Sound Transmission of Wood-Frame Rain Screen Cavity Wall Assemblies

CCBST 2017

Vancouver

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Faculty Building Science Graduate Programs

School of Construction and the Environment

BCIT™

Agenda

Context

Building Science Community and Advisory Committee

- Review of existing data of wood-frame assemblies
- Process for candidate selection

Method

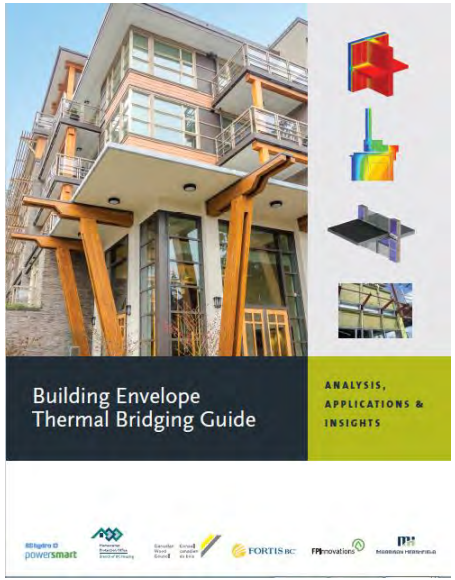
Drainage and ventilation's gaps on test sample

Selected Results

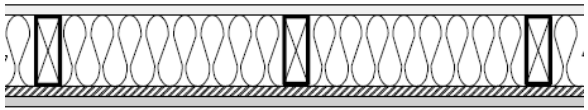
Proposed Candidates for ASTM E-90 measurements

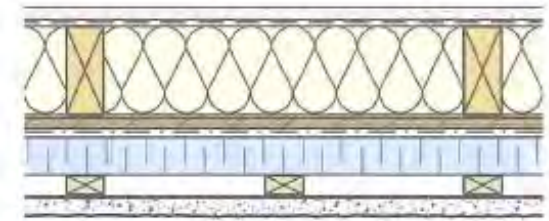
Context

Recent increase in thermal performance requirements in BC (HPO, 2011; MH, 2014; BCBC, 2012; CVBBL, 2014) has promoted new wall assemblies which have not been acoustical evaluated. Modelling of split insulation and rain screen cavities can not be validated.



Acoustic investigation -objective





Sound Transmission Loss - Acoustical Principles for Consideration

Rain Screen Cavity Width

Mechanical decoupling of external layers

Mass-air-mass resonance

Absorption of sound by exterior insulation

June 23, 2016 Advisory Committee

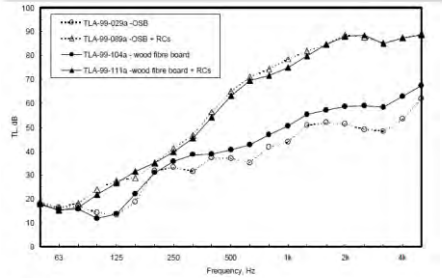
Combination of all possible variations in each layer provides an unfeasible amount of possible variations

Principles for selecting assemblies / candidate selection process:

		# Options
Interior Board	Material	3
	RC	2
Cavity Insulation	Material	4
Wood Studs	Size	2
	Spacing	2
	Staggered	2
Sheathing	Material	2
Exterior Insulation	Material	5
	Thickness	3
Strapping	Material	4
	Attachment	4
	Cavity Width	4
Cladding	Material	6

- alignment w/ thermal performance codes
- no repeats of previous studies
- field-lab screen for critical variables

Extended data field



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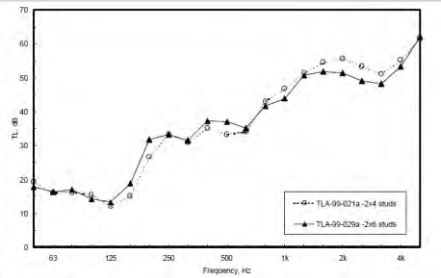
TLA-99-029a	VIN1_OSB11_WS140(406)_GFB152_G13	25
TLA-99-089a	VIN1_GFR25_OSB11_WS140(406)_GFB152_RC13(610)_2G13	35
TLA-99-104a	VIN1_WFB13_WS140(406)_GFB152_G13	25
TLA-99-111a	VIN1_GFR25_WFB13_WS140(406)_GFB152_RC13(610)_2G13	33

Sheathing



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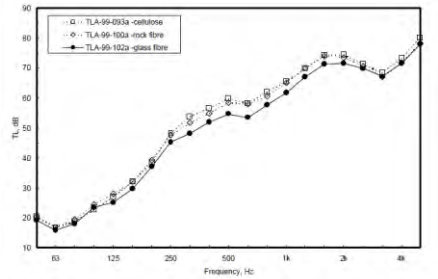
TLA-00-021a	VIN1_OSB11_WS89(406)_GFB89_G13	24
TLA-99-029a	VIN1_OSB11_WS140(406)_GFB152_G13	25

