CASE STUDY OF THE SOUND REDUCTION OF VARIOUS RESIDENTIAL GLAZING TREATMENTS

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Abstract

This paper presents the results of a case study of the achievable sound reduction of glazing treatments for a typical South Australian residential property. A loudspeaker, located externally, was used to generate a broadband noise signal and the resultant internal noise levels were measured for each glazing treatment. The treatments included retrofitting a double hung timber window, built in the late 1800's, with Magnetite glazing systems of different thicknesses and air cavity sizes, as well as upgrading the existing window suite with thicker laminated glass and acoustically rated seals. The study compares each glazing system and discusses the effect that each window upgrade has on predicted internal noise levels from a road traffic noise source.

1. Introduction

Noise from transport infrastructure is a well-recognised issue to both the community and governments. Major transport projects are often required to design noise mitigation measures to meet outdoor noise targets. In cases where a noise barrier cannot reduce noise levels sufficiently to meet an outdoor noise target, architectural treatments, such as window and door upgrades, are generally considered. As part of a major South Australian infrastructure project, the Department of Planning, Transport and Infrastructure (DPTI) commissioned a study to investigate the achievable noise reduction provided by various building facade treatments, in particular window treatments, for a typical residential dwelling located in the project area. This paper therefore presents the results and comparisons of the various window treatments tested, including secondary and triple glazing treatments as well as retro fitting thicker glazing and acoustic seals into a double hung timber window suite built in the late 1800's.

2. Test Details

2.1 Test environment

The subject property was built in the late 1800's as a traditional four-roomed layout with an out-house extension at the rear. The external wall construction was a double brick wall with a total thickness of

230mm, which indicated that there was either none or minimal cavity in the wall construction for this building. Normally a double brick wall system is 270mm thick with a 50mm cavity between to two brick leaves for this era of building in South Australia. As is also typical for residential buildings of this era, the building contained vertical sliding timber sash windows (i.e. double hung). The subject-glazed area was approximately 1.4m^2.

The test room was unfurnished and all possible sound flanking paths were sealed i.e. door, fireplace, through wall vent and cracks and crevices. The ceiling height of the test room was approximately 3m and the room had a total volume of approximately 45m^3. The test area was constructed as follows:

- Masonry wall with painted plaster finish
- Plaster Ceiling with insulation above
- Raised timber floorboards. The floor was ventilated underneath as was typical of the era. The floor vent was located at the base of the wall underneath the window of the facade being tested.

2.1.1 Reverberation time

Reverberation time measurements were undertaken with 3 people inside the test room, which was representative of testing conditions. A total of nine reverberation time measurements were carried out with the average RT60 times presented in Table 1.

Table 1. Measured reverberation times

Octave band centre frequency (Hz) reverberation times (s)						
63	125	250	500	1k	2k	4k
1.2	0.8	1.5	1.6	1.5	1.3	1.1

2.1.2 Glazing configurations

Testing was carried out on the following glazing system configurations:

- Existing sash window with 3mm glazing
- Existing sash window with 3mm glazing + Magnetite secondary glazing
- Existing sash window with 3mm glazing + Magnetite triple glazing
- Upgraded sash window 10.38mm laminated glazing
- Upgraded sash window 10.38mm laminated glazing + Magnetite secondary glazing

2.1.3 Magnetite glazing system

Magnetite (Australia) Pty Ltd provided the Magnetite glazing system suitable for testing. The Magnetite glazing system is a retrofit system in which a clear, optical grade, acrylic panel attached to an existing window suite, using magnetic seals. This creates an air cavity between the window and the secondary magnetite system. A PVC subframe with steel strips is installed on the inside of the existing window frame which then allows the acrylic panel to be attached using continuous magnetic strips, thereby providing an acoustic seal.

The study investigated the impact of two thicknesses of Magnetite secondary glazing – 4.5mm and 10mm, as well two different air cavity sizes (i.e. distance between the nearest existing window pane and the retrofit Magnetite pane), namely 75mm and 150mm. A schematic of the general installation process is presented in Figure 1.

