THE POTENTIAL OF AGRICULTURE WASTE MATERIAL FOR NOISE INSULATOR APPLICATION TOWARD GREEN DESIGN AND MATERIAL


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Abstract – This paper aims is introducing new insulator based on natural fiber composite which is combination between coconut fiber and natural latex. The noise insulator now days mostly produced from synthetic materials such as synthetic rubber or petroleum gel based. This new design and material selection is considered environmental issue toward green technology. The coconut fiber and natural latex develop to study the mechanical and physical properties of natural fiber and natural latex. The different latex contain will be effected to the noise insulator application.

Keywords – Insulator, coconut fiber, natural latex, green technology.

1.0 INTRODUCTION

Noise pollution generally refers to unwanted sound produced by human activities unwanted in that it interferes with communication, work, rest, recreation, or sleep. Unlike other forms of pollution, such as air, water, and hazardous materials, noise does not remain long in the environment. However, while its effects are immediate in terms of disturbance, they are cumulative in terms of temporary or permanent hearing loss. Society has attempted to regulate noise since the early days of the Romans, who by decree prohibited the movement of chariots in the streets at night. In the United States, communities since colonial days have enacted ordinances against excessive noise, primarily in response to complaints from residents. It was not until the late 1960s, however, that the federal government officially recognized noise as a pollutant and began to support noise research and regulation. Federal laws against noise pollution included the National Environmental Policy Act of 1969, especially sections concerning environmental impact statements; the Noise Pollution and Abatement Act of 1970; and the Noise Control Act of 1972, which appointed the Environmental Protection Agency (EPA) to coordinate federal research and activities in noise control.

Subjected to 45 decibels of noise, the average person cannot sleep. At 120 decibels the ear registers pain, but hearing damage begins at a much lower level, about 85 decibels. The duration of the exposure is also important. There is evidence that among young Americans hearing sensitivity is decreasing year by year because of exposure to noise, including excessively amplified music. Apart from hearing loss, such noise can cause lack of sleep, irritability, heartburn, indigestion, ulcers, high blood pressure, and possibly heart disease. One burst of noise, as from a passing truck, is known to alter endocrine, neurological, and cardiovascular functions in many individuals; prolonged or frequent exposure to such noise tends to make the physiological disturbances chronic. In addition, noise-induced stress creates severe tension in daily living and contributes to mental illness.

Noise control is very important nowadays and not even limited to our daily life. The noise control is very important to in industry both small and medium or high technology industries. Noise can cause major problems and not only limited to the physical condition but it’s also can affected mentally itself.

The purpose for this research is to produce new inventor insulator for reducing excessive noise. Noise insulator already used, but this research to design the noise insulator from natural fiber composite. Mostly insulator used the petroleum based to produce noise, vibration and heat insulator. This research will study the potential for the natural fiber composite.

2.0 MATERIAL SELECTION & PREPARATION

The selected materials are coconut fiber in type Chopped Strand Mat and latex as know as the waste materials. Natural fibers exhibit many advantageous properties as reinforcement for composites [4]. They are low-density materials, yielding relatively light weight composite with high specific properties. Natural fibers also offer significant cost advantages and benefits associated
with processing, as compared to synthetic fibers such as glass, nylon, carbon, etc. However, mechanical properties of natural fiber composites are much lower than those of synthetic fiber composites. Another disadvantage of natural fiber composites which makes them less attractive is the poor resistance to moisture absorption [1]. Hence use of natural fiber alone in polymer matrix is inadequate in satisfactorily all the technical needs of a fiber reinforced composite. In an effort to develop a superior, but economical composite, a natural fiber can be combined with a synthetic fiber in the same matrix material so as to take the best advantage of the properties of both the fibers [4] – [5]. In this research, mainly objective have been stressed as above to exposed the potential of natural fiber. Natural Fiber Composite also can reduce the waste materials from do nothing become very valuable findings for the future [1].

A. Coconut Fiber

Coconut fiber is obtained from the fibrous husk (mesocarp) of the coconut (Cocos nucifera) from the coconut palm, which belongs to the palm family (Palmae). Coconut fiber has high lignin content and thus low cellulose content, as a result of which it is resilient, strong and highly durable. The remarkable lightness of the fibers is due to the cavities arising from the dried out sieve cells. Coconut fiber is the only fruit fiber usable in the textile industry. Coir is obtained by retting for up to 10 months in water followed by sun-drying. Once dry, the fiber is graded into "bristle" fiber (combed, approximately. 20 - 40 cm long) and "mattress" fiber (random fibers, approx. 2 - 10 cm long) [1].

