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BORASSUS WOOD ACOUSTIC TESTS ON THE KUNDT TUBE FOR DETERMINATION ACOUSTIC CHARACTERISTICS

LOLO Komlan[*1], BANAKINAO Sinko[2], AFIO Ayarema[3]
[1,2,3]Laboratory of Structure and Mechanics of Materials (LaS2M), University of Lome
[1,3]Department of Mechanical Engineering, University of Lome, 01 BP 1515 Lome 01 – TOGO
[2]Department of Civil Engineering, University of Lome, 01 BP 1515 Lome 01 – TOGO.

ABSTRACT

Noise as an acoustic phenomenon producing an unpleasant and disturbing auditory sensation constitutes a real danger for man and for the environment. Faced with the dangers that noise represents for humans, various solutions are possible in order to reduce them by confining it or by using absorbent materials. Borassus wood would respond to this desire to absorb noise in the habitat. Unknown in the spectrum of wood, the determination of the acoustic parameters will be the subject of this work.
The materials are used in the habitat for decorative purposes without knowing the acoustic role. The acoustic range is evaluated by tests carried out on samples taken from the Borassus. The samples are cut so the fibers are cut and chopped. The evaluation is made on the tube of the Kundt model from expanded polystyrene for its validation. Three (03) categories of measurements are carried out with three (03) samples at different frequencies between 125 and 4000 Hz. From the transfer function, the reflection of the material is determined following the three categories of measurements. The results are obtained on the basis of the tube produced and calibrated.
This work which remains the beginning of the acoustic characterization of Borassus attests that Borassus is a reflective material on the hard part. The spongy part is not characterized but remains a valuable zone.

Keywords: Borassus wood, friction, brake pads, evaluation.

1. INTRODUCTION

During World Hearing Day held on March 02, 2021 on the theme: deafness, hearing loss, disabilities held by the WHO, it was established that approximately 1.5 billion people have a more or less pronounced hearing impairment and that among these people, 430 million are in need of rehabilitation services. This figure will be, in 2050, almost 2.5 billion people with more or less pronounced hearing loss and at least 700 million people will need rehabilitation services.

Noise as an acoustic phenomenon producing an unpleasant and disturbing auditory sensation constitutes a real danger for man and for the environment. Faced with the dangers that noise represents for humans, various solutions are possible in order to reduce them. These solutions will be to confine the noise from the source or to use absorbent materials because it is inevitable in some designs.

But it is clear that the characteristics that give the absorbent character to these materials are variable from one material to another and to be sought. These parameters are : the acoustic absorption coefficient α, the acoustic reflection coefficient R and the acoustic impedance Z of the medium. The acoustic impedance is a quantity characteristic of the nature of the medium in which the acoustic wave propagates.

The acoustic characteristics of a material can be determined by the prediction method, the reverberation room method according to standard NF S 31-003 or the Kundt tube method according to standard NF S 31-065. The software prediction method can only predict the absorption coefficient. Before this prediction, the physical characteristics intrinsic to these materials, namely porosity, tortuosity, resistance to air flow, viscous and thermal characteristic lengths must be specified. The use of this method becomes long and complex. The reverberation room only makes it possible to determine the absorption coefficient but it is also expensive because of the construction of the room and the devices to be used [1]. The Kundt tube uses the transfer function technique, an ISO 10534-2 standardized method. Less expensive, it makes it possible to determine the acoustic characteristics sought. Among these methods, the choice is made on the Kundt tube because of its pedagogical interest for measuring the acoustic energy absorption coefficient of porous or fibrous materials.

Borassus wood is a timber (construction wood), little known to the scientific world for reasons of belonging to the family of false woods but it has enough advantages. The purpose of this work is to determine the reflection of Borassus and deduce the absorption coefficient for its usefulness, if possible, in comfort and to do so, the tube must be designed and validated.

2. MATERIAL AND METHOD

The material to be tested is Borassus wood (see fig. 1). Slices of Borassus are caught on a stipe. From the slices, the samples are prepared in series. A series is a set of three samples. The material to be tested, Borassus wood (see fig. 3.a.), is worked at the carpenter's by cutting blocks (see fig. 4) into paving stones. In order to obtain the specimens to be tested, the blocks are cut cylindrically on a portable drill (see fig. 5) in the Fablab mechanical laboratory.

