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MECHANICAL PROPERTIES AND CHARACTERIZATION STUDIES IN NATURAL FIBER/ LIGNITE FLY ASH REINFORCED HYBRID COMPOSITES

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ABSTRACT

In this project the variation of mechanical properties in lignite fly ash filled fiber reinforced composite with water absorption is studied. Hybrid composites are recent trends advancement of composite materials that consist of two reinforcement phase fiber-fiber, particle-particle & particle fiber. Hybrid composites will have the properties of both the reinforcement phases which improve the properties of material. In this project particle-fiber hybrid composite is considered for study of mechanical properties. The particle used is Lignite Fly Ash (LFA) and fiber used is Palmyra and the matrix phase is unsaturated polyester resin. The composites are fabricated in the combination of Palmyra/Fly ash. The composite is fabricated using Compression molding process at 90:8:2 weight mixing ratios of raw materials. The fiber is extracted using water retting process; the extracted fiber chopped into 2 mm short length fiber and refined it by treating it with NaOH and CH3COOH. The refined fiber is spread over the die of dimension 300 x 125 x 3 mm, then mixture of unsaturated polyester resin, LFA, catalyst and accelerator is poured over the fiber. The die is closed and placed in compression molding machine under a compressive load of 5 to 10 tones and cured for 2 – 3 hours. The fabricated composites are cut as per ASTM standards for tensile, compressive, flexural and hardness test. One set of specimen is immersed in water for 24 hours for water absorption and tested. The other set is tested without water absorption and the variation in mechanical properties is studied. From the results obtained it is found the tensile, compressive & flexural properties increases with increase water absorption for Palmyra/Fly ash composite. The sample characterization was by X-Ray Diffraction (XRD), and Scanning Electron Microscopy (SEM) to probe the microstructure and geopolymerization reactions.

Keywords: *Palmyra Fibre, Tensile Strength, Compressive and Flexural Strength.*

1. Introduction

The need of modern composite materials is that they are light as well as strong. By choosing an appropriate combination of matrix and reinforcement material, a new material can be made that exactly meets the requirements of a particular application. Composites also provide design flexibility because many of them can be moulded into complex shapes. The Lignite Flyash(LFA) is taken from the thermal power plant . In the thermal powerplant the LFA is dumped as a waste product. The mould was made of stainless steel. The fibers chosen are Palmyra & Sansevieria. The Palmyra fiber is extracted from the fruit of the palm tree. The palm tree is available on the sides of the cultivated lands. Most commonly it is cultivated on the south side of India. The unsaturated polyester resin which polymerise upon heating to form highly-cross linked, network polymers. Polyesters, which are used in composites materials in combination with reinforcement, belong among Unsaturated Polyester Resins.

2. Fabrication of Composite

Composite is fabricated using Compression molding process. The Lignite flyash is weighed according to the required weight percentage. Unsaturated polyester resin is mixed the catalyst MEKP and kept still for a while to remove air bubbles. For 1 litre of UP resin 5 ml of MEKP is added. The Lignite flyash is mixed with 150 ml of unsaturated polyester resin and stirred slowly in order to avoid the formation of air bubbles. A lamination sheet is placed inner side of the die for easy removal of specimen after curing. The dye is placed in a press.

The fiber with certain percentage is spreaded over the dye. Initially the dye is compressed with the fiber. Now 30-40 ml of cobalt naphthenate (accelerator) is added to the mixture and stirred slowly. Then the mixture is poured into the dye of size 300 x 125 x 3 mm

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and kept for curing. It should be cured for a period of 2-3 hours to set perfectly. After 3 hours the specimen is taken out of the dye and cut in ASTM standard sizes for different testing.

Fig. 1 Fabrication of Composite

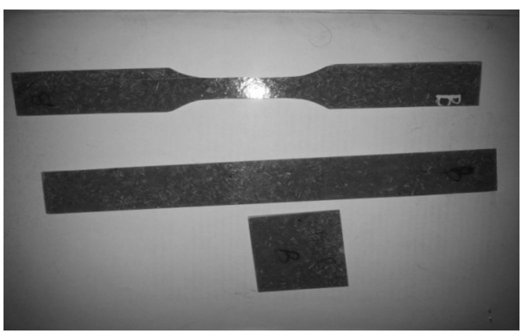

Fig. 2 Specimen for testing

2.1 Fiber used

In this project Palmyra fiber is used. The Palmyra fiber is extracted from palm fruit which is the fruit of palm tree. The fiber is extracted by water retting process. The extracted fiber is chopped into 2mm height as short length. And the fiber is treated with chemicals.

