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Tensile, Bending Testing on Straw Fiber Composites 0^0 and 90^0 Angle Orientations with Polyester Matrix

Gugun Gundara[1]*, Nifal Nugraha[2], Acep Wagiman[3]

Teknik Mesin, Universitas Muhammadiyah Tasikmalaya

Corresponding Author: Gugun Gundara mesin.irama@gmail.com

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ABSTRACT

Currently, the development of science and technology continues to develop in all fields, such as vehicle construction, building construction, industry, and also the field of materials engineering, especially composites. Composite materials generally consist of two elements, namely fibers as a filler and a binding material for these fibers which is called a matrix. In composites, the main element is fiber, while the binding material uses polymer material which is easy to form and has high binding power. The aim of this research is to determine the effect of straw fiber length oriented at 0° and 90° angles in polyester matrix composites on tensile and bending strength. The influence of straw fiber length provides a value for maximum tensile strength with a value of 28.604 Mpa with a fiber length of 15 mm and an angle of 0°. Meanwhile, the angle direction of 900 has a greater value at a fiber length of 10 mm, amounting to 19.619 MPa. The influence of straw fiber length provides a value for maximum bending strength with a value of 86.29 MPa with a fiber length of 10 mm and an angle of 0°. Meanwhile, the maximum tensile strength value at an angle of 900 with a fiber length of 15 mm is 40.02 MPa

INTRODUCTION

Currently, the development of science and technology continues to develop in all fields, such as vehicle construction, building construction, industry, and also the field of materials engineering, especially composites. This development cannot be separated from the increasing need and scarcity of materials available in nature. The use of materials for industry still relies heavily on non-renewable metal materials. Therefore, replacement materials are needed that can be renewed and have mechanical properties that can offset the advantages of metal materials [1].

One of them concerns fiber-reinforced composites, whether from variations of matrix as a binder or fiber as a reinforcing material, woven types to matrix and fiber base materials. Research is also developing on the use of natural fiber materials for several variations of synthetic and natural matrices. Natural fiber-reinforced composites are increasingly being intensively developed in connection with their use in various areas of life as well as demands for the use of materials that are cheap, easy to obtain, light, have strong mechanical properties, are corrosion resistant and are environmentally friendly, so that they can become alternative materials other than metal and glass fiber. not environmentally friendly [2].

Composites have superior properties such as lightness, strength, resistance to corrosion, and the raw materials are available in large quantities. The fibers used in composite materials are divided into two, namely natural fibers and synthetic fibers. Synthetic fibers are made in industry with certain dimensions and are homogeneous, such as glass fiber, gravite and Kevlar. Meanwhile, natural fibers are fibers produced from animals, plants and geological processes. Composite materials generally consist of two elements, namely fiber as a reinforcing material and resin as a fiber binding material. From this mixture, composite materials are produced which have mechanical properties and characteristics that are different from those of the constituent materials [1].

Previous research showed that the influence of natural fiber provides added value to the strength properties of materials, especially straw fiber. Straw fiber influences the elastic modulus value. The effect of rice straw fiber produces 4427.4030Mpa. It can be interpreted that straw fiber has the least influence on the properties of the composite materials tested. Specimens added with rice straw fiber with a test sample size of 20 x 8 x 400 mm [3].

The length of straw fibers affects the tensile stress value in the composite [4]. This was demonstrated by testing a sample that added straw fiber with a length of 3 mm. The addition of straw fiber with 3 mm and 5 mm showed a higher tensile stress value compared to the tensile stress in the non-straw fiber composite. Apart from that, the sample with the addition of 5 mm straw fiber showed the most optimum value, namely 12.17 MPa. This is caused by the bond between the matrix and filler being well connected. The 7 mm sample shows a lower value compared to the value for the 3 mm, 5 mm and fiberless samples.

The results of research [5] produced tensile strength with a volume fraction of 30%, 40%, and 50% respectively, namely 25,631 MPa, 16,465 MPa, and 12,277 MPa with an elastic modulus of 2,178 GPa, 3,254 GPa, and 3,391 GPa, with type fiber orientation unidirectional Lamina with an angle of 90°, and for fiber orientation type unidirectional Lamina with an angle of 0°, with a volume fraction of 30%, 40%, and 50% respectively are 139,219 MPa, 223,392 MPa, and 248,677 MPa, respectively. 6,326 GPa, 6,781 GPa, and 8,301 GPa.

