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Tensile strength of glass fiber-reinforced waste PET and Kenauf hybrid composites

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Abstract. Increasing the amount of plastic waste from year to year is inevitable due to the increased use of plastics by people in the World. This study aims to evaluate the mechanical behavior, in this case, the tensile strength of a hybrid composite between kenaf natural fibers, PET plastic waste and glass fibers for wallboard. This research takes the form of experimental tests in the laboratory. The composite material to be made is a mixture of plastic, kenaf fiber with glass fiber with polyester reinforcement. Both kenaf and glass fiber is made in sheet form. The hypothesis developed in this laboratory study from previous research found that kenaf and glass fiber hybrid material can be used for partition material. Results showed that hybridization with glass fiber enhanced performance properties. A value of 48,5 MPa for tensile strength is achieved from waste PET glass kenaf hybrid composite without immersion.

1. Introduction

The Director of Waste Management at the Ministry of Environment and Forestry, Novrizal Tahar revealed, in the period 2002-2016, there was an increase in the composition of plastic waste from 11 percent to 16 percent. Such conditions will certainly cause concern for the sustainability of the environment in the future.

Recycling waste has always been the subject of discussion in handling the problem of plastic waste, especially in Indonesia. But the problem is the negative impact of plastic waste turns out to be as big as its function. It takes 1000 years for the plastic to decompose by decomposing the soil completely. This is a very long time. therefore the use of plastic material can be said to be unfriendly or conservative for the environment if used without using certain restrictions. Whereas in everyday life, especially in Indonesia, the use of plastic materials can be found in almost all life activities.

Increased research using plastic waste as construction materials is currently being actively carried out. For example the use of plastic waste as wall material, ceiling and road construction. Specifically, research on ceiling material has been widely produced as a composite material, among others, Composites from Polypropylene (PP) reinforced with Palm Oil Empty Fruit Bunch Fiber [1]. In line with this, research on the use of composites using natural fibers that can be cultivated is increasing because consumers are aware of the environment to preserve nature [2]. In its application natural fibers are mixed with synthetic fibers that are man-made [3]. The selection of PET (Polyethylene Terephthalate) plastic was used as a base material in this study is not only because it can be obtained easily, this material can also melt at a temperature of 100 ˚C - 180 ˚C and has the advantage of being able to glue strongly when it is integrated with other materials.

The combination of renewable and synthetic natural fiber materials appears to be an extraordinary and abundant structural material for the replacement of non-renewable fibers such as expensive synthetic fibers [4]. The strength of natural fibers is usually very limited and to improve it is done using chemical modification techniques [5]. Research on composite composites or hybridization of natural fibers with natural fibers, synthetic fibers with natural fibers and synthetic fibers with synthetic fibers in a single matrix has been carried out [6]. This study aims to evaluate the mechanical behavior and structure of hybrid composite composites between natural kenaf fibers, PET plastic waste and glass fibers for construction material applications.

1.1. PET plastic waste

The type of plastic that will be used in this study is the type of PET (Polyethylene Terephthalate), this sign usually has a recycled logo with the number 1 in the middle and the writing PETE or PET (Polyethylene Terephthalate) under the triangle. Usually used for clear, transparent/transparent colored plastic bottles such as mineral water bottles, drink bottles, juice bottles, cooking oil bottles, soy sauce bottles, chili bottles, and almost all other beverage bottles.

1.2. Tensile test

The results obtained from tensile testing are very important for engineering and product design because they produce material strength data. Tensile testing is used to measure the resistance of a material to the static force that is given slowly. One way to determine the magnitude of the mechanical properties of metals is by tensile testing. Mechanical properties that can be known are the strength and elasticity of the metal. Tensile tests are mostly carried out to complete the basic design information of the strength of a material and as supporting data for material specifications. The strength and elasticity values of the test material can be seen from the tensile test curve.

Figure 1. Tensile testing machines

1.3. Composite fiber

Composites fiber is widely used because of their lightweight, high chemical resistance and specific rigidity, and low prices. Compared to metals, fiber composites are widely used and are widely used in various fields of application such as shipping, automotive, aeronautics, sports equipment, civil structures, etc.

Several studies have been carried out on composite materials related to shipping products [8], research related to automotive products [8], research related to civil structural products [8]. Previously it was known that many of the advantages of natural fibers compared to glass fibers and man-made carbon are fewer health risks, low prices, low densities proportional to certain stress properties, free of abrasive equipment, no skin irritation, recyclable and environmentally friendly [9].For this reason, natural fibers are combined with glass fibers in a composite form.

