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RESEARCH ARTICLE OPEN ACCESS

Investigation of Mechanical Properties of Hemp Fiber Reinforced Polyester Composite

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ABSTRACT
The abundant availability and accessibility of natural fibers are the major reasons for an emerging new interest in sustainable technology. Natural fibers, asreinforcement, have recently attracted the attention of researchers because of their advantages over other established materials. They are environmentally-friendly, fully biodegradable, abundantly available, nontoxic, non-abrasive, renewable, and cheap, and have low density. Natural fibers have recently become more attractive to researchers, engineers and scientists as an alternative reinforcement for fiber reinforced polymer composites. The tensile properties of natural fiber reinforced polymers (both) are mainly influenced by the interfacial adhesion between the matrix and the fibers. Further the mechanical properties can be improved with several chemical modifications on the composites. The present work, natural fiber (sisal, hemp and combination) reinforced polyester resin composites were produced and are tested for mechanical properties and further compared with the normal plastics. The mechanical properties of sisal and hemp reinforced polyester resin composites were found to increase with increasing fiber weight fraction. The compressive and flexural properties of hemp fiber reinforced concretes (FRC) were examined in this research. The main factors affecting compressive and flexural properties of the FRC materials were evaluated with an orthogonal test design. Fiber content by weight has the largest effect. The method for casting hemp FRC has been optimized. Under the optimum conditions, compressive strength increased by 4 %, flexural strength increased by 9 %, flexural toughness increased by 144 %, and flexural toughness index increased by 214 %.

KEY WORDS: Natural Fiber, Sisal, Hemp ,FRC, Mechanical properties

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I. INTRODUCTION:

Now a day scientist much concentrated on nature friendly materials. Based on it, they have been doing so many researches. This materials does not do any harm our life's and another living organisms. The Selection of a material is not only satisfies industrial requirements. But also this nature, a modern material urgently required for us. Composite materials with natural fiber reinforcement full fill our requirement. Because this natural fiber based composites is growing rapidly both in terms of their industrial applications and fundamental research.New applications of Fiber-Reinforced Polymer Composites (FRPCs) are rising in non-traditional sectors, like civil infrastructure, infrastructure, automobile field, and power distribution. Composite materials make two (or) more various type of portions bonded to form a new material. In these portions, one portion is matrix and another one is reinforcement. One portion is bonded to another one.

Composites are materials consisting of two or more chemically distinct constituents, on a macro-scale, having a distinct interface separating them. One or more discontinuous phases are bonded in a continuous phase to form a composite. The continuous phase is usually weaker than the discontinuous phase. The discontinuous phase is called reinforcement. The continuous phase is termed as the matrix. The Matrix are several types like metallic, ceramic, polymeric. If the matrix is polymer is called as polymer matrix composite.

The present research work is study the reinforcement potential of hemp fibers in polymer composites.

Hemp is old building material use in non-conventional construction field. Hemp is fast-growing and renewable resource. Easily available and cheap. Moreover, it has the advantages of straight grain, beautiful color, high strength and toughness, and excellent abrasion resistance. Based on the mechanical properties, appropriate for composite products should be considered based on their strength to weight ratio. As a result, hemp has a low strength to weight ratio, it is desirable for some applications. Hemp composites have similar properties to wood composites. Then, hemp-based composites alternative to wood-based composites and will become an important forest based product in the future. In general, hemp is stronger than wood in bending strength, compression strength, and parallel to grain and is similar in shear strength parallel to grain. The strength of hemp in grain direction is extremely high. Due to the thick wall and long Culm, hemp can be processed into many forms of particles, such as flour, fibers, flakes, chips, excelsior, strips, strands and veneer. Moreover, hemp has a long straight grain which can compensate the potential shortcoming.

Fly ash waste of power generated plants. It is coming from coal burning at time of stem generation. As the utilization of power is increasing day by day the solid waste is also increasing. There is a direct result of huge quantities of fly ash, about 80-90 million tonnes in India. Many amount of ash is coming from power plants at time of steam generation at least some amount is used for natural fiber making. Several reach all done on jute reinforcing composite. Now a day's show much attention on natural reinforced composite because environmental protection.

