External Façade Sound Insulation and Passive Ventilation

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Abstract

External noise from road traffic, airports and industry is becoming more problematic. Consumers have changing and increasing expectations of the amenity value and acoustic quality in their homes. Greater demands are put on what we require from the space inside a home and the sustainability of the consumable resources.

In New Zealand activities in the environment are under the legal jurisdiction of the Resource Management Act 1991, including noise pollution. In order to obtain a Resource Consent the territorial authority may require the construction of a new dwelling to be sufficiently sound insulated to provide a prescribed sound level (often 35dBA at night) within the habitable spaces. In most noisy locations this normally requires the windows to be closed and for mechanical ventilation to be provided.

This paper examines an alternative approach, which unlike mechanical ventilation has a low initial capital cost and does not consume electrical power throughout the serviceable life of the building. A passive ventilation system is tested on site for sound insulation and compared to open and closed windows. It was found that passive vents provide adequate sound insulation together with some permanent ventilation of the space.

The current New Zealand Building Code requirements of Clause G4 for Ventilation are considered and compared to what would be needed in order for passive vents to be developed as an alternative solution for the building code. A multidisciplinary approach is required to deliver a practical solution and a scope of the research work to achieve this goal is set out.

Introduction

This paper is about a plea for action to address the seemingly disparate needs of acoustic insulation and passive ventilation. The intended outcome is an integrated Acceptable Solution in Clauses G6 Sound and G4 Ventilation of the New Zealand Building Code (NZBC) approved documents. There is a need to coordinate the necessary building code performances to achieve an integrated generic solution. The current status of the relevant NZBC Clauses in respect of passive vents is understood to be the following.

The justification for providing a nationally implemented acceptable solution of this nature is that the current method of sound insulation in a noisy external environment is closed windows and continuous mechanical ventilation for each room space with the corresponding consumption of our limited non renewable resources. The current mechanical technique means a significant initial capital cost with ongoing running and maintenance costs. In contrast a passive ventilation solution requires minimal initial capital cost, no running costs and minimal maintenance costs. A national cost benefit analysis should be carried out in order to further clarify the justification in a commercial monetary based argument but this is not the subject of this paper. It is taken in this paper that the conclusion of such an analysis would be overwhelmingly in favour of a balanced solution including both acoustic insulation and passive ventilation.

The failure of the industry to

NZBC Requirements

Clause	Performance type	Required Performance	Status
B2	Durability in Service	15 years +	In place
G4	Passive Ventilation	Air changes per hour	Passive ventilation performance not quantified
H1	Thermal Efficiency	Energy consumption per annum	Thermal efficiency performance not quantified
G6	Sound Insulation	20 to 30 dBA	Statistical confirmation of these initial results
E2	External Moisture	Weathertight	Verification method set out in NZBC

provide such a solution so far is related to the multi-disciplined technical input that is required to solve a fairly simple problem, together with a lack of leadership by building research and regulatory organisations.

However, as a first step the performance of a common brand of a passive vent must be quantified in the field and this is the subject of this paper.

NZBC Requirements

In NZBC Clause G4 Ventilation acceptable solution G4/AS1 there is an active and a passive means of ventilation to the habitable space of a dwelling. The active solution requires mechanical ventilation to provide at least one air change per hour and the passive solution requires 5% of the floor area to be openable window area. A passive ventilation requirement expressed in air changes per hour is not included. Furthermore the passive ventilation solution relies on the occupants actively opening and closing the windows and of course this may never happen. It is obvious that a passive solution with permanent vents is required. Where necessary, these permanent vents must be capable of providing the necessary sound insulation. However in all cases the permanent vents must deliver simultaneous compliance with the NZBC performance requirement for durability, energy efficiency and external moisture. Currently the NZBC does not consider sound insulation requirements for the external envelope of a building. The internal noise performance level is normally set by each territorial authority under the district rules required by the Resource Management Act.

