Technical Note No 38

Acoustic performance of windows

This Technical Note is one of four on building envelope acoustics. The series comprises:

TN 37 Introduction to building envelope acoustics
TN 38 Acoustic performance of windows
TN 39 Sound transmission through building envelopes
TN40 Sound environment behind a building envelope

Introduction

This Technical Note deals with the acoustic performance of windows in heavyweight walls. For this type of construction the windows are the dominant paths for sound transmission from outside the building to inside.

This Note deals with the sound reduction of different forms of glazing, performance of the whole range of glazing from single glazing, through double glazing to double windows. The effects of window ventilators are also considered.

For walls of light weight construction and those containing larger areas of glazing TN 39 'Sound transmission through building envelopes' applies.

General principles

In general the achieved noise reduction to external noise is controlled by the weakest component in the envelope. If the sound insulation of the solid or opaque wall of a facade is at least 15 dB higher than that of the glazing, noise transfer through the wall can be ignored and transmission through the windows, and other openings, alone may be considered. This is most common as typical single brick walls have an R_m of 45 dB and cavity brick walls of better than 50 dB.

Whilst the window will be the weakest component in a heavy weight wall, the presence of openings in or around a window may completely dominate its performance.

Glazing performance

Data on the acoustic performance of glazing is widely available but needs to be used with caution. The acoustic data in the public domain tends to relate to the performance of a standard pane size of 1480mm x 1230mm fitted and sealed directly to the acoustic test chamber. In practice, if a window is of similar dimensions the framing normally has only a nominal effect on the acoustic performance if all joints are tight fitting. However, if there is a marked increase in the pane size or rigidity of the frame, a significant worsening of the acoustic performance is likely. Thus specifiers and architects are cautioned against taking acoustic data for standard pane sizes and applying them to large elements of a building's facade.

Single panes

The Sound Reduction Index for a pane of monolithic glass depends on the glass thickness, Values for a pane of monolithic glass 1480mm x 1230mm are given in Table 1 but these exclude any framing effects. This table lists sound reduction according to three frequency weighting schemes: mean value, R_m, the weighted value, R_w, and the road traffic weighted value, R_{Tra} (This is explained in more detail in Technical Note TN 37).

Glass type	Sound Reduction (dB)		
	R_m	R_W	R_{TRA}
4mm	26	29	27
6mm	28	31	28
10mm	31	33	30
19mm	36	38	34
6.4mm PVB	29	32	28

Table 1. Sound reduction values for single glazing of 1480mm x 1230mm.

Sound insulation is generally dominated by the Mass Law, which describes how insulation usually increases with the mass per unit area of partitions. When controlled by mass, the insulation also increases with frequency. Figure 1 shows the measured sound insulation of some single glazing. At low frequencies the behaviour is according to the Mass Law, but at high frequencies sound insulation is compromised by coincidence.

The **coincidence effect** occurs when the wavelength of the incident acoustic wave is similar to the wavelength of free bending waves in the panel. The lowest frequency at which this occurs is known as the **critical frequency**. As shown in Figure 1, there is a marked drop in insulation around the critical frequency (2kHz for 6mm glass). The critical frequency is lower for thicker glass.

The coincidence effect can be diminished by using laminated glass with a polyvinylbutyral (PVB) interlayer. With a special acoustic interlayer the coincidence effect may be further reduced; this is used for high acoustic performance glazing.

Sealed double glazing units

Air cavities between glass panes will normally provide superior sound insulation to a single glass pane of comparable glass size and thickness. However, the acoustic effect will depend upon the width of the air cavity. An unduly narrow cavity may lead to a reduction in acoustic performance; use of the optimum cavity widths for good thermal double glazing will usually provide a worthwhile acoustic benefit; however, the optimum cavity widths for acoustic performance are in the order of 100mm to 200mm. Thus most higher performance sealed double glazed units rely on higher mass and in some cases on the use of carefully selected laminated glass to enhance the acoustic performance whilst adhering to the cavity widths required to optimise the thermal performance.