Based on the results of previous research, further research was carried out by testing the effect of straw fiber angles of 0° and 90° made with a volume fraction of 30% on the length of straw fibers made in varying polyester matrix composites by testing tensile and bending strength.

METHODS

The test carried out to determine the tensile and bending strength using the research method is using the experimental method, which is a way to look for a causal relationship between two influencing factors.

Materials Used

The materials used in this research are:

1. Epoxy Resin
2. Straw Fiber
3. Catalyst
4. Mirror glaze functions as a coating between the mold and the composite so that the composite can be easily removed from the mold.

Tools Used

The tools used in the research include:

1. Digital scales to measure the mass of resin and fiber.
2. Molds made of glass, to form tensile and bending test specimens.
3. Measuring cup.
4. Vernier caliper.
5. Scales (per gram).
6. Universal Testing Machine for tensile testing.

Research Procedure

The research procedure is divided into 4 (four) stages, namely:

1. Fiber preparation.
2. Composite printing and pressing.
3. Post-curing and finishing of test specimens.
4. Testing and data processing.

Composite Molding and Pressing

The composite manufacturing process is carried out using the hand lay-up method. The steps are as follows:

1. Prepare several molds made of acrylic, then clean them of all kinds of dirt and dust.
2. The weight of the resin is weighed based on the total volume of the mold according to the fiber volume fraction.
3. The weight of the resin has been measured, transferred to a plastic glass container.
4. Next, the resin is mixed with the catalyst according to the specified size.
5. One surface of the mold has been wetted with a mixture of resin and catalyst. Next, a layer of fiber is prepared which will be attached to the mold which has previously been cut into pieces and cleaned.
6. After the straw fiber layer has been attached according to the direction of the fibers and the length of the fibers, pour back the remaining resin, then spread it slowly to avoid the formation of voids (air bubbles) in the matrix.
7. Then dry for several hours. When the composite material is dry, it is removed from the mold and further dried in the open air until the material is completely hardened.
8. Repeat the steps above for variations in fiber direction and other fiber lengths. The standards used for specimens are:

a. Tensile test using ASTM D 638 standard

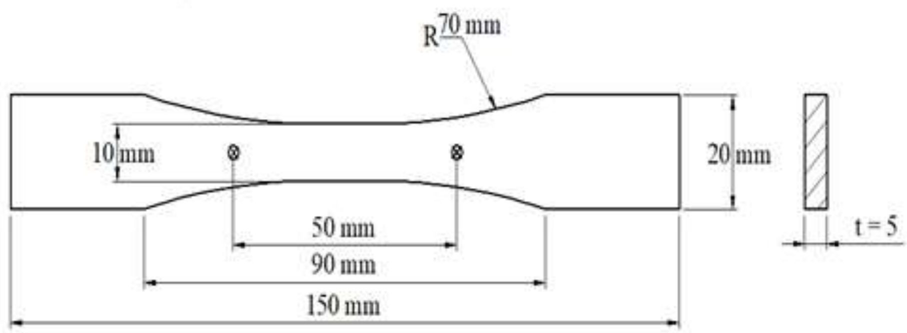

Figure 1. Geometry of Tensile Test Specimens

a. Bending testing uses ASTM D790 standards

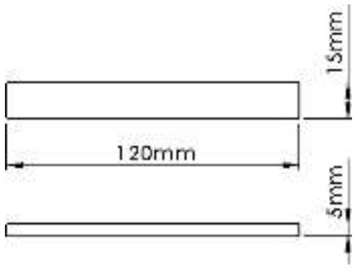

Figure 2. Bending Test Specimen

a. Test Specimen

The specimens made consisted of tensile and bending test specimens with a fiber volume fraction of 30%. Where the variable used is fiber length, namely 10 mm and 15 mm for each specimen with fiber directions 00 and 900.

