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Study in the measurement of noise air insulation in laboratory of the effect in the diffuse field

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We can obtain, in a transmission chamber, the Transmission Factor. In the standard 140-1 are described the characteristics of this chambers. One of these features seeks to ensure a field diffuse within these chambers. Nevertheless, we cannot assure an incident between 0º and 90º on the wall test , there is a limit lower than 90.In this paper, it is studied the mistake committed valuation in insulation due to the indetermination of limit angle. Expressions used for calculating the insulation in transmission chamber are obtained from transmission description in diffuse field, in which case the angle is 90º. In this work is studied, for different materials commonly used in test of chambers transmission, the influence of the angle in the results of Transmission Factor.

Introduction

In the directive of the European Union, EU Directive 89/106/EEC [1] "Marking of Construction Products. Buildings Regulations Advisory Body (BRAB)", affecting all member states and in the ANNEX I, point 5; Protection against noise, says "The construction works must be designed and built in such a way that noise perceived by the occupants or people nearby is kept down to a level that will not threaten their health and will allow them to sleep, rest and work in satisfactory conditions". Each of the member states should take measures to comply with this regulation. To meet this criteria about the protection against air noise; there are procedures that are based on simplified solutions, or other procedures which are fundamental to a detailed study based on the prediction methods that are currently known in the case of air noise insulation and with regard to Spain in particular are described in the Norm UNE EN 12354-1:2000 [2].

Regardless of the option taken to comply with this legislation, it is necessary to know information obtained in chambers transmission. It is necessary to know the Transmission Lost, TL. In addition, this information must be determined with the least possible uncertainty, so that there is no accumulation of errors in formulations or successive computational procedures. The following procedures for conducting correct measures and estimates are described in standard ISO140-1[3] u ISO 140-3[4].

This paper aims to study the effect of dissemination in obtaining the Transmission Lost obtained in chamber transmission. The effect of the diffuse field will be studied through the effect of the angle limit of incidence on the wall test.

Transmission coefficient

The Transmission coefficient, $\tau(\theta)$, represents the energy transmitted with regard to energy incident. This Index can be calculated by depending on the incident angle on the wall test [5, 6]. From this one Index we can calculate the Transmission Lost.

$$TL = -10\log\tau_d \tag{1}$$

The Transmission coefficient in the diffuse field can be obtained through the following expression:

$$\tau_d = \frac{\int_0^{\theta_{lim}} \tau(\theta)\cos\theta\, sen\,\theta\, d\theta}{\int_0^{\theta_{lim}} \cos\theta\, sen\,\theta\, d\theta} \tag{2}$$

Where, θ_{lim}, represents the major inclination with regard to vector surface we can obtain the influence on the wall test. There is a disagreement regarding the determination of this angle . Some authors say that the angle limit is 90 º (parallel to the wall test). Others authors suggest that, due to the conditions of design in these chambers, it is difficult to influence them with a low angle of 80º.

In the case of a thin, infinite and elastic plate, that separates two regions of space I and II, the plate has no connection whatsoever between the two[7,8]. There are simple expressions that improve the results provided by the Law on Mass:

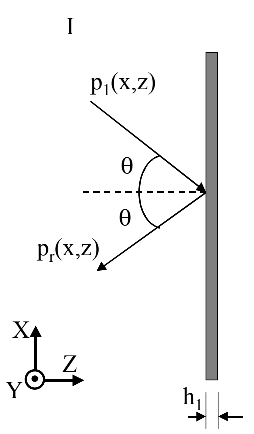


Fig.1 Geometry of the thin plate mode

$$\tau(\theta) = \frac{(2\rho_o)^2}{\left(\frac{\omega^3\cos\theta D sen^4\theta\eta}{c^5} + 2\rho_o\right)^2 + \frac{\omega^2\cos^2\theta(D\omega^2 sen^4\theta - mc^4)^2}{c^{10}}} \tag{3}$$

