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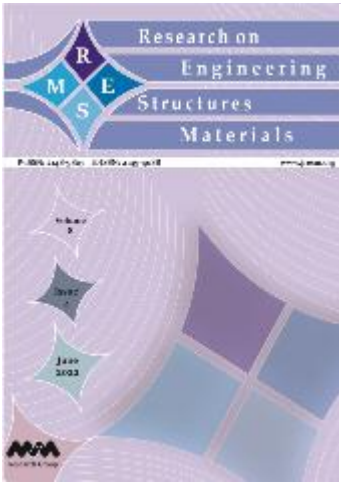


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*Technical Note*

# Investigation of normal concrete properties with the addition of micro reinforcement

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**Abstract**

The research on concrete is currently developing very rapidly. One of them is research on concrete with micro reinforcement. This study aims to find out how much influence the variations in micro reinforcement used have on the strength of concrete. This study was conducted with variations in the percentage of addition of micro reinforcement with various types of micro reinforcement. In this study, FTIR analysis was also carried out to determine the absorption area and group of micro reinforcement compounds. The micro reinforcement used is Jute, Bamboo, Rattan and Plastic with an additional percentage of 0.5%; 1%; 1.5% and 2% against the weight of cement. The test was performed at the age of 28 days, with a compressive strength test. The results showed that there was a significant influence on the compressive strength of non-micro reinforcing concrete compared to micro reinforcing concrete. The optimal compressive strength of concrete with the addition of micro reinforcement (Bamboo/Rattan) was obtained in concrete with a percentage of 1.5% with an optimum compressive strength of 23.31 MPa, plastic reinforcement 22.93 MPa (addition of 1.5%), rattan micro reinforcement 22.93 MPa (addition of 2%), and hemp micro reinforcement (addition of 2%) 20,665 MPa. The results of the FTIR analysis form of the compound group and the most optimal absorption area in micro reinforcement micro-compound groups of bamboo and rattan reinforcement has 3 peaks with the form O - H, C - H and CH2. When compared to compound groups in concrete without micro reinforcement, it only has 2 compound groups, namely, O – H and CH2 only.



## 1. Introduction

The Research about material micro reinforced which has good tensile strength, so it is expected to add ductility to normal concrete, increase compressive and tensile strength to make it more resistant to cracking. The use of rattan as a micro-reinforced material is intended to minimize the impact of poor concrete properties, including having a high enough specific gravity so that it will cause a loading effect due to its own weight. Plastic waste is used as a fine aggregate in varying amounts in burlap fiber reinforced concrete to test its suitability. The use of plastic waste as a substitute for fine aggregates. Since plastic bottles are harmful to the environment and human health, using them in concrete will help protect the environment and human health. The main component of concrete is the partial replacement of fine aggregates and coarse aggregates. Plastic fibers are artificial fibers used in concrete to increase the split tensile strength and bending strength of concrete (1), (2), (3).

