Experimental study of Natural composite Material on Acoustic properties

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Abstract. The nature of natural fibers is porous, which is useful feature for sound absorption. These types of materials (natural) are less ecofriendly and ecofriendly. This study deal with the effect of using natural composite material as sound insulation, many types of natural materials with fiber glass had been used in this study, i.e. cotton, wool, fronds and vegetarian fibers with different thicknesses. The study consist of built attest rig to measure the different frequencies and sound waves experimentally to calculate the transmission losses and coefficient of transmission losses that are dialing from function generator use sound pressure level. The best results of transmission losses recorded for the composite materials (Polyester + Random + wool) and (polyester + fiber glass + cotton) in three thickness 6mm, 8mm and 10mm. From other side, the best results of absorption of noise at different frequencies recorded for (polyester + fiber glass + cotton) and (Epoxy + fiber glass + plan fronds) in three thicknesses.

Keywords: Natural composite material, Acoustic properties, Transmission losses.

1. Introduction

Noise is one of the significant reasons of environmental pollution. The rise in noise pollution is effect of airplanes, rapid industrialization, trains, vehicular traffic…etc. which has reverse result on the health of human. The evolution in technological through the globe has many benefits for provide the quality in the life but, there is other side results on the health of human where, recently depending on statistical information proved that the population percentage was suffering from headaches about (53%), high blood pressure about (36%), hearing disabilities about (36%), anxiety about (40%), (67%) irritability, insomnia about (61%) and cardiovascular diseases about (15%) [1]. To reduce the noise problem at sensitive areas like scientific laboratories, hospitals, classrooms, offices and residential areas etc. acoustic treatment is necessary so that the human in the sensitive areas are not affected on pollution get from the sound send out from many sources. The porous materials were greatly used in order to control the noise which has high ability to absorb the sound. These types of material are listed as porous fibrous medium or foam. Foam is get from polyurethane. Foams have voids which close the energy of sound where considered as a good medium to acoustic absorbing. Fibrous medium used for made the sound absorbers such as rock wool or glass which has good acoustic absorption properties. [2]. In order to control the noise, this technique has been used which called passive noise control method, many materials used in this method such as glass wool, asbestos and polyurethane foam etc. [3]. These types of material are flammable, dangerous in society [4]. So that it is very important to identify the natural fibers to replace synthetic materials used to absorb the noise which have advantages because it is available, recyclable, low cost and ecofriendly. Natural fibers have important attention in the applications of acoustics field. The diversity of natural fibers is previously being used for commercial utilization in construction applications and buildings. Natural fibers are probably listed as wood fibers, vegetable fibers, stalk, baste or skin fibers, fruit fibers, leaf fibers and seed fibers [5], many types of naturals fiber have high range for applications like bagasse, cattail, reeds, corncob, date palm, cotton, durian, oil palm fiber, rice, sansevieria fiber, pineapple leaves, sunflower and straw bale etc. [6]. The sound propagation in materials in theoretical methods are based on physical considerations, but in practical applications, more complex independent variables like porosity limits and
tortuosity are used [7]. The absorb of sound is used to reduce or control noise within a room, while transmission loss of sound which is used to illustrate the sound transmission from one room to another, also to reduce the level of sound in a room. The increase of sound absorption in a room may lead to reduce the reverberation time of room. This time measured in seconds which takes for a sound in order to decrease level about 60 dB. In order to get special speech intelligibility, the time reverberation in a room must be less than 1 seconds.

Malawade UA et.al [8] discussed method of preparation a specimen for the various compositions. Rice husk, Bagasse, Wood dust and Rice straw was tested in order to obtain their potential of loss the sound. The apparatus build up to measure sound loss potential included receiver and emitter. The experimental tests were achieved by obtained the level of sound at receiver without obstruction also the tests were repeated by insert the sample in between. The difference between two test readings considered the sound loss for this sample. Also, the sound absorption coefficient for each test was measured and compared it with similar materials used in the tests.