In the case of the diffuse field applying Eq.(2):

$$\tau_d = \frac{\displaystyle\int_0^{\theta_{\lim}} \frac{(2\rho_o)^2 \cos\theta sen\theta d\theta}{\left(\frac{\omega^3 \cos\theta D sen^4\theta\eta}{c^5} + 2\rho_o\right)^2 + \frac{\omega^2 \cos^2\theta (D\omega^2 sen^4\theta - mc^4)^2}{c^{10}}}}{\frac{sen^2\theta_{\lim}}{2}} \quad (4)$$

D is the bending stiffness of the layer, η.,is the loss factor, c, is the sound speed in air,ρ0, is the density of layer's material and ω is . the angular frequency. The latter expression allows us to approach the problem in the case of impermeable thin layers.

Calculation of Uncertainty

From the expression of Transmission coefficient for the diffuse field, Eq. (4), we can make an estimate of error. We assume a breakdown of the expression of the transmission coefficient diffuse field in two terms. The first term represents the contribution from the normal incidence angle to the limit (cutting angle) and secondly its contribution to 90 º

$$\tau_d = \frac{\int_0^{\pi/2} \tau(\theta)\cos\theta sen\theta d\theta}{\int_0^{\pi/2} \cos\theta sen\theta d\theta} = \frac{\int_0^{\theta_{\lim}} \tau(\theta)\cos\theta sen\theta d\theta + \int_{\theta_{\lim}}^{\pi/2} \tau(\theta)\cos\theta sen\theta d\theta}{\int_0^{\theta_{\lim}} \cos\theta sen\theta d\theta + \int_{\theta_{\lim}}^{\pi/2} \cos\theta sen\theta d\theta} \quad (5)$$

Identifying the numerator and denominator as A and B

$$\tau_d = \frac{A}{B} \quad (6)$$

We can make an assessment of the uncertainty committed. For the numerator:

$$A = \int_0^{\pi/2} \tau(\theta)\cos\theta sen\theta d\theta = \int_0^{\theta_{\lim}} \tau(\theta)\cos\theta sen\theta d\theta + \int_{\theta_{\lim}}^{\pi/2} \tau(\theta)\cos\theta sen\theta d\theta$$
$$= \tau_{dcam} + \int_{\theta_{\lim}}^{\pi/2} \tau(\theta)\cos\theta sen\theta d\theta \quad (7)$$

And for the denominator:

$$B = \int_0^{\pi/2} \cos\theta sen\theta d\theta = \int_0^{\theta_{\lim}} \cos\theta sen\theta d\theta + \int_{\theta_{\lim}}^{\pi/2} \cos\theta sen\theta d\theta =$$
$$\frac{sen^2\theta_{\lim}}{2} + \left(\frac{1}{2} - \frac{sen^2\theta_{\lim}}{2}\right) \quad (8)$$

Applying Eq.(7) and Eq.(8) and the theory of errors associated with a ratio of two terms:

$$\left|\frac{\partial\tau_d}{\tau_d}\right| = \left|\frac{\partial A}{A}\right| + \left|\frac{\partial B}{B}\right| = \quad (9)$$
$$\left|\frac{\int_{\theta_{\lim}}^{\pi/2} \tau(\theta)\cos\theta sen\theta d\theta}{\int_0^{\pi/2} \tau(\theta)\cos\theta sen\theta d\theta}\right| + \left|\frac{\frac{1}{2} - \frac{sen^2\theta_{\lim}}{2}}{\frac{1}{2}}\right| =$$
$$\left|\frac{\int_{\theta_{\lim}}^{\pi/2} \tau(\theta)\cos\theta sen\theta d\theta}{\int_0^{\pi/2} \tau(\theta)\cos\theta sen\theta d\theta}\right| + \left|1 - sen^2\theta_{\lim}\right|$$

the expression (9) shows the relative error of the generically association with the angle limit. An analysis of this expression can be seen as the first term depends on the conditions of equipment, frequency, etc., and secondly we enter a relative error fixed, eg 82 would be 2%.

