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Study of physical and mechanical properties for natural fiber composites under varying stacking sequence using natural rubber latex resin

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ABSTRACT

Hybrid composites of varying fibers stacking sequences are manufactured under hot compression moulding process using natural rubber latex resin. The study focus on the physical and mechanical properties of new hybrid composites under different stacking sequences using natural resin as binder. The properties of the different ply are compared with each other giving results on based on their interfacial bonding between the fibers and the resin. The fiber composites are tested for water absorption, tensile, flexural, Impact and hardness tests. The properties are found better than mono or single fiber laminates or with glass fiber reinforced composites. The fracture or breaking points are noted in order to identify the crack development and propagation. Natural rubber resin bonding is to be dried and heated at constant temperature in order to increase the interfacial bonding.

Keywords: Natural fiber, rubber, water absorption, tensile, flexural, impact, hardness

Introduction

Natural fiber composites plays a major role in structure and components development in the field of civil, mechanical and automotive applications because of their weighing, mechanical, recycle and eco-friendly characteristics. Natural fibers properties are considered in selection of materials in the recent product design and developments. These attractive properties and ease of manufacturing helps to develop various newer fiber matrix materials [1]. It is also found that the properties of hybrid composites improves and thus greater properties are achieved in using suitable polymer resins and fillers. The effects of fillers and their interfacial bonding helps in increasing the physical and mechanical properties of the composites. Some studies say that the use of rubber as resin or filler in manufacturing of natural fiber composites. In order to manufacture a lightweight anti slip interfacial boding composite material, natural rubber latex is selected a resin for hybrid composite material. The varying stacking sequences also improves the mechanical properties and bonding of resins with the fiber materials [2]. Hence, different hybrid natural fiber composites are being developed using natural and polymer resins and thus their physical and mechanical properties are studied.

Properties of the fibers.

The availability, physical and mechanical properties are considered in selection of natural fibers. The table shows the properties for the natural fibers that are adopted in the development based on their availability, stacking sequence and ease of manufacturing [2] [3].

Fiber	Density (g/cm^3)	Diameter (μm)	Length (mm)	Tensile Strength (MPa)	Young's Modulus (GPa)	Elongation at Break (%)	Moisture Content (%)	Specific gravity
Jute	1.23	5 - 20	0.8 - 6	185 - 773	20 - 55	1.5 – 3.1	12	1.5
Banana	1.35	12 - 30	0.4 – 0.9	530 - 915	25 - 32	5 - 6	11	1.35
Cotton	1.21	12 - 35	15 - 55	285 - 595	6 - 10	2 - 10	34	1.55

Table 1. Properties of natural fibers selected

Composite preparation

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The Composite samples of different compositions with different weight percentage of fibers were prepared. First, a sample of layers having jute, cotton, and banana are prepared. Then layer of banana, jute, cotton is prepared [2]. The hybrid composites are manufactured using compression mould making process [3]. The process is adopted to manufacture hybrid composites at varying stacking sequences with greater dimensional accuracy [2]. This method is also best opted for thermosetting resins and rubber resins. The natural rubber latex resin being used for the manufacturing of the composites, hence under high pressure and temperatures the composites gets cured. Latex is known for its tensile and elongation abilities, as well as tear resistance and overall Resilience, elasticity, tear properties, recovery, and waterproofing [4]. Most common abrasives will not affect. Natural rubber latex acts as an elastic band during cold weather, which helps prevent the formation of cracks while at the same time, retain asphalt stiffness. During hot weather, natural rubber acts as a film which improves shear resistance which subsequently prevents asphalt flow. The elastomer properties of natural rubber latex contribute significantly to improving long term pavement performance. Field latex, on the other hand, contains about 36% rubber, a small number of impurities and about 64% water. Field latex only can remain in liquid form for a maximum of up to three hours. There is a need to preserve latex as raw materials for natural rubber for long-term storage for future use in different applications.

Figure 1. Weighing of banana, cotton and jute fibers

The composite matrix is placed layer by layer after dipping in the rubber latex and placed inside the mould. The materials are arranged in the stack longitudinally and angularly being placed at angles of 0^{o} – 45^{o} – 0^{o}. The latex resin is filled in order to have a uniform distribution and compressed in the mould at a pressure of 3 bar and heated to a temperature of 60^{o}C [3] [4].

Figure 2. Mould, latex immersion and stacking of fibers

Similarly, all the composites of various sequences of ply are manufactured and being removed from the mould using the agent and cleaned for cutting processes [2]. The composites are then placed under the sun for natural drying. A uniform pressure is being applied on the surface of the composites and being cured for atleast 24 hours. Now the materials are taken for cutting and are being trimmed for the required dimensions for testing [5] [6].

Type	Ply sequence	Ply designation	Ply composition
Jute Reinforced Composite	J/B/C	C1	Jute fiber (60g) + banana fiber (70g) + cotton (50g)
Cotton Reinforced Composite	C/J/B	C2	Cotton (50g) + jute fiber (60g) + banana fiber (70g)
Banana Reinforced Composite	B/C/J	C3	Banana fiber (70g) + cotton (50g) + jute fiber (60g)

Table 2. Ply stacking sequence and composition

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Physical and mechanical testing of the composites.

