Mechanical characterization of hemp fiber reinforced polyester composites

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***Abstract*-The natural fibers are bio-cellulose form of cells of plant and animal skin. The natural fibers are plentiful in quantity. They possess low mass, good strength and other capabilities. The use of those fibers leads to green environment rather than harming the environment, is biodegradable in nature and renewable source of energy. The paper suggests different types of natural fiber which can be used as composites and among them, using hemp fiber composite and recognizing the mechanical characteristics of it. The paper investigates the composites form which is formed using the natural fiber hemp and polyester resin varying their proportion and obtaining its mechanical and other properties. The composites composition which leads to high mechanical properties are proposed to be used in many application and also replacement to glass fiber products.**

***Keywords*- Natural fibers, hemp and its properties, composite form, mechanical characterization**.

I: INTRODUCTION

The natural fibers are part of mother earth. They are biodegradable in nature and harmless to environment. The use of natural fiber gives us sustainable development regarding renewable source of energy. Natural fibers are now influencing the automobile and other industries by its good mechanical properties replacing the conventional plastics used in old times [1]. U.S.Bongarde et al. [2] proposes that Natural fibers come from different plants, animal skin and other organic materials. These fibers have strings form in nature. Natural fibers are eco-friendly, light in mass, good mechanical strengths, renewable form, economical and biodegradable in natures. Drzal Lawrence et al.[3] researches different natural fibers include hemp, bamboo, husk, coir, sisal, jute, kenaf, flax, and many others when bind to any type of resin, get composites form of natural fiber composite shows good mechanical properties. Vasanta V Cholachagudda et al. [4] classifies the use of coir and rice husk with epoxy resin to form a composites which is safe and economically available material can be used for day to day life. Jochen Gassan [5] researches the different natural fiber reinforce plastics mainly made of jute yarns and woven with epoxy resin to form composites regarding getting increasing mechanical properties with increase in critical load and failure load when subjected to tension-tension fatigue behavior. N.V. Rachchh et al. [6] researches that by changing the rattan fiber percentage with polyester resin there is change in composite mechanical properties and suggest the proportion up till fiber is unable to bind up with resin. Thingujam Jackson Singh et al. [7] concludes that the bamboo and sisal fiber composites which have strong properties and are lasting in nature and also have potential to replace the conventional materials used in other applications. David Plackettet al. [8] concludes the composites formed from PLA and jute polymer is gives double strength at its bind able proportions. Paul Wambuaet al. [9] researched and suggested the mechanical properties of natural fiber composites and the natural fiber having good potential of replacing glass fiber in many applications. S.V. Joshi et al. [10] concluded that the upcoming potential of natural fiber composites in market appears high because they are cheaper, lighter and environmentally degradable than of glass fiber composites in general. And also suggest of future research in field of NRP for achieving equivalent or superior technical performance and component life.GIRISHA K G et al. [11] researches the mechanical properties like impact strength, tensile strength and flexural strength of fibers which are bind up with resin in different orientation of fiber gives different results and highest in 90 degrees of orientation of fiber. K. P. Ashik et al. [13] suggests that comparing natural fiber and glass fiber reinforced composites; the natural fibers were superior in industrial application. Moreover, due to the usage of natural fibers in different engineering application and construction industries.

II: BACKGROUND

Over many decades the use of composites plastic have been an innovation in industries. The potential of those plastics composites are gaining acceptance in many fields of engineering. The green and sustainable revolution is taking place.

The composites have properties like low mass and thus are good to be the economically viable materials. Also the effort of producing economical and good appearance composites components tends to mark on the innovation in manufacturing.

The use of composites material are outstanding in the modern era. The glass fiber and natural fiber are replacing the conventional materials now a days.