Fig. 3 Fibers

2.2 Chemical treatment

The extracted fiber is treated with chemical such as sodium Hydroxide (NaOH) as base and Acetic acid (CH_3COOH) as acid

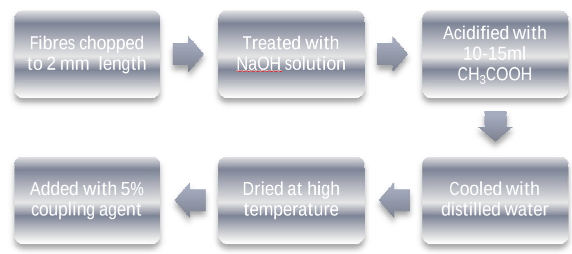

Fig. 4 Chemical Treatment

After the chemical treatment done, the fiber is allowed for fabrication

3. Tensile Strength

The test process involves placing the test specimen in the testing machine and applying tension to it until it fractures. During the application of tension, the elongation of the gauge section is recorded against the applied force. The machine does these calculations as the force increases, so that the data points can be graphed into a stress-strain curve.

4. Compression Strength

The compressive strength is the capacity of a material or structure to withstand loads tending to reduce size. It can be measured by plotting applied force against deformation in a testing machine. Some material fracture at their compressive strength limit; others deform irreversibly, so a given amount of deformation may be considered as the limit for compressive load.

5. Flexural Strength

Flexural strength, also known as bending strength, or fracture strength, a mechanical parameter for brittle material, is defined as a material's ability to resist deformation under load. The transverse bending test is most frequently employed, in which a specimen is bent until fracture or yielding using a three point flexural test technique. The flexural strength represents the highest stress experienced within the material at its moment of rupture. It is measured in terms of stress

6. Hardness

Rockwell scale is a hardness scale based on indentation hardness of a material. The Rockwell test determines the hardness by measuring the depth of penetration of an indenter under a large load compared to the penetration made by a preload. There are different scales, denoted by a single letter, that use different loads or indenters. The result is a dimensionless number noted as HRA, where A is the scale letter.

7. Mechanical Properties

The Mechanical properties of the hybrid composite is analysed using various Tests. The comparison is done by with water absorption and without water absorption. The two sets of sample is taken initially. First sample is tested without any water absorption process. Then second sample is immersed in water for 24hrs. After the water absorption process the sample is allow for testing.

7.1 Tensile strength

Table 2. Comparison of Tensile Strength

PALMYRA FIBER		
Test	Without water absorption	With water absorption
Tensile	6.53Mpa	17.32 Mpa

Effect

From the results it can be observed that the tensile strength increases with the increase in the water absorption in specimen.

7.2 Compressive Strength

Table 3. Comparison of Compressive Strength

PALMYRA FIBER		
Test	Without water absorption	With water absorption
compression	17.56Mpa	14.8Mpa

Effect

From the results it can be observed that the compression strength decreases with the increase in the water absorption in specimen

7.3 Flexural strength

Table 4. Comparison of Flexural Strength

PALMYRA FIBER		
Test	Without water absorption	With water absorption
Flexural	65.33Mpa	112.78Mpa

Effect

From the results it can be observed that the bending strength increases with the increase in the water absorption in specimen.

7.4 Hardness

Table 5. Comparison of Hardness

PALMYRA FIBER		
Test	Without water absorption	With water absorption
Hardness 1	92RHN (Rockwell hardness number)	88RHN

Effect

From the results it can be observed that the hardness decreases with the increase in the water absorption in specimen

8. XRD Analysis

X-ray diffraction patterns of composites derived from various fiber (Palmyra) The d spacing was calculated from peak positions using Bragg's law:

$$d = \lambda/(2 \sin \theta)$$

The d spacing for peak position at $2\theta = 37°$ is found to be 2.3804 for the palmyra composite. It indicates that in Palmyra fiber reinforced Polyester resin , the d spacing value is at the peak position $2\ \theta = 2.3804$ The increase of interlayer spaces lowers the interlayer attraction force and facilitates the intercalation of this fiber very effective in this particular composite. X-ray diffraction analysis leads to conclude that modification of unsaturated polyester resin with different naturally occurring fibres influences the average d-spacing values. From XRD patterns, it is concluded that the d-spacing of polyester to 2.4 nm in all samples. It has been observed from XRD that Polyester undergoes interaction with FA crystallites and exhibits semi-crystalline behaviour. Polyester-FA composites show peaks of fly ash as well as polyester indicating that fly ash crystallites have been uniformly mixed within the polymer chain.

