ACOUSTIC ABSORPTION PROPERTIES OF ORDINARY MATERIALS AND BUILDING COMPONENTS

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Di Bella Antonino; Rossetti Silvia; Zecchin Roberto

Dipartimento di Fisica Tecnica, Università di Padova, Italy

Via Venezia 1,

35131 Padova

Italy

Tel: 0039 049 827 6884

Fax: 0039 049 827 6896

antonino.dibella@unipd.it; silvia.rossetti@unipd.it; roberto.zecchin@unipd.it

ABSTRACT

Data on sound absorption concerning materials specifically conceived for acoustics purposes are usually available, but it is difficult to find reliable values concerning traditional or ordinary materials (e.g. wood, gypsum board or plaster), which, in case of large area, can affect the acoustic response of a special environment.

In this paper the acoustic behaviour of different materials and building components is analysed. Results of laboratory tests of sound absorption are reported. The aim of the work is to underline the need for reliable data and to inspect the influence of composition and mounting conditions on sound absorption of such materials.

INTRODUCTION

In the field of acoustic design it is extremely important to have reliable data concerning materials and building systems. Related to this aspect an experimental analysis is being carried on at Dipartimento di Fisica Tecnica, University of Padova, in the acoustics Laboratory. The aim is to investigate the acoustic properties of building elements, some of which frequently used in residential and commercial buildings and some others especially used in auditoria. The former are gypsum board panels, used to create light partitions and suspended ceilings, and the latter are wood panels of different composition fixed on a wood framework.

DESCRIPTION OF THE MEASUREMENTS

Acoustic absorption measurements have been carried out according to the standard ISO 354/85 [1], in the acoustic laboratory of the Department.

Reverberation time measurements have been performed both with a multi analyser system (B&K 3560) connected to a pc and with a sound level meter. An omni directional sound source (B&K 4296) has been used to generate random pink noise.

The acoustic absorption coefficients of the various systems have been derived from the reverberation time values.

SIMPLE SYSTEMS

Acoustic Behaviour of Gypsum Board Panels

The standard configuration consists of 120x300x1.25 cm panels placed on metal studs (see figure 1).
Several measurements have been carried out, each with different mounting and constraint conditions. The main differences between them are due to:

- type of gypsum board (simple single layer, top PVC layer on simple board)
- number of overlaid gypsum boards
- cavity depth
- constraints number and location.

The aim of these measurements is to find out the physical aspects, which can affect the amount of absorption provided by such a building system. In fact, once its behaviour has been derived from experimental tests, it is possible to modify the acoustic response of the environment in which it will be placed, according to the required results. It can be noticed, as well, that panel absorption is often responsible for the lack of reverberation in rooms at low frequencies. This must be taken into account when approaching the acoustical design of halls for music and speech.
In the following sections results for some of the above mentioned configurations are shown.

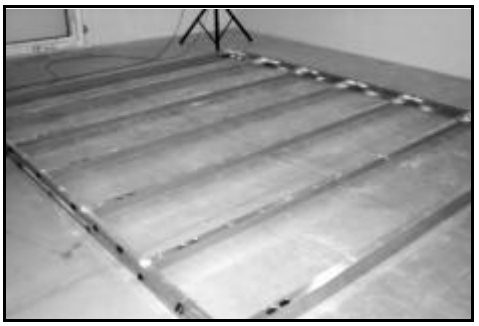

Figure 1 – Framework of the system

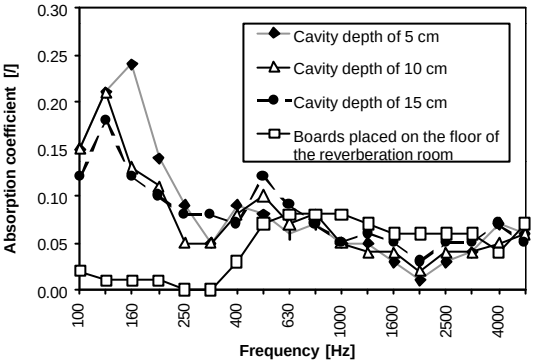

Figure 2 – Absorption coefficients for configurations with single layer of gypsum boards and different cavity depths

