European Prediction Models for Building Acoustics

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Abstract: To provide a link between the acoustic performance of building products and elements - as measured by standardised laboratory measurement methods - and the acoustic performance in the realised buildings, CEN has started to create prediction models for several acoustic aspects in buildings. The chosen approach for the models on airborne and impact sound transmission applies separate independent transmission paths between rooms. For these models a new quantity has been introduced to characterise the structure borne sound transmission at junctions of building elements. Further work is focusing on finalising the parts on facade sound transmission from outside to inside and vice-versa, describing measurement methods to determine the junction quantity and verifying the accuracy of the models.

INTRODUCTION

About nine years ago work has started in the European standardisation organisation (CEN) to create prediction models for several acoustic aspects in buildings: airborne sound transmission, impact sound transmission, facade sound transmission, facade sound radiation, absorption in enclosed spaces and the noise caused by technical equipment. So far the prediction models for the first four aspects are (almost) finished [1, 2, 3, 4]. The work on the part concerning equipment noise has yet to start, handicapped as it is by a lack of available knowledge in this area. Further work is focusing on the description of measurement methods to determine the necessary input data for the models [5] and on verification of the models in order to indicate more precisely their reliability in predicting the acoustic performance of buildings.

SOUND TRANSMISSION BETWEEN ROOMS

The chosen approach for the models on airborne and impact sound transmission applies separate independent transmission paths between rooms, which can be shown to be a first-order estimation of a SEA approach [6]. The sound transmission by each path can be predicted by considering the transmission from an element in the source room to an element in the receiving room. The total transmission follows from the summation over all transmission paths or at least summation over the most important ones. The implemented version is restricted to the most important transmission paths: the direct transmission and three flanking paths for each flanking element.

The airborne and impact sound insulation between rooms can be predicted from the acoustic performance of the building elements, like walls and floors, and the acoustic performance of the junctions between these elements [1,2]. To express the acoustic performance of junctions a new quantity was introduced, the vibration reduction index $K_{ij}$ [7, 8]. Measurement methods for this quantity are under development [5], while for most common types of junctions estimations can be based on the results of earlier research work.

FIGURE 1. Illustration of transmission paths between rooms
The flanking sound reduction index $R_{ij}$ for airborne sound transmission via one path from element $i$ to element $j$ can be written as [1]:

$$R_{ij} = \frac{R_i + R_j}{2} + R_{v,ij} + 10\log_{10} \frac{S_i}{S_j} = \frac{R_{lab,i} + R_{lab,j}}{2} + K_{ij} + 10\log_{10} \frac{S_i}{l_{ij}}$$

(1)

and a similar relation exists for flanking impact sound [2]:

$$L_{n,ij} = L_{n,i} + \frac{R_i - R_j}{2} - D_{v,ij} - 10\log_{10} \left( \frac{S_j}{S_i} \right) = L_{n,lab,i} + \frac{R_{lab,i} - R_{lab,j}}{2} - K_{ij} - 10\log_{10} \frac{S_i}{l_{ij}}$$

(2)

$S_i$, $S_j$, and $S_k$ are the areas of the elements $i$, $j$ and the separating element. $R$ is the sound reduction index of the elements involved and $L_n$ the impact sound pressure level of the element which is exited by the tapping machine. These quantities do depend on the damping of the vibrations in the elements in the considered situation, which can be deduced from the calculated structural reverberation time $T_r$.

$$R = R_{lab} - 10\log_{10} \frac{T_r}{T_{r,lab}} ; \quad L_n = L_{n,lab} + 10\log_{10} \frac{T_i}{T_{i,lab}}$$

(3)

The direction-averaged level difference over the junction, $D_{v,ij}$, is to be deduced from the vibration reduction index $K_{ij}$ taking into account the damping of the vibrations in the elements by the equivalent absorption length $a$:

$$D_{v,ij} = K_{ij} - 10\log_{10} \frac{l}{a_i a_j}$$

$$a = \frac{2,2\pi^2 S}{c_i T_i} \sqrt{\frac{f_{ref}}{f}} \text{ with } f_{ref} = 1000 \text{ Hz}$$

(4)

As a first approximation, however, the damping can be assumed to be independent of the situation, hence the structural reverberation time in (3) can be taken as equal to the one in the standardised laboratory situation and the absorption length in (4) can be taken as a constant being numerically equal to the element area $S$. This leads to the indicated approximations in (1) and (2).

The vibration reduction index $K_{ij}$ of a junction is defined by the reversed eq. (4), and is in definition and meaning equivalent to the sound reduction index $R$ of an element. It can be calculated theoretically or determined from measurements; a standardised measurement method is being developed [5]. For common types of mainly homogeneous elements the standard [1] contains data, based on the mass of the elements, the type of elements and the type of junction. For double leaf elements an approach to estimate this quantity has been presented in [8].

The prediction of the effect of wall linings and floating floors can normally be included by simply adding the improvements $\Delta R$ and $\Delta L_n$ to the appropriate transmission paths.

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REFERENCES