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Micro Reinforced Concrete as a composite material consisting of ordinary concrete and other materials in the form of Micro Reinforced (rods with a diameter between 0.10 and 0.20 mm with a length of about 20 mm to 50 mm). The addition of micro reinforced material to concrete is intended to correct the weakness of the properties possessed by concrete, that is, it has low tensile strength (4), (5), (6), (7), (8). One of the important properties of concrete is ductility. Ductility i.e. the ability of a structure or its components to perform repeated alternating inelastic deformations beyond the limits of the first melting point, while maintaining a large amount of its load carrying capacity (9). The addition of micro reinforced material to concrete is to increase the energy absorption capacity of the mixed matrix, which means to increase the ductility of concrete. The addition of ductility also means the addition of concrete behavior to fatigue and shock. Micro Reinforced Concrete has advantages over micro reinforced concrete in several structural properties including ductility, resistance to shock loads (impact resistance), tensile and bending strength (tensile and bending strength), fatigue (fatigue life), resistance to shrinkage and resistance to wear (abrasion) (8), (10). Observations of various stress curves of various concrete strengths, show that generally the maximum compressive strength is *achieved* when the unit value of the ε' compressive strain reaches 0.002, then the value of the f'c stress will decrease with increasing the value of the crushed test object strain at the value of ε' reaching 0.003-0.005. High strong concrete is more fragile and will disintegrate at a lower maximum strain value compared to low strong concrete. In concrete testing it was established that the maximum working strain taken into account on the outermost compressed concrete edge of Micro Reinforced was 0.003 as the crushed limit (9). The maximum working strain of 0.003 may not be conservative for high strong concrete with an $f'_c$ value between (11). The addition of Micro Reinforced to normal concrete can increase the pressure at peak loads. Fibrous concrete can absorb more energy than normal concrete before crushing (12), (13), (5), (14), (15), (16), (17). Micro-Reinforced Contribution to stress – concrete strain is distinguished by two types (18), (19), (31), namely: 1). Micro reinforced materials are very fragile with matrices, shown in Figure 1 where it appears that the shrinkage of matrix collapse is much greater than the collapse strain of micro-reinforced materials. 2). A very strong micro-reinforced material with a brittle matrix shown in Figure 1 shows that the matrix limit strain capacity is lower than the micro-reinforced strain capacity. The matrix will collapse before the full potential of the micro-reinforced work, the matrix that has been cracked is held back by Micro Reinforced that contributes energy through the bonding process and the reinforced micro is pulled out. The figure is a curve of the relationship between the pressure on Micro Reinforced concrete and the brittle matrix.

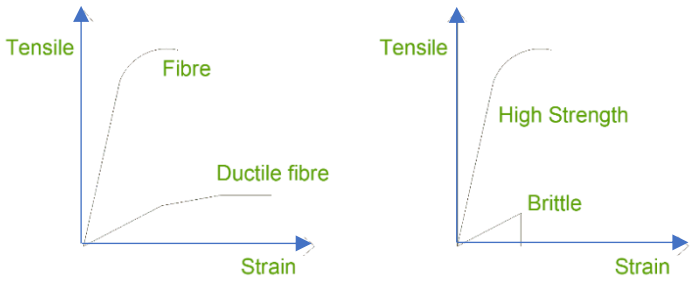



Fig. 1 Micro reinforced concrete stress-strain curve with visage matrix (31)

When the micro-reinforced material begins to be uprooted or damaged, the slope of the curve may reach zero, and the capacity of the ability to carry the load begins to decrease. This type of collapse allows maximum utilization of Micro Reinforced properties and

matrices. As a result of comparison, Figure 2 below is the data obtained from the results of a study entitled The Use of Micro Reinforced Rattan to Improve Concrete Quality, (29).

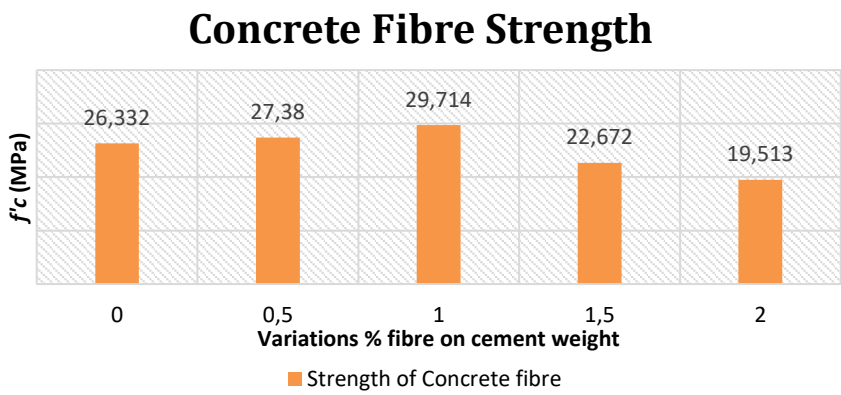



Fig. 2 The relationship of compressive strength and the percentage of micro reinforcement, [29]

