Acoustical Properties of Honeycomb Fabric with Advance Material Micro-Plates

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Abstract

This paper presents the results of experiment carried out with customized fabric design using advanced materials, to determine the significant amount of sound waves absorbed and compare it to the acoustic fabrics available in the market. The designed fabric absorbs the sound waves through a porous layer having honeycomb pattern that converts sound energy into thermal energy. The advanced fabric material diffuses the reflected sound waves within the micro-plate`s structure layer, yet the minimum amount of waves penetrates through the fabric as compare to the other acoustic fabrics. The experimental results showed 20-23 dB insulation value with the advanced material used.

Keywords: Acoustic fabrics, Multilayer fabric, Absorption, Honeycomb weaves.

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INTRODUCTION

Sound insulation has been a trigger issue for scientists since the sounds with certain frequency levels are different as noise pollution. Sound can be pleasing to human ears in definite range; human ears can perceive sound ranges from 20 to 20000 Hertz. Loud sound is usually controlled by adding number of layers between the source and the receiver; more the number of layers better will be the insulation. The layers can be a series of combinations of layers; it can be materials with different thickness and high damping layers. Owing to the different speeds of sound in the different layers, the wavelength of the incident wave has to acclimatize with each layer, this separation of layers results in the loss of energy at every layer front and a spreading of the coincidence immerses (Christina, 2009).

The sound absorption coefficient for materials is the percentage of incident sound waves energy which is absorbed by that testing material. The coefficient depends upon the sound frequencies and the values which are usually synchronized with the standard frequencies of 250, 500, 1000, 2000 and 4000 Hertz. The noise reduction coefficient (NRC) value measures the amount of sound absorbed into a fabric and passed through it. NRC is an average of values from 250 to 2000 Hertz. Absorption coefficients are sometimes expressed as percentages, for example, a material with NRC value of 0.40 means that the 40% of the sound is absorbed and 60% travels through the fabric (Marian, 2005).

In this effort, the basic concept of absorption has been studied with the acoustic multi-layered fabrics having material like foams, ceramic layers, esthetic layers, woven, and non-woven fabrics. Meanwhile, by introducing advanced material layer with the structure having micro-sized that of absorption values than the average acoustic materials. A lot of multi-layered acoustic panels and boards are used for different purposes, the main disadvantage of multi-layered acoustic structures are generally expensive to manufacture. The absorbing materials used in the acoustic structures (fabrics) are mostly ceramics, steel wool or KEVLAR (Perlikowsk, 1999).

MATERIALS AND METHODS

As for the experimental analysis, test sample (A), have non-woven acoustic fabric, sell under the name of technical fiber (cellulose + glass fiber) with the width of 27mm were taken. Sample (B), a modified design of fabric with sandwiched layer of honeycombed fabric made from fiberglass, and a double layered sheet with numerous micro-plates facing each others, with a thickness of about 25mm. Sample (C) contains fabric made with a layered of mineral fibers with the thickness of 28mm.

Materials with good acoustic properties are found to be with porous in structure, more porous the material more sound waves will diffuse. It is found that, thickness of such acoustic materials is also essential in absorbing sound; thick materials have more capability to absorb than the thin layered fabrics. The aim of this work was to find an acoustic design with less thickness and more sound absorbability.

The reverberation test chamber method was employed in this study on the basis of ISO Standard 354 - Acoustics - Measurement of sound absorption in a reverberation room. This method is based on measuring the reverberation time in a room before and after the introduction of the test samples. The absorption of the materials is then measured by comparing the reverberation times between both of the measurements, taken with and without the sample material in the reverberant room. In ISO Standard 354, the mounting of the test samples frame are taking as read to be solid materials without any cavities. The test samples are sealed to the surface of the wall or ground, open or busted cavities also be sealed to prevent the air leakage to avoid sound absorption enclosed.

Test samples sized approximately 10m² were mounted on the floor (Type-A), in fully *reverberant* enclosed chamber according to ISO 354. For every test, sample materials were placed in middle of the room and the samples were sealed to the ground with steel duct tape. To avoid errors in the test results temperature and humidity was kept constant. Three non-directional microphones and 2 loudspeakers were positioned in corner, making 6 measuring positions in total including 4 decays averaged for each position. 4 configurations were tested; sample A, B, C and empty room. For each configuration an averaged reverberation time was obtain from third-octave band system. The sound absorption from the materials at different frequencies were measured with random sound level meter (SLM - Measurement Level 26 dB to 130 dB and Measurement Frequency range 31.5 Hz to 8 KHz) with standard sound pressure calibrator.

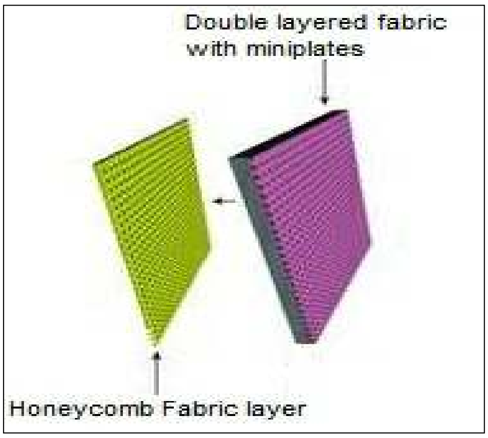

Figure 1: Fabric design with the layers of honeycomb and micro-plates

RESULTS AND DISCUSSION

The analysis was aimed at selecting a fabric design with more capability to absorb sound waves with less thickness. On the basis of the acoustic sound level measurements are listed in Table: 1 for all samples, measured for the middle frequencies of the octave bands, it can be stated that the permissible sound ranged in 1000 Hertz are likely to be absorbed by all the samples. The sample (B) with micro-plates showed more absorbability than the rest of samples. The measurement results are presented in Figure 2.

