Experimental Investigation on Sound Absorption Property of a Panel Board Using Maize Stem

P Ramshankar¹,²,⁴, Binu Sukumar²,⁴, S Kishore Kumar³,⁴, V Karan³,⁴ and C Karthick³,⁴

⁴Department of Civil Engineering, R.M.K. Engineering College, Kavaraipettai, Tamil Nadu, India.

Corresponding author: Ramshankar P
E-mail address: rsram25@gmail.com

Abstract. In this project our aim is to produce a soundproofing board which is made out of Maize stem (stalk). Due to increase in number of industries, factories and vehicle traffic cause serious noise pollution. So to overcome this, use of Sound proofing panels in the structural elements could significantly help to reduce the sound as well as gives a good environment to work. People nowadays demand for a better working environment. Many commercialized sound proofing materials are available in the market, the cost of these materials would be much higher and also it could cause health issues when people are exposed with the material. So use of sound proofing panels made with agro-waste could be a better solution, an attempt has been made to produce a soundproofing board which is made out of stalk portion of maize plant. The board’s sound absorption property is studied in this research by using Impedance test and the cost of maize stem board is cheap enough so that everyone can afford it.

Keywords: Maize stalk, Resin, Impedance Tube test.

1. Introduction

Building acoustics is the science of controlling noise and unwanted sound within the building space. To fulfill the purpose of noise control, it is necessary to consider both the nature of sound and phenomena of hearing. Sound in a building can be classified into two types such as wanted sound which we have to hear and unwanted sound called noise. The unwanted noise has to be removed from the space. Sound is a form of energy and it is a known fact that it cannot be destroyed. So, removing unwanted noise obviously means transforming it into another form of energy. Here comes the role of acoustic panels. Acoustic panels are nothing but a porous layer on which when sound incidents, the fiber in the panel vibrates and it develops friction between the layers of air and fiber. This produces heat, thus converting sound energy into heat energy. This action is commonly termed as sound absorption. The noise control process includes both sound insulation and sound absorption. Sound insulation helps to absorbing the sound waves and thereby helps in reducing the transfer of noise that passes through a
material.

Rapid development of industries and mass transportation systems may cause serious noise pollutions, which has adverse effects on human health and natural ecosystem. The effective solution to control noise can be achieved by using variety of noise reduction materials like sound absorbing panels. Sound absorption is not a new term to us. The idea of utilizing coconut coir and paddy straw in the ceiling of theatres and auditoriums is been followed by us since olden days, in the sense to absorb sound. Now-a-days many new innovations are been done in this area of acoustic panels. Acoustic panels are nothing but a composite made out of fibers, polymer adhesive with a porous coating.

Most commercially available sound absorption material for acoustic treatment consists of Synthetic-Fiber or Fiberglass materials. Though these acoustic panels are excellent sound absorbers, in developing countries like India, the tendency to use these panels are reducing because they are highly expensive. In addition to that, the manufacturing process of these acoustic panels affects the environment in many ways. Also the acoustic panel installation is another challenging process because, the shredding of these materials can be detrimental to health if exposed to the eyes or lungs or if their fibers are inhaled.

People are in need of acoustically sound building, but are not ready to spend excessively to these acoustic panels. When international schools, banks and offices are ready to use these acoustic panels, our government schools, hospitals, public sector units etc., are hesitating to buy these products because of their cost. This led the path of using mineral fiber boards. An attempt has been made in this project work to achieve an acoustic panel made out of agricultural waste (MAIZE STALK) with good sound absorption property. Surely this will be a valuable evaluation in the field of sound and noise control technology.

![Absorbing sound](image)

**Figure 1. Working Principle of Acoustic panel**

2. Literature Study

Mahzan et al. (2009) investigated the performance of rice husk waste in sound absorption. From this study it can be noted that the panel thickness, fiber to binder ratio influence the sound absorption in large extent.

