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INVESTIGATIONS OF TENSILE BEHAVIOUR OF BASALT FIBER COMPOSITE

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Abstract. In recent years, both industrial and academic world are focussing their attention toward the development of sustainable composites, reinforced with natural fibres. In this present work, the tensile behaviour of basalt fiber composites were investigated. The manufacturing of the composite is done by hand lay method. Morphological analysis were done by scanning electron microscopy. The objective was to study the effect of surface modifications and mechanical properties when tensile test and hardness test was performed on the fibre. It results showed increase in strength of composite 3 when compared to the other two composites 1, 2.

Keywords: Hybrid composites, Hand lay method, Mechanical properties.

1. Introduction

Nowadays, Automotive industries are focussing on developing eco-friendly materials for their components. Hence, study and development of newer materials namely nanocomposites, fiber composites and metal matrix composites is necessary which are having better mechanical behaviour and other properties. Sakthivel and Ramesh [1] (2013) studies that basalt fiber is a material made from extremely fine fibers of basalt, which is composed of the minerals plagioclase, pyroxene, and olivine. It is similar to fiberglass, having better physicomechanical properties than fiberglass, but being significantly cheaper than carbon fiber. It is used as a fire proof textile in the aerospace and automotive industries and can also be used as a composite to produce products such as camera tripods. Basalt fiber is made from a single material, crushed basalt, from a carefully chosen quarry source. Sim,J et al [2] (2005), it was studied that steel fiber used in UHPC has a high aspect ratio of about 100 and a high strength to 2500Mpa. However, there are drawbacks in that steel fiber has a potentially high corrosion possibility and its density is three times higher than that of a concrete matrix, which results in the sinking of steel fiber during mixing and casting, and finally, a poor fiber dispersion. Although the synthetic fiber has no corrosion possibility, and its density is about 0.5 times that of concrete matrix and its cost is high. Vijaya Ramnath et al [3] (2014), studied mechanical behaviour of hybrid composite (banana jute glass fibre) and compares it with single fibre composites. Hand layup method is used to fabricate the composites. The tensile, flexural, impact, double shear



and delamination tests are performed. Scanning Electron Microscope (SEM) was used to know the fracture direction, matrix structure and fibre orientation. They concluded that hybrid composite has better overall mechanical properties when compared to mono composites. Sathish et al [4] (2015), performed a study on mechanical and thermal properties of banana-kenaf glass fiber reinforced epoxy composite fabricated by a hand layup process. They observed that the hybrid composite in which fibers are arranged at 45 degrees inclination has better properties than the others. The experimented specimen were analysed on Scanning Electron Microscope (SEM) through which the internal structure variations are observed. Park et al [5] (2012), the tensile strength of UHPC also ranges from 12.0 to 19.1 Mpa while the tensile strain capacity ranges from 0.3% to 0.79% in 28 days. Vijaya Ramnath et al [6] (2015), investigated the effect of fiber twisting and the fibre orientation on the mechanical properties of fiber composites. Compression moulding is used to fabricate the two test fibers namely twisted neem and twisted kenaf were taken and twisted to increase the mechanical properties. The result shows that there is a significant improvement in mechanical properties of composites due to the presence of twisted fibers. Russel and Graybeal [7] (2013), studied that UHPC tends to have a very low water content and can achieve sufficient rheological properties through a combination of optimized granular packing and the addition of high-range water reducing admixtures. Straight steel fiber of 0.2mm in diameter is generally used for UHPC.

Yuvaraj et al [8] (2016), it was investigated about mechanical behaviour of sisal epoxy hybrid composites where epoxy hybrid composite was fabricated by hand layup process. They concluded that due to their bio-degradability, low strength to weight ratio, these hybrid composites absorb high breaking load, hardness and delamination is increased. It also proved that composite with equal fibre ratio of glass and sisal has improved the mechanical properties. Vijaya ramnath et al [9] (2014) evaluated the mechanical properties of abaca- jute-glass fiber reinforced epoxy composite. It is found that the abaca-jute hybrid composite has better properties than the abaca fiber in tensile and shear. The internal structure of the composite is observed under Scanning Electron Microscope (SEM) from which it is noted that fiber pull out and voids are observed due to improvement in fabrication procedure. Association Française de Génie Civil (AFGC) [10] (2002) shows that ultra-high performance concrete (UHPC) tends to have the following properties: a compressive strength that is greater than 150 Mpa, inter fiber reinforcement that ensures non- brittle behaviour, and a high binder content with special aggregates. Vijaya Ramnath et al [11] (2014) Determined the mechanical properties of intra-layer abaca-jute-glass fiber reinforced composite. The composite is made up of five layers with three layers of jute and abaca enclosed by two layers of glass fibers. The composites are manufactured with three different fiber orientations and the compositions are varied in three different proportions. The fabricated composite samples are tested to investigate their various mechanical properties. Dias and Thaumaturgo [12] (2005) studied that basalt fiber has a higher strength compared to other types of fibers and a similar density with the concrete matrix as well as no corrosion possibility. Furthermore, the basalt fiber can retain about 90% of the normal temperature strength up to 600°C. Previous studies reported that basalt fiber is effective for strengthening concrete and improving the fracture behaviour of concrete. Vijaya Ramnath et al [13] (2016) investigated the Shear and Hardness of Abaca based Hybrid composite fabricated by hand layup process. Abaca fiber has more strength than other fibers like kenaf, banana and sisal, the composite with this fiber can be suitable replacement

