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Experimental Investigation and Analysis of Glass Fiber Epoxy Reinforced with Rubber and Wood Powder

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Abstract - *The current experimental work concentrating with the mechanical properties of rubber and wood powders reinforced with glass fiber epoxy composite laminates. Rubber and wood powders epoxy composites was fabricated by using hand lay-up method with different filler concentration. Samples were cut from the laminate which is fabricated by using the ASTM standards for different experiments like tensile, compression, impact and water absorption tests will be carried out. For tensile, compression and impact, samples were cut in the flat bar shape. It was observed that at 20% weight of filler content, powders which gives the best results for compression strength and tensile strength properties of the composite under consideration. The test results are taken by using data acquisition system. From the experimental results, analysis was also done comparatively between GFRP and GFRP with rubber and wood powder by ANSYS Workbench 13.*

Key Words: **Composites, Rubber and wood powder, Mechanical Properties, ANSYS Workbench.**

1. INTRODUCTION

In passenger car bumper is made up of rubber, steel, aluminum, or plastic that is mounted on the front and rear of a passenger car. When a low speed collision occurs, the bumper system absorbs the shock to prevent or reduce damage to the car. In the present trends the weight reduction has been the main focus of automobile manufacturers. Less fuel consumption, less weight, effective utilization of natural resources is main focus of automobile manufacturers in the present scenario [1]. The above can be achieved by introducing better design concept, better material and effective manufacturing process. In spite of its advantages, it stays back in low strength to weight ratio [4]. It is reported that weight reduction with adequate improvement of mechanical properties has made composites as a viable replacement material for conventional steel.

In the present work, the bumper material GFRP used in passenger vehicles is replaced with a composite bumper made of glass/epoxy composites. The model of the bumper taken from the journal [2]. The objective was to compare the mechanical properties and cost saving. The mechanical properties of most reinforcing fibres are considerably higher than those of un-reinforced resin systems.

This project work will focus on existing material performance, advantage and limitations. Based on observations of materials improvements will be made in terms of shape, size and or material based on design modification objectives [8].

2. MATERIAL USED

The materials and methods used for the processing of the composites under this investigation. It presents the details of the characterization and tests which the composite samples are subjected to.

2.1 Glass Fiber Reinforcement Plastic (GFRP)

Glass is one of the oldest known man-made materials; the practical strength of glass, however, has always been a limiting and puzzling factor. Still today the mechanical properties of glass fibers are twofold a) a special quality is the high strength b) the brittle fracture is limiting its application [3]. An understanding of the structure of glass in relation to how and why it breaks is crucial in both improving existing applications of glasses and in new functionalities and application of all kinds of glasses, not only fibre glass.

2.2 Rubber Powder

Micronized rubber powder (MRP) is classified as fine, dry, powdered elastomeric crumb rubber in which a significant proportion of particles are less than 100 μm and free of foreign particulates (metal, fiber, etc.). MRP particle size distributions typically range from 180 μm to 10 μm. narrower distributions can be achieved depending on the classification technology.

2.3 Wood Powder

Wood flour is finely pulverized wood that has a consistency fairly equal to sand or sawdust, but can vary considerably, with particles ranging in size from a fine powder to roughly the size of a grain of rice.

Wood flour is commonly used as filler in thermosetting resins such as bakelite, and in linoleum floor coverings. Wood flour is also the main ingredient in wood/plastic composite building products such as decks and roofs.

3. MATERIAL PROPERTIES AND FABRICATION

The properties of the materials GFRP and GFRP mixed with the rubber and wooden powder and also epoxy resin are tabulated as follows,

3.1 Material Properties

Table. 1 Material Properties

S. No.	Parameters	Density	Volume Fraction	Weight Fraction
1	GFRP (grams/cm3)	1.8	1.49	1.3
2	GFRP with rubber & wood powder(cm3)	270	270	270
3	Epoxy(grams)	486	402.3	234

3.2 Fabrication Method

The lamination is prepared by hand lay-up method. The GFRP mat which is collected from local sources. Then it is properly cleaned and cut to appropriate size. Wooden mold with dimensions of 300 x 300 x 10 mm were prepared for lamination. For different volume fraction of fibers, an amount of epoxy resin and hardener (ratio of 10:1 by weight) was thoroughly mixed in glass jar.

