Applied Acoustics 71 (2010) 523–530

Contents lists available at ScienceDirect

Applied Acoustics

journal homepage: www.elsevier.com/locate/apacoust

The prediction of the vibration reduction index K_{ij} for brick and concrete rigid junctions

Alessandro Schiavi [a,*], Arianna Astolfi [b,*]

[a] Istituto Nazionale di Ricerca Metrologica, Strada delle Cacce, 91, 10135 Torino, Italy
[b] Politecnico di Torino, Department of Energetics, C.so Duca degli Abruzzi, 24, 10129 Torino, Italy

ARTICLE INFO

Article history:
Received 6 March 2009
Received in revised form 18 December 2009
Accepted 4 January 2010
Available online 27 January 2010

Keywords:
Vibration reduction index
Rigid junction
Empirical model
In-field acoustical measurements
Sound insulation

ABSTRACT

The vibration reduction index, K_{ij}, is related to the transmission of the vibrational power over a junction between structural elements. Two empirical models are proposed to evaluate K_{ij}, on the basis of statistical evaluations of numerous in-field tests carried out on rigid junctions between floors made by concrete beams and ribbed slab with brick blocks and brickwork walls, a type of junction that is frequently encountered in Southern European and Mediterranean buildings. These models can be applied in order to calculate the sound insulation properties, such as the normalized impact sound pressure level, L'_n, and the apparent sound reduction index, R', of walls and floors in buildings.

The first model allows the single number value of the vibration sound reduction index of a junction to be calculated, on the basis of the real properties of the materials that constitute the junction. A new quantity, the "essential" mass per unit area, was introduced to implement the model.

The second model provides an estimation of the K_{ij} as a function of frequency, subdivided between BB-junction, as ribbed slab with brick blocks floor–brick wall, and CB-junction, i.e. concrete beam–brick wall.

1. Introduction

In recent years increased interest in the possibility of determining the acoustical performances of buildings using calculation model based on properties and characteristics of the materials and components, has been observed.

The main calculation models for airborne and structural acoustical insulation have been gathered together in the EN 12354 Standards series. More recently, very sophisticated *software*, that implement the prediction models of the above mentioned Standards, has been developed.

Nevertheless the ease in using the prediction models should always be subordinate to the employment of very accurate input experimental data. In the case of not accurate input data, the models can supply results that are far from the real acoustic performances which should successively be checked through in situ experimental tests.

The vibration reduction index K_{ij}, specified in Standard EN 12354-1 [1] and EN 12354-2 [2], is defined as a quantity that is related to the vibrational power transmission over a junction between structural elements, normalized to make it an invariant quantity with respect to the length of the junction and to the mechanical properties of the two elements involved. The vibration reduction index shows the aptitude of a structural discontinuity to mitigate the vibration velocity level, and hence the sound pressure level, between an element under stress (due to impact or pressure wave) and one closely connected to it, such as a side wall or a floor.

The knowledge of the vibration reduction index K_{ij}, is particularly important because it allows the in situ quantities Apparent sound reduction index, R'_w, and Normalized impact sound pressure level, L'_n, to be accurately determined if the laboratory data of R and L_n of the used partitions are available [3]. It should be emphasized, however, that the vibration reduction index measurement methods, mentioned in Standard EN ISO 10848-1 [4], should only be carried out in controlled laboratory conditions [5], although, in Annex E of standard EN 12354-1 and in [6], it is indicated that these methods are "probably" also feasible in-field situations.

Measurements of the vibration reduction index K_{ij} of various types of junctions between a floor and vertical partitions have been carried out in some residential building sites. The building typology is beam and block floors and brickwork walls, typical of the Southern Europe buildings. The measured data have been compared with the theoretical/empirical prediction models proposed in Standard EN 12354-1. In literature, other authors [e.g. 7–9] have observed differences between estimated data (using EN 12354 series Standards or SEA model) and measured data of the vibration reduction index K_{ij} with hollow elements and masonry partitions. In this work some specific constructive properties that influence

* Corresponding authors.
E-mail addresses: a.schiavi@inrim.it (A. Schiavi), arianna.astolfi@polito.it (A. Astolfi).

0003-682X/$ - see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.apacoust.2010.01.001

the predictions of acoustic behaviour have emerged from the data analysis and two new prediction models have been proposed for this building typology.

The first model allows the vibration reduction index to be calculated on the basis of the material of the partition effectively involved in the junction: a new quantity, called "essential" mass per unit area, is introduced. The second model is derived from statistical evaluations of K_{ij} measured values in the 100–5000 Hz frequency range.

