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Comparative Study on Acoustical Behavior of Cement Mortar using Sound-Absorbing Materials

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Abstract

An experimental study has been conducted to study the acoustic performance by replacing five different sound-absorbing materials (Eggshell, Fly ash, Seashell, Baggese ash, Jute fiber) to the cement mortar. The study aimed to explore the feasibility of using these materials in developing the sound-absorbing panel. Thus, the grade of the mortar mix arrived from IS 1237-2012 as 1:3. Sound absorbing materials were replaced by 30% of the weight of sand. Samples were cured for about 7 days. The sound absorption coefficient was determined by Impedance tube test in the frequency range of (250 - 2000) Hertz. From the results of the experiment, a Comparative study has been carried out for the different samples.

Keywords: Acoustic, feasibility, absorption, frequency.

I. INTRODUCTION

The use of recycled waste materials and natural materials in the construction field has kept on increasing for the past decade. Due to environmental hazards and global warming, the researcher's attention turned towards the effective reuse of recycled and natural materials. At the same time, traditionally used acoustical materials like polyurethane foam, synthetic fibers, and glass fibers cause global warming, also it affects human health. Due to these issues, the demand for alternative materials is increasing day by day. These increasing demands have induced the researchers to use natural and recycled waste materials. This study was projected mainly on environmental effects and economical means of using sound-absorbing materials. Chokri Othmani et al. (2016) described the sound absorption behavior of sugarcane ash under the title"Experimental and theoretical investigation of the acoustic performance of sugarcane waste-based materials" The studied material showed its efficiency to absorb sound with a high acoustic absorbing coefficient. The result of this study can be as 1) Decrease of fiber size increases the flow resistivity and the acoustic absorption coefficient. 2) The decrease of resin content causes an increase in flow resistivity and a decrease in the acoustic absorption coefficient. Vikrant Tiwari et al. (2004) described the sound absorption of cenosphere reinforced concrete. Cenosphere is a hollow micro - balloons made up of Aluminium silicate. The volume of the cenosphere was taken as 70% and the water-cement ratio was 0.4. Highway surface course (class-1) design was used for making the cenosphere-rich asphalt concrete specimens. It consists of coarse aggregates and fine aggregates (sand) in different gradations and asphalt binder (6% by weight). The mass density of cement concrete decreased by 40% as the volume fraction of the cenosphere increases to 70%. Sound absorption of cement concrete increases with the addition of cenosphere up to 40% volume fraction and decreases with the further addition of cenospheres. No significant change in sound absorption characteristics of cement concrete was observed with the change in specimen thickness. With the increase in the volume fraction of cenospheres from 0 to 20 to 40%, there is a successive increase in sound absorption. With a further increase in the volume fraction of cenospheres from 40 to 60%, a systematic decrease in sound absorption was observed. PV. Bansod et al. (2016) described the sound absorption of natural jute fiber by the particle swarm optimization method. A sample of diameter 29mm and length 100mm was tested for its sound-absorbing behavior by using an impedance tube test and the results showed an increased sound-absorbing of 50 to 6400 Hz. Thus jute can be used as sound-absorbing material for building applications.

II. MATERIAL DESCRIPTION

Sound absorbing materials used in this study are as follows: Sugarcane bagasse ash, jute fiber, fly ash, eggshell, and seashell. Sugarcane is a perennial crop that cultivated about 60 million acres all over the world. Almost 60% of the sugarcane produced are commercially used in the production of sugar and molasses. For every 10 tonnes of sugarcane crushed, a sugar factory produces 3 tonnes of wet sugarcane bagasse. These wet sugarcane bagasse are collected and dried under sunlight for 7 days. Sugarcane bagasse ash is obtained by incinerating the dry sugarcane fiber in an uncontrolled temperature. The eggshell is a common waste material available all over the world. About 100 billion eggs are produced in India, from which 90 billion eggs are consumed, out of which 11 billion kilograms of eggshells are generated. These eggshells are collected and dried under the sun for 7 days and then converted to powdered form. Seashell is a part of an animal body, which is hard, composed mainly of calcium carbonate. Seashells are washed away from the sea to the seashores as a result of waves. These seashells are collected and dried for about 7 days. Then it is converted to powdered form. Fly ash is a waste material obtained on the ignition of coal from the thermal power plant. Fly ash is rich in aluminium silicate, which can produce lightweight cement mortar that can absorb sound. India is the leading country in producing jute. Though 80% of the jute produced is used for handlooms and textiles, the rest 20% is used for various purposes. These jute fibers are collected and chopped to a length of 5mm.

III. SPECIMEN DESCRIPTION

The mortar mix proportion is a basic requirement for designing a panel according to the project, the mix proportion may vary. To control the strength and economy, the definite mix proportion is needed. According to the "Code of practice for Cement Concrete Flooring Tiles" of IS 1237: 2012 the mix ratio was determined. From clause 6.3 the proportion of cement to aggregate in the backing of the double layer tiles shall be 1:3. Therefore, the mix ratio is determined as 1:3. The dimensions of the specimen were taken according to the Impedance tube test. Portland pozzolana cement was used; the mortar mix proportion of cement, special sound-absorbing materials and sand were 1:3 and the water-cement ratio of 0.55. The mortar mix was poured into two cylinders of diameter 99.5 mm and 50 mm height. After one day from casting, the samples were removed from the mold and placed into the water for 7 days.

