ACOUSTICAL INVESTIGATION OF LANEWAY HOUSE FACADES

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1. INTRODUCTION

Façade transmission loss (TL) of six laneway houses (LWH) in Vancouver were investigated through measurement and modelling. Laneway houses are a popular type of small residence[3] that increase housing stock and effective density throughout Vancouver's single family residential zones. Noise levels in Vancouver's residential laneway environment may be high, exceeding 65LAeq [1]. LWH have many size-, mass- and design-related disadvantages that require acoustical attention.

Design-related challenges include limited distance from noise sources, relatively large glazing-to-façade and façade-to-floor-area ratios, and small interior volumes. Common design in the LWH include: non-absorptive interior surfaces and minimal furnishing, open-plan living spaces, double-height ceilings, and outdoor-oriented design with generous use of operable glazing components and patio space. All wall assemblies evaluated are wood-frame construction, with common cladding systems (wood, fibre cement planks, and stucco). A summary of the case studies' characteristics is presented in Table 1. Case studies B, C and D were fully-furnished at time of investigation.

Despite high-risk noise concerns, municipal LWH design publications do not address exterior noise nor specify care in locating noise-sensitive spaces, and suggest window placement and setback limits incompatible with sound design principles outlined in Vancouver's Noise Control Manual. Thus, LWH may have insufficient exterior noise insulation for residential health and comfort, warranting this investigation, in which assessment tools were also explored.

2. METHOD

Façade TL data and performance metrics of the case studies were calculated from measured and modelled data. In-situ measurements followed the ASTM E966 and C423 standards and the modelling tools used were the Canadian Housing and Mortgage Corporation (CMHC) traffic noise model [2] and the LWH model. The CMHC traffic noise model uniquely predicts road traffic noise levels at the exterior of each LWH façade and the required façade sound insulation for each designated space to meet residential room criteria, and includes room and construction considerations.

The LWH model is the numerical area-weighted composite TL of a multi-component façade. The wall portion was modelled in AFMG's Soundflow software based on known or best-estimated assembly construction details. Standard input values include material properties, dimensions, and layer sequence. Lateral airgaps through a typical cladding type, such as lap joints of horizontal fibre cement plank siding, were accounted for. Adding miniscule air gaps between each layer of solid panel material as would exist in real construction improved Soundflow output conformance to laboratory-measured data of similar wall construction. Laboratory test data from the NRC [3] was used for fenestration units.

Results from all methods were evaluated against CMHC criteria and analyzed. Procedures in the CMHC, ASTM E1332 and ASTM E413 were used to calculate the insulation rating metrics of acoustical insulation factor (AIF), outdoor-indoor transmission class (OITC) and sound transmission class (STC).

3. RESULTS

3.1 CMHC criteria and CMHC model results

Four out of the six LWH were estimated to have excessive road noise exposure up to 64LAeq (Table 1). LWH A and B were estimated to each have three of four sides exposed to road traffic noise above 55LAeq. Façades B, C and E have lower criteria than the others (Figure 1). A has the highest insulation requirement due to the highest outdoor level and most sensitive indoor use. B has the lowest criteria due to lower outdoor level and a kitchen interior more forgiving of noise. A, C and E did not meet component AIF requirements.

Table 1: Case studies noise exposure, facade and room information

Case Study ID	A	B	C	D	E	F
Estimated noise exposure (LAeq)	61	54-59	50	54	54	44
Test facade size (m^2)	7.6	7.8	28.8	13.9	10.1	20.0
Fenestration/facade ratio	12%	24%	22%	0%	46%	19%
Test room floor area (m^2) (approx. ±1 m^2)	7.2	19.0	30.0	20.7	19.5	27.0
Façade/floor area ratio	106%	41%	96%	67%	52%	74%
Test room volume (m^3) (approx. ±2.5m^3)	17.5	42.9	122.0	44.4	65.1	57.5
Test room use	S/B	LK	LDK	LD	LDK	LDK
Room condition	E	F	F	F	E	E
Architectural features		O	OH^2		O H^{2}LB	OH^2
Room absorption @500Hz (Sabines, m^2)	2.8	14.3	30.4	13.6	12.8	12.9

S=study, B=bedroom, K=kitchen, D=dining, L=living room; E=empty, F=furnished, O=open plan, H^2=double height ceiling, LB=lofted open bedroom

3.2 Empirical results

Façade TL ratings calculated from measured 1/3 octave band TL data indicate that half of the case studies, A, E, and F, did not meet criteria, and that C only marginally passed (Figure 1). STC values range from 26 to 35 (Figure 1) and OITC values range from 24 to 30 (Figure 2). B and D are the highest performers in terms of STC at 35 and 36,

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[3] Under 900sq.ft.(84m^2), averaging 650sq.ft.(60m^2), under 1.5 stories.

respectively. In terms of OITC, B is highest at 30; A, C, D and F perform similarly at 26 to 27.

