inter-noise 25th Anniversary Congress – Liverpool 96

INCE: 51.3

LABORATORY ANALYSIS OF THE AIRBORNE SOUND TRANSMISSION THROUGH A PREFABRICATED STRUCTURAL GLAZING

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1. SUBJECT

In several recent architectural projects glass is used as a part of the structural concept of a facade. The facade construction of this paper was built out of modular elements of 1.25 m width, which cover the full story-height (3.42 m) of an office tower for the EC in Brussels. The air-borne sound insulation against the busy traffic environment was of major concern and for some parts of the facade a sound insulation R_{route} of 44 dB(A) was recommended by the consultant. This paper concerns the experimental acoustical study on a real scale laboratory set-up with 11 variants. The main goal was to analyze the different transmission paths and to evaluate the global performance.

2. TEST SET-UP AND MEASURING PROCEDURE

The test set-up was constructed with four prefabricated elements: two transparent panels and two opaque panels (figure1). One window frame opened, the other one was fixed. The opaque panels consisted of a glass panel at the outside, an intermediate airspace and a metal sandwich panel. An supplementary inside cladding is used in some experiments.

The classical measurement procedure followed the ISO prescriptions 140-1 and 140-3. The measurement procedure using the sound intensity was in agreement with the informative annex E of ISO 140 part 5 on the measurements of airborne sound insulation of facade elements and facades (revision of ISO 140-5: 1978 forwarded for DIS-voting ISO/CD ISO/TC 43/SC2 N 492).

A Real Time Dual Channel Frequency Analyser B&K 2144, equipped with an intensity probe and two specially selected B&K 4181 1/2" microphones was used for the measurements. From the comparison of classical measurements and measurements with microphone distances of 12 and 50 mm, whether or not additionally corrected for phase mismatch, we decided to use the

measurements without supplementary correction and with a microphone distance of 12 mm (figure 2).
The façade was divided into partial surfaces depending on the dimensions. For the larger panes an edge surface was choosen to have a better idea of the influence of the joints. Without internal cladding a total of 85 partial surfaces was used, with internal cladding this number was 'reduced' to 58.
As could be expected, some difficulties occurred in the lower frequency range. This was mainly due to conditions of high reactivity in the case of nearby strong radiating surfaces (missing points on some graphs). In several cases it showed to be necessary to shield these surfaces. The interpretation as 'partial sound insulation' can also be erroneous. The local sound intensity measurement can also include the sound radiation of nearby surfaces.

3. MEASURING RESULTS

Classical measurement on the large opening (3.27x2.97 m^2)
The global results can be summarised as follows:

	R_w	R_{route} (dB(A))
4 types of glazings without internal cladding	38 (double glazing) to 41(double window)	34.1 to 38.4
4 variants of glazing with an internal cladding	40 (double glazing) to 48 (double window)	36.5 to 44.2
2 types of glazing with partial internal covering	40 (double glazing) 45 (double window)	36.3 to 41
1 variant with an improved sandwich panel (simulation).	41 (was 41)	39.1

Generally the sound insulation was characterised by a rather flat sound insulation curve with two dips. The first one in the region of 125-160 Hz due to the mass-spring-mass resonance of the double panels (glass and sandwich panels) and the second one in the region of 1250-1600 Hz, due to the coincidence frequency for the glass panes. The best results were obtained with the double window constructions. It was shown that in this case the airtightness of the interior pane was of major importance (+3dB). Additional absorption at the cavity boundaries offered a very limited additional improvement (only +1 dB). Perforations to the exterior frame for ventilations nearly had any influence (+0 dB).
The 44 dB(A) sound insulation value could only be obtained by combining a double window construction and a high degree of interior cladding.