Stud (size, spacing, staggered)

NRC –CNRC IRC IR-818
J.S.Bradley and
J.A. Birta (2000)

Cladding types



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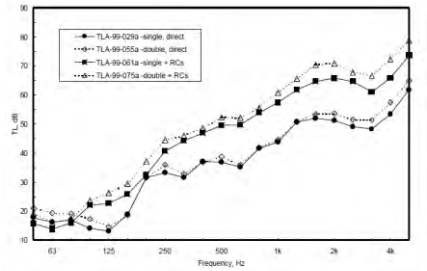
TLA-99-102a	VIN1_OSB11_WS140(406)_GFB152_RC13(610)_2G13	34

Wall Insulation



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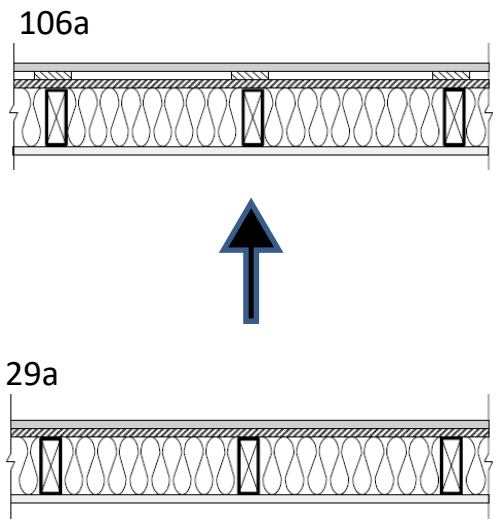
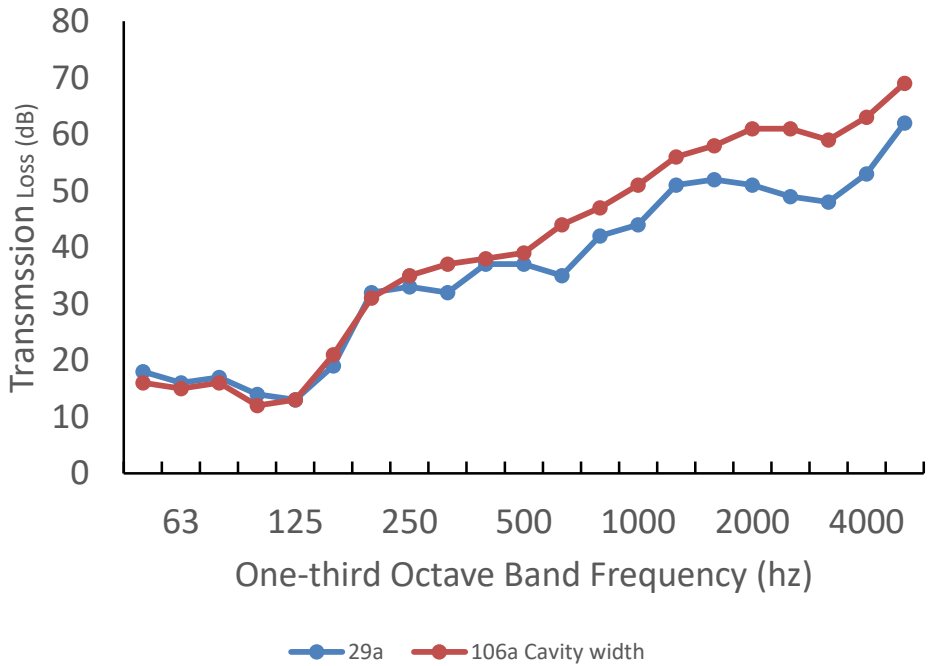
TLA-99-055a	VIN1_OSB11_WS140(406)_GFB152_2G13	27
TLA-99-061a	VIN1_OSB11_WS140(406)_GFB152_RC13(610)_G13	32
TLA-99-075a	VIN1_OSB11_WS140(406)_GFB152_RC13(610)_2G13	34

