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Study of Mechanical Strength of Composite Materials Made from Marble and Sago Fiber Waste for *Rencong* Marble Souvenirs Storage

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Abstract

Kedai Kandang Village, South Kluet District, South Aceh Regency, is one of the sago-producing areas. In this study, the waste resulted from the processing of sago was used as a reinforcing material for composite materials. This research was conducted to determine the mechanical strength of the composite made from marble waste reinforced with sago fiber waste to be used as *rencong* Marble souvenir storage. The composition of the mixture in the samples used was 85:10:5, 80:10:10, 90:7.5:2.5, and 80:12.5:7.5. The mechanical strength was determined through tensile strength testing. The results of the tensile test showed that the highest tensile strength values were shown in the sample with the percentage composition of a mixture of resin, marble powder, and sago fiber, 85:10:5. The average maximum stress value obtained is 18.707 N/m². The average modulus of elasticity obtained is 1.462 N/m².

Keywords:
Composites, marble powder, resin, sago fiber, tensile test.

1 Introduction

Kandang Village is one of the villages located in South Kluet District, South Aceh Regency which has various potential agricultural commodities with the main livelihood of the local community being farmers. One of the fundamental agricultural commodities available in Kandang Village is Sago. Sago, which is also known as *Metroxylon sp.*, is a tropical wet palm plant growing in marginal land, which is native to many parts of the world, including Indonesia [1]. Sago, in Kandang Village, is used by residents through a grating process. Sago waste is a by-product of starch processing which produces three types of waste, namely cellular residues of fibrous sago pith (dregs), sago bark, and wastewater [2]. Judging from the total weight of sago stalks, the percentage of sago waste in the form of sago bark and sago pulp produced from the sago production process is about 26% and 14% respectively. Sago fiber waste contains lignin, cellulose, and hemicellulose. Lignin residue is 20.67%, cellulose is 19.55%, and the rest is extractive and ash [3]. In Kedai Kandang Village, the sago waste generated from the sago processing process is considered useless and is dumped into the South Kluet River. Consequently, improper disposal of sago waste will cause a bad impact to the environment.

On the other hand, South Aceh Regency is also known as a marble-producing area. Local marble has been processed and produced into various products with high marketability [4]. One of the latest products that have become a South Aceh Regency superior product is marble stone *rencong*. Consequently, the demand for marble stone *rencong* is very high to be used as regional souvenirs. On the other hand, the rest of the processing of marble products in the form of marble powder is still accumulated and left as waste. Therefore, the waste of sago and marble powder must be utilized into something more valuable and beneficial for the local community needs.

The results of some previous studies reported that marble powder can be utilized as a mixture of composite materials [5]–[8]. In addition to that, several studies of sago-based composites have been reported [9]-[10]. Sago waste can be used as raw material for making bio-composite materials, by taking natural fibers found in sago trees and tied with certain reinforcements [11]. Bio-composite is a material consisting of more than two materials combined to form a material that has different properties from the original material. Natural fibers can be used instead of conventional fibers such as glass and carbon. The development of composite materials from natural fibers will be more profitable than synthetic fibers. Natural fibers not only serve to increase strength but can reduce the weight of the resulting composite material. Besides being easy to obtain, natural fiber has economic value and is biodegradable [12]. This study aims to develop new materials by reducing waste, in this case waste resulted from processing Sago and marble, and the impact that it will have on the surrounding environment. In this study, waste of sago palm fiber and marble powder was used as raw materials for the manufacture of composite materials. The product will be used for marble stone *rencong* case.

2 Material and Method

This research was conducted in order to produce a composite material made from waste of marble powder and sago palm fiber. This research was carried out at the Composite Laboratory of the Study Program of Mechanical Engineering at the South Aceh Polytechnic, which lasted for 6 months. The flowchart of the research is shown in Fig. 1.

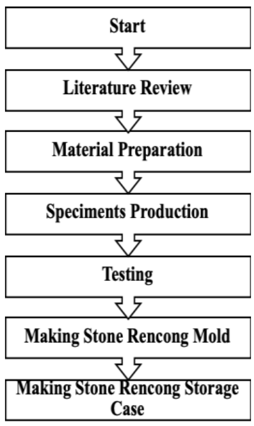

Fig. 1. The flowchart of the research.

2.1 Materials

The materials and tools used in this study were marble powder, sago fiber, and resin, specimen molds, measuring cups, wax, catalyst, 70% alcohol, stirrer container, spoon, digital scale, and 100 mesh sieves. The Marble powder was collected from Marble Processing Unit (UPT Marmer) in The Polytechnics of South Aceh. The sago fibers waste was obtained from Keude Kandang Village, South Kluet District, South Aceh Regency, and Indonesia. The epoxy resin was purchased from the local chemical supplier.