Putra et al. (2013) studied the performance of sugarcane waste fibers in the building acoustics with binder as polyurethane and polyester. It was found that mix composition of 70:30 provides best
acoustic performance with absorption co-efficient more than 0.5 for frequency 1000 to 4500 Hz. Koizumi et al. (2002) developed a sound absorbing material using natural bamboo fibers. It was found that, the absorption co-efficient increases with decrease in diameter of bamboo fibers. Mohd et al. (2016) studied the behavior of sound absorption on a coir fiber composite. It was observed that with the increase in layer thickness increase the sound absorption in lower frequency. It was also concluded that long dissipative process of viscosity and thermal conduction in the fluid inside the material are the reasons for good sound absorption in samples of larger thickness.

3. Material Used:

3.1 Maize Plant

Maize stalk or stem portion is around 6-7 feet tall, the outer most covering of these stalk portion are very hard and the inner most part is spongy in nature and light weight. In our research the inner most portion of the stalk is used for the preparation of the boards.

Figure 2. Inner part of the Maize stalk

Figure 3. Grinded Maize stalk

3.2 Resin

Urea formaldehyde is a non-transparent thermosetting resin. This is the most used resin when comes to particleboard, mineral fiber board, wood based product etc. Urea formaldehyde attributes to high tensile strength, flexural strength, less absorption of water, high surface hardness, good elongation at break etc.

4. Experimental Results and Discussion:

Sound absorption can be quantified in terms of sound absorption co-efficient ($\alpha$) or noise reduction co-efficient (NRC). The sound absorption co-efficient of any material can be measured by impedance tube method, reverberation room method etc. Reverberation room method is the most accurate method for measuring sound absorption co-efficient, but it is highly expensive. The impedance tube method is most easiest and economical method for finding sound absorption co-efficient. Hence in our research, a board specimen is prepared using maize stalk and resin, then the sound absorption co-efficient of prepared specimen is measured using impedance test. Sound absorption co-efficient is the fraction of Sound Energy absorbed by a material and it is expressed as a value between 0 and 1. Absorption co-efficient 0 represents no absorption that is total reflection and absorption co-efficient 1 represents perfect absorption that is no reflection.
4.1 Casting of Specimens

The specimen is prepared by using mixing of granular sized maize particle stalk with urea formaldehyde resin and chemical adhesive for binding. The matrix composed of 80% granular maize stalk, 16% urea formaldehyde and chemical bonding agent 4%. The matrix is weighed, maize stalk is mixed first with urea formaldehyde in a warm water at 60°C. After mixing thoroughly chemical adhesive bond is added with them.

Table 1. Proportion of Design mix

| Materials            | Proportion |
|----------------------|------------|
| Maize Stalk          | 80 %       |
| UF Resin             | 16 %       |
| Chemical Adhesive    | 4 %        |

Figure 4. Specimen prepared with design mix

4.2 Impedance Tube Test

The impedance tube is a straight, rigid, cylindrical tube, consisting of two ends such as transmitting end and receiving end. The sample which is to be tested for sound absorption should be placed in the receiver end. The sound source generated plane waves at the transmitting end. The sound pressure is measured in two places, near the test sample end.

Measurement of sound absorption involves cutting each sample into four circle of diameter 29.5mm and 99.5mm. 4 sets of two circles of diameter 29.5mm and 99.5mm were cut from each sample and sound absorption co-efficient was measured. The circular molds that we used helped us to achieve perfect circles, so as to get exact measurement. The measurements were taken according to ASTM E1050-08 standard. Care should be taken when the circular samples are prepared. The surface should be smooth and uniform so that the measured value will be exact.
Figure 5. Test setup of impedance tube: (a) Large tube for measuring frequency range 50 - 1600Hz; (b). Small tube for measuring frequency range 500 - 6400 Hz.

