ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

*(An ISO 3297: 2007 Certified Organization)*

**Vol. 3, Issue 11, November 2014**

# Experimental Research on the Fundamental Mechanical Properties of Basalt Fiber Reinforcement with Epoxy

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**ABSTRACT**:The basalt fiber is becoming an alternative to glass fiber and carbon fiber due to its advantages like cost effectiveness, ecological safety and easy availability. The experimental investigation study of basalt fiber reinforced epoxy composites was conducted and their tensile, flexural and impact Strengths were analysed. Owing to the scarcities of information about their mechanical performances in present literature studies, this work was directed towards providing mechanical characterization of basalt-fiber reinforced epoxy composite, manufactured at various ratios such as 35:65, 40:60, 45:55 (Fiber: Resin). The composite laminates were prepared by mixing chopped strand basalt fiber and epoxy with proper cutting agents using open mouldings method. The specimen is prepared from composite laminates and the ASTM standards D3039, D790 and D256 were considered for analysing their mechanical properties such as tensile strength, flexural strength and impact strength respectively. The best suitable fiber resin ratio with respect to strength has been concluded as the result.

**KEYWORDS**:Basalt fiber, open moulding method, mechanical characteristics, ASTM standards.

## I. INTRODUCTION

A significant and steady growth in manufacturing of composite materials is seen today, of which the fiber is one of the basic reinforcing elements. Thermal, sound-proof, and filtering materials are some of the applications of fibrous materials. Basalt, a common extrusive volcanic rock formed by decompression melting of the earth's mantle, contains large crystals in a fine matrix of quartz.

The manufacturing process is actually simpler than glass fiber processing because the basalt fiber has a less complex composition. The manufacturing process is as follows: Quarried basalt rock is crushed, then washed and loaded into a bin, attached to feeders that move the material into melting baths in gas-heated furnaces. Molten basalt flows from furnace through a platinum-rhodium bushing with 200, 400, 800 or more holes and the fibers can be drawn from the melt under hydrostatic pressure. Then a sizing is applied to the surface of the fibers by a sizing applicator. Finally, a winder allows realizing some large spools of continuous basalt filament. New technologies in industrial production helps in production of basalt fibers with costs equal or even less than the cost of glass fiber.

Some of the advantageous properties of basalt fiber include: relatively high mechanical strength, abrasion resistance and elasticity, besides having excellent adhesion properties to polymer resins and rubbers and more importantly, ecologically clean and non-toxic to the end user. The specialty continuous fibers derived from basalt rock have proven technical characteristics, performance specifications and apparent superior cost-effectiveness in comparison with commonly used glass & carbon fibers. Basalt fibers offer performance similar to S-2 glass fibers at a price point between S-2 glass and E-glass. Some of the restrictions of glass fibers are: specific durability, temperature of application, chemical stability, especially in alkaline environments. Carbon fibers at their high cost have no prospects of mass application. It is here the basalt fiber find its properties useful and desirable.

Basalt fiber has a great advantage of being well-compatible with carbon fiber. The consequence is that high efficient hybrid materials can be manufactured by adding small (pre-determined) amount of carbon fibers to basalt fibers. The

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obtained thread, differing insignificantly in cost (owing to small content of expensive carbon fiber) will demonstrate considerably better elastic properties compared with basalt fiber (notice that elastic modulus of basalt fiber is around 11.000 kg/mm2, whereas that of carbon fiber is 22.000-56.000 kg/mm2).

Lopresto V. et al (2009) In this work, mechanical tests were carried out on comparable E-glass and basalt fibre reinforced plastic laminates, with the principal aim of evaluating the possibility to replace glass fibers in most of their applications. The results obtained on the two laminates were compared showing a high performance of the basalt material in terms of young modulus, compressive and bending strength, impact force and energy. Yan Q.Y. et al. (2005) the physical properties of basalt, such as density, viscosity, permeability, and heat conductivity, were studied experimentally in their work.

Epoxy resin is a kind of thermosetting (solid) resin. When main agent is blended with the hardener of appropriate ratio, after cross linkage for hardening, a network structure of three-dimensional space is formed. Therefore, this product has equipped with a special physical property, mechanical property, and chemicals-resistant, etc.
The properties of basalt fiber and epoxy resins created the curiosity to test the mechanical performances of basalt-fiber reinforced epoxy composite, manufactured at various ratios such as 35:65, 40:60, 45:55 (Fiber: Resin). The composite laminates were prepared by using open molding method. Specimens were prepared as per the ASTM standards and tested with the objective of finding the best suitable fiber resin ratio with respect to strength.