Testing Process Flow Diagram

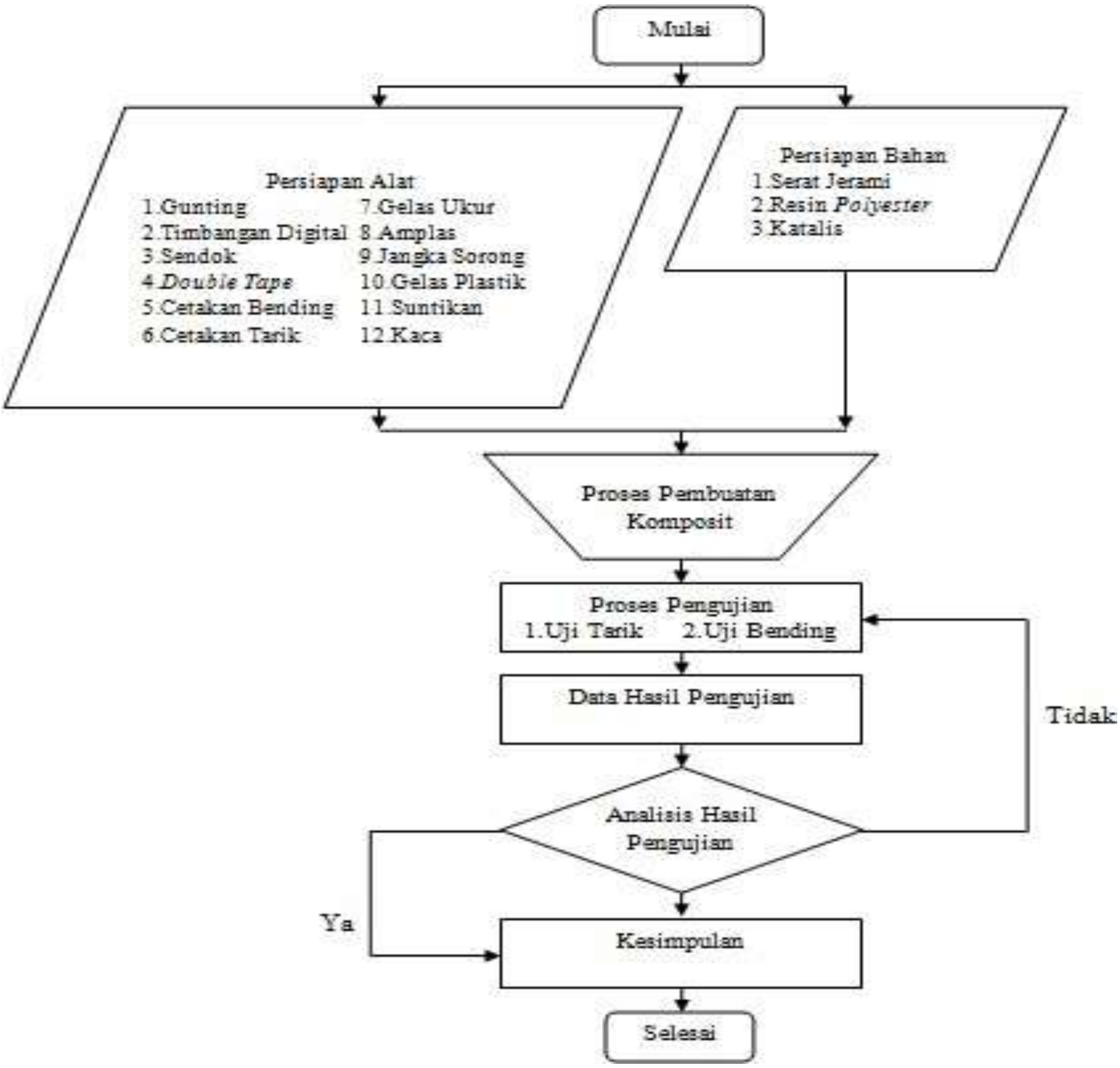

Figure 3. Research Process Flow Diagram

RESULTS

This research uses a natural fiber composite, namely straw fiber. The number of test specimens prepared was 32 (thirty two) pieces. The tests carried out were tensile and bending tests, for each research variable the number of specimens was 4. The fiber volume fraction was 30% for all specimens. The following is a picture of the specimen:

Figure 4. Tensile Test Specimen With Corner 00


Figure 5. Tensile Test Specimen With 90 Angle


Figure 6. Bending Test Specimen with An Angle Of 00


Figure 7. Bending Test Specimen with 90 Angle

Tensile testing was carried out to determine the capability of the composite at each fiber volume fraction. The composite fracture that occurred was an LGM (Lateral at Grip Middle) fracture or a fracture in the middle of the specimen. This condition shows that the fracture occurred as desired and means the load is distributed evenly. However, there were several specimens that broke not at the load point or in the middle of the test specimen due to areas lacking fiber as a result of uneven fiber distribution, resulting in low internal stress in that area. So, when withdrawing, this area was the first to break. Apart from being caused by clamping the specimen (holder) in the testing machine too tightly, it can also occur because when mixing the resin with the catalyst it is not evenly distributed so that the strength of the composite is concentrated at one point.

Figure 8. Specimen From Tensile Test Results with An Angle of 00

Figure 9. Specimen from Tensile Test Results at a 90 Angle

Figure 10. Test Result Specimen Bending with Corner 00

Figure 11. Specimen from Bending Test with Corners 90

DISCUSSION

The following is the tensile strength data obtained in testing each specimen. These results are the average tensile test results for each specimen based on fiber direction and fiber length.

Table 1. Data on 00/10 mm Tensile Test Specimen Results

No	Tensile strength (MPa)	Strain %	Modulus of Elasticity (Gpa)
1	10,625	15%	10,591
2	22,415	18%	2,647
3	19,952	11%	6,962
4	31,521	18%	12,356

Composite relationship graph with 0° angle direction fiber length 10 mm.

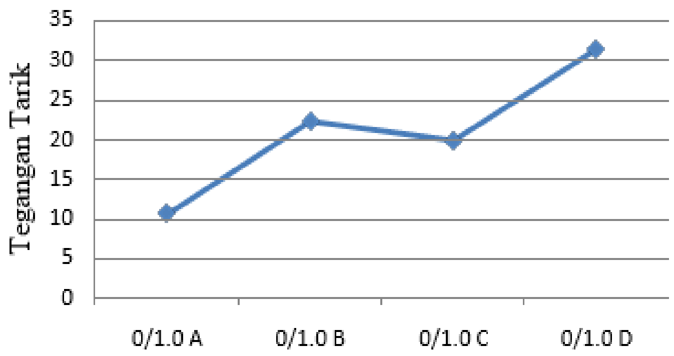

Figure 12. Graph of 00/10 mm Tensile Test Results

Table 2. Data on 00/15 mm Tensile Test Specimen Results

No	Tensile strength (MPa)	Strain %	Modulus of Elasticity (Gpa)
1	28,015	13%	28,048
2	36,038	7%	33,539
3	28,015	6%	25,105
4	22,351	17%	19,123

Composite relationship graph with 0° angle direction fiber length 15 mm

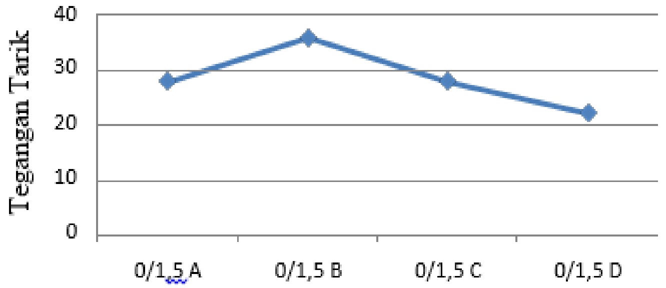

Figure 13. Graph of 00/15 mm Tensile Test results

Table 3. Data on 900/10 mm Tensile Test Specimen Results

No	Tensile strength	Strain %	Modulus of Elasticity
1	23,982	23%	18,829
2	21,834	26%	5,982
3	19,164	12%	6,766
4	13,497	10%	13,435