Water absorption test

Water absorption increases with time of the composites being placed in the water for the given period of time [5] [7] [10] [11]. The composite specimens are made ready according to ASTM 570 and are immersed in water for a short period of 24 hours. Hence using mass difference the values are measured for the composites.

Composite	Initial mass of composites (gm)	Final mass of composites after immersion (gm)	Mass difference (gm)	Water absorption Percentage (%)
J/C/B	180	182	2	1.11
B/J/C	180	184	4	2.22
C/B/J	180	181	1	0.56

Table 3. Water absorption test

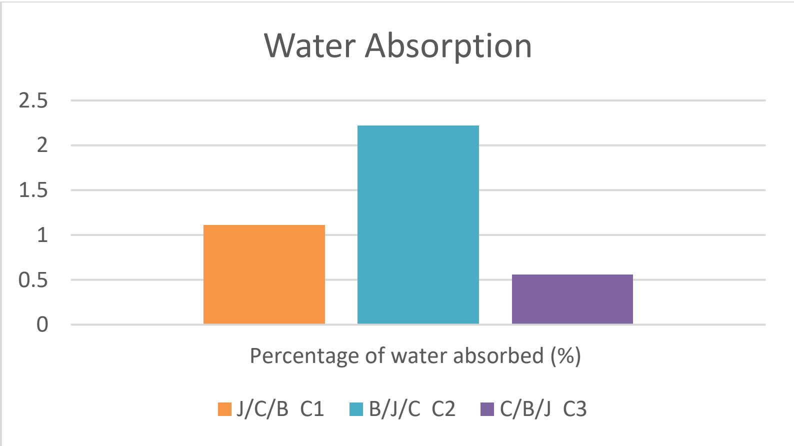

Figure 3. Percentage of water absorbed

Tensile testing of composites

The samples are cut for the dimensions as per the ASTM D 3039-76 for 40 mm length of three varying points. The composites are placed in the universal testing machine having a cross head speed of about 2 mm/min [8] [9] [12]. The tensile load is applied on the materials having uniform cross section area and break points are evaluated. The specimens are separated and are kept for future SEM tests to identify the fracture points and the development of crack. The elongation in break percentage is also evaluated by measuring the varying length at the various breaking points.

Figure 4. Tensile test

Composite	Ply designation	Tensile strength (MPa)	Elongation at break (%)
J/B/C	C1	272	2.6
C/J/B	C2	256	2.1
B/C/J	C3	264	2.3

Table 4. Tensile strength of composites

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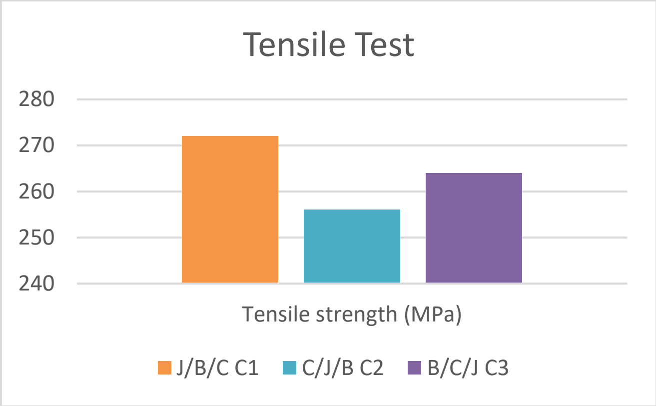

Figure 5. Tensile strength of composites

Flexural testing of composites

It determines the force required to bend the materials for the given application of load which helps in determining the stiffness of the material. The test is carried under ASTM D7264 of three-point loading at centre distance. The specimen is made to lie flat on the supporting span and load is applied at the centre, by the V-groove or the nose. Load is applied slowly and the composites are made to bend [8] [9] [12]. The point at which crack formation for the applied uniform load and the breaking is noted.

Figure 6. Flexural test

Composite	Ply designation	Flexural strength (MPa)
J/B/C	C1	155
C/J/B	C2	146.5
B/C/J	C3	151

Table 5. Flexural test

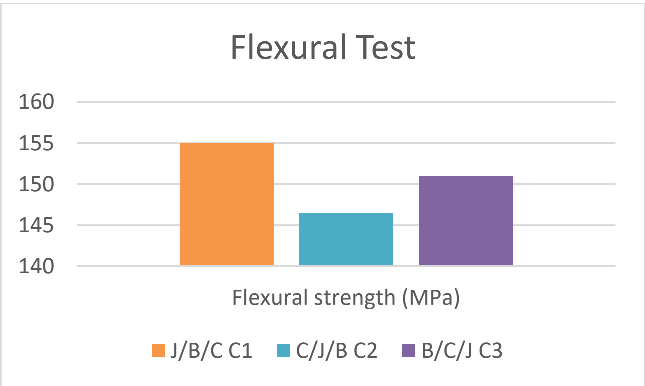

Figure 8. Flexural strength of composites

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Impact testing of composites

Impact test was carried out in order to find the amount of energy or shock carried or dissipated by the composite materials. IZOD test is carried for the specimens for the dimensions based on ASTM D6110 standards. The samples are mounted on the test bench and the impact load at low velocity is applied on the materials and thus the loss in energy or the strength absorbed is calculated [8] [9] [12].