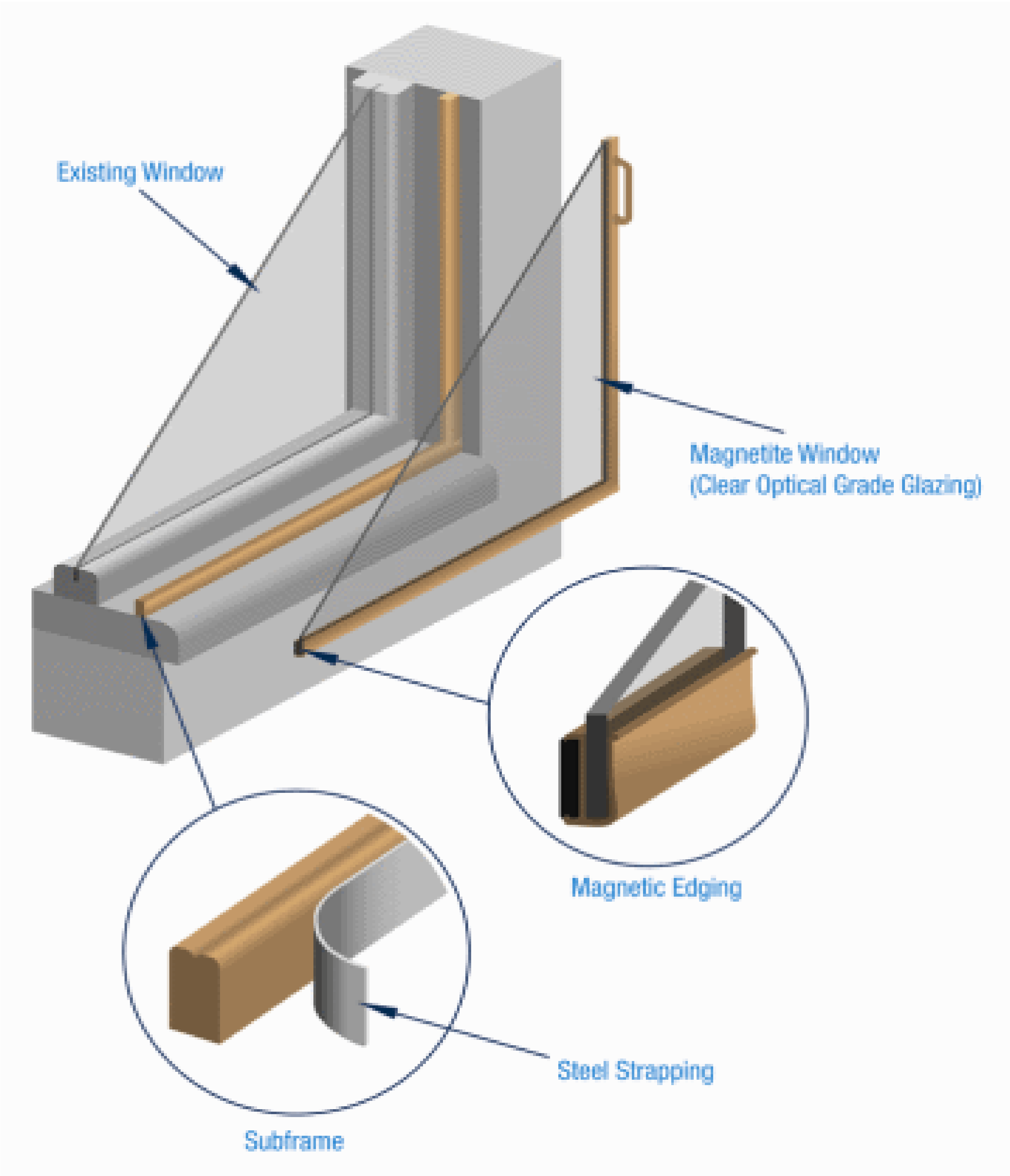

Figure 1. Magnetite secondary glazing installation (image courtesy of http://www.magnetite.com.au/Fits-Existing-Window.aspx)

2.1.4 Window suite upgrade

The upgrade works included replacing the original 3mm glass with a 10.38mm laminated pane and installing Raven RP 150 seals (double batwing) around the sides and lower sash perimeters and a Raven RP 113 seal (strip) across the central transom as shown in Figures 2 and 3.