Resilient channels

Interior Drywall

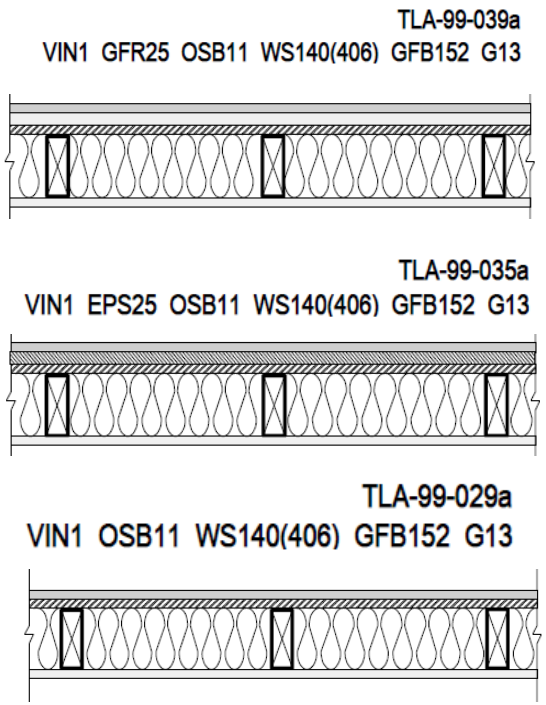
Limited data on a Rain screen walls



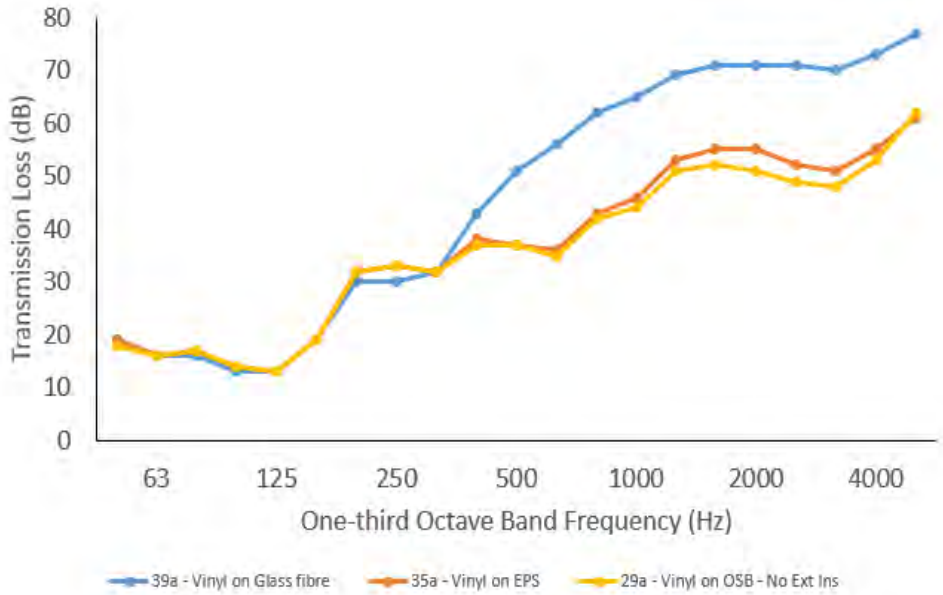


Bradley and Birta (2000)

Limited data on exterior insulation



Bradley and Birta (2000)



Rigid glass fibre board – 1.3 Kg/m2
XPS – 0.6 Kg/m2

Advisory Committee June 23, 2016

Establish **base wall** onto which the exterior layers to be tested:

Interior board,12.7 mm gypsum board

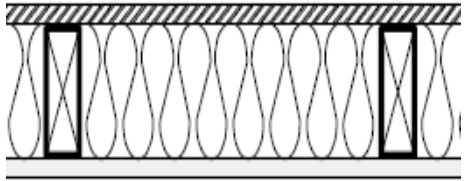
Wood studs 38 x 140 mm, 400 mm o.c.

Interior insulation, glass fibre batt

Sheathing, 19 mm plywood

Inclusive of a polyethylene film vapour barrier

And spun-bonded polyolefin water resistive barrier



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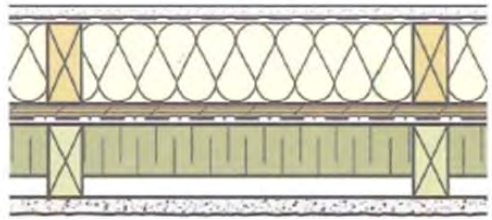
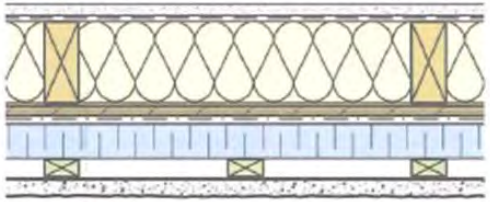
Outboard of sheathing variables to establish:

- Cavity width
  - Building code minimum
  - Acoustical decoupling recommendation



- Cladding attachment
  - Bridged
  - Un-bridged



- Exterior insulation type
  - Thickness
- Cladding

57 Rainscreen Cavity wall assemblies

Bridged Wall Types				
Cladding Attachment	Exterior Insulation	Ext. Insulation Thickness	Rainscreen Cavity Width	Cladding
S1	None	---	3/8"	Vinyl
				F CB
			1"	Repeat
S2	Mineral Wool	1 ½"	3/8"	Vinyl
				FCB
			1"	Repeat
		3"	Repeat	
	XPS	Repeat		
Un-bridged Wall Types				
Mineral Wool	1 ½"	S1	3/8"	Vinyl
				FCB
			1"	Repeat
		S3	Repeat	
	3"	Repeat		
XPS	Repeat			
Mineral Wool	1 ½"	S1	3/8"	Stucco
	3"			
XPS	1 ½"			

