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# An experimental investigation on the influence of volume fraction using Straw fiber on the bending and tensile strength of material composites

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A B S T R A C T

Rice straw fiber is considered as agricultural residue that has not been widely used other than as animal feed. In addition, the development of composite material technology that uses natural fibers provides interesting mechanical properties to be developed. This paper aims to investigate the effect of different concentrations of fiber usage on bending and tensile strength. The comparison of concentrations of fiber usage are 35% , 40% , 70% dan 80%. The straw fiber was decreased the moisture content using a microwave and the treatment with NaOH for removed the hemicellulose and lignin in the fibers. The manufacture of this biocomposite uses a matrix of Urea Formaldehyde with a hand lay up technique. The results of the mechanics test(bending and tensile strengths) show that the strength value obtained on the straw fiber variation, namely the highest average value of the Tensile test is 4.82 MPa at a ratio of 40 : 60, while the lowest is 2.88 MPa at a comparison 35 : 65 and and the highest average value of the bending test is at a ratio of 80:20 (6.64 N/mm$^2$), while the lowest is 40:60 (2.45 N/mm$^2$).

**Keywords:** Rice straw fiber, composite, natural fibers, bending and tensile strength, hand lay up, filler, matrix.

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## 1. Introduction

For some years ago, composite have been found to replace metal in industries or some part in environmental. The beginning, traditional materials, metal or synthetic fibre that were being used in the automotive industry[1]. The composite composed from fibre and matrix. The Composite can defined as a material that is made of two or more materials that are separate and differ at the macroscopic level and then forms a single component so that a new material is obtained that has different mechanical properties and characteristics from the forming material[2]. Other defined can be defined as a combination of two or some more materials that results in better properties than those of the individual components used alone[3][4]. Fibre Besides that, synthetic fibres have been widely used in the valuable commercial products mainly the composites area.

Studi about characteristics of cellulose fibers extracted from rice straw by two different treatments : chemical and thermal steam explosion. For the chmical treatment with sodium-hydroxide(NaOH) solutions with varying concentration were applied to treat fibers. Base on morphological results show that an increase of NaOH concentration caused decreases the fibers average diameter and length and fiber yielding; however, the aspect ratio of length-to-width increases with increasing NaOH concentration[3]. Manickam (2015) study about the mechanical properties and wear characteristics of untreated and treated Roselle fibre/vinyl ester composites with fibre content. The results showed that Roselle fiber with a fibre content of 40%, both alkaline and non-alkali treated, has better mechanical properties The analysis show that fibre content beyond 40% decreased significantly the tensile, flexural, and impact strength of samples[5]

Study about using the Hand lay up process method by arranging the fibers regularly without gaps, after finishing setting then the resin is poured into a mold with natural fibers from rice straw. The results obtained indicate that the addition of fiber will result in an increase in the value of impact strength and tensile strength in composite materials[6][7].

Amirin K, et al (2020) examined the effect of NaOH concentration on sisal fiber reinforced composites using concentration percentages of 0%, 5%, 10%, 15%. The result show that improvement of the mechanical properties of biocomposites has been successfully carried out by applying concentrations of alkaline sodium hydroxide solutions of 5%, 10%, and 15% on sisal fiber for 120 minutes[8]. Studi about surface treatment of palm fiber as composite reinforcement by immersion using NaOH solution was able to improve mechanical properties[9]. determining the effect of the concentration of sodium hydroxide solution, namely 5%, 10%, 15% and 20% by weight on the flexural strength of coconut fiber reinforced composites. The targeted results are the flexural strength values of coconut fiber reinforced composites that have been soaked in sodium hydroxide solution for 3 hours with concentrations of 5%, 10%, 15%, and 20% by

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weight. The concentration of sodium hydroxide solution does not significantly affect the flexural strength of coco fiber[10].

