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Mechanical Behaviour of Coir and Wood Dust Particulate Reinforced Hybrid Polymer Composites

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Abstract*: *Nowadays polymer composites are emerged material which is used for extensive variety of applications because of their exclusive and beautiful characters. They have high durability, high strength-to-weight ratio and abrasion resistance. In this study the mechanical characteristics of coir and wood dust particle reinforced polyester composites using hand layup process were analyzed. The prepared composites were characterized using Scanning Electron Microscope and also the mechanical behaviors such as tensile strength and flexural strength were estimated using computerized testing machine.

Keywords: Coir, wood dust, Tensile strength, Flexural Strength.

I. INTRODUCTION

Two or more physically or chemically distinct materials combined together to give a unique combination of properties, one of which is reinforcement and the other is matrix or binder which hold the reinforcement is called as composite materials [1]. Due to unique and attractive properties, these polymer materials are widely used to achieve the necessity for many designs in manufacturing products [7-9]. A fiber-reinforced polymer composite consists of various types of aluminum oxide; glass and carbon fibers and many other components are used as reinforcing components in traditional fiber-reinforced composites. Natural plant fibers like hemp, sisal, coir, henequen and bark have been used as fibers in composites in recent years. [2].

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Now a day's carbon and glass fibers are replaced by natural fibers like jute and sisal fibers because of their low cost and easy accessibility [3]. Recently, natural fibers have obtained extensive consideration for replacing the synthetic fiber from plastic industries. Natural plant fibers are progressively used as reinforcing element in thermoplastics because of their low thickness, reduced tool wear, good thermal and mechanical characters, low price, infinite availability, and eco-friendly disposal instead of conventional synthetic fibers like glass and aramid fibers [4]. Coir is multipurpose, renewable, low-priced, abundant and decomposable lignocellulosic fiber which is used for producing an extensive variety of engineering products (Satyanarayana et al., 1982). Coir fiber has also been tested as reinforcement in various composite materials [5]. When compared with synthetic fibers, the natural lignocellulosic materials are used all over the world. These fibers are renewable and propose better quality. [6].

Recently, the natural fibers have been getting significant concentration as a standby for chemically derived fiber. The benefits of the plant fibers are low thickness, low-priced, tolerable specific strength, reduced tool wear, decent thermal insulation behaviors, recycling, renewable resources without affecting the environment [10]. At the present time, the growing consideration is being paid to coir fiber. Nowadays the coir fibers are commercially used in natural rubber latex industries for manufacturing automobile interior parts [11]. In this literature the various uses and applications of coir fiber based polymer composites are labeled. The products like helmets post-boxes made by coir fiber reinforced polymer composites having 38MPa flexural strength up to 9 to 15 weight % of coir fiber loading [12]. The mechanical characters of coir reinforced polymer composites are increased when it is used along with some other fiber particles. Shiv Kumar, Dr.B.Kumar et al. have explored the mechanical behaviors of coir fiber and coconut shell particle reinforced epoxy composite. They have stated that ultimate strength and modulus of elasticity increase with addition of coir [14]. Addition of red mud up to a certain limit with coir strengthened polyester composites increases the flexural strength of the composites [15]. The composite treated woven coir- polyester exhibits superior mechanical properties [16]. The coir fiber based composite's flexural, tensile strength and the hardness value upgraded by increasing the fiber up to 60% of weight. [17]. The coir is a suitable fiber for manufacturing the thermoplastic composites, especially for partial replacement of expensive and heavier glass fibers [17].

Naturally wood is three-dimensional polymeric composite which is primarily consists of cellulose, lignin and hemicelluloses. In addition, the wood is a natural and original composite [18] Wood plastic composites (WPC) is a comparatively new kind of materials that covers a wide range of composite materials utilizing an organic resin binder (matrix) and reinforcement composed of cellulose materials. Through the literature survey, coir fiber has good mechanical properties when it is combined with other fibers, but there are no more studies are available on coir and wood dust particle reinforced polymer composite. This paper deals with the mechanical characters of coir and wood dust reinforced hybrid composites.

II. MATERIALS AND METHODS

A. Coir Fiber

Coir is granular elements, which are take out from coconut husk. After harvesting, the prepared coconuts are splitted, and the Coconut oil is extracted from the inner fruit. The fiber is extracted from the pith that covers the inner kernel. In this process the elements that are between the fibers were used usually to be plowed in clay soil to loosen up the soil. Recently, these coconut fiber dust particles have been processed and packed in various compressed forms sold as Coir.

Fig.1.Coir Pith Particles

B. Wood Dust

Teak wood dust particles were collected from Ajitha wood Furniture Mart, Azhagiamandapam, Kanyakumari Dist. During the machining of teak wood timbers for making different types of furnitures, huge amount of wood dust particles wasted to the environment and which are having more cellulose content for improving the mechanical properties. They were collected and used for making composite samples.

Fig.2. Teak wood dust Particles

C. Polyester Resin

The unsaturated isothalic polyester resin is used as the matrix which are prepared by the reaction of polyhydric alcohols and dibasic organic acids are having a relative density as 1.11-1.23 g/cm^3 and boiling range as 145-148^{o}C and the thermal deformation temperature is 50-60^{o}C. It has high strength of tensile, bending and compression.

