IOP Conference Series: Materials Science and Engineering

PAPER • OPEN ACCESS

Mechanical Properties of Hybrid Marble Powder and Kenaf Fibre Reinforced Polyester Resin Composites

To cite this article: Nuzuli Fitriadi *et al* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **506** 012016

IOP Conf. Series: Materials Science and Engineering **506** (2019) 012016 doi:10.1088/1757-899X/506/1/012016

Mechanical Properties of Hybrid Marble Powder and Kenaf Fibre Reinforced Polyester Resin Composites

NuzuliFitriadi[1*], Lindawati[1], IsmiArdiansyah[1]
[1]Mechanical Engineering Study Program, Politeknik Aceh Selatan

*Corresponding author: nuzuli@poltas.ac.id

Abstract. Kenaf fibre is one of the strongest natural fibres in the world today. Therefore, the purpose of this study is to create a new composite of Kenaf fibres combined with marble waste powder. The incorporation of marble powders and Kenaf fibres using a matrix of a polyester resin type has never been done. Thus, this study aims to create and test various composite material composites (mixture of matrix, marble powder and Kenaf fibre) which will produce different mechanical properties and obtain good tensile strength in test specimens with several composition variations. Preparation of test specimens was carried out with 4 (four) compositions of matrix mix and marble powder; 50:50, 60:40, 70:30 and 80:20 with the weight of Kenaf fibre is fixed 2 gram. The largest tensile test value is 63,407 MPa, obtained from 80:20 composition with the largest E value 3,03GPa. The largest compression test value is 33.49, obtained from the composition of 60:40 with the largest E value of 2,35GPa. The largest bending test value is 19.80 MPa, obtained from the composition of 80:20 with the largest E value of 36,55GPa. From the research results of tensile test, compression test, and bending test which possess good value is between 60:40 and 70:30 of composition ratio.

1. Introduction

The kenaf plant (Hibiscus cannabinus L.) is a short-lived herbaceous plant-producing fibres such as hemp, roselle, and jute. The kenaf fibres are produced from the bark of the stem. In Indonesia, kenaf planting spread in Lampung, West Java, East Java, and South Kalimantan with average productivity of 0.9-1.2 tons / ha of dry fibre [1]. Low productivity leads to high competition at the farm level in obtaining the kenaf plant [2].

Kenaf fibres have been widely used in various aspect of daily life products such as for sacking raw materials, pulp materials, paper, and polypropylene composites in the polymer industry and car dashboards. In addition to environmentally friendly, kenaf fibre is also strong. The mechanical properties of kenaf pulps derived from kenaf leather with 6% sodium hydroxide (NaOH) usage have met the NUKP slurry specifications as specified in SNI 6106-1999, ie 4,24 mm long fibre, freeness 760 mL CSF, tensile index 66,54 Nm / g, crack index 5,72 kPam2 / g and tear index 18,09 mNm2/g [3].

Various study on the feasibility of using kenaf fibre have been carried out. Ishak et al. conducted comparative study of mechanical properties of short kenaf bast and core fibre reinforced unsaturated polyester composites with varying fibre weight fraction. The result showed that the kenaf bast fibre reinforced-composites had higher mechanical properties than kenaf core fibre composites. In addition, the optimum fibre content, 20%, provided the highest tensile strength for both bast and core fibre composites [4]. Other studied the mechanical properties of kenaf/polyester composites processed through vacuum infusion method. Vacuum infusion process for the kenaf-polyester composite manufactured resulted in a higher strength, low cost alternatives, and environmental friendly [5]. Investigated the mechanical properties of kenaf/polypropylene composite with variation of fibre weight and length. The result showed higher fibre length improved the impact properties of composite. Based on these related studies, it can be seen that kenaf fibre is feasible to be used with various filler combination for bio composite material development [6].

On the other hand, South Aceh District is well known for marble stone production. The marble stone has been widely produced for various home interior need, home appliances, and as a material for carving art. The activity of processing of raw stone into a valuable product produces marble waste that lead to environmental problem. Thus, this marble waste should be reused to obtain new products that have economic value. For that purpose, this study is conducted to create a new composite of kenaf fibres combined with marble waste powder.

