



**IN SITU MEASUREMENTS OF THE STRUCTURAL REVERBERATION TIME OF SEVERAL
BRICK WALLS**

PACS:43.55.Rg

Alba, Jesús¹; Venero, Juan²; del Rey, Romina¹; Ramis Soriano, Jaime³; Escuder, Eva¹; Gavalda, Raquel¹

¹Grupo de Dispositivos y Sistemas Acústicos y Ópticos, DISAO
Departamento de Física Aplicada; Escuela Politécnica Superior de Gandía; Universidad Politécnica de Valencia
Carretera Nazaret-Oliva S/N, Grao de Gandia 46730 (Valencia) España
Teléfono (96) 284.93.14 - (96) 284.93.00
Fax : (96) 284.93.09
E-mail :jesalba@fis.upv.es, roderey@doctor.upv.es, evescude@fis.upv.es

² Chova, S.A. (División Acústica)
Carretera Tavernes-Liria, km 4,3
Tavernes de la Vallidigna 46760 (Valencia) España
Teléfono: 96 282 21 50
Fax: 96 282 36 61
E-mail: juan.venero@chova.com

³ Dpto. Física, Ingeniería de Sistemas y Teoría. Universidad de Alicante
Apdo. Correos, 99; 03080 Alicante
e-mail: jramis@ua.es

ABSTRACT

The structural reverberation time is the parameter used in the standard UNE-EN 12354 to transform the sound reduction index values measured in laboratory in to in situ values. This adjustment is obtained through the comparison of the structural reverberation time measured at the laboratory and the structural reverberation time measured in situ. In this work several in situ measurements of the structural reverberation time of brick walls are presented and analyzed. Evaluation of the measurement with conventional equipment and the dispersion obtained is made, and the possible effects of the mass per unit area and the type of coating in the results are studied. In addition, data measured are compared with the values predicted in UNE-EN 12354-1.

INTRODUCTION

The current worry about a better quality of life from the acoustics' point of view is related with a better quality of acoustic in the construction. This worry has allowed investigating about the acoustic isolation in the construction. The acoustic isolation values obtained under laboratory conditions can be different than the measurements obtained in a build and these differences can be due to flanking transmissions across the constructive solutions. Some measurements of the structural reverberation time have been realized based in current normative [1-3] and in some research studies published about the issue [4-11].

This parameter affects to the flanking transmissions. According to the normative UNE-EN 12354-1, the acoustic values of the constructive solutions can be taken from normalized measurements or calculated from theoretical calculations, empirical estimations or from measurements in situ.

The structural reverberation time can be evaluated from the total loss factor, α_{TOT} . There is inverse proportion between structural reverberation time and the total loss factor, so the structural reverberation time can be related with the sound reduction index: the more the structural reverberation time increases the more sound reduction index provides the element.

The structural reverberation time can be theoretically determined by:

$$T_s = \frac{2,2}{f h_{TOT}} \quad (1)$$

where h_{TOT} is the total loss factor, which is given, according to the UNE -EN 12354-1:2000, by:

$$h_{TOT} = 0,01 + \frac{m}{485 \sqrt{f}} \quad (2)$$

where m is the mass per unit area. This equation is only correct when $m < 800 \text{ kg/m}^2$.

EXPERIMENTAL PROCEDURE

The structural reverberation time of an element is determined with point excitations near the accelerometer, with a hammer, by a rap, and the vibratory response is measured with the accelerometer, shown in figure 1. Five measurements are realized, it means that five raps are made round the accelerometer and this responses are recorded by a frequency analyzer. The measurement time needed is 10 seconds, which includes some seconds before de rap and after it the time needed to allow the amplitude decay until background noise. Depending on the kind of constructive solution, it can be necessary to rap few centimetres of the accelerometer to be able to record the high frequency response. The time elapsed since the excitation has stopped until the amplitude level decreases 60 dB is the structural reverberation time depending on the frequency. Generally, a dynamic range so large is not available, and for this reason the reverberation time is fulfilled by linear extrapolation of shorter evaluation range, 20 or 30 dB. The structural reverberation time, T_s , of the element is determined by the average of the five measurements to each one of the different measurement positions distributed on the element surface which is studied.