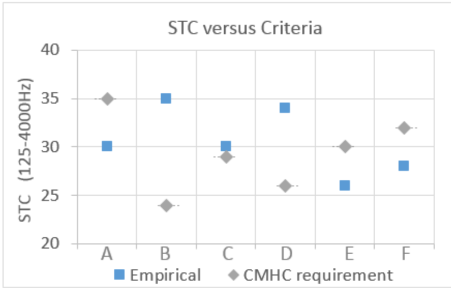

Figure 1. STC (field) versus criteria

3.3 LWH model

Outdoor-indoor TL (OITL) by the LWH model was compared to empirical data. In B, modelled façade data closely aligns with field-measured data from 125Hz to about 2000Hz (Figure 2). In the other five of six case studies, conformance between field and model data is seen in the frequency range of 200Hz to 1250Hz. The largest discrepancies between the LWH model and field-measured data are found in the higher frequencies around 1600Hz and above.

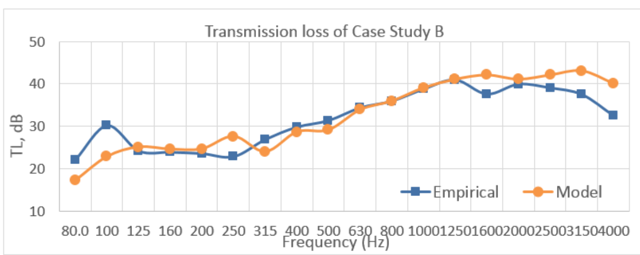

Figure 2: Modelled vs. measured OITL

Figure 3 compares field to model OITC for each test façade. Conformance between field and model values is seen in two cases studies, B and C. In the other four of the six case studies, modelled OITC values are higher than measured by 3 points.

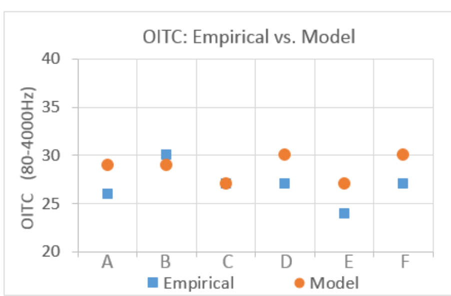

Figure 3: OITC: measured vs modelled

4 DISCUSSION

Empirical and model TL data both indicate that the case study LWH need acoustical improvement, especially in A, E and F. Façade insulation ratings are low across the board, and indoor absorption (Table 1) may be too low in many cases to reduce indoor levels. Based on outdoor noise level estimated by CMHC, A, B and E have outdoor living areas that require additional noise protection.

CMHC-estimated component AIF deficiencies are attributed to, in A: the highest façade/floor area ratio, and the highest outdoor levels coupled with the most sensitive space; in C and E: extensive use of glazed doors.

The results reflect a correlation between architectural characteristics of the LWH and lower acoustical insulation. A, having the highest facade/floor ratio at 106%, has the second lowest measured OITC of 26; B, having the lowest façade/floor area ratio at 41%, has the highest measured insulation ratings OITC 30 and STC 35. E, having the highest fenestration/facade ratio at 46%, has the lowest measured facade insulation of OITC 24 and STC 26. D, with the lowest fenestration/façade ratio at 0%, has the highest model OITC 35 and the second highest empirical STC 34.

In all cases, the LWH model, particularly in Soundflow data, estimated significantly higher TL around frequencies of 1600Hz and above than in measured data. This may be due to additional air leaks existing in real construction, such as at inaccessible details like joints, nails and screws, and service penetrations. Other general discrepancies between model and measured data are primarily attributed to flanking, as in the case of E, where the room has a source-facing roof/ceiling, an adjacent metal garage door, and an adjoining wall with a window near the test façade.

Although the LWH model produced some data that closely approximated measured data, in most cases it overestimated façade performance and thus should not be relied upon for criteria compliance without improvement or additional consideration for discrepancies.

5 CONCLUSION

This case study investigation of Vancouver LWH revealed excessive outdoor noise levels, insufficient façade insulation, and limited indoor absorption. A number of case studies demonstrated a strong correlation between LWH characteristics and low façade insulation. Acoustical education and regulatory drivers are called for in the design and construction of LWH to protect resident health and comfort. Tools to aid this process, such as the CMHC and the LWH models, should be further explored. LWH exposed to high traffic noise need acoustical improvement. Practical steps include installing acoustical fenestration (including skylights), treating air leaks, adding sound-attenuating façade systems like brick cladding or living walls, and taking care in designing sleeping areas and open plans to protect sensitive spaces from noise.

6 REFERENCES

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[3] Bradley & Birta, "Laboratory Measrements of the Sound Insulation of Building Façade Elements," IRC/NRC, 2000.