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A Study on Impact Strength Characteristics of Coir Polyester Composites

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Abstract

To study the energy absorption capability of coir polyester composites, experimental studies were conducted as per ASTM D256 norms. Experiments were conducted on specimens with both untreated and treated with 5 % NaOH solutions. The specimens of 2 mm, 3 mm, 4 mm, 5 mm and 6 mm thicknesses with fiber volume fraction of 10 %, 15 %, 20 %, 25 % and 30 % were tested to study the variation of their impact strength with variation in specimen thickness and fiber volume fraction respectively. From the results it is observed that, as the thickness and fiber volume fraction of both treated and untreated coir polyester composite specimens increases, the impact strength also increases. Untreated coir polyester composite of 30 % fiber volume fraction yielded its highest impact strength of 1.570 N-m. Similarly treated composite specimens also yielded its peak impact strength of 1.275 N-m at its 30 % fiber volume fraction.

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Keywords: composite; coir; impact strength; natural composite; treated coir.

1. Introduction

Coir is one of the most eligible natural fibers to use as reinforcement with polyester matrix. Coconut fiber is extracted from the external shell of a coconut fruit. The standard name, scientific name and plant group of coconut fruit fiber are Coir, Cocas Nucifera and Arecaceae respectively. There are two types of coconut fruit fibers- brown fruit fiber extracted from mature coconut fruits and white fruit fibers extracted from tender coconuts. Brown fruit

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fibers are thick, strong and have high abrasion resistance. White fibers are smoother and finer, but also weaker. Coconut fibers are commercially available in three forms, namely bristle, mattress and decorticated. Brown fruit fibers are ones most commonly used in engineering applications. It is abundantly available in India. Usage of coir in the production of natural fiber reinforced composites increased its commercial value, which is agriculture by products. Because of its curved structure, it is very difficult to orient the fibers in desired directions during composite casting. It is highly desirable to fabricate randomly oriented fiber reinforced composites using coir fibers. Matured coir fiber reinforced polymer matrix composites are used for many engineering applications like automobile industries; construction purposes; aeronautical engineering etc. Handling of coir fibers is easier than synthetic fibers because, these are non toxic, light in weight, eco friendly and low cost. Coir/coconut fibers are obtained from outer shell of matured coconut fruits. Conventionally these fibers are used to manufacture ropes, mats and decorative items. Now a day’s many researchers tried to explore the mechanical behavior of coir reinforced composite materials. Amongst Bujang et al [1] presented their observations that dynamic characteristics (such as natural frequency) of the coir-polyester composites are complected with its mechanical properties and it can be forecasted by analyzing its mechanical properties. Ali [2] reported that coconut fibers are most ductile and energy absorbent material. Zaman et al [3] reported that mechanical properties of coir fiber reinforced composites have a strong association with their dynamic characteristics. Sathiyamurthy et al [4] have reported in their study that Artificial Neural Network (ANN) models can be effectively utilized for prediction of mechanical properties of inorganic filler embedded coir polyester composites. Rajamuneeswaran et al [5] have reported that impact strength of coir reinforced polyester composites can be enhanced by the intrusion of crab carapace as filler material. Khan and Joshi [6] have reported in their study that mechanical and morphological properties of coir fibers can be improved by treating them with ferric nitrate and ammonium chloride. Ganesh et al [7] have reported in their study that strength to withstand the impact load of coir-vinyl ester composites can be enhanced by the intrusion of termite mound particulate as filler materials. Anyakera [8] has reported that coconut palm frond fibers are of competent alternatives to replace synthetic fibers as reinforcement in polyester matrix, which can be used for the application of building constructions, and also he concluded that surface treatment to coconut frond fibers improves the mechanical properties of composites.