2.2 Specimens' Production

Before being used, marble powder and sago fiber were prepared through a sieving and drying process. The application of bio-composite polymers is determined by their properties, because a specific application normally requires specific mechanical properties. To determine the best mechanical strength of product, the test specimens were made by several variations in the composition of resin, marble powder and sago fiber: 85:10:5, 80:10:10, 90:7.5:2.5, 80:12.5:7.5. The specimen mold used was made of silicon rubber with size of 230 mm in long, 60 mm in wide and 30 mm in thick. Marble powder-fiber sago waste composite specimens were made by using the hand lay-up method.

2.3 Testing

Mechanical strength of the specimen test was determined through tensile strength testing. The test was carried out to determine the strength of the test specimen against a given load using a set of compressive strength test compressor machine in accordance with ASTM D 638-03 tensile testing standard [13]. A test specimen was placed in the specimen holder, and then a certain load was given. The test was carried out 3 times for each specimen composition. The results of the tensile test on the specimens will show the value of the modulus of elasticity.

2.4 Making Marble *Rencong* Mold

The Marble *rencong* mold was made of plywood material. The size of plywood used was 300 mm long, 100 mm wide and 15 mm high. The construction of the mold for the marble *rencong* storage was done by nailing each corner of the mold. The resulting mold is shown in Fig. 2.

Fig. 2. Mold of *rencong* marble souvenirs storage.

2.5 Making Stone *Rencong* Storage Case

The mold that has been made is then smeared with wax so that the dough does not stick to the mold. Materials for making molds in the form of marble powder, sago fiber, and resin are weighed and then made dough. The composition used for the mixture of marble powder, sago fiber, and resin is the composition of the test specimen with the highest tensile test results. After all the ingredients are well mixed and become dough, then the process of pouring the dough into the mold is carried out. The final step of this stage is lifting the middle *rencong* mold.

3 Results and Discussion

3.1 Test Result

The results of the tensile test on a specimen with a composition of 85:10:5 are shown in Fig. 3. Specimen test 1.1 is marked in blue, specimen testing 1.2 is marked in red and specimen test 1.3 is marked in green.

Fig. 3 shows the highest maximum stress 19.552 N/m² found in specimen test 1.1 while the lowest maximum stress 17.983 N/m² found in specimen test 1.2. The highest modulus of elasticity 3.904 N/m² found in specimen test1.1, while the lowest modulus of elasticity 0.121 N/m² obtained in specimen test 1.2. The average maximum stress value from the results of the three specimen tests is 18.707 N/m² and the average elastic modulus is 1.462 N/m². Next, the result of the tensile test result of the specimen with a composition of 80:10:10 is shown in Fig. 4.

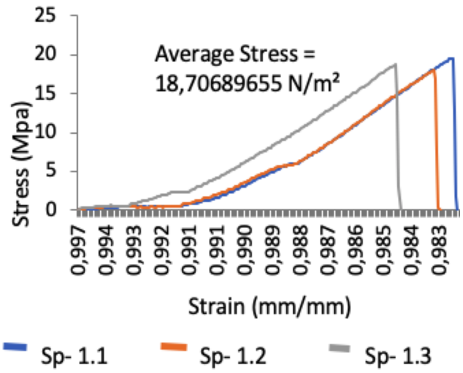

Fig. 3. The results of the tensile test of three specimens with a composition of 80:10:5.

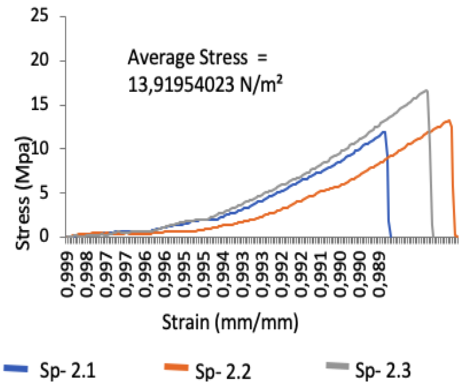

Fig. 4. The results of the tensile test of three specimens with a composition of 80:10:10.

