Sound Absorption Type Single Reflex Bandpass from Rolled Kinds of Areca Nut with Polyurethane and Gypsum Matric

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Abstract. This research is directed to sound absorption performance test on single-reflex bandpass type speaker box from a fiber of Areca Nut with polyurethane and gypsum matrix. The variables of this study change the frequency into 3 types namely, 125, 250 and 500 Hz and then modify the sound pressure into 10 types, namely, 31.5, 63, 125, 250, 500, 1000, 2000, 4000, 8000 and 16000 Hz. The preparation of the research material begins with a cutting of the areca nut, splitting, drying, picking fiber, chopping, and blending, sieving, making 3 types of sheet-shaped, mixing polyurethane with gypsum and printing specimens. Preparation of research materials in the form of box specimen type single reflex bandpass which is then tested with the method of buzz and sound pressure (SPL). While the value of voice pressure (SPL) circularly on the axis X, Y and Z obtained the highest average value 57 dB on the Y3 axis and the lowest average value of 51.59 dB on the X2 axis.

1. Introduction

When designing a room in which one of the primary functions of the office is listening to sounds, such as a recording studio, auditorium, concert hall, home theatre, conference room, school class, workplace, modern room, etc., we must pay attention to the acoustic aspect. If the design does not pay attention to the acoustic aspect, it can be ascertained that the function of the room has failed. Some acoustic events that occur in a room are a reflection, absorption, diffusion, diffraction, and so on. The listener hears the acoustic events as echo, reverberation, boom-flat bass, and so on. The number of repetitions, the length of the hum, and so on when combined, will form a particular acoustic space.

On the other hand areca king (Roystonea regia) is found almost throughout Indonesia even able to grow at an altitude of 1400 m above sea level. King of the king is a plant that is not branched and grows upright. This plant can grow up to a maximum height of 30 m in general. Utilization of pinang king waste in the city of the field especially only thrown away if it has been aged 10 to 15 years. The
method of utilization owned by this plant is only a few, such as ornamental plants in urban parks, yard houses, firewood (midrib) in the countryside and as a tree air conditioning. The creation of a speaker box which is then tested for sound absorption performance is a feasible method to try based on existing theories such as making sound absorbing board from coco Fiber, which all plant Fiber is sourced from nature around. Areca Nut is found almost throughout Indonesia even able to grow at an altitude of 1400 m above sea level. King of the king is a plant that is not branched and grows upright. This plant can grow up to a maximum height of 30 m in general. Utilization of Areca Nut waste in the city of the field especially only thrown away if it has been aged 10 to 15 years. [1] [2] [3].

The method of utilization owned by this plant is only a few, such as ornamental plants in urban parks, yard houses, firewood (midrib) in the countryside and as a tree air conditioning. The creation of a dedicated speaker box which is then tested for its sound absorption performance is a viable method to try based on existing theories such as the making of sound absorbing board from coco fiber, which all plant fibers are sourced from nature around us including areca nut.

2. Methodology
Research on the use of stem fiber Areca Nut as a raw material of acoustic specimens is a preliminary study on the potential of fiber Areca Nut as acoustic raw material. The research was designed as experimental laboratory research. In this study, the method of making and forming to be a particle board which is then applied to a speaker box into a method selected to be used as a specimen for sound absorptivity test.

The ingredients to be used in the manufacture of these acoustic specimens are as follows:

a. The areca nut fiber with mesh size 32
b. Gypsum as an adhesive on this specimen is gypsum SNI 15-0129-2004.

c. Polyurethane is obtained from a mixture of Polyisocyanate (PUNA) and Polyol compound (PU.B)

Measurement of sound pressure (SPL) with frequency on speaker box made of fiber stick nut, gypsum and polyurethane using Sound Pressure Level (SPL) Bruel and Kjaer. The sound pressure testing procedure (dB) is done in the sequence of steps as follows:

a. Mediator 2238 Bruel & Kjaer (SPL) is directed to the earpiece and placed in a predetermined position (3-point axis)
b. Bring the 2238 Bruel & Kjaer mediator to the ON position
c. Mediator 2238 instantly reads sound pressure (SPL)
d. Record and prepare the camera to take a picture of the sound pressure on the mediator 2238 when its value is constant.
Figure 1. Position of sound intensity measurement based on predetermined frequency with position 3 axis.