B. Natural Latex

Latex refers generically to a stable dispersion (emulsion) of polymer micro particles in an aqueous medium. Latexes may be natural or synthetic. Latex as found in nature is the milky sap of many plants that coagulates on exposure to air. It is a complex emulsion in which proteins, alkaloids, starches, sugars, oils, tannins, resins and gums are found. In most plants, latex is white, but some have yellow, orange, or scarlet latex is the early process to collect the fresh natural rubber. The word is also used to refer to natural latex rubber; particularly for non-vulcanized rubber. Such is the case in products like latex condoms and latex clothing. It can also be made synthetically by polymerizing a monomer that has been emulsified with surfactants. Many plant functions have been attributed to latex.

C. Natural Composite Fabrication.

The specimen preparation for this research starts with The coconut fibers are extracted from coconut shell by hand and dried in sunlight for 12 hours until all the moisture is removed from the fiber. These two materials were thoroughly mixed and stirred at low speed until it become uniform. The matrix material was poured into the mould slowly in order to avoid air trapping. The mixture was left for 2 hours so that it becomes a little tacky. After that, the coconut fiber woven fabric was laid on the matrix layer, which was covered by another layer of matrix by pouring the mixture slowly onto the surface of the fiber woven fabric.

After mixing, the compounded rubber is plastic and is now ready to be shaped. This is done in a variety of ways and is frequently combined with vulcanization in which the rubber undergoes a chemical reaction at a high temperature, becoming converted from the plastic state into a strong, highly elastic material. In purpose to produce the natural fiber composite as a noise insulator, the amount of the coconut fiber will be constant while the amount of the natural latex will be changes. In other ways, this research will investigate the effect of the natural latex due to the noise insulator.

The first condition is containing 0 percent from total coconut fiber weight. Next, the amount for natural latex increase 5 percent to come 5 percent from coconut fiber weight. Then the condition is 10 percent from the coconut fiber weight is natural latex. All the sample increase 5 percent until contains 60 % of latex by coconut fiber weight ratio. In this specimen, the shaping product will depend on the standards that used.

3.0 RESULTS & DISCUSSION

A. Tensile Test

Specimen made from 100 percent of coconut fiber shows it’s easy to broken because there have no latex that use to bind the coconut fiber. The average value of maximum stress is lower than the value for fiber composite contain with the latex. Compared with the specimen with 5 wt. % of latex, it’s quite hard to broken because contain some latex that bind the coconut fiber together. The specimen also has ductile properties because it’s can elongate before broken at one point. The average of maximum stress value for fiber composite for 5 wt. % latex is 0.14125 MPa which is higher than the fully fiber composite. It means that, the existence of matrix in the composite can affected the properties of the material such as strength, toughness and others factor.

The value of maximum stress fiber composite with 60 wt. % of latex is better compared with the fiber composite with 5 wt. % of latex. This is because the latex can bind all the fiber composite homogeneously with more quantity and not easy to broken the bonding between the fibers. It means that, the higher amount of latex in the composite, the higher value of strength. The curve of graph of fiber composite from 5 wt. % until 60 wt. % is almost similar to each other and the different is only the value of maximum stress. But,
the specimen is totally different with the fiber composite. Stress increased linearly than break immediately when it reached at broken point. Necking condition on specimens was seen during in elastic region and specimen failure in mode of brittle. Average value for Young’s modulus is 0.001266 MPa and it means that it has more elastic properties compared with the fiber composite.

Figure 1: Young’s Modulus for 14 types of specimen at tensile test.

Figure 1 shows the different percentage between the highest value of force which is represent by specimen No.9 compared with actual product is the specimen No.14 have greater young modulus percentage value about 97.54 % to actual product. While the different value between specimen No.1 and specimen No.9 is about specimen No.9 greater 166.71 % young modulus than specimen No.1. By the way, if compare specimen No.1 with actual product represent by specimen No.14, the percentage different is about 1426%. The others comparison is between specimen No.5 to the average value. Specimen No.9 bought about 0.051528 MPa, while the average value is 0.02652 MPa. So, the percentage different is about 94.30 % higher than average but for specimen No.14, it goes inversely which is lower than average value about 45.51 %. While, specimen No.1 is about 12.13 % different to the average.

B. Compression Test

The red line in Figure 2 represented the average value for each specimen which is contains different percent of latex. While the blue line show the average value for specimen. The average value is 0.095657 MPa. The average value for all specimens at the blue line which is the value is 0.39262 kN. All the data shows the percentage average data of fiber composite and the sample of synthetic rubber that were produced from compression test. This data were obtained after the specimen was compress until 400 N.

