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ACOUSTIC INTENSITY MEASUREMENTS AND THEIR APPLICATION TO THE SOUND TRANSMISSION LOSS OF PANELS AND WALLS.

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INTRODUCTION

The sound transmission loss of panels and walls has been measured by using the new acoustic intensity method [1,2,3]. The method involves the measurement of the incident and transmitted acoustic intensities over the complete frequency range of interest in building acoustics e. g. 100 Hz to 4000 Hz. The incident intensity is calculated from measurements of the space averaged sound pressure level in the reverberant room on the source side of the panel or wall. The transmitted intensity is measured directly behind the panel or wall in the receiving room, by using a two-microphone intensity technique. The measurements are done between two transmission rooms from which the receiving room has been made relatively absorbent.
Measurements of the sound transmission loss with the acoustic intensity method have been compared with the results from the classical two-room method and with theory. The results are satisfactory.

SOUND TRANSMISSION LOSS MEASUREMENTS

Classical method

The most widely used method for measurement of the sound transmission loss of panels or walls is the two-room method. This method consists of the use of two reverberant rooms which are separated by the investigated panel or wall. A steady sound is made in the transmitting room. Two microphones are moved randomly in the transmitting and receiving room and the space averaged sound pressure levels L_{p1} and L_{p2} are determined. The sound transmission loss of the panel or wall may be deduced from the following formula:

$$R = L_{p1} - L_{p2} + 10\log S/A \quad \text{(dB)} \qquad (1)$$

with $S(m^2)$ the area of the panel or wall and $A(m^2)$ the total absorption of the receiving room. It is assumed that there is no flanking transmission and that all the energy is transmitted through the panel or wall.

Acoustic intensity method

In this method the measurements of the sound transmission loss are based on the two microphone acoustic intensity method. The incident intensity on the panel or wall is calculated from the diffuse field intensity:

$$I_{im} = p^2_{rms}/4\rho C \qquad (2)$$

where p_{rms} is the space averaged rms sound pressure measured in the transmission room, ρ is the density of air and C is the speed of sound in air. The incident intensity level is related to the space averaged sound pressure level by:

$$L_{Ii} = L_{pm} - 6 \quad \text{(dB)} \qquad (3)$$

The transmitted acoustic intensity is measured by a face to face microphone probe, directly behind the panel or wall in the receiving room. The transmitted intensity I_t is the component of the intensity in the direction of the line joining the two faced microphones and is given by:

$$I_{tm} = I_m\{S_{12}\}/\rho\omega\Delta r \qquad (4)$$

with I_m the imaginary part of the complex value {}, S_{12} the cross spectrum between the sound pressure measured with the two microphones, ω the angular frequency and Δr the microphone separation. The correction for the phase shift between the two channels of the instrumentation was made as follows. The measured cross spectrum S°_{12} is given by:

$$S^\circ_{12} = S_{12}.H_1(f).H^*_2(F) \qquad (5)$$

with H_1 and H_2 the frequency responses of the signal of the microphone 1 and 2. Thus:

$$\text{phase}(S_{12}) = \text{phase}(S^\circ_{12}) - \text{phase}(H_1.H^*_{12}) \qquad (6)$$

In the phase shift determination the microphones were mounted at the same longitudinal position in an anechoic room in front of a loudspeaker with a sound signal P(f). The cross spectrum is given by:

$$S^\circ_{12} = H_1.H^*_2.|P|^2 \qquad (7)$$

The phase shift is directly obtained.

The sound transmission loss is calculated from:

$$R = L_{pi} - 6 - L_{It} = L_{Ii} - L_{It} \quad \text{(dB)} \qquad (8)$$

EXPERIMENTAL INVESTIGATION

A schematic diagram of the experimental set-up is shown in fig. 1. Measurements were done following the classical method, without the absorbing material in the receiving room; and with the intensity method, with absorbing material in the receiving room. It is much easier to measure the transmitted intensity when the receiving space is non reflecting. Even the standard deviation on the measurements is less. The intensity probe was placed so that the centerpoint between the two microphones and the panels or walls was 4 cm. This distance is not critical. Indead measurements have shown that distances up to 10 cm from the panel or wall give, within the measuring accuracy, no changes in the measured intensity.

