength greater than 20 MPa.
- 18Joules energy absorbed in charpy impact test.
- Water absorption less than 0.5% of its total weight.
- Poor conductor of electricity and heat.

V. Conclusion

(1) Thorough Investigation was conducted on Asbestos, Glass fiber , GFRP composite materials and GFRP with natural filler and various laminate was made by cost effective methods. Evaluation of compostite materials - asbestos, glass fiber , GFRP , GFRP with natural filler studied in detail and research was proceeded with laminate preparation from glass fiber woven fabric with natural fillers- powders of egg shell, sugarcane bagasse, water hyacinth, human hair and prosposis julifora.

(2) Detailed comparative study on mechanical properties such as tensile strength, compressive strength, impact strength and water absorption properties were done and observed that GFRP + Human hair as natural filler hold comparatively better mechanical properties and water absorption properties when compared to normal GFRP, GFRP +Egg Shell, GFRP +Prosopis Julifora, GFRP + SCB, GFRP + Water hyacinth Composite matrix.

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