The longer the material will be more advanced, for this reason, it is encouraged to have some ideas contained in research in the field of materials, namely by utilizing natural fibers and artificial fibers as reinforcement from new composite materials which will later become quality composite materials.

a study on the analysis of the synthesis of bioplastics from rice straw as raw material using organic solvents and analyzing the effect of the mass ratio of starch to cellulose on the characteristics of bioplastic products. Straw delignification process using 5% and 35% ethanol solution at $80^0$ C for 120 minutes[11]. The study of making biocomposite polymer of areca nut shell fiber added with alumina powder and conducting hardness and wear tests for brake lining applications. The results obtained indicate that the hardness and wear tests of the biocomposite products made can be applied to the brake lining manufacturing process[12].

This research will examine the effect of volume fraction of natural fibers on the increase in bending strength, tensile and hardness of the composite core with natural fiber cores.

## 2. Material and Methods

The stages carried out in this research include determining materials and composition comparisons, treatment methods, making test specimens and data analysis. This research was conducted using straw fiber collected in the Madiun city area.

The process stages for making straw fiber composites are in accordance with the following process on **Figure 1**.

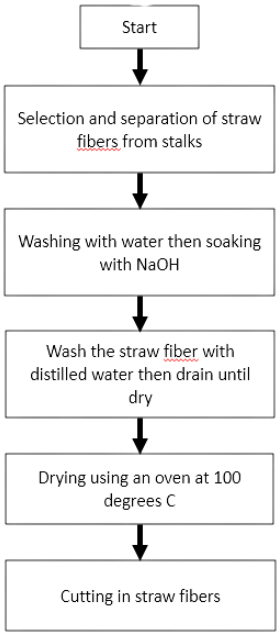



**Figure 1.** Flow diagram of straw fiber

The process of extracting straw fiber can be done using various techniques, including the straw fiber from rice stalks being removed from the rice straw. Cleaning straw fiber using clean water to remove remaining dirt on the fiber. Next, the fiber is dried briefly in the sun for approximately 5 minutes. The dry straw fibers are then soaked in a NaOH solution of 5% of the total weight of the fibers to reduce the Lignin content through a delignification process for 2 hours. Next, the straw fiber is rinsed and soaked again using distilled water (95%) so as not to cause damage to the fiber, then dried in the sun for 1 hour. Pengeringan dilanjutkan dengan Drying in an electric oven for 2 hours at 100° C to maximize the removal of lignin residues.

The process of making this straw fiber composite is carried out using the hand lay up method. The comparison for making specimens between fiber and matrix in this study used variations including: 35:65; 40:60; 70:30 and 80:20. Next, the process of making bending and tensile test specimens is according to the following process flow.

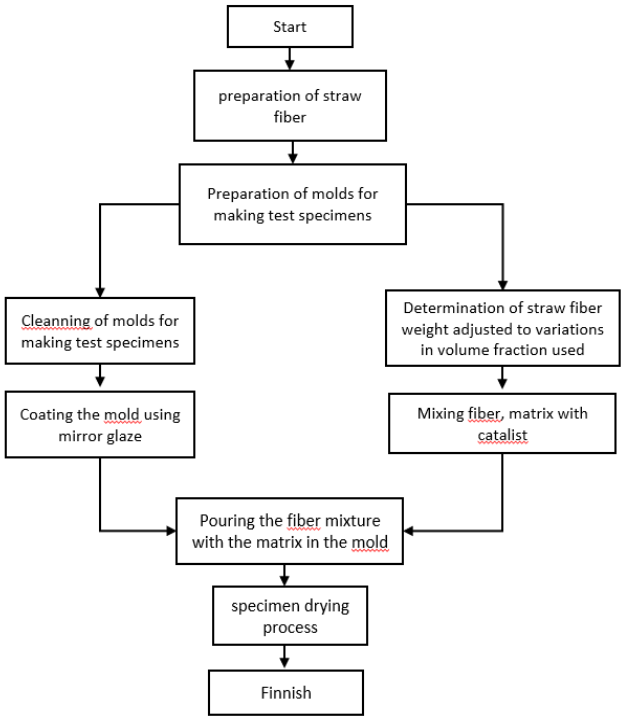



**Figure 2.** Flow diagram for making test specimens

The geometry of the test specimen refers to the ASTM D7264 Bending Test Specimen Standard Test Method (mm) for Polymer Matrix Composites. Based on ASTM D7264 standard, all specimen dimensions are in mm and tolerances are specified. Figure 3 shows the profile and dimensions of the specimen for the bending test.

