

NOISE ABSORBERS PROPERTIES OF REED FOR USING IN FITTING ACOUSTIC ENCLOSURES.

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ABSTRACT

The aim of this research work is to study the possibility of using reeds as acoustic absorber in fitting enclosures. Reed is a fibrous raw material consisting of hollow tubes with knots and might be expected to play the role of a porous absorber.

In recent years, an increasing attention has been turned to natural fibres in order to combine high acoustic and thermal performances with a low impact on the environment.

Beforehand reed might be a very promising material from an acoustic point of view, because it has been widely used in traditional thatched roofs and walls due to its excellent thermal and structural behaviour. It is also an organic and cheap material easy to obtain.

In order to carry out the scientific research, the procedures of the standard EN ISO 354:2003 have been followed. This Standard specifies a method of measuring the sound absorption coefficient of acoustical materials used as wall or ceiling treatments, or the equivalent sound absorption area of objects, such as furniture, persons or space absorbers, in a reverberation room.

The obtained results show that reeds have a good sound absorption and can be used to achieve a proper fitting acoustic enclosure.

1.- INTRODUCTION

Reed is a perennial plant belonging to the family of the gramineae or Poaceae and it is a large grass native to wetland sites found throughout temperate and tropical regions of the world. The height of the plant is in between 1.5 to 4 metres, reaching a maximum diameter of 2 cm. The density of the material when dry is approximately 160 kg/m³, although it can be higher depending on the degree of compaction to which the material is subjected.

Reed is one of the oldest natural building materials. Different cultures from all over the world have used reeds as a construction material due to its excellent properties, normally combined with mud and wood, creating shelters and cabins for thousands of years. Reeds are a species with many different uses: a very well known one is the use of its stems or canes as construction material for huts, roofs, enclosures, etc..., whether they be individually placed or joined together forming a reed screen. In landscaping, reed is used as a material for fences, wind deflector walls, blinds meadows and tree protection.

This cane has traditionally been used in Europe to roof rural houses, due to its good thermal insulation. Reed is well known as a solid roofing material used as a natural roof covering since centuries. Especially the insulating properties and water

resistance are making reed a perfect thatching material. Reed has proved to be a reliable natural insulation for the ecological construction.

Reeds have also been used in construction together with other materials such as bamboo, for making walls and also formwork. Thin reed mats have also been used in the construction of internal partitions as a backing for plaster. In building construction, reed can also be used as reinforcement, insulating wall panels and dry lining elements.

Reed absorption acoustic behavior is studied in this paper in order to control the reverberant sound field in enclosed spaces. It has been analysed the influence of the material thickness in the sound absorption coefficient α_s .

The aim of the research described in this paper is to study the feasibility of applying reeds in fitting acoustic enclosures.

2.- MATERIALS AND METHODOLOGY

In this work the reeds were in the form 1m long stems with diameters of 0.6 and 0.8 cm, held together in layers with wire in the form of panels of 1x1x0.05 m, with an approximate density of 160 kg/m³

Reed mats are porous in nature with gaps along reed length due to the irregularity of the reed diameters. These connect with large voids between reeds and this results in air paths through the reed mats [1]. Recent research has established that because of this pore structure, thick reed mats have good sound absorption characteristics, with excellent performance at medium-high frequencies. The preliminary measurements of the sound absorption coefficient of different configurations of reeds have demonstrated that reeds offer the potential to act as sound absorbers in demanding external environments [2].

Experimental data of the absorption tests were obtained in the reverberation chamber of Acoustics Laboratory in the School of Architecture (UPM). The volume of the reverberation chamber was 65 m³. The acoustic measuring equipment (Type Pulse 2260 acoustic analysers, sound sources, processing software, etc.) was manufactured by Brüel&Kjaer. The accuracy of the measuring equipment has periodically been verified by certified calibration laboratories.

