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Mechanical Behaviour of Coir Fibre Reinforced with Polyester Composite

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Abstract: Coir fibres are commonly used in various industrial applications. The purpose of this research was to study the effect of alkali treatment and fibre content with different percentage on tensile and flexural strength of polyester resin reinforced by coir fibre. In this study, coir fibre were treated with sodium hydroxide (NaOH) concentration 5% for 24 hours at room temperature and dried for 48 hours. The coir fibre content was also varies from 10% and 20%. Hand lay-up method was used to fabricate the composite. Composite material is a material that consists of a combination with at least two or more constituent materials which have significance contrast chemical or physical properties. From the literature review, the treated coir fibre would increase the strength of the coir fibre reinforced with polyester composited compared to untreated coir fibre. The results from previous researcher shown that the fibre content in weight percentage and alkali treatment with suitable condition which is 5% of NaOH concentration are playing major role on the improvement of tensile strength and flexural strength

Keywords: Coir, Fibre, Alkali, Sodium Hydroxide

1. Introduction

This composite material is generally used in many fields of industries. Weight reduction, energy efficiency are always areas which manufacturer concentrates when developing a new product. When two or more materials are mixed then that whole material is called composite material. The characteristics of the two materials combined will be different [1].

Todays, manufacturer is continuously trying their best to create great characteristics of material which are strong eco-friendly and biodegradable. Composites are one of the materials which are flexible, high performance and broadly utilized within the fabricating industry. As a waste product after consumption, coconut coir is available in abundance in tropical countries. Such abundance can make it profitable for composites based on fillers, while waste reduction. As compared to synthetic fibres, natural fibres have high particular quality and recyclability. Natural fibres have cleared its way in applications such as space investigates marine and automotive industry. All plants fibre contains

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cellulose as their major basic component, though animal fibres basically comprise of protein. Natural fibre is biodegradable because it comes from nature. This makes them more promising as compared to synthetic fibre [2] .Processing and sourcing of coconut coir is inexpensive compared to other artificial fillers. The addition of coconut fibre to the matrix polymer is found to increase the damping ratio, making the material suitable not only for strength-related properties, but also for reducing the strong resonance structure [3].

The aim of this research is to investigate the tensile strength and flexural strength of coir fibre treated with sodium hydroxide and to investigate the weight percentage on alkali treated the coir fibre reinforced polyester composites.

2. Materials and Methods

2.1 Materials

The coir fibre that was earned from a local plantation and mature coconut was chosen to collect its coir. Polyester resin and methyl-ethyl-ketone catalyst was purchased from local supplier. Sodium hydroxide in crystal form and mould which is tile was obtained from local supplier.

2.2 Preparation of Coir Fibre

Mature coconut coir fibres were choose. The coir extraction includes the breakup and removal of the coir fibre package from the coconut fruit. The fibre then is extracted to the appropriate size and stored appropriately. Plastic granulator machine was used to cut the coir fibre to reduce the size of fibres into short coir in average 1-3cm.

2.3 Fibre Treatment

Coir fibre are chemically treated in order to remove lignin containing materials such as pectin, hemicellulose and waxy substances. Alkali treatment was very important in creating a rougher fibre surface that could be improved by mechanical properties. For alkali treatment, the level of concentration sodium hydroxide (NaOH) was 5% and the soaking time (24 hours) at room temperature was selected. After 24 hours of NaOH treatment, the coir fibres were washed with distilled water to remove excess NaOH until obtained a pH = 7. Finally, coir fibres were air dried for 48 hours for drying process.

2.3 Composite Fabrication

The mould is prepared as per ASTM D3039 and ASTM D790 with dimension 175mm x 125mm x 2mm and 154mm x 65mm x 3mm respectively. Initially mould is gently cleansed and is set free from moisture and releasing agent was sprayed into inner side of the mould. Weight the fibre of different weight percentage (10% and 20%). Coir fibre and polyester matrix are mixed and the mixture are poured into the mould and allowed to cure at room temperature for 24 hours. After completion curing process, samples of test specimen are cut into the required dimension as following the ASTM standard which are ASTM D3039 for tensile test and ASTM D790 for flexural test. The same procedure was followed to prepare different types of composites as per the nine combinations of fibre parameters. Table 1 show the composition of polyester resin and coir fibre