## II. MATERIALS AND METHODS

Basalt Fiber is an environmentally friendly high performance fiber, it is an ideal low cost fiber to instead of carbon and aramid fiber, Basalt Chopped Strand is chopped from continuous basalt fiber as per indicated length, this product have chemical resistant, high strength, high modulus, wide range of work temperature, magnetic wave passable, similar coefficient of thermal expansion with concrete, mainly used for concrete reinforcement, it can improve the concrete defect when temperature is not good(wheel rut when high temperature, crack when cold temperature), and also improve the impact resistant and compressive resistant properties, prevent water penetration, thus can increase the concrete service life, this basalt chopped strand can be also used in FRP and friction products, with the properties of high strength, high modulus and resistance to friction.

Hand lay-up technique is the simplest method of composite processing. The infrastructural requirement for this method is also minimal. The processing steps are quite simple.The paraffin wax is applied on the lower and upper die plate. The acetate sheet is placed on the wax applied surface of die plate and again wax is applied over the acetate sheet. The stripper plate is placed on the lower die in which the guide pin should match with the stripper plate.The chopped strand basalt fiber is spreader over stripper plate and epoxy resin is applied between the basalt fiber. Finally the upper die is used to close the match plate mould in which guide pin is used to locate it correctly with lower die.

## III. SHEET PREPARATION

The chopped strand basalt fiber is spreader over stripper plate which is placed on the lower die cavity of compression moulding. Epoxy resin is mixed with accelerator LY951 under the ratio of 10:1 (resin: accelerator) respectively and stirred well. The mixed chemicals should be used within 20 minutes to avoid solidification.
The quantity of basalt fiber and epoxy resin to be used for the three different ratios 35:65, 40:60 and 45:55 (fiber: Resin) are calculated based on the definition “density of a material is mass per unit volume”.

$$m = \rho v$$

Where,
m = Mass of the material in Kg
ρ = Density of the material in Kg/m3
v = Volume of material in m3
Density of glass fiber – 2700 Kg/m3
Density of epoxy resin – 1230 Kg/m3

DOI: 10.15680/IJIRSET.2014.0311059

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

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The area of die is 0.3 X 0.3 X 0.003 m. The mass of the basalt fiber and epoxy resin that is used in different ratios are calculated by using the above formula. The calculated values are tabulated.

Table 1: Mass of Material Used Based on Fiber Resin Ratio

| Material | Mass in Kg for different ratio | | |
|---|---|---|---|
| | 35:75 | 40:60 | 45:55 |
| Basalt Fiber | 0.1225 | 0.14 | 0.1575 |
| Epoxy Resin | 0.2275 | 0.21 | 0.1925 |
| Accelerator | 0.0225 | 0.021 | 0.01925 |

Die set moved into the compression moulding machine for curing under pressure of 1 X 107 Pa and 80oC temperature for 4 hours. After curing the composite sheet is removed from the mould set.

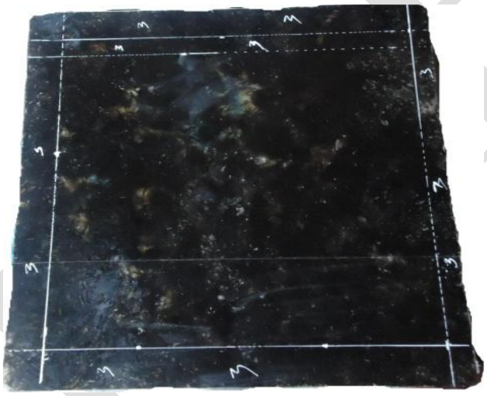

Fig. 1 Glass fiber reinforced polyurethane resin composite sheet

## IV. TESTING

Tensile Strength Test

The specimen is prepared according to the ASTM D3039 standard. The testing is carried out in tensile testing machine with displacement velocity at 1.5 mm/min. The gauge length for testing specimen is 80 mm. Initially the breadth and width of specimen is observed and the area of cross section is calculated. The output result is a stress strain curve, from this the ultimate stress, elongation percentage, yields stress and break load is calculated. Three specimens are tested for each fiber resin composition ratio.