Table 1: Analytical test values of sound absorption for different acoustic fabrics

Test Samples	Frequency Standard Values (Tuning Forks) (Hertz)						Noise reduction coefficient (NRC)
	125	***250***	***500***	***1000***	***2000***	***4000***	
A	0.05	0.24	0.56	0.8	0.9	0.9	0.625
B	**0.50**	**0.94**	**0.80**	**1.0**	**1.0**	**1.0**	**0.935**
C	0.18	0.35	0.90	0.99	0.83	0.60	0.767

Note: The experiments were undertaken (with conventional or unconventional methods) only for the result analysis of different materials.

The design of the fabric (Sample B) works same as of the other acoustic materials by changing sound energy into thermal energy. At the first layer, the honeycombed woven fiberglass has a porous structure, in such materials sound energy is mainly converted into thermal energy by viscous friction between the oscillating particles of the sound propagating medium (air) and the structure of that particular porous material.

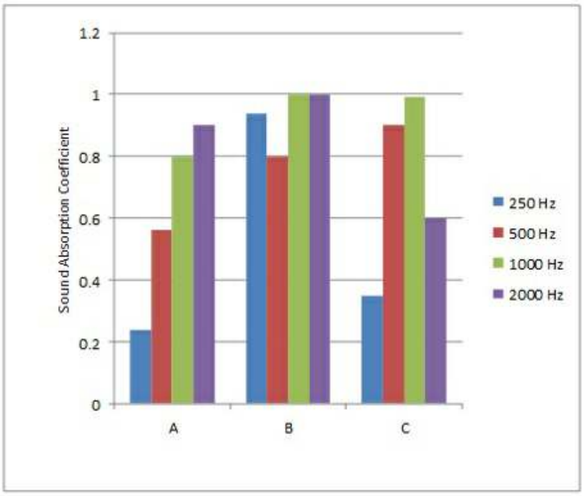

Figure 2: Acoustic sound materials at different frequency bands

The rest of the sound waves which were not absorbed by the first layer pass to the second layer, in the double layered fabric, first layer has some loopholes to pass through the sound waves to the micro-plates. Micro-plates faced to each other reflect the waves and reflects again because of the rigid structure of the plates. Thus most of the waves were diffused, while some with different frequency waves passed through the fabric and some reflect back from the loopholes but they are absorbed by the porous structure of fiberglass (Christina, 2009).

As mentioned earlier, the noise reduction coefficient (NRC) is an average of values from 250 to 2000 Hertz; from Fig: 2 it showed that acoustic fabrics made from mineral fibers has sufficient sound absorbability ranging from 500 Hertz to 1000 Hertz.

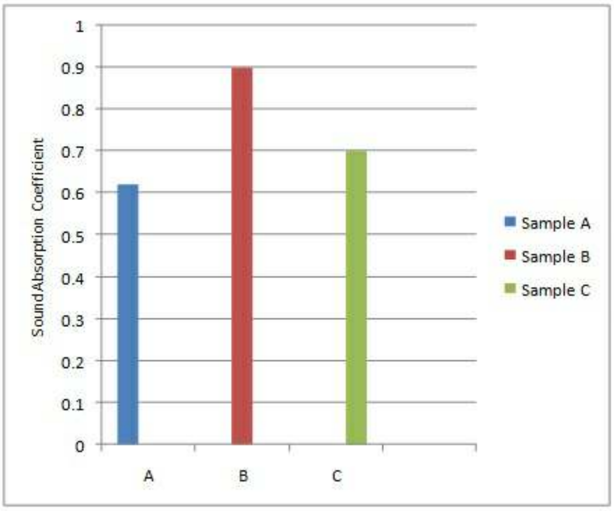

Figure 3: Samples with Noise Reduction Coefficient values

From the result analysis of three samples, it provides the amount of sound which is absorbed by the fabric and the amount which passes through it. The NRC value (0.935) of sample (B) shows that 93.5 % of sound was being absorbed by the fabric and rest passed through it. As from the other samples with NRC values (A=0.625 and C=0.767), 62.5 % and 76.7 % sound was absorbed and rest traveled through them (Perlikowsk 1999).

CONCLUSION

The analysis of the experiments carried out provides the details of acoustic fabrics with certain honeycomb woven glass fibers and with the layer of micro-plates, are more absorptive than other fabric materials taken for experiments. The sample material, especially the sample (B), the definite limitations for commercial or industrial usage, because different conditions have certain requirements of sound absorbent abilities from materials. So, suitable materials must be used according to the required sound absorbability.

The fabric diffuses the reflected sound waves within the structure yet the minimum amount of waves penetrate through the fabric as compared to the other acoustic fabrics, it was also found that the modified fabric design are 26-29 dB more absorbent than the other fabrics. The acoustic materials have different absorbing levels with different sound frequencies, so materials for special purposes can be used with required sound isolations.

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