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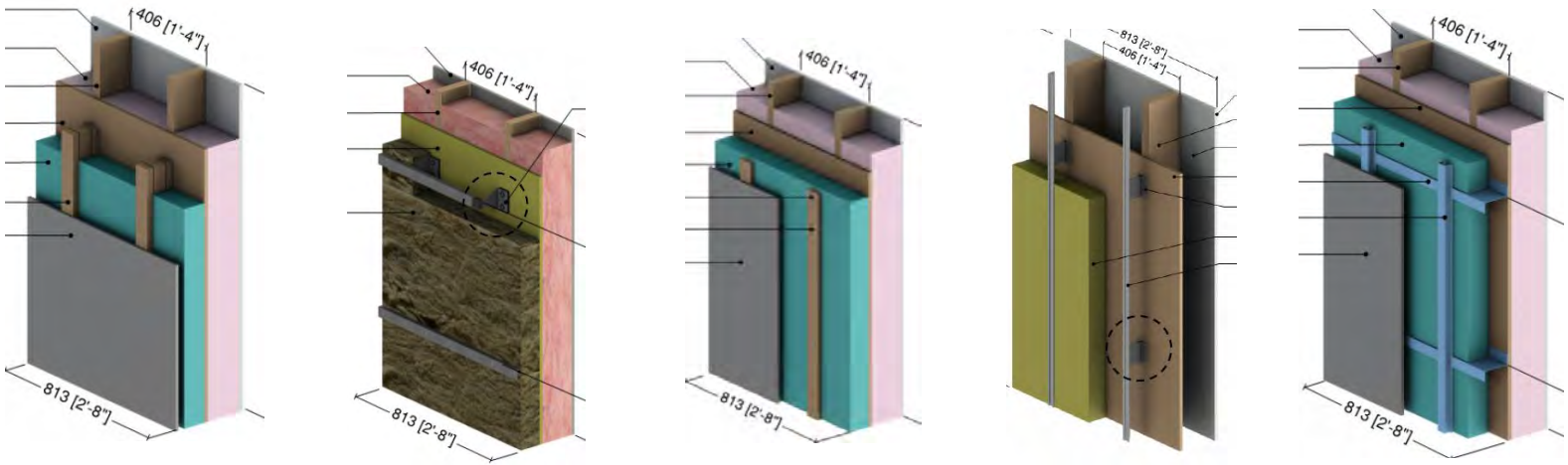
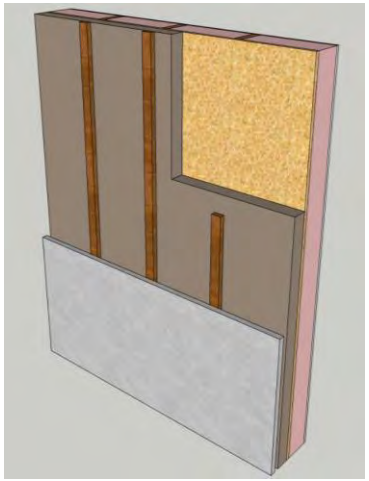
Cladding attachments



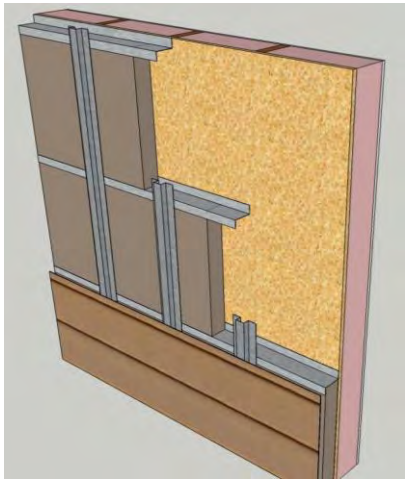
Line connection: Continuous wood strapping over insulation
Point connection: Bracket with horizontal aluminum slats
Hybrid connection: Horizontal Z-girts w/ steel furring hat track