Table 1: Composition of polyester resin and coir fibre

Sample		Weight percentage (%)	
		Polyester resin	Coir fibre
Tensile	Untreated Coir fibre	90	10
		80	20
	Treated Coir fibre	90	10
		80	20
Flexural	Untreated Coir fibre	90	10
		80	20
	Treated Coir fibre	90	10
		80	20

3. Results and Discussion

This section discusses the effect of alkali treatment conditions on coconut fibre in order to achieve the first research objective. Starting from the previous chapter, all methods for preparing samples have been fully described and explained. The results from the two mechanical testing was analysed in this chapter in order to complete this research properly. This chapter consists of analysis, presentation and interpretation of the finding resulting from previous research.

3.1 Tensile strength

Tensile testing is one of the most important and common types of mechanical testing. The tensile force, also known as pulling force, is applied to the sample during the tensile test and the response of the sample is measured. This test can determine how long the sample can be elongate and its strength Specimens are load into the tensile grips and the test begin by separating the tensile grips at a speed.

Dos Santos et al. [4] studied the effect of sodium carbonate on the tensile strength of polyester and coir fibre reinforced composites. In view of its application as a reinforcing agent in composites reinforced with polyester and epoxy polymer, the surface modification caused by sodium carbonate in coconut shell fibres was studied. Coir fibre was treated with a 10% by weight sodium carbonate solution at room temperature for different periods of time (24, 96 and 168 hours). Tensile strength also improved significantly after 96 hours of alkali treatment. The tensile modulus ranges from 2.52 to 3.13 GPa. Matrix phase (MP) and processing time significantly affect tensile strength, and their effects indicate that a higher tensile modulus can be achieved when polyester is used.

Next, (Balaji & Senthil Vadivu [5] studied the mechanical properties of coir fibre and cotton fibre reinforced unsaturated polyester composites for packaging applications. Using hand lay-up method, the tensile test was carried out with different amounts of coir fiber and unsaturated polyester reinforced cotton fibre. The sample composed of unsaturated cotton polyester has better tensile strength, reaching 30.97 MPa. The sample number 1 consist of 80% of resin and 20% of coir show the least of tensile strength which is 17.92 MPa. With the addition of cotton fibre, the tensile strength of the manufactured composite material increases linearly.

M. Arsyad [6] observed that the effects of alkali (NaOH) treatment on the surface of coconut fibre include surface roughness, tensile strength, and the ability of the coconut fibre to bond with the polyester matrix. The coconut fibres are immersed in alkaline solutions with concentrations of 5%, 10%, 15% and 20%. . In the treatment 20% alkali causes the degradation of lignin greatest, so that the lignin content of at least. The lignin will affect fibre strength, fibre strength will be high if the number of lignin is low because lignin is stiff and brittle. The highest strain coir fibre obtained on 5% treatment, namely by 50%, but for the other treatments tend to decrease compared with the elongation of coir fibre without treatment.

Jayabal et al. [7] conducted research on coir-polyester composite materials, which aroused people's interest in the development of woven coir fibre reinforced polyester composite materials. The soaking time and concentration of NaOH solution also play an important role in improving the tensile and bending properties of fibre composites. Green coir fibre is used to reinforce polyester. he tensile strength of the treated woven coir fibre-reinforced polyester composite material is increased by 40%. The combination of NaOH concentration and immersion time of 5% and 72h obtained the best tensile strength value.

Jayabal and Natarajan [8] studied that the fibre content expressed as a percentage by weight plays an important role in improving the tensile strength performance than the fibre length. The Increasing fibre length value above or below this value will not only affect the tensile properties. A maximum tensile property value of 15.6 MPa was obtained only for the maximum fibre length of 150 mm. Fibre content or fibre loading plays an important role in the mechanical properties of coir fibre and polyester composites. The Maximum tensile performance is obtained at 20% fibre load.

3.2 Flexural Strength

The flexural force can be defined as the maximum force applied to the tensile or compressive side of the sample. It can also be described as the ability of the sample to undergo deformation under load before it begins to fail. The force applied to a single point on the sample will cause it to bend until it becomes a "V" shape.