III: MATERIALS AND METHODS

This chapter describes the details of processing of the composites and the Experimental procedures followed for their Mechanical properties Evaluation. The raw materials used in this work are

1. Hemp fiber
2. Polyester resin

A. Material preparation

The development of composites begins with the hemp fiber which is first to be cleaned from roots to strands form of hemp. The hemp is then cleaned to fiber strands form. These fiber strands are now ready to use in composite development. After the hemp was cleaned the fiber were sectioned in 50 mm pieces. Thus the orientation remains same and isentropicity of plate is gained. The polyester resin is been mixed with other chemicals such MEKP (methyl ethyl ketone peroxide) and cobalt and which are hardener and catalyst.

The proportion of mixture: 930 grams of resin + 10 ml of cobalt + 10 ml of MEKP. This leads to heating of resin naturally and thus can be used to form composites.

The Base plate is created of wood which supports and holds the composites until it gets solid. The dimensions of wooden base plate is (250 X 250 X 10) in mm. The aluminum foil will be used for restriction of resin and wood contact.

Composites would be prepared using hand lay-up method. The 50 mm strand would be kept along the plate with 90 degrees of orientation.

The aluminum foil would be first covered with resin and then Hemp fiber. The process will last up to require thickness is not attained of 10mm. Then it would be kept for solidifying. There would be 6 plates of varying fiber-resin proportion. [6]. The plastic sheet is used for providing surface and lining between wooden base and composite plate, the plastic sheet was coated with petroleum jelly so it can be easily removed from composites. The proportions of composites are [6]

Sr.	Fiber (%)	Resin (%)
1	5	95
2	7.5	92.5
3	10	90
4	12.5	87.5
5	15	85
6	17.5	82.5

Table-1

IV: COMPOSITE DEVELOPING

1. Composite preparation

A wooden mold of dimension (250×250×10) mm^3 is used for base of developing composites sheet. Here, six composite plates were developed with different material composition ratio. In first composition as above table suggest 5% fiber and 95% polyester resin including hardener and catalyst were thoroughly mixed with gentle stirring manually. And after that, different plates were developed containing 7.5%, 10%, 12.5%, 15%, and 17.5% respectively. Then by using hand layup technique, first layer of homogenous mixture of resin was spread on a thin plastic sheet with petroleum jelly lining. Above that chopped hemp fibers are arranged and then solution is poured and so on. This procedure has been done up to getting the required thickness which was up to 10 mm

To avoid formation of air bubbles hand fixation was used and then after pressure was applied from the top and the base plate and was allowed to settle at room temperature for 10 hours. This procedure was carried out for preparation of composites plates. After 10 hours the plates were taken out of the mold, cut into different sizes for further experimentation and testing.

There are the six different material compositions according to the percentage of weight fraction which were tested different tests like Barcol hardness report, flexural properties at maximum force, tensile properties at maximum force, compressive properties, density report.

2. Experimental procedure

❖ ***Sample cutting for testing***

The composites were sampled from the plate according to reference standard. For barcol hardness test, the composites were sampled according to ASTM D-2583. The flexural and tensile properties composites were sampled according to ASTM D-790-10 and ASTM D-638 respectively. For density measurement, composites were sampled according to ASTM-792.

❖ ***Procedure for density testing***

In this test, composite were sampled according to reference standard and then density setup was used. First, sample was put on the water which gave the density of sample in air. After that the samples was kept in water for density of sample in water. At last it resulted in combined density of sample in both air and water.

❖ ***Procedure for flexural properties at maximum force***

Flexural properties were measured with the help of universal testing machine. In UTM, the samples were mounted on the flexural attachment. It was kept lower side of the UTM. Then load was applied on the sample until it get fractured.

❖ ***Procedure for tensile properties at maximum force***

Tensile properties measured with the help of universal testing machine. In UTM, the samples were mounted on the tensile attachment. It was kept upper side of the UTM. Then load was applied on the sample giving tension to sample. Due to tension, it was fractured.

❖ ***Procedure for Barcol hardness testing***

In this test, Barcol hardness meter was used to measure the hardness of plate. The pointer of BHU was placed on different location of plates. Five reading of the hardness per plate noted and average was taken.