Lab translation

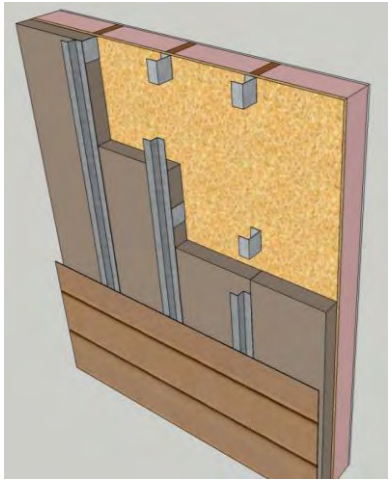
Cladding attachments



S1



S2



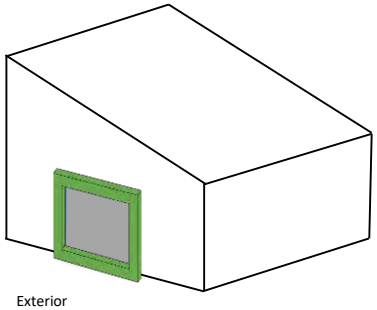
S3

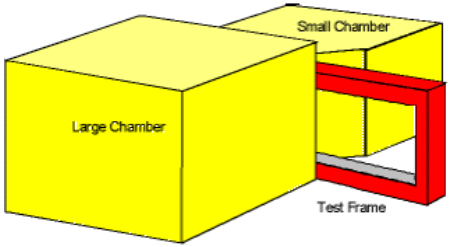
Bridged S1 : Continuous wood strapping without insulation
S2 : Z-girts w/ steel furring hat track

Un-bridge S1: Continuous wood strapping with insulation
S3: Clips and furring S-track

Research methods

CANDIDATE SCANS at BCIT
ASTM E966 Field Measurements of Airborne Sound Insulation of Building Facades and
Facade Elements /ISO 15186 Measurement of sound insulation in buildings and of building elements using sound intensity





2.44 x 2.13 m opening

Image: IRC/NRC

FINAL TEST at NRC Direct Transmission Loss suite
ASTM E90 Laboratory Measurement of Airborne Sound Transmission of Building Partitions and Element

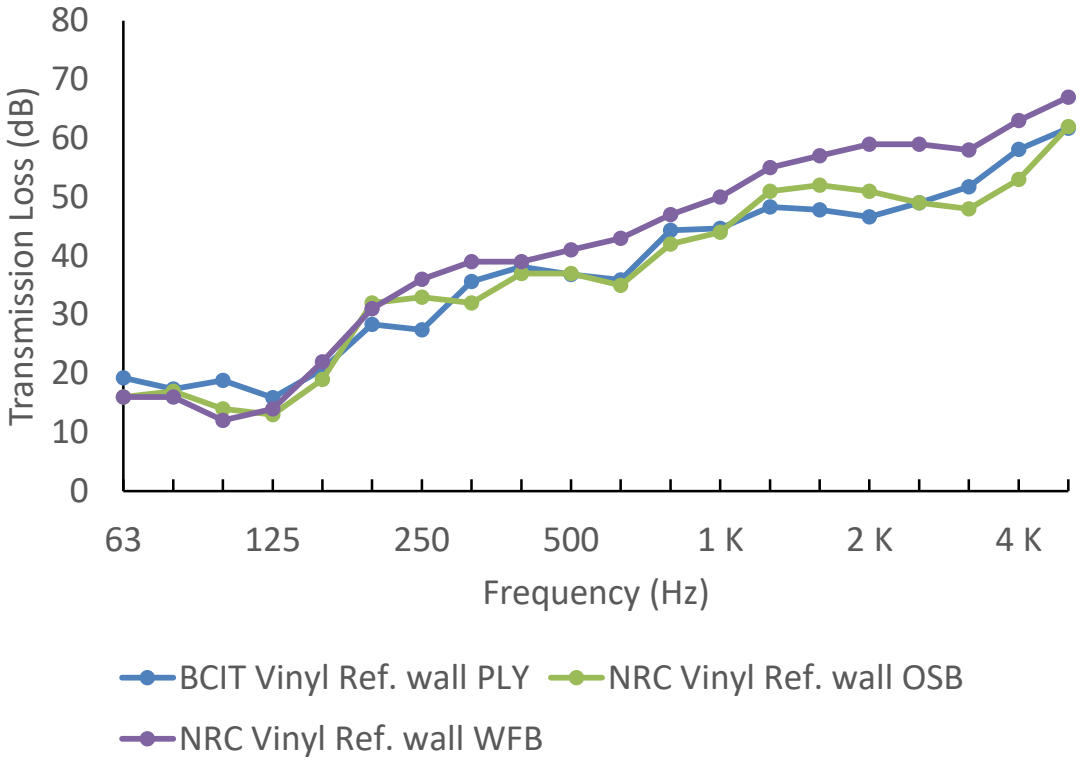
BCIT Field lab for scanning candidates

BCIT Field lab for scanning candidates

BCIT Field lab for scanning candidates

BCIT Field lab for scanning candidates

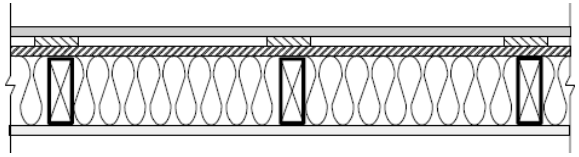
BCIT Hybrid Test vs IRC/NRC ASTM E-90



Critical specimen detail

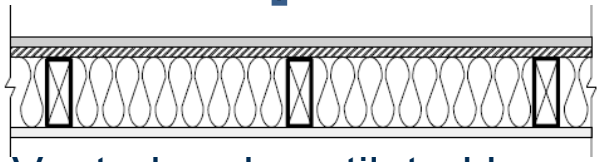
What are the effect of rain screen cavity width and ventilation's gaps on the acoustical measurements of exterior wall assembly?

