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Comparitive study of Acoustic properties of Weaved Coir Mats

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Abstract: *In this paper we report a study on acoustic properties of coir mats –a biofibremat of various weaving patterns. In this study coir-mat has been introduced as one of the sound absorbing materials.There are many advantages of coconut fibres because they are moth-proof,non-hazardous,resistant to fungi and ecofriendly with good sound absorption.The study reveals the effectiveness of coir mats as sound absorber and its applications in building acoustics and automotive applications . Coir mats of different weaving were selected for the study viz;Panama, Herringbone, Boucle weaving,mesh matting,Twill weave matting,Diamond weave matting,PVC tufted mat,Lovers Knot,VC2 mat etc.The experiment is performed on an impedance tube apparatus as per ASTM E 1050/ISO 10534-2. The experimental analysis is made for the frequency range 100 Hz-6300 Hz.The results reveal that the mats show good sound absorption coefficient at high frequencies and also the mats with latex backing and increased thickness exhibit appreciable absorption of coir mats.*

Keywords: *coir mats,panama weave,Herringbone weave,Boucle weave mesh matting,Twill weave matting,Diamond weave matting,PVC tufted mat,Lovers knot,VC2 mat,Absorption coefficient,NRC,boimats,biofibre*

I. Introduction

Noise pollution generally refers to unwanted sound produced by human activities . 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. Apart from hearing loss, such noise can cause lack of sleep, irritability, 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.

Acoustics is currently one of the most important fields of study in all countries of the world. Noise control is one of the major requirements to improve the living environment.There are several methods to decrease noise,one of which uses sound absorption materials.Sound Absorption coefficient(SAC) is defined as the fraction of randomly incident sound energy which is absorbed by the surface.

Most practical sound absorbing products used in the building construction industry consist of glass- or mineral-fiber materials. Because of the dominance of these materials in the commercial market, the study of sound propagation in alternative materials has been limited. However, the growing concern about the potential health risks popularly seen as being associated with fiber shedding from glass- or mineral-fiber materials provides an opportunity for wood-based sound absorbers to be developed for use in applications traditionally occupied by glass- or mineral-fiber products.

Many investigations have been carried out to find the potential use of new materials for sound absorption applications. Research on natural fibres shows that they have potential to be used as sound absorption panels. Agriculture waste of coconut fiber,rice husk and oil palm may be used as substitutes for synthetic fibers and wood based raw materials for acoustic absorption purposes. These fibres have many advantages because they are cheaper, renewable and abundant, non-abrasive and do not give rise to health and safety issues during processing and handling [1-4].

It is reported that porous layer backing and perforated plate on coir fiber can improve noise absorption coefficient at low and high frequencies[5]. The absorption of coir fiber can be enhanced by compressing the material.Some studies examined the sound coefficient of coconut coir fiber for the purpose of substituting the conventionally used materials such as glasswool and rockwool and reported that the coconut coir fiber has high potential to be utilized as sound absorbing materials[6].Davern reported that the the porosity of the perforated plate and density of the porous material would significantly affect the acoustic impedance and sound absorption coefficient of the panel,and the frequency band near the resonance frequency achieve high acoustic absorption[7].Lee an Chen found that the acoustic absorption of multilayer materials is better with a perforated plate backed with airspaces[8]. Researchers have succeeded in developing particle composite boards using agricultural wastes[9-10].

Coir mats are extracted from a coconut byproduct and used to create natural aesthetically appealing doorway mats. Coir Mats are available in a range of colours, sizes and designs. The brushing qualities of coir doormats and their ability to keep the dirt away make the product a unique one. Mats are available in plain, natural and bleached, available with woven or stencilled designs and bevelled patterns for use in interior or exterior door fronts. These mats offer a host of benefits including durability, weather resistance and easy maintenance.

Coir Matting is primarily used as a floor furnishing material. Because of its sound deadening characteristics, it is being used on a large scale for furnishing stairs, corridors, and auditorium and cinema halls. A wide range of attractive designs and colours as well as quality makes it a favourite item for interior decorators. Research revealed the effectiveness of coir fiber in sound absorption,however the use of coir mats as an acoustic material is rarely studied.

This paper mainly aims at the comparitive study of acoustic absorption coefficient and various acoustic parameters of coir mats having different patterns of weaving.

