Exterior Noise Ingress in Greater Vancouver Residential Buildings: Prediction versus Field Measurements

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1 Introduction

Many municipalities in Greater Vancouver prescribe acoustical requirements for residential and mixed-used development permitting applications in order to control exterior noise (e.g., road, rail and aircraft traffic noise) to noise sensitive portions of dwelling units such as bedrooms, living/dining rooms, kitchen, and bathrooms. Hence, an assessment is performed to determine the necessary façade construction details to meet prescribed interior noise limits.

ISO 15712-3 *Building acoustics – Estimation of acoustic performance of buildings from the performance of elements – Part 3: Airborne sound insulation against outdoor sound* [1] is considered by many to be the current best practice for predicting noise transmission through the building envelope.

IBANA-Calc [2], an indoor noise prediction software developed by the National Research Council Canada (NRC), is an alternative commonly used in Canada for similar noise ingress calculations. IBANA-Calc was specifically developed to predict sound insulation against aircraft noise, but the software allows for other noise source inputs.

A comparison of noise predictions using the two calculation methods, with the same inputs, shows that they generate different results. For a number of residential development projects, BKL had the opportunity to conduct post-construction measurements to determine the actual 24-hour noise levels inside suites and compare them with predictions performed with IBANA-Calc and ISO 15712-3 to assess the accuracy and identify potential causes for differences.

2 Sound Insulation Predictions Overview

With ISO 15712-3 and IBANA-Calc, interior noise levels are calculated based on the facade noise exposure, transmission loss of the building envelope elements, receiving room dimensions and the amount of absorption in the receiving room. This calculation is performed for each exterior facade of a room and added together to estimate the indoor noise level.

2.1 Facade Noise Exposure

Exterior noise levels are typically estimated using site measurements, theoretical calculations, or a combination of the two.

2.2 Transmission Loss

Spectral transmission loss (TL) data for each facade component (wall, window, etc.) is used to perform sound insulation calculation for ISO 15712-3 and IBANA-Calc. TL data is often obtained from laboratory measurements, field measurements, or theoretical calculations depending on which is available and judged to be more reliable.

2.3 Receiving Room Absorption

In IBANA-Calc, the room absorption can be specified as a percentage of floor area, ranging from 50% to 150%. 100-120% are commonly used values, which corresponds to reverberation times of 0.3-0.4 seconds for a typical floor-to-ceiling height of 2.4 m.

Instead of specifying a specific amount of absorption in the receiving room, ISO 15712-3 normalizes all indoor noise sound pressure levels to a reference reverberation time of 0.5 seconds.

2.4 Calculation Method

ISO 15712-3 defines the indoor sound level resulting from traffic noise transmission through a building element as:

$$L_2 = L_1 - TL + 10 * log\left(\frac{S}{A}\right) + 3,$$

where,
L_1= free-field sound level on the outside surface
L_2 = sound level in the receiving room
TL = transmission loss value
S = area of building facade
A = equivalent sound absorption area in receiving room

However, IBANA-Calc, being developed for aircraft noise ingress measurements, uses the following equation, which better correlated with their test results:

$$L_2 = L_1 - TL + 10 * log\left(\frac{S}{A}\right)$$

3 Post-Construction Measurements Overview

BKL conducted post-construction measurements in four wood-frame residential construction developments where a pre-construction acoustic assessment had also been completed. Indoor and outdoor measurements were performed simultaneously. Reverberation time measurements were also conducted to compare with the assumptions made in IBANA-Calc. The sound absorption for the modelled rooms was then adjusted to reflect actual conditions during measurements by matching the broadband reverberation time that was measured.

