VIBRATION REDUCTION INDEX K_{IJ} IN HOLLOW CONSTRUCTIONS: APPLICATION OF THE EUROPEAN STANDARD EN12354 TO THE SPANISH CONSTRUCTIONS

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ABSTRACT

The vibration reduction index Kij is one of the key parameters when using the new European prediction tools developed in the EN 12354. The standard gives an estimation of this parameter using the relation between the masses of monolithic elements. However, past studies showed the need for more complete researches in this field, involving also hollow construction elements, commonly used in southern Europe.

This paper presents some results of field measurements of the K_{ij} parameter, showing meaningful differences with the calculated values.

INTRODUCTION

The acoustical quality of dwellings in Spain was guaranteed up to day with the compliance of the building regulation NBE-CA88 [1]. This regulation established laboratory requirements to each construction element depending on its use (separating or partition walls, floors…). However, the new Spanish Building Regulation [2] will consider the whole building as a product itself (performance-based-regulation). In this way, the building is responsible for fulfilling the acoustical insulation requirements: not only the separating element (floor, wall...) must comply with the regulation, but also flanking transmissions should be taken into account. In addition, *in situ* measurements could be performed to verify that the building complies with the quality requirements.

All this background leads to the need for prediction tools allowing architects and engineers to evaluate each transmission path and the global behaviour from the design stage. This problem has been studied for long time in Europe [3,4], resulting in the European Standard EN 12354 [5]. This standard presents a simplified method of the SEA model and provides a reasonably accurate prediction [6,7], with the advantage of using usual laboratory results (R, Ln…).

One of the key parameters in the CEN models is the vibrational reduction index Kij, which characterises the energy transmission at a joint between elements. Annex E of the EN12354-1 gives an estimation of this parameter using the relation between the masses of the elements. This annex has been developed for monolithic elements. However, previous studies [8,9] show

that important differences may appear when using hollow elements, like ceramic bricks or beam and block floors.

Being concerned about this problem, the Building Regulation Department of the Basque Government has launched a research project in collaboration with the Technological Center LABEIN and the CSTB to adapt the EN12354 standard to the Spanish.

EXPERIMENTAL APPROACH

The research (still in progress) has been based on experimental field measurements in different buildings and trying to undertake many different construction elements. The K_{ij} parameter has been measured according to prEN ISO 10848-1 [11] from the known expression:

$$k_{ij} = \frac{D_{v,ij} + D_{v,ji}}{2} + 10 \times \log \frac{I_{ij}}{\sqrt{a_j \times a_i}} \qquad (1)$$

where:
- $D_{v,ij}$ = is the velocity level difference (in dB) between elements i and j, when i is excited.
- I_{ij} = junction length between elements i and j
- a_i ; a_j = equivalent absorption lengths .

Junction velocity level difference measurement using a standard tapping machine and a hammer as excitation sources.

The equivalent absorption length is obtained from the following expression:

$$a_{i,situ} = \frac{2.2 \cdot p^2 \cdot S_i}{C_0 \cdot T_{s,i,situ}} \cdot \sqrt{\frac{f_{ref}}{f}} \qquad (2)$$

Where:
- $T_{s,i,situ}$ = is the structural reverberation time (measured in situ).
- S_i = is the surface area
- f_{ref} = 1000 Hz

RESULTS

Some representative results are shown for different cross and tee junctions involving beam and block floors with different hollow brick walls. The floor blocks can be either ceramic or concrete, with a surface mass about 300 kg/m^2 (bare floor). The walls can also be ceramic or concrete

bricks. Partition and separating walls were measured, with surface densities (including the plaster layer) from 75 to 250 kg/m^2.

A comparison between the measured values and those given in the EN12354 is discussed below.