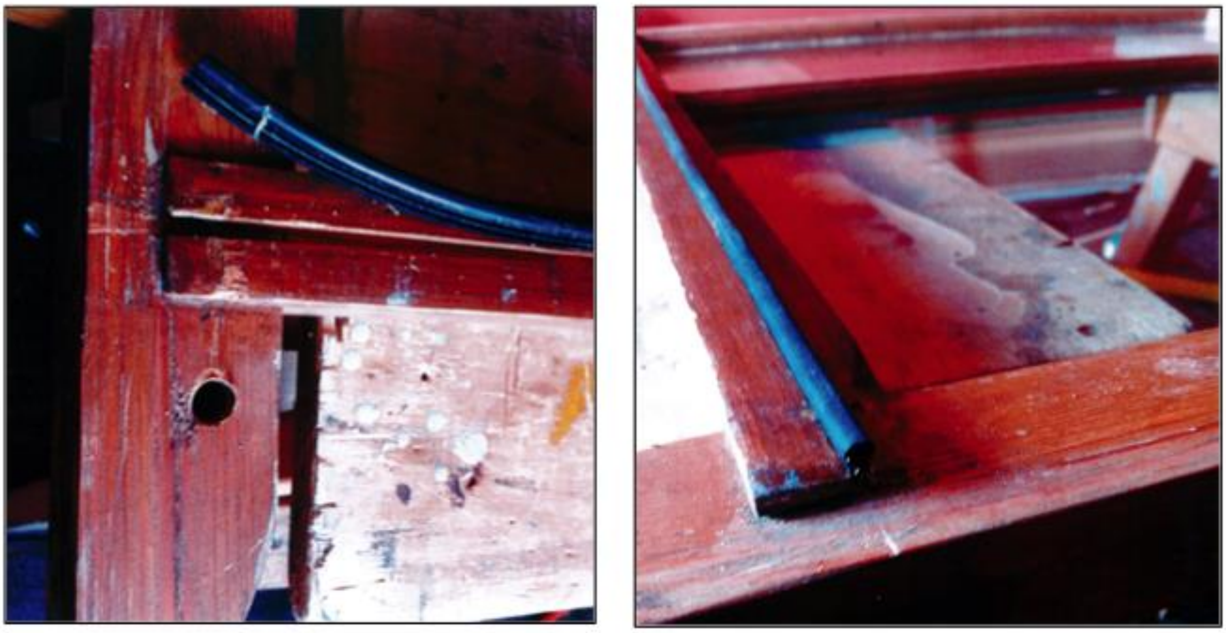

Figure 2. Raven RP 113 central transom seal

Figure 3. Raven RP 150 perimeter seals and laminated glazing

3. Methodology

The primary aim was to determine the measured insertion loss of the various window system under test. Measurements were carried out over two days to allow the existing 3mm glazing to be tested and then upgraded to 10.38mm laminated glass.

Day 1 – Determine the insertion loss of the existing facade with the addition of Magnetite glazing as follows. Note that "/75" and "/150" refers to the approximate air cavity size, and "/4.5" and "/10" refers to the thickness of the Magnetite glazing:

- 3mm single glazing
- 3/75/4.5 (double glazed)

- 3/150/4.5 (double glazed)
- 3/75/10 (double glazed)
- 3/150/10 (double glazed)
- 3/75/4.5/75/4.5 (triple glazed)
- 3/75/4.5/75/10 (triple glazed)
- 3/75/10/75/10 (triple glazed)

Day 2 – Determine the insertion loss of the façade with the Magnetite glazing in conjunction with the upgraded existing window suite as follows:

- 10.38mm single glazing
- 10.38/75/4.5 (double glazed)
- 10.38/150/4.5 (double glazed)
- 10.38/75/10 (double glazed)
- 10.38/150/10 (double glazed)

3.1 Procedure

3.1.1. Loudspeaker

This study utilised a JBL EON15 G2/230 model (S/N: PO353 – 73380). This speaker model has a crossover frequency of 1500 Hz. The bass and treble gains were adjusted to maximum amplification, which resulted in the frequency response as measured in the plane of the test window presented in Figure 4. A broadband noise signal was reproduced through a loudspeaker which was located at a distance of approximately 4m from the facade containing the window and was placed at an angle of approximately 45° to the plane of the window. Figure 5 shows the locations of the loudspeaker with reference to the test property.

The source noise signal contained significant acoustic energy at low frequencies (between 50 and 200 Hz). The noticeable troughs in the frequency response at 250 Hz and 800 Hz are due to the two band amplifiers being set to full amplification. The low frequency amplification was desired in order to investigate the response of the test facade in this frequency range as well as to ensure that the source noise level was well above the background noise level generated by adjacent road traffic.