❖ ***Procedure for Compressive testing***

In this testing, CTM (Compressive testing machine) is used to measure the compressive stress of plate, First of all, samples were mounted on the CTM. Then after load was applied on the top surface of the plate up till it gets totally deformed and noted reading of compressive stress when samples were gone under failure.

V. RESULT AND DISCUSSION

the testing of composites results in below graphs.

1. Barcol Hardness properties of composites:

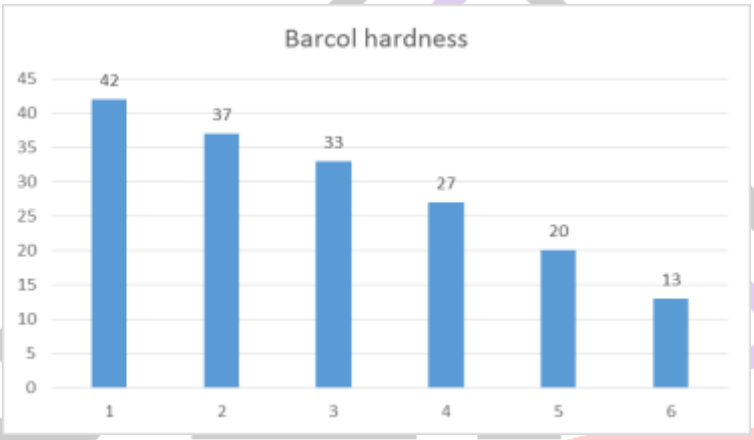
- The barcol hardness testing was done on six composites plate and the results are noted in form of table.

Sr.	Composite composition	Barcol hardness

Sr.	Composite composition	Flexural stress (KN)
1	5% fiber and 95% solution	42
2	7.5% fiber and 92.5% solution	37
1	5% fiber and 95% solution	76
2	7.5% fiber and 92.5% solution	108.2
3	10% fiber and 90% solution	126.76
4	12.5% fiber and 87.5% solution	119.33
5	15% fiber and 85% solution	101.45

Table-2

- As we can observe from above readings that the hardness deviates when the percentage of fiber is increased.
- The graph shows analysis of composite plates of barcol hardness v/s density.



Graph-1

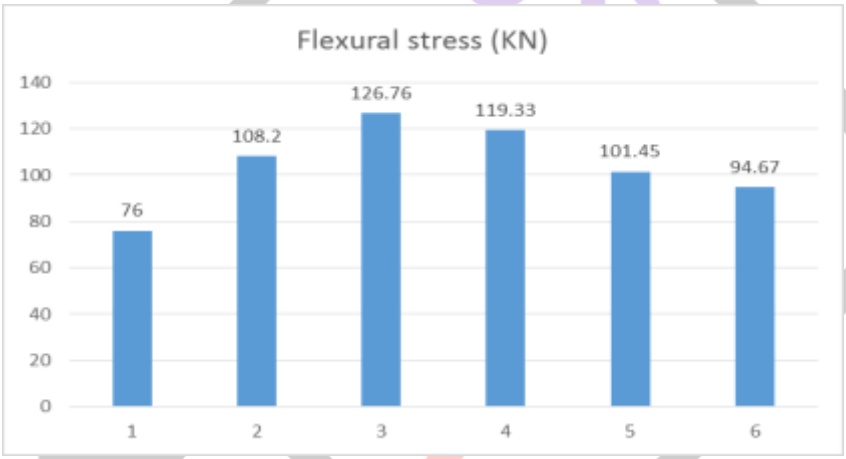
- As the density of composite increases with increase in fiber volume and decrease in resin volume the hardness of composites decreases as show in above chart

2. Flexural test:

6	17.5% fiber and 82.5% solution	94.67

Table-3

- The Flexural testing was done on six composites plate and the results are noted in form of table.
- The graph shows analysis of composite plates of Flexural Stress v/s Flexural strain.