Figure 9. Flexural test

Composite	Ply designation	Impact energy absorbed (Joules)	Impact strength (J/mm^2)
J/B/C	C1	155	5.16
C/J/B	C2	146.5	4.83
B/C/J	C3	151	5.03

Table 6. Impact strength of composites

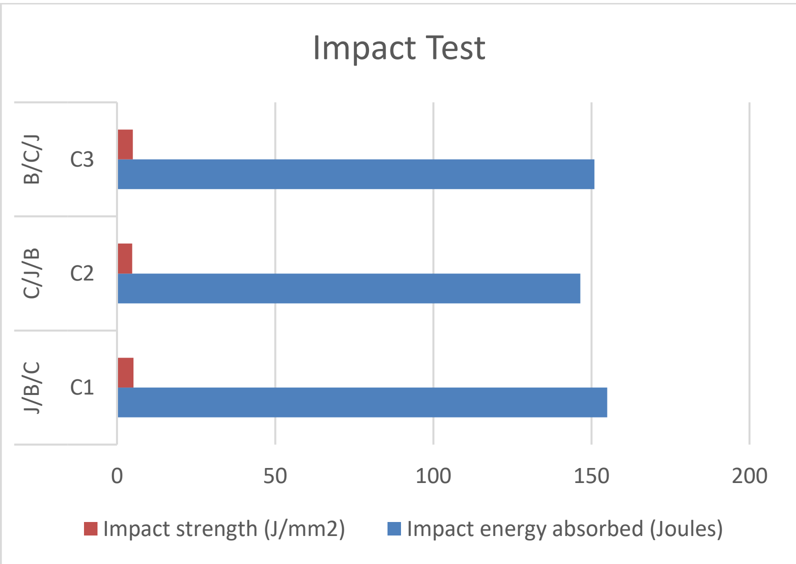

Figure 10. Impact strength of composites

Hardness testing of composites

Brinell hardness test is carried for the specimens in which predetermined loads are applied on the surface of the composite materials by mean sof carbide ball intenders for a fixed time and released gradually. The test forces can be varied from 500 N to 3000 N. an average of 1500 N is applied on the surfaces and indentations are noted and thus providing the hardness number [8] [9] [12].

Composite	Ply designation	Hardness number
J/B/C	C1	9.2
C/J/B	C2	6.8
B/C/J	C3	7.4

Table 7. Hardness test

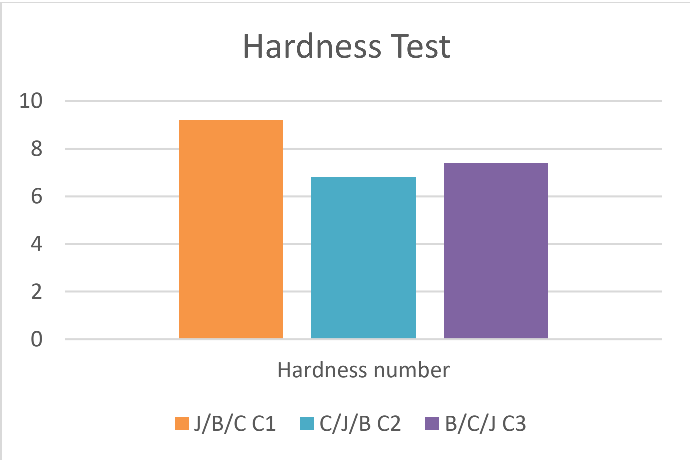

Figure 11. Hardness of composites

Results and Conclusions

Thus, the physical and the mechanical properties of hybrid natural fibers composites for the varying stacking sequence and the use of natural rubber latex was tested and studied. The studies concludes that the stacking sequence does not majorly affects the properties of the composites. The bonding of rubber with the natural fibers are not good in bonding or fillers. This affects the strength of the composites materials and thus can be applied as vibration absorber or of lightweight materials for automotive or railway assembly of components. The physical water absorption is higher for B/J/C stacked fiber composite due to lesser surface bonding between cotton and jute fibers with the filler material. The mechanical properties of hybrid composites are found greater than single laminated thermoset or thermoplastic composites. The above testing results shows the tensile, flexural, impact and hardness for J/B/C is higher when compared with other hybrid laminates. B/C/J composites are also found to be having better properties with other fiber composites. If the bonding of fillers and resins between fibers are good then the mechanical properties will be higher. Additives can also be added with latex and fillers so that the interfacial bonding of fibers can be improved.

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