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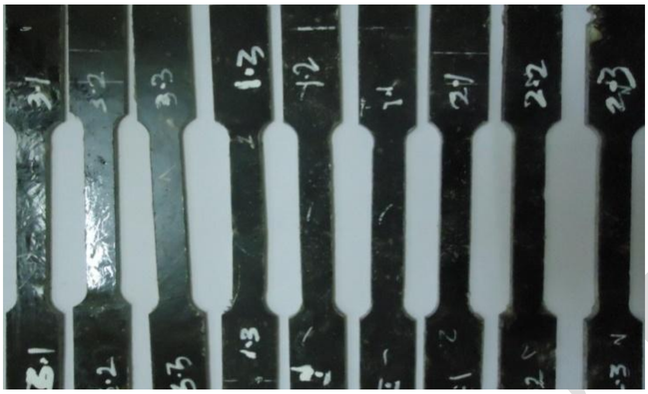

Fig 2: Tensile Strength Testing specimens

Flexural Strength Test

The specimen is prepared according to the ASTM D790 standard. Three point flexural testing method is followed. The testing is carried out in tensile testing machine with displacement velocity at 1.5 mm/min. The gauge length for testing specimen is 80 mm. Initially the breadth and width of specimen is observed and the area of cross section is calculated. The output result is a load Vs displacement curve, from this the ultimate stress and break load is calculated. Three specimens are tested for each fiber resin composition ratio.

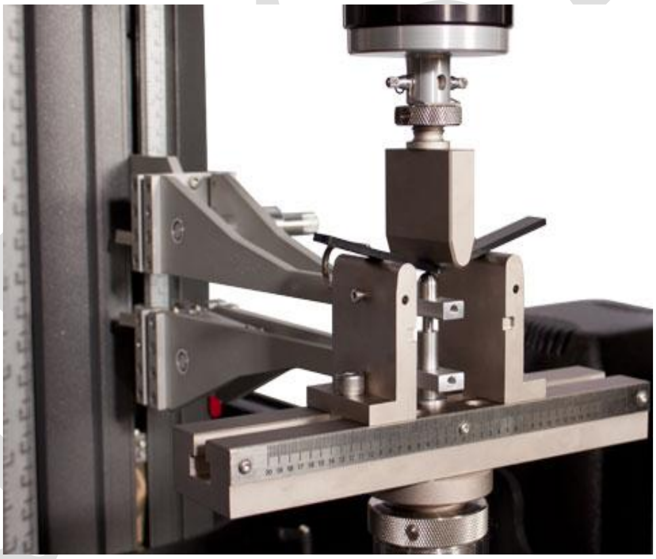

Fig. 3: Flexural testing setup

Impact Strength Test

The specimen is prepared according to the ASTM D256 standard. The testing is carried out in Izod impact testing machine. Initially the breadth and width of specimen is observed and the area of cross section is calculated. The 'V' notch in the specimen plays a vital role in testing, so the specimen should be placed in the testing fixture correctly according to the standard. The energy observed by the specimen during testing is directly observed from the pointer scale. Three specimens are tested for each fiber resin composition ratio.

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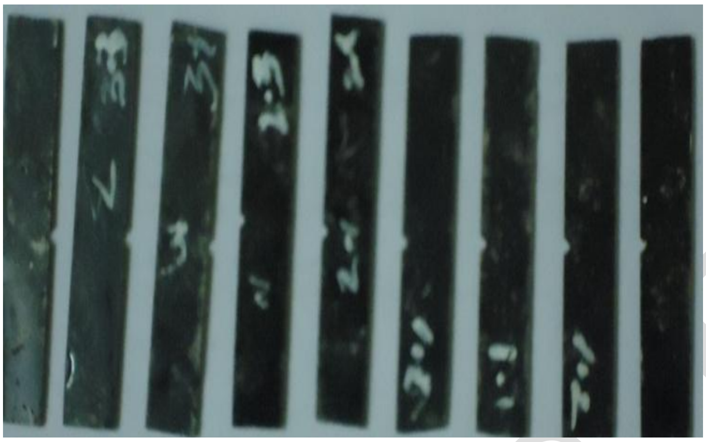

Fig 4: Impact Strength Testing specimens

## V. RESULTS AND DISCUSSION

Tensile Strength

The results of tensile strength tested components are compiled and the tensile strength is calculated. The fig.5 shows the tensile strength of three different specimens for each ratio. The 45:55 fiber resin ratio has more tensile strength while comparing to other two ratios due to more fiber content. It shows that when fiber content increases the strength of the composite also increases, but at some point it will decline due to lack of bonding element (Epoxy). However in this experiment shows the 45:55 fiber resins ratio has high tensile strength while comparing to other two ratios.