II. Test Material And Experimental Test Procedure

Coir mats of different weaving pattern are available.Mats with panama weaving,Herringbone weaving , Boucle weaving ,mesh matting,Twill weave matting,Diamond weave matting,Lovers knot,PVC tufted mat and VC2 mat are selected for the study.Sound absorption coefficient ,Noise reduction coefficient(NRC) etc of the mats are studied.The test procedure is done using impedance tube apparatus as per ASTM E 1050/ISO 10534-2 [11]

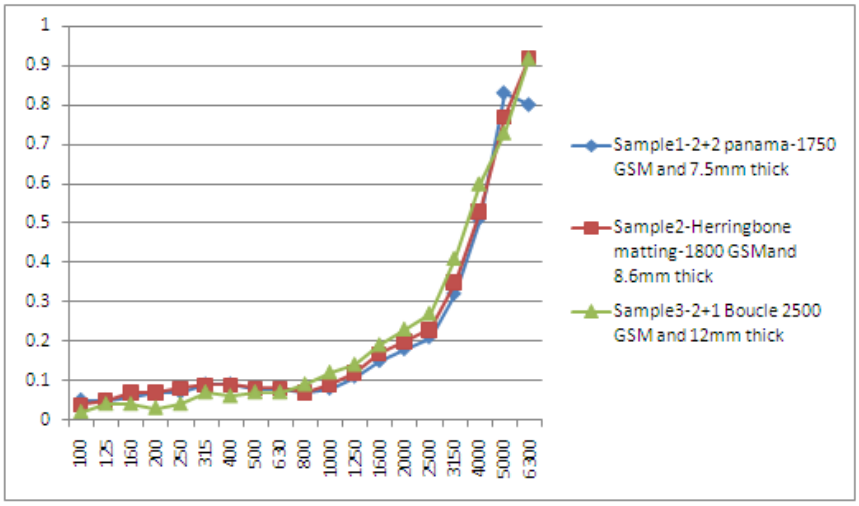
Test Procedure

- The normal incidence sound absorption coefficient (NISAC) measurement was carried out on coir mat samples using impedance tube as per ISO 10534-2 / ASTM E- 1050.
- Multichannel data acquisition system PULSE,Type 3560D,B&K Denmark make
- Power Amplifier,Type 2716,B&K Denmark make
- 1/4" Microphones,G.R.A.S.,Denmark make
- The samples were cut of 45 mm and 100 mm diameter using die cutter. The impedance tube of different diameters were used to evaluate the sound absorption from 100 Hz – 6300 Hz at one third octave frequency band.
- During testing the coir mat was facing the source side. Also measured the sound absorption facing latex side to see the effect of latex on sound absorption.
- The Noise Reduction Coefficient (NRC) is calculated for each sample. NRC is single number value, which is average of sound absorption coefficient at 250 Hz, 500 Hz, 1000 Hz and 2000 Hz.
- The sound absorption measurements were carried out at room temperature 26^0C $\pm 1^0$C and humidity 49 ± 1%.
- Flow resistivity measurements were carried out on 100mm diameter samples to study and compare variation in sound absorption coefficient.

III. Result And Discussion

Normal incidence sound absorption coefficient values of sample 1,2and 3

One third octave frequency,Hz	Sample 1-2+2 panama-1750 GSM and 7.5mm thick	Sample 2-Herringbone matting1800 GSM and 8.6mm thick	Sample 3-2+1 Boucle 2500 GSM and 12mm thick
100	0.05	0.04	0.02
125	0.05	0.05	0.04
160	0.06	0.07	0.04
200	0.07	0.07	0.03
250	0.07	0.08	0.04
315	0.09	0.09	0.07
400	0.09	0.09	0.06
500	0.08	0.08	0.07
630	0.08	0.08	0.07
800	0.07	0.07	0.09
1000	0.08	0.09	0.12
1250	0.11	0.12	0.14
1600	0.15	0.17	0.19
2000	0.18	0.20	0.23
2500	0.21	0.23	0.27
3150	0.32	0.35	0.41
4000	0.51	0.53	0.60
5000	0.83	0.77	0.73
6300	0.80	0.92	0.92
NRC	**0.10**	**0.11**	**0.12**