Because the critical frequency depends on glass thickness there are advantages for double glazing in using panes of different thicknesses. The frequency with poor performance of one pane is covered by better performance of the other pane.

Table 2 shows some sound reduction values for a standard pane size of 1480mm x 1230mm. A full set of sound reduction indices is given in Table 4. As noted earlier, care is required when applying the data to take in to account pane size and framing effects.

Glazing unit	Sound Reduction (dB)		
	R_m	R_W	R_{TRA}
4-12-4	27	29	25
6-12-6	28	31	26
6-12-6.4PVB	30	33	27
10-12-4	33	35	29
10-12-6	33	35	32
10-12-6.4 PVB	35	38	34

Table 2. Sound reduction values for sealed double glazing units of 1480mm x 1230mm.

Effect of gas filling

Insulating units may have the cavity filled with argon gas to improve thermal performance. Such units exhibit exactly the same acoustic performances as standard air-filled units of the same glass combination.

For applications where middle frequency acoustic performance is the most critical (e.g. speech), units may be filled with sulphur hexafluoride (SF_6) gas mixtures. This slightly elevates the corresponding R_w index. Simultaneously, the use of SF_6 introduces a significant resonance at 200-250 Hz and, for noises dominated by low frequency components (road traffic, railways, aircraft on take-off, etc.), this is detrimental. Such units generally offer lower effective sound insulation in these situations than standard air-filled units.

Window size

In most cases, the effective performance of a facade is determined by the glazing. Clearly, the bigger the window, the more noise energy can be admitted (or escape) but, owing to the way in which sound levels are additive, this is a relatively small effect. It can be assumed, without serious error, that doubling or halving the window area produces an aggregate corresponding noise level change of 3 dB or – 3 dB respectively, which can only just be noticed.

The standard window opening for acoustic testing to European standards is 1.23 x 1.48m.

The size of window determines the resonant frequencies of the glazing and the frame. A doubling of the window area changes the frequency by no more than a factor of two for a rigid frame. As most sounds comprise a comparatively wide range of frequencies this has little effect on overall sound transmission for simple windows. However, where the acoustic performance is important, large pane sizes are specified and no representative acoustic lab test data is available, it may be advisable to undertake an acoustic laboratory test prior to the glass configurations being finalised. On major projects, confidence is now sometimes gained by commissioning such a test of the proposed glass configurations. The testing is undertaken within weeks of the award of the curtain walling sub-contract using glass at the intended pane size and similar (in terms of dimensions and mass per metre run) off-the shelf profiles. This approach reduces the risk of a non-compliant installation on the one hand or of over-specification of the glass configurations on the other.

Effect of window frame

Laboratory and field measurements have shown that, up to a glazing R_w of about 37 dB, the window frame is not often a serious leak path and the sound insulation of the glazing can be adopted as being representative of the window as a whole. Beyond R_w = 37 dB, it is prudent to evaluate the acoustic performance of the proposed framing; more substantial frame sections may be necessary to be compatible with very high performance glazing.

Notwithstanding the above, a poor acoustic performance will arise if opening or sliding joints are not tight fitting; or if there are significant air paths via trickle vents, drainage slots, handles and hinges, or reveals. Sliding sashes may be particularly difficult to seal.

Double windows

Double windows or secondary sashes comprise a primary window and a secondary glazing with a wide air gap between the two. This air gap reduces any acoustic coupling between the separate panes of glass or insulated glazing units.

Where high sound insulation of windows is required, airspace widths of greater than 100mm may be used. The same principles apply here as for sealed double glazing units, that the use of dissimilar glass thicknesses has acoustic advantages. A combination of 6 and 10mm panes would be typical.