The optimum load was found in the 1% Micro Reinforced rattan variation of 29,714 MPa and experienced a decrease in load if added greater than 1%. Micro Reinforced Concrete with the addition of additive ash boiler scale is made using Micro Reinforced empty oil palm bunches and boiler scale obtained from one of the palm oil processing plants in the Purwodadi Kuala Pesisir area of Nagan Regency (20). Test the average compressive strength of cylindrical concrete with the addition of empty bunches of palm micro-reinforced on concrete with a life ratio of 0% for 28 days each of 31.85 MPa. At 4% Micro Reinforced is 25.89MPa. Then 5% Micro Reinforced concrete is 26.23 MPa. In 6% micro reinforced concrete is 28.78MPa. In 7% concrete, Micro Reinforced is 30,384 MPa. At 8% of micro reinforced concrete is 30.57 MPa. The crack patterns that occurred in this study were shear and columnar crack patterns. All in all, it can be seen that the compressive strength of concrete has increased, although it is still below the normal concrete compressive strength, it is getting bigger and bigger than $f'_c$ 25Mpa, and can be used as structural concrete (21). This shows that the more Micro Reinforced rattan is added, the less work ability of the concrete mixture. From the testing of concrete compressive strength, concrete tensile strength, and bending strength of concrete blocks, the highest concrete strength addition result on the addition of Micro Reinforced rattan is 1% of the weight of cement. The compressive strength of concrete has increased by 12.84% from normal concrete. The tensile strength of split concrete has increased by 22.17% from normal concrete. For the bending strength of concrete blocks experienced an increase of 9.69% from normal concrete (21). Rattan was chosen to be developed because in general rattan has good natural strength, is flexible and lightweight in dry conditions. Based on the results of research that has been carried out, the results obtained that rattan material with epoxy resin lamination has a compressive strength of 46.8MPa increased by 47.2% when compared to the compressive strength of rattan without lamination of 31.8MPa. The average impact strength of rattan test results before lamination with epoxy resin was 39 kJ/m$^2$ and after going through the lamination process increased by 64% to 64 kJ/m$^2$ (22).

Preservatives used to preserve micro reinforcement are boron and CCB (copper-chrome-boron) with cold bath modifications and the Boucherie method. Endurance testing refers to (23). The test results showed that boron is effective on petung bamboo to increase resistance to soil termites, dry wood termites, as well as weathering fungi, while for resistance against dry sawdust beetles, the effectiveness of boron and CCB is almost