Composite relationship graph with 90° angle direction fiber length 10 mm

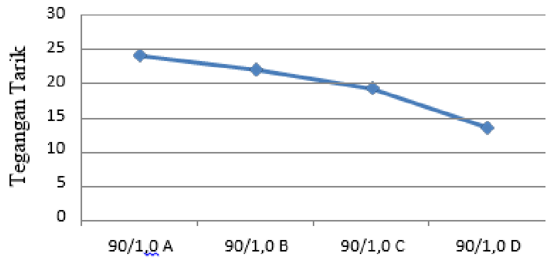

Figure 14. Graph of 900/10 mm Tensile Test Results

Table 4. Data on 900/15 mm Tensile Test Specimen Results

No	Tensile strength (MPa)	Strain %	Modulus of Elasticity (Gpa)
1	16,579	21%	10,787
2	17,556	22%	17,554
3	15,300	32%	7,453
4	17,449	26%	6,570

Composite relationship graph with 90° angle direction fiber length 15 mm

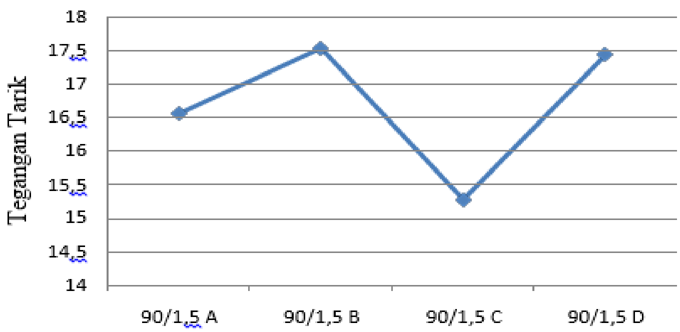

Figure 15. Graph of 900/15 mm Tensile Test Results

Based on the table of tensile test results with angle orientations of 00 and 900, it can be seen in the graph that the tensile test results with a fiber length of 10 mm have a lower tensile stress value compared to those with a fiber length of 15 mm, with the average value of tensile stress for a fiber length of 10 mm being 21.128 MPa. , and the average tensile strength value for a fiber length of 15 mm is 28.04 MPa. By increasing the length of the fiber, the tensile strength also increases, this shows that a composite strengthening mechanism occurs, where the length of the fiber makes the tensile strength value of the composite higher. Composite.

The low risk of shearing occurs because the bond between the fiber and the matrix is getting better, so that, when a load is applied by the tensile testing machine, the fiber and matrix almost together support the load. If the bond between the fiber and the matrix is not good, this could be due to the fact that there is still dirt attached to the fiber.

In contrast to the 900 fiber direction, the longer the fiber direction, the smaller the tensile strength value, this is because the fiber is unable to withstand the tensile load because the direction is not elongated. So that between the fiber and resin there is no stronger bond.

Table 5. Data on 00/10 mm Bending Test Specimen Results

No	Name Specimen	Thick (mm)	Wide (mm)	Max Load (N)	Voltage Bending (MPa)
1	Spesimen 1	5.00	15,00	235,368	94,14
2	Spesimen 2	5.00	15,00	245,175	98,07
3	Spesimen 3	5.00	15,00	225,561	90,22
4	Spesimen 4	5.00	15,00	156,912	62,76

Composite relationship graph with 0° angle direction fiber length 10 mm

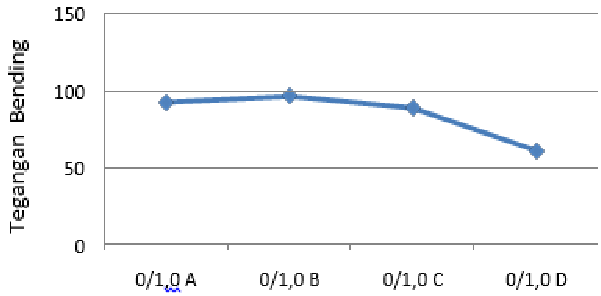

Figure 16. Graph of 00/10 mm Bending Test Results

Table 6. Data on 00/15 mm Bending Test Specimen Results

No	Name Specimen	Thick (mm)	Wide (mm)	Max Load (N)	Voltage Bending (MPa)
1	Spesimen 1	5.00	15,00	196,140	78,45
2	Spesimen 2	5.00	15,00	245,175	98,07
3	Spesimen 3	5.00	15,00	215,754	86,30
4	Spesimen 4	5.00	15,00	176,526	70,61