Lining the reveals with acoustic absorbent material (fibreboard) is beneficial because it can reduce reverberation in the cavity, giving an overall improvement of 2-6 dB, according to its area and absorption characteristics.

Increasing the width of cavity produces an increased sound insulation, but not pro rata. Beyond a spacing of about 200mm it is normally uneconomical to install such windows because the incremental acoustic improvement is small.

Window type	Sound Reduction (dB)		
	R_m	R_W	R_{TRA}
6-100-4	44	46	37
6-150-4	44	47	39
10-200-6	47	49	50

Table 3. Sound reduction values for double windows of 1480mm x 1230mm.

Window ventilation

Any ventilation opening provided within a window will reduce its sound insulation. Open sashes will have the greatest effect but even openings as small as 1 percent of the window area will have a significant effect unless the air path is suitably treated.

A window with an opening of 10 percent or greater will have sound reduction index of less than 10dB whatever glazing is used, Figure 1.

A standard trickle ventilator with no measures taken to reduce sound transmission through it may create an opening of 1 percent of the window area and lead to a maximum of 20dB for the sound reduction index of the window, Figure 1.

Sound transmission through an integral window ventilator may be reduced by lining it with an absorbent material. Frequently this is combined with the use of internal baffles to lengthen the path taken by the sound and increase the area of the absorbent surface. It is unlikely that a simple trickle ventilator incorporated into the head of a glazed opening or window frame will have sufficient depth to provide any effective sound absorption.

However, the use of double windows will permit the use of deep ventilators that can achieve sound reduction indices comparable with those of the double window. The sound reduction index of a ventilator should be obtained from laboratory measurement. An alternative is to have acoustically treated ventilators independent of windows.

Window testing

The Sound Reduction Index for a material or component is established by measurement following the procedures in BS EN ISO 140-3:1995. Testing requires a transmission suite comprising two chambers. The window is mounted in a heavy wall between the two chambers. Noise is generated in one chamber, the source room. Noise levels are measured, usually in third octave bands, in both rooms in order to establish the Sound Reduction Index.

To facilitate national and international comparison of results for different configurations, testing is normally undertaken by product manufacturers using the standard size of 1.23m x

1.48m previously referred to. In contrast, for project related testing, it is commonplace to specify window or curtain walling test samples of up ten square metres to reflect the project design although larger test samples can be accommodated if required in some test chambers. Nevertheless, the information contained in this Technical Note refers only to the standard data available.

The Sound Reduction Index may be quoted as a single value such as R_{TRA}. However, values of sound reduction at octave or third octave bands should also be available, Table 4.

Specification

When specifying window performance it should be remembered that a difference in noise level of 3dB is only just discernible. To have any noticeable effect on internal levels glass thicknesses of 10mm or acoustic laminated glasses have to be considered.

Windows are normally sold as products and the supplier cannot be responsible for the overall performance of the wall. It is therefore necessary for the specifier to state the required sound reduction characteristics of the window. The aim is to provide sound insulation that will give the required internal noise levels. To do this precisely it is necessary to know the external noise levels and an acoustic consultant may be employed to measure noise levels. This is more normally the case where building is to take place on a noisy site or where a particularly quiet internal environment is required.

When specifying the acoustic performance, the specifier may wish to express the acoustic performance required in terms of a Sound Reduction Index appropriate for the predominant external noise: R_{tra} in the case of traffic noise, otherwise R_w.

However, to ensure effective communication with the supply chain it is often more helpful to specify the noise reduction in decibels required at each octave band.

Alternatively the specifier may select a product having regard both for sound reduction characteristics and cost.

Manufacture, and Installation

Very small air gaps can have a profoundly detrimental effect on the aggregate window acoustic performance. Air gaps of only 1 percent of the total window area can reduce the overall potential sound insulation to less than 20dB equivalent to thin single glazing. If a window incorporates opening lights of any kind, it is essential that efficient seals be fitted.