Figure 1: Borassus wood and the coring tool for cutting the sample

Borassus wood ; ***b.*** *coring tool for cutting*

The experimental material is the Kundt tube designed and validated (See fig. 2). The components of our test bench (the Kundt tube) are presented in the following (see fig. 3). Our tube is made of a PVC pipe with an external diameter of 65 mm and an internal diameter of 50 mm resting on a rectangular section of wood (80×45 mm) and a length of (800 mm) serving as a support. A sample holder system consisting of a cylindrical steel

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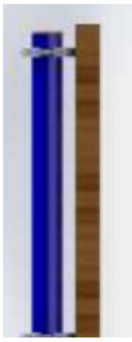
container and a screw-nut system at the end of which a plastic sleeve used to move the test sample allows the sample to be tested to be housed.

Figure 2 : Kundt tube mouting diagram

On the other side of the pipe is the speaker. The tube is equipped with two (02) microphones connected to a signal amplifier with two (02) inputs. At one end of the tube is a speaker that generates a signal. Two microphones are placed in the middle of the tube on the same generatrix, separated from each other by 75 mm. A distance of 375 mm separates the first microphone from the loudspeaker. At the other end will be placed the test piece. the incident wave is reflected by the sample. The presence of the two microphones makes it possible to break down the signal from the loudspeaker into the incident part and the reflected part.

a.



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b.

c.

Figure 3 : the components of the test bench

Amplifier ; ***b.*** *Sound card ;* ***c.*** *Microphone* ***d.*** *Tube*

The principle of the test is as follows. A pure periodic sinusoidal signal programmed on octave frequencies is emitted from one side of the loudspeaker and on the other side is placed the specimen to be tested. The method uses a tube of uniform section, of fixed length (figure 2). The standing wave field is created by a loudspeaker powered by a sinusoidal signal, generated then amplified by the LF generator/LF amp chain. This signal is emitted by the computer. The acoustic field created in front of the specimen made up by the absorbent material is explored by means of a microphone.

Figure 4.a shows the experimental block diagram. The measurements, at the level of the microphones, were carried out in 03 ways :

- the measurements are made by keeping the tube open on the side of the sample holder (without material and without the sample holder system) which makes it possible to record the value of the incident pressure at the level of each microphone ;
- with the tube closed without the material, the total pressure is recorded at each microphone ;
- the manipulations are repeated again but this time the sample is placed in the tube.

Fluctuations in density, pressure within the tube, and velocity are assumed to be uniform over each straight section of the tube. The transverse dimensions of the tube are small compared to the acoustic wavelength.

Figure 4.b is the modeling of the signal in contact with the surface of the sample. The emitted signal has an energy which, on contact with the surface of the material, breaks down into 03 :

- an energy absorbed (I absorbed) by the material which is dissipated in heat ;
- a reflected energy (I reflected) which returns into the tube ;
- a transmitted energy (I transmitted) which could not be absorbed which passes to the other side of the tube.

