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IN SITU MEASUREMENTS OF THE STRUCTURAL REVERBERATION TIME OF SEVERAL FLOORS

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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 floors 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.

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, $?_{TOT}$. 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:

$$T_s = \frac{2,2}{f h_{TOY}} \qquad (1)$$

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

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

where m is the mass per unit area. This equation is only correct when m < 800 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, Ts, 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.

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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, $T_{s,lab}$:

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

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:

- Beam and hollow concrete block floor (250 mm) gypsum plastered 10 mm, m = 383,5 Kg/m^2.

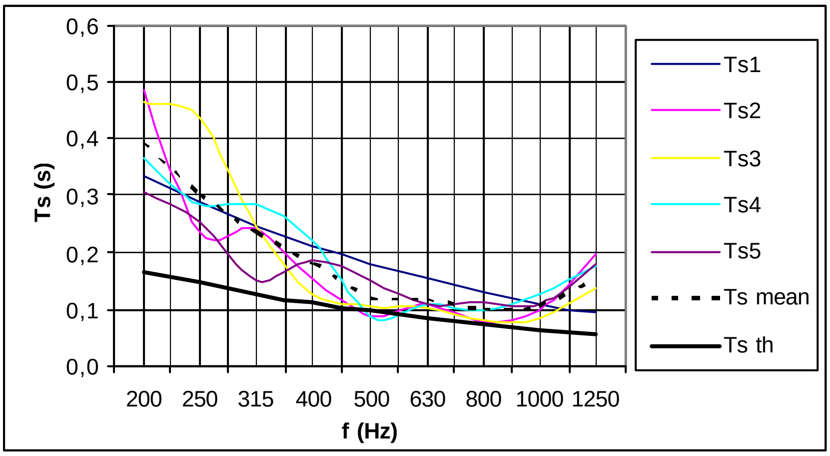

Figure 2: Structural reverberation time. 250 mm beam and block floor.

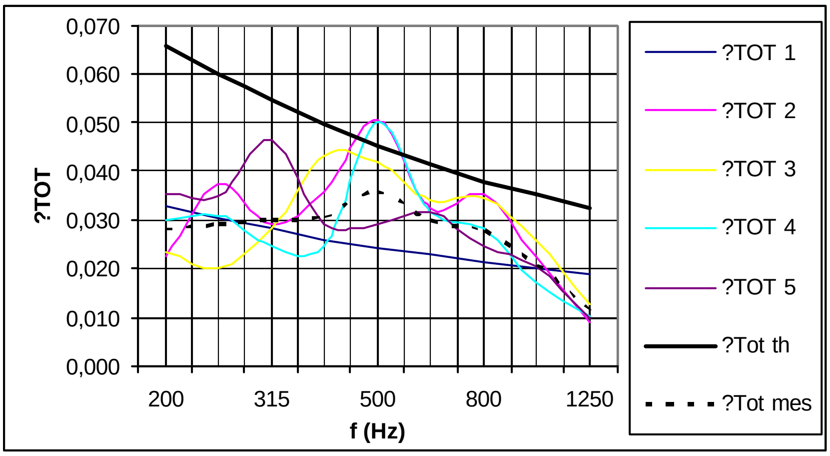

Figure 3: Total loss factor. 250 mm beam and block floor.

- Beam and hollow concrete block floor (250 mm) gypsum plastered 10 mm plus floating floor (5 mm polyetylene foam ChovAIMPACT and 40 mm mortar screed, m = 126 Kg/m^2).

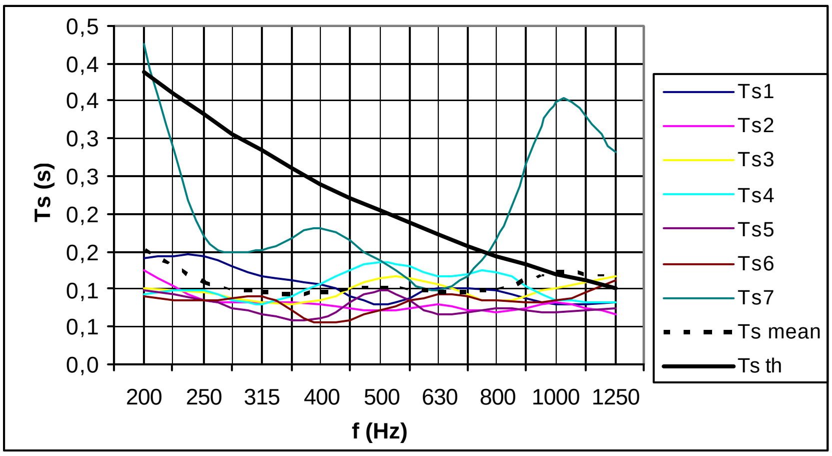

Figure 4: Structural reverberation time. Beam and block floor plus floating floor without finish.

