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Measurement of the Sound Absorption Coefficient of Fiberboard by Two Microphone Method[*1]

Chun Won Kang[*2†], Hee Jun Park[*2], In Soo Jeong[*2], and Gwang Chul Kim[*2]

ABSTRACT

The sound absorption coefficients of three types commercial fiberboard were experimentally measured under a relatively low frequency range of 50 to 1600 Hz by the two microphone transfer function method. The sound absorption coefficient of 30 mm thick fiberboard was higher than that of 18 mm thick fiberboard at the frequency range of 50 to 1.2 KHz. The sound absorption coefficient of medium density fiberboard was a little higher than that of low density fiberboard.

Keywords : sound absorption coefficient, two microphone method, fiberboard

1. INTRODUCTION

Wood based materials such as particleboard, plywood and fiberboard has been used as a construction material, because of good hardness, resistance to weathering and elastic properties. In construction fields, however, proper acoustic characteristics such as sound absorption coefficient, transmission loss and normal acoustic impedance of a component is necessary to successfully design a structure.

For the measurement of normal incident sound absorption characteristics of materials, a common sound absorption coefficient and the acoustic impedance measurement technique is the standing wave ratio method. This method uses impedance tube that are closed by an excitation source at one end and the unknown impedance at the other end. The source generates a sinusoidal signal which results in a standing wave pattern in the tube. From the ratio of the minimum and maximum pressure of the standing wave, the sound absorption coefficient and the acoustic impedance are calculated.

A widely used other method is the two microphone method. Many researchers reported the technique for the sound absorption coefficient and acoustical impedance measurement by two microphone method (Seybert and Ross, 1977 : Chung and Blaser, 1980 : Suzuki *et al.*, 1981: Katz, 2000 : Boonen and Sas, 2004). This method, which is described in ISO-10534-2, uses the transfer function measured between two microphones at two distinct positions in the

*1 Received on June 4, 2005; accepted on August 4, 2005.
*2 Department of Forest Products, Iksan National College, Iksan 570-752, Korea
† Corresponding author : Chun Won Kang (kcwon@iksan.ac.kr)

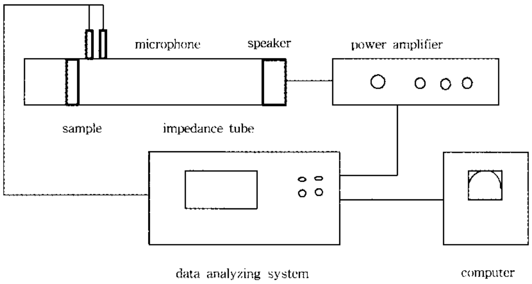

Fig. 1. Schematic diagram of the test apparatus for the two microphone method of measuring sound absorption coefficient

impedance tube. Haines and James (1989) reported that the excellent agreement was obtained between standing wave method and two microphone method. Seybert (1977) suggested that great care is needed in mounting the sample on the impedance tube because of the possibility of error by the gap between the tube and sample specimen. Some researchers suggested that the calibration technique of the two microphone transfer function method to measure acoustical properties accurately (Chung and Blaser, 1980 : Katz, 2000: Boonen and Sas, 2004).

In this study, we measured the sound absorption coefficient of a three types fiberboard by two microphone transfer function method to estimate the acoustical properties of fiberboard supposing that it is used as constructing material.

2. MATERIALS and METHODS

2.1. Sample Specimens

The sample specimens used in this study were commercial fiberboard which were 18 mm thick low density, 18 mm and 30 mm thick medium density. Here, the value of low density and medium density were 0.46, 0.60 respectively. These fiberboard were prepared for cylindrical type sample specimen by mill cutting. The diameter of sample specimen was 99.7mm and average moisture content was about 12%.

2.2. Two Microphone Method

The sound absorption properties of fiberboard was determined by two microphone transfer function method. The two microphone method is shown schematically in Fig. 1. The set-up consists of a straight tube which is the measurement acoustic wave guide. At the right end, an excitation source, a loudspeaker is connected. In the tube, a broadband random wave was formed from signal generator induced to loudspeaker. At the left end, the sound absorption coefficient to be measured is connected. Two microphones are mounted on the inner wall of the tube near the sample end of the tube.

