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Effect of Tapioca Starch Concentration on Mechanical Properties of Sansevieria Trifasciata Fiber-Reinforced Composites

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Abstract. *The addition of fiber to composites is an effort to increase mechanical strength; however, the use of natural fibers as reinforcement in composites still experiences various problems. This article aims to determine the effect of adding concentration of tapioca starch (Manihot esculenta starch) on the mechanical characteristics of composites using mother-in-law's tongue (Sansevieria trifasciata) fibers. The composite was made using the hand lay-up method, and the composite used SHCP 2668 polyester resin matrix, mekpo catalyst, mother-in-law's tongue fiber (Sansevieria trifasciata), and tapioca starch (Manihot esculenta starch) as reinforcement. The fiber alkali treatment used is 5% NaOH, while for weighing the fiber using a fiber weight fraction of 30%, weighing the catalyst using 10% of the total weight of the specimen mass, and making this composite using varying concentrations of tapioca starch (Manihot esculenta starch): 0%, 10%, 20%, 30%, 40%, 50%, with a weight of 100% total matrix mass of 50 grams, The specimen tests in this study used tensile tests and bending tests, with tensile tests using the ASTM-D3039 standard and bending tests using the ASTM-D790 standard. From tensile testing and bending or bending testing Good tensile strength values with a high modulus of elasticity were obtained from composites with the addition of tapioca starch concentration (manihot esculenta starch), while good buckling or bending strength values with a high elastic modulus were obtained from composites without an additional concentration of tapioca starch (manihot esculenta starch) or the original specimen. So it was concluded that the results for the tensile test would be good if the composite was made using an additional concentration of tapioca starch where the strength of the composite material would be stronger, but on the other hand, the addition of a concentration of tapioca starch was not good for bending or bending tests where the results of the bending or bending test were better without additional concentration. tapioca starch because it is more elastic.*

Keywords- *Sansevieria Trifasciata, Amilum Manihot Esculenta, SHCP 2668 Polyester Resin, ASTM-D3039, ASTM-D790, Hand Lay Up Method.*

I. INTRODUCTION

Composite technology is currently increasingly developing, one of which is reinforced composites, both laminate composites, particle composites, and fiber composites. The condition for the formation of a composite is that there is a surface bond between the matrix and the filler. This inter-surface bond occurs due to adhesion and cohesion forces. In composite materials, adhesion-cohesion forces occur in three main ways: interlocking between surfaces, electrostatic forces, and Vanderwall forces.[1]. The advantages of composite materials are that raw materials are easy to obtain, resistant to corrosion, easy to design, have a longer service life, can be recycled, have high durability, are able to absorb heat, and are economical.[2]. One of the fiber composites is the most widely developed, using both fiber and plant fibers. One of the most developed is composite technology using plant fibers; apart from being easy to find, the material is also easy to find. Natural fibers have been tried to replace the use of synthetic fibers, such as Boron, Aluminum Oxide, Graphite/Carbon, Kevlar-49, Silicone Carbide, and E-Glass. Even though it doesn't completely replace it, the use of natural fibers instead of synthetic fibers is a wise step in saving the environment from waste produced and limited non-renewable natural resources.[3].