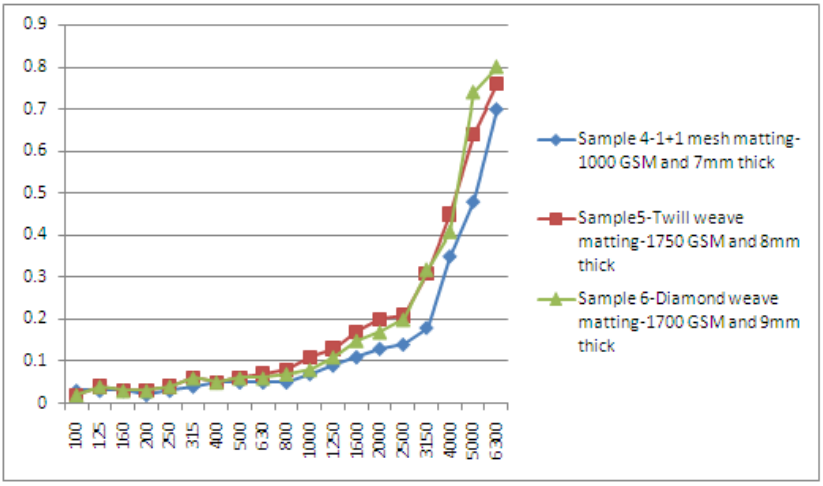


X-axis-Frequency in Hertz
Y-axis-Normal incidence sound absorption coefficient

Sound absorption coefficient of samples 1,2&3(Panama weaved mat,Herringbone matting,Boucle weaved mat respectively) for frequencies 100 Hz-6300 Hz is measured. Samples 1,2&3 show less sound absorption upto 2000Hz.This is due to low sample thickness and low flow resistivity.Above 2000 Hz the sound absorption increases.Panama weaved mat shows maximum sound absorption of 0.83 at 5000 Hz.For Herringbone and Boucle weaved mat maximum SAC is 0.92 at 6300 Hz.The NRC values of the samples are 0.10,0.11 and 0.12 respectively.These samples show better absorption on increasing the thickness and also when latex backed has reported in author's study[12].

Normal incidence sound absorption coefficient values for sample 4,5,6

One third octave frequency,Hz	Sample 4-1+1 mesh matting-1000 GSM and 7mm thick	Sample5-Twill weave matting-1750 GSM and 8mm thick	Sample 6-Diamond weave matting-1700 GSM and 9mm thick
100	0.03	0.02	0.02
125	0.03	0.04	0.04
160	0.03	0.03	0.03
200	0.02	0.03	0.03
250	0.03	0.04	0.04
315	0.04	0.06	0.06
400	0.05	0.05	0.05
500	0.05	0.06	0.06
630	0.05	0.07	0.06
800	0.05	0.08	0.07
1000	0.07	0.11	0.08
1250	0.09	0.13	0.11
1600	0.11	0.17	0.15
2000	0.13	0.20	0.17
2500	0.14	0.21	0.20
3150	0.18	0.31	0.32
4000	0.35	0.45	0.41
5000	0.48	0.64	0.74
6300	0.70	0.76	0.80
NRC	**0.07**	**0.10**	**0.09**

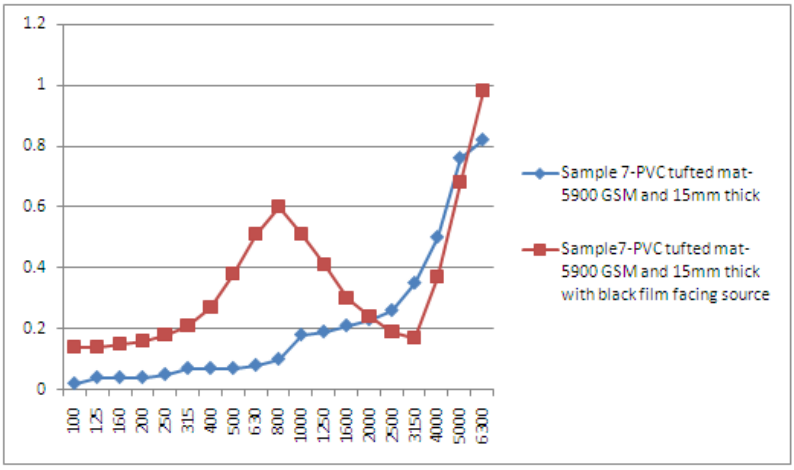


X-axis-Frequency in hertz
Y-axis-Normal incidence sound absorption coefficient

Sound absorption coefficient of samples 4,5&6(Mesh matting,Twill weave matting,Diamond weave matting respectively) for frequencies 100 Hz-6300 Hz is measured.samples 4,5 and 6 shows maximum value of SAC at 6300 Hz which 0.70,0.76 and 0.80 respectively.NRC values for samples 4,5 and 6 are 0.07,0.10 and 0.09 respectively.Mesh matting shows less absorption when compared with the other samples.This is because of its non-dense weaving pattern.