106a



Sealed in previous test

29a



Vented and ventilated have air gaps which were not accounted for

In previous evaluations……need to establish standard

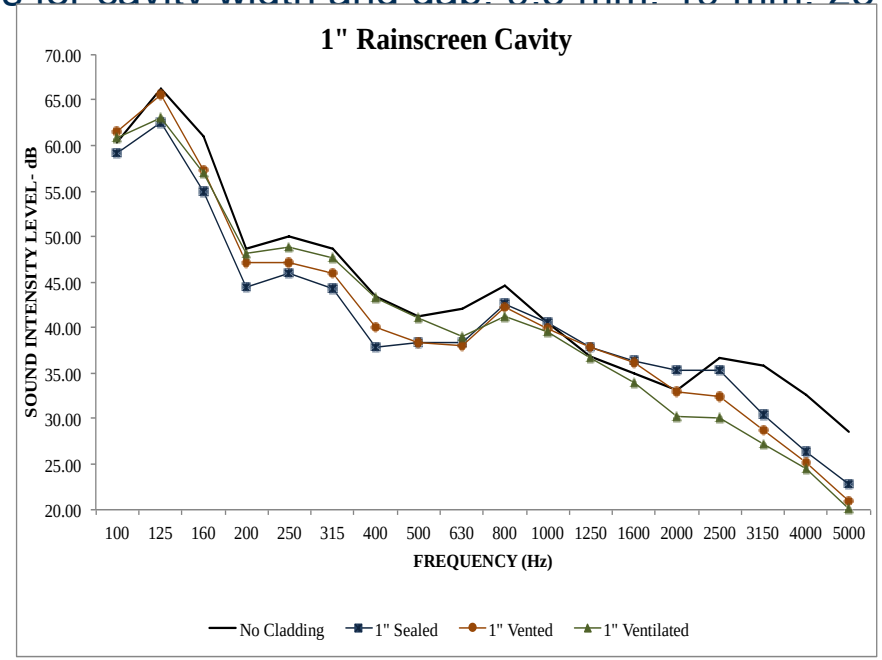
Investigate cavity width and gap

cladding with sealed cavity.

cladding with vented cavity, one equivalent width gap

cladding with ventilated cavity, two equivalent width gaps

Dimensions for cavity width and gap: 9.5 mm, 19 mm, 25 mm



Analysis: drainage & ventilation detail

Cavity & gap widths	Average deviation <1000 Hz	Average deviation >1000 Hz	Maximum deviation dB (Hz band)
9.5 mm (3/8”)	1.3	1.3	2.5 (1K Hz)
19 mm (3/4”)	1.7	1.3	4.0 (2 K Hz)
25 mm (1”)	2.7	2.9	5.3 (500 - 2 K Hz)

Sealed specimens (over all widths)		
Average	4 dB Over-estimate 8 dB (250 Hz)	3 dB Under-estimate 6 (2500 Hz)

<u>Direction provide: single drainage gap for all specimens</u>

57 Rainscreen Cavity wall assemblies

Addition of the rainscreen cavity

Base wall vs Reference cavity wall
direct attachment of cladding (Bridge S1, wood strapping)

#33 Vinyl Base wall [28/39] to
#36 Vinyl REF - 3/8” cavity [28/39], #37 Vinyl REF - 1” cavity [28/38]

#34 FCB Base wall [29/40] to
#35 FCB REF - 3/8” cavity [29/40], #37 FCB REF - 1” cavity [28/40]

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

Selected results

Addition of exterior (split) insulation

Reference cavity walls vs 1-1/2” mineral wool

#36 Vinyl REF - 3/8” cavity [28/39], #37 Vinyl REF 1” cavity [28/38]

ADD 1½” MW	#1	S1[26/37]	#4	S1 [27/38]
	#7	S2 [29/40]	#6	S2 [29/40]
	#39	S3 [27/39]	#41	S3 [28/40]

Observations: Pattern not strong to argue in favour of the added insulation, something about S2 as a connector is emerging: see 3” insulation.