Classical measurements in the measurement opening for windows and small elements (1.5x1.25 m^2)

The following table gives a short description together with the obtained global results.

short description	global result R_w dB	global result R_{route} dB(A)
sandwich 0.8/95 mm (0.8 mm steel/ mineral wool/gypsum board12.5 mm/0.8 mm steel)	41	31.3
sandwich 0.8/95 mm + airspace 75 mm+ glaspane 8 mm	52	43.1
sandwich 0.8/95 mm + airspace 75 mm with absorption at the borders+ glaspane 8 mm	52	43.1
sandwich 3/95 mm with a 3 mm steelplate	46	34
sandwich 3/95 mm with a 3 mm steelplate + airspace 75 mm + glasspane 8 mm	56	48.2
sandwich 0.8/95 mm derived from the intensity measurement on the composed panel in the large opening (panel dimensions: 1x2 m^2, other elements covered)	49	41.2
sandwich 0.8/95 mm derived from the intensity measurement on another small element of the composed panel in the large opening (panel dimensions: 1x0.6 m^2, other elements covered, averaged over 5 partial surfaces)	49	40.9
idem averaged over 1 partial surface	49	42.6

The results showed the lowest values situated around 125 Hz. This was of course due to the mass-spring-mass resonance. The steep increase of the sound insulation above this frequency, was only interrupted when the additonal 8 mm glazing panel was used. But this latter dip has no influence on the global result which is determined by the lower frequency bands.

The effect of the additional window pane was as expected: it had a major influence: + 11.8 dB(A) ! The effect of using 3 mm steelplate instead of 0.8 mm was limited to 2.7 dB(A) without additional glass pane and to 5.1 dB(A) with the glass pane.

Intensity measurements on the sandwich metal panels

In order to obtain results from a realistic mounting in window frame, the sound insulation values were also derived from the intensity measurements. Depending on the choice of the averaging procedure we obtained 40.9 to 42.6 dB(A) (compared to 43.1 dB(A) in the small opening) (figure 3).

Intensity measurements on the glass panels
The best result was obtained for the double window construction: 46.9 dB(A) (8/15/6 + glazing panel 10 mm). The use of a layered double glass pane improved the sound insulation of a more common double glass pane from 30.8 to only 34 dB(A) (comparing 10/12/6 to 10/12/4.4.4 and measured by intensity measurement on the global frame, with additional covering on the stands and sandwich panels).

Intensity measurements: a global analysis of the facade construction
The comparison of the sound insulation value showed the connections to be the weakest points. The shielding of the other transmission paths was necessary to obtain a correct sound insulation value in the case of stronger radiation of the other parts (figure 4). For a good understanding we referred all insulation values to the same total transmission surface of the global wall. This equivalent sound insulation $R_{eq,i}$ is found as:

$R_{eq,i} = R_{intensity,i} + 10\log\frac{S_{global}}{S_i}$. With: $R_{intensity,i}$ the true sound insulation as measured by intensity, S_{global} the surface of the total opening and S_i the surface of the analysed partial surface. These results allowed to compare the transmitted power. We show some of the results for the first construction. The global analysis was repeated for the first five constructions.
The classical method and the intensity analysis compare very well (figure 5). The equivalent insulation values of the glazed and sandwich parts where compared for the variant with the double window. Both are almost equal. For the variant with the single double glazed window, the glass pane was the weakest part, but the horizontal elements show to be as important as the sandwich panels (figure 6).

4. CONCLUSIONS

This paper reported about a practical example of the use of the different measuring techniques for obtaining the global and partial sound insulation values. Classical measurement technique and sound intensity measurements were applied for the analysis of the sound transmission through a complex facade structure. The intensity technique allowed for a comparison of the different transmission paths. But in many cases additional shielding was necessary to obtain the correct transmitted power. This makes the technique not as straighforward as one would expect.

Acknowledgments

This research was done for the PERMASTEELISA Group. The authors are very gratefull for the carefull execution of the complicated and difficult construction work in the laboratory of the KULeuven.