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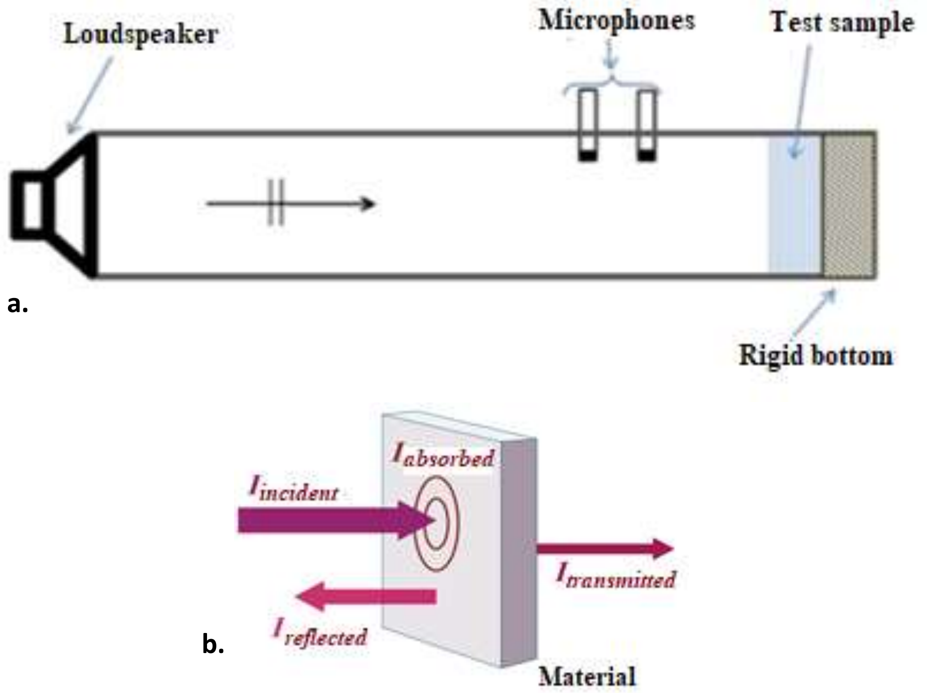

Figure 4 : basic diagram of the experiment

The incident and reflected wave measured by the two microphones are recorded on disk for processing. The frequencies were variable. At each frequency, the reflection coefficient is determined. The measurements were taken on polystyrene with a diameter of 50 mm and a thickness of 40 mm. These measurements were repeated 3 times. Each time, the reflection coefficient is determined for the validation of the tube.

Remember that the tests are made on cylindrical samples using a designed and calibrated tube. The sampling cutting process is presented by the series of figures (see fig. 5).

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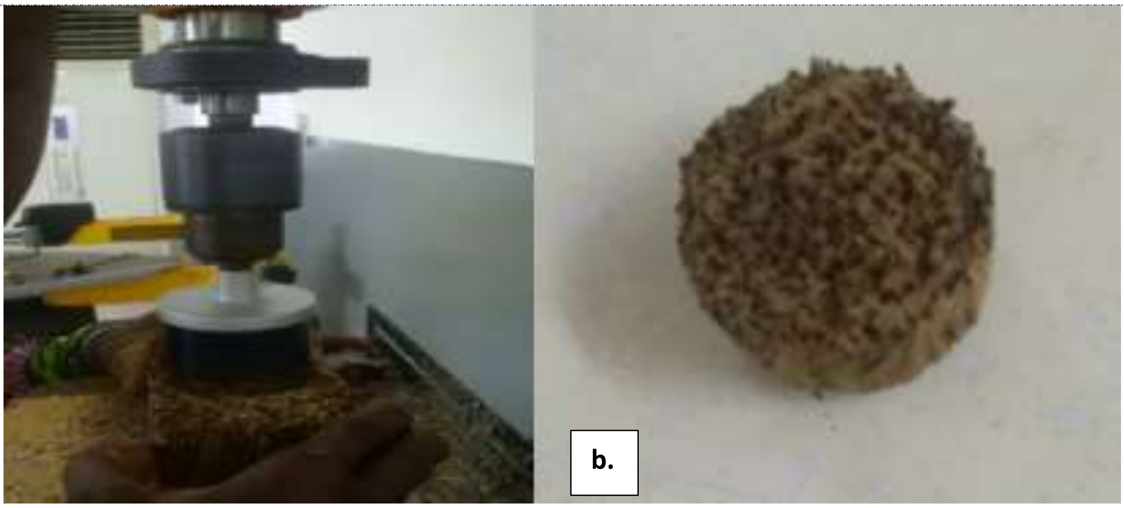

Figure 5 : Sampling cutting process

cutting the slat into blocks ; ***b.*** *Sampling using the carrot tool*

The samples have a cylindrical shape, with a thickness of 40 mm. They are cut in the direction of the fibers. Figure 5 shows the specimen to be tested. The experiment is carried out on a frequency band ranging from 250 to 2000 Hz. These cylindrical samples are placed in the tube at each chosen frequency.