material for automotive applications. The properties like double shear and hardness were evaluated and the result shows that the double shear properties and hardness of the hybrid composites [GFRP + Abaca + Raffia] is higher than other two combinations.

2. Experimental details

2.1 Materials

Basalt is a igneous rock formed as a result of Lava cooling at the surface of the planet. It is drawn into continuous fiber by rock melt drawing at about 1500°C. It is similar to fiberglass, having better mechanical properties than fiberglass. GFRP is very commonly and widely used polymer which are made from extremely fine fibers of glass which makes them lightweight, strong and robust. When compared to metals it has better bulk strength and other mechanical properties. Epoxy resin when used along with the hardener give very high bonding properties between the fibre layers to form a composite. The best bonding properties were obtained by using the combination of Epoxy LY556 resin and HY951 hardener at the room temperature.

2.1.1 Hand lay-up process

Basalt fiber and GFRP of 250 mm length were used to prepare the specimen. The size of the fabricated laminate is restricted to 250×250×5 mm. The composite consists of 1, 2 and 3 layers of basalt fibers names as composite 1, 2 and 3. The mats were impregnated with epoxy resin. Then the basalt fibers are dried under the hot sun to remove the moisture. The fiber layers are washed in thinner. This removes the impurities and makes them ready for binding with the resin. Then basalt fibers are placed on the die which is placed on the table. Then it is completely spread with the epoxy resin. The resin gets mixed with the fiber and may tend to dried up in the open atmosphere under hot sun for 48 hours.

3. Testing of composites

3.1 Tensile Test:

A universal testing machine was used to carry out the testing and it was done at room temperature. The grippers are used to hold the ASTM: D638 (figure 1) standard specimen in order to carry out the testing and the load is applied until the specimen breaks. The stress vs strain graph is generated.

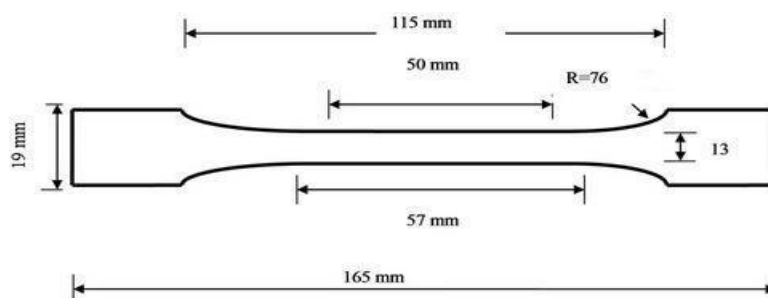


Figure 1: Tensile test specimen

Hardness test

Hardness is the property which resists the indentation in the material. This test is performed in order to find the hardness of the composite fabricated. In this work Rockwell Hardness test is performed. Here, hardness is found by measuring the depth of penetration of an indenter under a specific load.

4. Results and discussion

4.1 Tensile properties

The composite specimens 1, 2 and 3 were tested on a universal testing machine to find their tensile properties. The results of the test shows that both specimens 2 and 3 have a higher ultimate tensile strength, higher percentage of elongation as compared to specimen 1. Table 1 shows the tensile test performed on composite 1,2 and 3 and maximum stress and maximum strain values are tabulated.