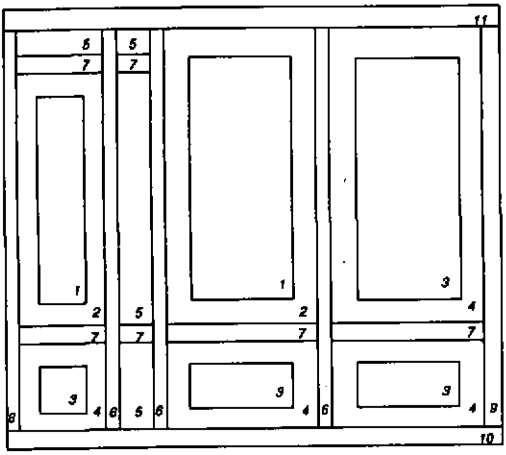


figure 1

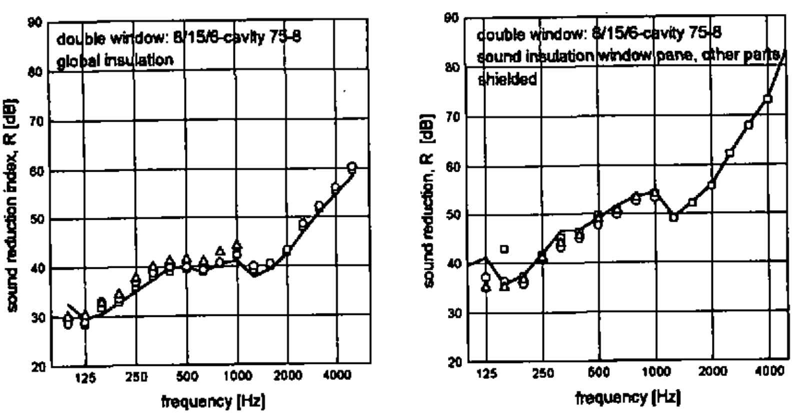
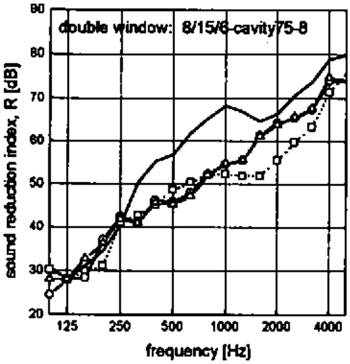
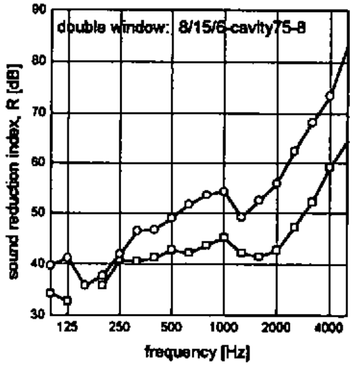


figure 2



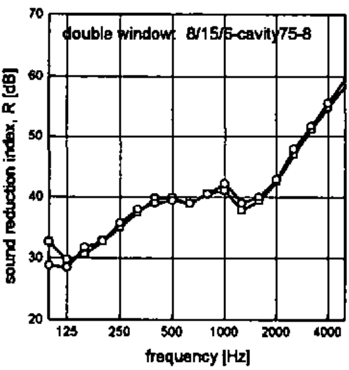
—— sandwich/75 mm cavity/glasspane 8 mm, classical, small opening, Rroute 48.2 dB(A)
···□··· intensity, 100 x 200 cm2, shielding of window posts and glasspanes, Rroute 41.2 dB(A)
—o— intensity, 100 x 60 cm2, shielding of window posts and glasspanes, global, Rroute 40.9 dB(A)
—△— intensity, 100 x 60 cm2, shielding of window posts and glasspanes, central part, Rroute 42.6 dB(A)

figure 3



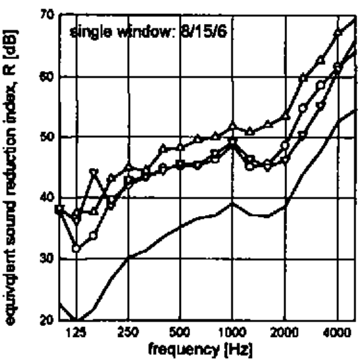
—□— double window sound reduction, intensity measurement with a shielding of the other paths
—o— double window sound reduction intensity measurement without shielding other paths

figure 4



—□— classical measurement
—o— intensity

figure 5



—— global, intensity
—o— horizontal frame
—△— vertical frame
—▽— sandwich

figure 6