The samples tested occupied an area of 5 m². The experimental placement of some of the tests carried out is shown in (fig. 1).



fig. 1 "Placing of reed panels on the floor"

Tests were performed following the protocols of the standard EN ISO 354(2003), type A mounting. In this standard [3], the average reverberation time in the reverberation room is measured with and without the test specimen mounted. From these reverberation times, the equivalent sound absorption area of the test specimen, A_T , is calculated by using Sabine's equation:

$$A_T = A_2 - A_1 = 55,3V \left(\frac{1}{c_2 T_2} - \frac{1}{c_1 T_1} \right) - 4V(m_2 - m_1) \quad (1)$$

where

A_2 The equivalent sound absorption area of the reverberation room containing a test specimen, in square meters, is calculated using the formula:

$$A_2 = \frac{55,3 V}{c_2 T_2} - 4V m_2 \quad (2)$$

A_1 The equivalent sound absorption area of the empty reverberation room, in square meters, is calculated using the formula:

$$A_1 = \frac{55,3 V}{c_1 T_1} - 4 V m_1 \quad (3)$$

V is the volume, in cubic meters, of the empty reverberation room;
 c_2 is the propagation speed of sound in air at the temperature t_2 ;
 T_2 is the reverberation time, in seconds, of the reverberation room after the test specimen has been introduced;
 c_1 is the propagation speed of sound in air at the temperature t_1 ;
 T_1 is the reverberation time, in seconds, of the empty reverberation room;
 m_1 is the power attenuation coefficient, in reciprocal meters, calculated according to ISO 9613-1 using the climatic conditions that have been present in the empty reverberation room during the measurement;
 m_2 is the power attenuation coefficient, in reciprocal meters, calculated according to ISO 9613-1 using the climatic conditions that have been present in the empty reverberation room during the measurement.

The sound absorption coefficient α_s of a plane absorber or a specified array of test objects is calculated using the formula:

$$\alpha_s = \frac{A_T}{S} \quad (4)$$

where

A_T is the equivalent sound absorption area of the test specimen, in square meters.

S is the area, in square meters, covered by the test specimen.

3.- EXPERIMENTAL RESULTS

This section shows a summary of the results obtained in the experimental research carried out with the reed panels.

First of all, it is analysed what is the effect due to mounting. Type A mounting was performed. The test specimen is placed directly on the floor of the reverberation room.

The tests were carried out in two different situations:

- 1) The perimeter edge of the test specimen was covered with a 20 mm thickness OSB board to prevent the edges from absorbing sound.
- 2) The edges of the test specimen were exposed. In this case, the area of the edges has been included in calculating the test specimen area and the sound absorption coefficient.

(fig.1) shows the placement of the samples in these situations. Different panel thicknesses have been used varying from 5 to 15 cm.

(fig.2), (fig.3), and (fig.4) show the sound absorption coefficients obtained for different thicknesses of reeds with and without covered edges.

(fig.5) and (fig.6) show what is the effect of the reed thickness in each different situation.

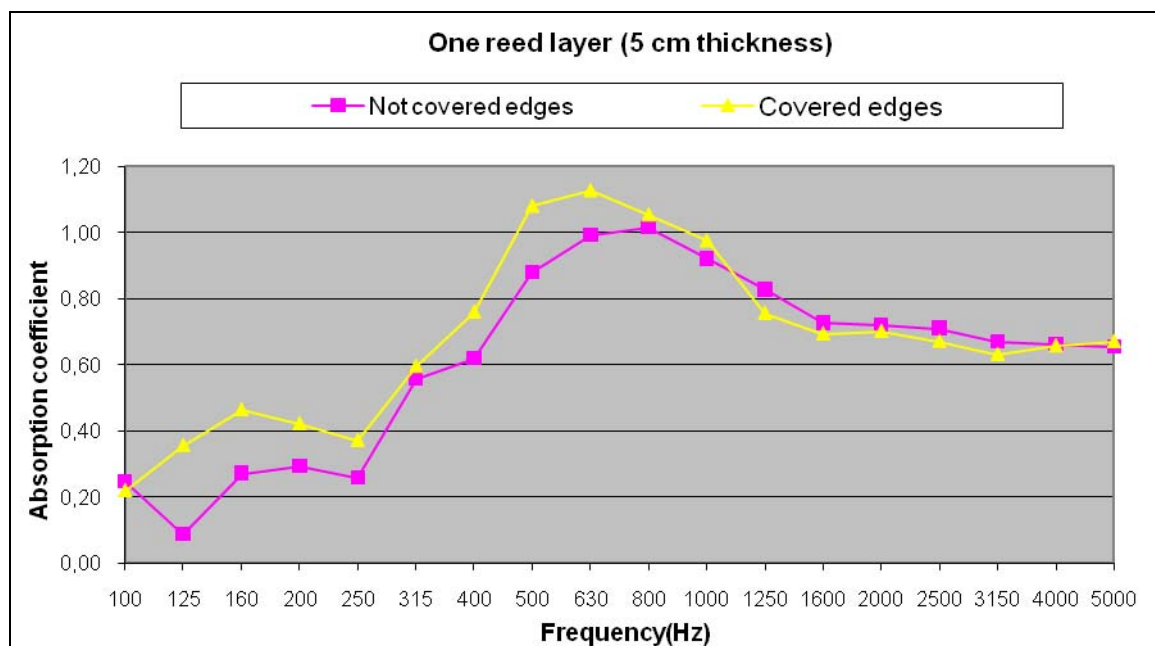


fig. 2 "Sound absorption coefficients of one reed layer with and without covered edges"