Figure 2 shows that the different percentage between the highest value of young modulus which is represent by specimen No.7 compare with actual product is the specimen No.7 have greater young modulus percentage value about 43.52 % to actual product. While the different value between specimen No.1 and specimen No.7 is about specimen No.7 greater 105.77 % young modulus than specimen No.1. By the way, if compare specimen No.1 with actual product represent by specimen No.14, the percentage different is about 195 %. The others comparison is between specimen No.7 to the average value. Specimen No.7 bought about 0.13759 MPa, while the average value is 0.095697 MPa. So, the percentage different is about 60.92 % higher than average but for specimen No.14, it goes inversely which is lower than average value about 45.51 %. While, specimen No.1 is about 12.13 % different to the average.

C. Moisture Absorption

Figure 3 shows result for the 14 specimens at moisture absorption test. In moisture absorption, latex contains actually will effected the moisture absorption percentage. The more latex in natural fiber composite, the less moisture will absorb by coconut fiber. But, during handle experiment on this research, the data not show the relation between the amount of latex and moisture percentage. Sample No.1 show the percentage of moisture absorption is 2.742 % compare to the sample No.2 which is show 3.188 %. If the result true as theory, the value of absorption between sample no.1 and No.2 is sample No.1 should have the greater amount. This problems may be occurs during mixing process when the latex and coconut fiber are not mixed well and homogenous.

The moisture content is inversely proportional to the density in the case natural fiber composite. A lower density yields higher porosity, spaces and voids. Consequently, the moisture content increases when the porosity increases as coconut fibers can absorb more moisture [2].
D. Noise Absorption Test

Soundproofing or noise insulator is any means of reducing the sound pressure with respect to a specified sound source and receptor. There are several basic approaches to reducing sound: increasing the distance between source and receiver, using noise barriers to block or absorb the energy of the sound waves, using damping structures such as sound baffles, or using active anti noise sound generators. Noise insulator affects sound in two different ways, which is Noise reduction and noise absorption. Noise reduction simply blocks the passage of sound waves through the use of distance and intervening objects in the sound path. Noise absorption operates by transforming the sound wave. Noise absorption involves suppressing echoes, reverberation, resonance and reflection. The damping characteristics of the materials it is made out of are important in noise absorption. The wetness or moisture level in a medium can also reflect sound waves, significantly reducing and distorting the sound traveling through it, making moisture an important factor in soundproofing.

Noise absorption testing is a test to determine and obtained the value of specimen that can absorb the noise when the constant noise was applied. This testing also to compare the natural fiber composite with the actual product that already established in the market. Each specimen exposure to the noise source in range 10 minutes and obtained the reading every single minutes for each specimen. The noise exposure level that applied to all tested specimen are constant because the needed was to determine the coefficients of noise for each specimen.

Sources of noise are used as a test signal and also know as sound pressure. The absorption of the room and its content based on assumption that the noise diffuse before and during decay rate and that no additional out sources enters the rooms during testing. In order to get the value for noise absorption coefficient, the value for the sound absorption should be obtained firstly. The sound absorption can be calculated as shown in formula below:

\[ A = \frac{0.9210V}{C} \]  

Which is:
- \( A \) = Sound Absorption, m²
- \( V \) = Volume of Reverberation Room, m³
- \( C \) = Speed of Sound, m/s
- \( D \) = Decay Rate dB/s

After got the value for sound absorption, the value for noise coefficient also can be determined by using noise coefficient formula as below.

\[ \alpha = \frac{Sound\ Absorption}{Overall\ Area} \]

In this experiment, there are a few factors that should be considered such as velocity of sound speed. Because doing this in control room, the velocity of sound is not 343 m/s anymore. The velocity should be higher or lower depends on the medium that sound can pass through. To calculate the velocity of sound in control room, the formula as show below.

\[ C = 20.047 \sqrt{(273.15 + T \degree C)} \text{ m/s} \]  

\[ = 20.047 \sqrt{(273.15 + 26)} \text{ m/s} \]  

\[ = 20.047 \sqrt{299.15} \]  

\[ = 346.73 \text{ m/s} \]

Another consideration is volume of the simulation room also should be considered. The volume is constant value for all test because used the same simulation room. The volume of the simulation room can be calculated as shown in below.

\[ V = \text{Length (m)} \times \text{Width (m)} \times \text{Thickness (m)} \]  

\[ = 0.21 \times 0.23 \times 0.297 \text{ m}^3 \]  

\[ = 0.01435 \text{ m}^3 \]
Figure 5 and Figure 5 shows the value for sound absorption for each specimen. The reference value is on the specimen No. 14 which is representing actual product that used in automotive industries. Specimen No. 14 bought value for sound absorption is $6.232 \times 10^{-5}$ m$^2$. The nearest value to the actual product is specimen No. 6 which the value is $6.228 \times 10^{-5}$ m$^2$. The lower the value goes, the better the sound absorption and will get the best noise coefficient to apply into daily usage. The best value for sound absorption is specimen No 12 which is contains 55 wt. % of latex. The value is $6.125 \times 10^{-5}$ m$^2$. As theory stated [3], latex has ability to convert energy of motion and allows it to absorb vibrations. The data that obtained during sound absorption analysis, the result should be consider corrected because proved by the references book as stated in [3].