Measurement of absorption coefficient of sound is calculated for 2 microphone buzzer space. To calculate the absorbance coefficient of sound used equation as follows:

\[ p_1 = Ae^{-jkx_1} + Be^{jkx_1} \]
\[ p_2 = Ae^{-jkx_2} + Be^{-jkx_2} \]
\[ H_{21} = \frac{P_1}{P_2} \]
\[ H_{21} = \frac{Ae^{-jkx_1} + Be^{jkx_1}}{Ae^{-jkx_2} + Be^{-jkx_2}} \]

b. Calculate the reflection factor and the absorption coefficient of sound by the formula:
\[ r = \frac{H_{21} - e^{-jks}}{e^{jks} - H_{21}} e^{2jkx_1} \]
\[ \alpha = 1 - |r|^2 \]

3. Results and Discussion

In this Case the results of research activities that have been done by previous researchers, namely mass density testing, porosity testing, sound absorption test by using the method of impedance tube, thermal testing and surface structure testing. It described in the form of tables and graphs for getting the best value which then becomes the reference material for the manufacture of soundproofing material. Followed by the selection of mesh and fiber composition which has the best average value without overriding its physical form. Then a suitable and simple printing technique for making particle board which is then used as a speaker box. After all the steps are done to get the particle board, the particle board is ready to be assembled and tested using the buzzer method and the sound pressure value (SPL).

The use of Areca king fiber material in the manufacture of a soundproof material specimen from polyurethane and gypsum containing fiber of areca nut is varied 70%, 60%, 50%, 40% and 30% weight/weight and the fiber size used is 10 mesh, 14 mesh and 32 mesh. While polyurethane foam and gypsum made with a ratio of 2: 1. Polyurethanes consist of polyisocyanate and polyol compound, which in the manufacture of these specimens the ratio of Polyisocyanate and polyl is 2: 1. So for the production of a mixture of specimens weighing 150 or can be seen as in table 1 below:

| No. | Powder % (gr) | Poly Isoianate % (gr) | Poliol % (gr) | Gypsum % (gr) | Summary (gr) |
|-----|---------------|-----------------------|--------------|--------------|-------------|
| 1   | 70            | 13,3                  | 6,7          | 10           | 100         |
| 2   | 60            | 17,78                 | 8,89         | 13,33        | 100         |
| 3   | 50            | 22,22                 | 11,11        | 16,67        | 100         |
| 4   | 40            | 26,67                 | 13,33        | 20           | 100         |
| 5   | 30            | 31,11                 | 15,56        | 23,33        | 100         |

Mass Testing Results, Porosity, Sound Efficiency Coefficient, Thermal Properties and Surface Structures

a. Results of mass density testing and porosity.
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Figure 2. The size of the test specimen of mass density and porosity

Table 2. The average sound absorption coefficient of 10, 14 and 32 mesh pin betel fiber specimens with composition 70%, 60%, 50%, 40%, 30% fiber.

| No. | Powder   | The average absorption coefficient ($\alpha$) |
|-----|----------|--------------------------------------------|
|     |          | 30% | 40% | 50% | 60% | 70% |
| 1.  | Mesh 10/32 | 0.2382 | 0.3793 | 0.4193 | **0.5279** | 0.3399 |
| 2.  | Mesh 14/32 | 0.3988 | **0.4131** | 0.3305 | 0.3305 | 0.3613 |
| 3.  | Mesh 32   | 0.3558 | 0.4647 | **0.6016** | 0.4915 | 0.4279 |

The average sound absorption coefficient of the three powder sizes and the percentage of powder content varies (70, 60, 50, 40 and 30%), which has been measured at frequency 125; 250; 500; 1000; 1500 and 2000 Hz indicate that the powder size and composition affect the sound absorption coefficient, as shown in Table 2 and Figure 4.

Figure 3. Graph of powder size and powder composition with average sound absorption coefficient

Figure 3 above shows the relationship of sound absorption coefficients with different powder compositions having various sizes of different particles, demonstrating that:

a. The same size of the same powder in different fiber compositions will result in various sound absorption coefficients at various frequencies.
b. The large size of different powders in the same powder composition will result in different sound absorption coefficients at the same frequency.

