# Calculating facade sound insulation for different incident spectra:

## a new method to determine the optimum single number rating

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## Deduction:

The calculation of the correction term $C_j$ is:

$$C_j = X_{Aj} - X_w$$

Where

$j$ is the subscript for the sound spectra Nos. 1 and 2. Nos.1 is used to calculate $C$ correction; Nos.2 is used to calculate *Ctr*. Here is $C_{tr}$ used as an example i.e. $j$=2 is assumed.

$X_w$ is the single number quantity, such as $R_w$, $D_{ne,w}$.

$X_{Aj}$ is calculated by the following equation:

$$X_{Aj} = -10\lg\sum 10^{(L_{ij}-X_i)/10} \text{ dB}$$

Here the sound reduction index $R_i$ and $C_{tr}$ calculation are used as example. The $j$ in the above equation can be removed and $X_i = R_i$ is assumed. Therefore, we get the following equation:

$$X_A = -10\lg\sum 10^{(L_i-R_i)/10} \text{ dB}$$

Where $L_i$ is the standard level at frequency $i$ used to calculate $C$ and $C_{tr}$. It is noted that $L_i$ are values smaller than 0.

Given that the incident sound $L_{1,i}$ reduces $\Delta_i$ to $L_i$:

$$L_i = L_{1,i} - \Delta_i$$

The above equation changes to:

$$X_A = -10\lg\sum 10^{(L_{1,i}-\Delta_i-R_i)/10}$$

Equation we used for the glazing calculation: for frequency *i*

$$L_{2,i} = L_{1,i} - R_i + 10\log T_0 + 10\log(S/V) + 11$$

therefore:

$$L_{1,i} - R_i = L_{2,i} - [10\log T_0 + 10\log(S/V) + 11]$$

Substitute $L_{1,i} - R_i$ into $X_A$:

$$X_A = -10\lg\sum 10^{\{L_{2,i} - [10\log T_0 + 10\log(S/V) + 11] - \Delta_i\}/10}$$

Put the constant parts out:

$$X_A = 10\log T_0 + 10\log(S/V) + 11 - 10\lg\sum 10^{(L_{2,i} - \Delta_i)/10}$$

As $C_{tr} = X_A - R_w$:

$$R_w + C_{tr} = 10\log T_0 + 10\log(S/V) + 11 - 10\lg\sum 10^{(L_{2,i} - \Delta_i)/10}$$

Similarly,

$$D_{ne,W} + C_{tr} = 10\log T_0 + 10\log(n/V) + 21 - 10\lg\sum 10^{(L_{2,i} - \Delta_i)/10}$$

# Discussion:

## Ideal spectrum

if the incident sound spectrum equals the traffic spectrum as mentioned in ISO 717, then $\Delta_i$ will be the same, $\Delta$ , in every octave bands, then the above equation becomes:

$$R_w + C_{tr} = 10\log T_0 + 10\log(S/V) + 11 + \Delta - 10\lg\sum 10^{L_{2,i}/10}$$

the sum $10\lg\sum 10^{L_{2,i}/10}$ is the internal noise level design target $L_2$. Substitute $L_i = L_{1,i} - \Delta_i$ into the above equation:

$$R_w + C_{tr} = 10\log T_0 + 10\log(S/V) + 11 + L_{1,i} - L_i - L_2$$

## General wide band spectrum

if the incident sound spectrum does not identically equal to the road traffic spectrum, $\Delta_i$ varies in different bands. It cannot be taken out of the sum.

If the design target is NR curve, then the $L_{2,i}$ at different octave band centre frequency is specified. The required Rw+Ctr can be calculated accordingly, as $L_{2,i}$ and $\Delta_i$ are known parameters.

If the design target is a single number, such as BS 8233 internal noise levels, the result of the sum $\sum 10^{(L_{2,i}-\Delta_i)/10}$ is dominated by the maximum of $L_{2,i}$ and minimum of $\Delta_i$. In this case, the calculation principle is that keeping $L_{2,i}-\Delta_i$ as the same value.

First, the $L_{2,i}$ at different frequency is normalised by the shape of $\Delta_i$

then, apply the blue equation to calculate the required Rw+Ctr

## Advantages

As shown in the blue equation, the incident sound spectrum is reflected in the Rw+Ctr value. Our glazing calculation does not need to be based on the manufacturer's test data sheet.

## Disadvantages

For some sources with peaks, this method overestimates the glazing spec. Details are still not thoroughly studied.

Abstract for IOA conference:

# Title

Calculating facade sound insulation for different incident spectra: a new method to determine the optimum single number rating

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# Abstract

The requirement for facade sound insulation to control external noise ingress is often based on measured noise levels. If the most significant noise source is general road traffic travelling between 30 - 50 kmh and there are no intervening features that may cause a change of frequency content, such as barriers, then the source spectrum is likely to be well represented by the idealised spectrum in BS EN 1793-3. In this case, facade sound insulation calculations can accurately be based on the A-weighted source noise level, and facade sound insulation based on the parameter Rw + Ctr described in ISO 717-1. However, if the source noise is not well represented by this reference spectrum, using single figure calculations adds additional uncertainty to the analysis. The level of additional uncertainty can be difficult to quantify.

This paper describes a new method to determine the lowest single figure performance value for facade elements that will achieve the internal noise level limits for the incident spectrum. The single figure values are determined in terms of either $R_w + C_{tr}$, $R_w + C$, $D_{n,e,w} + C_{tr}$ or $D_{n,e,w} + C$ as most appropriate for each element and incident spectrum. This method reduces over-specification of facade element performance; this is valuable for glazing, for example, which is typically the most expensive part of the building per square metre.