A COMPARISON OF THREE METHODS FOR THE IN SITU DETERMINATION OF ACOUSTIC ABSORPTION COEFFICIENTS

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1. INTRODUCTION

This paper compares three methods used in order to determine the absorption coefficient of a surface *in situ.* The first two methods are well known, using a reflection method [1] and a subtraction technique [2] to separate the incident and reflected sound waves of the impulse response. The third method [3] utilizes two measurements, the first at a surface under study and the second at a rigid surface at the same location in order to calculate the absorption coefficient.

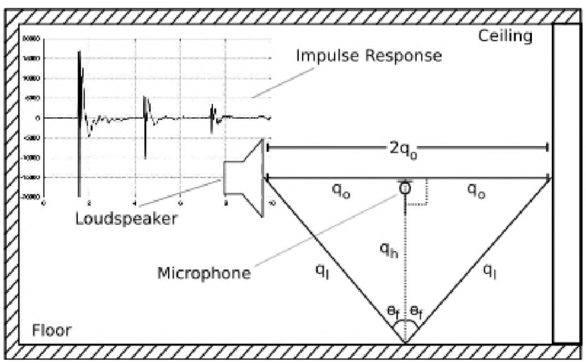

Fig. 1. Configuration of the reflection method. A microphone is placed halfway between a loudspeaker and a study surface. The inset is a typical impulse response showing the incident and two reflected signals.

2. IN SITU MEASURMENT METHODS

2.1 Reflection Method

The reflection method is described in [1,4] and shown in Figure 1. The incident and reflected sound waves, p_I and p_R, are modeled as spherical waves. This results in the following absorption coefficient [4]

$$\alpha = 1 - \rho = 1 - \left| \frac{3p_R}{p_I} \right|^2 \quad (1)$$

where α and ρ are respectively the absorption and reflection coefficients for sound intensity. This development assumes that the centre of radiation of sound is at the baffle of the loudspeaker. In general the sound is radiating from the acoustic centre, δ, which is important at low frequencies.

2.2 Subtraction Technique

The subtraction technique is described in [2]. Two pressure measurements are determined as shown in Figure 2, a) p_I, and b) p_{IR}. The absorption coefficient may then be calculated by

$$\alpha = 1 - \left| \frac{p_{IR} - p_I}{p_I} \right|^2 . \quad (2)$$

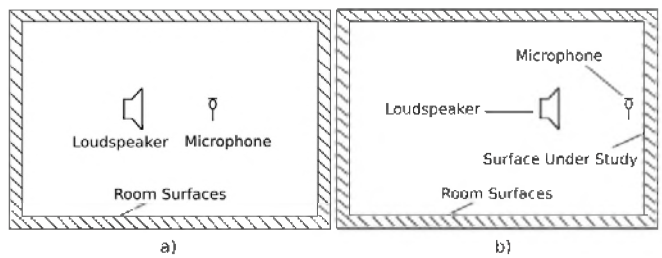

Fig. 2. Configuration of the subtraction technique. a) Measurement away from room surfaces. b) Measurement at the surface under study.

2.3 Surface Pressure Method

The surface pressure method was introduced in [3]. The *in situ* implementation of this technique is discussed in [5,6]. A rigid surface is approximated by mounting a thin steel sheet against the surface under study. Two measurements are taken, one directly on the surface under study, p_S , and the second similar measurement with an interveaning reflective sheet, p_R. The configuration is similar to Figure 2 b). Approximations are discussed in [5] which lead to the absorption coefficient of the surface,

$$\alpha = 1 - \left| 2\frac{p_S}{p_R} - 1 \right|^2 . \quad (3)$$

3. RESULTS AND DISCUSSION

Three surfaces were measured: a resonant surface (wood panelled wall) , an absorptive surface (office divider) and a rigid surface (glazed block wall). The results are shown in Figures 3 and 4.