The specimen of soundproofing material of the areca nut fiber using polyurethane and gypsum as this matrix comprises a combination of a fiber of Areca raja, polyurethane (consisting of isocyanate and polyol) and gypsum. Different powder compositions of the matrix will affect the surface of the
specimen if 30% of the powder passes through the 10-mesh screen but does not pass through the 14-mesh screen mixed with 70% polyurethane and gypsum (polyurethane: gypsum = 2:1).

Then the polyurethane and gypsum will fill Cavities contained between the powders, 70% polyurethane and gypsum can fill the holes to the surface of the specimen so that the surface of the specimen becomes hard, flat and there are polyurethane and gypsum that are porous on its surface. If the powder composition is increased to 40, 50, 60 and 70%, this will cause the surface of the specimen to be different. In specimens with 70% powder plus 30% polyurethane and gypsum, 30% polyurethane and gypsum are insufficient to fill cavities between fibers to surface, resulting in a rough surface with little polyurethane and gypsum.

Similarly, if the specimen is made of a smaller powder size, the cavities between the powders will be smaller than the larger size fibers. The cavity between these powders will be filled with polyurethane and gypsum, the specimen specimens made with a 30% powder composition will be different from the specimens made from 70% powder. Surface specimens made from powder composition are 70% rougher than specimens made from 30% powder composition. The three types of powder sizes used, the powder that passes through the 10-mesh screen but does not pass through the 14-mesh screen produces a rougher specimen surface than a powdered specimen that passes through a 14-mesh screen but does not pass 32-mesh. And surface specimens made from powders that pass through a 14-mesh screen but do not escape from a rougher 32-mesh screen from the surface of specimens made from powders that give 32 mesh, the smaller the powder size used will produce smoother and pore surfaces - the dimensions on the surface of the specimen will also be smaller.

In the manufacture of these specimens the movement of polyurethane is limited by closing the mold with a dense time of printing. It will affect the shape and the large pores contained in the specimen and into the pores of the surface of the sample will also be different so as to produce different sound absorption character.

The data of mass density test result, porosity and the average sound absorption coefficient of soundproofing material made from the fiber of pining Raja by using polyurethane and gypsum can be arranged into the table, as in table 3.

Table 3. The results of the mass density, purity and noise absorption coefficient tests of the average of soundproof material specimens of the areca nut fiber using polyurethane and gypsum as matrices.

| No. | Powder (Mesh) | Powder (%) | Mass Weighting (gr/cm³) | Porosity φ (%) | Average sound absorption coefficient (α) |
|-----|---------------|------------|-------------------------|----------------|-----------------------------------------|
| 1   | 10/14         | 30         | 0,6951                  | 10,8569        | 0,3399                                  |
| 2   | 10/14         | 40         | 0,6051                  | 20,7906        | 0,5279                                  |
| 3   | 10/14         | 50         | 0,6012                  | 23,9092        | 0,4193                                  |
| 4   | 10/14         | 60         | 0,4995                  | 36,4315        | 0,3793                                  |
| 5   | 10/14         | 70         | 0,3740                  | 52,0583        | 0,2382                                  |
| 6   | 14/32         | 30         | 0,6425                  | 13,3019        | 0,3613                                  |
| 7   | 14/32         | 40         | 0,5697                  | 25,6396        | 0,3305                                  |
| 8   | 14/32         | 50         | 0,4899                  | 46,5667        | 0,3305                                  |
| 9   | 14/32         | 60         | 0,434                   | 55,7269        | 0,4131                                  |
| 10  | 14/32         | 70         | 0,3738                  | 56,2502        | 0,3988                                  |
| 11  | 32            | 30         | 0,5959                  | 30,4280        | 0,3558                                  |
| 12  | 32            | 40         | 0,5928                  | 44,5360        | 0,4647                                  |
| 13  | 32            | 50         | 0,4511                  | 55,6001        | 0,6016                                  |
| 14  | 32            | 60         | 0,4335                  | 57,8791        | 0,4915                                  |
| 15  | 32            | 70         | 0,3731                  | 58,2029        | 0,4279                                  |
To facilitate the determination of the highest average coefficients of the above test results data (table 3), then the above data can be made into graphical form, as shown in Figure 5. below this:

![Figure 4. Graph of relationship of fiber content of betel nut with porosity and average sound absorption](image)

Table 3 and Figure 4 shows that the increase in porosity is not directly proportional to the increase in sound absorption coefficient, the highest average sound absorption coefficient of the soundproofing material of the areca nut fiber using polyurethane and gypsum as a matrix of 0.6016 is produced by materials made from powders that pass from Screen 32 mesh, with 50% powder composition, 0.4511 gr/cm³ mass density and 55.6% porosity.

