ISSN 2348 – 8034
Impact Factor- 4.022

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

# A REVIEW ON REINFORCEMENT OF BASALT AND CARBON FIBERS

**Vemu Vara Prasad[*1] & T. Sowjanya[2]**
[*1]Assistant Professor, UCEK, JNTU Kakinada
[2]PG Scholar, UCEK, JNTU Kakinada

## ABSTRACT

At present, as there is an increase in the use of eco-friendly products natural fibers are reinforced for fabrication of low cost and light weight composites. This review presents briefly on basalt and carbon fibers (Uni-directional) which are used as reinforcement materials for composites. An advantage of the basalt and carbon fibers includes high physical, chemical, mechanical properties. The present paper discusses the basics of basalt and carbon chemistry. Apart from this, an attempt to showcase the tests to investigate the mechanical properties like tensile strength, impact strength can be performed. The enhanced properties suggest possible applications of these composite materials in various fields.: At present, as there is an increase in the use of eco-friendly products natural fibers are reinforced for fabrication of low cost and light weight composites. This review presents briefly on basalt and carbon fibers (Uni-directional) which are used as reinforcement materials for composites. An advantage of the basalt and carbon fibers includes high physical, chemical, mechanical properties. The present paper discusses the basics of basalt and carbon chemistry. Apart from this, an attempt to showcase the tests to investigate the mechanical properties like tensile strength, impact strength can be performed. The enhanced properties suggest possible applications of these composite materials in various fields.

***Keywords-*** *Basalt Fiber, Carbon Fiber, Reinforcement.*

## I. INTRODUCTION

Carbon fibers are fibers about 5-10 mm in diameter and composed mostly of carbon atoms. To produce a carbon fiber, the carbon atoms are bonded together in crystals that are more or less aligned parallel to the long axis of the fiber as the crystal alignment gives the fiber high strength-to-volume ratio (making it strong for its size).Several thousand carbon fibers are bundled together to form a tow, which may be used by itself or into a fabric.

The properties of carbon fibers, such as high stiffness, high tensile strength, low weight, high chemical resistance, high temperature tolerance and low thermal expansion, make them very popular in aerospace, civil engineering, military and motorsports, along with other competition sports[1-4].However, they are relatively expensive when compared with similar fibers, such as glass fibers or plastic fibers[5].

The major drawback of using carbon composite is expense of production resulting in the use of very low loading conditions [1]. The problems of weakness and brittleness can be resolved by hybridization technique that is by replacing some of the layers of carbon fibers with ductile fibers. This may also result in cost benefit and improvement of mechanical and physical properties.

Carbon fibers are usually combined with other materials to form a composite. When combined with a plastic resin and wound or molded it forms carbon-fiber-reinforced polymer has a very high strength-to-weight ratio, and is extremely rigid although somewhat brittle. However, carbon fibers are also composited with other materials, such as with graphite to form carbon-carbon composites, which have a very high heat tolerance.

Generally hybrid composites are fabricated when two or more materials are reinforced with common matrix. With this mixing it results to provide new and superior properties within the embedded material like improved ductility, elastic modulus, light weight and flame retarding ability [6-8].The various assemblies and arrangement of fibers and their orientations with in fiber lead to characteristic change in properties.

Based on above observations light weight, strong, durable and economically viable fibers are currently required for fabrication of hybrid composites. Presently there is an availability of several organic and inorganic fibers in the market, but many of them either lack structural strength or durability or are extremely cost. Basalt fiber which is an inorganic fiber with extremely good properties is the present material choice [9-14].

The first attempts to produce basalt fiber were made in the United states in 1923 These were further developed after World War II .This was done by researchers in the USA, Europe and the Soviet Union especially for military and aerospace applications[15-17]. Recently, interest in the use of basalt fibers is increased because of its extremely good modulus, improved strain to failure, high strength, better chemical resistance, excellent stability, high temperature resistance, non-toxic, natural, eco-friendly, inexpensive and it is also easy to process[11,13]. After extrusion from basalt-based molten igneous volcanic rock, which is found in flowing lava, basalt fiber is obtained.

Currently, carbon fibers are extensively used in automotive industry due to their superior mechanical properties. By utilizing the reinforcing material one could decrease weight by 40-60%, but cost of process is not economically viable [18]. Thus need for lowering the production and delivery cost without enduring a loss in carbon fiber reinforcing material could be done by reinforcement of basalt fiber to it. In short, by this fibers acts as a load bearing components. The present review focuses on the extensive use of basalt and carbon fiber (Uni-directional) reinforced materials.