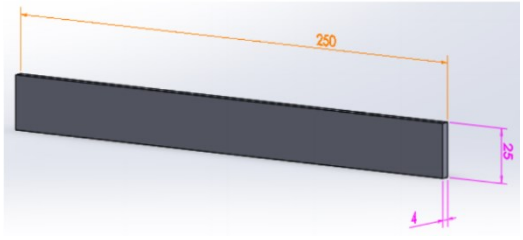



**Figure 3.** Geometry of ASTM D7264 Bending Test Specimen

The geometry of the test specimen refers to the ASTM D638 tensile Test Specimen Standard Test Method for Composites. Based on ASTM D638 standard, all specimen dimensions are in mm and tolerances are specified.

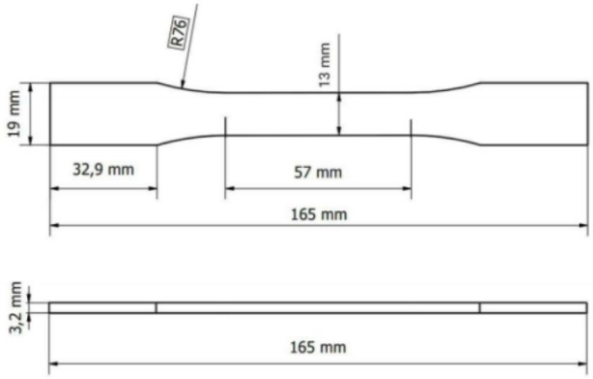



**Figure 4.** Geometry of ASTM D638 tensile test specimen

This tensile test is carried out by placing the specimen on the top of the Universal Testing Machine or more precisely the top plate. As the following picture shows **Figure 5**.

**Figure 5.** Tensile Test process of specimen

This bending test dilakukan untuk memperoleh kekuatan bending dari specimen komposit yang divariasikan fraksi volumenya. Pengujian bending ini dilakukan dengan Universal Testing Machine (UTM) As the following picture shows **Figure 6**.

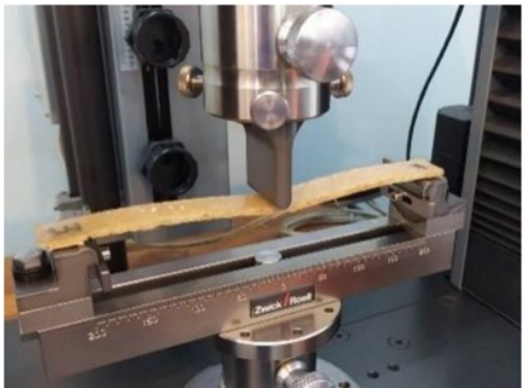


**Figure 6.** Bending test process of specimen

## 3. Results and discussions

### 3.1 Analysis of Mechanical and Physical Properties

Based on the results of this research, the output was obtained in the form of mechanical properties of straw fiber composites with a ureaformaldehyde matrix. These mechanical properties are obtained from the tensile and bending test processes. Apart from producing mechanical properties, composite structure data was obtained through SEM testing to determine the morphological structure of the composite itself. The image below shows the specimens that will be tested on **Figure 5.**

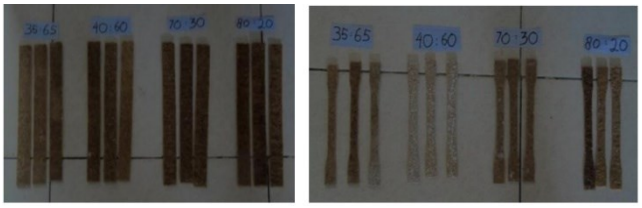



**Figure 5.** Bending and Tensile Test Specimens

After mechanical testing is carried out using a Universal Testing Machine (UTM), the results of the specimen testing will be obtained to determine the highest strength value from the specimen testing shown **Figure 6**.