equivalent (24). Natural fibers outperform synthetic fibers in mechanical properties, are cheaper, come from renewable resources, and are recyclable. As a result, partially replacing Meta kaolin for Portland cement reduces $CO_2$ emissions while extending the life of the structure. In this study, concrete was tested by Meta kaolin cement replacement and the addition of burlap fiber. The percentage of burlap fiber added is 0%, 1%, 2%, 3%, 4%, 5%, and 6%. The percentage of meta kaolin replacement is 0%, 3%, 6%, 9%, 12%, 15%, and 18%. Prepare a new mixture with 5% meta kaolin and a different percentage of Jute Fiber after analysis. The concrete value used in the analysis is M35 (25). Micro reinforcement is commonly used in the resistance and reinforcement of concrete cracks. Various fibers are usually used in concrete mixes to achieve the desired strength and resistance. Recently, in response to the problem of global warming and the need for a more sustainable society, manufacturing with natural ingredients has become more active in developing countries. Bamboo, with its low cost, rapid growth, and wide growth distribution, is expected to make a significant contribution to earthquake-resistant construction and seismic retrofit technology in developing countries. The authors investigated the mechanical behavior of bamboo fiber reinforced concrete members. The possibility of using 'Bamboo' effectively is discussed based on the results of this experiment. Similarly, results for the aspect ratios of different fibers were obtained, revealing that there is an aspect ratio of 40. An increase in the weight fraction of the fiber results in a consistent increase in ductility to the optimal content (1.0%), with a fiber aspect ratio of 40. Overall, the study found that adding bamboo micro reinforcement to concrete increases concrete strength, toughness, torque, and tensile stress. More research is needed to determine the long-term durability of concrete enhanced with bamboo micro reinforcement (26). The addition of micro reinforced materials changes a lot in the behavior of concrete after cracking, for example, there is an increase in tensile strain after concrete collapses, resulting in harder and more impact-resistant concrete. The increase in concrete hardness is strongly influenced by the concentration of Micro Reinforced and the resistance of Micro Reinforced to tensile which is mainly determined by the comparison of Micro Reinforced aspects (length/diameter ratio) and other factors such as surface shape and texture. Micro Reinforced concrete mix planning is determined based on (15). The use of Micro Reinforced in concrete mixtures is carried out after the soaking process using a solution of Sodium Hydroxide (NaOH) against micro reinforced rattan which functions to separate the dirt on the Micro Reinforced and avoid easy printing. Compressive strength is the ability of concrete to accept extensive unification compressive force. The compressive strength of concrete identifies the quality of a structure. The higher the desired strength of the structure, the higher the quality of the concrete produced (4). The compressive strength value of concrete is obtained from standard tests with a commonly used test object in the form of a cylinder. The dimensions of the standard test piece are 300 mm high, 150 mm in diameter. The compressive strength of each test piece is determined by the highest compressive ($f'_c$) that the test piece reaches a lifespan of 28 days due to the compressive load during the experiment. Concrete will have high compressive strength if it consists of good quality local materials. The constituent material of concrete that needs attention is that the aggregate reaches 70 - 75% of the volume of concrete (11). Tensile testing is a method of determining the strength of a material by applying a force load. Tensile test results are critical for product engineering and design as they produce material strength data. Tensile testing is used to determine the resistance of a material to slow-applied static forces. Tensile tests are usually used to supplement basic design information on material strength and as supporting data for material specifications. The tensile test curve reveals the strength and elasticity values of the test material (4). Based on the results of research conducted by the tensile strength of rattan parallel to Micro Reinforced shows a fairly high value of 481.99 kg / $cm^2$. This rattan strength has the potential to be used for building purposes, namely concrete with high tensile strength (1).

## 2. Material and Methods

In the treatment carried out on specimens, it is to add a varying percentage of micro reinforcement, with various types of micro reinforcement, namely: Bamboo / Rattan, Gowon, Rattan and Plastic. In this second treatment, the variation in the percentage of micro reinforcement addition was 0; 0.5; 1; 1.5; and 2%. Micro bamboo and rattan reinforcement is made by shaving so that the results of bamboo rattan shavings are long but small in diameter or square size of about 1 mm x 2 mm. The shavings are then cut into pieces with a machete so that they have a length of 20 mm. The treatment of microplastic and hemp reinforcement was also cut by 1 mm x 2 mm x 20 mm. The press weight of the plan is 25MPa for a cylinder test piece measuring 15/30 cm using a cement water factor (w/c) of 0.52. The coarse aggregation used is natural stone with a maximum aggregation diameter of 19 mm. The design of the normal concrete mixture uses the method (7), which requires a concrete design mixture taking into account its economic side and paying attention to the availability of materials in the field, ease of work, as well as the durability and strength of concrete work. Figure 3 shows the variety of different types of micro reinforcement.

(a) (b)

Fig. 3 Micro Reinforcement Bamboo (a) and Hemp (b)

(a) (b)

Fig. 4 Micro Plastic Reinforcement (a) and Rattan (b)

FTIR tests are performed to determine the chemical bonding information of bamboo. Such chemical bonds are indicated by distinct peaks. This test was performed for the first time to measure the bond between Betung bamboo fibers (Dendrocalamus asper) and rattan fibers. Here's how FTIR works:

The beginning of the substance to be measured is identified in atomic or molecular form. Infrared light, which acts as a light source, is split into two beams, one passing through the

sample and one passing through the reference beam. Then pass through the chopper. After passing through a prism or diffraction grating, the beam hits a detector and is converted into electrical signals and recorded by a recorder. An amplifier is also needed if the generated signal is very weak, (27).