3.1.2 Measurement locations

The source signal noise levels were measured in the plane of the open window to obtain a reference noise level against which the insertion loss due to differential glazing configurations would be measured. Measurements of the signal noise levels within the room were carried out using a sweeping spatial average procedure. Measurements of the spatial average noise levels were taken over periods of not less than 30 seconds in the room. Background measurements were taken at a single point in the centre of the room and traffic flow was observed to ensure no atypical events occurred.

4. Results

This section documents the test conditions and results of the testing carried out over the two days. In all cases, the measured insertion loss is determined using the measured noise level in the plane of the window as the reference level.

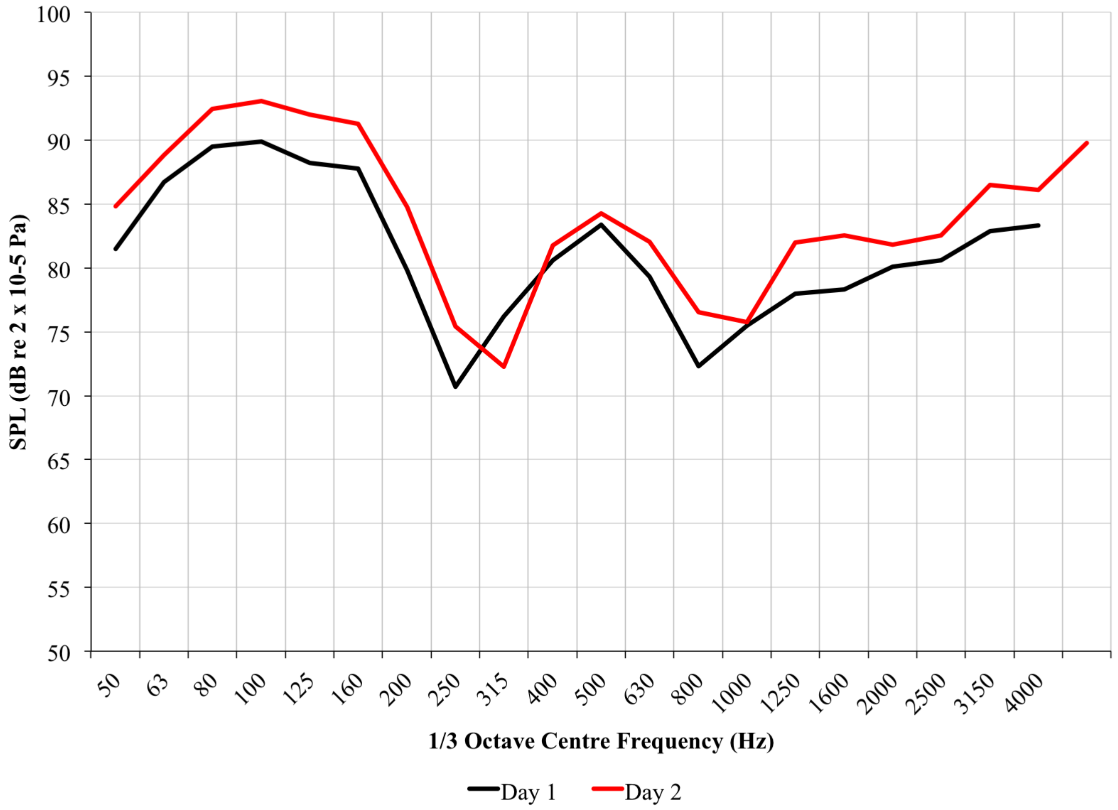

Figure 4. Measured frequency response of source signal

Figure 5. Speaker location and window under test

4.1 Double glazing

The results from the testing of the secondary glazing are presented in Figure 6. For reference, the results also include the measured insertion loss with the original glazing only.

Analysis of the above graph shows that the secondary glazing increased the performance of test facade by approximately 10dB at the 400Hz third octave band centre frequency and tended towards an increase of 20dB at 4kHz third octave band centre frequency. Below 400Hz, the increase is not as significant although the 10mm acrylic secondary glazing with a 150mm air gap did provide a relatively large increase in performance between the125Hz and 160Hz third octave band centre frequencies.