2. Type of junctions

A sample of 32 horizontal junctions between floors and vertical walls were analyzed. These junctions are subdivided into 27 cross-junctions and 5 T-junctions. The building typologies are those of traditional multistory residential buildings with concrete structure, floors made by concrete beams and ribbed slab with brick blocks and brickwork walls. The junctions are relative to eight couples of overlapped rooms with rectangular floor areas varying between 10 and 15 m^2. The rooms of each couple are identical in shape and dimensions and have at least one external wall with a window or a French window and a balcony.

The junctions are further subdivided according to the material of the partitions effectively involved in the junctions: i.e. two series of junctions, ribbed slab with brick blocks floor–brick wall (BB), and concrete beam–brick wall (CB), are considered. The typologies of the cross and the T-junctions of the BB and CB series pertaining to the present study are reported in Fig. 1, where the ribbed slab with brick blocks floors and the brick walls are marked with "B" and the concrete beams are marked with "C".

The subdivision of the junctions into two series, BB and CB, also could refers to junctions between vertical walls: a BB junction is between two brick walls, while a CB junction is when a concrete pillar is interposed in the corner between two brick walls. Some examples of BB and CB junctions are reported in Figs. 2 and 3, where the structure made in brick (or with prevalence of brick) is marked with "B" and the structure in concrete is marked with "C".

The specific characteristics of each analyzed junction, such as the geometry, typology, material and masses per unit area of the jointed elements and the relative mass ratio, are reported in Table 1. Regardless of the typology of cross and "T" junctions of the BB and CB series, the masses per unit area of the bare floors are obtained as the weighted average of the full surface, considering the concrete beams and the ribbed slab with brick blocks areas. In the case of vertical walls, with an air–gap, only the masses per unit area of the internal partition are considered. The masses per unit area were determined on the basis of laboratory measurements of the weight of the single brick elements.

3. The measurement methodology

3.1. The fundamental quantities determinable experimentally

The vibration reduction index K_{ij}, expressed in dB, depends on various quantities, which can be determined experimentally:

$$K_{ij} = \frac{D_{v,ij} + D_{v,ji}}{2} + 10\lg\frac{l_{ij}}{\sqrt{a_i a_j}}\ \text{dB}, \quad (1)$$

where $D_{v,ij}$ is the junction velocity level difference between elements i and j, when element i is excited [dB]; $D_{v,ji}$ is the junction velocity level difference between elements j and i, when element j is excited [dB]; l_{ij} is the length of the junction between elements i and j [m]; a_i is the equivalent absorption length of element i [m]; and a_j is the equivalent absorption length of element j [m].

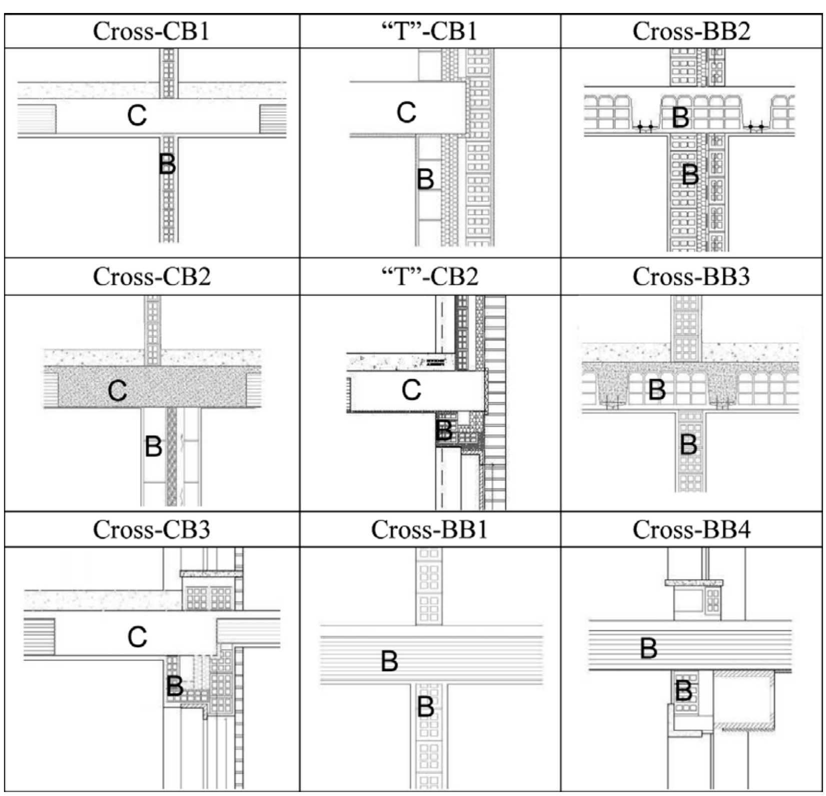

Fig. 1. Typologies of cross and T-junctions of the CB and BB series. The ribbed slab with brick blocks floors and the brick walls are marked with "B", the concrete beams are marked with "C".