Adding fibers to composites is an effort to increase mechanical strength. Fiber composites are divided into two categories: natural fiber composites and synthetic fiber composites. Natural fibers have environmentally friendly properties that can be used as an effective alternative reinforcing phase in polymer composite materials compared to synthetic fibers[4]. Sansevieria, or mother-in-law's tongue, is an ornamental plant that is commonly used to decorate the interior of a room or house because this plant can grow in conditions with little water and sunlight. Sansevieria has hard, upright leaves with sharp or pointed tips. This plant can absorb dangerous pollutants in the air because it contains the active ingredient pregnan glycoside, which is helped by opening the leaf stomata during the day, and there is osmotic pressure, which functions to reduce pollutants.[5].*Sansevieria* has the ability to absorb pollutants or toxins in the air, including benzene, trichloroethylene, formadehyde, and carbon monoxide[6].The mother-in-law's tongue plant also has great potential as an agricultural pest control because it obeys[7]. The mother-in-law's tongue plant (Sansevieria trifasciata) contains flavonoids, triterpenoids, saponins, and steroids, namely natural metabolites that have the potential to control agricultural pests. Basically, this plant fiber has the potential to be used as a reinforcement because it has quite good mechanical properties, but it has not yet been widely researched or studied in its application as a composite reinforcement.[8]. According to[9],taking plant fiber goes through several stages, namely bleaching, fiber extraction (degumming), and fiber decomposition. The use of natural fibers as reinforcement for composite materials still causes various problems. The disadvantages of natural fibers as composite reinforcements include hydrophilic properties, low mechanical properties, limited processing temperatures, low binding force of the matrix and fiber, and being easily degraded.[10]. To go beyond this, research has begun to be carried out to improve the properties of natural or plant fibers as reinforcements in composites. According to research[11], Natural fibers contain lignocellulose, which is hydrophilic because it contains many hydroxyl groups. According to[12]NaOH (Sodium Hydroxide) soaking treatment on mother-in-law's tongue fibers had a significant effect on the elastic modulus value. The fiber was soaked in a 5% NaOH solution for 120 minutes to remove the lignin layer on the fiber[13].By removing this wax layer, the bond between the fiber and the matrix will become stronger, resulting in a higher tensile strength of the composite.[14]

Apart from improving the properties of the fiber, it is also done to increase the adhesive power of the fiber, one of which is using a mixture of materials. Starch, or starch, is a complex carbohydrate that is insoluble in liquid, in the form of a white powder, tasteless, and odorless. Starch has the chemical formula $(C_6H_{10}O_5)_x$. One of the most commonly used starches is cassava starch. Cassava starch has the ability to act as a better binder compared to corn starch and potato starch.[15]. Cassava (Manihot esculenta Crantz) is a tuber plant that is easy to grow in tropical areas, including Indonesia. Cassava is the third staple food source in tropical countries after rice and corn. Cassava tubers are generally used in the form of starch or flour[16]. Cassava starch can function as a filler, binder, and crusher[17]. Cassava starch, or Manihot esculenta starch, commonly called tapioca starch, is generally used as a food ingredient, and tapioca starch is very useful, especially if used as a source of carbohydrates. This flour also contains glucose, which is the main source for the body. Tapioca starch is an organic material from cassava starch that contains polysaccharides, so it can be used as an adhesive because it forms a fairly strong layer.[18]. Tapioca starch (Manihot esculenta starch) is used as a reinforcement in the composite to be made. The adhesive properties of the starch are expected to maximize the bonding force of the matrix in the composite. The matrix used in making this composite is SHCP 2668 polyester resin and mekpo catalyst. This research on making composites using mother-in-law's tongue fiber (Sansevieria rifasciata) and adding a concentration of tapioca starch (Manihot esculenta starch) used tensile tests with the ASTM D-3039 standard and bending or bending tests with the ASTM D-790 standard. The principle of the tensile test is to apply a regular and uniform tensile load to a test object of a certain size[19]. while the bending or bending test is carried out by means of a rod-shaped specimen being supported on both sides, then a load is applied between the two supports until the specimen breaks.[20].

Figure: For the tensile test, it was found that the highest tensile stress value was shown in the specimen (20%), namely 22.3 6 N/mm2. And the highest strain value is shown in the specimen (0%), namely 0.1802. Meanwhile, the highest elastic modulus value was shown in the specimen (20%), namely 203.6 N/mm2. For the bending test, the highest bending stress value was obtained in the specimen (0%), namely 519.149 N/mm2, and the highest modulus of elasticity value was shown in the specimen (0%), namely 4.512 MPa.