Dos Santos et al. [4] found that after 96 hours after coir treatment the flexural modulus of co-reinforced polyester compounds increased by 28%. Flexural strength is affected by matrix phase and treatment time, ranging from 23.58 to 31.42 MPa. The experiment shows that the sodium carbonate treatment of the coir fibre for 96 hours significantly improves the flexural modulus and strength of the coir fibre reinforced polyester composite material, and overcomes the main operational problems from conventional alkaline treatment, such as corrosion and extensive neutralization.

Next, Balaji and Senthil Vadivu [5] found that with the addition of cotton fibre, the flexural strength of the composite material increased linearly. The flexural strength of the cotton-unsaturated polyester composite sample is 15.90 MPa and the flexural strength of the coir-unsaturated polyester is 9.78 MPa. Greater flexural strength is found in composites containing large amounts of cotton and small amounts of coir fibres.

Jayabal et al. [7] studied polyester and coir fibre composites, which initiated interest in developing woven coir fibre reinforced polyester composites. The average tensile strength value of the woven coir fibre composite is 31.3 MPa. The flexural strength of the treated woven coir fibre reinforced polyester composite material is increased by 42%. The combination of NaOH concentration and immersion time of 2% and 98 hours obtained the best flexural strength value.

Next, Jayabal and Natarajan [8] studied that the fibre content in weight percentage plays an important role in improving the flexural strength performance than the fibre length. Increasing the fibre length value above or below this value will not only affect the flexural properties. Fibre content or fibre loading plays an important role in the mechanical properties of coir fibre and polyester composites. Maximum flexural strength is obtained under 30% fibre load. The maximum value of the coir–polyester composites is 38.5 MPa and the fibre load is 30%.

Table 2 : Summaries of some previous research that closely related to this research

Year	Fibre	Resin	Fibre content and length	Treatment condition			Tensile test	Flexural test	Analysis from the test
				Alkali (%)	Time (hours)	Temp (C)			
2018 [4]	Coir	Polyester	volume fraction of 30%	Sodium carbonate (Na_2CO_3) 10%	24, 96 168	RT	ASTM D3039	ASTM D790	96 hours provides significant enhancement of tensile and flexural modulus and strength of coir fibre reinforced polyester composites
2017 [5]	Coir	polyester	volume fraction 0%, 4%, 8%,12%,16% and 20 %	NaOH 5%	1	RT	ASTM D 3039	ASTM D790	The cotton-unsaturated polyester composite material show the maximum tensile strength of 30.97 MPa when compared with the other combinations of coir-cotton-unsaturated polyester.
2017 [6]	Coir (singles fibre)	Polyester	-	NaOH 5%, 10%, 15% and 20%	3	RT	ASTM 3379-02	-	In the 20% NaOH obtained tensile and shear strength is highest, respectively 280, 94 N/mm2 and 3, 09 N/mm2.
2013 [7]	Coir	Polyester	volume fraction of 24%	NaOH 2 %, 5 %, and 8 %	24, 48, 72, 96, 120	RT	ASTM D 3039	ASTM D790	The better values of tensile and flexural strength were obtained for the combination of NaOH concentration and soaking time of 5 % & 72 h and 2 % & 96 h respectively

2014 [8]	Coir	Polyester	weight percentage of 10, 20, and 30, 50, 100, and 150 mm length	-	-	-	ASTM D638	ASTMD 790	The maximum tensile and flexural properties were obtained in the fibre loading of 20%.

4. Conclusion

In conclusion, this study was carried out to investigate the mechanical properties of polyester resin reinforced by coir fibre. There are some variable used in this study which are the alkali treatment concentration and the coir fibre content. These two factors contribute greatly to the mechanical properties of the composite. In order to determine the mechanical properties of the composite, tensile and flexural test was carried out. These two types of test are the most typical test to ascertain the mechanical properties of a material. The concentration of alkali treatment in this study is 5% while the coir fibre content are 10% and 20%. The alkali treatment removed the lignin and pectin of coir fibre. This cause the surfaces properties and adhesion of coir fibre with matrix which is the polyester resin to be intensify. From the previous review, it show the suitable combination of NaOH concentration and soaking time which 5% & 72 hours for tensile strength while 2% and 96 hours for flexural strength. It can be concluded that the suitable of NaOH concentration with combination of soaking time and combination of fibre content influence the value of tensile and flexural strength. The mechanical properties of the coir fibre reinforced polyester composite managed to be enhance by applying these conditions.

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