Table 1 below summarizes the measurements taken:

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Table 1: Summary of measurements taken

Building	Floor/ Room Type	Noise Source	Description[1]
Richmond House	2/F Bed	Hwy/ Aircraft	• No carpet; unfurnished • 3-13-3 window • VIN_PLY9_WS89_ GFB89_G13
Vancouver Townhome	2/F Living	Arterial Road	• No carpet; Unfurnished • 3-13-3 window • HARDI9_PLY13_ SWS89_2G13
Vancouver Townhome	1/F Den	Arterial Road	• Carpeted; Unfurnished • 6-13-4 window • HARDI9_PLY13_ SWS89_2G13
Vancouver Condo	2/F Living	Arterial Road	• Carpeted; unfurnished • 5 window • STUC23_PLY9_WS140 _ GFB152_G13
Vancouver Condo	2/F Living	Arterial Road	• Carpeted; unfurnished • 5 window • STUC23_PLY9_WS140 _ GFB152_G13
Vancouver Condo	4/F Bed	SkyTrain	• Carpeted; unfurnished • 3-13-3 window • 5-13-3 sliding glass door • VIN1_PLY13_WS140_ GFB152_G13

[1] Numbers denote thickness in mm
Window/Sliding Glass Door: Glazing-Airspace-Glazing thicknesses
VIN: Vinyl Siding
HARDI: Hardi Panel Siding
PLY: Plywood
WS: Wood Studs
GFB: Glass Fibre Batt Insulation in Stud Cavity
RC: Resilient Channels
G: Gypsum Wall Board

4 Results

Measured indoor noise levels were corrected to a reverberation time of 0.5 seconds for comparison with ISO 15712-3 predictions. As-measured results were compared with IBANA-Calc predictions that were adjusted to match the measured reverberation times. Table 2 below shows the summary of the comparison between predicted and measured indoor sound levels.

Table 2: Calculated difference between predicted and measured indoor sound levels (dBA) for ISO 15712-3 and IBANA-Calc

Building	Floor and Room Type	ISO 15712-3	IBANA-Calc
Rmd House	2/F Bed	-2	-5
Van TH	2/F Living	4	-1
Van TH	1/F Den	1	-8
Van Condo	2/F Living	-3	-9
Van Condo	2/F Living	-4	-10
Van Condo	4/F Bed	-2	-6
Average Difference		-1.0	-6.5
Standard Deviation		3.0	3.3

5 Discussion

There are a number of factors which could contribute to the discrepancies between the prediction results.

Noise Transmission Equation: The most significant difference between the ISO 15712-3 and the IBANA-Calc calculation is the +3 dB term which results in lower predictions from IBANA-Calc.
Exterior Noise Exposure Definition: In this study, exterior noise was measured using microphones mounted on the surface, 2 m from the surface or in the free-field, and then corrected to match the specific input of ISO 15712-3 and IBANA using the assumption $L_{1,free\text{-}field} = L_{1,2m} - 3 = L_{1,surface} - 6$, as described in ISO 1996-2 [3]. However, this equation may not hold true in some cases, which may result in incorrectly defining the exterior noise exposure.
Transmission Loss Assumptions: Since lab TL data was used in the calculations, the in-situ quality of construction could be a significant source of error.
Flanking Transmission: ISO 15712-3 also considers flanking noise transmission, which depends on the wall, floor and ceiling material properties and the type of connections.
Room Reverberation: Considering the reverberation time assumption difference between ISO 15712-3 and IBANA-Calc (0.1-0.2 s), this could result in up to a 2 dBA difference. IBANA-Calc predictions would be lower by using the default values.

6 Conclusion

Post-construction measurements were performed at four wood-frame construction buildings and the results were compared with noise predictions calculated using ISO 15712-3 and IBANA-Calc. Assuming the measurements conducted are representative, the ISO 15712-3 method provides significantly more accurate results for ground-based transportation noise.

References

[1] International Organization for Standardization (ISO). 2005. Building acoustics – Estimation of acoustic performance of buildings from the performance of elements – Part 3: Airborne sound insulation against outdoor sound. Reference No. ISO 15712-3:2005. Geneva, ISO.
[2] Birta, J., Bradley, J.S., Estabrooks, T. 2001. IBANA-Calc User's Manual. Ottawa, National Research Council.
[3] International Organization for Standardization (ISO). 2007. Acoustics – Description, measurement and assessment of environmental noise – Part 2: Determination of environmental noise levels. Reference No. ISO 1996-2:2007. Geneva, ISO.