Composite relationship graph with 0° angle direction fiber length 15 mm

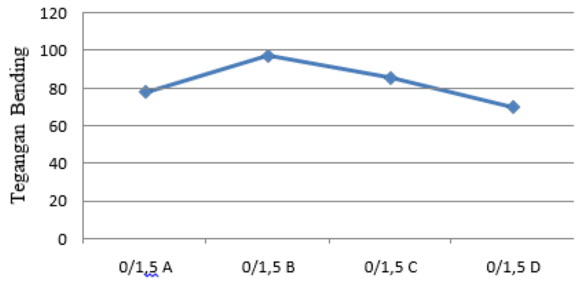

Figure 17. Graph of 00/15 mm Bending Test results

Table 7. Data on 900/10 mm Bending Test Specimen Results

No	Name Specimen	Thick (mm)	Wide (mm)	Max Load (N)	Voltage Bending (MPa)
1	Spesimen 1	5.00	15,00	75,249	30,09
2	Spesimen 2	5.00	15,00	76,053	30,42
3	Spesimen 3	5.00	15,00	74,444	29,77
4	Spesimen 4	5.00	15,00	72,846	29,13

Composite relationship graph with 90° angle direction fiber length 10 mm

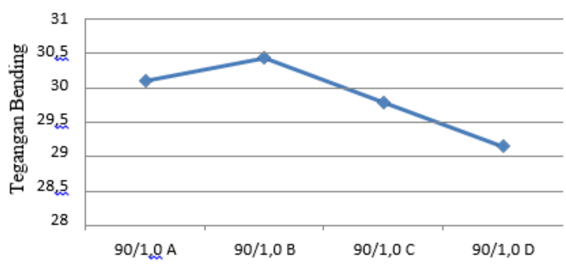

Figure 18. Graph of 900/10 mm Bending Test results

Table 8. Data on 900/15 mm Bending Test Specimen Results

No	Name Spesimen	Thick (mm)	Wide (mm)	Max load (N)	Voltage Bending (MPa)
1	Spesimen 1	5.00	15,00	98,462	39,38
2	Spesimen 2	5.00	15,00	104,866	41,94
3	Spesimen 3	5.00	15,00	103,267	41,30
4	Spesimen 4	5.00	15,00	93,666	37,46

Composite relationship graph with 90° angle direction fiber length 15 mm

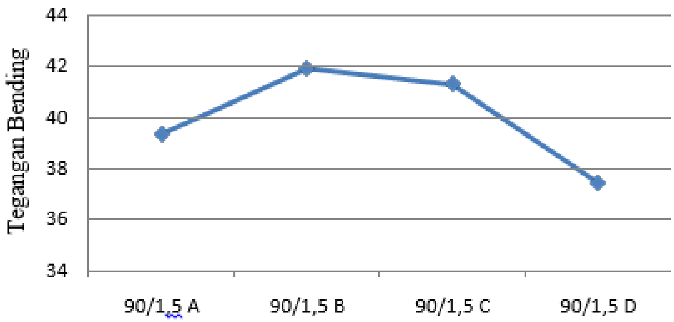

Figure 19. Graph of 900/15 mm Bending Test Results

The opposite occurred in the bending test results of straw fiber composites, where the tensile strength value with an angle of 00 for a fiber length of 10 mm was 86.29 MPa, and the tensile strength value with a fiber length of 15 mm was 83.35 MP.

The tensile strength value at an angle of 900 for a fiber length of 10 mm is 29.85 MPa, and the tensile strength value for a fiber length of 15 mm is 40.02 MPa. This means that the fiber experiences tensile strength values in the longitudinal position, whereas in the bending test specimen the longitudinal direction of the fiber is at an angle of 900.

Conclusion

After carrying out tensile tests and bending tests using the method of varying the angle direction of 0° and 90° with fiber lengths of 10 mm and 15 mm. The following conclusions can be obtained:

1. The influence of straw fiber length provides a value on maximum tensile strength with a value of 28.604 Mpa produced with fiber length
b. 15 mm and direction angle 0°.
2. The influence of straw fiber length gives a value to the maximum bending strength with a value of 86.29 Mpa produced with fiber length
c. 10 m and direction angle 0°.
3. So the fiber length and angle direction influence the strength of the composite.

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