YANG WeiDong and LI Yan [9] studied the properties of sound absorption for natural fibers and their composites of reinforced. The sound absorption coefficients for three different types of natural fibers, such as flax, jute, ramie fibers and their composites were obtained by two microphone transfer function technique in the impedance tube. Also, comparing the results obtained with synthetic fibers and their composites. The results show that the both type of natural fibers and their composites have excellent ability to reduce the noise. The hollow lumen and multi-scale structures of natural fibers give a share in the high performance of absorption sound. In addition, the properties of the sound absorption for these natural fibers were also measured by the Garai-Pompoli and Delany-Bazley models; they obtained excellent agreement with the experimental results. Moreover, the multi-functional composite materials can be getting from natural fibers so both the acoustical and mechanical functions can be carried out.

Pritesh Vishwasrao Bansod et.al [10] studied acoustical properties of natural material like jute which is prepared using numerical and experimental techniques. The coefficient of normal incidence sound absorption and the sound transmission loss are obtained for building materials (jute) by using the transfer matrix method. The numerical and theoretical calculations illustrate a matching with the experimental calculations in the medium frequency and high frequency ranges of benefit. The experimental tests for sound transmission loss and sound absorption coefficient don at frequency ranges from 50 to 4000 Hz.

The aim of the study of Alzbeta Samkova and Petr Kulhavy [11] is to investigate if the improvement of the physical properties achieved for fiber-reinforced construction materials. This research is study the estimation of changes in the acoustic attenuation of the basic plaster composites when adding a reinforcement of high strength fiber. The plasters materials used here are already used in building constructions (gypsum, cement, and lime-cement). In these types of material which considered the matrix, a little glass fiber and basalt dispersion of length about (8.5 and 12.0 mm) have been added. In order to test the materials acoustic absorption, a resistance tube was used. It can be concluded that the acoustic absorption had been very good for all of tested specimens regardless on the amount reinforcement added.

This study will identify the properties of sound absorption of natural materials that can be used in a variety of practical fields as environmentally friendly, cheap and available materials.

2. Experimental work

The accomplishment of the experimental part of this work consists from:

1-Acoustic Chamber: It is a box made from wood in dimensions (25 cm. in length ‘25 cm in width and 46 cm in depth) as shown in figure (1).

The upper surface slides to make us able to open and close the box easily in horizontal level; we must put the specimen exactly (in vertical level) in the middle of the box.

One of the sides of the box is open to put load speaker and the other side of the box is closed and it contains a hole of (1.5cm) in diameter exactly in the middle to fix a device (SPL) in side.

The inside of the box is covered with sponge which it's surface is shaped (Zig_Zag) the distance between top to top (3cm) and from top to bottom (2cm) and the thickness of the whole of the sponge is (3cm), contains the load speaker, and it is insulated from inside to prevent the sound reflection and insulated the sound from the outside sound and noise.
2-Load speaker in size (25cm).

3-Sound pressure level meter: in order to measure the sound pressure levels, sound pressure level meter is used. As it's known the ear of human is not evenly sensitive to whole levels of sound, these meter types have internal frequency systems weighting to obtain the readings amounting to how the human hear the sound levels. The system weighting is built up as weightings known A, B, C. In this time just the weightings A and C are used. The most frequently weighting used today is A type due to it reaches to measurement of sound which closely reflect how the human really hear. These curves of response, in this plot the response in dB vs. frequency in Hz are plotted. When exposure to weight A levels over 85 dB in continuous that cause dangers in hearing. The ear of human can be detect the changes in level of sound as 1 dB, thus can be happened under good conditions of listening. Any way, 10 dB changes in level of sound is usually can be hearing by ear as twice as thunderous or one/half as thunderous.

4-Function generator: it is an electronic test device used in order to generate various electrical waveforms types with many ranges of frequencies. The sine, triangular, square and saw tooth shapes are the most prevalent waveforms which obtained by function generator. These types of waveform require an external or internal trigger source. The integrated circuit which responsible to generate these waves considered as function generator too (ICs). These generators not used for the applications have stable frequency signals or low distortion; in spite of function generators utilize the RF and audio frequencies. Many types of function generators be phase-locked to an external signal source or can be development by using another function generator, to inspection and maintenance the electronic devices. Such as, it can be used as a source of signal to introduce an error in signal at a control loop or to inspection amplifiers.
Producing a specimen is achieved by using a mold made from glass; it is formed from 2 glass plates. The dimension of each one is (30 * 30 cm) it’s depth is (3mm) and a glass farm with dimensions; outside is (30*30cm) inside is(20*20cm) and thicknesses (2mm).