Graph-2

- As from the above figure, it clearly analyze the data which lead to highest flexural strength of composite plate having composition of 10% fiber and 90% resin.

3. Tensile Strength at Maximum Force:

- The tensile testing was done on six composites plate and the results are noted in form of table.

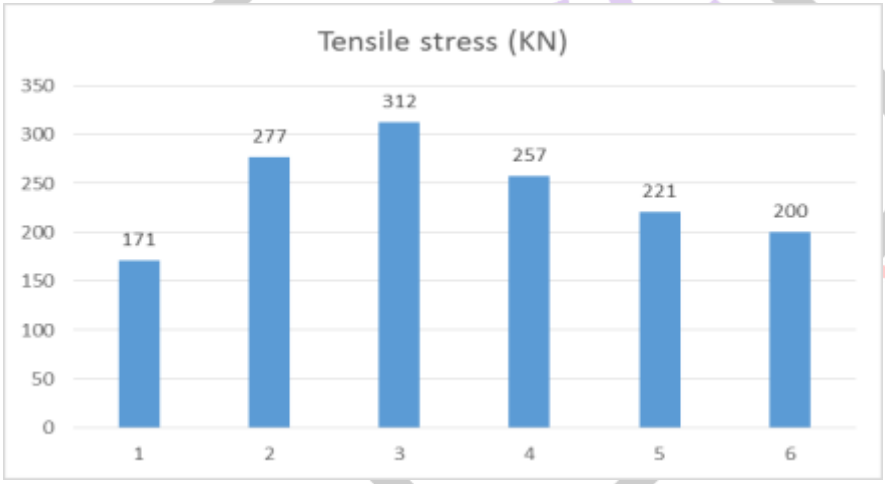
Sr.	Composite composition	Compressive stress (KN)

- The tensile strength was measured using UTM (universal testing machine)

Sr.	Composite composition	Tensile stress (KN)
1	5% fiber and 95% solution	171
2	7.5% fiber and 92.5% solution	277
3	10% fiber and 90% solution	312
4	12.5% fiber and 87.5% solution	257
5	15% fiber and 85% solution	221
6	17.5% fiber and 82.5% solution	200

Table-4

- As we can see the above table readings the tensile testing, the results up to 10% and 90% composition the reading is highest
- The graph shows analysis of composite plates of Tensile Stress v/s tensile strain.



Graph-3

- As from the above figure, it clearly analyze the data which lead to highest tensile strength of composite plate having composition of 10% fiber and 90% resin.

4. Compressive Strength at Maximum Force:

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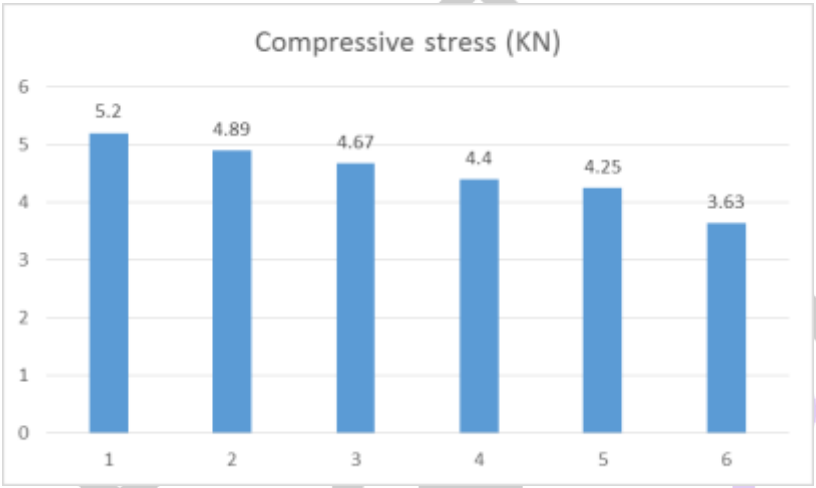
1	5% fiber and 95% solution	5.2
2	7.5% fiber and 92.5% solution	4.89
3	10% fiber and 90% solution	4.67
4	12.5% fiber and 87.5% solution	4.40
5	15% fiber and 85% solution	4.25
6	17.5% fiber and 82.5% solution	3.63