II. IDENTIFICATION OF HEMP FIBER:

Hemp (cannabis sativa L)) is one of the most important cereal crops in the world and is one of the four major food grains of many countries . It is a staple food for millions of poor rural people in Asian and African countries. Besides being a major source of staple food for human beings, it also serves as an important source of fodder, animal feed and industrial raw material. Hemp is grown in semi-arid climate where other crops do not stand well. The crop withstand in drought condition. The origin of cannabis sativa L is generally believed to be around the present day Philippines.

Fig 1: Hemp plant

2.1 Retting and manual extraction method

In this method, the culms of Hemp plants were cut at their base and the leaves at the nodes and end of the culms were trimmed. After trimming, the culms were dried in shade for a period of one week. The node portions were removed by cutting, and the culms were separated into pieces of 160 mm length. The short culms separated are composed of exodermises (bark), vascular bundle sheaths, soft tissue cells and endodermis (inner surface layers). The hollow cylindrical portion of culms was taken for extracting fiber and made into four strips peeling them in longitudinal direction. These strips were soaked in water for a period of about 10 days. After this process the strips were subjected to a mechanical process, by beating them gently with a plastic mallet in order to loosen and separate the fiber. The resulting fiber bundle was scrapped with sharp knife and combed until individual fibers were obtained. The hemp fiber (MTU 2036) is widely found in local fields. The hemp fibers were extracted from the stem of the hemp plants. Hemp plants are cleaned and dried under sun for two days to remove moisture content. Further, the fibers were kept in oven for 6 hours at 70^0 C to ensure that maximum moisture was removed.

Fig 2: Hemp fibers

III. FABRICATION OF COMPOSITES:

3.1 TENSILE TESTING SPECIMENS:

The standard test method for tensile properties and flexural properties of fiber-resin composites, ASTM-D638M-89 is used to prepare specimens as per the dimensions. The test specimen has a constant cross section with tabs bonded at the ends.

The mould is prepared on smooth ceramic tile with rubber shoe sole to the required dimension. Initially the ceramic tile is cleaned with shellac (NC thinner) a spirituous product to ensure clean surface on the tile. Then mould is prepared keeping the rubber sole on the tile. The gap between the rubber and the tile is filled with mansion hygienic wax. A thin coating of PVA (polyvinyl alcohol) is applied on the contact surface of specimen, using a brush. The resulting mould is cured for 24 hours.

Hand layup method is adopted to fill the prepared mould with general purpose polyester resin of ECMALON 4413 grade, supplied by ECMAS RESINS PVT. LTD. Hyderabad, as matrix and various fibers as reinforcement. ECMALON 4413 is an unsaturated polyester resin of ortho-pathalic acid grade with clear colourless or pale yellow colour. Its viscosity is 500-600 CPS (Brookfield Viscometer) and specific gravity is 1.13 grams/c.c. at 250 C. Acid Number (mg KOH/g) is 22 and monomer content is 35%. Cobalt accelerator and MEKP catalyst are added for curing the resin at room conditions. The quantity of each of these materials, added is 1.5% of the volume of resin. The gel time is found to be about 25 min. The accelerator is mixed thoroughly with the resin and the catalyst is added later to avoid explosion. A thin coating of the resin is applied to the mould surface and known weight of the fiber is placed along the longitudinal direction of the specimen so that the fibers are oriented 00 along the axial direction of the specimen. Then the rest of the mould is filled with the resin making sure that there are no air gaps in the mould. Then, a thin Polyethylene paper of 0.2mm thick is placed on the rubber mould. A flat mild steel plate is placed on the mould and left for 24 hours to cure. Later the specimen is removed and machined to obtain the final dimensions (160mm*25mm*3mm). The specimen is cleaned with NC thinner and wiped off to remove dirt particles. The ends of both flat sides of the specimen are roughened enough using a sandpaper, so as to bond the end tabs.