There is also research on composites reinforced with Arengga pinnata fiber with an epoxi matrix that shows that the tensile and bending properties of composites reinforced with Arenga pinnata fiber show that specimens with a volume fraction of 60% : 40% and a fiber orientation of 0° produce the most optimum test values for both tensile and bending tests. where the highest average values of tensile and bending strength are 56.99 MPa and 85 MPa, and the highest average values of tensile and bending elastic modulus are 1,914 GPa and 3.89 GPa[21]. There is also research on making test specimens with thorn pandan fiber and polyester resin in accordance with the tensile test standard ASTM D3039. The results of the research show that the maximum tensile strength value is when the composite composition is 40% by weight of polyester resin and 60% by weight of thorny pandan fiber, namely 0.45 Kg .f/mm2 with an average maximum load value that can be withheld of 43.87 Kg.f[22].

II. METHODS

This is experimental research with the aim of investigating the effect of adding tapioca starch concentration on the strength of composite engineering using sansevieria fiber. The matrix used is SHCP 2668 polyester resin, and the sansevieria fiber used is treated with 5% NaOH and a fiber weight fraction of 30%, and the fiber is cut to a size of ±1 cm. The total mass weight of the specimen is 50 grams, where only the weights of the resin and tapioca starch are calculated, while the weights of the fiber and catalyst are not counted in determining the mass weight of the specimen. For fiber, use a weight of 0.95 grams and a catalyst weight of 10% of the total weight of the specimen mass (5 grams). The addition of tapioca starch starts at varying concentrations of 0%, 10%, 20%, 30%, 40%, and 50%. In making this article, the research process was carried out in the mechanical engineering and food technology laboratory at the Muhammadiyah University of Sidoarjo, while material testing was carried out at the Malang State Polytechnic. Experimental methods include data collection methods and composite printing methods.

The materials used include SHCP 2668 polyester resin, mekpo catalyst, Sansevieria trifasciata fiber, and tapioca starch. Meanwhile, the tools used include specimen molds made from RTV 48 silicon, digital scales, plastic cups, and others. This article uses an equation that can be calculated in its research, including: making NaOH or 5% alkali treatment by mixing 500 ml distilled water and 25 gram NaOH, which is written in the following equation:

$$gr = Alkaline\ treatment \times v = \ldots (grams)$$

Then we can know the dosage of NaOH and distilled water in making alkali with 5% treatment, while for the volume fraction of fiber using the following equation:

$$Vf = = \frac{Wf/_{Pf}}{Wf/_{Pf} + Wm/_{Pm}} \text{..............(\%) ......(1)}$$

And making composites uses the following equation:

a. Find the mass of the matrix / weight of the matrix

   Mk-Va=.......grams ....(2)

b. Looking for concentration variation (%)

   $\frac{\text{Mamilum}}{Mk}$ x 100% =…% ………………….(3)

c. Find the mass/weight of starch

   Vk% = $\frac{Vk}{100}$ x Mk = …. Grams…………...(4)

After doing the calculations, you get 45 grams of polyester resin and 5 grams of starch flour, or use a varying concentration of 10% tapioca starch. In the composite printing process, the mold is made from RTV 48 silicon with a mold size of 3cm by 20cm and a thickness of 5mm.

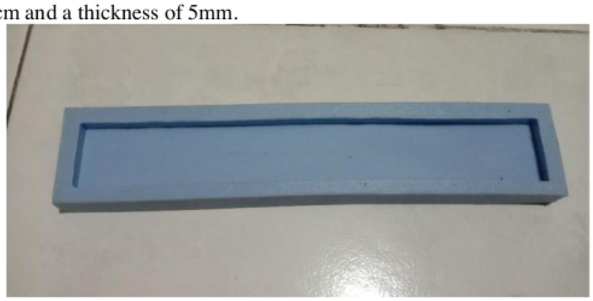


Figure 1. Specimen mold

After the process of calculating the composition of the materials for making the composite, the next thing to do is weigh all the materials, followed by the mixing process using the resin sequence→Tapioca starch→Sansevieria fiber→Catalyst.