Table 1: Result of Tensile test

COMPOSITES	MAXIMUM STRESS (N/mm ²)	MAXIMUM STRAIN (%)
COMPOSITE 1	72	3.9
COMPOSITE 2	94	5.8
COMPOSITE 3	98	5.4

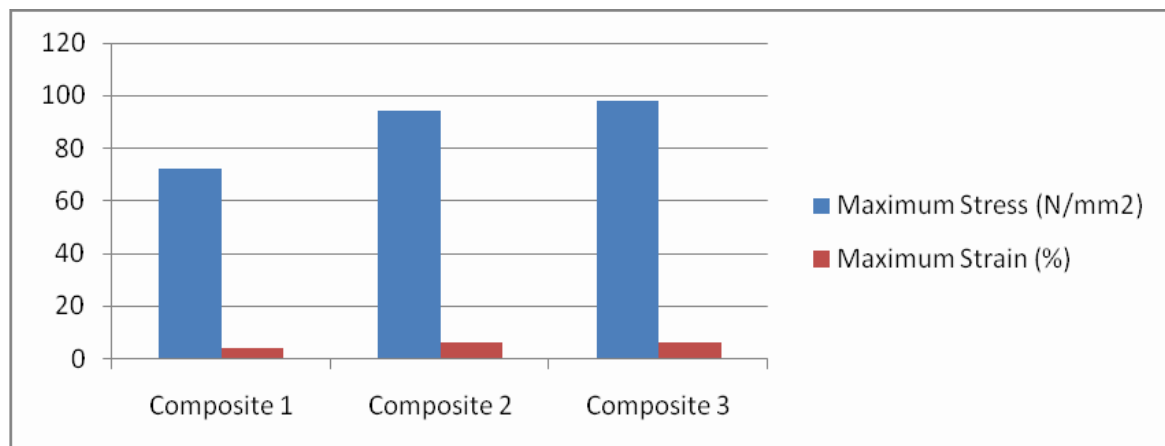


Figure 2: Result of Tensile test

From figure 2, it is clear that composite 3 which contain 3 layers of basalt has high strength as compared to other composite.

4.2. Hardness Properties

The composite specimens 1, 2 and 3 were tested on Rockwell Hardness Testing Machine . The results of the test shows that both specimens 3 have a higher hardness value compared to specimen 1 and 2. Table 2 shows the hardness test performed on composite 1,2 and 3 and the trial values are tabulated.

Table 2: Results of Hardness test

COMPOSITES	Trial 1	Trial 2	Trial 3	Average hardness
COMPOSITE 1	351.8	352.6	352.8	352.4
COMPOSITE 2	362.7	361.2	362.4	362.1
COMPOSITE 3	378.2	379.1	378.6	378.6

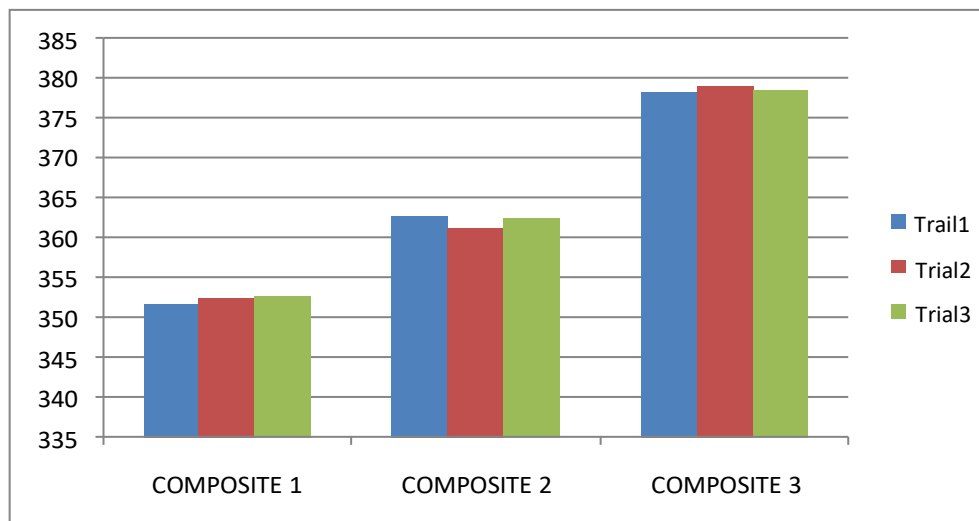


Figure 3: Comparisons of hardness

From the figure 3, it is clear that composite 3 shows better hardness than other composites, since it contains more layers of basalt fibers.

5. Conclusion

In this work basalt fiber composite is fabricated with hand lay up process in three different compositions of fiber layers. Tensile and hardness test were performed as per ASTM standard, and it is observed that composite 3 which contains three layers of basalt fibers has better tensile and hardness behavior. From the above result it can be suggested that the fabricated composites can be used for automotive applications and also as replacement for asbestos, high strength glass, silica, chemical resistant glass for industrial applications.

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