Additionally, Tran et al [9] have reported that interfacial adhesion of untreated coir fibers with polypropylene matrix shows hydrophobic properties with a low polar fraction of the surface energy. But 5 % alkali treated coir exhibits higher surface energy with an increased polar fraction. As a conclusion they reported that agreement between wetting analysis and composite interface mechanical tests are good. Ahad et al [10] have depicted in their study that both banana fibers and coconut husk (it is the outer roughest part of the coconut which is fibrous in nature) improves their surface roughness by alkaline (NaOH) treatment. They reported that improved surface roughness in turn increases the mechanical properties of composites. Prasad et al [11-14] showed that ANN is one of the adoptable predicting tools to prognosticate the properties of coir fibers reinforced composites. It minimizes the difficulties like experimental work which demands high initial investment and manpower and time. Gowda et al [15] reported the probabilistic behavior of tensile properties of coir fiber reinforced polymer matrix composites. They concluded that, by deriving the ranges of tensile strength of coir polyester composites, it will be helpful to fabricate the coir polyester composites of desired thickness and fiber volume fractions based on required tensile strength.

From the survey of literatures, observations can be made that, the less work was been conducted and reported in the field of comparative study of impact properties of chemically treated and untreated coir fiber reinforced polyester matrix composites. Hence in the present study analysis of impact properties of raw (untreated) coir and 5 % NaOH treated coir fibers reinforced polyester matrix composites are conducted.

2. Materials and methods

In the present study unsaturated polyester resin of density 1.14 g/cc is used as matrix material. Polyester resins are unsaturated synthetic resins formed by the reaction of dibasic organic acids and polyhydric alcohols. Maleic Anhydride is a commonly used raw material with diacid functionality. Unsaturated polyesters are condensation polymers formed by the reaction of polyols (also known as polyhydric alcohols), organic compounds with multiple alcohol or hydroxy functional groups, with saturated or unsaturated dibasic acids. Cobalt napthanate and methyl ethyl ketone peroxide are used as curing agent and catalyst to prepare the matrix solution respectively. The resin, curing agent (hardener) and catalyst are mixed in the ratio of 100:1:1 respectively to prepare the matrix solution. Hot compression moulding machine is used to fabricate the sample specimens of thickness 2 mm, 3 mm, 4 mm, 5 mm and 6 mm respectively. Each of these thicknesses were fabricated with 10 %, 15 %, 20 %, 25 % and 30 % fiber volume fractions individually.

10 mm length short coir fibers of density 1.14 g/cc were used to fabricate both raw and 5 % NaOH treated coir fiber reinforced polyester composites. These fibers were soaked in the 5 % NaOH solution for 24 hours time duration and cleaned well by the running water. So, chemically treated coir fibers were dried for 48 hours time span in hot sun before using to cast the treated coir fiber reinforced polyester matrix composites. All the specimens were fabricated in the room temperature (24o – 28o C). Temperature of both base plates of hot compression moulding machine were maintained for 85o C during the fabrication process. Digital temperature indicator was adopted to record the temperature of hot compression moulding machine. Care has been taken to uniformly distribute the desired quantities of fibers within the spacers frame and to achieve the coveted thickness of composite panels during fabrication.

ASTM standard D256 norms are adopted to study the impact strength of both types of composites (raw and 5 % NaOH treated coir polyester composites). The sizes of testing specimens are considered as 65 mm x 13 mm x ‘t’, where ‘t’ is the thickness of specimens varied from 2 mm to 6 mm. Totally 50 numbers of samples are tested to analyze the impact strength behavior of coir polyester composites.