Description of Field Test

The site testing was carried out on a fine sunny day in December 2001 using a two and a half year old ground floor apartment at a retired persons complex in Henderson, Auckland.

Site testing was generally in accordance with ISO140 Part 5; 1998 to obtain $D_{ls2m,n,T}$. The loud speaker was located externally and positioned with an angle of 45° at a distance of 7 metres from the central axis of the external façade of the particular room. The analysis included single figure descriptors of the façade performance for both speech and road traffic noise.

Investigation Summary

The on-site acoustic tests investigated the performance of the external façade as follows;

Window construction details

All the window and door joinery was white powder coated aluminium with neoprene rubber glazing beads to the windows and nylon brush seals to the doors. There were two windows in the bedroom with an aluminium frame glazed door. In the lounge was a ranchslider with a lower fixed light and two opening top hung opening lights. Glass was 4mm thick to window sashes and laminated glass 6mm thick to doors. There were vents on the upper part of the two bedroom windows, but there were no vents in the lounge windows. The Interlock design is simple and utilises a vent at the head or cill rather than incorporating the vent into the jambs. The top hung opening sashes had security stays (Interlock brand) on each side at

Table 1 Summary of Room and Component Dimensions

	Room Dimensions	
Description	**Bedroom**	**Lounge**
Volume	29.2 m^3	71.5 m^3
External wall area	10.9 m^2	9.1 m^2
Window and door glazed area	4.1 m^2	4.9 m^2
Ratio of glazed area to external wall area	38%	53%
Internal vent area (2 windows)	4480 mm^2	N/A
External vent area (2 windows)	7000 mm^2	N/A
Open window area with handled catches in place (2 windows)	59,080 mm^2	N/A
Open window area with security stays fully open (2 windows)	466,000 mm^2	464,000 mm^2
Floor area	10.8 m^2	24.8 m^2
Glazed area of top hung sashes	1.5 m^2	1.3 m^2
Ratio of opening light glazed area to floor area	13.9%	5.2%
Ratio of open area with sashes on security stays to floor area	4.3%	1.9%

the lower part of the sash. There were handled catches on the lower transom of each sash. There were two positions for the bedroom window handled catches, closed and partly open. Whereas, the handled catches in the lounge only had the closed position. The two kitchen windows at the front of the apartment were fixed lights with fire rated glass and did not include any vents or openable lights for ventilation.

Wall Details

The external wall consists of 7.5mm Harditex fibre cement sheet on 90mm deep timber studs at 600mm centres with 75mm fibreglass batts in the wall cavity and 9.5mm standard plasterboard on the inside face

Room and component dimensions

Dimensions were taken in order to calculate the following room parameters; volume of each room, open vent area, open window area with sash on security stays, open window area with sash on handled catches, external wall area, external glazed door and window area and percentage ratio of door and window glazed area compared to external wall area. (A summary of the dimensions are presented in Table 1).

Observations

It is notable that neither the bedroom (4.3%) nor the lounge (1.9%) comply with NZBC G4/ AS1, which requires that the openable window area is 5% of the floor area. It seems that passive ventilation is not considered adequately.

A summary of the acoustic results is presented in Table 2. The usual performance descriptor is expressed as a single number using speech as the reference. However, since speech is not the most important criterion by which to assess insulation against external noise, road traffic noise is also used as a reference for assessing these results. Consequently an adjustment has been included, which takes account of the low frequency component of road traffic in a C correction, designated C_{tr}. The frequency range for this correction can vary and the one selected is for a wide frequency range from 50 to 5000Hz.

1. There is very little difference in the sound insulation performance of the open window when on the security stays (18dB) and when on the handled catches (19dB). When the results are adjusted for traffic noise ($C_{tr,50\text{-}5000}$) there is a small increase in this difference to 2dB (15 dB on security stays and 17dB when on its catch).