Fig:1 a) GFRP Mat b) Hand lay-up c) Epoxy resin

The figure illustrates the mold used to construct the composite. For quick and easy removal of composite, mold release sheet was put over the glass plate and a mold release spray was applied at the inner surface of the mold. After keeping the mold on a ply board a thin layer of the mixture was poured the fiber lamina was distributed on the mixture. Then again resin was applied over the fiber laminate and the procedure was repeated to get the desired thickness. The remainder of the mixture was then poured into the mold. Care was taken to avoid formation of air bubbles.

Then the surface was allowed to dry after cleaning it with a thinner solution after drying, the surface was coated with silicon spray the surface was given a few minutes to get it set for the mold lay-up. A plate of dimensions 300 x 300 x 10 mm was fabricated by this process the prepare fiber laminate is taken and placed on to the mold again. The balance resin is poured on the fiber kept on the mold and care is taken such that the fiber material is entirely soaked in the resin and the top plate is closed and weight is applied around 120-150 kg the mold was allowed to preserve at room temperature for 120 hrs.

4. EXPERIMENTAL TESTING AND RESULTS

After the fabrication the laminate materials were cut into different shapes required for various experimental testing in the laboratory to check the mechanical properties whether the sample can be used in the bumper material.

4.1 Tensile Test

The tensile test is generally performed on flat specimens the most commonly used specimen geometries are dog-bone and the straight side type with end tabs. The specimen used in present case is shown in figure4.1. The tensile tests were conducted according to ASTM D 3039-76 standard on a computerized Universal Testing Machine. The tests were performed with constant strain rate of 2 mm/min.

Specimen: Sample was cut into flat shape (150x30x5) mm

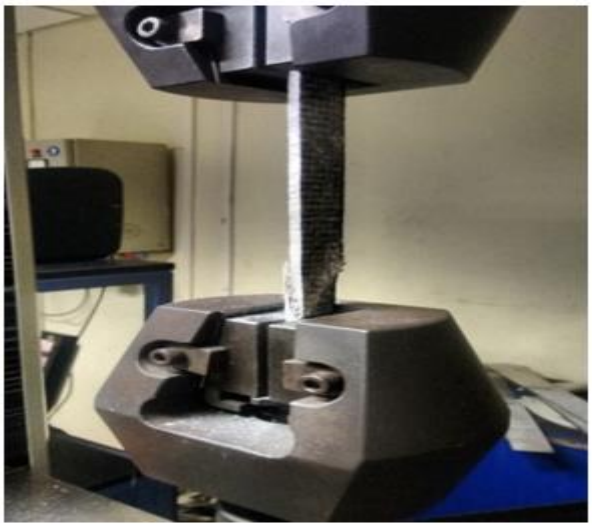

Fig 2. Tensile test

Samples of both GFRP and GFRP with rubber and wooden powder are tested in Universal Testing machine. Observed readings are noted and the same was tabulated to compare with one another.

Table.2 Tensile test result comparison

TESTING PARAMETRES	GFRP	GFRP WITH R&W
Gage thickness(mm)	5.26	4.575
Gage width(mm)	24.535	25.68

Original cross sectional area(mm^2)	139.88	117.48
Compression load(kN)	20.3	23.39
Compression strength(N/mm^2 MPA)	145	199.5