Figure 1. Hammer near accelerometer to measure the structural reverberation time

According to EN 12345 detailed procedures for the structural transmission, the acoustic sound reduction index of the constructive elements obtained in laboratory must be transformed in to in situ values. This conversion is made by the ratio of the structural reverberation time measured in situ, $T_{s,situ}$, and the obtained in the laboratory, $T_{s,lab}$:

$$R_{situ} = R - 10 \lg \frac{T_{s,situ}}{T_{s,lab}} \text{ dB} \quad (3)$$

This correction can influence more or less on the sound reduction index results depending on the element studied. According to this equation, the more the structural reverberation time in situ is different from the obtained in the laboratory the more the acoustic isolation decreases when it's converted in to in situ values.

A measurement campaign on the structural reverberation time of some elements was made in order to compare with the theoretical values and verify the difference between the acoustic isolation obtained in the laboratory and the values obtained in situ using the correction shown in the last equation.

EXPERIMENTAL RESULTS

The structural reverberation times obtained in several constructions are shown afterwards. These are from the following constructive solutions:

Simple wall hollow brick (LHD7) 70 mm, plastered both sides with 10 mm gypsum. $m = 88,1 \text{ Kg/m}^2$.

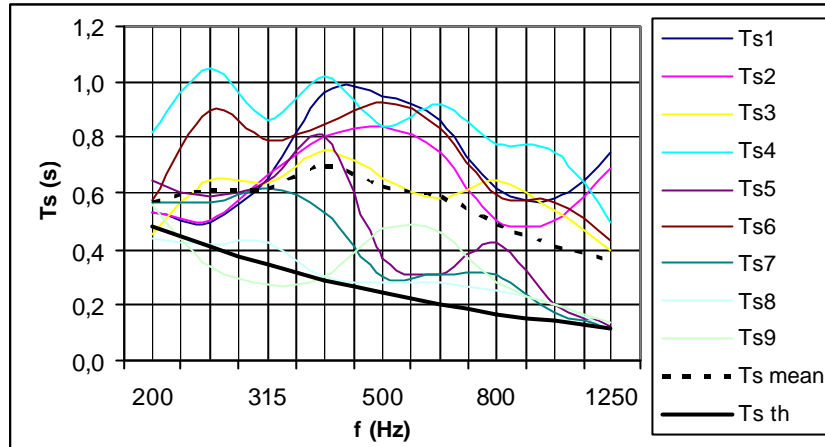


Figure 2: Structural reverberation time. LHD 70 mm plastered both sides.

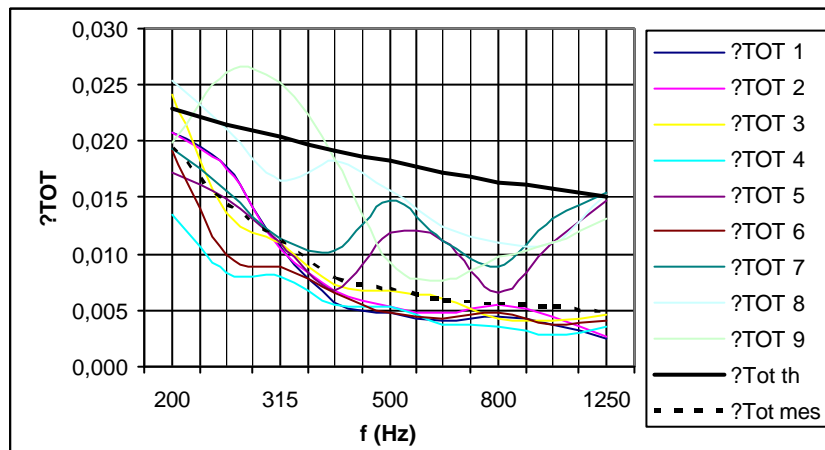


Figure 3: Total loss factor. LHD 70 mm plastered both sides.

- Hollow brick wall (LHD7) 70 mm, plastered one side with 10 mm gypsum ($m = 76,6 \text{ Kg/m}^2$) as a part of a double wall with a multilayer material ChovACUSTIC PLUS inside the cavity.