2. With the vents open the sound insulation (i.e. $D_{ls2m,n,T,w}$) is reduced only 3dB, compared to the fully closed windows ($D_{ls2m,n,T,w}$ =33dB). When the results are adjusted for traffic noise ($C_{tr,50\text{-}5000}$) the difference reduces to 1dB (27dB cf 28dB).

3. The closed glazed windows to the lounge and bedroom have similar performances and differ in $D_{ls2m,n,T,w}$ by only 2dB, the average being 34dB $D_{ls2m,n,T,w}$. When the results are adjusted for traffic noise ($C_{tr,50\text{-}5000}$) there is no difference, with a common value of 28dB.

4. There is a 12dB improvement in insulation performance between the vents being open ($D_{ls2m,n,T,w}$ 30dB) and the open window on security stays ($D_{ls2m,n,T,w}$ 18dB). When the results are adjusted for traffic noise ($C_{tr,50\text{-}5000}$) the difference is still 12dB (27 dB vents only and 15dB windows on security stays).

5. There is an average of 16dB loss of sound insulation performance between a closed window (average $D_{ls2m,n,T,w}$ 34dB) and a window on security stays ($D_{ls2m,n,T,w}$ 18dB). When the results are adjusted for traffic noise ($C_{tr,50\text{-}5000}$) there is an average difference of 14.5dB ($D_{ls2m,n,T,w}$ 28dB for a closed window and $D_{ls2m,n,T,w}$ 12 and 15dB for a window on security stays).

Evaluation

Previous experience of acoustic testing in dwellings, leads one to expect about a 1dB difference between the R_w of a separating partition and $D_{n,T,w}$ - when there is no significant flanking transmission. The predicted performance for 4mm float glass is R_w 29 and 6mm laminated glass is R_w 34.

The values of $D_{ls2m,n,T,w}$ 33 and 35dB for the bedroom and lounge respectively with windows closed were slightly better than expected. It was initially considered that the dominant factor would be the windows and these would tend to leak and provide a lower performance than the theoretical prediction. The larger windows in the lounge should therefore provide the lowest performance but the reverse was found in practice. The bedroom windows have vents but the lounge windows do not have vents. The 2dB lower performance for the bedroom windows compared to the lounge windows suggests that the closed vents above the bedroom windows could be an airborne sound flanking path into the room. Alternatively the thinner 4mm glass in the bedroom compared to the 6mm glass in the lounge could also have made a 2dB difference.

Width of window opening

In the bedroom, the minimal difference of 1dB between the window on security stays versus handled catches shows that the normal 18mm opening for the handled catches on top hung sashes produces a significant drop in the insulation performance. Consequently the handled catches do not provide a worthwhile amount of sound insulation with simultaneous ventilation and cannot provide a ventilation/ acoustic insulation solution for the NZBC.

The same value of 18dB in each room, for the windows on security stays with the same width of opening, suggests that the test method is consistent.

Open and closed vents

The vents are designed to provide some fresh air ventilation. However, it was shown that the shape and position of the vents can also allow them to provide good attenuation of airborne sound. In the bedroom there is a difference of 12dB between the windows open on security stays and windows closed with just the vents open. This strongly suggests that the open vents provide a worthwhile airborne sound insulation. The performance when the windows and vents closed are compared to windows closed with vents open is 33dB and 30dB respectively. The amount of leakage through the open vents is therefore about 3dB. When road traffic noise is taken into account the loss of sound insulation performance due to the open vents is reduced to 1dB. Consequently if these vents can be shown to provide the required passive ventilation for a habitable space in regard to NZBC Clause G4 Ventilation, then this brand of vent could be a ventilation/ acoustic solution for NZBC Clauses G4 and G6.