Fig 3: Die for making tensile testing specimens

3.2 IMPACT TESTING SPECIMENS:

The standard test method for impact properties of fiber–resin composites,ASTM-D256-97 is used to prepare the specimens as per the dimensions. Unidirectional composites were prepared, using polymer matrix to access the reinforcing capacity of natural fibre. ECMALON 4411 is an unsaturated polyester resin of ortho-pathalic acid grade with clear colourless or pale yellow colour. Its viscosity is 500-600 CPS (Brookfield viscometer) specific gravity is 1.13 grams/.c.c , at 250 C .

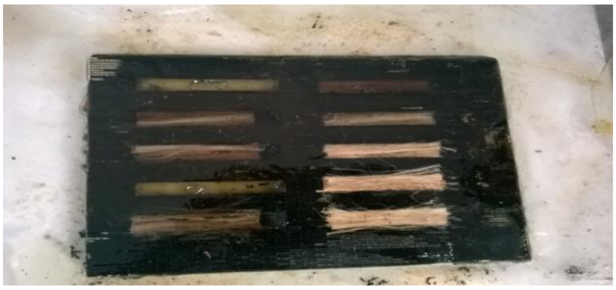

Fig 4: Die for making impact testing specimens

3.3 BENDING TESTING SPECIMENS:

The standard test method for tensile properties and flexural properties of fiber-resin composites, ASTM-D638M-89 is used to prepare specimens as per the dimensions. The test specimen has a constant cross section with tabs bonded at the ends.

The mould is prepared on smooth ceramic tile with rubber shoe sole to the required dimension. Initially the ceramic tile is cleaned with shellac (NC thinner) a spirituous product to ensure clean surface on the tile. Then mould is prepared keeping the rubber sole on the tile. The gap between the rubber and the tile is filled with mansion hygienic wax. A thin coating of PVA (polyvinyl alcohol) is applied on the contact surface of specimen, using a brush. The resulting mould is cured for 24 hours.

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24 hours to cure. Later the specimen is removed and machined to obtain the final dimensions (160mm*25mm*3mm). The specimen is cleaned with NC thinner and wiped off to remove dirt particles. The ends of both flat sides of the specimen are roughened enough using a sandpaper, so as to bond the end tabs.

Fig 5: Die for making bending/flexural testing specimens

IV. MANUFACTURING PROCESSES AND CLASICAL TESTING METHODS

The following section will describe about manufacturing process and experimental procedure
1. Specimen making
By Hand Lay-Up fabrication process
Cutting the fibers based on ASTM standards.
2. Tensile test.
3. Bending test.
4. Impact test.

4.1RAW MATERIALS

Raw materials used in experiments are:
1. Natural fiber.
Hemp
2. Polyester resin
3. NaOH

4.2 HEMP FIBRE:

Hemp fiber is length is high, smooth, shiny plant. It is available from plants cannabis sativa l.
Hemp is one of the low cost natural fibers.
Hemp fiber contains cellulose and lignin.
Hemp fiber is biodegradable and flexible for processing.
Hemp fiber has desirable low density relatively good tensile and flexural modulus.
Hemp fibers have higher strength to weight ratios than steel.

4.3 POLYMER: POLYESTER RESIN:

The polyester resin unsaturated type grade ECMALON was purchase from Ecmass Resins (Pvt.) Ltd., Hyderabad, India. The resin has 1258 kg/m3 density, it has viscosity at 25degrees 500 centipoises and monomer content is 35%. And all so contain accelerator (Cobalt Naphthate) and catalyst (Methyl Ethyl Ketone Peroxide) MEKP.

4.4Properties of polymers

Excellent adhesion to different materials
Great strength, toughness resistance
Excellent resistance to moisture contact and resistance to chemical attack
Excellent mechanical properties and electrical properties.
Odorless, do not have any taste and non toxic.
Negligible shrinkage.

V. TESTING OF THECOMPOSITES:

5.1 Tensile Test:

This type of test (tensile strength) is performed on the flat specimens. The specimens (unidirectional composite) are making based on ASTM D 638-89 standards to measure the tensile properties of our composite. The dimensions of the specimens were 160mm (length) 12.5mm (width) 3mm (thickness). The maximum tensile strength is find-out before ultimate point. Ultimate point means wherever the material is breaking. The generally use specimen for tensile test is the dog-bone type. At the time of the test a uniaxial load is applied to two ends of the specimen. Four samples are preparing with different fiber combinations and all so different volume fraction and all the specimens are test by electronic tensometer.