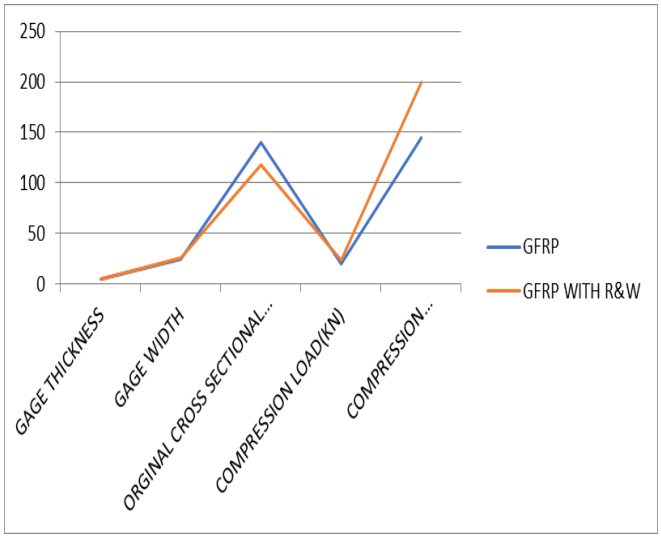

Chart.1 Variation of tensile test result

4.2 Compression Test

A compression test is any test in which a material experiences opposing forces that push inward upon the specimen from opposite sides or is otherwise compressed, "squashed", crushed, or flattened. The test sample is generally placed in between two plates that distribute the applied load across the entire surface area of two opposite faces of the test sample and then the plates are pushed together by a universal test machine causing the sample.

Samples of both GFRP and GFRP with rubber and wooden powder are tested in Compression Testing machine. Observed readings are noted and the same was tabulated to compare with one another.

Fig.3 compression test

Table.3 Compression test result comparison

TESTING PARAMETRES	GFRP	GFRP WITH R&W
Gage thickness(mm)	5.435	4.52
Gage width(mm)	24.51	26.4
Original cross sectional area(mm^2)	133.22	119.63
Compression load(kN)	1.035	0.91
Compression strength(N/mm^2)	8	8

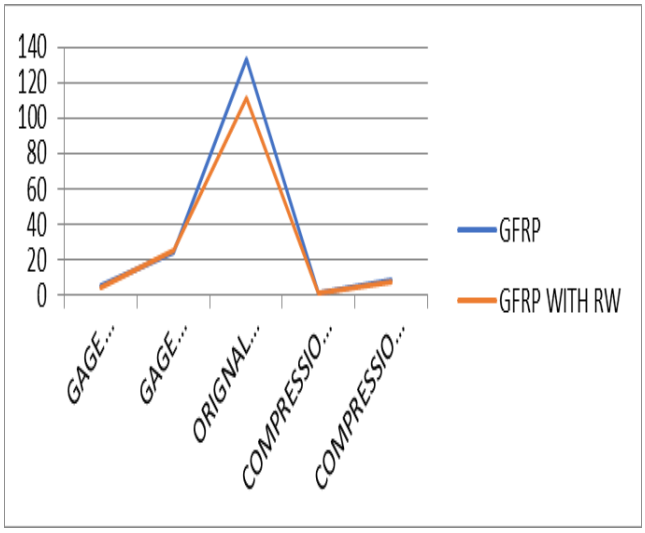

Chart.2 Variation of compression test result

4.3 Impact Test:

Impact test is a standardized high strain-rate test which determines the amount of energy absorbed by a material during fracture. This absorbed energy is a measure of a given material's notch toughness and acts as a tool to study temperature-dependent ductile-brittle transition.

Fig.4 Impact test

Table.4 Impact test result comparison

TEST TEMPERATURE	NOTCH TYPE	SPECIMEN SIZE(mm)	GFRP	GFRP WITH R&W
24*C	Un notched	4.8*10*80	7.33	8

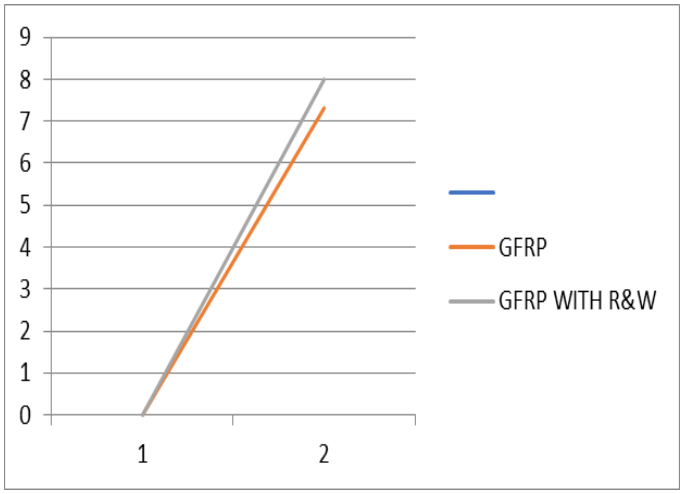

Chart.3 Variation of impact test result

4.4 Water Absorption Test

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. 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.