Normal incidence sound absorption coefficient of sample-7

One third octave frequency,Hz	Sample 7-PVC tufted mat-5900 GSM and 15mm thick	Sample7-PVC tufted mat-5900 GSM and 15mm thick with black film coating facing source
100	0.02	0.14
125	0.04	0.14
160	0.04	0.15
200	0.04	0.16
250	0.05	0.18
315	0.07	0.21
400	0.07	0.27
500	0.07	0.38
630	0.08	0.51
800	0.10	0.60
1000	0.18	0.51
1250	0.19	0.41
1600	0.21	0.30
2000	0.23	0.24
2500	0.26	0.19
3150	0.35	0.17
4000	0.50	0.37
5000	0.76	0.68
6300	0.82	0.98
NRC	**0.13**	**0.33**

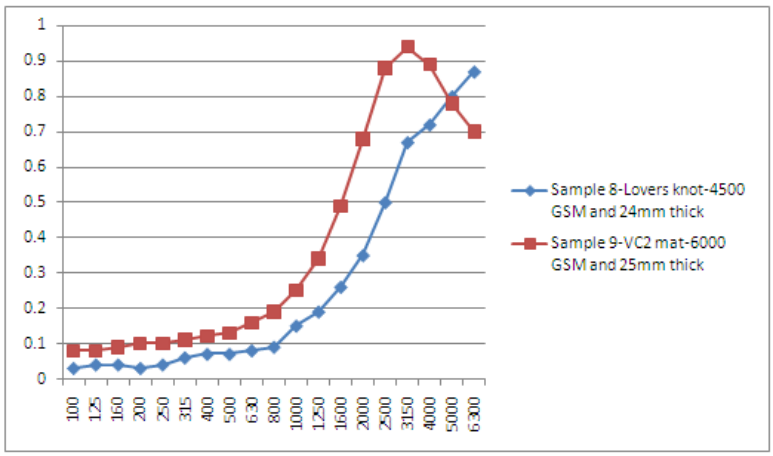


X-axis-Frequency in hertz
Y-axis-Normal incidence sound absorption coefficient

PVC tufted mats show good absorption above 2000 Hz.Maximum value of SAC is 0.82 in the first case and 0.98 in the second case of this sample. The same mat when tested with the black film facing the source shows good absorption even at low frequencies.NRC values of the sample are 0.13 and 0.33 respectively.

Normal incidence sound absorption coefficient of sample 8 and 9

One third octave frequency,Hz	Sample 8-Lovers knot-4500 GSM and 24 mm thick	Sample 9-VC2 mat-6000 GSM and 25 mm thick
100	0.03	0.08
125	0.04	0.08
160	0.04	0.09
200	0.03	0.10
250	0.04	0.10
315	0.06	0.11
400	0.07	0.12
500	0.07	0.13
630	0.08	0.16
800	0.09	0.19
1000	0.15	0.25
1250	0.19	0.34
1600	0.26	0.49
2000	0.35	0.68
2500	0.50	0.88
3150	0.67	0.94
4000	0.72	0.89
5000	0.80	0.78
6300	0.87	0.70
NRC	**0.15**	**0.29**



X-axis-Frequency in hertz
Y-axis-Normal incidence sound absorption coefficient

Both samples(Lovers knot and VC2 mat) shows good absorption when frequency is increased above 1000 Hz.Lovers knot mat shows maximum SAC of0.87 at 6300 Hz and VC2 mat shows max SAC value of 0.94 at 3150 Hz.NRC of these samples are 0.15 and 0.29 respectively.VC2 matshows good sound absorption when compared with Lovers knot mat.

Considering sound absorbing property of coir mats,the reverberation time of an auditorium is measured with coir mats fitting as acoustic material.Results show that coir mats reduce the reverberation time of the auditorium to an optimum level which is suitable for speech and music.

IV. Conclusion

Out of the nine samples examined for absorption coefficient,a few samples are the good candidate for acoustic applications.For VC2 mat sound asorption coefficient significantly increases at low and high frequencies and shows NRC=0.29. But its surface density of mass is a bit high. Samples with increase in thickness and also backing with latex or PVC possess good sound absorption coefficient. Coir industry is a traditional industry in India.Coir and coir products earn the livelihood of a significant segment of population ,especially in southern region of India.Considering its absorption features coir mats can be used in buildings and auditoriums for acoustic applications.Work is in progress to develop an acoustic panel as a product using coir mats as a base material.

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