5.2 Impact Test:

The specimens are preparing for impact test accordance to the ASTM D256-88 to measuring impact strength. The specimens dimensions are 63.5(length)*12.7 mm (deep)* 10 mm (wide). Low velocity instrumented is use impact tests are performed on the composite specimens. The composite specimen v notch placed at the testing peace. The impact testing machine having pendulum strikes the required piece at the point v notch with pendulum hammer, measuring the Spending energy of different pieces are noted by dial indicator.

5.3 Flexural (bending) Test:

The fabricated specimens were tested using a 2 ton capacity - Electronic Tensometer, METM 2000 ERI model, with a cross head speed of 2 mm/min in accordance with standard ASTM D790 under ambient conditions. The schematic

representation of load application is as shown in Figure . Load and elongation values are determined for the all samples.
Utilizing the experimental values of load and elongation, flexural strength (fs), flexural modulus and elongation at break were determined.

5.4 SPECIMENS AFTER TESTING:

The mechanical testing of composites structures is requires to obtained parameters such as strength and stiffness is a time consuming and often difficult process. The data obtained from these can then be directly related with varying degrees of simplicity and accuracy to any structural shape. The test methods outlined in this section merely represent a small selection available to the composites scientist.

5.5 Tensile Testing

Tensile testing method utilizes the classical coupon test geometry is shown in the figure. It consists of central region called the gauge length, within which failure is expected to occur and the two end regions which are clamped into a grip mechanism connected to a test machine. These ends are usually tabbed with a material such as aluminum, to protect the specimen form being crushed by the grips. This test specimen can be used for longitudinal, transverse, cross ply and angle ply testing. It is a good idea to polish the specimen sides to remove surface flaws especially for transverse tests.

Fig 6: Specimens of Hemp fiber polyester composite after tensile testing

5.5 Impact testing:

Impact test measures the energy required to bend the impact testing conditions Natural fibers from the hemp stalk is extremely durable and can be used in the production of textiles, clothing, canvas, rope, cordage, archival grade paper, paper, and construction materials.

Fig 7: Specimens of Hemp fiber polyester composite after impact testing

5.6 Flexural testing:

The flexural test measures the force required to bend a beam under three point loading conditions. the data is often used for select the materials for parts that will be support loads without flexing is shown in the below figure. Flexural modulus is used as an indication of a material's stiffness. Since the physical properties of many materials (especially thermoplastics) can vary depending upon the temperature, it is sometimes appropriate to test materials at temperatures that simulate the intended end use environment. It is a good idea to polish the specimen.

Fig 8 : Specimens of Hemp fiber polyester composite after flexural testing

VI. COMPARISON OF WITH AND WITHOUT NaOH TREATED COMPOSITES

6.1TENSILE PROPERTIES OF HEMP FIBER COMPOSITES:

Table-1: Effect of volume of fiber on Mean tensile strength of with and without NaOH treatment.

S. No	Weight of fiber (grams)	Volume of fiber (%)	Tensile strength without NaOH (Mpa)	Tensile strength with NaOH (Mpa)
1	0.5	04	32..533	68.53
2	1.0	10	88.533	95.2
3	1.5	14	91.73	149.33
4	2.0	18	109.86	161.33

Table-2: Effect of volume of fiber on Mean Tensile modulus of with and without NaOH treatment.

S.No	Weight of fiber (grams)	Volume of fiber (%)	Mean tensile modulus without NaOH (Gpa)	Mean tensile modulus with NaOH (Gpa)
1	0.5	05	2.32	3.0
2	1.0	10	2.9	2.9
3	1.5	15	3.4	3.5
4	2.0	19	4.2	4.8

Table-3: Effect of volume of fiber on specific tensile strength of with and without NaOH treatment.