A multi-channel spectrum analyzer with built-in signal generator is used to obtain the transfer function between the microphones. In this measurement, the microphone closer to the sound source is the reference channel. From the transfer function H_{12}, the pressure reflection coefficient R of the material is determined from the following equation:

$$R = \frac{H_{12} - e^{-jks}}{e^{jks} - H_{12}} e^{j2k(L+s)}$$

where L is the distance from the sample face to the first microphone and s is the distance between the microphones, $k=2\pi f/c$, f is the frequency, and c is the speed of sound. From the reflection coefficient, the absorption coefficient α of the sample specimens can be determined from the following equations:

$$\alpha = 1 - R^2$$

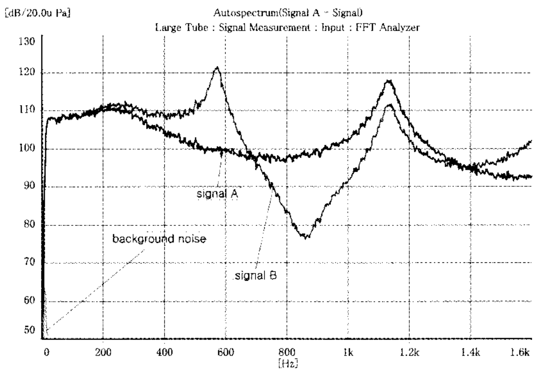

Fig. 2. The signals and background noise in the impedance tube.

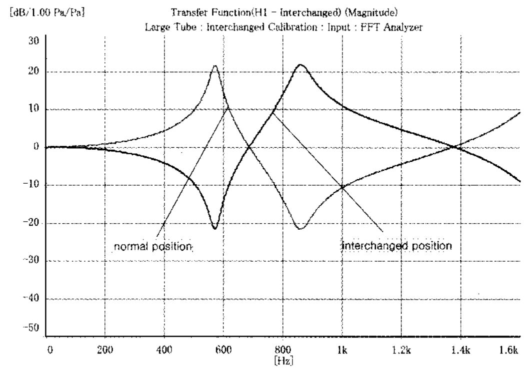

Fig. 3. The transfer functions of interchanged and normal position of two microphones in the impedance tube.

3. RESULTS and DISCUSSION

3.1. Signal-to-noise Ratio

Accurate measurements of material absorption require that the sound field be substantially larger than the background noise inside the tube. The ISO standard recommend that the level of sound in the tube be at least 10 dB greater than the background noise level, but 20~30 dB is preferred. To achieve this low background level, the tube must be constructed of heavy materials and must be sealed properly at all openings. In this study, we sealed the openings between sample specimen and impedance tube by vacuum grease coating to prevent the influence of air gap.

Fig. 2 shows the background noise and two microphone signals in the impedance tube at experimental condition. As seen in the figure, about 60 dB background noise exists in the narrow frequency range that is out of estimation frequency range and the A and B signals of two microphones attached inside impedance tube are over 30 dB greater than the background noise in the estimation frequency range.

3.2. Microphone Calibration

The two microphones used in the impedance tube were calibrated relative to each other using the standard switching technique. By applying a random signal to the loudspeaker and mounting a calibration sample in the sample holder, the sound field inside the tube is well defined. Additionally the microphones can be switched or interchanged without affecting the sound field. By measuring the H1 response in the normal and the switched position and multiplying the two response the result is a response that can be interpreted as the system error function. The response function shown as in the Fig. 3. was used to correct the measurements on the test samples and this procedure ensured that any magnitude and phase variations in the measurement were a function of the sound field.

