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Mass variation effect of teki grass (cyperus rotundus) composite against tensile strength and density

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Abstract. The primary purpose of this study is to determine the tensile strength using ASTM D638 - 02a type IVB and density of *teki* grass (Cyperus rotundus) composite. The production process is carried out by mass variation of 2 gr, 3 gr, and 4 gr. Hand lay-up method with three repetitions is applied. Teki grass is chosen because it is easy to find and has some advantages biodegradable, harmless to health, available in large quantities, and cost-efficient. The test result showed the largest tensile strength is 21,61 MPa at 2-gram mass fiber. Fiber addition to 3 gram and 4-gram cause tensile strength decreases to 18,51 MPa and 11,65 MPa. It happens because the fibers are random and spread in all directions, so many fibers are undirectional with the tensile force. Beside that fibers addition made matrix volume reduced and a bond between fiber and matrix decreases, finally make fiber unable to hold the tensile force properly. It is recommended to use another type of ASTM D638 - 02a which has a larger narrow section like type I (13 mm) and type III (19mm) so specimens are not broken when removed from the mold, and there isn't any decrease in tensile strength.Density test showed that fiber mass does not significantly affect the density.

1. Introduction

Until now, industries remain to use synthetic fiber as their composite reinforcement materials. Synthetic fiber is specially employed in manufacturing industries of various products such as aircraft, boat hulls, wind turbine blades, car body, among others [1]. In 2009 the consumption of fiberglass around the world had reached 4 to 5 million tons per year and was expected in 2017 to reach 8.5 million tons per year [2].

Unluckily the fiberglass has some negative impacts, such as high cost, can not decompose naturally, limited, and is harmful to health [3]. Moreover, fiberglass can increase the risk of lung cancer. Since the size of fiberglass is varied, the small particles of this fiber will be inhaled if the mouth is not covered by masker and runs into the blood; meanwhile, the larger particles can irritate to skin, eyes, nose and throat. Therefore, researchers have currently attempted to find an alternative by replacing the synthetic fiber with natural fiber which has several advantages: easy to find, biodegradable, harmless to health, large availability in nature, and low cost [3].

In this study, the natural fiber used is teki grass (Cyperus rotundus) because it is not fully utilized and often found in the open fields. The teki grass is very adaptive and therefore it consists of weeds that are very difficult to eradicate. It has tubers which are capable of reaching one meter in depth, so such tubers are saved from tillage (30 cm). This grass is discovered all over the world, grows well when sufficient water is available, tolerant towards inundation, and able to withstand drought conditions. In addition, the matrix for binding the fiber is the polyester resin.

2. Research Methods

2.1 Equipments and Materials

During this research there are some equipments and materials involved, such as, print specimen with the same size as suggested by ASTM D638 - 02a type IVB [4], a tensile testing machine servo pulser, polyester resin and its hardener, teki grass (Cyperus rotundus), wax, glass coatings, gloves, measuring cups, scissors , digital scales, clippers, and other supporting equipments.

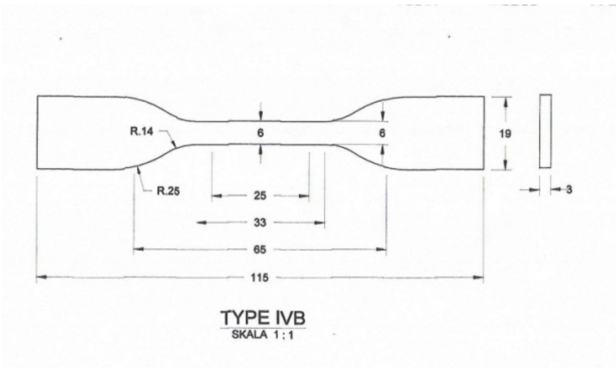


Figure 1. Tensile test specimens of ASTM D638 - 02a type IVB

2.2 Research Stages

1. The teki grass is pulled out from the ground, cleaned with water, soaked for one hour in the 5% solution of NaOH to remove the sap (lignin) and the impurities that can reduce the bond quality between the matrix and the fiber.
2. Drying the teki in the shiny sun for five days would remove its liquid.
3. After the teki is dried, it is weighed and cut into the desired size as determined in the manufacture of the specimen.
4. The metal mold is smeared with wax to make easy to remove the specimen from the mold when it becomes hardened. Glass is placed in the bottom part of the mold and is coated also smeared with wax.
5. The ratio of polyester resin and the hardener is in the range of 100: 1 and this mixture is poured into the mold.
6. Teki grass is laid down on the specimen in the fiber weight of 2 gr, 3 gr, and 4 gr.
7. Then the polyester resin is poured on the surface of the fiber.
8. Once the mixture began to thicken, resin and the glass placed on the top of the mold and pressed with ballast to eliminate the voids (air bubbles) which are trapped and to flatten the surface of the specimen.
9. Allow the specimen to become hardened for 12 hours; open the mold after 12 hours and the specimen is completely formed and ready for a tensile test.
10. The same stages are carried out to make density specimen.