D. Sample preparation using hand layup method

Sample fabrication using coir fiber particle and wood dust particle of sizes 600 microns reinforced with polyester resin was fabricated by using a square mold of volume 300x300x3 mm^3. At first, the mold-releasing agent (mansion Polish wax) was applied on its surface for polishing and to avoid the sticking of specimens in mold box. Afterwards, the polyester resin was prepared in the appropriate proportion. Cobalt naphthanate is used as the accelerator and it is added with the polyester resin with the ratio of 100:1 (100 ml resin x 1ml accelerator). Then the proper proportions of powder particles of coir and wood dust were added with polyester resin and stirred properly. Finally, 1% of Methyl ethyl ketone peroxide was added as catalyst with the polyester resin which is used for the sample preparation. The mixture of resin and fiber particle was poured in to the mold box, and then the mold box was closed, pressed by load at certain level and cured at atmospheric temperature.

A loading was given for compressing the mold at atmospheric temperature for one day (24 Hours). The pressure was maintained at 10kg/cm^2. The required composite specimen was obtained after curing.

III. SCANNING ELECTRON MICROSCOPY OF COMPOSITES

SEM micrographs of coir + wood dust particles reinforced polymer composite specimens of designation 25% of fiber particles, 30% of fiber particles and 35% of fiber particles is shown in figure 3.

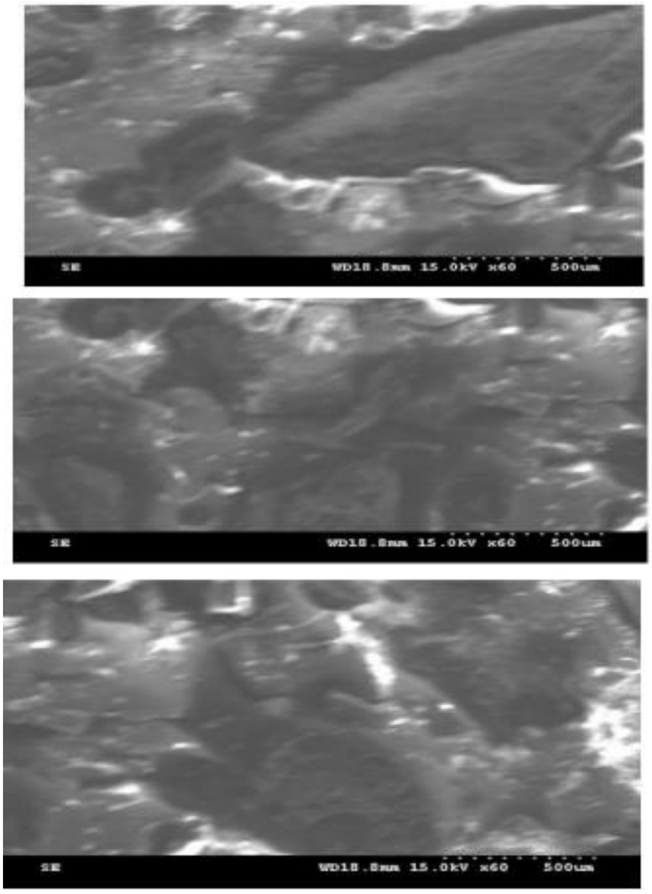

Fig.3. SEM Images

The coir and wood particle distribution into the matrix are clearly shown in SEM images. From the images it showed that the uniform distribution and bonding of fibers into the matrix.

IV. EXPERIMENTATION

A. Tensile Test

Tensile test was conducted for five sample specimens in each type of composites according to ASTM D-638. The tensile test was conducted on a INSTRON 8821S computerized UTM at 3 mm/min crosshead speed. The resulting load was measured by using 5 KN load cell.

B. Flexural Test

Flexural test was done according to the ASTM standard D790 for five samples in each type of composites using an INSTRON 8821S (INSTRON, USA) universal testing machine at 2 mm/min cross head speed. The specimen dimensions for flexural test is 13cm X 1.3cm X 0.3cm.

V. RESULTS & DISCUSSIONS

A. Effect of fiber content on mechanical behaviors of coir fiber reinforced polymers (CFRP)

The experimental tensile strength value of coir particle reinforced polyester composites are shown in Table 1. When the coir particle content increases in the composites, the tensile strength value is also increases. The composite specimen having 15% of coir fiber content has a tensile strength of 14.7MPa. The tensile strength value of the composite specimens increased 15% when the coir fiber particle content in the composite increased from 15 to 25weight %. For 5 % increase of coir fiber, increases the tensile strength value around 15%. The tensile property of the specimens increased 13 % while coir fiber particles increased from 25 to 30 weight % in composite and the tensile strength value of the composite specimens increased 10 % while fiber particle increased from 30 to 35 weight % in composite. When the fiber particle content increased more than 25%, the tensile strength is gradually decreased. It is also observed that the progressive decrease in tensile strength with increasing fiber loading more than 35-wt% as shown in Fig. 4. The tensile strength of the composite depends on the adhesion between the matrix and reinforcement. Due to the increase of fiber content beyond a certain level, the bonding between the matrix and reinforcement may be poor. This could cause the increase of the brittleness of the composite and it should be affect the tensile characters of the composites.

