Investigation about the sound absorption coefficients of sound absorbing wooden structures

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Abstract

This paper investigates the absorption characteristics of sound absorbers in combination with wooden construction materials. The wooden structure may be with open cells. The absorption coefficient is measured using the impedance tube method. However, the effect of the size and the pattern of the open-area are examined. Moreover, the paper shows the effect of the structure thickness on the sound absorption coefficient.

Introduction

The acoustics of enclosures, such as conference halls, cinemas, are of great importance. In enclosures, the sound conducting medium is bounded on all sides by walls, ceiling, and floor. These room boundaries absorb a certain fraction of the sound energy incident up on them, whereas another fraction of the incident energy is reflected to the medium. The combination of these reflected components yields to a certain room reverberation that influences the acoustical properties of the enclosure.

Using different materials in wall construction or applying special arrangements varies the frequency-dependent sound absorption of the wall. For a certain room purpose, it is required to achieve a desired amount of reverberation at any given frequency band [1]. Perforated panels absorbers are normally manufactured from plastic or metal. Acoustic properties of such perforated panels absorbers are studied [2][3]. These panels are considered to be too costly for commercial uses. Wooden structures sound absorbers were used for wall finishing in enclosures.

The paper studies the sound absorption of various arrangements of wood-based sound absorbers. The objective is to investigate the effect of the size and the pattern of the open-area, as well as the effect of the structure thickness on the sound absorption coefficient of the wooden structure sound absorber. The next section describes the experimental procedure. Section 3 discusses the results of the measurement for various arrangements of wood-based sound absorbers. The last section summarizes the main conclusions.

Experimental procedure

Equipment

An impedance tube is used to measure the normal incidence sound absorption coefficient of the test samples on a rigid backing.

Test samples description

Two different perforated wooden plates, each of thickness 1.5 cm, are tested. Each plate has a pattern of circular holes having different diameter as shown in figure 1. Circular cuts of each plate are used as test samples for the acoustic testing purposes. Table 1 describes each test sample, and figure 2 shows test samples with various holes pattern.

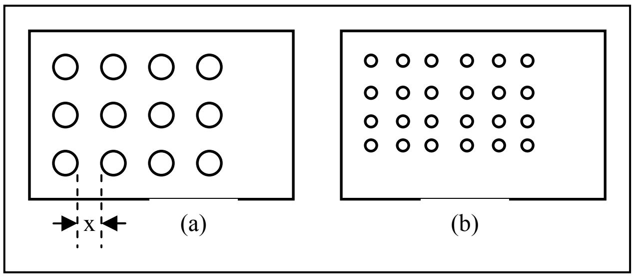

Figure 1: Perforated wooden plates. (a) hole diameter = 2.5 cm, inter-hole distance, x = 2 cm. (b) hole diameter = 1.2 cm, x = 1 cm.

Table 1: Description of test samples. Sample 7 is a circular cut of 5.5 cm diameter, whereas other samples are of 6.5 cm diameter.

Sample No.	Hole diameter in cm	Hole pattern	Perforation ratio %
1	1.2	S1	20.4
2	1.2	S2	23.9
3	1.2	S3	23.9
4	2.7	L1	34.5
5	2.7	L2	17.3
6	2.7	L3	17.3
7	0	L4	28.4

Experimental tests

The sound absorption coefficient is measured for various sound absorbing wooden structures. Figure 3 shows the sound absorbing wooden structure under test.

The sound absorption coefficient is measured for each test sample using different values of d with various absorbing medium as follows:

1. d = 3.5 cm, and absorbing medium is air.
2. d = 10 cm, and absorbing medium is air.
3. d = 10 cm, and absorbing medium is Rock wool.

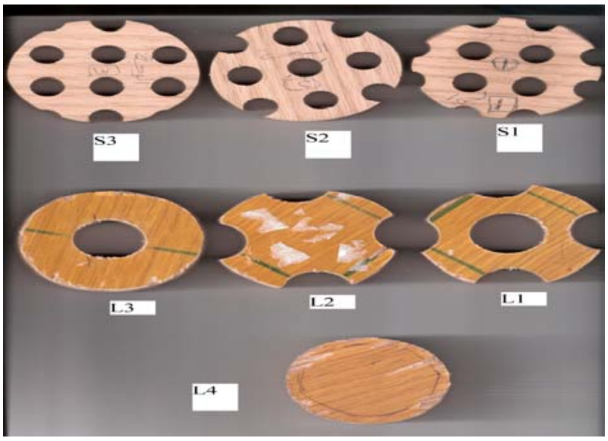

Figure 2: Test samples with various holes pattern.

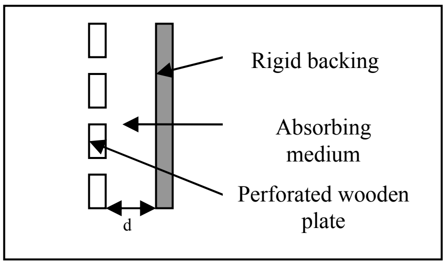

Figure 3: Sound-absorbing wooden structure.