3. Results and discussions

Table 1 shows the impact strength of untreated coir polyester composite materials. Figure 1 shows the variation of impact strength of the untreated coir polyester composite materials with their fiber volume fractions. All the tests are conducted according to ASTM D256. Here, the indented (notched) specimens are kept in cantilever position and the pendulum swings around to break the specimen. The impact energy (N-m) is obtained from the dial gauge that fitted on the machine. The specimen measurement is 65 mm x 12.7 mm. Figure 1 reveals that impact strengths of each polyester composite materials increase with increase in their thickness and fiber volume fraction (up to 30 %). From the results of impact strength properties of untreated coir polyester composite, it is observed that, impact strength viably relies on the fiber content and fiber-matrix bondage. The specimens of 2 mm, 3 mm, 4 mm, 5 mm and 6 mm thick untreated coir polyester composite have shown their highest impact strength as 0.736 N-m, 0.956 N-m, 1.030 N-m, 1.079 N-m, and 1.570 N-m respectively. Table 2 shows the impact strength values of treated coir polyester composites. Figure 2 shows the variation of impact strength with fiber volume fraction of treated coir polyester composites. Here all the specimens are showing the increase of impact strength as there is an increase in both fiber volume fraction and thickness. 2 mm, 3 mm, 4 mm, 5 mm and 6 mm thick specimens of 30 % fiber volume fraction recorded their highest impact strength as 0.809 N-m, 0.966 N-m, 1.006 N-m, 1.079 N-m and 1.275 N-m respectively.

From the data shown in of tables 1 and 2 it is clear that, 4 mm and 5 mm thick specimens displayed the routine behavior that is, impact strength of treated coir polyester composite is higher than untreated specimens, yet 2 mm, 3 mm and 6 mm thick specimens demonstrated a very different behavior with their fiber volume fraction. That is, impact strength of 5 % NaOH, 24 hours treated coir polyester composite is less than untreated coir-polyester composites. From the literature survey, treated natural fiber reinforced composite specimens generally shows high mechanical properties when compared with untreated specimens (refer [8, 9, 10, 16, 17]). Yet, according to literatures [18] and [19], it is also clear that as the concentration and time span of alkaline (NaOH) treatment for natural fibers (like jute, coir, sisal and so on) increases, impact strength reduces. However literature [19] especially specifies that fiber length is specifically relative with the impact strength of composites. That implies as the fiber length of composites increases, impact strength increases. So determination of optimum alkaline treatment method (process) and the fiber length of natural fibers reinforced composites to upgrade the mechanical properties like tensile strength, flexure strength and impact strength is another thirst zone.

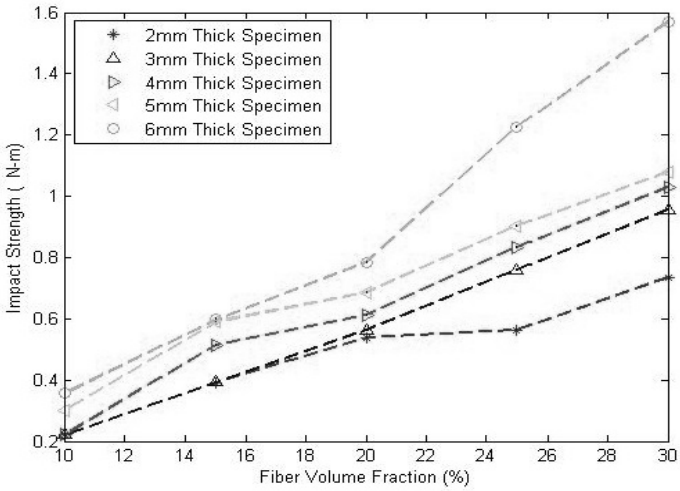

Figure 1: Variation of impact strength of untreated coir reinforced polyester composites with fiber volume fraction.

Table 1: Impact strength properties of untreated coir reinforced polyester composites.

SI No	Thickness (mm)	Fiber Volume Fraction (%)	Impact strength (N-m)
1	2	10	0.221
2	2	15	0.392
3	2	20	0.540
4	2	25	0.564
5	2	30	0.736
6	3	10	0.221
7	3	15	0.392
8	3	20	0.564
9	3	25	0.760
10	3	30	0.956
11	4	10	0.221
12	4	15	0.515
13	4	20	0.613
14	4	25	0.834
15	4	30	1.030
16	5	10	0.299
17	5	15	0.589
18	5	20	0.687
19	5	25	0.903
20	5	30	1.079
21	6	10	0.356
22	6	15	0.598
23	6	20	0.785
24	6	25	1.226
25	6	30	1.570