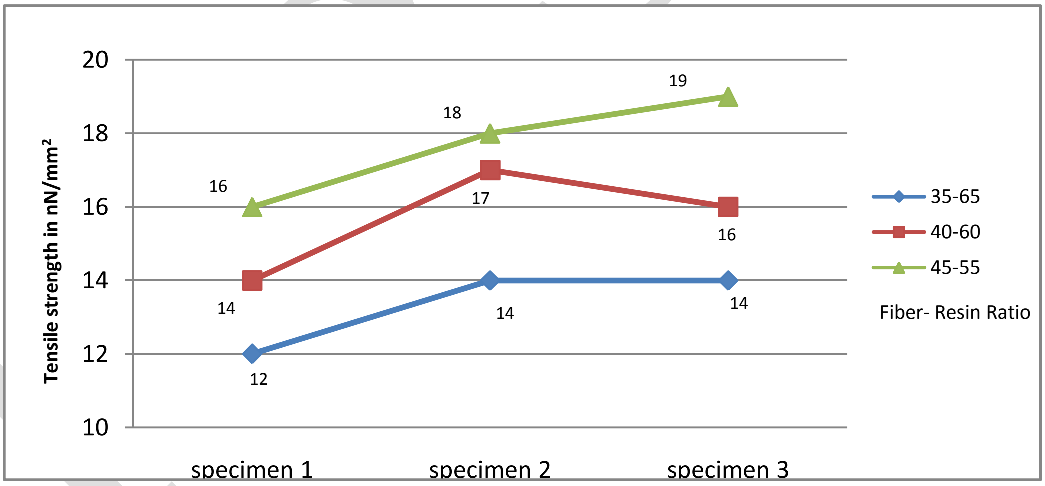


Fig. 5 Tensile strength of glass fiber reinforced polyurethane resin composite vs three different specimen for each ratio

Flexural Strength

From the testing results the flexural strength is calculated by using 3-point flexural formula and the graph is plotted. The fig.6 shows the flexural strength of three specimens for each ratio. The 45:55 has more flexural strength while comparing to other ratio. The composite has a epoxy resin which has a flexible property, so the material will have good elasticity, while compare with other resin.. But at some point the strength will be reduced to lack of bonding element (epoxy). However this experiment shows the 45:55 fiber resin ratio has good flexural strength while comparing to other two ratios.

IIJRSET
ISSN: 2319-8753
International Journal of Innovative Research in Science, Engineering and Technology
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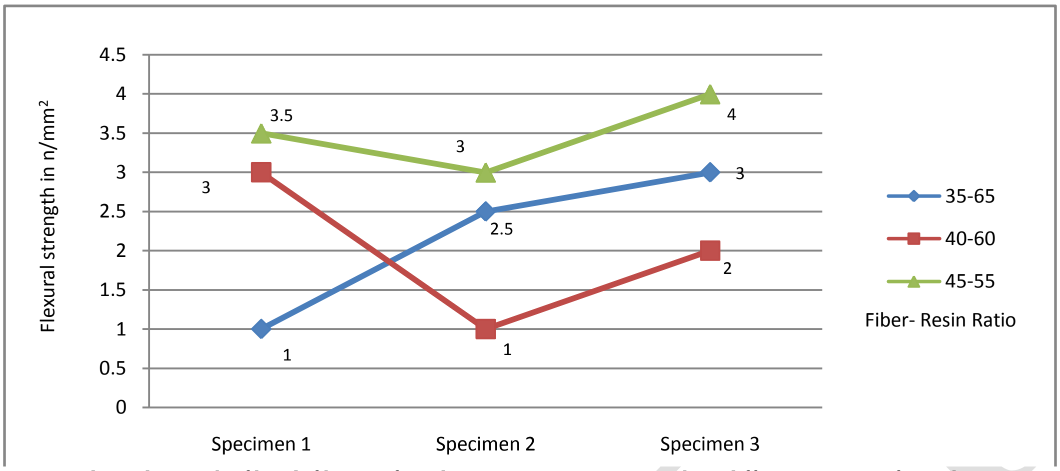


Fig. 6: Flexural strength of basalt fiber reinforced epoxy resin composite vs three different specimen for each ratio