The results obtained from the composite study of natural fiber hybrid with glass fibers are to increase the tensile strength, the flexural and mechanical strength of the material [6]. A study is very supportive in this applied research in the development of composite (hybrid) kenaf fibers and unsaturated polyester reinforced glass for civil structure applications [3]. In that study, it was found that the value of mechanical strength was the same as the mechanical strength in composite fiberglass reinforcement (GFRP) glass. But the advantage is that the composite can combine natural fibers and artificial fibers, and the price is cheaper and the material more easily obtained. A mixture of kenaf fiber and glass is more environmentally friendly. In terms of mechanical strength, it has been proven that kenaf fiber is one of the superior fibers compared to several other fibers. As shown in table 1 which is the result of scientific research in the field of material science.

Table 1. Mechanical properties of several natural and synthetic fibers [9].

Fibre	Density (gr/cm^3)	Tensile strength (MPa)	Elastic modulus (GPa)	Elongation at break (%)
Jute	1.30	393 – 773	26.5	1.5 – 1.8
Sisal	1.50	511 – 635	9.4 – 22	2.0 – 2.5
Flax	1.50	500 – 1500	27.6	2.7 – 3.2
Hemp	1.47	690	70	2.0 – 4.0
Pineapple	1.56	170 – 1627	60 – 82	2.4
Cotton	1.50 – 1.60	400	5.5 – 12	7.0 – 8.0
Kenaf	1.45	930	53	1.6
E-glass	2.55	3400	71	3.4
Carbon	1.40	4000	230 - 240	1.4 – 1.8

From some of the research that has been done above, the researchers began to make applied research which is a combination of material engineering with civil engineering. Researchers believe that applied products will be obtained well regarding previous studies. Over the years more and more people are researching natural composite materials including composites made from kenaf fibers. Likewise the composite mixture between natural fibers and synthetic fibers as mentioned above.

2. Methodology

Research conducted includes quantitative descriptive research methods. The type of research is experimental research conducted on variables for which data do not yet exist, so it is necessary to process through the provision of certain treatments/treatments to research subjects that are then observed/measured for their impact. The procedure of processing can be seen in figure 2.