Figure 5 shows the best specimen can be determined from the highest value of absorption. Specimen No.12 is the best specimen with the absorption rate is about $6.125 \times 10^{-5}$ m$^2$. The percentage different between specimen No.12 and actual product which is represent by specimen No.14 is 1.75 %. Meaning that, specimen No.12 absorbs 1.75 % higher than actual product does. If compare specimen No.12 and specimen No.1, the different in percentage is the specimen No.1 can absorb is less 4.05 % than specimen No.12 do. By refer to the Figure 5 also, the researcher can determined the percentage different between specimen No.1 and specimen No.14 is absorb 2.26 % more than specimen No.1. But, the biggest percentage different is between specimen No.12 and specimen No.15. Specimen No.15 represent the simulation room is without any insulator inside. The different is 5.49 %. Meaning, the ability of the specimen No.12 can absorb sound from natural condition which is without any insulator is up to 5.49 %.

While, if compare the percentage to the average value, specimen No.12 shows the different with average value is about 1.91 %. Based on the average also, the researcher can obtained the percentage value for specimen No.14 which is bought about 0.16 % compare to the average value. But, if compare the average value to the specimen No.1 and specimen No.15, the percentage value to absorb sound is lower than average value. Both got the different percentage about 2.1 % and 3.51 %.

Figure 6: Noise coefficient for 15 types of specimen.

Figure 6 shows the value for noise coefficient for each specimen. This part is very critical part because the value of noise coefficient will determined the best specimen for noise insulator. The reference value is on the specimen No. 14 which is representing actual product that used in automotive industries. Specimen No. 14 bought value for sound absorption is $1.413 \times 10^{-3}$. The nearest value to the actual product is specimen No. 6 which the value is $1.412 \times 10^{-3}$. The lower the value goes, the better the noise coefficient to apply into daily usage. The best value for sound absorption is specimen No 12 which is contains 55 wt. % of latex. The value is $1.389 \times 10^{-3}$. As same to sound absorption, latex has ability to convert energy of motion and allows it to absorb vibrations [3]. The data that obtained during sound absorption analysis, the result should be consider corrected because proved by the references book as stated in [3]. The value for noise coefficient is very important in order to select which is the best specimen if the entire requirement remains same.

Figure 6 shows the best specimen can be determined from the highest value of coefficient. The relationship same as the sound absorption, so, specimen No.12 is the best specimen with the coefficient rate is about $1.389 \times 10^{-3}$. The percentage different between specimen No.12 and actual product which is represent by specimen No.14 is 1.7. If compare specimen No.12 and specimen No.1, the different in percentage is the specimen No.1 can absorb is less 4.03 % in coefficient rate than specimen No.12 do. By refer to the Figure 6 also, the researcher can determined the percentage different between specimen No.1 and specimen No.14 which is the specimen No.14 coefficient rate is 2.26 % more than specimen No.1. But, the biggest percentage different is between specimen No.12 and specimen No.15. Specimen No.15 represent the simulation room is without any insulator inside. The different is 5.49 %. While, if compare the percentage to the average value, specimen No.12 shows the different with average value is about 1.9 %. Based on the average also, the researcher can obtained
the percentage value for specimen No.14 which is bought about 0.17% compare to the average value. But, if compare the average value to the specimen No.1 and specimen No.15, the percentage value to absorb sound is lower than average value. Both got the different percentage about 2.1% and 2.87%.

4.0 CONCLUSION

After all the specimens that have been tested, it shows that the specimens with 55 wt. % of latex have the best properties for noise insulator properties. From Noise absorption analysis, it shows that this specimen can absorb the noise that supplied to the specimen. The noise level supplied is 101.69 dB, but, after natural fiber composite with 55 wt. % of latex was implemented to the simulation reverberatory room, the noise level reading reduces to the 96.58 dB. This natural fiber composite shows very good noise insulation properties and very suitable for various application. The most suitable application is for building and construction as a noise insulator. This research proved that green material such as coconut fiber really suitable to replaced synthetic material by do some modifications on material and design toward green technology [6].

5.0 REFERENCES