Impact Strength

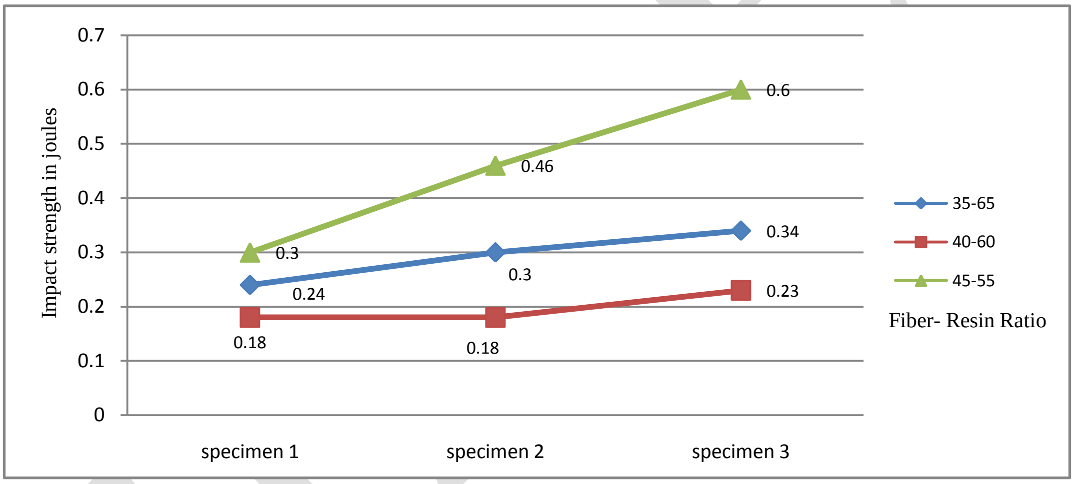


Fig. 7: Impact strength of basalt fiber reinforced epoxy resin composite vs three different specimen for each ratio

The fig.7 shows the impact strength of three different specimens for each ratio. The results show that the ratio of 45:55 has very high impact strength due to changing the fiber resin ratio. During the impact test while comparing to other two ratio, 45:55 gives very huge difference has shown in chart. The composite made of basalt fiber reinforced with epoxy has a very high impact strength and less elasticity comparing with other resin of basalt composition.

## VI. CONCLUSION

The Tensile strength, Flexural Strength and Impact strength of basalt fiber reinforced epoxy resin composite was studied. From the results obtained, the fiber resin ratio 45:55 has more tensile and impact strength comparing to other two ratios. But there is no big variation in flexural strength due to change in ratio. From this experimental study we can conclude that by increasing the fiber content in the composite material the tensile and impact strength will be increased, but at some point the strength will start decrease due to lack of adhesion material (resin).

## REFERENCES

[1] Amirova L.M., Saifutdinov R.K., Magsumova A.F. and Amirov R.R., “Modification of Epoxy Binders for Glass and Basalt-Reinforced Plastics”, Russian Journal of Applied Chemistry, Vol. 74, No. 11, pp. 1943-1946, 2001.

[2] Babievskaya I.Z., Dergacheva N.P., Fomichev .S.V. and Krenev1 V.A., "Modifying the Composition of Gabbro Basalts by Leaching with Hydrochloric and Phosphoric Acids", Theoretical Foundations of Chemical Engineering, Vol. 44, No. 4, pp. 580–583, 2010.
[3] Bashtannik P.I., Kabak A.P. and Yu,Yakovchuk, "The Effect Of Adhesion Interaction On The Mechanical Properties Of Thermoplastic Basalt Plastics", Mechanics of Composite Materials, Vol. 39, pp.223-229, 2003.
[4] Cziga N.T., Skei K.P. " Fracture and failure behavior of basalt fiber mat-reinforced vinyl ester/epoxy hybrid resins as a function of resin composition and fiber surface treatment", Journal Of Materials Science,Vol.40, p.5609–5618, 2005.
[5] Fomichev S.V., Dergacheva N.P., Steblevskii A.V. and Krenev V.V., "Production of Ceramic Materials by the Sintering of Ground Basalt", Theoretical Foundations of Chemical Engineering, Vol. 45, No. 4, pp. 526–529, 2011.
[6] Gur'ev E., Neproshin I. and Mostovoi G., "The effect of basalt fiber production technology on mechanical properties of Fiber Wear", Journal Of Materials Science, Vol. 261,pp.201–207, 2006.
[7] Kochetkova N.N., Dergacheva N.P., Fomichev V. and KrenevV.A.,"Interaction of Basalt with Hydrochloric Acid", Russian Journal of Inorganic Chemistry, Vol. 54, No. 6, pp. 842–847, 2009.
[8] Peng Ye, Lauren Reitz, Chris Horan, and Richard Parnas, "Manufacture and Biodegradation of Wheat Gluten/Basalt Composite Material", Journal of Polymers and the Environment, Vol. 14, No. 1, pp.189-198, 2006.
[9] Qi-huaWanga, Xin-rui Zhang, Xian-qiang Pei, "A Study on the friction and wear behavior of basalt fabric composites filled with graphite and nano-SiO2", Cent. Eur. J. Eng., Vol.1, pp.234-243, 2011.
[10] Sergey Nikoghosyan K., Aram A., Sahakyan N., Vasak B., "The influence of hydrochloric acid treatment and temperature on the electro-physical properties of super-thin basalt fibers", Surface & Coatings Technology, Vol.205,pp.224–231, 2010.

## BIOGRAPHY

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DOI: 10.15680/IJIRSET.2014.0311059