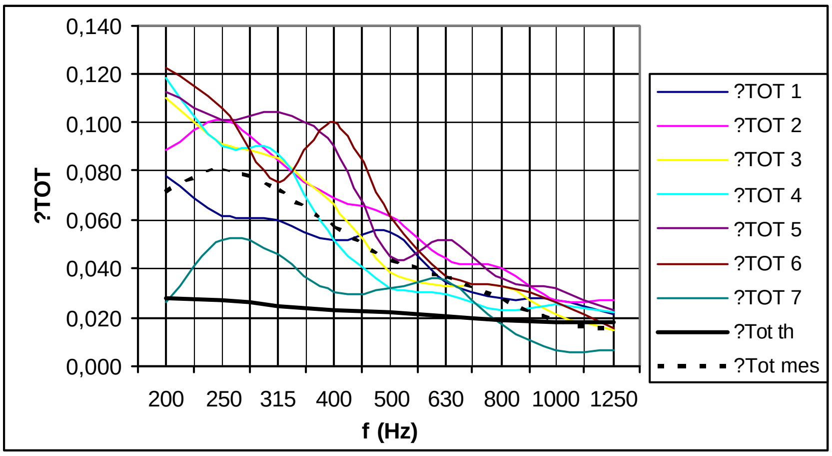

Figure 5: Total loss factor. Beam and block floor plus floating floor without finish.

- Beam and hollow concrete block floor (250 mm) gypsum plastered 10 mm plus floating floor (5 mm polyetylene foam ChovAIMPACT and 40 mm mortar screed) finished with tile (m_1 = 146 kg/m2) or with laminated floor (m_2 = 126 Kg/m^2). The average of the mass per unit area has been used to calculate the theoretical value.

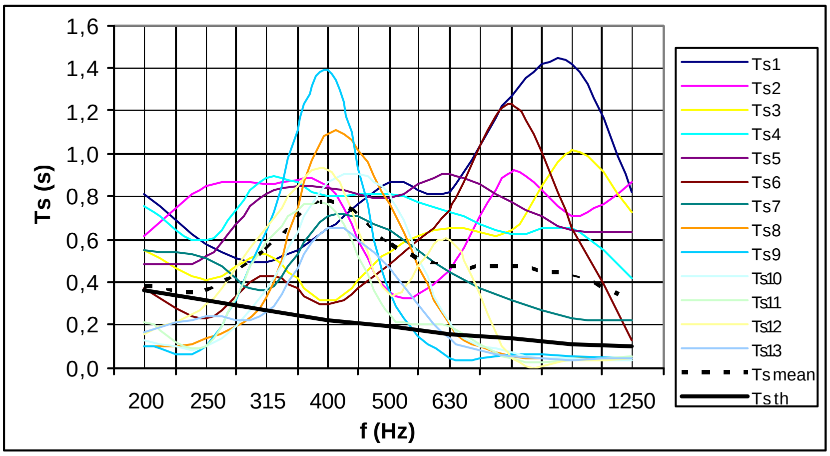

Figure 6: Structural reverberation time. Beam and block floor plus floating floor finished with tile or laminated floor.

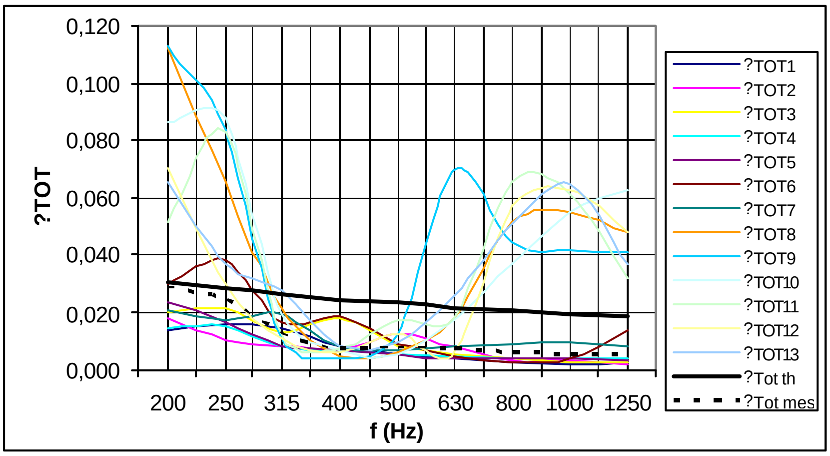

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Figure 7: Total loss factor. Beam and block floor plus floating floor finished with tile or laminated floor.