Results and discussions

Effect of size and pattern of the open-area

Figure 4 and figure 5 show the absorption coefficient for each test sample using d = 10 cm, and the absorbing medium is rock wool. Although sample no. 4 has the largest perforation ratio, figure 5 shows that sample no.4 and sample no. 5 have nearly the same absorption coefficient. Moreover, no significant differences are shown while comparing the absorption coefficient of sample no. 2, in figure 4, to the absorption coefficients of sample no. 4. and sample no. 7, in figure 5. Thus, the distribution of the open-area on the rand of the test sample in a symmetric manner yields to a higher absorption coefficient especially in the mid frequency bands [500 - 1000] Hz.

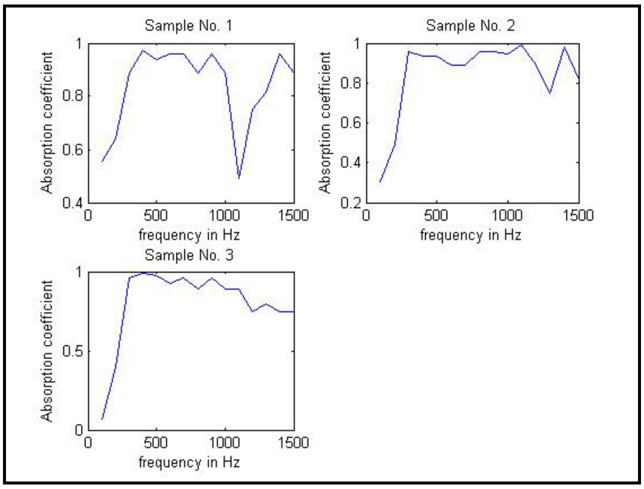

Figure 4: Absorption coefficient for sample no. 1, 2, and 3. d=10cm and the absorbing medium is rock wool.

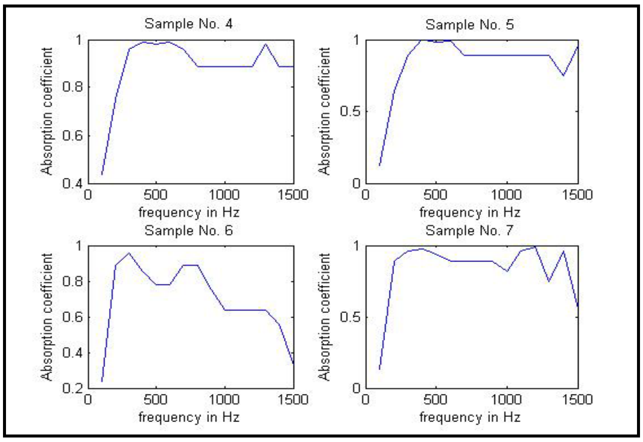

Figure 5: Absorption coefficient for sample no. 4, 5, 6 and 7. d=10cm and the absorbing medium is rock wool.

Effect of structure thickness

Figure 6 shows that increasing the thickness, d, for sample no. 1 that has small hole diameter lowers the absorption coefficient within the shown frequency range, whereas increasing d for sample no.4 that has larger hole diameter yields to a peak absorption at 700 Hz.

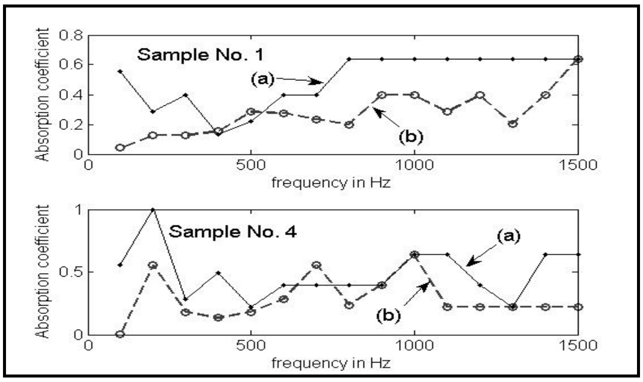

Figure 6: Absorption coefficient for sample no. 1 and no. 4. (a) d = 3.5 cm, and absorbing medium is air. (b) d = 10 cm, and absorbing medium is air.

Conclusions

The normal incidence sound absorption coefficient of various test samples is measured. The holes pattern affects the absorption coefficient of the sample and higher absorption coefficient is obtained for a symmetrical distribution of the holes on the rand of the test sample. Moreover, as the thickness of the structure increases, a peak absorption that depends on the size of the hole is found.

References

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[3] Lu, M.; Hopkins, C.; Seiffert, G.: Sound absorption characteristics of porous steel manufactured by lost Carbonate sintering. Mater. Res. Soc. Symp. Proc. 1188 (2009), LL07-04.