1 Results

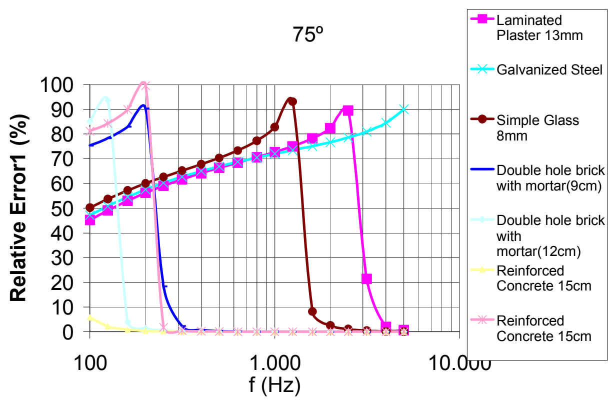
1.1 Results for Impermeable Thin Caps

An initial study has been conducted combining expression Eq. (4) and Eq. (9). The materials that have been studied in this work are shown in Table 1.

Thin Plate	m (kg/m^2)	D (Nm)	η	h (mm)
Laminated plaster 13 mm	9,0	377,3	0,01	13
Galvanized Steel	10,0	95,2	0,004	1
Simple Glass 8 mm	12,0	2523,1	0,054	8
Double hole brick with mortar-9cm	117,6	797870,7	0,017	120
Double hole brick with mortar-12cm	123,0	2965528,4	0,02	150
Concrete Block 20cm	270,0	17224946,5	0,1	200
Reinforced Concrete 15 cm	351,0	3166955,15	0,006	150

Table 1 Impermeable layer studied

First, it conducts a study of the first term associated with the numerator. Figure 2 shows their behaviour for two angles of study. In Figure 3, it examines the second term, associated with the denominator, and dependence with the angle limit. Figure 4 shows both contributions. In all cases the results depend upon the frequency.



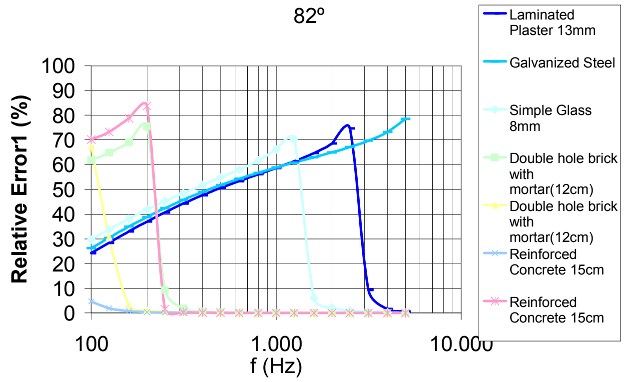


Fig. 2 Relative errors associated with the numerator for the various partitions and for different angles limit.

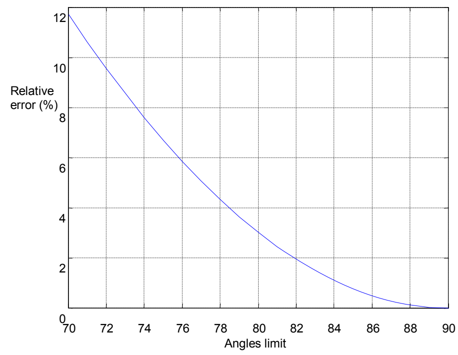
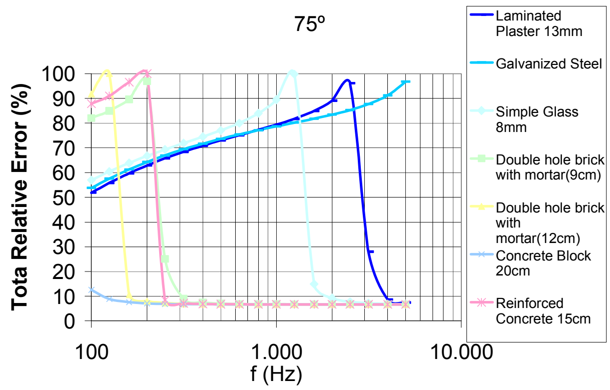


Fig. 3 Error relative associated with the denominator.