If we compare the shape of the structural reverberation time in the first and second cases, the values measured are lower than the calculated values. The lowest values are reached for the floating floor probably due to the effect of the impact sound attenuation of the polyethylene foam.

The similitudes between both graphics are greater form the frequency of 500 Hz and have more differences in the lower frequency region.

In the last case, the one with the floating floor with the mortar screed covered the effect of the top material (either tile or wood) has a strong influence in the results and introduces some clear resonances in the results. Moreover, the values measured are much greater than the ones calculated theoretically just the opposite as in the first and second examples.

Trying to calculate a single number of the Ts 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 0,1s in the in situ measurements and 0,02 s in the calculated values. These results are shown in the following figures:

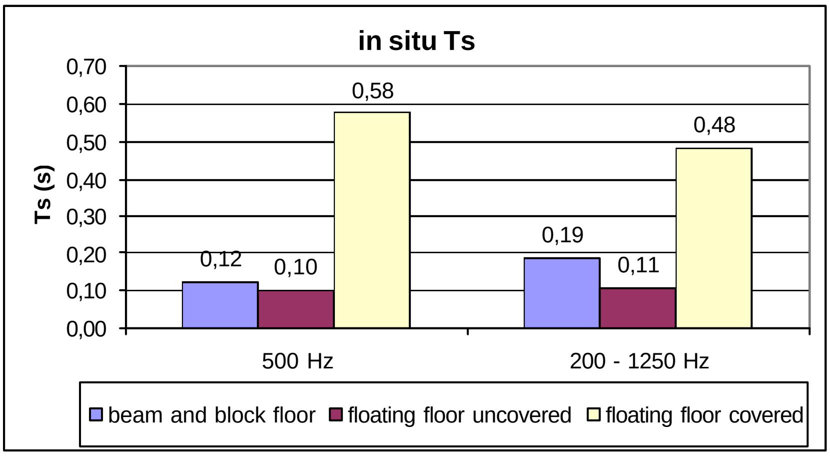

Figure 8: Structural reverberation time single value measured in situ

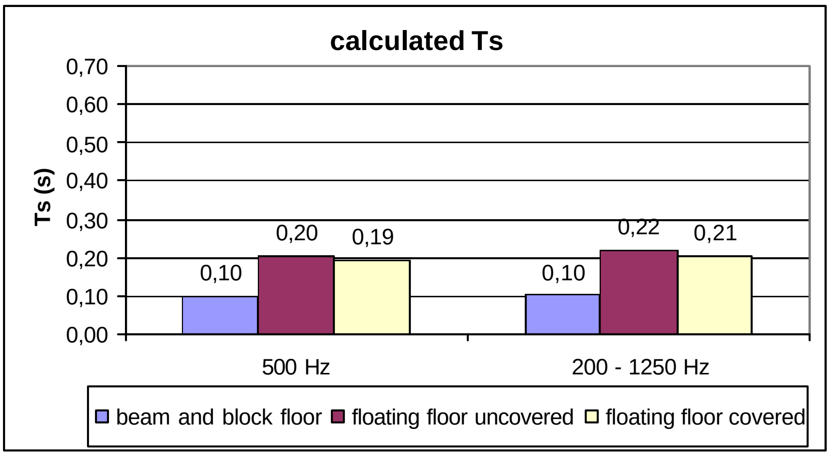

Figure 9: Structural reverberation time single value obtained theoretically

The measured structural reverberation times differs from the calculated 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.

Again the bigger difference is found in the covered floating floor.

If we take, as an example, the values obtained for the bare beam and block floor and take the single value at 500 Hz (0,12 s) its quite similar as the one calculated theoretically (0,10 s) so the effect in the sound reduction index using equation (3) is low (0,8 dB); on the other hand, if we compare the same values (Ts at 500 Hz in situ and calculated) of the floating floor covered, the deviations are so great that the influence on the sound reduction index is of 5 dB,

SYSTEMATICAL ERROR

From equation (1) we can get the total loss factor from the results of the structural reverberation time but we have to take in account that some values are quite low, around 0,1 seconds so the loss factor value is affected by the accuracy range of the structural reverberation time measurement.

CONCLUSIONS

Results show no straight connection between the mass of the elements and the results of the structural reverberation time, but some agreement between theoretical and measured values is found in a few cases.

The effect of the topping in the experimental results is quite strong, so probably when the measurements are made without the mortar screed finished the results are better for taking these values as the reverberation times of the constructive element.
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 research in both laboratory and in situ conditions should continue.

ACKNOWLEDGMENT

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