Table.1. Mechanical Characters of coir fiber reinforced polyester Composites.

Coir particles wt %	No of specimens Tested	Tensile Strength (*MPa*)	Flexural Strength (*MPa*)
15	5	14.7	25.78
20	5	17.6	18.321
25	5	25.67	19.35
30	5	29.58	22.68
35	5	32.46	25.61
40	5	30.224	23.64

Flexural modulus is directly proportional to the flexural stress. When the quantity of coir fiber particle increases in the composite, the flexural modulus value also increases. Therefore, flexural stress increases. The values are listed in the Table 1. The flexural value of the specimens increased 20 % when the coir fiber particle increased from 20 to 30-weight%. Further increase of coir fiber quantity from 30 to 35 weight % the flexural strength is also increased around 20%. However, the further increment of the fiber contents more than 35-wt% in the composite leads to the decrement of flexural strength value of the composite samples. This is due to the lower elasticity modulus and flexural strength of coir fiber.

B. Effect of addition of wood dust particles on the mechanical properties of CFRP

The addition of wood dust and coir particle to the polyester matrix resulted in changes of the mechanical properties.

Table: 2 Tensile Strength of coir fiber/wood Dust-polyester Composites

Fiber Content wt. %	No of Samples Tested	Coir particles wt. %	Wood Dust wt. %	Tensile Strength (*MPa*)
15	5	7.5	7.5	16.25
20	5	10	10	21.32
25	5	12.5	12.5	32.57
30	5	15	15	38.56
35	5	17.5	17.5	40.32
40	5	20	20	37.142

The tensile strength of the samples were increased by nearly 10 % when 7.5 % wood dust particles are added with the same quantity (15%) of fiber content. Further increase of the percentage of wood dust particle from 7.5% to 20% in the same proportion of the fiber content of the composite samples the tensile strength of the composites increased from 17% to 24%.

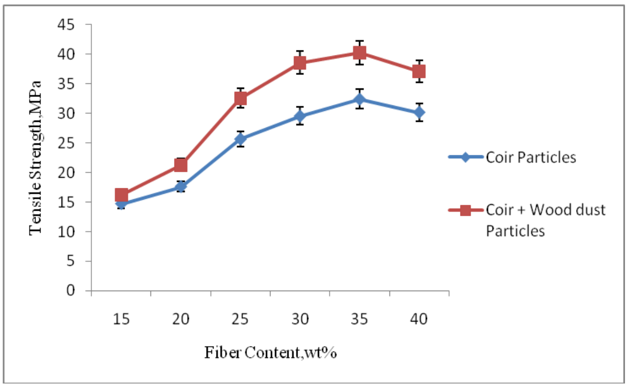

Fig. 4 Variation of tensile properties of CFRP by the addition of wood dust particles.

However, the addition of the coir fiber content and wood dust particles beyond 35-wt% of the composite leads the decrement of tensile strength of composite samples. Because bonding between the reinforcements and matrix is low as a result of decreasing polymer matrix.

Table 3. Flexural Strength of coir fiber/wood Dust-polyester Composites

Coir particles Wt %	No of Specimens Tested	Coir particles Wt %	Woo d Dust Wt %	Flexural Strength (MPa)
15	5	7.5	7.5	29.43
20	5	10	10	21.02
25	5	12.5	12.5	24.05
30	5	15	15	29.52
35	5	17.5	17.5	33.62
40	5	20	20	32.78

Adding of wood dust particles in every composite specimen was increase the flexural strength. The flexural strength of the specimen, which is having 15% of fiber content with 7.5% wood dust, is 12% greater than the composites without the wood dust. When the wood dust particles increased from 10 to 35-wt%, the value of flexural strength is also increased up to 45% as shown in figure. 5.

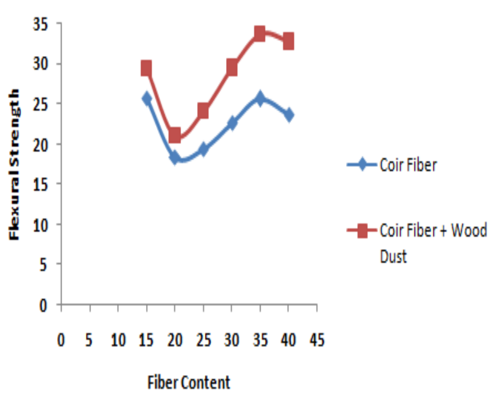

Fig .5. Effect of fiber content on flexural strength

VI. CONCLUSION

The coir and wood dust particle reinforced polymer composite using polyester resin was prepared using hand layup process.

- SEM characterization showed uniform distribution of coir and wood dust reinforcement in polyester matrix.
- The tensile and flexural strength increases with increasing the coir and wood dust particle. The tensile strength of the samples increased by 15% when the fiber content increased from 15 to 25-wt% in the composites. The flexural strength of the samples increased 20 % when the coir fiber content increased from 20 to 30-wt%.

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