**Testing of thermal properties of mixed fiber stem of plantain, polyurethane and gypsum**

![Figure 5. Graphic images of DTA test results on fiber + polyurethane + gypsum](image)

Testing of sound absorbing material consist of the mixture of a fiber of pining Raja, polyurethane gypsum with differential thermal analysis instrument (DTA) by heating up to 6000°C temperature, the material has three changes:
a. Changes occur at 600°C temperatures in which the peak direction is right, and this indicates the occurrence of variations in the material, the nature of the reaction of this change is the endo term, usually in this region the evaporation of water molecules and other volatile substances.

b. There is a shift in temperature 3100°C, the direction of peak its left, this indicates the occurrence of changes in the material, the reaction properties of this change is the Exo term, but the material has not been burned.

c. There is a change in temperature 4750°C, the direction of the peak is left, this indicates the change in the material, the reaction properties of this change are an Exo term, and the material has been burned.

**Test Result with Space Drone Method**

Tests of 50% fiber composition specimens at 125 Hz frequencies can be seen as shown in Figure 7 Below:

![Sound Signal Recorder](image)

**Figure 6.** Measurement of amplitude in mic 1 and 2 with frequency 125 Hz

From the calculation of sound absorption coefficient (α) of 32 mesh fiber with composition of 50% fiber at 125 Hz frequency using Microsoft excel obtained α = 0.7297. To find out the sound absorption coefficient of 32 mesh fiber with 50% composition at frequencies 125, 250 and 500 Hz is calculated the same way and the results are arranged into a table, as shown in the following table:

**Table 4.** The result of the sound absorption coefficient test of 32 mesh pin fiber stem fiber with the composition of 50% fiber

| No. | Frequency | A       | B       | X1     | X2     | k       | α      |
|-----|-----------|---------|---------|--------|--------|---------|--------|
| 1   | 125       | 1.803591| 0.937666| 0.2750 | 0.2    | 2.3432  | 0.7297 |
| 2   | 250       | 1.803415| 1.189378| 0.2750 | 0.2    | 4.6865  | 0.5650 |
| 3   | 500       | 1.165405| 0.449226| 0.2750 | 0.2    | 9.3731  | 0.8514 |
Figure 7. Graph of test result of sound absorption coefficient of 32 mesh fiber specimen with 3-frequency (125 Hz, 250 Hz and 500 Hz)

Graph above is a data made based on the values of absorption coefficient obtained from the test results mesh 32. Based on the above graph can be explained on mesh 32 lowest absorption value is at a frequency of 250 Hz with an absorption value of 0.5650 and the highest coefficient is at a frequency of 500 Hz with an absorption value of 0.8514.

4. Conclusion

Based on a series of studies and analyses that have been done and reported in the previous chapters, it can be deduced from the results of this study:

a. The highest sound absorption rate absorbed by single-type reflex bandpass spacer box with polyurethane and gypsum matrix is 0.8514 at 500 Hz frequency.

b. The maximum sound absorption values mentioned above belong to class B with a range of 0.8 to 0.9 at a frequency of 500 Hz following the standard values permitted by ISO 11654

c. From Sound Pressure Level (SPL) test result on sound absorbing material, the highest average value is at 125 Hz frequency with 75 dB value which is proof that the supporting equipment is a low type (low frequency), speaker.

d. The results obtained in circular (ball) for sound pressure testing (SPL) obtained the highest average value on the Y3 axis with a value of 57 dB with a measurement distance of 0.5 meters and the lowest average value is on the X2 axis with a value of 51, 59 dB with a measurement distance of 0.75 meters.

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