Table-4

- The graph shows analysis of composite plates of Compressive stress



Graph-4

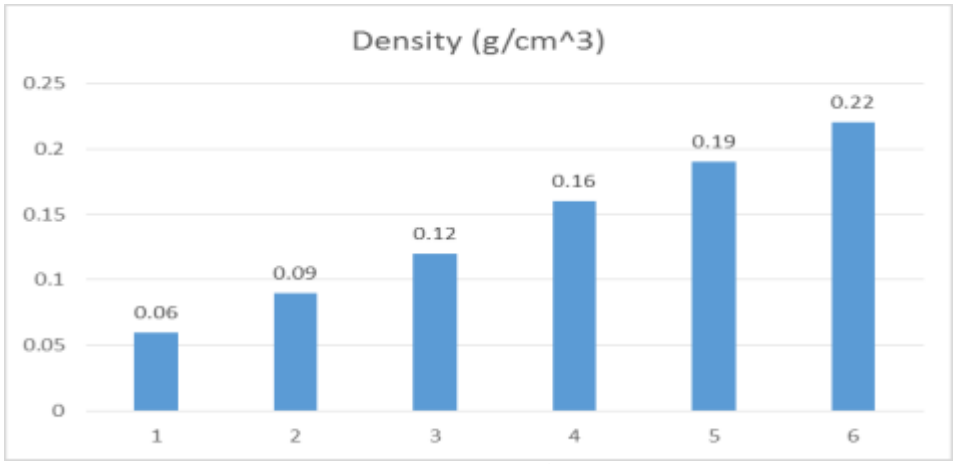
- As from the above figure, it clearly analyze the data which lead to highest Compressive strength of composite plate having composition of 10% fiber and 90% resin

5. Density measurement

Table-6

Sr.	**Composite composition**	**Density (g/cm^3)**
1	5% fiber and 95% solution	0.06
2	7.5% fiber and 92.5% solution	0.09
3	10% fiber and 90% solution	0.12
4	12.5% fiber and 87.5% solution	0.16
5	15% fiber and 85% solution	0.19
6	17.5% fiber and 82.5% solution	0.22

- The Density testing was done on six composites plate and the results are noted in form of table.



Graph -5

- As we can see that as fiber to resin ratio, when the percentage of fiber is increased we have increase in density of composite.
- But as the density increases results in decreases of hardness of plate as measured above
- Graph shows analysis of composite plates of Density module of composites.
- The increase in fiber percent gives higher density as analyzed by the graph

VI: CONCLUSION

This study involves mechanical characterisation of properties of hemp fiber polyester composites. Experimental and analytical observation of hemp fiber Polyester composites leads to following conclusions:

- The tensile strength of hemp fiber polyester composites improves by increasing fiber percentage initially up to 10% fiber and then decreases as fiber percentage is increased. Addition of fiber leads to slight decrement in tensile properties as load cannot be transferred from composited fiber to resin formation effectively. The best properties were found for composite containing 10% fiber and 90% resin solution.

- The compressive strength of composite improves by adding the fiber to it. So the prepared composite can be used for applications which demands high compressive strength like vibration damping and isolation base for machines and vehicles.

- As last, the natural fiber hemp polyester composites can lead to green manufacturing and can be used for sustainable green environment, which has strength to replace conventional materials.

VII: FUTURE SCOPE OF WORK

The future scope of this work is suggested to be very vast as it has different technique and procedure to follow

- The orientation of fiber can be kept at different degrees and the procedure can be followed
- Different fiber can be used in this technique
- Hand layup method can be replayed by sheet up or roll up method
- The buckling analysis can be done of the same composites using ANSYS.
- The uniformity testing can also be done on composites verifying the fiber-resin ratio is as up to mark

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