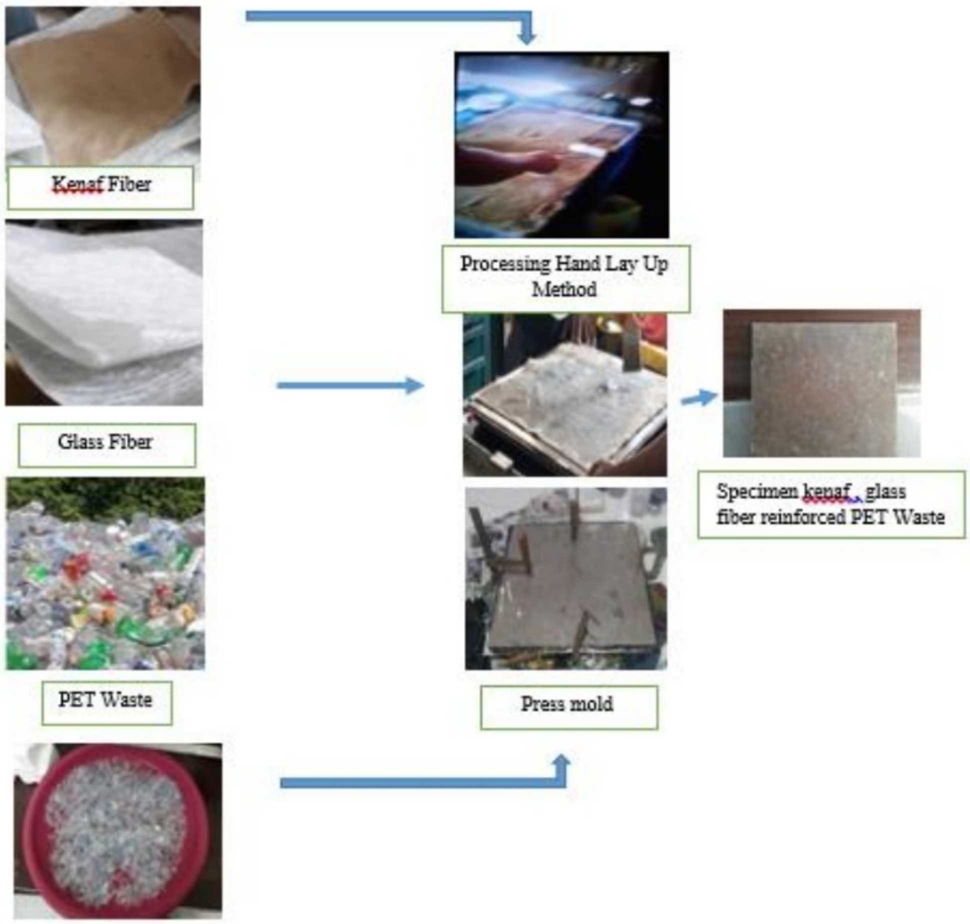

Figure 2. Composite manufacturing procedures.

2.1. Research specimen material

The composite material was fabricated by melt processing followed by molding press of glass fiber-reinforced waste PET and Kenauf Hybrid Composites. Both kenaf and glass fiber is made in sheet form. Specimen thickness after formed into a composite is 5 mm. Formulation of the composite prepared for this study used kenaf fiber which has a dimension of weight per square meter: 650 gram / m^2. While the glass fiber which is a Chopped Strand Mat (CSM) weights square meter: 350 g / m^2. The two fibers are combined using SHCP (High Polymer Chemical Products Singapore Pte Ltd) polyester resin 268 types of BQTN polyester. In making plastic composite composites, kenaf fibers and glass using the method of hand lay-up and press mold. Hand lay-up is the simplest method and is a process with an open method of the composite fabrication process. As for the process of making with this method is by pouring the resin by hand into a woven fiber, then applying pressure as well as leveling it using a roller or brush. The process is repeated until the desired thickness is reached. In this process, the resin directly contacts the air and the molding process is carried out at room temperature. To study the effect of water absorption on the mechanical properties, tensile tests were performed on the wet samples after the samples reached the saturation limit and The specimens are made in two types. 1 type of tensile specimen tested before immersing. And 1 other type was immersed first for 5, 10 and 15 days before tested tensile. The dimensions of the test specimen for tensile testing are as follows:

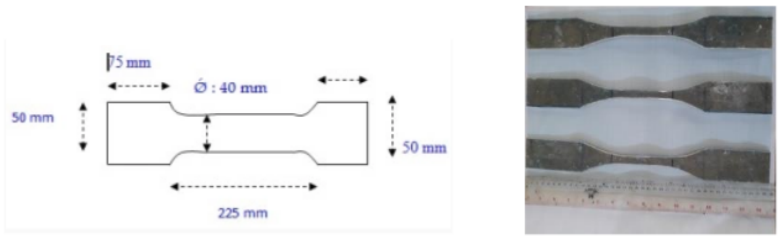

Figure 3. Specimens.

2.2. Testing procedure
Test procedures for the composite plastic tensile test in this study using a testing procedure based on ASTM D-638 for tensile tests. Testing procedures include measuring specimens of standard size, measurement of initial length (Lo) or gage length and cross-sectional area of sliced test specimens, measuring specimens on the upper grip and lower grip on the tensile testing machine, tensile testing machine functioned with a crosshead speed of 1 mm / min and tensile loading until the test object is broken, recording the yield load and breaking load contained on the scale, release of the test specimen on the upper and lower handles, reuniting the two as before, measuring the length of the strain that occurs.

2.3. Morphological tests
Fractographic studies with scanning electron microscopy (SEM) were carried out in detail on the tensile fracture surfaces the specimens composite nonplastic and plastic composite using a scanning electron microscope (model Hitachi S-2500, Tokyo, Japan).

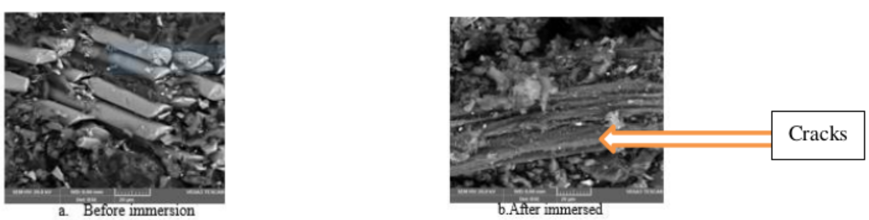

Figure 4. Morphological test results for the Waste PET Kenaf Hybrid Composite by using SEM.

3. Results and discussion
The data generated in this study are quantitative data (numbers) that include data on the results of tensile strength testing, peak load, extension. Testing the tensile strength using the ASTM D 638M-84 standard, some several tables and averages related to the tensile strength, namely maximum load, tensile strength, and elongation. More details can be seen in Table 2 below.