The standard used is ASTM E1252 (30). Samples that can be easily tested with FTIR include polymer pellets, parts, opaque samples, fibers, powders, wire coatings and liquids. A typical infrared scan is produced in the mid-infrared portion of the light spectrum. The mid-infrared region has wave numbers between 400 and 4000 $cm^{-1}$, corresponding to wavelengths between 2.5 and 25 microns (10-3 mm). The Figures 3 and 4 show the shape and type of micro reinforcement used in fresh concrete mixtures. Successively 3(a) is bamboo micro-reinforcement; 3(b) Hemp micro reinforcement, 4(a) plastic micro reinforcement, and 4(b) rattan micro reinforcement. The dimensions of micro reinforcement are 2 mm x 2 mm x 30 mm.

## 4. Results and Discussion

Figure 5 tends to show almost the same graphic pattern in concrete with the addition of micro reinforcement, i.e. the strength of concrete decreases with the addition of micro reinforcement of 0.5 – 1 % and the strength of concrete increases again in increments of 1.5 and 2%. There is a difference with the results of the study (14), (15), (16), (29), where the most optimal concrete strength is in the addition of 1.5% fiber. This is thought to be related to the dimensions of the fibers or reinforcement used which are different from the micro reinforcement used in this study. When compared with the test object in the first treatment, the compressive strength obtained was greater than the study (14), (15), (16), (29), with an optimal compressive strength obtained of 29.714 MPa (1% fiber addition). Figure 5 shows the optimum compressive strength in the addition of micro reinforcement of 1.5% with a compressive strength obtained of 23.21 MPa, when compared to non-micro reinforcing concrete having a compressive strength of 22.65 MPa.

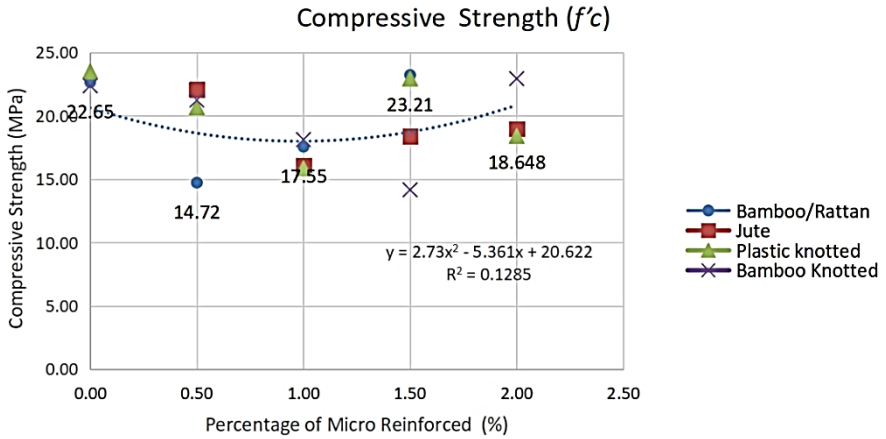
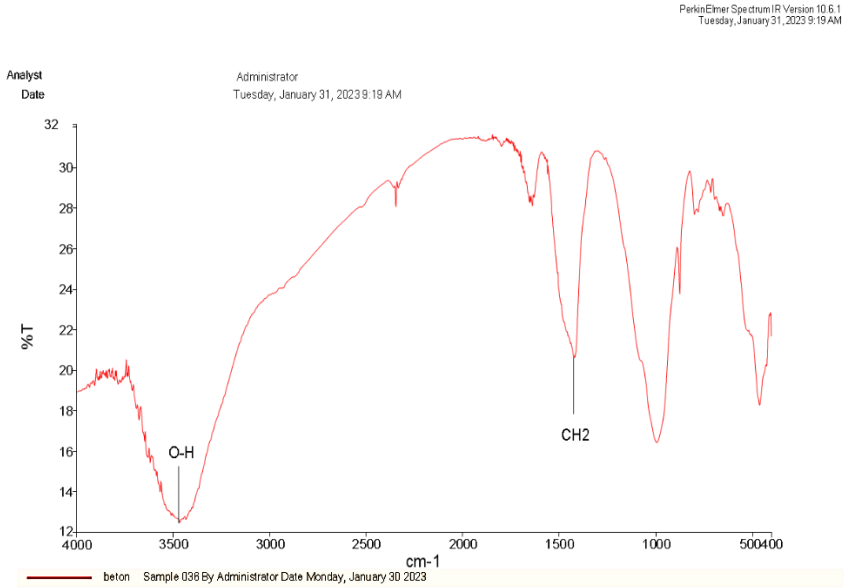