It is important to point out that double windows will only achieve their high performance potential if all air gaps are sealed. Effectively, this means that the frames carrying the glasses must either be fixed or be casements, incorporating pressure seals all round and also featuring multipoint locking to avoid twisting.

Sliding sashes are not able to secure the required airtightness and their corresponding acoustic performance is impaired.

Standards

BS EN ISO 140-1:1998
Acoustics. Measurement of sound insulation in buildings and of building elements. Requirements for laboratory test facilities with suppressed flanking transmission

BS EN ISO 140-3:1995, BS 2750-3:1995
Acoustics. Measurement of sound insulation in buildings and of building elements. Laboratory measurement of airborne sound insulation of building elements

BS EN ISO 717-1:1997
Acoustics. Rating of sound insulation in buildings and of building elements. Airborne sound insulation

BS EN 12354-4:2000
Building acoustics. Estimation of acoustic performance in buildings from the performance of elements. Transmission of indoor sound to the outside

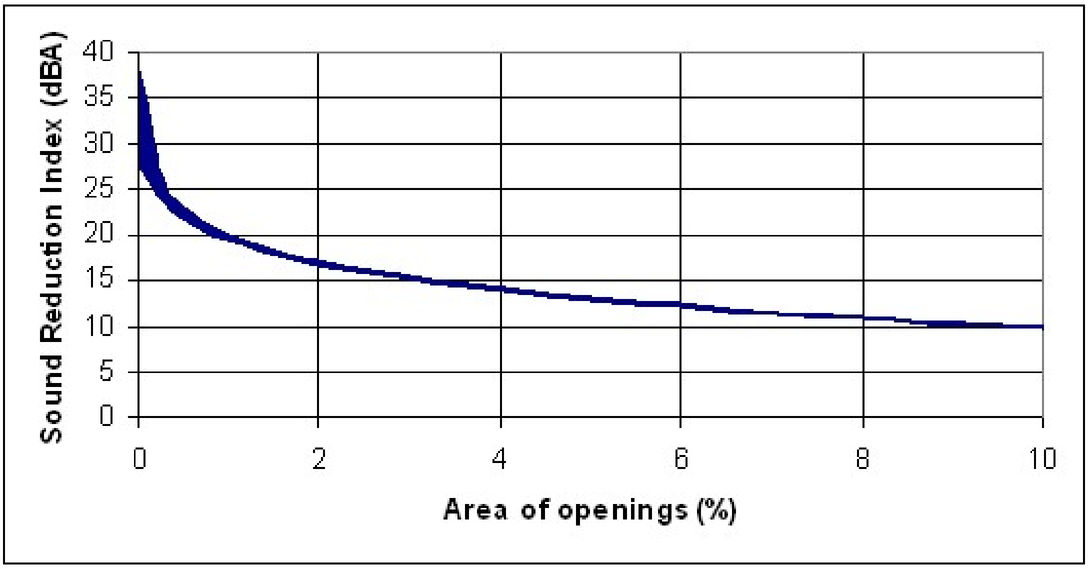

Figure 1. Maximum sound reduction index with openings as a percentage of the window area.

Glass type (mm)	Sound reduction index (dB) R_W	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz
4	29	17	20	26	32	33	26
4-12-4	29	21	17	25	35	37	31
6	31	18	23	30	35	27	32
6-12-6	31	20	18	28	38	34	38
8	32	20	24	29	34	29	37
6+	32	20	23	29	34	32	38
10	33	23	26	32	31	32	39
8+	33	20	25	32	35	34	42
8-12-4	33	22	21	28	38	40	47
6-12-6+	33	20	19	30	39	37	46
12	34	27	29	31	32	38	47
10+	34	24	26	33	33	35	44
10-12-4	35	24	21	32	37	42	43

mm+ is a laminated pane

Table 4. **Sound reduction indices for glazing of 1480mm x 1230mm**
(Full sound spectra are in accordance with prEN 12758-1)

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