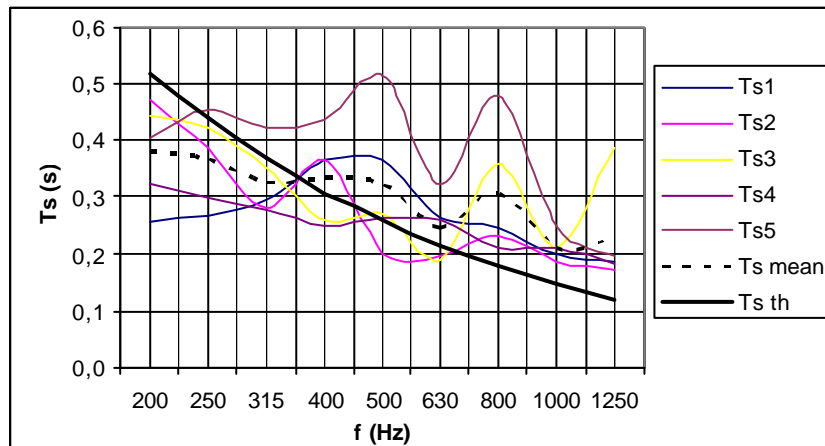


Figure 4: Structural reverberation time. LHD 70 mm plastered one side.

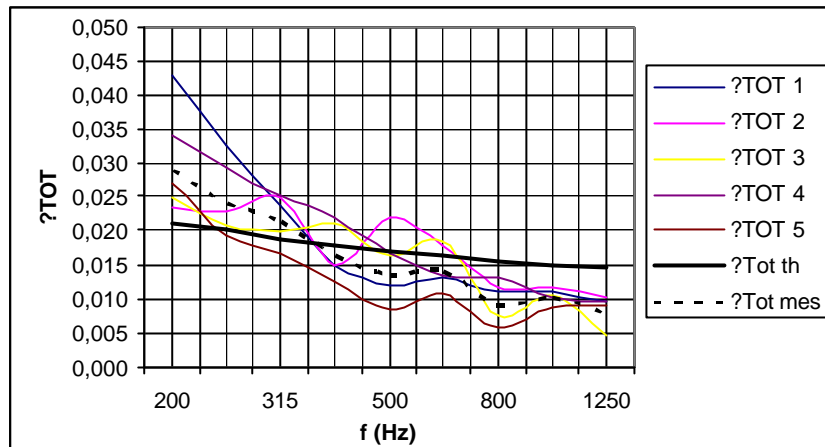


Figure 5: Total loss factor. LHD 70 mm plastered both sides.

Hollow big size brick wall (LGF7) 70 mm, plastered one side with 10 mm gypsum ($m = 55,6 \text{ Kg/m}^2$) as a part of a double wall with a multilayer material ChovACUSTIC PLUS inside the cavity.

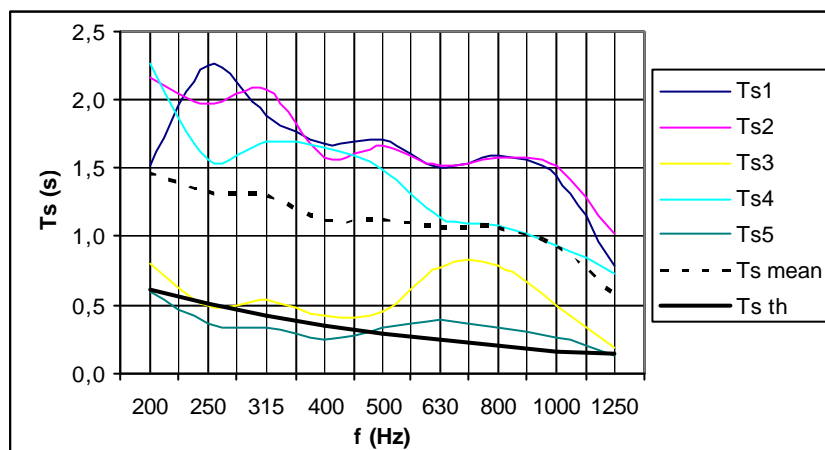


Figure 6: Structural reverberation time. LGF 70 mm plastered one side.