Room	Description of opening	$D_{ls2m,n,T,w}$ dB	$D_{ls2m,n,T,w + Ctr,50\text{-}5000}$ dB
Bedroom	Bedroom windows on security stays, door and vents closed	18	15
	Bedroom windows on catches, door and vents closed	19	17
	Bedroom windows and door closed and vents open	30	27
	Bedroom windows and vents closed	33	28
Lounge	Lounge windows on security stays	18	12
	Lounge windows and door closed	35	28

Table 2 Results Summary

www.acoustics.org.nz

The New Zealand Acoustical Society website offers information on society activities and details of the elected officers of the Society.

Other ideas which are being developed are:

- Adding a search engine for archives of *New Zealand Acoustics*,
- Providing a list of members of the Society,
- Publishing reviews of the 16th Biennial Conference.

Please send further suggestions and feedback to Thomas Scelo (t.scelo@auckland.ac.nz) or follow the instructions on the home page of the web site

Adjustment for traffic Noise

The adjustment for traffic noise ($C_{tr,50-5000}$) puts more emphasis on the low frequency part of the spectrum. Consequently small openings such as vents should perform better. This is found to be the case in the bedroom with only a 1dB loss of performance between the closed windows/doors and the open vents.

This outcome is encouraging and emphasises the need to analyse the ventilation data for the Interlock and other brands of vents and assess the adequacy for passive ventilation to meet the requirements of NZBC Clause G4.

Performance criterion for Clause G6 Sound could be set related to $D_{ls2m,n,T,w} + C_{tr,50-5000}$ or $D_{n,T,w} + C_{tr,50-5000}$ as well as a passive ventilation performance to satisfy G4 related to air changes per hour. If the ambient external noise source is sufficiently loud, it is the preferred method of measurement for external façade sound insulation rather than loud speakers. This is because it is the loudness of the real external noise which may cause concern for the occupiers of the room and it is that which must be addressed.

Further Research

Only one set of site acoustic tests has been carried out on the Interlock vent and obviously this is not a statistically valid sample. Further site acoustic tests in other buildings to give a representative sample size of at least six are required, on the same brand of vents, to confirm the reproducibility of the on site performance. In addition other brands and types of vents should be tested on site to a statistically valid number of samples using the same measurement technique and analysis methodology.

The acoustic and ventilation performance verification of this vent design could be a basis for the development of a generic design for use as an Acceptable Solution in the NZBC Approved Documents.

Ventilation test data has already been obtained for the Interlock Industries brand of window vent. It is know that BRANZ have already carried out the basic research to establish the passive ventilation needs expressed in air changes per hour. Further work is needed to determine the real passive ventilation provided by a vent on site taking into account, building form, site topography and geographical wind zones. In addition the thermal efficiency performance of a dwelling must also take into account the associated effects of energy loss due to permanent ventilation. Durability and external moisture effects must also be evaluated in terms of NZBC Clauses B2 and E2. The NZBC seems to operate by providing single performance solutions which are separate from each other. Real buildings satisfy all the NZBC requirements simultaneously and a harmonised approach should be adopted to provide NZBC Acceptable Solutions which satisfy all the building code clauses simultaneously rather than leaving it to the territorial authority or builder on site, who have neither the resources nor the skills to sort it out.

Justification to carry out this research depends on a responsible building industry organisation carrying out a cost benefit analysis to prove that this work would be in the national interest and then taking a leadership role to coordinate and implement the research and the work needed to produce a generic acceptable solution. How else can we act responsibly as a nation and have sustainable use of our consumable resources to conserve them for future generations? ❑

On the Lighter Side…

A conclusion is the place where you got tired of thinking.

He who hesitates is probably right.

The hardness of the butter is proportional to the softness of the bread.

To steal ideas from one person is plagiarism, to steal from many is research.

If at first you don't succeed, destroy all evidence that you tried.

Two wrongs are only the beginning.

A clear conscience is usually a sign of a poor memory.

If you must choose between two evils, choose the one you've never tried before.

A conscience is what hurts when all your other parts feel so good.

If at first you don't succeed, then skydiving is not for you.