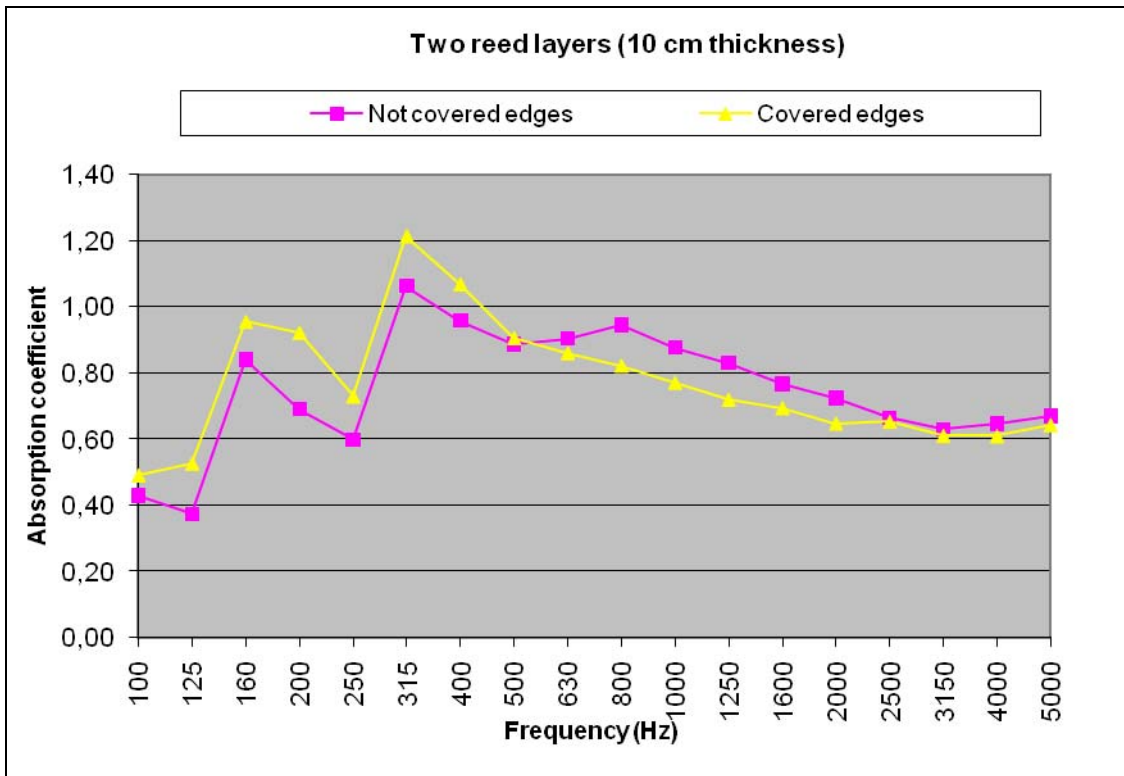


fig. 3 “Sound absorption coefficients of two reed layers with and without covered edges”