Table 6. Palmyra XRD Analysis details

Pos. [°2Th.]	Height [cts]	FWHM Left [°2Th.]	d-spacing [Å]	Rel. Int. [%]
18.7207	1.78	0.9446	4.74006	0.47
37.8472	379.38	0.0787	2.37718	100.00
44.0813	28.82	0.2362	2.05439	7.60
81.9046	131.54	0.1200	1.17526	34.67
82.1646	98.12	0.0960	1.17511	25.86

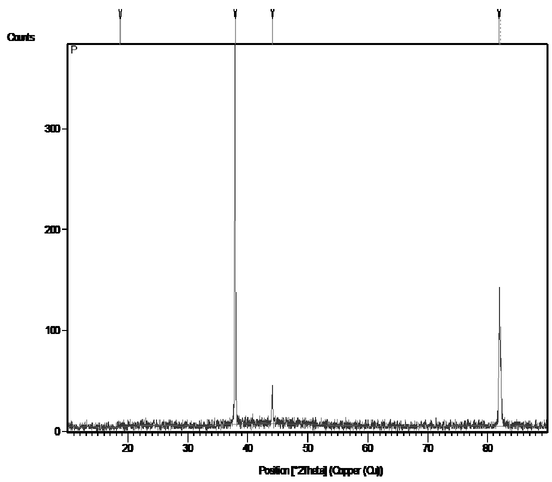

Fig. 5 Palmyra XRD Analysis

9. SEM Analysis

Scanning electron microscopy (SEM) is a method for high resolution surface imaging. The SEM uses an electron beam for surface imaging.SEM analysis was carried out to see the effect of the quality of adhesion between the Lignite Fly ash , Fibers and the matrix, because the biological attack on internal and external composite structures such as Lignite Fly ash , Fibers and matrix were major factors that contribute to the mechanical characteristic of the composite.

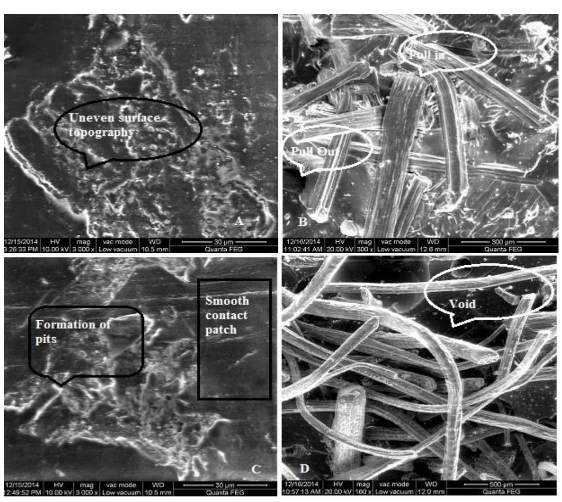

Fig. 6 Palmyra SEM Image

Compression moulding compounds can be made from unsaturated polyester resin as matrix material filled with Lignite Fly ash and Fibers. Scanning electron microscopic studies showed that agglomerated spherical particles of the as synthesized polymer composite with the amorphous morphology and thus has a better reinforcing and good adhesion between the reinforcements and the matrix. The surface represents a typical polyester surface and also the SEM images show that pull in and pull out of the fibers. The void will form over the rupture surface.

10. Conclusion

a) The hybrid composite with some percentage of LFA and fiber has been fabricated and the mechanical properties were studied. From the results of various tests it is observed that the tensile strength increases with increase in water absorption in the specimen.
b) The compression strength decreases with the increase in the water absorption in specimen.
c) The bending strength increases with the increase in the water absorption in specimen.
d) The hardness decreases with the increase in the water absorption in specimen.
e) Based on the application we can select the composite with their mechanical properties. Thus the mechanical properties of LFA filled fiber reinforced composite is studied successfully.

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