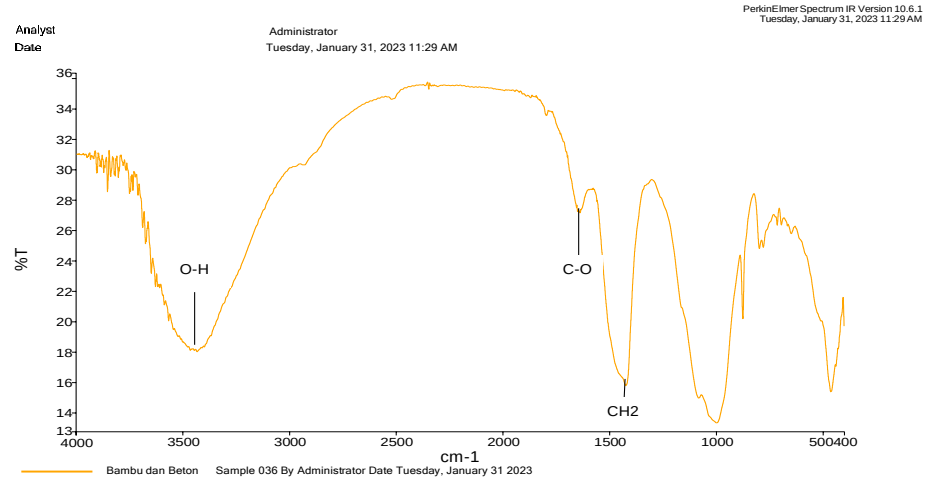

Fig. 5 Graph of the relationship of Percentage of Micro Reinforcement with concrete compressive strength




Tabel 1.
Daerah Serapan Infra Merah Beton

| Daerah Serapan (cm$^{-1}$) | Ikatan dan Jenis Gugus Fungsi |
|---|---|
| 3467.97 | O-H Streching |
| 1419.71 | CH2 Banding |

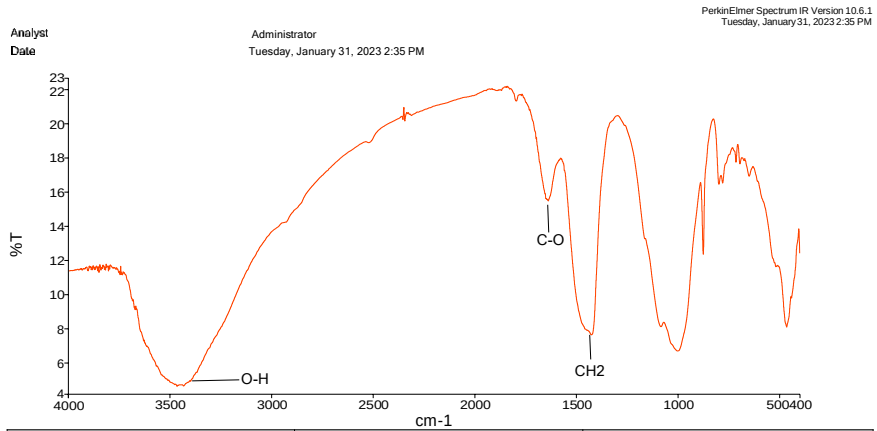
Fig. 6 Graph of Groups of micro non-reinforcing concrete compounds