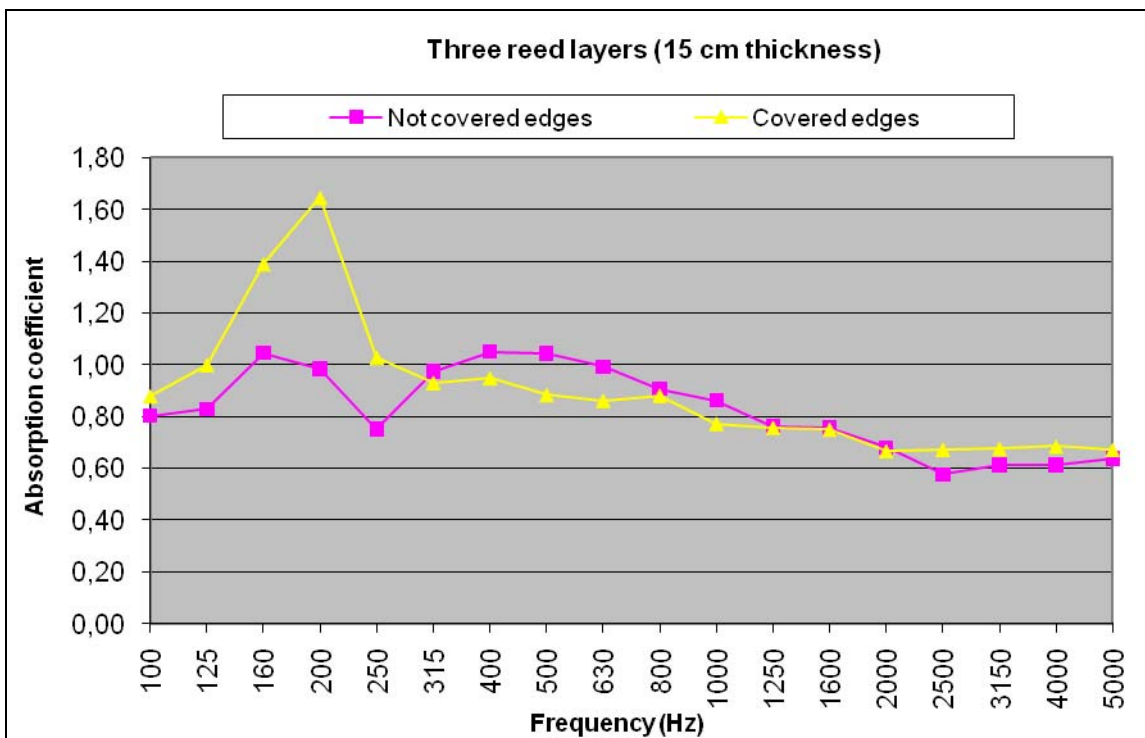


fig. 4 “Sound absorption coefficients of three reed layers with and without covered edges”

As it can be noticed in (fig.4) and (fig.5), in case of covered edges and reed thickness 15 cm, absorption coefficient at 200 Hz frequency is considerably higher than $\alpha_s = 1$.

The sound absorption coefficient is larger than $\alpha_S = 1$ because of diffraction effects and the chamber dimensions, which create great uncertainty in the measurements at low frequencies.