Fig. 1, Specimen preparation

Fig. 2, Samples of specimen

III. RESULT AND DISCUSSION

The samples consisting of different sound-absorbing materials like Seashell, Sugarcane bagasse ash, Jute fiber, Eggshell, and Fly ash were measured by impedance tube test and compared with each other.

The impedance tube test was carried out by the PSG College of Technology. peelamedu, Coimbatore. (PSGTECHS COE INDUTECH). The instrument used was Acoustic material testing – Impedance tube.

As per Indian Standard Organization, the Sound absorption co-efficient is the arithmetic average of values of the sound absorption coefficient of the material at frequencies of 250Hz, 500Hz, 1000Hz and 2000Hz.

A. Seashell

Seashells sample showed a sound absorption of 0.03 for lower frequency and for higher frequency range of 500, 1000, 2000, 4000, 5000, 6300Hz respectively.it was about 0.07, 0.66, 0.11, 0.35, 0.25, 0.49. It showed a higher sound absorption of 0.66 in 2000Hz.

TABLE 1

Frequency (Hz)	Sound Absorption Co-efficient
250	0.04
500	0.07
1000	0.66
2000	0.11

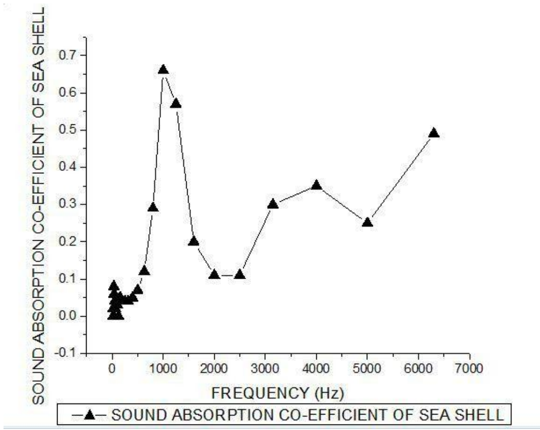

Fig. 3, SAC chart of Seashell

B. Flyash

Seashells sample showed a sound absorption of 0.03 for lower frequency and for higher frequency range of 500, 1000, 2000, 4000, 5000, 6300Hz it was about 0.06, 0.41, 0.12, 0.87, 0.58 respectively. It showed a higher sound absorption of 0.87 at 4000Hz.

TABLE 2

Frequency (Hz)	Sound Absorption Co-efficient
250	0.03
500	0.06
1000	0.41
2000	0.12

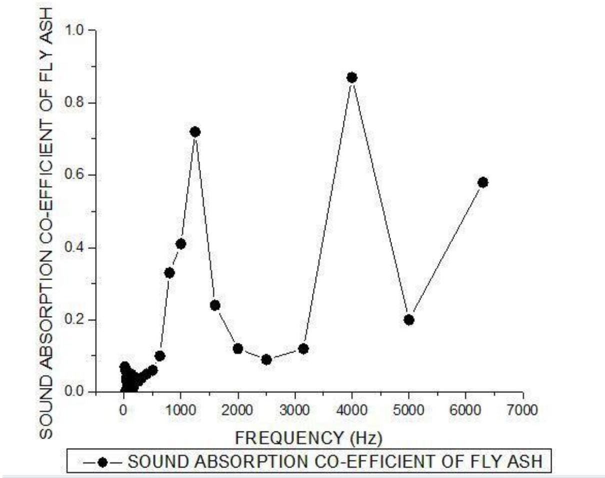

Fig. 4, SAC chart of fly ash

C. Buggase Ash

Seashells sample showed a sound absorption of 0.19 for lower frequency and for higher frequency range of 500, 1000, 2000, 4000, 5000, 6300Hz it was about 0.57, 0.84, 0.47, 0.70, 0.79 respectively.It showed a higher sound absorption of 0.84 at 1000Hz and was dropped to 0.47 at a range of 2000Hz.

TABLE 4

Frequency (Hz)	Sound Absorption Co-efficient
250	0.19
500	0.57
1000	0.84
2000	0.47

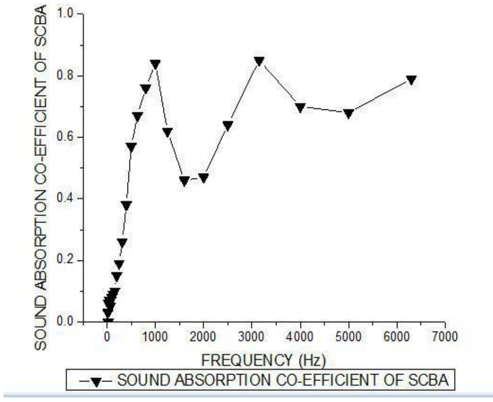

Fig. 5, *SAC chart of Baggase Ash*

D. Jute Fibre

Jute fiber sample showed a sound absorption of 0.03 for lower frequency and for a higher frequency range of 500, 1000, 2000, 4000, 5000, 6300Hz it was about 0.14, 0.47, 0.15, 0.86, 0.49 respectively. It showed a higher sound absorption of 0.86 at 4000Hz.