Cross junctions:

Figure 1 shows the flanking-flanking K_{ij} for a lightweight concrete brick wall joined to a beam and concrete block floor (a) and a hollow ceramic brick wall joined to a similar floor (b). In wall (a) the junction is parallel to the beam direction, while in wall (b) the junction is perpendicular to the beams. It is noticeable that, although in both situations the measured K_{ij} is quite invariant with the frequency (at least in the low-medium frequency range), the measured values are about 5-6 dB higher than those given in the EN12354 (same value in both measurement, as the surface density was the same for both walls). This could be due to the hollow construction of the floor, which leads to a higher attenuation at the joint. The same behaviour has been measured for other combinations of floor and walls. Unfortunately, as the floor ceiling was covered with a plaster layer, it is impossible to assess if the wall was standing over the concrete beam or over the blocks when the wall was parallel to the junction. More work will be necessary to evaluate the effect of the beam position in parallel junctions.
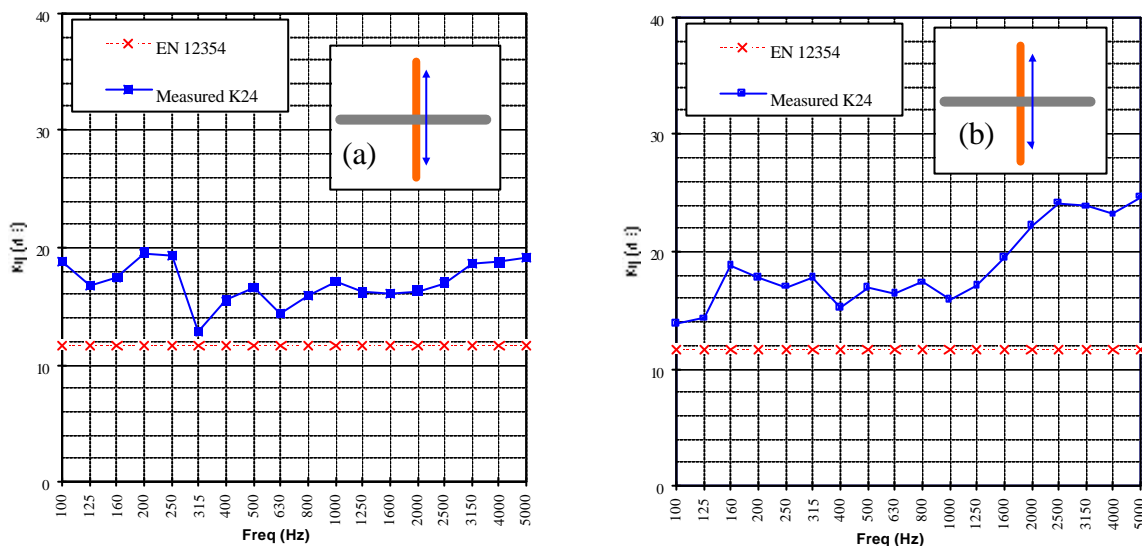

Figure 1: wall to wall transmission (+junction). (a) Junction parallel to the beam direction. (b) Junction perpendicular to the beam direction