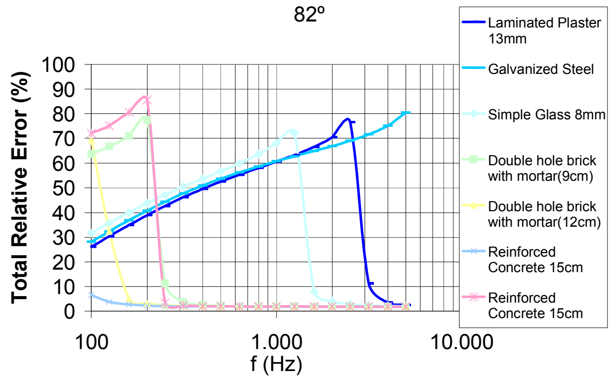
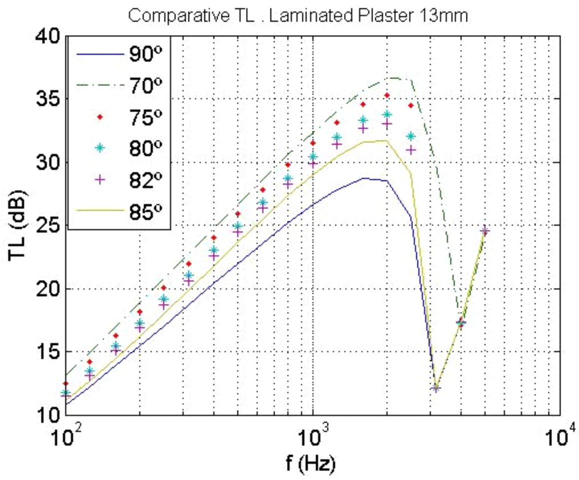
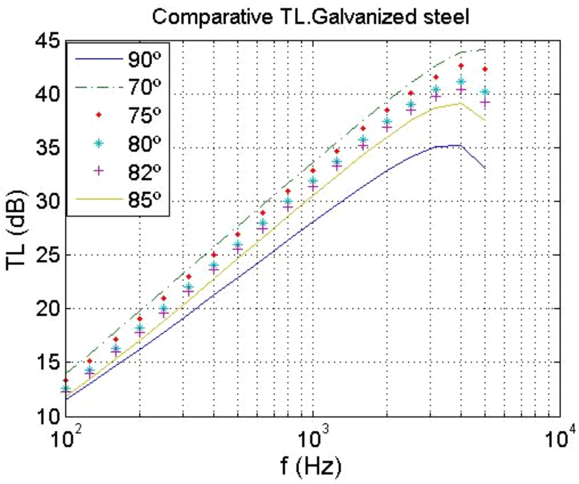
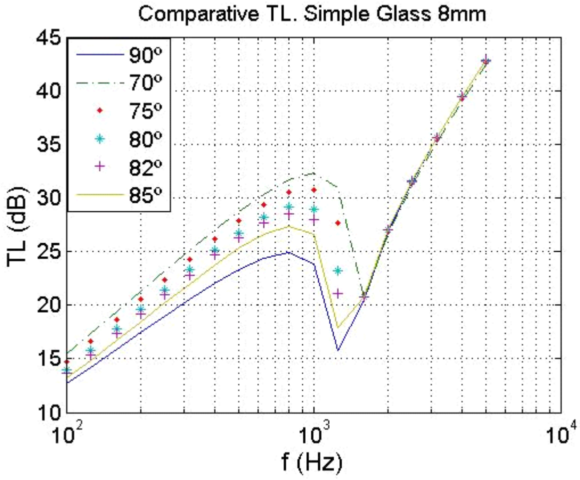