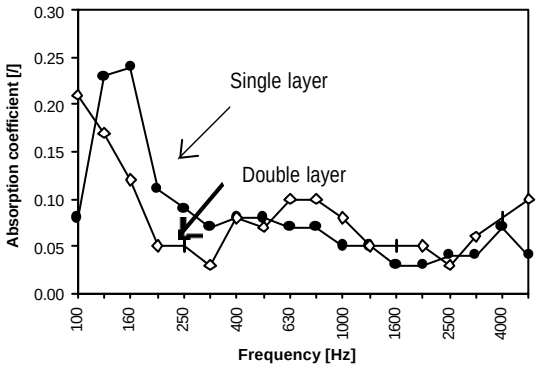

Figure 3 – Comparison between single and double layer configuration

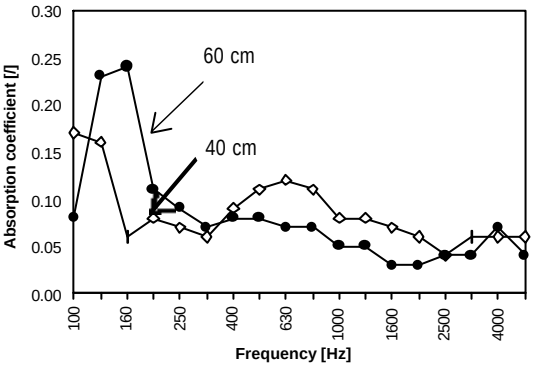

Figure 4 – Comparison between configurations with different studs pitch (60 and 40 cm)

Single layer of gypsum board with different cavity depths

Figure 2 shows the absorption coefficients obtained from the measurements carried out on a single layer of gypsum boards with different cavity depths (5, 10, 15 cm).
The coefficients referring to boards directly placed on the floor of the reverberation room without framework, are shown in the same figure.

Double layer of gypsum boards

In figure 3 results for double layer gypsum boards are shown. The absorption peak, due to the increased mass, as compared to the previous one, appears to be shifted towards lower frequencies.

Reduced studs pitch

The reduction of the studs pitch (from 60 to 40 cm) has a similar effect as the one described before for the double layer. In figure 4 the related coefficients are shown.

Remarks on these measurements

The aim of the measurements was to reproduce in the reverberation room the real mounting conditions of the system and to find out a way of characterizing its acoustic behaviour. Of course several uncertainties may occur, mainly due to problems in mounting conditions, but still the results so far obtained confirmed the theoretical analyses on such systems and previous results on similar systems obtained by other researchers [2], [3], [4].

Acoustic Behaviour of Composite Metal Plates

The standard configuration consists of three composite metal plates (double leaf of aluminium foils with PVC layer, 150x300x0.4 cm each, mass per unit area 5.3 kg/m²), placed on wood frame (see figure 5 and 6).

Several measurements have been carried out, each with different mounting and constraint conditions. The main differences between them are due to:

- frame layout
- cavity depth

Like above, results for some of the listed configurations are shown.

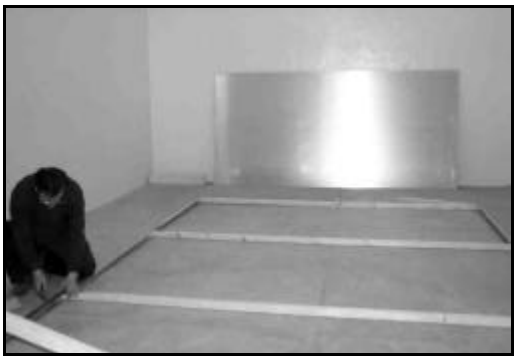

Figure 5 – Rectangular frame

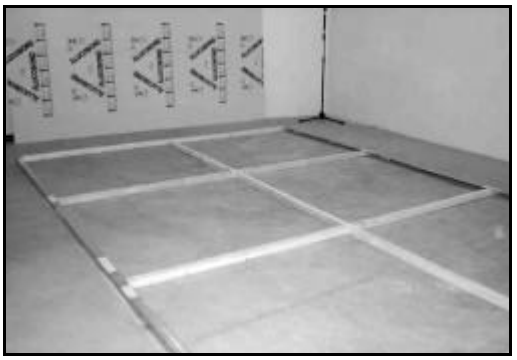

Figure 6 – Square frame

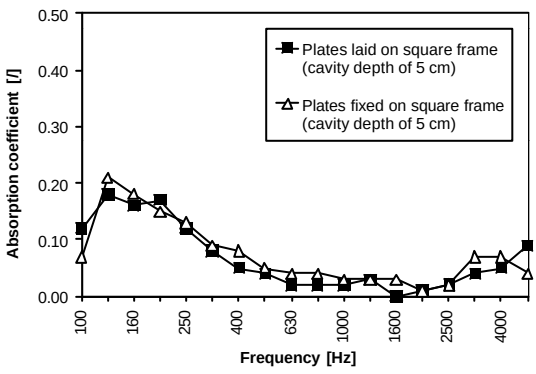

Figure 7 – Absorption coefficients for configurations with different type of connections to the frame