Table.5 water absorption test result comparison

SAMPLE	INITIAL WEIGHT (gms)	FINAL WEIGHT (gms)	DIFFERENCE WEIGHT (gms)	WATER ABSORPTION IN %
GFRP	8	8.5	0.5	6.25
GFRP WITH R&W	8.2	8.82	0.62	7.56

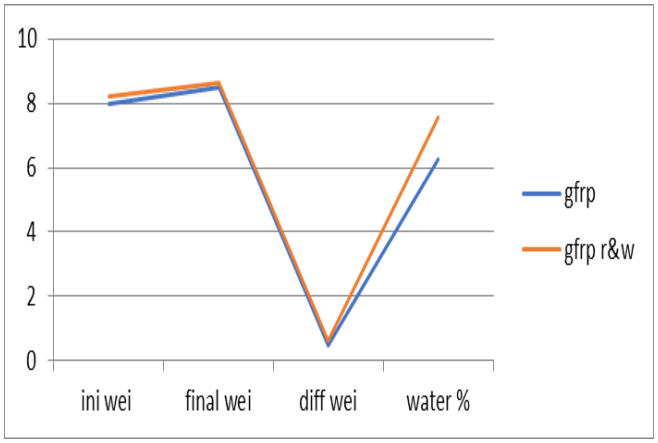

Chart4 Variation of water absorption test result

5. FINITE ELEMENT ANALYSIS AND RESULTS

5.1 Finite Element Analysis (FEA) is the simulation of any given physical phenomenon using the numerical technique called Finite Element Method (FEM). It is necessary to use mathematics to comprehensively understand and quantify any physical phenomena such as structural or fluid behavior, thermal transport, wave propagation, the growth of biological cells, etc.

ANSYS allows us to model composite materials with specialized elements called layered elements. Once we build our model using these elements, we can do any structural analysis (including nonlinearities such as large deflection and stress stiffening. We need to take special care in defining the properties and orientations of the various layers since each layer may have different orthotropic material properties. SOLID45 is used for the 3-D modeling of solid structures.

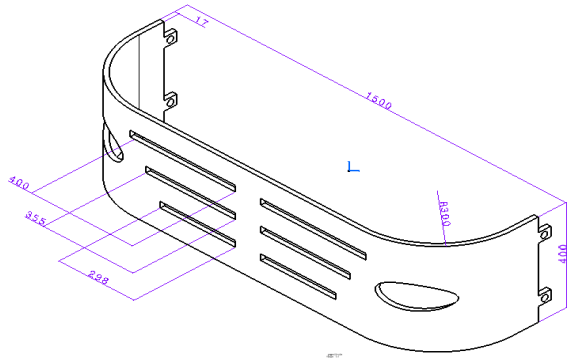

Fig.5 Design of model of bumper in CATIA

5.2 Ansys Results

The 3D model of the bumper was drawn using catia and then post processed with the ANSYS software by defining the various attributes of fabricated materials of GFRP and GFRP with rubber and wooden powder both are separately analyzed and compared with one another to known the improvement of mechanical properties of GFRP with rubber and wooden powder composite to the normal GFRP material. Following particulars related to Ansys pre-processor inputs have been considered for the analysis of a beam under static load condition.