Sl. No	Weight of fiber (grams)	Volume of fiber (%)	Mean specific tensile strength without NaOH Mpa/(kg/m^3)	Mean specific tensile strength with NaOH Mpa/(kg/m^3)
1	0.5	4	0.030	0.037
2	1.0	10	0.056	0.059
3	1.5	14	0.065	0.081
4	2.0	18	0.080	0.086

6.2 IMPACT PROPERTIES OF HEMP FIBER COMPOSITES:

Table-4: Effect of volume of fiber on impact strength of with and without NaOH treatment of hemp fiber/polyester composites.

Sl. No	Weight of fiber (grams)	Volume of fiber (%)	Mean impact strength without NaOH (Joules/mm)	Mean impact strength with NaOH (Joules/mm)
1	0.5	05	0.05	0.1
2	1.0	10	0.19	0.22
3	1.5	14	0.28	0.48
4	2.0	20	0.4	0.6

6.3 FLEXURAL PROPERTIES OF HEMP FIBER COMPOSITES:

Table-5: Effect of volume of fiber on Mean flexural strength of with and without NaOH treatment of hemp fiber/polyester composites.

Sl. No	Weight of fiber (grams)	Volume of fiber (%)	Mean flexural strength without NaOH (Mpa)	Mean flexural strength with NaOH (Mpa)
1	0.5	4	125	175.09
2	1.0	09	158.33	200.00
3	1.5	13	191.66	216.67
4	2.0	18	233.33	275.00

Table-6: Effect of volume of fiber on specific flexural strength of with and without NaOH treatment of hemp fiber/polyester composites.

Sl.No	Weight of fiber (grams)	Volume of fiber (%)	Mean specific flexural strength without NaOH Mpa/(kg/m^3)	Mean flexural strength with NaOH Mpa/(kg/m^3)
1	0.5	5	0.080	0.120
2	1.0	11	0.155	0.180
3	1.5	14	0.185	0.200
4	2.0	19	0.200	0.210

7. GRAPH REPRESENTATION OF WITH AND WITH OUT NaOH TREATED COMPOSITES:

7.1 TENSILE PROPERTIES OF HEMP FIBER COMPOSITES :

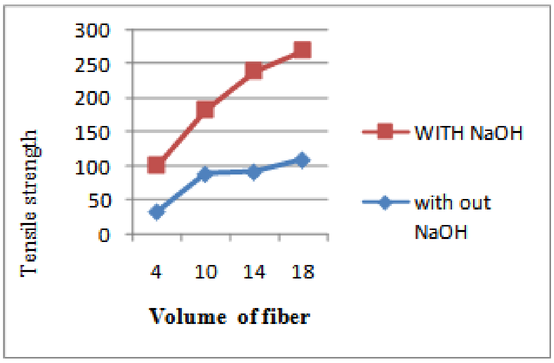

Fig 9: Effect of volume of fiber on Mean tensile strength of with and without NaOH treatment of hemp fiber/epoxy composites.

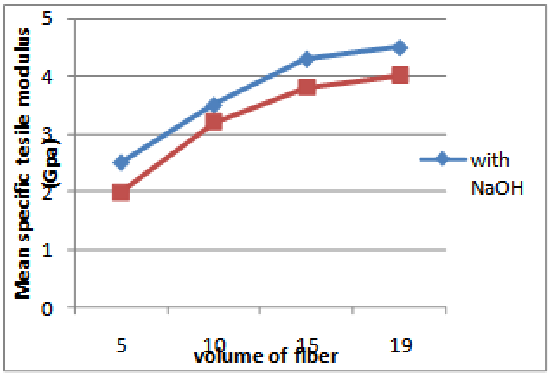

Fig 10: Effect of volume of fiber on Mean specific tensile modulus of with and without NaOH treatment of hemp fiber/polyester composites

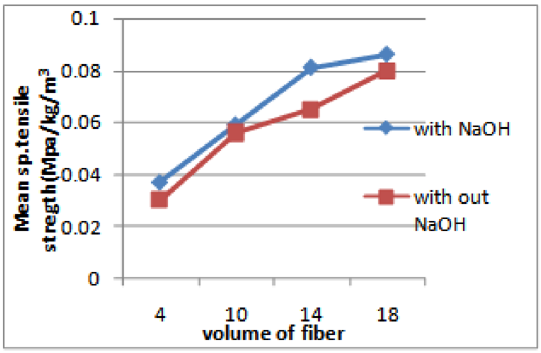

Fig 11: Effect of volume of fiber on specific tensile strength of with and without NaOH treatment of hemp fiber/polyester composites.