Fig. 4 shows the results of tensile test of three specimens with a composition of 80:10:10. Specimen test 1.1 is marked in blue, specimen testing 1.2 is marked in red and specimen test 1.3 is marked in green. From the Fig. 4, it can be explained that the highest maximum stress, 16.655 N/m², occurs in specimen test 2.3, while the lowest maximum stress, 11.828 N/m², is shown by specimen 2.1. For modulus of elasticity, the highest value 0.485 N/m², is shown by specimen 2.3 while the lowest modulus of elasticity, 0.121 N/m², is shown by specimen 2.2. Based on the three specimen tests, the average maximum stress value calculated is 13.92 N/m² and the average elastic modulus found is 0.282 N/m². In addition, the results of the tensile test with the third composition 90:7.5:2.5 is shown in Fig. 5. The results of the tensile test of three specimens with a composition of 90:7.5:2.5.

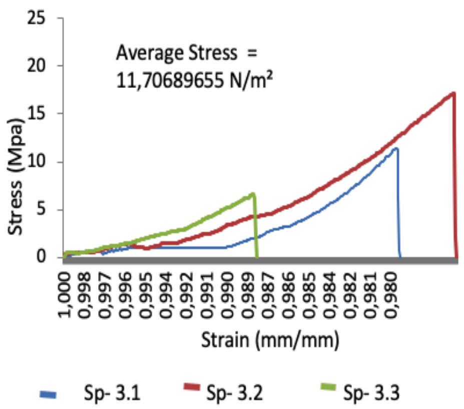

Fig. 5. The results of the tensile test of three specimens with a composition of 90:7.5:2.5.

Fig. 5 displays the results of tensile test of three specimens with a composition of 90:7.5:2.5. It can be seen that the highest maximum stress occurs in the specimen 3.2 that is 17.138 N/m². Meanwhile, the lowest maximum stress occurs in specimen 3.3 that is 6.517 N/m². For modulus of elasticity, the highest value is shown by specimen 3.1 that is 0.605 N/m², while the lowest modulus of elasticity is 3.2, 0.484 N/m². According to the results of three specimens testing, the average maximum stress value obtained is 11.707 N/m² and the average elastic modulus obtained is 0.564 N/m². The results of the tensile test with the fourth composition specimen test, 80:12.5:7.5, is shown in Fig. 6.

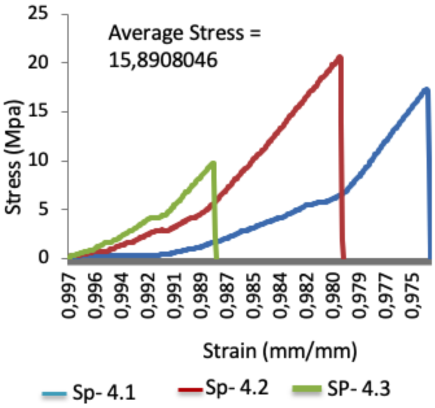

Fig. 6. The results of the tensile test of three specimens with a composition of 80:12.5:7.5.

In Fig. 6, the highest maximum stress occurs in specimen 4.2 is 20.638 N/m², while the lowest maximum stress occurs in specimen 4.3 that is 9.655 N/m² and the highest modulus of elasticity occurs in specimen 4.2 that is 0.726 N/m², while the lowest modulus of elasticity occurs in specimen 4.1 that is 0.365 N/m². Based on the three specimen tests, the average maximum stress value is 15.891 N/m² and the average elastic modulus is 0.525 N/m².

According to the data given above, it shows that the highest tensile test value was demonstrated by the test specimen with a composition of 85% resin, 10% marble and 5% sago fiber. The average maximum stress value obtained is 18.707 N/m² and the average elastic modulus value is 1.462 N/m². Generally speaking, reducing the percentage of resin used in composite material results in a decrease in the strength of the material. The resin serves as a binder between the fibers. The lower the amount of resin used, the bond between the fibers will also decrease. This will result in a decrease in the elastic properties of the resulting composite material. The value of the fracture strength of the fiber composite is directly proportional to the value of its elastic modulus. The more the number of fibers used, the smaller the value of the modulus of elasticity.

3.2 Marble *Rencong* Storage Case

The *rencong* storage case resulted from this study is shown in Fig. 7. The *rencong* storage case was made from a mixture of resin, marble powder, and sago fiber with the composition used 85:10:5. Fig. 7 shows that the composite material made from waste marble powder and sago fiber is very suitable to be applied for stone *rencong* storage case.

Fig. **7.** *Rencong* stone storage case.

4 Conclusion

Based on the results, it can be concluded that the highest tensile test value was obtained from the test specimen with a composition of 85% resin, 10% marble and 5% sago fiber. The specimens with a composition of 85:10:5 showed an average maximum stress value of 18.707 N/m² and an average modulus of elasticity of 1.462 N/m². Thus, *rencong* stone storage can be made by using a mold that is coated with a mixture of resin, marble powder and sago fiber with a composition ratio of 85:10:5.

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