Table 2. Average tensile tests.

No	Material type	0 day (MPa)	5 days (MPa)	10 days (MPa)	15 days (MPa)
1	Hybrid glass kenaf Composite	58.69	41.37	30.32	28.05
2	Glass Fiber-Reinforced Waste PET and Kenauf Hybrid Composites	48.50	47.50	42.29	32.60

3.1. Tensile stress-strain curves

Tensile stress-strain curves of Composite Hybrid glass kenaf and Composite Plastic Kenauf Composite are shown in figure 5. Non Plastic Composite shows a ductile fracture whereas both composites exhibit brittle fracture and show linear deformation at lower strain, where the matrix and fibers behave linearly and nonlinear deformation at higher strain, which continues until the complete failure of the composite. The nonlinear deformation behavior in the composites represents the (i) microcracks initiation at fiber end matrix interphase that propagates along the composite lengths, (ii) plastic deformation of the matrix, and (iii) microcrack opening in the matrix and the slow crack propagation through the deformed matrix. In the end, catastrophic crack propagation takes place through the matrix pulling out the fibers from the matrix.

The composite strength of fiber-reinforced waste PET, kenauf and glass hybrid composites decrease along with the addition of the immersed day, which is due Tensile Strength of glass kenaf hybrid composite. Also, a decreased of mechanical properties, in this case, the tensile strength of composite hybrid materials of Hybrid glass kenaf Composite after immersed in water with decreasing tensile strength gradually from immersion 5, 10 to 15 days can be seen in figure 6.

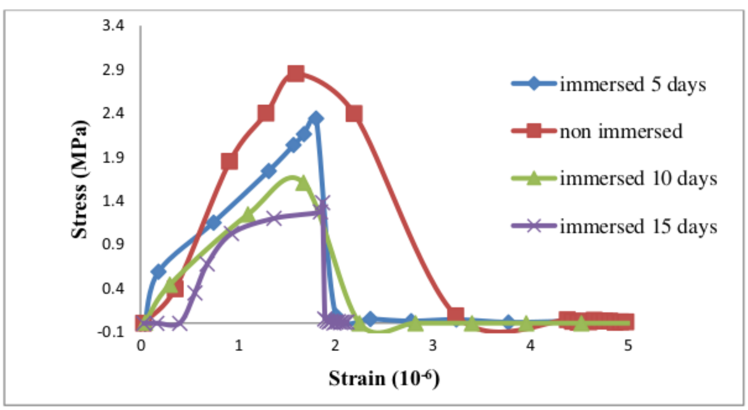

Figure 5. Tensile strength of fiber-reinforced waste PET, kenauf and glass hybrid composites.

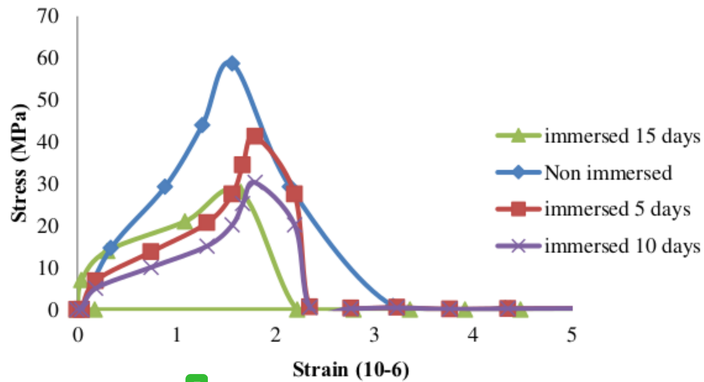

Figure 6. Tensile Strength of glass kenaf hybrid composite.

4. Conclusion

Based on the obtained data, it can be concluded that the tensile strength of waste PET glass kenaf hybrid composite decreased significantly along with the addition of immersion days. The research conducted by immersed the specimens for 5, 10 and 15 days it was found that the tensile strength of glass fiber-reinforced waste PET and kenauf hybrid composites were better than the tensile strength of the nonreinforced waste PET with the ratio of 41.37: 47.50 MPa. And after immersion for 5, 10 and 15 days decrease of the tensile strength of glass composite hybrid kenaf decreased until 57% while the comparison used of glass fiber-reinforced waste PET kenauf hybrid composites decreased to 32.78%. This means that glass mesh composite hybrids with reinforced waste PET can be used as materials for construction materials such as partition.

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