The farm is put around "Random" and the surface of the farm is also lubricated by the surface of the frame is also lubricated by Vaseline then the liquid substance which is formed from the (Polyester + Resin) is poured on "Random" then the surface of the second glass is lubricated to be put on the composite material (polyester + resin + random) to cast it by putting a load of value nearly (15Kg) for (24 hours) after that the mold is open and the specimen is got out.

To produce the sample formed from (polyester + resin + fiber glass) and another one from (Epoxy + hardener + fiber glass) By using a wood farm in dimension (24*24cm) outside, and (20*20cm) inside and (1cm) thickness.

Fixed a group of nails (the distance from one nail to another is 2mm) at the long of two parallel sides of the wood farm then put the plate of glass in dimensions (24*24cm) on the wood farm between two lines of nails), and then putting farm of glass of (2mm) in depth on the glass plate.

Then we're lubricating the surface of the glass farm and glass plate; then we begin to tighten up the fiber glass tightly with fixed nail with basing it on the surface of the glass plate after filling that required area with fiber glass (20*20cm) we're poured the substance that formed from (polyester + resin) on the fiber glass and we should moving the material by brush to distribute it uniformly and to saturated the fiber glass with (polyester + resin) when the bursting and all air gaps removed from the composite material; we'll press it with another glass plate by putting distributed load nearly (15 Kg) for (24 hours); then we'll open the mold and the specimen is got out.

We'll repeat the same steps to get another specimen but formed from (Epoxy + hardener) with fiber glass.

Different types of natural material are used such that; Cotton, Sheep wool, plan fronds and vegetarian fiber.

These materials are used to produce sandwiches with insulation walls that made from polyester, epoxy, fiber glass and random.

To produce "a sandwiches" we must be put the specimen and we put on it one of the natural materials (cotton, sheep wool, plan fronds and vegetarian fiber) in the form of plate and with demons- ions (20*20cm) then we'll put the second specimen and fix it by screw or by any other sticky substance such as” glue” we'll repeat the same steps to produce the specimen and sandwiches but only re-place the (polyester + resin) by (Epoxy + hardener)

This study included the following cases:

Case 1: polyester + Random + cotton in three thicknesses (6mm, 8mm, 10mm).
Case 2: polyester + Random + wool in three thicknesses (6mm, 8mm, 10mm)
Case 3: polyester + Random+ plan fronds in three thicknesses (6mm,8mm,10mm)
Case 4: polyester + Random+ vegetarian fiber in three thickness (6mm,8mm,10mm)
Case 5: Epoxy + Random+ cotton in three thicknesses (6mm,8mm,10mm)
Case 6: Epoxy+ Random+ wool in three thicknesses (6mm,8mm,10mm)
Case 7: Epoxy+ Random+ plan fronds in three thicknesses (6mm, 8mm,10mm)
Case 8: Epoxy+ Random+ vegetarian in three thicknesses (6mm,8mm,10mm)
Case 9: polyester + fiber glass+ cotton in three thicknesses (6mm,8mm,10mm)
Case 10: polyester + fiber glass+ wool in three thicknesses (6mm,8mm,10mm)
Case 11: polyester +fiber glass+ plan fronds in three thicknesses (6mm,8mm,10mm)
Case 12: polyester +fiber glass+ vegetarian in three thicknesses (6mm,8mm,10mm)
Case 13: Epoxy +fiber glass+ cotton in three thicknesses (6mm,8mm,10mm)
Case 14: Epoxy +fiber glass+ wool in three thicknesses (6mm,8mm,10mm)
Case 15: Epoxy +fiber glass+ plan fronds in three thicknesses (6mm,8mm,10mm)
Case 16: Epoxy +fiber glass+ vegetarian in three thicknesses (6mm,8mm,10mm)
Case 17: polyester +Random in one thickness (2mm)
Case 18: polyester +fiber glass in one thickness (2mm)
Case 19: Epoxy +Random in one thickness (2mm)
Case 20: Epoxy +fiber glass in one thickness (2mm)
3. Results and Discussion

All the following figures show the relation between transmission losses (TL) and frequency, in addition the relation between coefficient of transmission (α) and frequency for different types of specimen used in this work.