4.1 Triple glazing

The results of the triple glazing are presented in Figure 7. Again, the results also include the measured insertion loss with the existing 3mm glazing for reference. The results indicate that the triple glazing configuration offered a similar level of performance to the double-glazing configurations. This was most likely due to the flanking limitations of the magnetic seals.

4.3 Laminated glazing upgrade

A comparison of measured insertion losses (level difference) between the original 3mm glazing and the 10.38mm laminated glazing system is presented in Figure 8. Analysis of Figure 8 indicates that the upgraded 10.38mm laminated single glazed window offers increased sound reduction performance over the original 3mm single glazing. It may be seen that the upgraded window configuration offers 5 – 9 dB reduction of noise between the 50Hz to 200Hz third octave band centre frequencies.

The level difference in sound reduction performance reduces significantly at the 1 kHz third octave band centre frequency due to the coincidence dip of the 10.38mm laminated glass with respect to the 3mm glass. The coincidence dip is the frequency at which the glass panel natural frequency corresponds with the frequency of the incident sound pressure waves – generally, the thicker the glass, the lower in frequency the coincidence dip occurs.

The measured insertion loss of the upgraded window suite and the composite glazing configurations are presented in Figure 9. It may be seen from Figure 9 that the secondary glazing increased the performance of the test facade by approximately 10 dB at upwards of the 800Hz third octave band centre frequency. At low frequencies, specifically at the 80 Hz and 100 Hz third octave band centres, the 10.38/150/10 configuration performed best.

5. Discussion

To further evaluate the level of insertion loss achieved through the various glazing system configurations, internal noise levels due to road traffic were predicted. The octave band source noise levels were sourced from Minister’s Specification SA 78B *Construction Requirements for the Control of External Sound* (SA 78B) for a Type A Road with a 60km/h speed limit. The predicted overall sound reduction levels for road traffic noise are presented in Table 2.

As expected, the application of the Magnetite secondary glazing enhanced the performance of the existing sash window. With the 4.5mm thick acrylic pane, a predicted decrease in internal noise levels of 5 dB for a 75mm air gap and 6dB for a 150mm air gap was achieved. The 10mm thick acrylic secondary pane achieved a predicted decrease in internal noise levels of 6dB for the 75mm air gap and 9 dB for the 150mm air gap. A 9dB decrease in noise levels is subjectively equivalent to halving the loudness of the noise levels in the room.

It may be seen from Table 2 that utilising a triple glazing system had very little effect with an overall additional decrease in noise levels of 0 – 1dB in comparison to the secondary glazing system. This is likely due to sound flanking through the magnetic seals. Further to this, it was subjectively noted that the 3/150/4.5 created an audible low frequency drumming sound and this can be seen in Figure 5 where the insertion loss is less than that of the 3mm glazing at 100Hz.