2. Method

2.1. Manufacturing Method

Before making specimens, special treatment of kenaf fibres is previously soaked in 1% alkaline solution (NaOH) which serves to remove some contents such as lignin, oil, and protein that can cause decay in the fibre. The composition of the specimen was determined as shown in table 1. The composition differences focused on the resin and marble powder of 20%, 30%, 40% and 50%, while the use of the kenaf fibre was with a fixed composition of 2 grams. Use of 2 grams of kenaf fibre based on the volume of the mold.The steps taken in making specimens are as follows:

i. The mashed wood mold is given evenly lubricated.
ii. A catalyst of 1% of the resin volume is mixed with resin.
iii. Kenaf fibre is inserted into the mold.
iv. Resin that has been mixed with marble powder and catalyst is poured into a mold that has been stacked with kenaf fibres.
v. The composite mixture is then dried for ± 4 hours.
vi. After drying, the composite is removed from the mold.
vii. Next will be tested.

Table 1. Composition of test specimens.

No	Specimens type	Polyester Resin %	Marble powder %	Kenaf Fibre gr
1	Specimen A	80	20	2
2	Specimen B	70	30	2
3	Specimen C	60	40	2
4	Specimen D	50	50	2

Tools and materials used in this study as in figure 1.

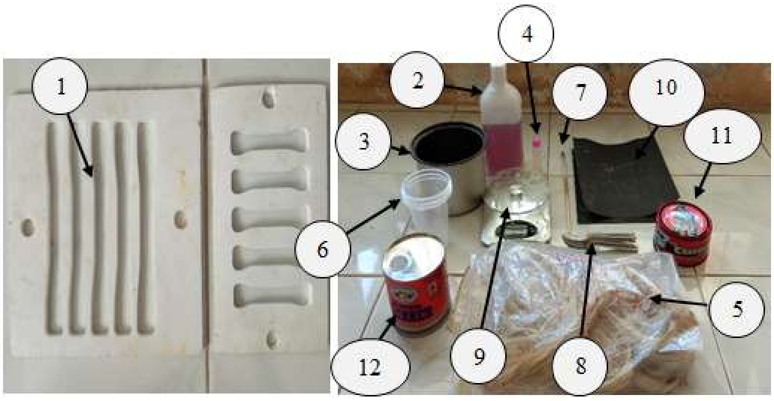

Figure 1. Materials and tools.

Image Description			
1.	Mold	7.	Brush
2.	Resin	8.	Spoon
3.	Marble Powder	9.	Digital scale
4.	Catalyst	10.	Sandpaper
5.	Kenaf fibre	11.	Wax
6.	Stirrer container	12.	Thinner

2.2. Measuring Method
After the specimen is made with the dimensions as in ASTM standard, some tests are performed as follows:

i. Tension test according to ASTM D 638-03 standard [7].
ii. Compression test according to ASTM D 695-02a standard [8].
iii. Bending test according to ASTM D790-02 standard [9].

The test equipment used in aServo Pulser test equipment located at Laboratory of Impact Research Center South Aceh Polytechnic.

3. Results and Discussion
3.1. Tensile Test
Tensile strength testing is one effort to know the material characteristics. Tensile tests were performed on 5 specimens per composition so that the average values as shown in table 2 can be obtained.

Table 2. The average yield of tensile testing.

Specimens type	Max. Stress (MPa)	Break Point Strain (%GL)	Upper Yield Stress (MPa)	Max. Load (N)	E (MPa)	E (GPa)
A	26.47	11.23	26.50	546.16	1588.12	1.59
B	33.71	13.42	48.58	513.66	2022.82	2.02
C	33.57	14.37	44.20	432.29	2014.32	2.01
D	50.53	21.86	42.80	454.62	3032.04	3.03

From the results of performed test, the maximum tensile stress is 50,53 Mpa. This number is to be found from the specimen as shown in figure 2.