TABLE 3

Frequency (Hz)	Sound Absorption Co-efficient
250	0.06
500	0.14
1000	0.47
2000	0.15

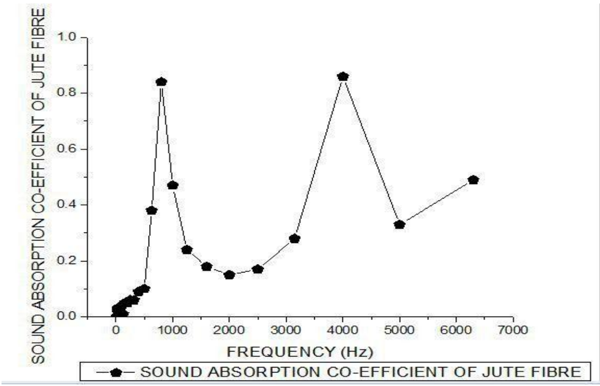

Fig. 6, SAC chart of jute fiber

E. Egg Shell

Seashells sample showed a sound absorption of 0.03 for lower frequency and for higher frequency range of 500, 1000, 2000, 4000, 5000, 6300Hz it was about 0.25, 0.86, 0.27, 0.83, 0.74 respectively. It showed a higher sound absorption of 0.83 at 4000Hz.

TABLE 5

Frequency (Hz)	Sound Absorption Co-efficient
250	0.10
500	0.25
1000	0.86
2000	0.27

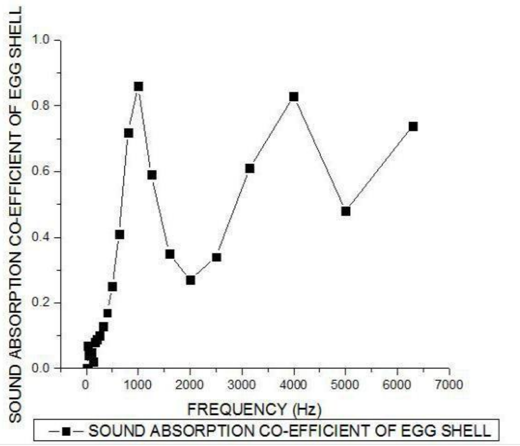

Fig.7, SAC chart of Eggshell

F. Sample motor

Normal mortar sample showed a sound absorption of 0.03 for lower frequency and for a higher frequency range of 500, 1000, 2000, 4000, 6300Hz it was about 0.06, 0.40, 0.16, 0.20, 0.43 respectively. It showed a higher sound absorption of 0.43 at 6300Hz.

Frequency (Hz)	Sound Absorption Co-efficient
250	0.04
500	0.06
1000	0.40
2000	0.16

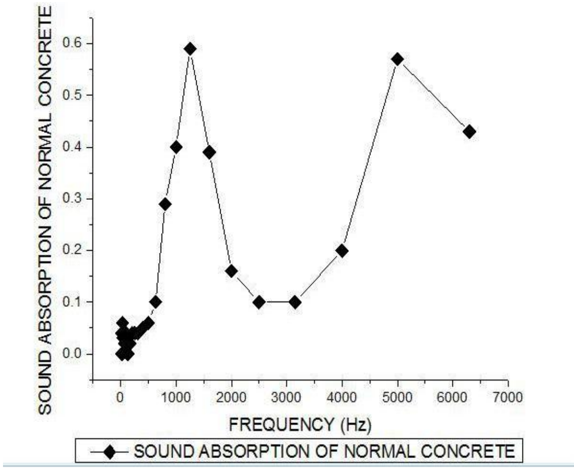

Fig. 8, SAC chart of Eggshell

IV. CONCLUSION

Natural and Recycled materials are becoming an interesting alternative, due to their good acoustic behavior, similar to traditional porous materials. Economical and eco-friendly building materials were proposed as jute fiber, seashell, eggshell, SCBA and fly ash. Six different sound absorbing cement mortars were cast under the ratio of 1:3 with 7 days curing in water and tested by Impedance tube test. Each sample showed good absorption at a particular frequency range. Thus the sound absorption coefficient of different sound-absorbing material was determined. As per International Standard Organization, NRC is the arithmetic average of values of the sound absorption coefficient of the material at frequencies of 250Hz, 500Hz, 1000Hz and 2000Hz. The octave or octave band is a range of frequencies whose upper-frequency limit is twice that of its lower frequency limit. For example, the 1000 Hertz octave band contains noise energy at all frequencies. Each octave and 1/3 octave bands are identified by a middle frequency and the reference middle frequency in acoustics is 1000 Hz. Jute fiber, seashell, eggshell, SCBA, fly ash and normal mortar from these sound-absorbing material samples, Eggshell sample has a higher sound absorption coefficient of 0.86 at the frequency of 1000Hz.

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