## II. CHEMISTRY OF FIBERS

**Carbon fiber**

Carbon fibers were developed in the 1950s as reinforcement for high-temperature molded plastic components on missiles. They were manufactured by heating strands of rayon until they carbonized. As the resulting fibers contained only about 20% of carbon and had low strength and stiffness properties this process proved to be inefficient. In the early 1960s, a process was developed using polyacrylonitrile as a raw material. By this about 55% of carbon contained carbon fiber is produced that had much better properties. For producing carbon fibers, the polyacrylonitrile conversion process quickly became the primary method [19].

During the 1970s, to find alternative raw materials experimental work led to the introduction of carbon fibers made from a petroleum pitch derived from oil processing. These fibers contained about 85% carbon and had excellent flexural strength. Unfortunately, they had only limited compression strength and were not widely accepted.

Later a process is developed for producing a high carbon content (99%) fiber using rayon as a precursor. To be used as a reinforcement for composites these carbon fibers had sufficient strength (modulus of elasticity and tensile strength) having high strength to weight properties and for high temperature resistant applications [20]. The exact composition of each precursor varies from one company to another and is generally considered a trade secret. Carbon fiber is displayed in Fig.1.

*Fig.1. Carbon fiber*

ISSN 2348 – 8034
Impact Factor- 4.022

**Basalt fiber**

Basalt is chemically rich with oxides of magnesium, calcium, sodium, potassium, silicon and iron along with traces of alumina. Table 1. Depicts the overall percentage distribution of chemical composition of basalt. Based on geographical distribution chemical content differs. Basalt is abundant because up to 33% of the earth's crust comprises of Basalt.

***TABLE-1: Composition of Basalt***

| Chemical composition of basalt rock | Percentage |
|---|---|
| Silicon dioxide ($SiO_2$) | 52.8 |
| Aluminum oxide($Al_2O_3$) | 17.5 |
| Iron oxide($Fe_2O_3$) | 10.3 |
| Magnesium oxide(MgO) | 4.63 |
| Calcium oxide(CaO) | 8.59 |
| sodium oxide($Na_2O$) | 3.34 |
| Potassium oxide($K_2O$) | 1.46 |
| Titanium oxide($TiO_2$) | 1.38 |
| Phosphorous pentoxide($P_2O_5$) | 0.28 |
| Manganese oxide(MnO) | 0.16 |
| Chromium oxide($Cr_2O_3$) | 0.06 |

Basalt fibers are manufactured from finely powdered basalt which is melted to a glassy molten liquid at a temperature 1500-1700 °C and then extruded into thin threads. Basalt fiber is displayed in Fig.2.

***Fig.2. Basalt fiber***

ISSN 2348 – 8034
Impact Factor- 4.022

## III. EXPERIMENTAL TEST PROCEDURES

Basalt and carbon fiber reinforced laminates with required dimensions were obtained and tested in various procedures. The basic mechanical properties of adopted basalt and carbon reinforced fiber are compared to individual properties of both the fibers. In order to produce plates with desired thickness required numbers of plies are impregnated using epoxy matrix in different stacking sequences for comparison.

According to ASTM specifications, various mechanical tests are to be carried out on different composites which were made: Tensile, compression, elastic modulus, specific modulus test. Table 2. indicates comparison of some properties of fibers as shown.

***TABLE 2: Basic properties***

| | **Basalt fiber** | **Carbon fiber** |
|---|---|---|
| Tensile strength(GPa) | 4.15-4.8 | 2.55-3 |
| Elastic modulus(GPa) | 93-110 | 230-290 |
| Specific modulus | 37.7-41.5 | 131-165 |
| Density(kg/m$^3$) | 2.65 | 1.8 |
| Elongation at break (%) | 3.15 | 1.3 |
| Max. temperature of application(°C) | 650 | 400 |

The various standard test methods for different stacking sequences are also performed by comparing with standard specifications of the materials and are then reported for each different test.

Using thermal mechanical analyser, mechanical properties of material at various changes in temperature can be analyzed. The heat transfer test can also be conducted by using Differential scanning calorimeter.

## IV. CONCLUSION

In this review, the research trends for the use of basalt fiber and carbon fiber (Uni-directional) reinforcement of composites. Basalt fibers are almost as favorable as other fibers. It was mainly used in military applications involving the fabrication of strong and light weight material for anti ballistic applications, automobile and aerospace applications [9,21]. As basalt is eco-friendly, chemically inert, highly resistant to corrosion, very low thermal conductivity making it superior to choose than any other reinforcement available today. The use of basalt with carbon fiber as a reinforcement may reduce overall cost [22,23]. Here, we have attempted to show latest trends in modern composites using basalt fiber as reinforcement along with carbon fiber with a detailed analysis of above mentioned properties.