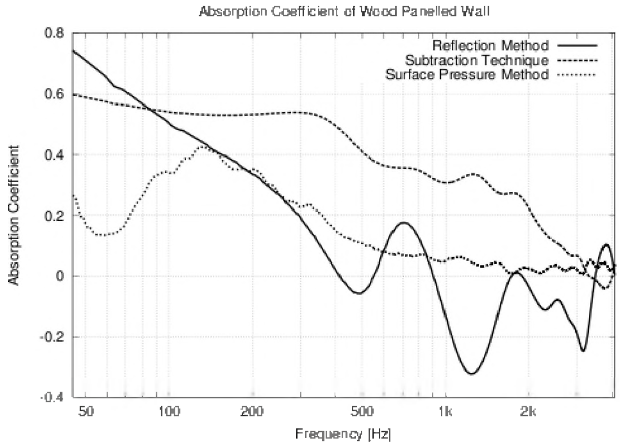

Fig. 3. Absorption coefficient of wood panelled wall. This wall should have little absorption besides an mass-air-mass resonance in the low frequency region (100-200 Hz).

In general, both figures show that each method yields different results. The reflection method and the subtraction technique have worse resolution than the surface pressure method. The former methods use approximately 2-3 ms of data whereas the last method uses 64 ms of data.

In particular, the data in Figure 3 should show a mass-air-mass resonance in the 100-200 Hz region. This is clearly seen using the surface pressure method, however this is not seen in the data for the other methods, since they do not have sufficient frequency resolution. Large differences and oscillations are apparent for the reflection method and subtraction technique. At low frequencies, this is caused by the truncation of the impulse response. At high frequencies the reflection method may suffer from diffraction effects caused by the loudspeaker. Note that the spherical wave assumption in the reflection method will not be valid at high frequencies. The subtraction technique is difficult since small variations in loudspeaker-microphone distance can result in an incomplete subtraction. Diffraction from the edges of the sheet may influence the surface pressure method.

Interestingly, the absorption coefficients for the office divider are much closer than for the wood panelled wall (see Figure 4). The results diverge at low frequencies due to frequency resolution limitations. Only the reflection method and surface pressure method were used on the glazed block wall. Results from the surface pressure method indicate that this surface should have zero absorption over the whole frequency range. However, the reflection method yields results that are negative over most of the frequency range of interest. The reflected pressure is greater than the incident pressure in this case (after multiplication by three, see (1)). Diffraction effects from the loudspeaker and the supporting structure are also suspected in these measurements. More details on the surface pressure method and other *in situ* methods is given in [6].

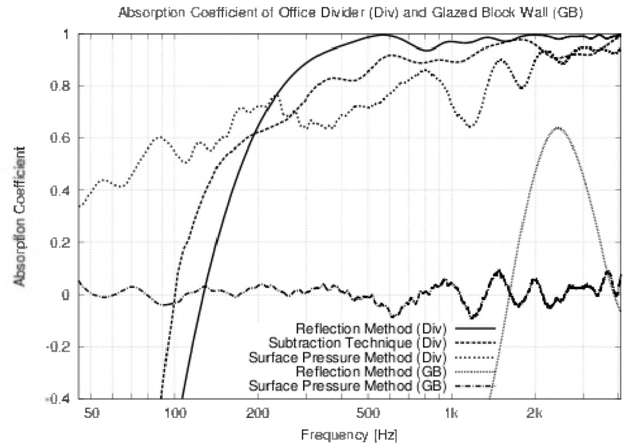

Fig. 4. Absorption coefficient of an office divider (three upper curves) and a glazed block wall (two lower curves). The office divider should have very high absorption at high frequencies and a reduction in absorption as frequency is decreased. The glazed block wall should have little absorption at all frequencies. This is confirmed by the measurement results.

In conclusion, we have compared three different methods that may be applied *in situ* to determine the acoustic absorption coefficient. The first two methods are quick to implement, however require the separation of incident and reflected sound waves in the time domain. The surface pressure method requires a thin sheet to be placed in front of the surface under study in order to create a rigid boundary. No windowing is necessary, and therefore the limitations on the frequency resolution are not the same as in the former measurement methods. A calibration measurement could aid the accuracy of this method.

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