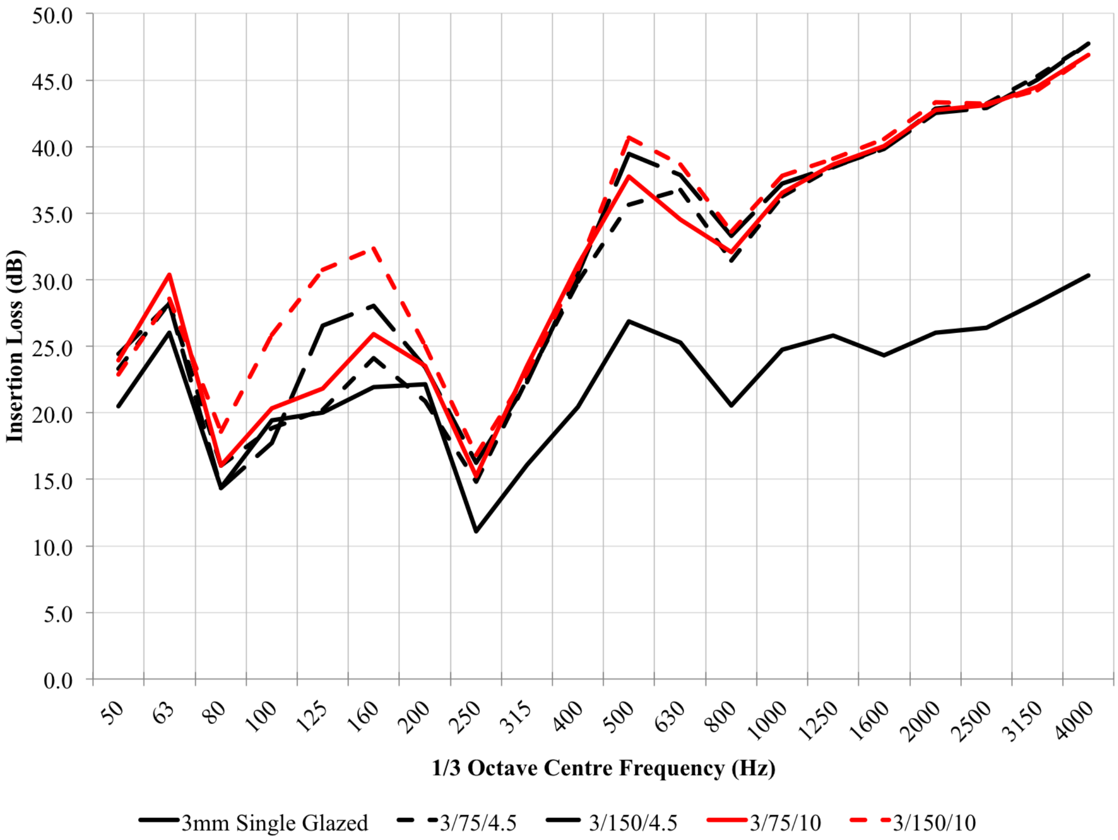

Figure 6. Measured double glazing insertion loss comparison

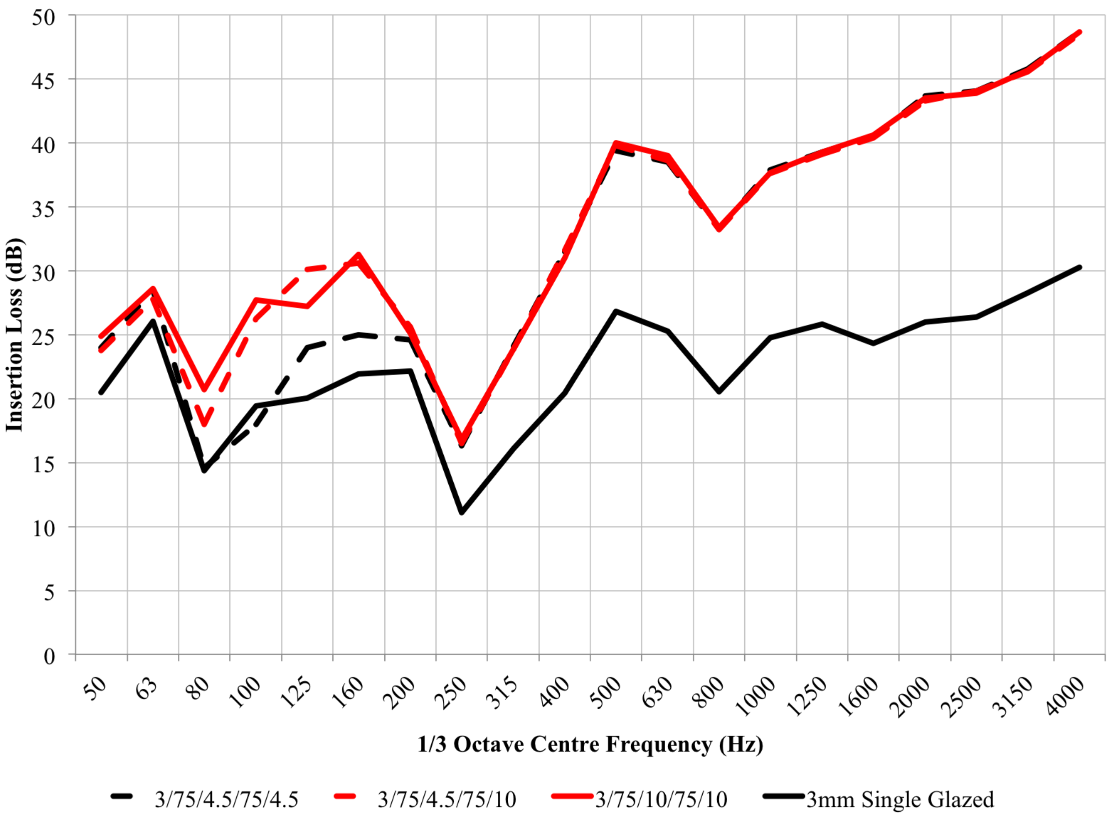

Figure 7. Measured triple