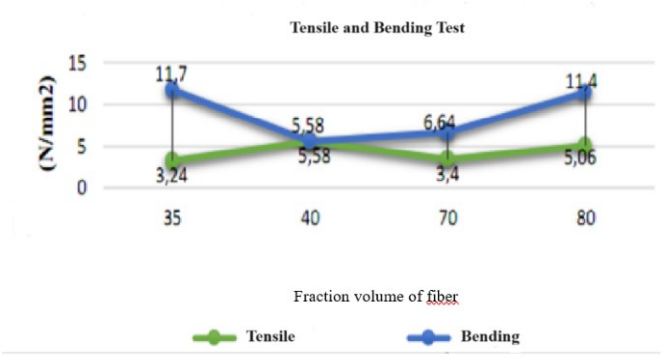



**Figure 6.** Tensile and bending test result

Based on the tensile test, it was found that the volume fraction affects the tensile strength of the composite, there is a tendency for strength to increase with the addition of fiber volume fraction, the maximum value at 40% variation is 5.58 MPa[7]. Tensile testing is carried out with the aim of determining the maximum tensile strength of the composite material. The addition of fiber shows that the distribution of the load received is transferred to the fiber, so that its strength increases[13]. Furthermore, based on bending test data, it shows a tendency that the greater the volume fraction, the greater the bending strength, although at the beginning the data jumped slightly. This explains that volume fraction affects bending strength, bending strength is proportional to the size of the volume fraction used[14][15].

Based on the results of data processing shown in Figure 7, the average stress-strain value in the ratio 70:30 is the largest, amounting to 0.01360%. And then the lowest stress-strain test results were obtained at the 35:65 variation of 0.00575%.

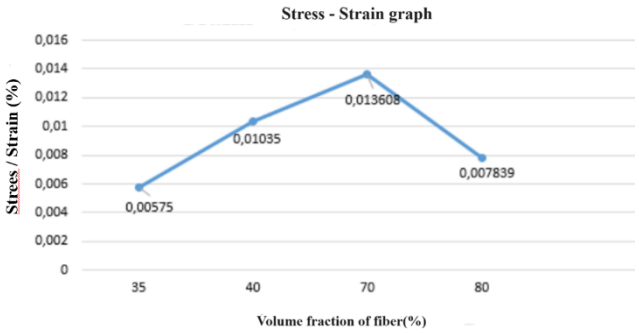
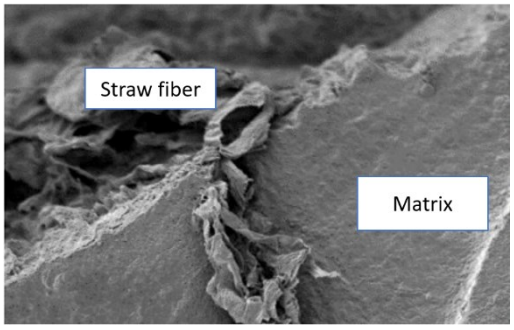



**Figure 7.** Average of stress-strain

Next, SEM testing was carried out to see the magnification of the morphology between Fiber & Resin in the specimen. The microscopic results of SEM testing on the test specimen show the position of the straw fibers, the matrix and the bonds that occur. The bonding phenomenon between the matrix and fiber is shown in Figure 8 below.




## 4. Conclusion

This research has been carried out well so that the following conclusions can be drawn. Based on result received it was concluded that volume fraction had an influence on tensile and bending strength, Comparison of Straw fiber using NaOH solution with Urea Formaldehyde matrix produced the best ratio in the 35:65 variation in the tensile test specimen of 11.7 MPa & bending test in the 40:60 variation of 5.58 MPa. And then SEM test results show magnification at 1000x level showed that the straw fiber structure and matrix were dispersed and also integrated well.

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