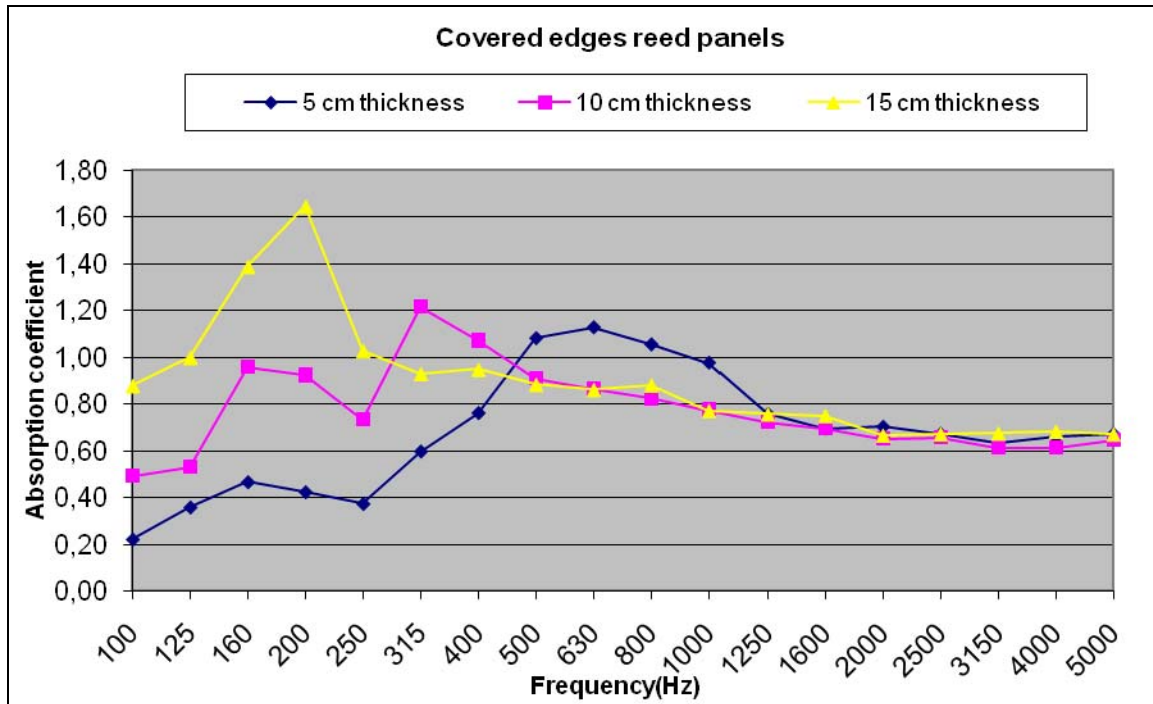


fig. 5 “Effect of the reed thickness in sound absorption coefficient. Covered edges”

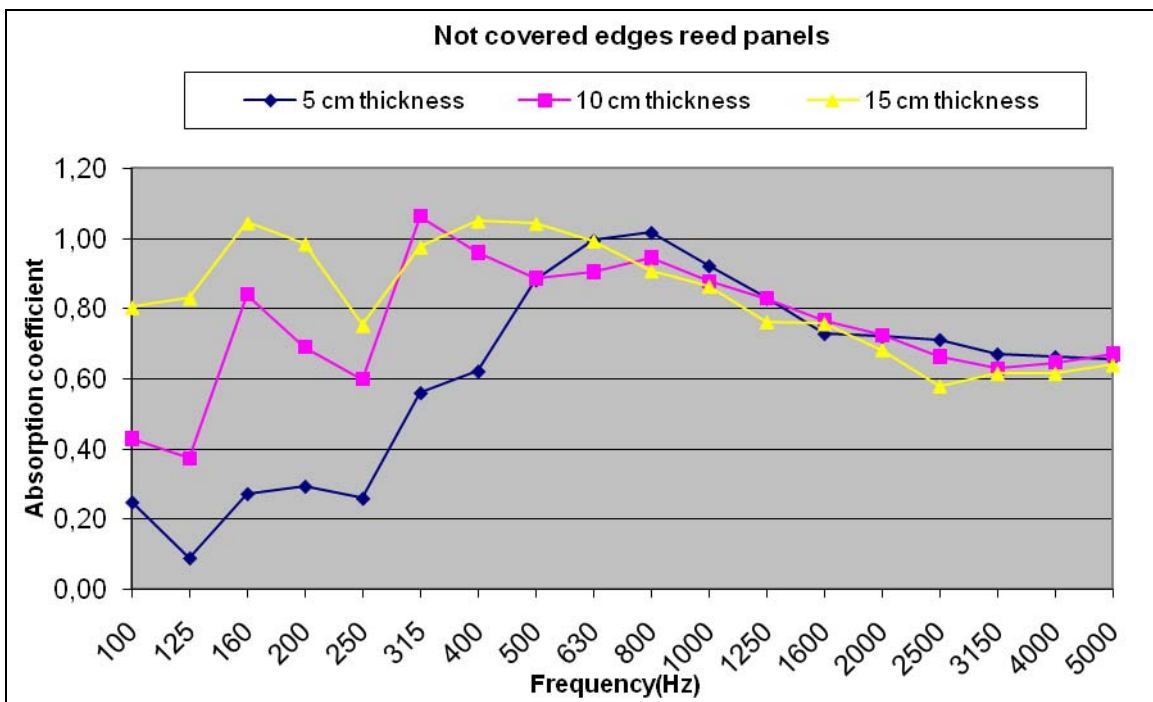


fig. 6 “Effect of the reed thickness in sound absorption coefficient. Not covered edges”

Reed absorbent behavior when its edges are covered is like a set of associated resonators in series and in parallel, consisting of closed tubes at both ends. The resonance frequency of the system moves to low frequencies when the thickness of the material increases; at high frequencies (above 1 kHz), the absorption coefficient does not depend on the material thickness.

When the test specimen is placed directly on the floor of the reverberation room and the edges are exposed, the system is a combination of resonators in series and in parallel, consisting of closed tubes at both ends and closed tubes at one side and opened tubes on the other side in lateral edges.

In practice, when used as a surface finish material in enclosed spaces, the edges will be protected by the walls of the room and their acoustic behavior would be similar to the covered edges panels with the OSB board.