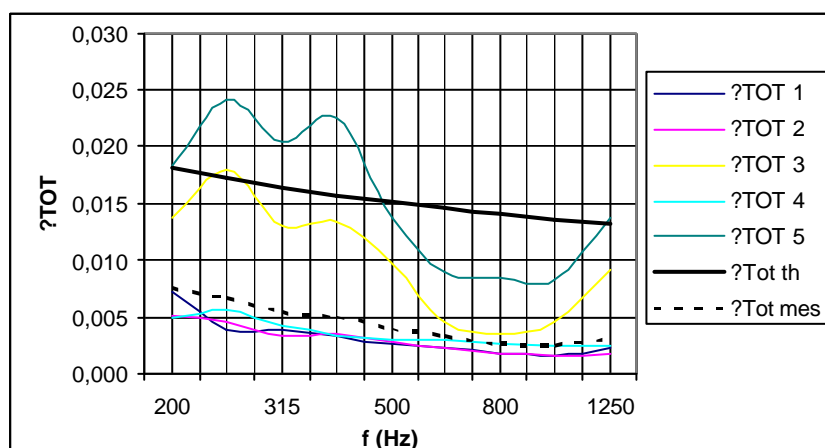


Figure 7: Total loss factor. LGF 70 mm plastered both sides.

Comparing the two double brick wall configurations, with the brick plastered one side and the multilayer material ChovACUSTIC PLUS inside, the relation between mass and reverberation time is verify. In other words, the more the mass increases the more the structural reverberation

time decreases, and vice-versa. The big size brick (LGF7) has a minor mass per unit area than the LHD7 and we can see that the structural reverberation time of the one that more weighs is minor.

Otherwise, comparing the two different LHD7 configurations with the wall plastered one or both sides; in spite of theoretically, the structural reverberation time of the brick wall with higher mass is minor.

Although the brick plastered both sides has a higher mass, the effect of the material behind the brick wall and the different field conditions (simple or double wall) seems to be more relevant in the influence of the structural reverberation time value.

Trying to calculate a single number of the T_s no references in the literature are found so there are two possibilities: take the structural reverberation time obtained at 500 Hz or calculate the average of the values within the frequency range 200 Hz to 1250 Hz, as the vibration reduction index according to the normative ISO 10848.

In the following graph we can verify that the single number ratios calculated in both ways are quite similar, been the maximum deviation 0,08s in the in situ measurements and 0,03 s in the calculated values. These results are shown in the following figures:

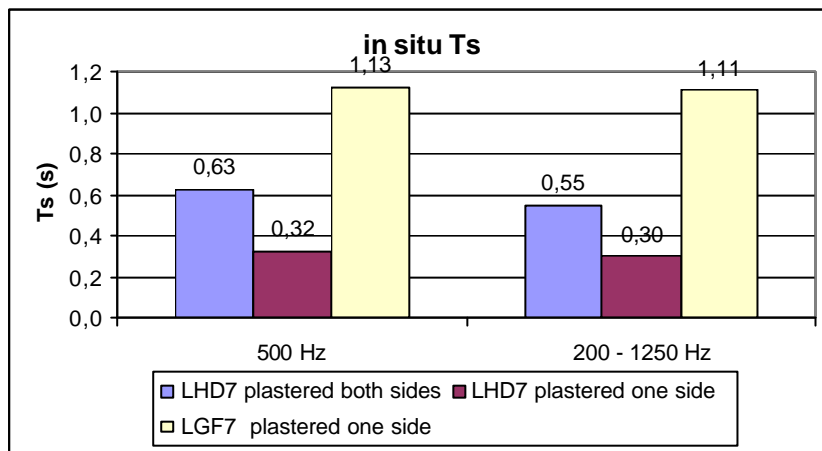


Figure 8: Structural reverberation time single value measured in situ

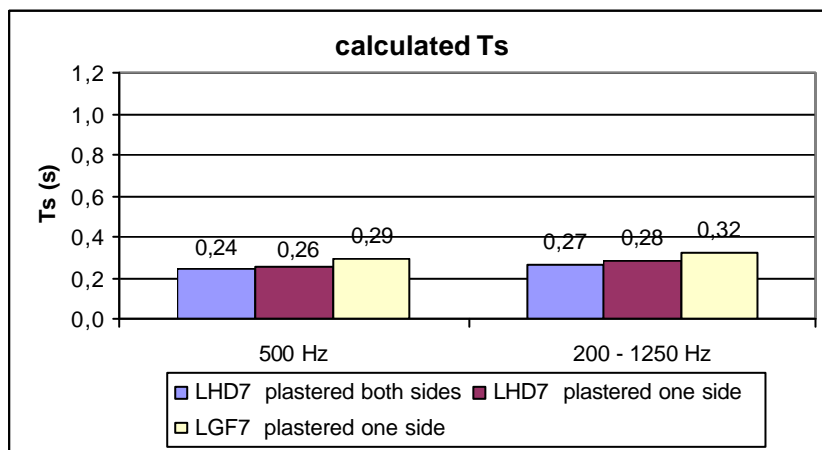


Figure 9: Structural reverberation time single value obtained theoretically

All the theoretical structural reverberation times are much lower than the measured values and the bigger the difference between them, the higher is the influence in the acoustic isolation sound reduction index, if we assume this theoretical values as laboratory values.