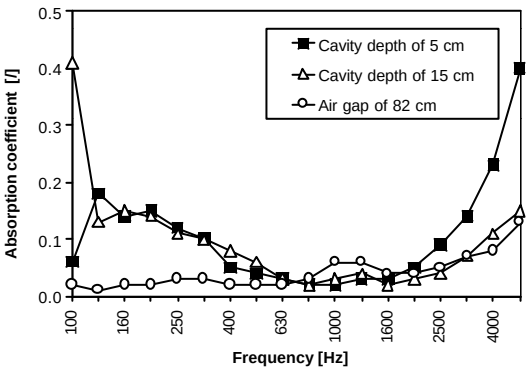

Figure 8 – Absorption coefficients for configurations with plates laid on rectangular frame and different cavity depths

Frame layout and constraints type

The influence of constraint type for the square frame is not relevant. The difference of the absorption coefficient between fixed and laid plate is about 1%. In figure 7 coefficients are shown.

Cavity depth

Figure 8 shows the absorption coefficients obtained from the measurements carried out on composite plates with two different cavity depths (5 and 10 cm). Coefficients of plates with the frame suspended at 82 cm from a reflecting plane are also shown in the same figure.

ASSEMBLED SYSTEMS: WOODEN SUSPENDED CEILING

Measurements described so far concern simple systems. Another series of measurements concerns the analysis of absorption of a wooden ceiling. The purpose of the analysis was to study and improve the reflection characteristics of the suspended ceiling located in a small theatre, subject to renovation works. The old ceiling was in fact made of very light wooden tablets and this was responsible for the lack of reverberation especially at low frequencies. A new ceiling has been conceived with a double layer of wooden boards and with the old tablets placed on the internal facing (towards the interior of the hall).

In order to test the acoustic efficiency of the system, tests have been carried out on a sample in reverberation room, mounted in such a way as to reproduce the relative position between the roof ceilings and the suspended ceiling.

Figure 9 and 10 show mounting details of the sample and absorption coefficient values.

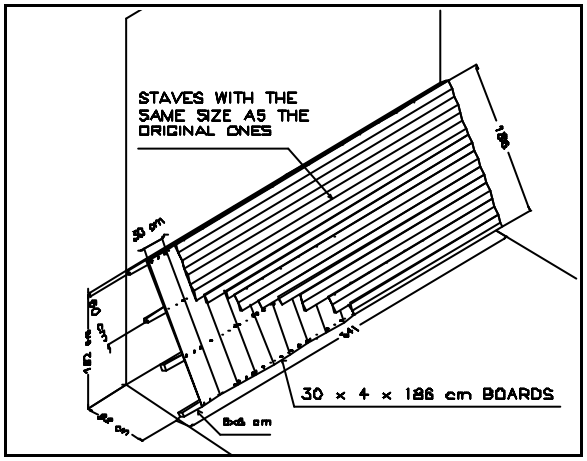

Figure 9: Mounting of the sample in the reverberation room

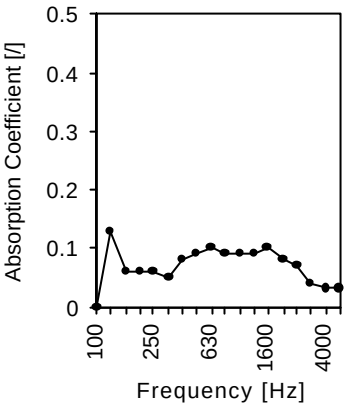

Figure 10: Absorption coefficients of the sample of suspended ceiling tested in the reverberation room

CONCLUSIONS

Measurements so far carried out allowed to significantly assess the acoustical behaviour of building elements not specifically conceived for acoustical purpose. The main results concern the effects that modifications to a standard mounting can have on the range and amount of maximum absorption at low frequencies. This can be very useful while approaching acoustical design of environments especially designed for music and speech.

BIBLIOGRAPHY

[1] ISO 354: 1985, *Acoustics – Measurement of sound absorption in a reverberation room*

[2] H. Kuttruff, *Room Acoustics*, Applied Science Publisher LTD, London, 1973

[3] F. Fahy, *Foundations of Engineering Acoustics*, Academic Press, 2001

[4] V. O. Knudsen, C. M. Harris, *Acoustical Designing in Architecture*, New York, John Wiley and Sons, Inc. London, 1950