7.2 IMPACT PROPERTIES OF HEMP FIBER COMPOSITES

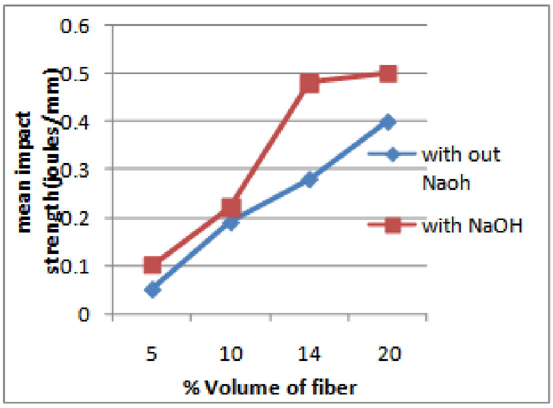

Fig 12: Effect of volume of fiber on impact strength of with and without NaOH treatment of hemp fiber/polyester composites

7.3 FLEXURAL PROPERTIES OF HEMP FIBER COMPOSITES:

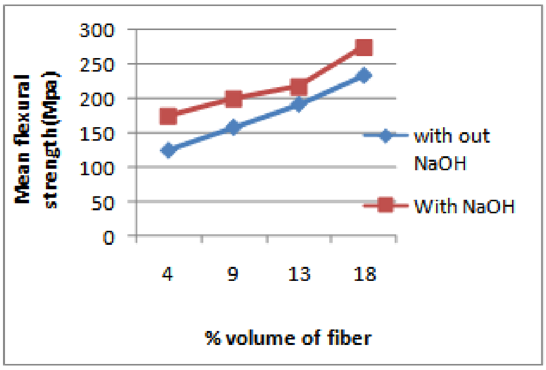

Fig 13: Effect of volume of fiber on Mean flexural strength of with and without NaOH treatment of hemp fiber/polyester composites.

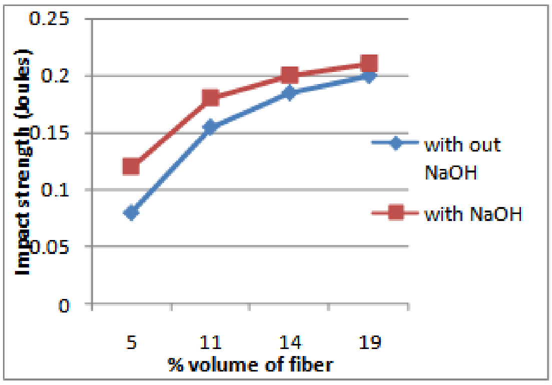

Fig 19: Effect of volume of fiber on specific flexural strength of with and without NaOH treatment of hemp fiber/polyester composites.

VII. CONCLUSION

In the present work composites samples are by hemp fiber and polyester resin and fiber is chemically treated for properties. Initially the fiber is extracted by means of retting process and after extraction of fiber the fiber is treated with the chemicals of NasOH and $kmno_{4.}$ And the specimens are prepared as per ASTM standard D790 and the specimens are the tested on the electronic tensometer for evaluation of results from values obtained from the electronic tensometer the tensile, impact and flexural properties are determined by using the formulae.

Finally the tensile, impact and flexural properties are evaluated and compared between untreated and chemically treated reinforced composites in the paper. By the treatment of fiber with NaOH solution the flexural properties are improved compared to the permanganate treated and unread fiber reinforced composite with the increase in the concentration of NaOH there is decrease in the properties because during the treatment at higher NaOH there is excess extraction of hemi cellulous and lignin from the fiber thus finally it causes the damage to the cell walls

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