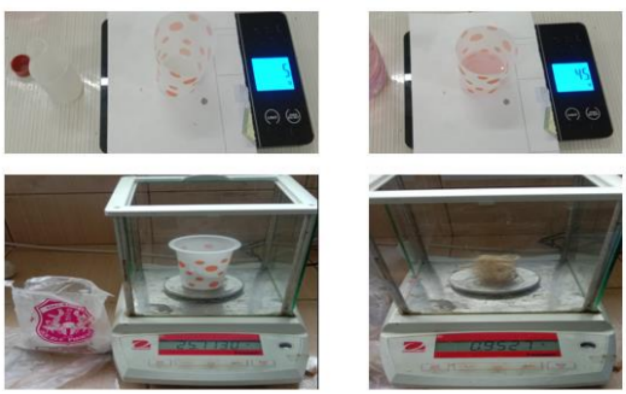


Figure 2. Weighing ingredients

Figure 3. The process of mixing all ingredients

Figure 4. The material is poured into the mold

Next, what is carried out is the drying process where the drying process, is carried out using room temperature with a drying time of approximately 24 hours, and the drying results are obtained by visual observation as in table 1.

No	Starch Flour Variations	Specimen Condition
1	0 %	• Drying time within 24 hours • Visually, the specimen has no voids/bubbles • Drying of specimens was carried out indoors • The condition of the specimen surface is hard and slightly sticky • The condition of the specimen in the lower area is hard and sticky
2	10 %	• Drying time within 24 hours • Visually, the specimen has no voids/bubbles • Specimen drying was carried out indoors • The condition of the specimen surface is hard and sticky • The condition of the specimen in the lower area is hard and sticky
3	20 %	• Drying time within 24 hours • Visually, the specimen has no voids/bubbles • Specimen drying was carried out indoors • The condition of the specimen surface is hard and sticky • The bottom area of the specimen mold is sticky
4	30%	• Drying time within 24 hours • Visually, the specimen has no voids/bubbles • Specimen drying was carried out indoors

		• The condition of the specimen surface is hard and slightly sticky • The condition of the bottom specimen is hard and sticky
5	40%	• Drying time within 24 hours • Visually, the specimen has no voids/bubbles • Specimen drying was carried out indoors • The condition of the specimen surface is hard and slightly sticky • The condition of the bottom specimen is hard and sticky
6	50%	• Drying time within 24 hours • Visually, the specimen has no voids/bubbles • Specimen drying was carried out indoors • The condition of the specimen surface is hard and slightly sticky • The condition of the lower specimen is fragile and slightly sticky

Table 1. Specimen condition data after the drying process

After the specimen drying process, t 8 next thing to do is form the specimen according to the test standards carried out, namely according to the shape of the ASTM D-3039 tensile test specimen and the ASTM D-790 bending test specimen.

Figure 5 Test Object Specimens

After forming the specimen, the condition or visual observation of the specimen is obtained as in table 2.

No	Variations of Tapioca Starch Flour	Specimen Condition
1	0%	There are no voids and homogeneous
2	10%	There are no voids and homogeneous
3	20%	There are no voids and homogeneous
4	30%	There are voids and heterogeneous
5	40%	There are voids and heterogeneous
6	50%	There are voids and heterogeneous

Table 2 The condition of the specimen after being formed

In tensile testing, parameter data will be obtained, and the results can be used to calculate stress, strain, and the tensile modulus of elasticity. So to calculate them, use the following equation:

a. Cross-sectional area

$A0 = t \times l$ ....(5)

Information:

$A0$ = Initial Cross-sectional Area ($mm2$).
t = Thickness (mm)
l = Width (mm)

b. Stress (Tension)

$$\sigma = \frac{P}{A0} \quad \text{...(6)}$$

or

$$\sigma = \frac{P \times 9.81}{A0} \quad \text{...(7)}$$

Information:

P = Load (Kgf).
$A0$ = Initial Cross-sectional Area ($mm2$).
σ = Voltage (Kgf/$mm2$).
9.81 = 1 kgf to Newton

c. Strain (Strain)

$$\varepsilon = \frac{\Delta L}{L0} \times 100\% \quad \text{...(8)}$$

Information:

ΔL = Difference in Length Increase
$L0$ = Initial Length.
ε = Strain (%)

d. Modulus of Elasticity

$$E = \frac{\sigma}{\varepsilon} \quad \text{...(9)}$$

Information:

σ = Voltage (Kgf/$mm2$).
E = Strain (%).

For bending or bending tests, the data parameters are obtained using the following equation:

a. Calculation of bending modulus of elasticity

$$Eb = \frac{1\ x\ L^3 x\ P}{4\ x\ bd^2 x\ \sigma} \quad \text{...(10)}$$

Eb = Bending modulus of elasticity
P = Load (N)
L = Length between bottom support points (mm)
σ = Bending stress (Mpa)
b = Width of test object (mm)
d = Thickness of the test object (mm)

b. Three Point Bending Calculation

$$\sigma = \frac{3PL}{2bd^2} \quad \text{...(11)}$$

Formula description:

σ = Bending stress (kgf/mm2)
P = Load or Force that occurs (kgf)
L = Point distance (mm)
b = Width of test object (mm)
d = Thickness of the test object (mm)

From the equations above, the results obtained can be used to draw curves or graphs for both tensile test results and bending tests.

III. RESULTS AND DISCUSSION

From the research process of making composites using sansevieria fiber with 5% NaOH treatment, a 30% fiber weight fraction and fiber cut to a size of ±1 cm, and with a SHCP 2668 polyester matrix with the addition of a concentration of tapioca starch (manihot esculenta starch) varying from 10%, 20%, 30%, 40%, and 50%. So the data obtained will be presented in tabular form to make it easier to observe the results that have been obtained, as shown in Table 3 below for tensile test results:

No	Specimen & Concentrati	P(N)	σ (N/m m2)	Δl (mm)	ε	E (N/mm2)

	on variations					
1	1 (0%)	998,316	19,198	9.01	0.1802	106.6
2	2 (10%)	1159,146	22,291	6.81	0.1362	163.6
3	3 (20%)	1163.06	22,366	5.49	0.1098	203.6
4	4 (30%)	702,156	13,503	6.15	0.123	109.7
5	5 (40%)	741,382	14,257	4.39	0.0878	162.3
6	6 (50%)	466,796	8,976	2.86	0.0572	156.9

Table 3 Tensile test results data

Table 3 is data from tensile test specimens, starting from specimens without an additional concentration of tapioca starch (manihot esculenta starch) or 0% to with the addition of tapioca starch concentration (manihot esculenta starch) varying from 10%, 20%, 30%, 40%, and 50%. This data is the result of tensile testing, which consists of the load received, elongation, stress, strain, and modulus of elasticity. From this data, a diagram is then created as follows:

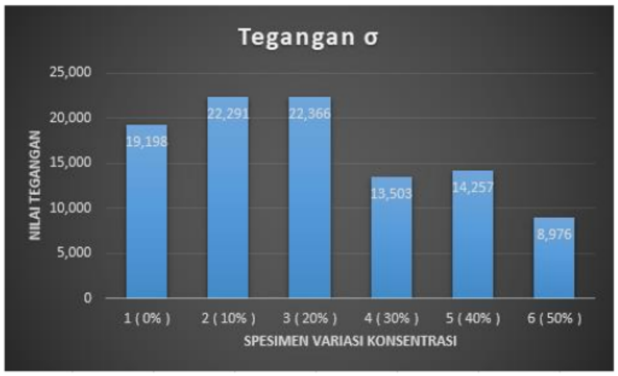


Figure 6 Tensile Test Stress Line Graph

From Figure 6 above, the highest tensile stress value is shown in specimen 3 (20%), namely 22.366 N/mm2. while the lowest tensile stress value was shown in specimen 6 (50%) with a value of 8.976 N/mm2.