If we take, as an example, the values obtained for the hollow brick wall (LHD 7) plastered both sides that appear in the figure 1 and take the single value at 500 Hz (0,63 s) while the theoretical value at 500 Hz is 0,24 s. The measured value is practically three times the

theoretical structural reverberation time. Introducing this results in the equation (3) the acoustic sound reduction index in the laboratory decreases about 4 dB when its turned in to in situ value.

CONCLUSIONS

Results show good agreement between a decrease in the mass per unit area of the single brick walls and an increase of the structural reverberation time.

In the case of the double wall seems to have more influence the material inside the cavity or the field conditions than the mass of the wall.

Although there is a big dispersion in some results due to different field conditions and the non homogenous characteristics of brick walls, the strong deviations between the theoretical and measured values of the different brick walls are clear. These differences can affect the in situ sound reduction index of a constructive element using the 12354 model. As the weight of this parameter in prediction results could be really important more research in both laboratory and in situ conditions should continue.

ACKNOWLEDGMENT

This work has been economically supported by the Ministerio de Fomento (REF 80026/A04)

References:

- [1] ISO 10848-parts 1, 2 and 3. Laboratory measurement of the flanking transmission of airborne and impact sound between adjoining rooms.
- [2] UNE-EN 12354-1 Building acoustics. Estimation of acoustic performance of buildings from the performance of elements.
- [3] UNE-EN ISO 140-4 Measurement of sound insulation in buildings and of building elements. Part 4: Field measurements of airborne sound insulation between rooms.
- [4] Esteban, A.; Cortés, A.; Villot, M.; Martín, C. "Vibration reduction index Kij in hollow constructions: application of the european standard EN12354 to the spanish constructions", *TecniAcústica*, Bilbao 2003.
- [5] Building Structures, Junctions,: transmission of vibrations-field measurements, NT acou 090, Nordtest method.
- [6] Martín, M. A.; Tarrero, A.; Aparicio, A., González, J, Machimbarrena, M. "Análisis de la transmisión sonora a través de una unión en cruz mediante el estudio de la amplitud de la aceleración. *TecniAcústica* 2005.
- [7] Schneider, M. Fischer, H.M. "Flanking transmission of masonry building elements with flexible interlayer", *ForumAcusticum* 2005, Budapest.
- [8] M^a A. Martín, A. I. Tarrero, A. Aparicio, J. González, M. Machimbarrena "Determinación del índice de reducción vibracional y análisis de los parámetros involucrados". *Tecniacústica 2006, 37º Congreso nacional de acústica. Encuentro ibérico de acústica. EAA Symposium on Hydroacoustics*, Gandia, 18-20 octubre, 2006
- [9] M^a A. Martín, A. I. Tarrero, A. Aparicio, J. González, M. Machimbarrena "Determinación del tiempo de reverberación estructural. Procedimiento y validación". *Tecniacústica 2006, 37º Congreso nacional de acústica. Encuentro ibérico de acústica. EAA Symposium on Hydroacoustics*, Gandia, 18-20 octubre, 2006
- [10] J. Alba, J. Ramis, J. Venero, E. Escuder, L. Berto, "Estudio del comportamiento del aislamiento acústico a ruido aéreo de medianeras de ladrillo hueco doble del 7", *Tecniacústica 2006, 37º Congreso nacional de acústica. Encuentro ibérico de acústica. EAA Symposium on Hydroacoustics*, Gandia, 18-20 octubre, 2006
- [11] J. Alba, J. Ramis, J. Venero, E. Escuder, L. Bertó, "Medida in situ de transmisiones indirectas y análisis de su influencia en el aislamiento acústico de una medianera", *Tecniacústica 2006, 37º Congreso nacional de acústica. Encuentro ibérico de acústica. EAA Symposium on Hydroacoustics*, Gandia, 18-20 octubre, 2006