## REFERENCES

1. *J.M.F.D. Paivaa, A.D.N.D. Santos, M.C. Rezende.,Mechanical and morphological characterizations of carbon fiber fabric reinforced epoxy composites used in aeronautical field,Mater Res, 12 (3) (2009), pp. 367–374.*
2. *I. Taketa, J. Ustarroz, L. Gorbatikh, S.V. Lomov, I. Verpoest.,Interply hybrid composites with carbon fiber reinforced polypropylene and self-reinforced polypropylene,Compos Part A – Appl Sci, 41 (8) (2010), pp. 927–932.*
3. *L. Hollaway.,Polymer composites for civil and structural engineering, Springer, New York (1993).*
4. *P.D.L.R. García, A.C. Escamilla, M.N.G. García.,Bending reinforcement of timber beams with composite carbon fiber and basalt fiber materials, Compos Part B – Eng, 55 (2013), pp. 528–536.*
5. *T.M. Kruckenberg, R. Paton.,Resin transfer molding for aerospace structures,Kluwer, The Netherlands (1998).*

6. *I.D.G. Ary Subagia, Y. Kim, L.D. Tijing, C.S. Kim, H.K. Shon.,Effect of stacking sequence on the flexural properties of hybrid composites reinforced with carbon and basalt fibers,Compos Part B – Eng, 58 (2014), pp. 251–258.*
7. *M.T. Dehkordi, H. Nosraty, M.M. Shokrieh, G. Minak, D. Ghelli.,Low velocity impact properties of intra-ply hybrid composites based on basalt and nylon woven fabrics,Mater Des, 31 (8) (2010), pp. 3835–3844.*
8. *S.H. Han, H.J. Oh, H.C. Lee, S.S. Su.,The effect of post-processing of carbon fibers on the mechanical properties of epoxy-based composites, Compos Part B – Eng, 45 (1) (2012), pp. 172–177.*
9. *V. Lopresto, C.Leone, I.D. Iorio.,Mechanical characterisation of basalt fibre reinforced plastic,Compos Part B – Eng, 42 (4) (2011), pp. 717–723*
10. *B. Wei, H.L. Cao, S.H. Song., Degradation of basalt fiber and glass fiber/epoxy resin composites in seawater,Corros Sci, 53 (1) (2011), pp. 426–431*
11. *X. Wang, Z. Wu, G. Wu, H. Zhu, F. Zen.,Enhancement of basalt FRP by hybridization for long-span cable-stayed bridge, Compos Part B – Eng, 44 (1) (2013), pp. 184–192.*
12. *V. Fiore, G.D. Bella, A. Valenza.,Glass-basalt/epoxy hybrid composites for marine applications,Mater Des, 32 (4) (2011), pp. 2091–2099.*
13. *T.M. Borhan.,Properties of glass concrete reinforced with short basalt fiber,Mater Des, 42 (2012), pp. 265–271*
14. *P. Larrinaga, C. Chastre, H.C. Biscaia, J.T. San-Jose.,Experimental and numerical modeling of basalt textile reinforced mortar behavior under uniaxial tensile stress,Mater Des, 55 (2014), pp. 66–74.*
15. *A. Ross., Basalt fibers: alternative to glass, Compos Technol, 12 (2006), pp. 44–48.*
16. *C. Colombo, L. Vergani, M. Burman.,Static and fatigue characterization of new basalt fiber reinforced composites, Compos Struct, 94 (3) (2012), pp. 1165–1174.*
17. *D. Pavlovski, B. Mislavsky, A. Antonov.,CNG cylinder manufacturers test basalt fibre,Reinf Plast, 51 (4) (2007), pp. 36–37.*
18. *S. Das.,The cost of automotive polymer composites: a review and assessment of DOE's lightweight materials composites research, Oak Ridge National Laboratory (2001) p. 1–49,Composites Part A, 47 (2013), pp. 109–123.*
19. *Houssam A.Toutanji, Tahar El-Korchi, R.Nathan Katz., Strength and reliability of carbon-fiber-reinforced cement composites, Cement and Concrete Composites, Volume 16, Issue 1, 1994, Pages 15-21.*
20. *L.M.Manocha, O.P.Bahl, Y.K.Singh Carbon., Mechanical behavior of carbon-carbon composites made with surface treated carbon fibers, Carbon Volume 27, Issue 3, 1989, Pages 381-387.*
21. *F. Sarasini, J. Tirillò, M. Valente, T. Valente, S. Cioffi, S. Iannace, et al.,Effect of basalt fiber hybridization on the impact behavior under low impact velocity of glass/basalt woven fabric/epoxy resin composites.*
22. *M.T. Kim, K.Y. Rhee., Flexural behavior of carbon nanotube-modified epoxy/basalt composites, Carbon Lett, 12 (3) (2011), pp. 177–179.*
23. *M. Pearson, T. Donchev, J. Salazar.,Long-term behavior of prestressed basalt fiber reinforced polymer bars,Proc Eng, 54 (2013),pp.261–269.*