A first experiment was conducted on a glass panel with dimensions of

1,56 mX1, 66 m and a thickness of 4 mm. The glass panel was clamped within the opening of one wall of the transmitting reverberant room. The edges between the glass panel and the frame, as well as the edges between the frame and the wall of the opening, were sealed with resilient putty to minimize leaks. Transmitted intensity measurements were made in 1/3 octave bands at 64 points distributed uniformly over the glass panel and the mean value was calculated by a Gen Rad 2505 Signal Analysis System. The results obtained by using the intensity method compared well with the sound transmission loss measurements made by the classical two-room method and with the mass law as presented in fig. 2.

Moreover a serie of experiments has been done on a new type of double wall partitions constructed of gypsum board glued together with a highly damping recycled material with different densities. The results obtained by using the intensity technique compared well with the sound transmission loss measurements made by the classical two-room method. In fig. 3 the measured sound transmission loss measurements are compared for a partition composed of 12 mm gypsum board/26 mm recycled damping material/12 mm gypsum board, glued together. In fig. 4 the measured sound transmission loss values are compared for a partition of 12 mm gypsum board/80 mm recycled damping material/12 mm gypsum board, glued together.

CONCLUSIONS

Advantages of this method compared with the conventional two-room method are: measurements can be done with only one reverberant room, measurements can be executed in a shorter time, and it makes possible the identification of leaks and the transmission of energy through different parts of composite panels or walls, for example facades and facade elements.

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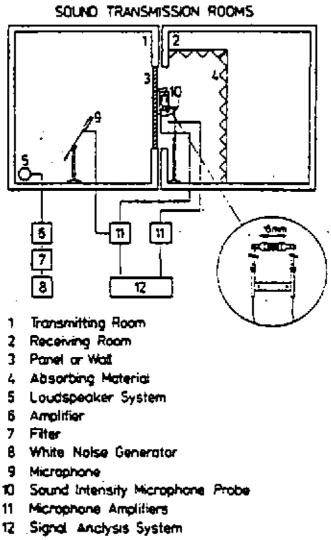

Fig.1. Experimental set-up.

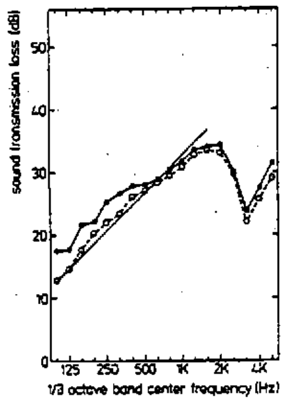

Fig.2.Transmission loss of a 4 mm thick glass panel. •—• classical two-room method, o--o intensity method, — Mass Law

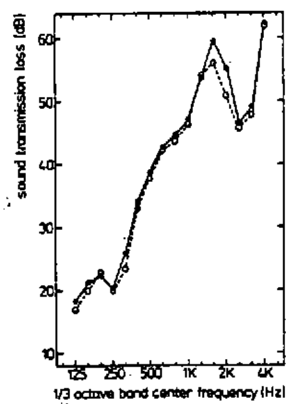

Fig.3.Transmission loss of a partition 12mm gypsum/26 mm recycled damping material/12mm gypsum, •—• classical two-room method, o--o intensity method.

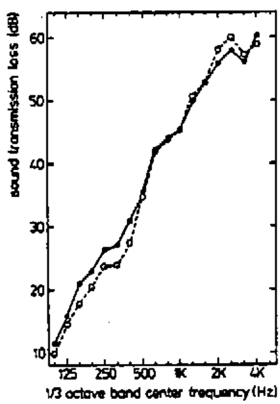

Fig.4.Transmission loss of a partition 12mm gypsum/80 mm recycled damping material/12mm gypsum, •—• classical two-room method, o--o intensity method.