Selected results

Addition of exterior (split) insulation

Reference cavity walls vs 3” mineral wool

#36 Vinyl REF - 3/8” cavity [28/39], #37 Vinyl REF 1” cavity [28/38]

ADD 3 ” MW	#22 S1[28/39]	#24 S1 [28/39]
	#20 S2 [29/43]	#18 S2 [29/43]
	#47 S3 [28/42]	#49 S3 [28/42]

Observation: Increase cavity with insulation can provide an increase in TL, with resiliently in attachment, again a nominal increase TL

(pattern for further E90 test)

Emerging pattern - Vinyl FSTC

1	Vinyl	S1 -Strapping	3/8"	Min. Wool	1 1/2"	26	37
29	Vinyl	S1 -Strapping	1"	XPS	3"	28	37
4	Vinyl	S1 -Strapping	1"	Min. Wool	1 1/2"	27	38
37	Vinyl	S1 -Strapping	1"			28	38
43	Vinyl	S3 - Clips	1"	XPS	1 1/2"	29	38
52	Vinyl	S3 - Clips	1"	XPS	3"	29	38
39	Vinyl	S3 - Clips	3/8"	Min. Wool	1 1/2"	27	39
22	Vinyl	S1 -Strapping	3/8"	Min. Wool	3"	28	39
24	Vinyl	S1 -Strapping	1"	Min. Wool	3"	28	39
25	Vinyl	S1 -Strapping	1"	XPS	1 1/2"	28	39
28	Vinyl	S1 -Strapping	3/8"	XPS	1 1/2"	28	39
33	Vinyl	Base Wall				28	39
36	Vinyl	S1 -Strapping	3/8"			28	39
41	Vinyl	S3 - Clips	1"	Min. Wool	1 1/2"	28	40
6	Vinyl	S2 - Z-Girt	1"	Min. Wool	1 1/2"	29	40
7	Vinyl	S2 - Z-Girt	3/8"	Min. Wool	1 1/2"	29	40
9	Vinyl	S2 - Z-Girt	1"	XPS	1 1/2"	29	40
12	Vinyl	S2 - Z-Girt	3/8"	XPS	1 1/2"	29	40
14	Vinyl	S2 - Z-Girt	3/8"	XPS	3"	29	40
15	Vinyl	S2 - Z-Girt	1"	XPS	3"	29	40
32	Vinyl	S1 -Strapping	3/8"	XPS	3"	29	40
45	Vinyl	S3 - Clips	3/8"	XPS	1 1/2"	29	40
53	Vinyl	S3 - Clips	3/8"	XPS	3"	30	41
47	Vinyl	S3 - Clips	3/8"	Min. Wool	3"	28	42
49	Vinyl	S3 - Clips	1"	Min. Wool	3"	28	42
18	Vinyl	S2 - Z-Girt	1"	Min. Wool	3"	29	43
20	Vinyl	S2 - Z-Girt	3/8"	Min. Wool	3"	29	43

Emerging pattern - FCB FSTC

10	FCB	S2 - Z-Girt	1"	XPS	1 1/2"	28	38
3	FCB	S1 -Strapping	1"	Min. Wool	1 1/2"	27	39
5	FCB	S2 - Z-Girt	1"	Min. Wool	1 1/2"	27	40
8	FCB	S2 - Z-Girt	3/8"	Min. Wool	1 1/2"	28	40
11	FCB	S2 - Z-Girt	3/8"	XPS	1 1/2"	29	40
13	FCB	S2 - Z-Girt	3/8"	XPS	3"	29	40
16	FCB	S2 - Z-Girt	1"	XPS	3"	28	40
26	FCB	S1 -Strapping	1"	XPS	1 1/2"	28	40
27	FCB	S1 -Strapping	3/8"	XPS	1 1/2"	29	40
34	FCB	Base Wall				29	40
35	FCB	S1 -Strapping	3/8"			29	40
38	FCB	S1 -Strapping	1"			28	40
2	FCB	S1 -Strapping	3/8"	Min. Wool	1 1/2"	29	41
30	FCB	S1 -Strapping	1"	XPS	3"	29	41
44	FCB	S3 - Clips	1"	XPS	1 1/2"	28	41
46	FCB	S3 - Clips	3/8"	XPS	1 1/2"	30	41
31	FCB	S1 -Strapping	3/8"	XPS	3"	30	42
51	FCB	S3 - Clips	1"	XPS	3"	29	42
17	FCB	S2 - Z-Girt	1"	Min. Wool	3"	29	43
21	FCB	S1 -Strapping	1"	Min. Wool	3"	30	43
23	FCB	S1 -Strapping	3/8"	Min. Wool	3"	30	43
40	FCB	S3 - Clips	3/8"	Min. Wool	1 1/2"	28	43
42	FCB	S3 - Clips	1"	Min. Wool	1 1/2"	28	43
54	FCB	S3 - Clips	3/8"	XPS	3"	30	43
19	FCB	S2 - Z-Girt	3/8"	Min. Wool	3"	29	44
48	FCB	S3 - Clips	3/8"	Min. Wool	3"	30	47
50	FCB	S3 - Clips	1"	Min. Wool	3"	30	47