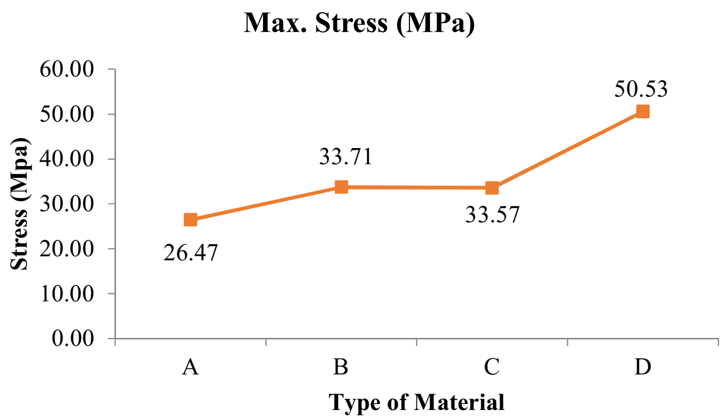

Figure 2. Maximum stress tensile test.

From the figure 2, it can be concluded that the stress is generally increased by increasing the percentage of resin content. Increasing the percentage of marble powder will reduce bonding properties of the polyester resin as a matrix to bind the kenaf fibres as reinforcement. The average of elastic modulus for this specimen is 3.03 GPa.

3.2. Compression Test
Compression strength test is one effort to know the material characteristics. Compression tests were performed on 5 specimens/composition types so that the average values as shown in table 3 can be obtained.

Table 3. The average yield of compression testing.

Specimens type	Maximum point Stress MPa	Maximum point Load N	Break point Strain %GL	Upper yield Stress MPa	Lower yield Stress MPa	Elastic modulus Gpa
A	19.03	1141.698	3.624	13.070	12.585	1.61
B	23.09	1361.352	4.586	19.518	18.063	2.35
C	24.46	1467.78	4.867	21.175	20.069	2.19
D	23.88	1432.72	6.102	18.403	17.931	1.96

From the results of this test obtained the best composition on Specimens type C with kenaf fibre as much as 2 grams of 24,46 MPa, as shown in figure 3. Average of elastic modulus for this specimen is 3,03Gpa. It is known that the more marble powder will increase the compressive strength. However, it is necessary to further study by bending so that the characteristics of this composite material can be known comprehensively.

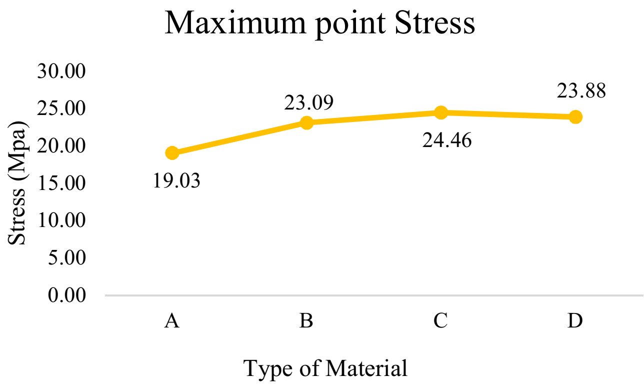

Figure 3. Maximum stress of compression test.

3.3. Bending Test

From table 4 it can be seen that there is a difference in value during bending testing.

Table 4. The average yield of bending testing.

Specimens type	Maximum point Stress MPa	Maximum point Load N	Break point Strain %GL	Upper yield Stress MPa	Elastic modulus Gpa
A	9.02	180.34	-4.93	9.65	49.88
B	11.15	223.02	4.66	9.20	33.52
C	15.91	318.16	12.18	14.80	43.87
D	17.05	341.02	8.00	15.47	36.55

The highest value is specimen D as shown in figure 4, stress point of 17,05 MPa and the lowest in specimen A with a stress of 9,02. The average stress of this composition is 13,28 MPa. Then obtained elastic modulus 36,55GPa. It is known that the more the marble powder will reduce the properties of polyester resin as the matrix but kenaf fibre as reinforcement able to increase the bending strength.

