SOUND TRANSMISSION LOSS OF WOOD-FRAME WALL ASSEMBLIES WITH RAINSCREEN CAVITY AND OPTIONAL SPLIT INSULATION

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INTRODUCTION

The sound transmission loss of wood-frame wall assemblies with rainscreen cavity and optional split insulation was investigated. New BC building codes and provincial guidelines (Homeowner Protection Office, 2011) require high performance exterior wall assemblies to be designed with the incorporation of rainscreen principles and to meet superior performance targets with regards to thermal and moisture performance; however, the sound isolation performance of these wall assemblies was not addressed. Evidence from previously reported test results (Bradley et al., 2000) suggested an improved overall STC rating is expected for rainscreen wall assemblies; however, the limited data is not sufficient to predict the transmission loss of the mandated assemblies. In addition, during the previous evaluations of rainscreen wall assemblies the specimen under test was fully sealed. This represents a face-sealed wall assembly, and does not account for cladding gaps which are required for drainage and ventilation in a rainscreen assembly. Therefore, the prerequisite to the acoustic evaluation of rainscreen assemblies was a specific investigation of the cavity and gap details of the test specimens installed for measurements.

Performance data of current assemblies is required for the validation of predictive modelling to accommodate the diversity of wall assembly solutions. The addition of the rainscreen cavity changes the approach in acoustic modelling from the use of double panel to triple panel sound transmission theory (Sharp, 1973). The data is also required for modelling of transportation noise through the building envelope to meet adopted criteria from Canadian Mortgage Housing Corporation and the World Health Organization.

The outcome of the prerequisite investigation was to include a drainage gap for the evaluation of rainscreen wall assemblies with variation in exterior insulation material, exterior insulation thickness, rainscreen cavity width, cladding attachment, and cladding material. This paper presents the impact of the cladding type and insulation type from the 57 rainscreen walls assemblies evaluated.

METHODOLOGY

At a field lab a sound intensity method was used to measure transmitted sound levels, this scanning approach provides accurate comparative results while being less demanding on infrastructure as per the ASTM E-90. In this hybrid method an outdoor source was provided as per ASTM E966 – 2010 and the

indoor sound levels were measured using a sound intensity probe as per ISO 15186 – 2003. The tests were completed with a noise source (directional loud speaker) positioned at mid-height of wall specimen at a 45º angle, at distant 2.30 m from the wall specimen. Inside a semi-anechoic measuring room, an intensity probe was used to measure sound intensity radiated normal from the wall specimen. Results were analyzed at one-third octave frequency bands to derive comparative transmission loss data and FOITC and FSTC data.

Each specimen wall was built into a framed opening of a mass wall isolated with a resilient interface to minimize flanking to the mass wall. The wall standard was comprised of: 12.7 mm (1/2") gypsum board, 6 mil poly membrane, 38 x 140 mm (2"x 6") wood studs at 406 mm (16") on center, 152 mm (6") fiber glass batt insulation filling stud cavities, plywood sheathing, and a spun bonded polyolefin membrane. All subsequent layers which comprised the wall assembly specimens were installed to the outboard of the membrane.

The prerequisite investigation on nine test assemblies utilized the wall standard with 7.5 mm (5/16") cement panel board cladding on wood strapping. The rainscreen cavity widths evaluated were 9.5 mm (3/8"), 19 mm (3/4") and 25.4 mm (1"). At each cavity width assemblies were evaluated as face sealed, with a drainage gap and with both drainage & top ventilation gaps. All gaps heights were the same dimension as the cavity width.

The 57 rainscreen wall assemblies evaluated were permutations of three claddings: vinyl siding, 7.5 mm (5/16") fiber cement board panel (FCB) siding and stucco; three cladding attachments: wood strapping, Z-Girts, and clips (custom-made for generic compatibility); two exterior insulation types: rigid mineral wool and XPS, at both 38 mm (1 1/2") and 76 mm (3") widths. FCB and Vinyl siding *Base* walls without a rainscreen cavity and without exterior insulation, and FCB and Vinyl siding *Reference* walls with rainscreen cavities - without split insulation were also evaluated.

RESULTS AND DISCUSSION

Results of the prerequisite investigation indicated that as the cavity width and gap heights increases from 9.5 mm to 19 mm to 25.4 mm transmitted sound intensity of vented & ventilated test specimens deviate from a face-sealed test specimen up to 2.8 dB, as averaged across the range of frequencies. The deviations are frequency dependent with a maximum deviation 5.3 dB at the 500 and 2K Hz. The result of this study indicated that use of a face-sealed wall test samples to evaluate rainscreen assemblies will results in measurements underestimating transmission loss at high frequencies and critically overestimate the measurement of transmission loss in low frequency. The outcome of the prerequisite investigation was to include a drainage gap for the evaluation of the 57 rainscreen wall assemblies.

The FOITC and FSTC ranges over the 57 tested assemblies were 26 to 37 and 37 to 52, respectively. The major contribution to increase the sound transmission loss of rainscreen cavity walls can be linked to using both an exterior insulation material that presents sound absorptive characteristics and heavier cladding materials.

The vinyl clad base and reference specimens measured equally, likewise the FCB base and reference specimens measured equally. Indicating that the rainscreen cavity itself did not increase transmission loss.

A vinyl rainscreen cavity wall with mineral wool exterior insulation can increase the FOITC by 1 point, and the FSTC by up to 4 points. With an XPS exterior insulation the increases are 2 points and 2 points, respectively. The range is attributed to insulation thickness, where 3" performed higher than 1-1/2", and cladding attachments.