3. RESULTS AND DISCUSSION

The work during the acoustic tests must be done on a frequency band ranging from 250 to 2000 Hz. The tube has a sufficient and uniform cross section to allow plane wave development. The walls are sufficient and thick so as not to interfere with the external environment of the tube. Figure 6 is the recording of the signals from microphones 1 and 2.

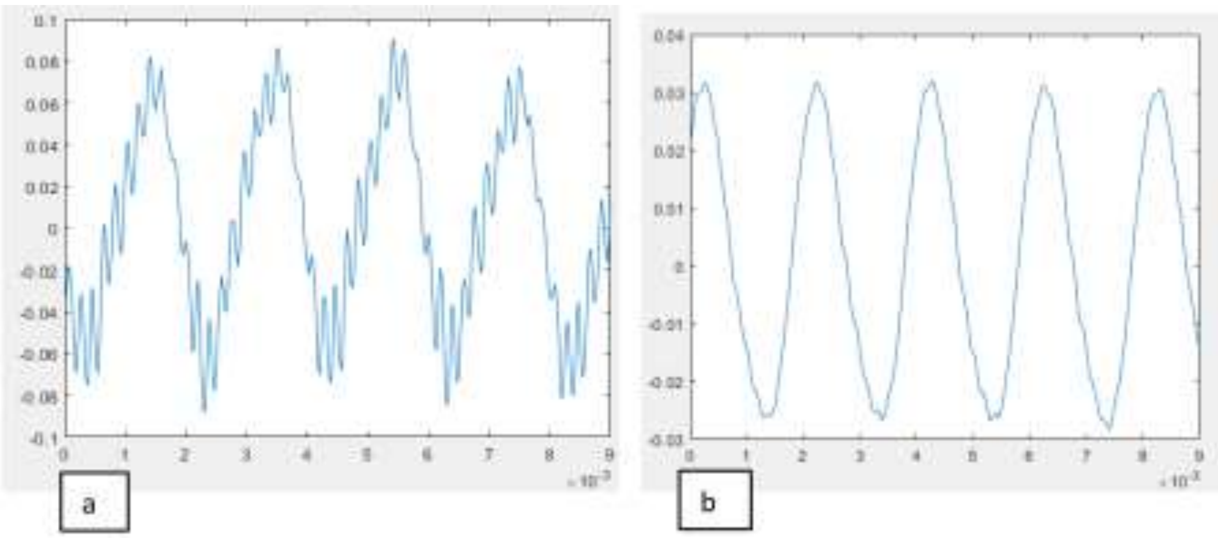

Figure 6: curves of the spectra of microphone 1 (a) and microphone 2 (b) at 500 Hz

By relying on the Matlab software with which a calculation program is written, the calculation of the transfer function is possible from the data recorded at the microphones and bring out the reflection coefficient. This program will not be shown in this work. But different relations will allow the rest of the calculations.

The tube is long enough to cause the waves to develop between the source and the sample. To validate the tube designed, tests carried out on expanded polystyrene give the results of table 1. The tube is validated from

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expanded polystyrene. The reflection value or the reflection coefficient is given in the table according to the frequencies. The reflection coefficient, denoted R, is the fraction of the incident energy that is reflected.

Table 1: Tube validation by R determination on polystyrene

Frequency in Hz	250	500	1000	2000
Series 1	0.7322	06554	0.7669	0.900
Series 2	0.7115	0.6032	0.7589	0.8900
Series 3	0.7282	06431	0.8010	0.8903
Typical deviation	0.008965	0.022281	0.01825	0.00464
Average	**0.72**	**0.63**	**0.77**	**0.89**

The result thus found shows consistency in the experiment. It highlights that at the 500 Hz frequency, the coefficient is lower than that obtained at the 250 Hz frequency. The values have increased at the different frequencies (1000 and 2000). The values found are greater than the references.