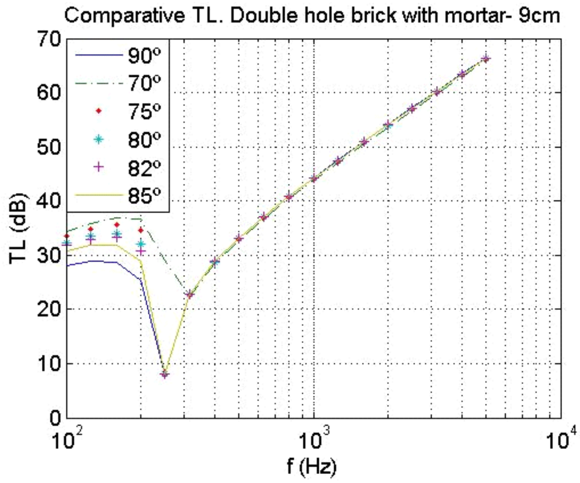
Fig. 4 Relative errors total.

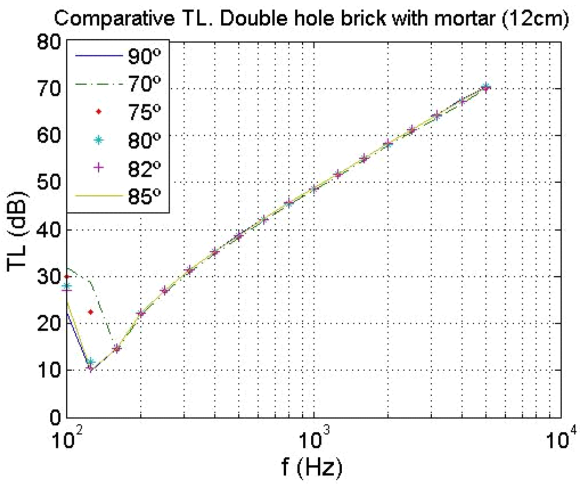
Figure 5 shows the different materials studied and the evolution of the value of TL depending upon the angle limit.











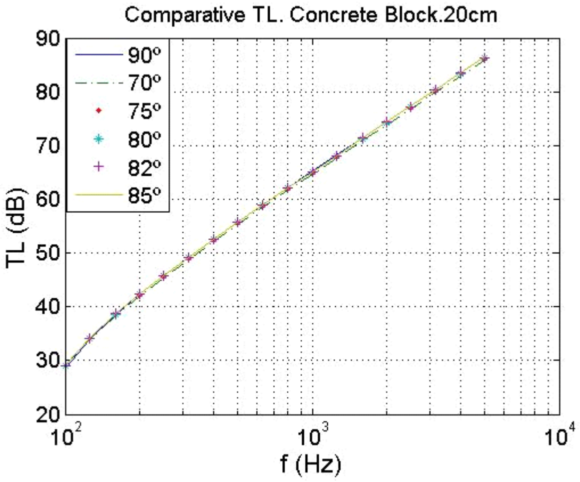


Fig.5

2 Conclusions

The conclusions that can be observed are as follows. Figure 2 shows a clear trend and a dependence with the critical frequencies of the studied materials. The error of more lightweight materials with higher critical frequencies, this ruled by the numerator. The opposite occurs when the mass is increased. This suggests that the term associated with the elasticity (bending stiffness) is critical for the relative error. Figure 3 indicates a tendency to associate an independent angle limit, and therefore inherent in the layout. As an example, to ensure a 2% limit the angle must be of 82 º. Figure 4 shows the accumulation of both effects. Regarding the effect on global values in dBs transmission coefficient, from 82º we have relatively low values, but in some cases we have an absolute error of 3 dB. We could seek to improve disclosure or assume this error in some materials. This error is not fixed and depends on the type of materials.

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