The FCB rainscreen cavity wall with mineral wool exterior insulation can increase the FOITC by 1 point, and the FSTC by up to 7 points. With an XPS exterior insulation the increases are 1 point and 3 points, respectively. The range is attributed to insulation thickness, where 3" performed higher than 1-1/2", and cladding attachments. With both cladding types the highest performing walls have 3" of insulation and resilient attachment systems.

Due to restraints Stucco Base and Reference walls were not evaluated. In comparison of a rainscreen wall with 3" of mineral wool the stucco cladding increased the FOITC and the FSTC by 7 points and 8 points respectively over vinyl and 6 points and 5 points over FCB cladding (See Table 1).

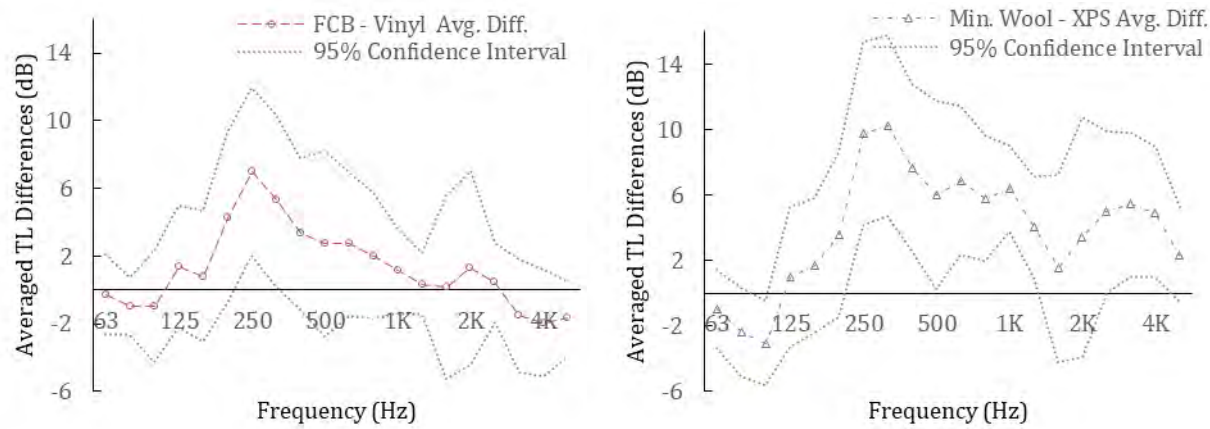
Table 1: List of walls and single-number ratings.

Wall #	Cladding Type	Cladding Attachment	Rainscreen Cavity Width	Exterior Insulation	Ext. Insul. Thickness	FOITC	FSTC
33	Vinyl	Base Wall	--	--	--	28	39
34	FCB	Base Wall	--	--	--	29	40
35	FCB	Reference	3/8"	--	--	29	40
36	Vinyl	Reference	3/8"	--	--	28	39
20	Vinyl	S2 - Z-girt	3/8"	Min. Wool	3"	29	43
53	Vinyl	S3 - Clips	3/8"	XPS	3"	30	41
48	FCB	S3 - Clips	3/8"	Min. Wool	3"	30	47
54	FCB	S3 - Clips	3/8"	XPS	3"	30	43
55	Stucco	Wood Strap.	3/8"	Min. Wool	3"	36	52

Single-number ratings are still largely used by the industry to be a watershed when selecting a wall, a window, or other building material. FSTC and FOITC must be carefully used due to lack of frequency dependent data according to study findings. FOITC tended to better express sound transmission loss than FSTC, because of its broader frequency calculation range. FOITC had narrower range (11 points) versus FSTC (15 points). A further observation and analysis of the frequency dependent TL data of a wall is required in order to verify a satisfactory sound attenuation at a particular frequency range of interest and to begin to understand the acoustical principles which apply to the overall performance. Results for cladding indicated that TL increased around 7 dB at 250 Hz and on average was higher than 2 dB from 200 to 800 Hz when for FCB walls compared to vinyl cladding walls (See Figure 1(a)).

As for the exterior insulation, results indicated that material type does influence the amount of sound absorption consequently reducing sound transmission. Most significant results were found for mineral wool causing an increase in TL greater than 4 dB between 200 and 1250 Hz and a maximum value of 10 dB over XPS. In this study, mineral wool presented higher results than XPS across the frequency spectrum hence aligning results with hypothesis. Results for insulation types were in agreement with Sharp (1973), Quirt et al. (1995), and Cambridge (2012) (See Figure 1(b)). Stucco cladding brought about a substantial impact for the tested walls. Results indicated that this much denser material was capable of significantly change the

low frequency sound levels and consequently the single-number ratings FSTC and FOITC. The change in TL for stucco walls reached nearly 17 dB at 250 Hz whereas there was consistent improvement between 63 and 400 Hz. Results for denser cladding aligned with Bradley and Birta (2000, 2001), Nightingale and Quirt (1999), Quirt and Warnock (1993), and Quirt et al., (1995).



(a) **(b)**

Figure 1: Averaged transmission loss of differences between: (a) FCB and vinyl claddings; (b) mineral wool and XPS exterior insulation

ONGOING RESEARCH

The impact of rainscreen cavity width, cladding to sheathing depth, and cladding attachment types on sound transmission loss from the 57 wall measurements are currently under investigation.

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