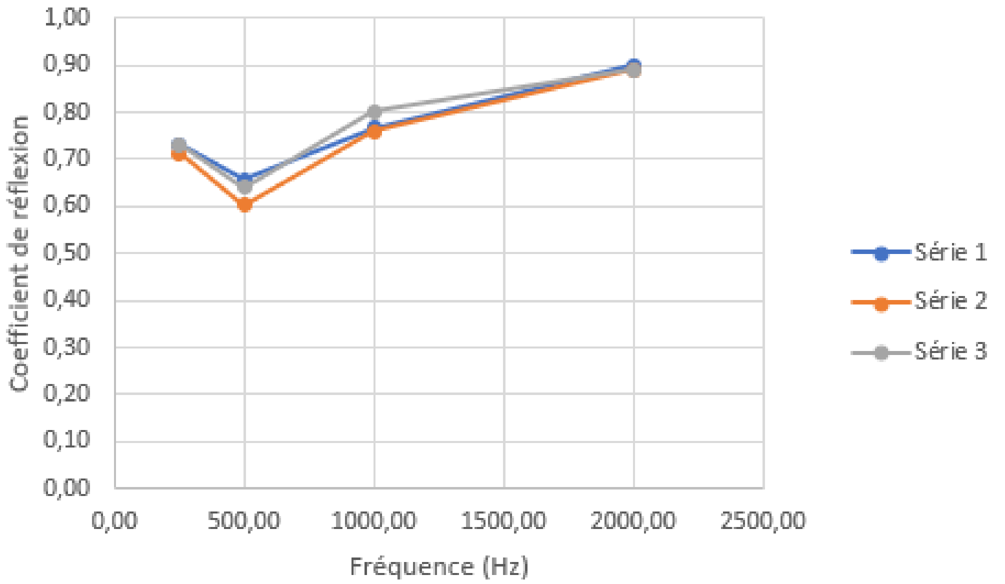

Figure 6 : curves showing the evolution of the reflection according to the frequencies (case of polystyrene)

After validation of the tube, the results on Borassus wood are reported in Table 2.

Table 2: Borassus results

Frequency in Hz	250	500	1000	2000
Series 1B	0.8732	0.6012	0.7032	0.806
Series 2B	0.8960	0.583	0.696	0.7732
Series 3B	0.8882	0.5725	0.656	0.7856
Average	**0.89**	**0.59**	**0.69**	**0.79**

The absorption of a material is characterized by an absorption coefficient. It varies depending on the frequency. This absorption coefficient α is given, assuming that no dissipation has occurred or the losses are negligible, by the relation 1:

$$\alpha=1-R \quad (1)$$

and the impedance Z of the tube is given by the relation 2.

$$Z = \rho C \frac{1+R}{1-R} \quad (2)$$

where ρ is 1.2 Kg/m^3 at a temperature of 20°C for a velocity equal to 344 m/s. According to ISO 10534-2, the absorption coefficient and sound impedance are related to the reflection coefficient by formula 2. From these relationships Table 3 is established with the values of reflection, absorption coefficient and impedance.

Table 3: Borassus results

Fréquence en Hz	250	500	1000	2000
Reflection	0.89	0.59	0.69	0.79
Absorption coefficient α	0.11	0.41	0.31	0.21
Impedance Z in $kg/m^2/s$	6925.86	1600.86	2055.36	3485.21

The work is done on a frequency band from 250 to 2000 Hz. The absorption coefficient α depends on the frequency of the wave and the nature of the medium. He believes with frequency. It is the penetrating power of the material tested; It increases rapidly with frequency. It is worth considering the band from 500 to 2000 Hz. The absorption coefficient of this Borassus wood decreases on the other hand the reflection coefficient increases. The Borassus values are close to those of the expanded polystyrene used to validate the tube. Polystyrene is a reflective material. This observation implicitly translates that Borassus wood is a reflective material.

4. CONCLUSION

This work allowed us to design the Kundt tube, which we validated by tests on expanded polystyrene. It served as the basis for the acoustic characterization of Borassus. As the thickness of the PVC tube used is not large, the room to house the experiment must be free of all audible signals. The hard area of Borassus wood would look like reflective wood. The study suggests that polystyrene and Borassus are reflective materials.

The acoustic characterization of Borassus remains a vast field to be exploited taking into account the zones and directions of the fibers.

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