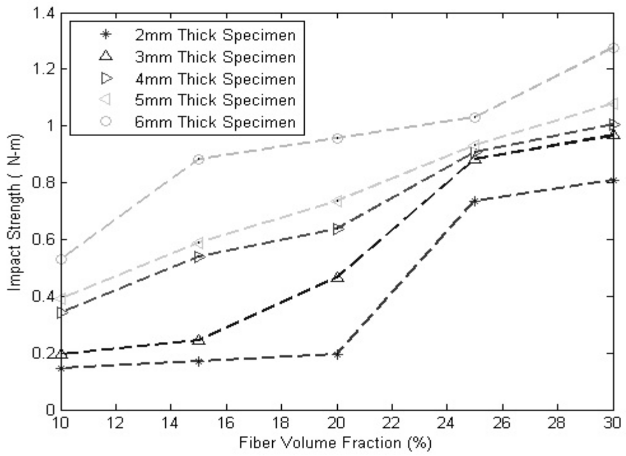

Figure 2: Variation of impact strength of treated coir reinforced polyester composites with fiber volume fraction.

Table 2: Impact strength properties of treated coir reinforced polyester composites.

SI No	Thickness (mm)	Fiber Volume Fraction (%)	Impact strength (N-m)
1	2	10	0.147
2	2	15	0.172
3	2	20	0.196
4	2	25	0.736
5	2	30	0.809
6	3	10	0.196
7	3	15	0.245
8	3	20	0.466
9	3	25	0.883
10	3	30	0.966
11	4	10	0.343
12	4	15	0.540
13	4	20	0.638
14	4	25	0.907
15	4	30	1.006
16	5	10	0.392
17	5	15	0.589
18	5	20	0.736
19	5	25	0.932
20	5	30	1.079
21	6	10	0.530
22	6	15	0.883
23	6	20	0.956
24	6	25	1.030
25	6	30	1.275

4. Conclusions

From Figures 1 and 2 it is observed that as the thickness and fiber volume fraction of both treated and untreated coir polyester composites increases, impact strength also increases respectively. From impact strength values of tables 1 and 2 (refer Figure 3) it can be concluded that, 10 mm long natural reinforcing fibers (Coir) is insufficient and 5 % NaOH treatment for 24 hours time span is high and failed to enhance the impact strength properties of 2 mm, 3 mm and 6 mm thick coir-polyester composites. Usage of this kind of plant fiber reinforced composites as Light doom, Mudguards, name and number plates and Engine guard in automobiles; switch gear, panels &

insulators in electrical industries and as non load bearing wall panels which are light weight alternative building material adequately decreases the load on substructures which results in decrease of dimensions of structural elements and utilization of river sand (now a day, it is one of the eco-social issues) in construction practice and thus, it upgrades the use of agriculture by product (refer [20, 21, 22, 23, 24]). It also adequately increases the speed of construction practice in comparison with traditional (conventional) construction methods. Further, the commercial value of coir fibers will also increase.

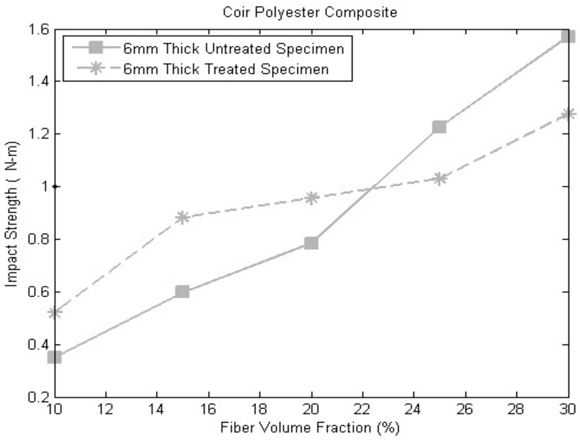

Figure 3: Illustration of variation of impact strength of 6 mm thick treated and untreated coir polyester composites with fiber volume fraction.

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