A SUMMARY OF THE CEN DRAFT BUILDING ACOUSTICS MODEL APPLIED TO A LIGHTWEIGHT DOUBLE LEAF CONSTRUCTION

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Introduction

This paper is a summary of an existing paper1 illustrating how the draft CEN Building acoustics model, Estimation of acoustic performance of buildings from the performance of products; Part 1: Airborne sound isolation between rooms2, might be applied to the lightweight multi-leaf constructions of North America.

The CEN model, originating in Europe, was designed to be applied to buildings formed from heavy monolithic concrete or masonry elements. It allowed for the description of transmission via flanking paths in terms of the transmission loss of the individual building elements (either measured or predicted) and a simple expression for the joint. The CEN model defines the flanking sound reduction for path ij as R_{ij} ,

$$R_{ij} = \frac{(R_i + R_j)}{2} + K_{ij,situ} + 10\log\frac{S_o}{L_{ij}L_o} \qquad [1]$$

where

$$K_{ij,situ} = \frac{D_{ij} + D_{ji}}{2} + 10\log\frac{L_{ij}L_o}{\sqrt{S_iS_j}} \qquad [2]$$

where R_i and R_j are the resonant transmission losses of building element i in the source room and element j in the receive room. K_{ij} is the joint factor, D_{ij} and D_{ji} are the velocity level differences, S_o is the area of the nominally separating element, S_i and S_j are surface areas of the elements in the flanking path, L_{ij} is length of the joint, and L_o is 1 metre.

Application to a flanking path

In this paper the CEN model will be applied to the lightweight multi-leaf construction shown in Figure 1. The dominant flanking path involves propagation from the source room 'A' to the receive room 'B' entirely via the side or flanking wall. Since this is a double wood stud wall there are two possible paths. Using the CEN nomenclature for flanking paths, there are Ff and F'f'. By inspection the path F'f' is considerably more direct than Ff, especially if the path of energy transport is the gypsum board cladding. Equation [1] would indicate that an idea of the relative importance can be obtained by considering the sound reduction of the elements F and F' which are shown in Figure 2. Clearly the path Ff is of negligible importance compared to F'f'. There is also a possible path involving the cavity, but since the cavity was completely full of absorption offering no direct line-of-sight, this path is not considered important.

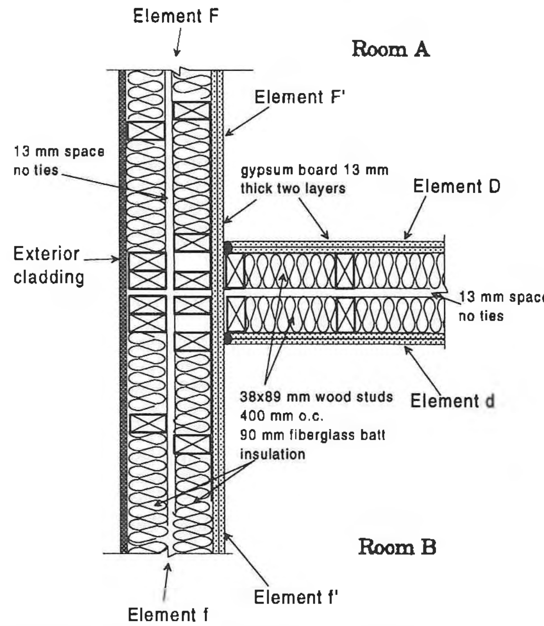

Figure 1: Plan section through the party and flanking walls.

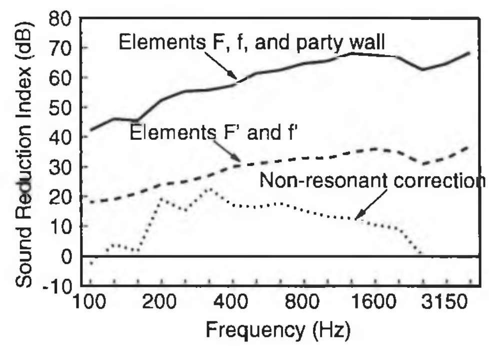

Figure 2: Measured sound reductions (using ISO 140) for the elements and the non-resonant correction for F' and f'.

Joint factor $K_{F'f'}$ for path F'f'

The effect of the 'tee' joint between the flanking and party wall must be considered. In order to use the joint equations given in Annex E[2] one must decide the type joint model that best suits the case at hand and the effective masses of the elements. If path F'f' is the dominant flanking path then, by examining Figure 1, the following can be written,

$$m_d = 2m_{F'} = 2m_{f'} \qquad [3]$$

where m is the surface density of the element indicated by the subscript. Figure 3 shows the CEN prediction for the joint factor K_{ij} for the two types of joints and the joint factor calculated from measured velocity level differences using equation [2]. The CEN joint factor for the intersection of two double leaf walls (equation E7[2] agrees well with the measured if the mass of the flanking wall is taken to be half that of the party wall (equation [3]). Treating the joint as the intersection of a double leaf wall and a homogeneous wall (equation E6[2]) underestimates the joint factor.