Figure 6. Large specimens with diameter 99.00 mm

Figure 7. Small specimens with diameter 29.00 mm
The composite made of maize stalk has been tested for sound absorption co-efficient. The acoustic characterization of maize stalk composite involves discussing in detail, the behavior of the composite under various sound frequency range, the factors which influenced the sound absorption, the negative factors which hindered sound absorption, practical feasibility of using these composites in building acoustics etc. Before going in detail about these topics, the results obtained for the samples are discussed in detail.

Two sets of samples were prepared of varying thickness 15 mm and 20 mm. In each sample four specimens were casted. Below table shows the test results of sound absorption co-efficient value measured in Impedance tube test.

Table 2. Sound absorption coefficient in Impedance tube test

| Frequency (Hz) | Sound Absorption Co-efficient |
|---------------|------------------------------|
|               | Sample 1 [15 mm Thickness]   | Sample 2 [20 mm Thickness] |
| 250           | 0.11                         | 0.13                        |
| 500           | 0.17                         | 0.20                        |
| 1000          | 0.26                         | 0.27                        |
| 2000          | 0.24                         | 0.27                        |

Figure 8. Graphical Comparison of Sound Absorption Co-efficient of 2 Samples [Sample 1 – 15 mm, Sample 2- 20 mm]
5. Conclusion

The following conclusions were drawn based on the Impedance test results.

- The sound absorption coefficient at 1000 Hz is found as 0.26.
- It is observed that the maize stalk having higher sound absorbing coefficient at high frequency compared to frequency range less than 1000 Hz.
- In maize stalk the thickness has very low influence comparing with other natural fibers.
- The strength aspect of the panel is comparatively more than other materials when visually inspected.
- The maize stalk performs better than tile, brick, wood plaster and plywood when comparing with the sound absorption coefficient of other materials represented in figure 9.
- As it was made with natural agro waste product it does not cause any harm to environment and the cost of production also very less when compared with other products.

6. References

[1] Putra, A, Abdullah, Y, Efendy, H, Farid, W M, Ayob, M R, Muhammad SajidinPy, 2013, ‘Utilizing sugarcane waste fibers as a sustainable acoustic absorber’, Procedia Engineering, pp.632-638.
[2] Putra, A, Abdullah, Y, Efendy, H, Mohamad, W M F W, Salleh, N L, 2013, ‘Biomass from Paddy Waste Fibers as Sustainable Acoustic Material’, Advances in Acoustics and Vibration.
[3] Satish Pujari. “Comparison of Jute and Banana Fiber Composites: A Review”. (2014) P.121-126.
[4] Yonghua Wang, Chengchun Zhang, Luquan Ren, “Influences of Rice Hull in Polyurethane Foam on Its Sound Absorption Characteristics”. (2013)P.1847-1855.
[5] Koizumi, T, Tsujiuchi, N, Adachi, A, 2002 ‘The development of sound absorbing materials using natural bamboo fibers, High Performance Structure and Composites.
[6] Mahzan, S, Ahmad Zaidi1, A M, Ghazali, M I, Yahya, M N, Ismail, M, 2009, ‘Investigation on Sound Absorption of Rice-Husk Reinforced Composite’, Proceedings of MUCEET2009 Malaysian Technical Universities Conference on Engineering and Technology.
[7] Myrtha, K, holia, O, Anung, S, 2007, ‘Physical and Mechanical Properties of Natural Fibers filled Polypropylene Composites and its Recycle’, Journal of Biological Sciences, pp. 393-396
[8] Nagakalyan, S, Anoopisam, Vijaykiran, B, 2015, ‘Interfacial Behaviour of Composites Polymer and Sugarcane Fiber’, *International Journal of Innovative Research in Advanced Engineering*, pp. 53-61.

[9] Ndimele, P, Kumolu-Johnson, C, Anetekhai, M, 2011, ‘The invasive aquatic macrophyte, water hyacinth {Eichhorniacrassipes (Mart.) Solm-Laubach: Pontedericeae}: problems and prospects’ *Research Journal of Environmental Science*, ISSN 1819-3412, pp. 509–520.