Figure 2 show the same situations, but concerning the floor to floor flanking transmission. In this situation, important differences can be observed between both junctions. The measured Kij when the junction is perpendicular to the beam (b) presents the same behaviour than those measured for the wall to wall transmission: non-frequency dependence in low and medium freq. range and values about 6dB higher than EN12354. However, the situation with the beams parallel to the junctions (a) shows a K_{ij} decreasing with the frequency, thought the average value is quite similar to the value given in the standard for low frequencies. Similar behaviours have been observed before [9] and could be due to an energy attenuation of the beam and block floors in the beam-perpendicular direction [10].
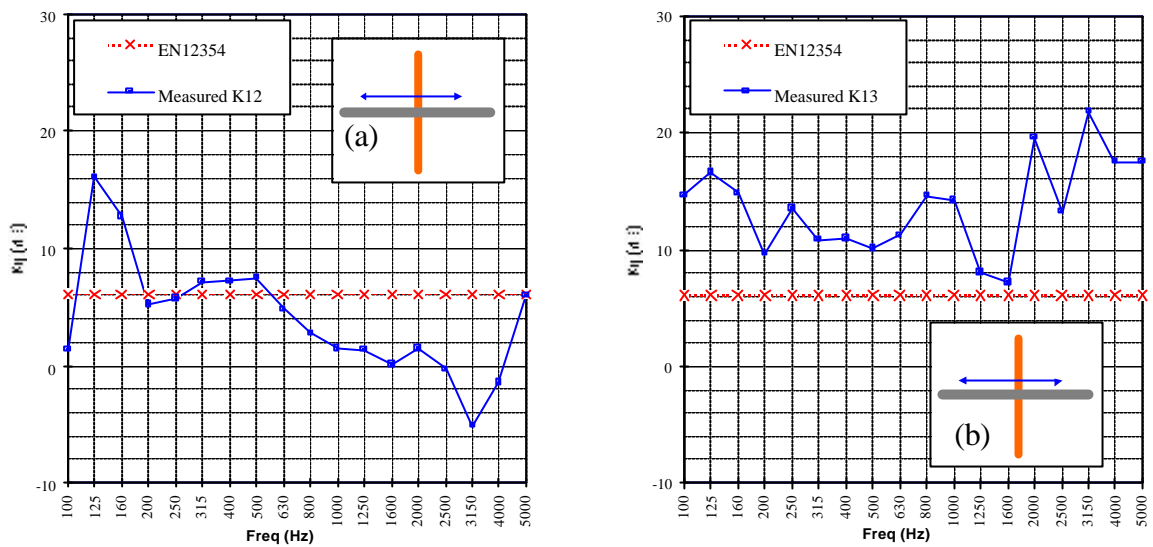
Figure 2: floor to floor transmission (+junction). (a) Junction parallel to the beam direction. (b) Junction perpendicular to the beam direction

Concerning the angle transmission throughout a cross-junction, *figure 3* shows two different situations: (a) hollow ceramic brick wall standing over a beam and block floor (rigidly joined) and a similar situation (b) but with a resilient layer between the wall and the floor (elastic junction).

For the rigid junction (a), once again a systematic deviation between the measured and calculated values has been found, although in this situation the difference is about 2-3 dB, probably due also to the hollow construction.

For the elastic junction (b), very important differences with the calculated values are found (deviations from 6 to more than 10 dB in the low frequency range). These differences at low frequencies can affect decisively the global estimate of the sound insulation, leading to important errors. Anyway these deviations could be due to an inappropriate characterisation of the elastic layer, so here is also another need of researching work.

Walls and beams where parallel in both situations. Measurements carried out in similar conditions but with perpendicular beams and walls showed the same behaviour.
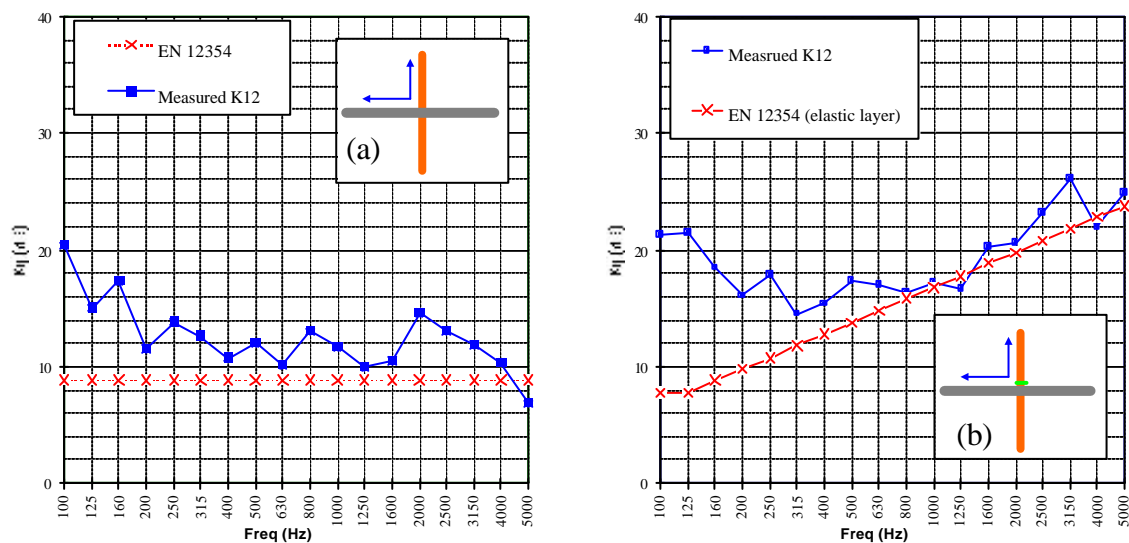