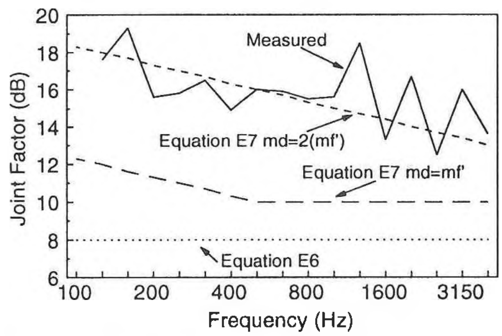

Figure 3: Measured and predicted joint factor K_{ij} using Annex E[1] and relationship given in Equation [3].

Sound reduction for the path F'f'

Having obtained a suitable model for the joint, the sound reduction for the flanking path F'f' can be determined using equation [1] and the measured sound reduction shown in Figure 2. Figure 4 shows the measured, SRI_{Meas}, and predicted sound reduction, SRI_{CEN1}, for the flanking path F'f'. The figure shows that the CEN model grossly underestimated the SRI for the path F'f' for frequencies less than the critical frequency (f_c=2900 Hz). The underestimation occurs because the SRI of the standard test methods is the sum of two transmission types: resonant and non-resonant. (Greatly simplified, resonant transmission dominates for frequencies above the critical frequency while non-resonant transmission dominates below the critical frequency.) Since, flanking transmission occurs through resonant transmission, the non-resonant component present in the standard test method SRI data represents a fictitious source of energy for frequencies below the critical frequency.

Figure 4 shows, that for lightweight constructions where the critical frequency is likely to occur in the middle of the building acoustics range, it is necessary to remove the non-resonant component from the input SRI data. Currently, there is no analytic method for obtaining the resonant transmission of a lightweight multiple leaf assembly. The closest might be SEA.

Determining the sound reduction for path F'f'

Providing details on obtaining the resonant component from measured data is beyond the scope of this summary paper and the reader is referred to a previous publication[1]. Figure 2 shows the non-resonant correction that must be added to the sound reduction data obtained from standard test methods for the elements F' and f' in order to give an estimate of the resonant SRI. The computed resonant SRI, the calculated joint factor K_{ij}, and equation [1] were used to estimate the SRI for the path F'f'. The results are shown as labeled as SRI_{CEN2} in Figure 4. When a reasonable estimate of the resonant SRI is used, the predictions are in quite good agreement with measured results. Differences between measured and predicted are likely due to experimental uncertainties and assumptions made in determining the resonant correction.

Net sound reduction

The net sound reduction between rooms A and B is given by summing the transmission coefficients of the direct path and all the flanking paths. For this case the paths are: Dd, F'f', F'd, and Df'. Figure 5 shows the two predictions, SRI_{CEN1} and SRI_{CEN2}. The measured data SRI_{meas} is included for comparison. The CEN prediction that made use of the non-resonant correction, SRI_{CEN2}, is in good agreement with measured results throughout most of the frequency range. However, the prediction that did not make use of the non-resonant correction, SRI_{CEN1}, consistently under estimates the net SRI for frequencies less than the critical frequency.

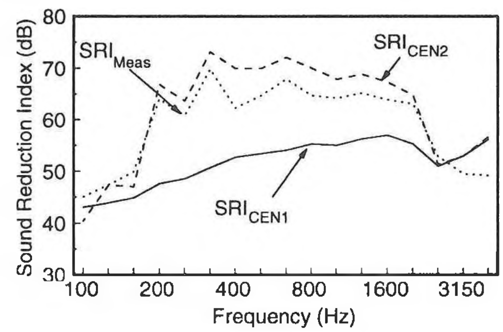

Figure 4: SRI for path F'f'. Measured: SRI_{Meas}, CEN prediction using standard test method SRI data: SRI_{CEN1}, CEN prediction using computed resonant SRI data: SR_{ICEN2}.

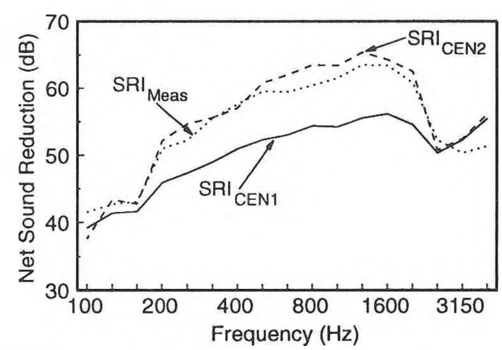

Figure 5: Net SRI between Rooms A and B. Measured: SRI_{Meas}, CEN prediction using standard test method SRI data: SRI_{CEN1}, CEN prediction using computed resonant SRI data: SRI_{CEN2}.

Conclusions

The accuracy of the CEN model to predict either the flanking or the net sound reduction depends on the ability of the user to identify the dominant flanking paths, select the best joint model, and obtain a reasonable estimate of the resonant sound reduction for the flanking elements.

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[1] T.R.T. Nightingale, "Application of the CEN draft building acoustics model to a lightweight double leaf construction," accepted Applied Acoustics.

[2] CEN/TC126/WG2 N96, "Estimation of acoustic performance of buildings from the performance of products; Part 1: Airborne sound isolation between rooms," Sixth working draft, 1993.