EFFECT CAUSED BY ONE REED LAYER COVERING TWO OPPOSITE WALLS OF AN ENCLOSURE IN THE REVERBERATION TIME

A simulation of the reverberation time in a 50 m³ empty enclosure is developed in this section. Then the simulation is carried out placing one reed layer covering two opposite walls in the same enclosure.

The empty enclosed room has no absorbent treatment in the interior surfaces and it can be noticed terrazzo flooring finishes and coating plaster walls and ceilings [4].

As it can be seen in (fig. 7), placing one reed layer covering two opposite walls in an enclosed space can reduce dramatically the reverberation time, with resulting improvement in speech intelligibility.

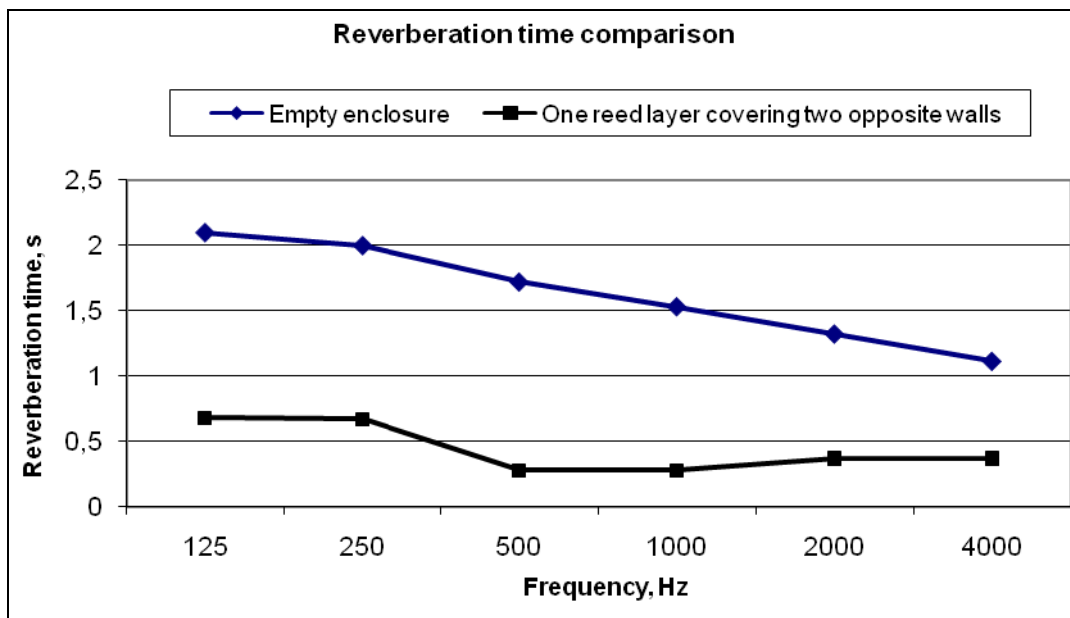


fig. 7 "Effect caused by one reed layer covering two opposite walls of an enclosure in the reverberation time"

4.- CONCLUSIONS

Experimental results obtained from the calculation of reed sound absorption coefficient show that, in case of covered edges, reed absorbent behavior is like a set of associated resonators in series and in parallel, consisting of closed tubes at both ends. In case of not covered edges, the system works like a combination of resonators in series and in parallel, consisting of closed tubes at both ends and closed tubes at one side and opened tubes on the other side in lateral edges.

The resonance frequency of the system moves to low frequencies when the thickness of the material increases; at high frequencies (above 1 kHz), the absorption coefficient does not depend on the material thickness.

The use of reeds as interior surface finish reduces the reverberant field in enclosed spaces and allows to obtain reverberation times appropriate to their use.

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REFERENCES

- [1] Jiménez Espada M. et al (2007), The acoustical potential of reed panels for partitions in sustainable construction. *ICA 2007*, Madrid, Spain.
- [2] V Chilekwa, G Sieffert, C.A. Egan and D Oldham (2006), The acoustical characteristics of reed configurations. *EuroNoise 2006*, Tampere, Finland.
- [3] EN ISO 354:2003. Acoustics - Measurement of sound absorption in a reverberation room.
- [4] Díaz, C; Pedrero, A (2005), The reverberation time of furnished rooms in dwellings. *Applied Acoustics*. 66, 945-956.