5.3 Deformation

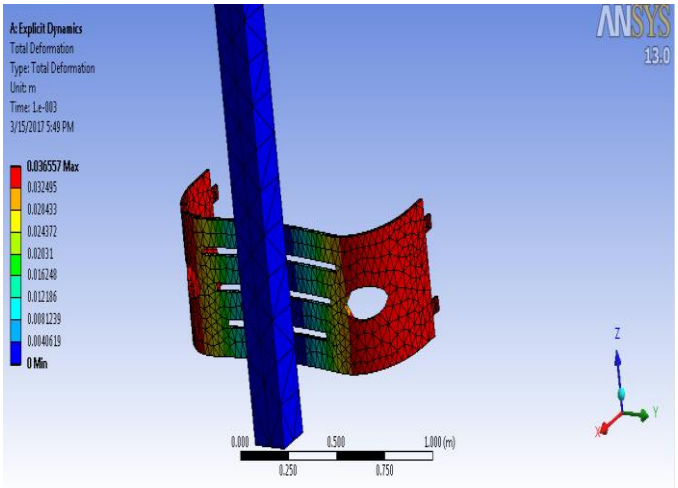

Fig.6 Deformation of GFRP

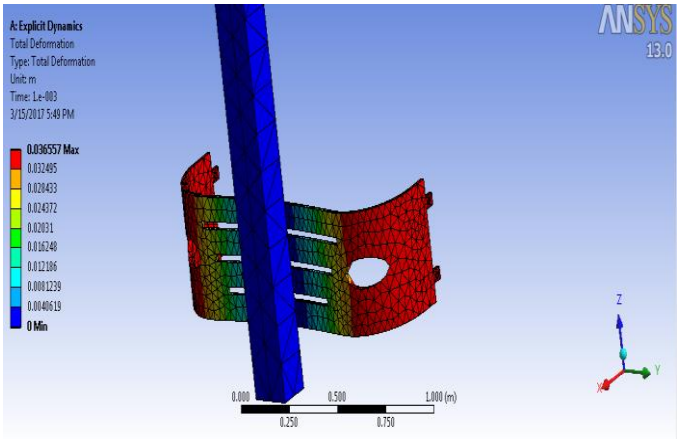

Fig.7 Deformation of GFRP with rubber and wooden powder

5.4 Normal stress

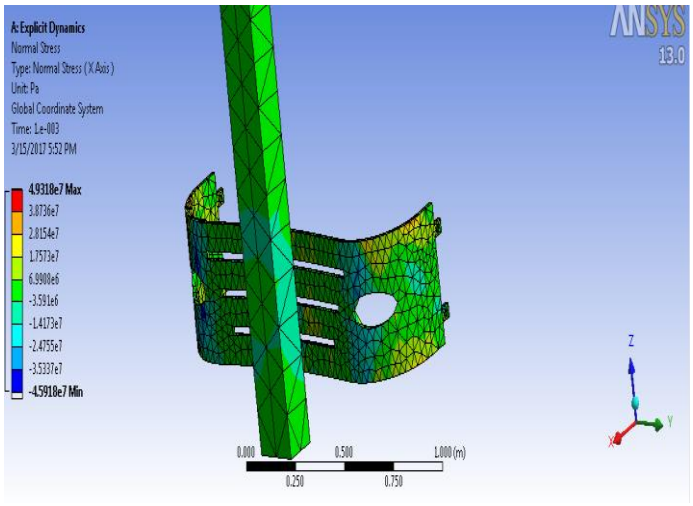

Fig. 8 Normal stress of GFRP

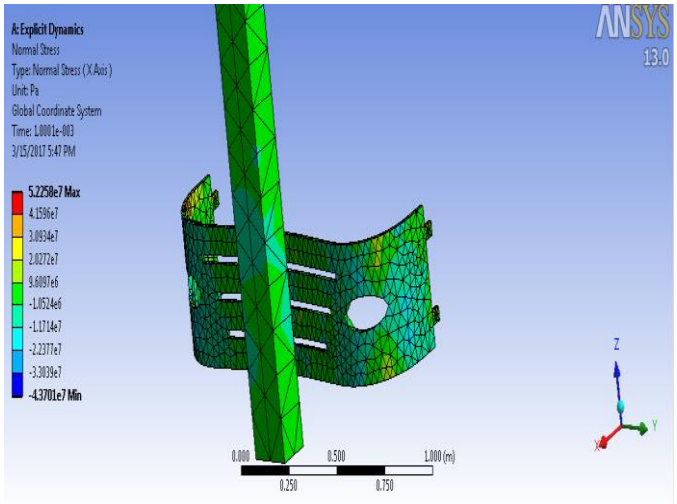

Fig. 9 Normal stress of GFRP with rubber and wooden powder

5.5 Von Mises Elastic Strain

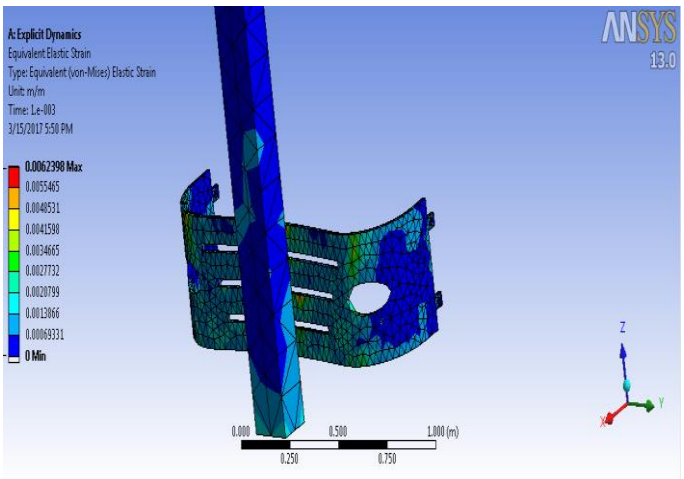

Fig.10 Von Mises Elastic Strain of GFRP

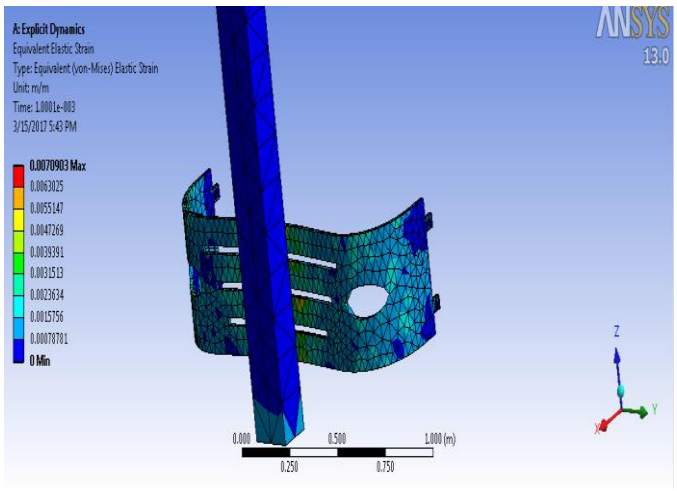

Fig. 11 Von Mises Elastic Strain GFRP with rubber and wooden powder

Table. 6 Ansys Results

RESULT PARAMETRES	GFRP	GFRP WITH R&W
Deformation(m)	0.036557	0.03719
Normal stress(Pa)	4.93E+07	5.28E+07
Von Mises Elastic Strain	0.00623	0.00709
Elastic Strain Intensity	0.0102	0.0089

6. CONCLUSIONS

From the obtained numerical result it was found that the well laminated GFRP reinforced epoxy with rubber and wood powders fabricated bumper having more strength also lesser weight when compared to the GFRP. Accordingtothe availability and brittle nature of the GFRP it is proposed to use the epoxy materials along with such above said powders. Also from the observed result it was found that displacement was higher than the GFRP and plastic materials.

This result causes the increasing failure duration. The glass fiber with rubber wood material absorbs more stress and reduces brittle nature. Both GFRP and GERP with rubber and wooden powder composite material experimental results are compared with the simulation results that are obtained from the ANSYS software. It is observed that the simulation values are

in-tuned with the experimental values. The procedure and simulation models that are used in this paper are very useful to researchers who willing to work experimental stress analysis and composites. Finally it was conclude that glass reinforced with rubber and wood powders composite material based bumper material suitable for automotive application such as car bumper and etc.

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