Figure 3: angle transmission (+junction). (a) Rigid junction. (b) Elastic junction

Tee junction:

Next figure shows the behaviour of tee junctions involving hollow ceramic bricks and beam and block floors (façade junction). In this situation the wall to wall flanking path is not affected by the beam direction, as façade walls stand always over a solid concrete beam. As can be observed in *figure 5* (a), the wall to wall attenuation across a T junction differs substantially from the EN12354 calculated data, with differences up to 10dB in low frequencies and even more when increasing frequency.

Angle path can be affected by the beam direction. Presented data belongs to a beam direction perpendicular to the façade, and shows (once again) a deviation of about 4dB compared with the EN12354 values. Measurements carried out when the beam direction was parallel to the façade showed slightly smaller differences, about 2-3 dB. In average, the deviations were very similar to those found for the angle path in + junctions.
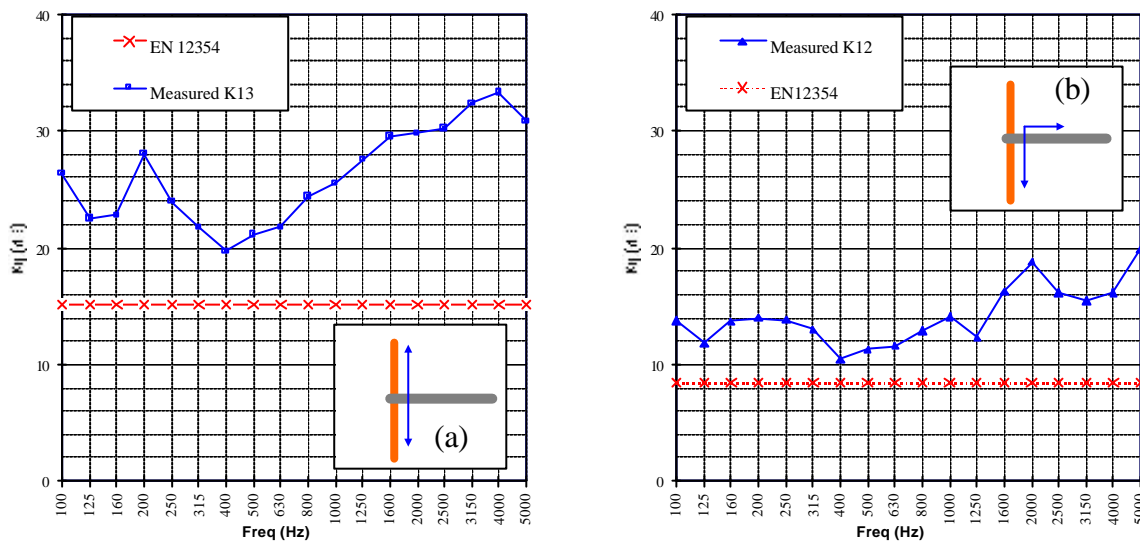

Figure 4: T junction: (a) wall to wall transmission. (b) angle transmission

CONCLUSIONS

- Significant differences have been found between measured and calculated values in almost all the different junction kinds. This is probably due to the hollow nature of the Spanish constructions.

- The differences are especially important with the transmission involving beam and block floors. Attenuation along the floor could be of great importance.

- Using the European Standard EN 12354 without any modification with usual Spanish constructions may lead to important mistakes when predicting the noise transmission paths and the global behaviour of a building.

- There is a need to do more research in this field and to validate the accuracy of the CEN models to be able to supply effective tools to the architects and building designers.

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