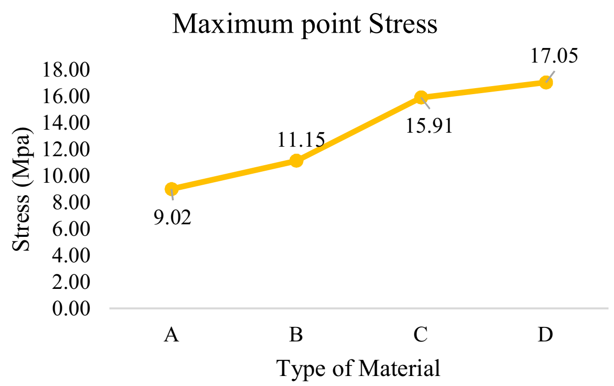

Figure 4. Maximum stress of bending test.

From the research of composite tensile test between the mixture of resin and marble powder, it is known that the highest value is specimen A with the highest value reaching 58,91 MPa, while the lowest value is specimen D with the composition kenaf fibre as much as 2 grams with value 21.35 MPa. The highest elasticity modulus is also possessed by the specimen A with a 3,03Gpa elasticity modulus value.

The results of the compressive test show that the highest value is specimen C with a value of 33,49 MPa with an elastic modulus of 2,35 GPa, whereas the lowest is specimen D with a value of 16,35 MPa and the modulus of elasticity 1,61 GPa.

The result of bending test shows that the specimen type which has the highest value is specimen A with a value of 19,80 MPa while the lowest value is specimen D with a value of 6.125 MPa.

From the result of tensile test, compressive test, and bending test all of specimen types is having ideal value will be recommended for the manufacture of the product. From the results of this study the type of specimen that has good and ideal value is specimen type A.

4. Conclusions

The conclusion of thhose 3 tests found the mechanical characteristics of this composite material are:

i. The largest tensile test value is 63,407 MPa, obtained from specimen A with the largest of elastic modulus value 3.03 GPa. The largest compression test value is 33,49, obtained from the specimen C with the largest of elastic modulus value of 2.35 GPa. The largest bending test value is 19,80 MPa, obtained from the specimen A with the largest E value of 36.55 GPa.

ii. From the research results of tensile test, compression test, and bending test which possess good value are specimen number B and C.

References

[1] Ayu Aizatul Natasa, ElzaZuhry, and Adiwirman 2016 Growth and Fibre Content of some Kenaf Varieties (Hibiscus Cannabinus L.), JOM Faperta Vol 3 No 2 pp 1-7

[2] Sudjindro 2004 Budidaya Kenaf (Hibiscus cannabinus L.) Seri Edisi Khusus Balai Penelitian Tembakau dan Tanaman Serat. Malang.

[3] Teddy Kardiansyah and Susi Sugesty 2014 Karakteristik Pulp Kimia Mekanis dari Kenaf (hibiscus cannabinus l.) Untuk Kertas Lainer *Jurnal Selulosa* Vol 4 No 1 Juni 2014 pp 37-46

[4] Ishak M R, Leman Z, Sapuan S M, Edeerozey A M M and Othman I S 2010 Mechanical properties of kenaf bast and core fibre reinforced unsaturated polyester composites. IOP Conf. Series: Materials Science and Engineering 11 of 9th National Symposium on Polymeric Materials (NSPM 2009).

[5] Moh Yuhazri, Phongsakorn Y P T, Haeryip Sihombing, Jeefferie A R, Puvanasvaran Perumal, Kamarul A M and Kannan Rassiah 2011 Mechanical Properties of Kenaf/Polyester Composites, International Journal of Engineering & Technology IJET-IJENS Vol: 11 No: 01.
[6] Loh X H, Mohd Daud M A, and Selamat M Z 2016 Mechanical properties of kenaf/polypropylene composite: An investigation, *Journal of Mechanical Engineering and Sciences* (JMES, Volume 10 Issue 2 pp 2098-2110
[7] Tension test according to ASTM D 638-03 standard.
[8] Compression test according to ASTM D 695-02a standard.
[9] Bending test according to ASTM D790-02 standard.