glazing insertion loss comparison

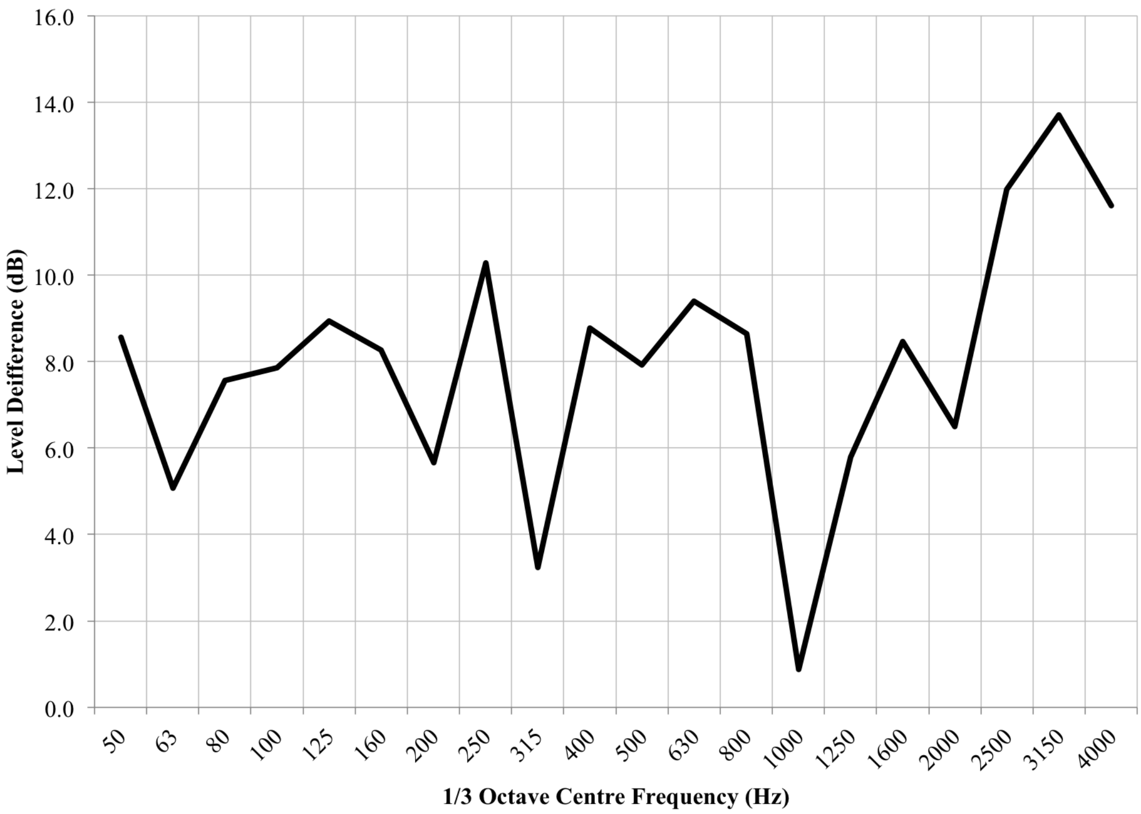

Figure 8. Measured insertion loss level difference between existing and upgraded window suits