3.3. Sound Absorption Properties

The most popular method of estimation of sound absorption coefficient is standing wave ratio method. This method requires (a) single frequency operation, (b) a traveling microphone inside the impedance tube to estimate the acoustic pressure, (c) a means of measuring the location of minimum and maximum acoustic pressures. So, this method is relatively time consuming due to these requirements. In this study,

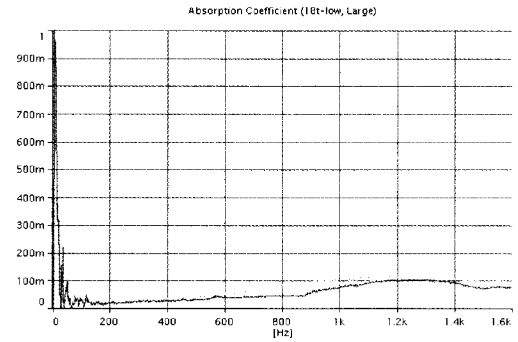

Fig. 4. The relationship between frequency and the sound absorption coefficient of 18 mm thick low density fiberboard.

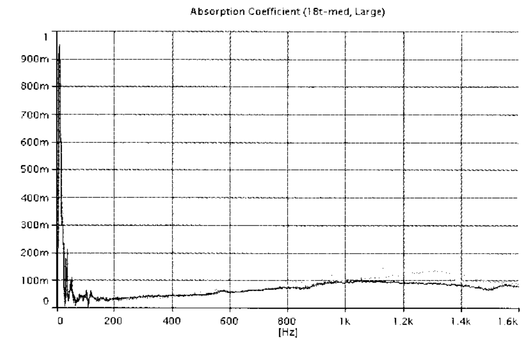

Fig. 5. The relationship between frequency and the sound absorption coefficient of 18 mm thick medium density fiberboard.

the sound absorption coefficient were measured with short time of continuous frequency range by two microphone method. This is a considerable savings of time and labor as compared to the standard standing wave method using microphone travelling and discrete frequency excitation.

Seybert (1977) reported that the two microphone method is potentially useful for evaluating acoustic properties at low frequency. We measured the acoustical properties of fiberboard at the frequency range of 50～1.6 kHz.

As shown in the Fig. 4, Fig. 5 and Fig. 6, the sound absorption coefficients of 30 mm thick fiberboard was 5%～15% higher than that of 18mm thick fiberboard at the frequency range of 50 Hz to 1.2 kHz. However, in the frequency range from 1.2 kHz to 1.6 kHz, sound absorption coefficients of three types of fiber board were almost the same.

The sound absorption coefficient of medium density fiberboard was a little higher than that of low density fiberboard. This trend increased with increasing of frequency. The sound absorption coefficient of 30 mm thick fiberboard of the frequency range of 200 to 1.0 kHz was about 5%～15% higher value compared with those of 18 mm thick fiberboard.

The sound absorption coefficients of commercial fiberboard ranged from 5% to 20% in the measured frequency range. These value are higher than those of other construction material such as concrete, steel and wood board. Therefore, it is considered that the fiberboard can be used as construction material for a more successful acoustic structure design.

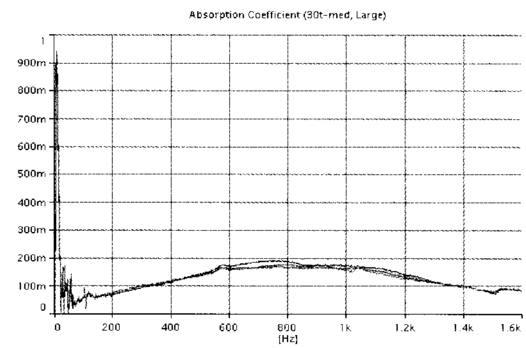

Fig. 6. The relationship between frequency and the sound absorption coefficient of 30 mm thick medium density fiberboard.

4. CONCLUSIONS

To estimate the possibility of use fiberboard as constructing material, the sound absorption properties of three types of commercial fiberboard estimated by two microphone transfer function method in the frequency range from 50 Hz to 1600 Hz. The results we obtained are summarized as follows :

1) The sound absorption coefficient can be estimated in a short time by two microphone transfer function method.

2) The sound absorption coefficient of 30 mm thick fiberboard was higher than that of 18 mm thick fiberboard in the frequency range of 50 Hz ~ 1.2 kHz.

3) It is considered that the fiberboard can be used as construction material in case of design of more successful acoustic structure.

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