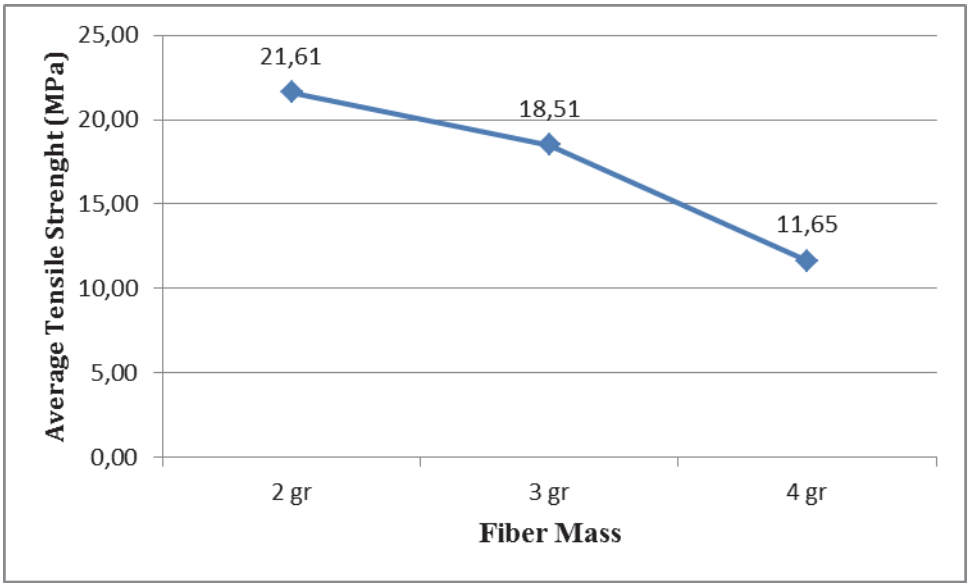
3. Results and Discussion

3.1 Tensile Test

After the specimens are removed from the mold, the next step is to hold the tensile test in which each composition is carried out three times. The test results of the tensile strength of composite specimens can be seen in table 1:

Table 1. Composite Tensile Strength

Fiber Mass	Specimen (n)	Tensile Strength (MPa)	Average Tensile Strength (MPa)
2 gr	Specimen 1	21,69	
	Specimen 2	22, 44	21,61
	Specimen 3	21,52	
3 gr	Specimen 1	19,07	
	Specimen 2	18,36	18,51
	Specimen 3	18,11	
4 gr	Specimen 1	12,12	
	Specimen 2	11,06	11,65
	Specimen 3	11,78	



The test result showed the largest tensile strength of the average is on the weight of 2 grams of 21.61 MPa. The addition of fiber weight to 3 gr and 4 gr makes the composite tensile strength decreasing to 18,51 MPa and 11,65 MPa. This happens because the fibers used are random fibers that spread in all directions so that many fibers are not unidirectional with the tensile force. Besides that, fibers addition made matrix volume reduced and the bond between fiber and matrix decreases, finally making fiber unable to hold the tensile force well.

From the observation, there are several broken specimens when removed from the mold that may occur because the specimen dimension is too small, especially in the narrow section (6 mm). So on unbroken specimens, it is estimated that there are small cracks that cause a decrease in the tensile strength. Therefore it is recommended to use another type of ASTM D638 - 02a which has a larger narrow section like type I (13 mm) and type III (19 mm).

3.2 Density Test

Soon after the specimens are removed from the mold, the following step is density test, which each composition is carried out three times with the fiber mass 2 gr, 3 gr, and 4 gr. The result showed that the lowest average density is 1,491 gr/cm^3, while the fiber mass addition to 3 gr and 4 gr only slightly raises the density to 1,586 gr/cm^3 and 1,679 gr/cm^3. It means the fiber mass addition does not significantly affect the density.

Table 2. Composite density

Fiber Mass	Specimen (n)	Mass (gr)	Volume (cm^3)	Density (gr/cm^3)	Average Density (gr/cm^3)
2 gr	Specimen 1	11,89	8	1,486	
	Specimen 2	11,93	8	1,491	1,491
	Specimen 3	11,97	8	1,496	
3 gr	Specimen 1	12,54	8	1,567	
	Specimen 2	12,73	8	1,591	1,586
	Specimen 3	12,8	8	1,6	
4 gr	Specimen 1	13,24	8	1,655	
	Specimen 2	13,61	8	1,701	1,679
	Specimen 3	13,47	8	1,683	

4. Conclusion

The largest tensile strength of 2 grams weight is 21.61 MPa.

1. Fiber addition to 3 gr and 4 gr make the composite tensile strength decreasing to 18,51 MPa and 11,65 MPa. It happens because the fibers are random and spread in all directions, so many fibers are unidirectional with the tensile force.
2. Fibers addition make matrix volume reduced and the bond between fiber and matrix decreases, finally making fiber unable to hold the tensile force properly.
3. Fiber mass addition does not significantly affect the density.
4. It is recommended to use another type of ASTM D638 - 02a which has a larger narrow section like type I (13 mm) and type III (19 mm) so specimens are not broken when removed from the mold, and there isn't any decrease in tensile strength.

References

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