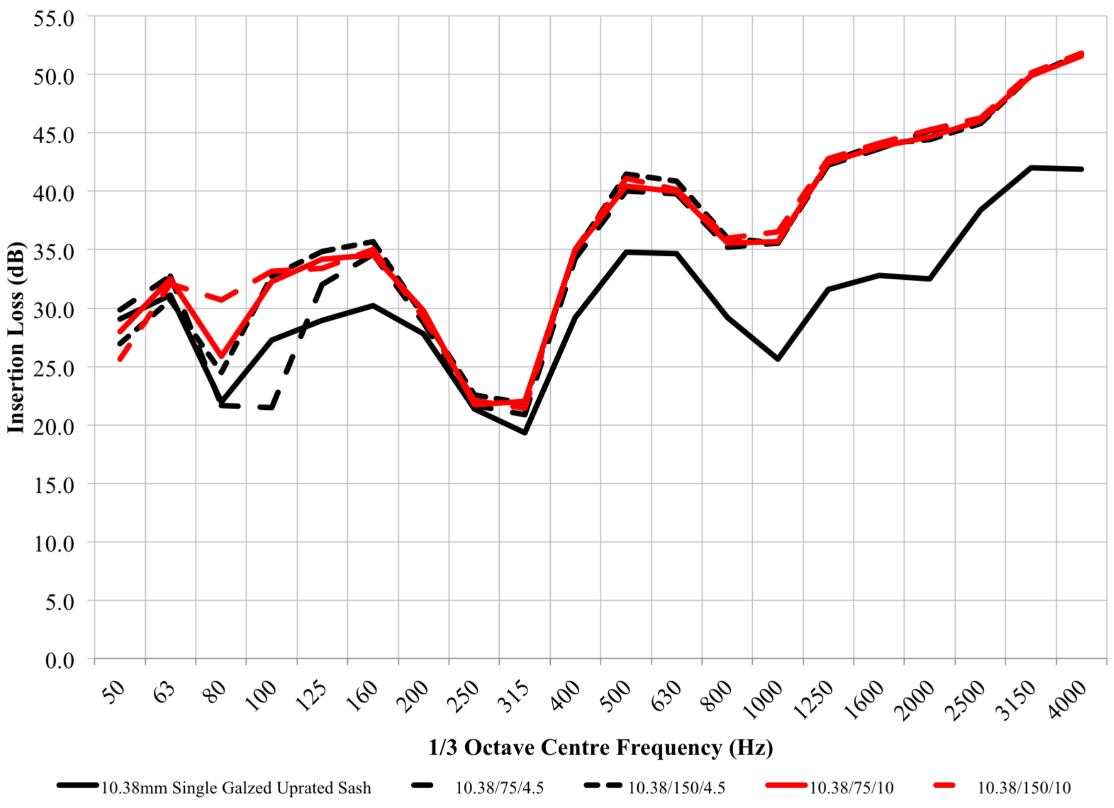

Figure 9. Measured insertion loss for upgraded and proprietary glazing (triple)

Table 2. Predicted sound reduction levels

Glazing Configuration	Predicted Sound Reduction (dB)
3mm existing single glazed	21
3/75/4.5	26
3/150/4.5	27
3/75/10	27
3/150/10	30
3/75/4.5/100/4.5	27
3/75/4.5/100/10	29
3/75/10/100/10	30
10.38mm retrofit single glazed	28
10.38/75/4.5	30
10.38/150/4.5	33
10.38/75/10	33
10.38/150/10	33

The acoustically upgraded window suite with the 10.38 mm laminated glazing system achieved a predicted decrease in overall internal noise level of 6 dB in comparison to the 3mm glazing which was subjectively a clearly noticeable improvement. The greatest reduction in internal noise level was achieved with the upgraded 10.3 8mm glazing plus the secondary glazing with the 150mm air gap. Both 4.5 mm and 10 mm thick acrylic panes achieved a similar overall reduction. However, the 10.38/150/10 configuration achieved the greatest insertion loss in the 80Hz third octave band, which was also subjectively noticeable. Our results indicate that the highest achievable attenuation is 12 dB (using the original 3mm glazing as the reference glazing), which is achieved with the 10.38/150/4.5, 10.38/75/10 and 10.38/150/10 configurations. It should be noted that for all tests, no obvious sound flanking was subjectively observed.

6. Conclusion

Testing of various facade treatments has been undertaken in a typical dwelling characteristic of that found adjacent the North-South Corridor in South Australia. All glazing treatments resulted in a significant improvement over the existing 3mm glazing configuration, with the minimum treatment (i.e. 4.5 mm thick Magnetite secondary glazing installed with a 75mm air cavity) providing a 5 dB reduction in road traffic noise. The upgraded window suite (10.38mm glazing plus acoustic seals) performed as expected and achieved a predicted reduction in road traffic noise of 7 dB in comparison to the original glazing and a 12 dB reduction when combined with a Magnetite glazing system. The cost of the retrofit was approximately double that of an equivalent Magnetite system, although had the benefit of being visually/operationally no different from the existing window. The 10 mm Magnetite secondary glazing system with the larger air-gap (150mm) performed generally better than the single 10.38mm laminated glazing upgrade. Therefore the acoustic performance achieved for the cost outlay was significantly better with the Magnetite system.

Acknowledgement

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