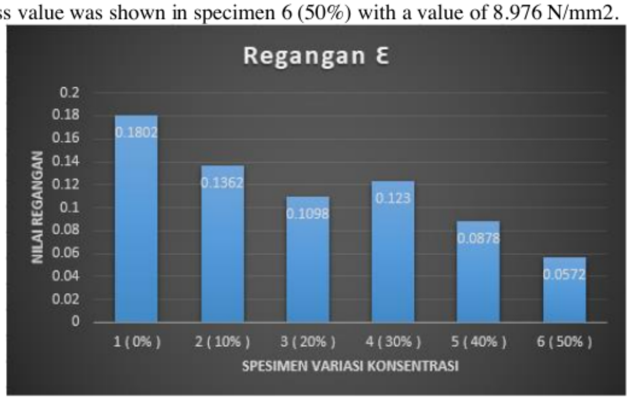


Figure 7 Tensile Test Strain Line Graph

From Figure 7, it can be seen that the highest strain value is shown in specimen 1 (0%), namely 0.1802, while the lowest strain value is shown in specimen 6 (50%) with a value of 0.0572.

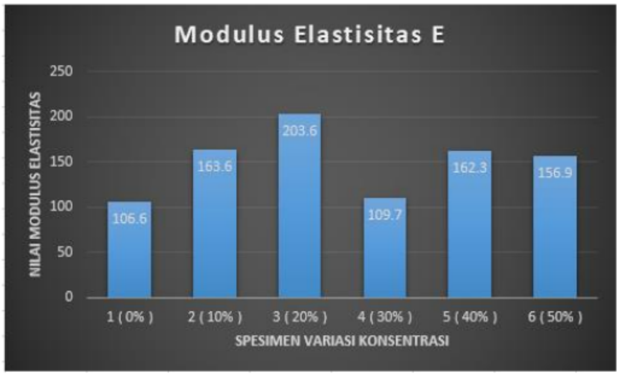


Figure 8 Tensile Test Modulus of Elasticity Line Graph

From Figure 8, it is found that the highest elastic modulus value is shown in specimen 3 (20%), namely 203.6 N/mm2. while the lowest elastic modulus value was shown in specimen 1 (0%) with a value of 106.6 N/mm2.

In the tensile test results of the specimens, each specimen is analyzed to determine how high and low the values are on the specimen, as shown in the table below. The image of the specimen is taken by lining it with a size of 2 cm, as in Table 4 and the following description:

Image of tensile specimen	**Variation**	**Information**	**Fracture image of tensile specimen**	**Information**
	0%	There are no voids		In a fault there are no voids
	10%	There are no voids		In a fault there are no voids
	20%	There are no voids		In a fracture there are no voids but there are lumpy fibers

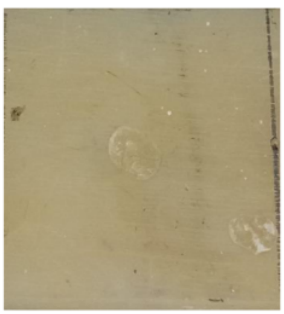
	30%	There are 30 small and medium sized voids		In the fault there is a medium sized void
	40%	There are 20 small and medium sized voids		In the fracture there are small voids and lumpy fibers
	50%	There are 8 medium and large size voids		In the fault there is a void of large size

Table 4 Image of specimen and fracture of tensile test specimen

And the bending test results data are as follows:

Specimen	P(N)	σ (N/mm2)	*L*(mm)	Eb (Mpa)
0%	107,873	519,149	61.70	4,512
10%	82,375	131,203	20.42	0.494
20%	66,685	142,779	27.45	0.893
30%	56,878	179,233	40,40	1,934
40%	43,149	35,473	10.54	0.131
50%	43,149	35,473	10.54	0.131

Table 5 Bending Test Result Data

From table 5 above, the results of bending or bending tests for specimens ranging from 0% to 50% are obtained, which contain the value of the load received, bending stress value, strain distance, and bending modulus of elasticity. From this data, a diagram is then created as follows:

Figure 9 Bending Test Curved Stress Line Graph

From Figure 9, it is found that the highest bending stress value is shown in specimen 1 (0%), namely 519.149 N/mm2. while the lowest bending stress value was shown in specimens 5 (40%) and 6 (50%) with the same value, namely 35.473 N/mm2.

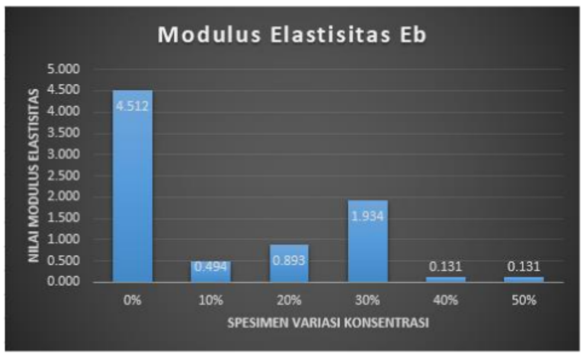
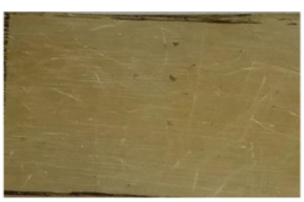


Figure 10 Bending Test Modulus of Elasticity Line Graph

In Figure 10 above, it is found that the highest elastic modulus value is shown in specimen 1 (0%), namely 4.512 MPa, while the lowest elastic modulus value is shown in specimens 5 (40%) and 6 (50%) with the same value, namely 0.131 MP

Based on the results of the bending or bending test of the specimen, each specimen is analyzed to determine how high and low the value of the specimen is, as shown in the table below. The image of the specimen is taken by lining it with a size of 2 cm, as in Table 6 and the following description:

Image of bending specimen	**Variation**	**Information**	**Image of bending specimen fracture**	**Information**
	0%	There are no voids		In a fault there are no voids
	10%	There are no voids		In a fault there are no voids

	20%	There are 15 small voids		In the fault there are small voids
	30%	There are 45 small and medium sized voids		In the fracture there are small voids and clumped fibers
	40%	There are 22 medium and large voids		In the fault there are small voids
	50%	There are 10 medium and large size voids		In the fault there is a void of large size

Table 6 Image of specimen and bending test specimen fracture

IV. CONCLUSION

Based on the results of composite engineering research using sansevieria fiber or mother-in-law's tongue plant by immersion in 5% NaOH and a fiber weight fraction of 30% with SHCP 2668 polyester matrix and the addition of varying concentrations of tapioca starch (0%, 10%, 20%, 30%, 40%, and 50%), starting from making composites to tensile tests and bending tests. So it can be concluded that the nature of the tensile test and bending test greatly influences the value of the elastic modulus. In the results of the tensile test, if the concentration of tapioca starch is added, then the modulus of elasticity value is high, inversely proportional to the value of the modulus of elasticity of the buckling or bending test, whereas if the concentration of tapioca starch is added, then the value of the modulus of elasticity is low. So the results will be good for the tensile test if the composite is made using an additional concentration of tapioca starch, where the strength of the composite material will be stronger, but on the other hand, the addition of tapioca starch concentration is not good for bending or bending tests, where the results of the bending or bending test are better without the addition of flour concentration. tapioca starch because it is more elastic.

THANK-YOU NOTE

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