1. Case 1: polyester + Random + cotton in three thicknesses (6mm, 8mm, 10mm).

2. Case 2: polyester + Random + wool in three thicknesses (6mm, 8mm, 10mm).

3. Case 3: polyester + Random + plan fronds in three thicknesses (6mm, 8mm, 10mm).
4. Case 4: polyester + Random+ vegetarian fiber in three thickness (6mm,8mm,10mm)

5. Case 5: Epoxy + Random+ cotton in three thicknesses (6mm,8mm,10mm)

6. Case 6: Epoxy+ Random+ wool in three thicknesses (6mm,8mm,10mm)
7. Case 7: Epoxy+ Random+ plan fronds in three thicknesses (6mm, 8mm, 10mm)

8. Case 8: Epoxy+ Random+ vegetarian in three thicknesses (6mm, 8mm, 10mm)
9. Case 9: polyester + fiber glass+ cotton in three thicknesses (6mm,8mm,10mm)

10. Case 10: polyester + fiber glass+ wool in three thicknesses (6mm,8mm,10mm)

11. Case 11: polyester +fiber glass+ plan fronds in three thicknesses (6mm,8mm,10mm)

12. Case 12: polyester +fiber glass+ vegetarian in three thicknesses (6mm,8mm,10mm)
13. Case 13: Epoxy + fiber glass + cotton in three thicknesses (6mm, 8mm, 10mm)

14. Case 14: Epoxy + fiber glass + wool in three thicknesses (6mm, 8mm, 10mm)

15. Case 15: Epoxy + fiber glass + plan fronds in three thicknesses (6mm, 8mm, 10mm)
16. Case 16: Epoxy + fiber glass + vegetarian in three thicknesses (6mm, 8mm, 10mm)

17. Case 17: polyester + Random in one thickness (2mm)
18. Case 18: polyester + fiber glass in one thickness (2mm)

![Figure 39. Relation between TL and Freq for case 18](image1)

![Figure 40. Relation between \( \alpha \) and Freq for case 18](image2)

19. Case 19: Epoxy + Random in one thickness (2mm)

![Figure 41. Relation between TL and Freq for case 19](image3)

![Figure 42. Relation between \( \alpha \) and Freq for case 19](image4)

20. Case 20: Epoxy + fiber glass in one thickness (2mm)

![Figure 43. Relation between TL and Freq for case 20](image5)

![Figure 44. Relation between \( \alpha \) and Freq for case 20](image6)
It is evident that the type of composite material influences the TL and α, at all cases all the specimens exhibited as pattern the same of sound absorption. For all cases, when the frequency increased, the TL and α also increased. This behavior indicates that it can be used these composite material where the sound depends of the frequency. It can be noticed that the composition of tested materials have influenced on the sound absorption.

From the results, it can be seen that the best results of transmission losses recorded for the composite materials (Polyester +Random + wool) and (polyester + fiber glass + cotton) in three thickness 6mm, 8mm and 10mm. From other side, the best results of absorption of noise at different frequencies recorded for (polyester + fiber glass + cotton) and (Epoxy + fiber glass + plan fronds) in three thicknesses.

For the same sample tested with different thicknesses, the differences showed on the TL and α observed that the composite material were getting in each case have different properties from where (scale of the wavelengths and homogeneous) along the thicknesses also to the specimen surface.

The analysis of the transmission losses results indicates to confirm the previous observations.

4. Conclusion

In this study the sound absorption properties of natural material for many types of composite material (cotton, wool, fronds and vegetarian fibers) with different thicknesses have been tested. The results show that the best results of transmission losses recorded for the composite materials (Polyester +Random + wool) and (polyester + fiber glass + cotton) in three thickness 6mm, 8mm and 10mm. From other side, the best results of absorption of noise at different frequencies recorded for (polyester + fiber glass + cotton) and (Epoxy + fiber glass + plan fronds) in three thicknesses.

The properties of the sound absorption for natural fibers were excellent to synthetic fibers like carbon fibers and glass because of their multi scale structures and unrivaled hollow. At high frequencies, natural fiber reinforced composites have good acoustic absorption behavior than the synthetic fiber reinforced composite.

It can be concluded, that the effect of the fiber size of distinctly promotes acoustic absorption in conjunction with fiber thickness, this is confirmed by the experimental results of this study.

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