Tabel 1.
Daerah Serapan Infra Merah Bambu +Beton Interpretation

| Daerah Serapan (cm$^{-1}$) | Ikatan dan Jenis Gugus Fungsi |
|---|---|
| 3435.09 | O-H Streching |
| 1638.43 | C-O Streching |
| 1424.13 | CH2 Banding |

Fig. 7 Graph of Bamboo micro reinforcing concrete Compound Group




| Sample Name | Description | Quality Checks |
|---|---|---|
| rotan dan beton | Sample 033 By Administrator Date Tuesday, January 31 2023 | The Quality Checks give rise to multiple warnings for the sample. |

Tabel 1.
Daerah Serapan Infra Merah Rotan +Beton Interpretation

| Daerah Serapan (cm-1) | Ikatan dan Jenis Gugus Fungsi |
|---|---|
| 3467.24 | O-H Streching |
| 1638.33 | C-O Streching |
| 1424.75 | CH2 Banding |

Fig. 8 Rattan micro reinforcing concrete Compound Group Graph

From the results of FTIR analysis we can see in Figure 6,7, and 8 Compound groups and peaks of the Chart. It shows the shape of the graph is almost the same but the transmittance value is different where non-micro reinforcing concrete has a higher transmittance value than micro reinforcement, bamboo and rattan. Then it can be seen that the absorption area is almost the same in the area of 3400 cm-1. For micro-compound groups of bamboo and rattan reinforcement has 3 peaks with the form O - H, C - H and CH2. When compared to compound groups in concrete without micro reinforcement, it only has 2 compound groups, namely, O – H and CH2 only.

## 5. Conclusions

Based on the results of data processing and discussion, the conclusions that can be drawn from the results of additional micro-research are strengthened on the strength of concrete. The optimal compressive strength of concrete with the addition of reinforced micro (Bamboo/Rattan) was obtained on concrete with a percentage of 1.5% with an optimum compressive strength of 23.31MPa, plastic 22.93MPa (addition of 1.5%), rattan 22.93MPa (addition of 2%), and Burlap (addition of 2%) 20,665MPa. It can be concluded from several variations of the addition of micro reinforcement obtained optimum compressive strength in concrete with micro reinforcement (Bamboo and Rattan), with a percentage of micro reinforcement addition of 1.5% to the weight of cement. Infrared spectra can provide information about functional clusters in compounds. Figure 6, i.e. the fiber-free concrete sample, has absorption peaks at wave number 3467.97, i.e. alcohol-phenol (H-bond) and carboxylic acid, and several peaks in the fingerprint region below 1300 cm $^{-1}$. Based on the nature of molecular vibrations, there are types of stretching vibrations and bending vibrations, the absorption range of stretching vibrations is in the range of wavenumbers (cm$^{-1}$) > 2500, and bending vibrations (bending) are in the range of wavenumbers < 2500 (cm$^{-1}$) range. 1500 cm$^{-1}$. The absorption region peaks at 2467.97 can be interpreted as an OH stretching group with an alcohol-phenol bond (H-bond) or as a carboxylic acid due to the broadening of the spectral shape. A CH2 bend appears in the peak at 1419.71 cm$^{-1}$ and alkanes have spectra in this region. In Figure 8 (concrete + rattan) a peak C = O appears,

extending to a wavelength of 1638.33 cm-1. Presence of double bonds and/or aromatic rings. In Figure 7, the C=0 bond occurs in the range 1750 to 1625 cm-1 where the C=0 bond is a carbon group in which a functional group consisting of carbon atoms is double-bonded to an oxygen atom. The presence of peak C═O gives a specific indication of the presence of carboxylic acid in the peak at 3467.97 cm $^{-1}$. Since the reactivity of oxygen is more electronegative than carbon, the electron density is attracted to carbon, increasing the polarity of the bond. Of the three septa, adding rattan and bamboo to concrete results in a C=O bond.

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