Emerging Patterns – Stucco FSTC

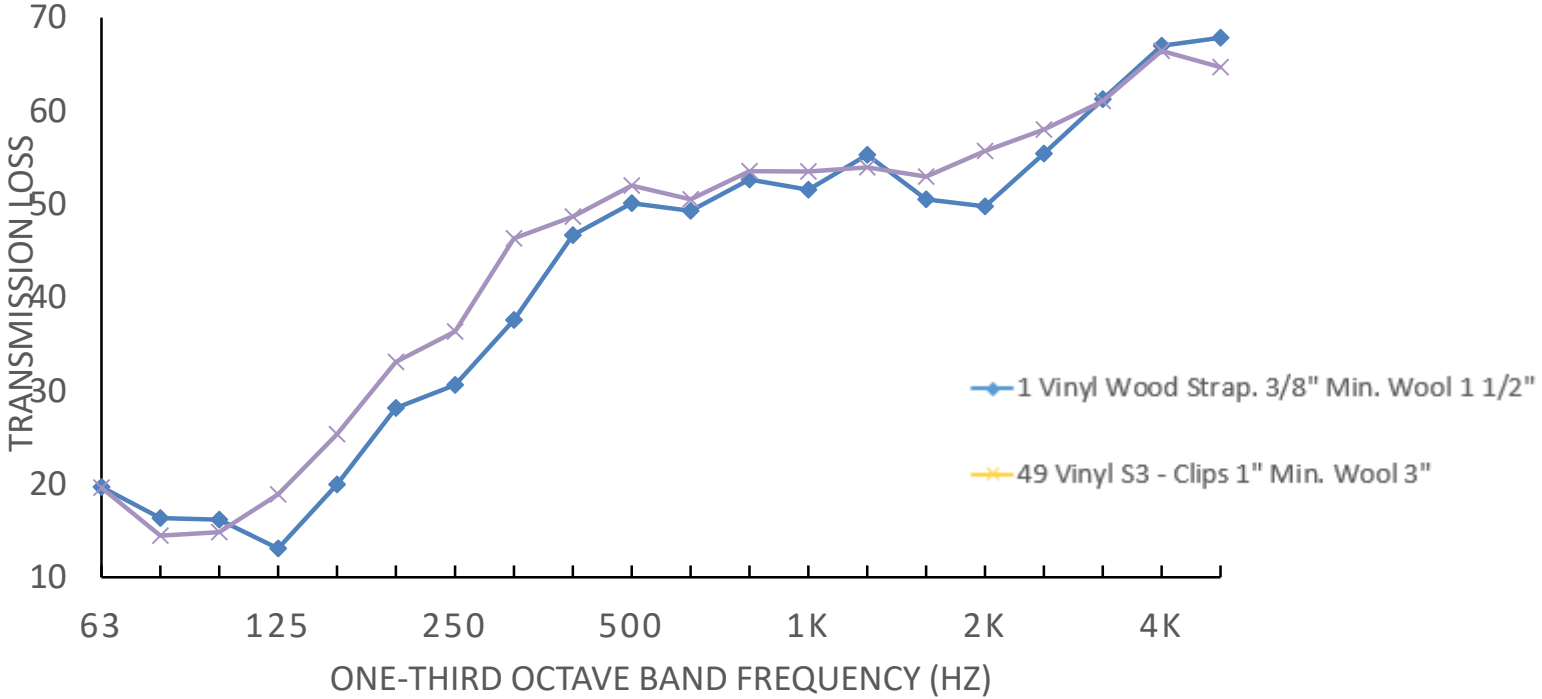
28	Vinyl	S1 -Strapping	3/8"	XPS	1 1/2"	28	39
27	FCB	S1 -Strapping	3/8"	XPS	1 1/2"	29	40
57	Stucco	S1 -Strapping	3/8"	XPS	1 1/2"	37	49
1	Vinyl	S1 -Strapping	3/8"	Min. Wool	1 1/2"	26	37
2	FCB	S1 -Strapping	3/8"	Min. Wool	1 1/2"	29	41
56	Stucco	S1 -Strapping	3/8"	Min. Wool	1 1/2"	37	51
22	Vinyl	S1 -Strapping	3/8"	Min. Wool	3"	28	39
23	FCB	S1 -Strapping	3/8"	Min. Wool	3"	30	43
55	Stucco	S1 -Strapping	3/8"	Min. Wool	3"	36	52
57	Stucco	S1 -Strapping	3/8"	XPS	1 1/2"	37	49
56	Stucco	S1 -Strapping	3/8"	Min. Wool	1 1/2"	37	51
55	Stucco	S1 -Strapping	3/8"	Min. Wool	3"	36	52

Given VINYL Cladding

Top: Resilient attachments **and** 3” mineral wool

Then: Resilient and 3” XPS or 1-1/2” mineral wool

Then: Wood strapping and either insulation or thickness

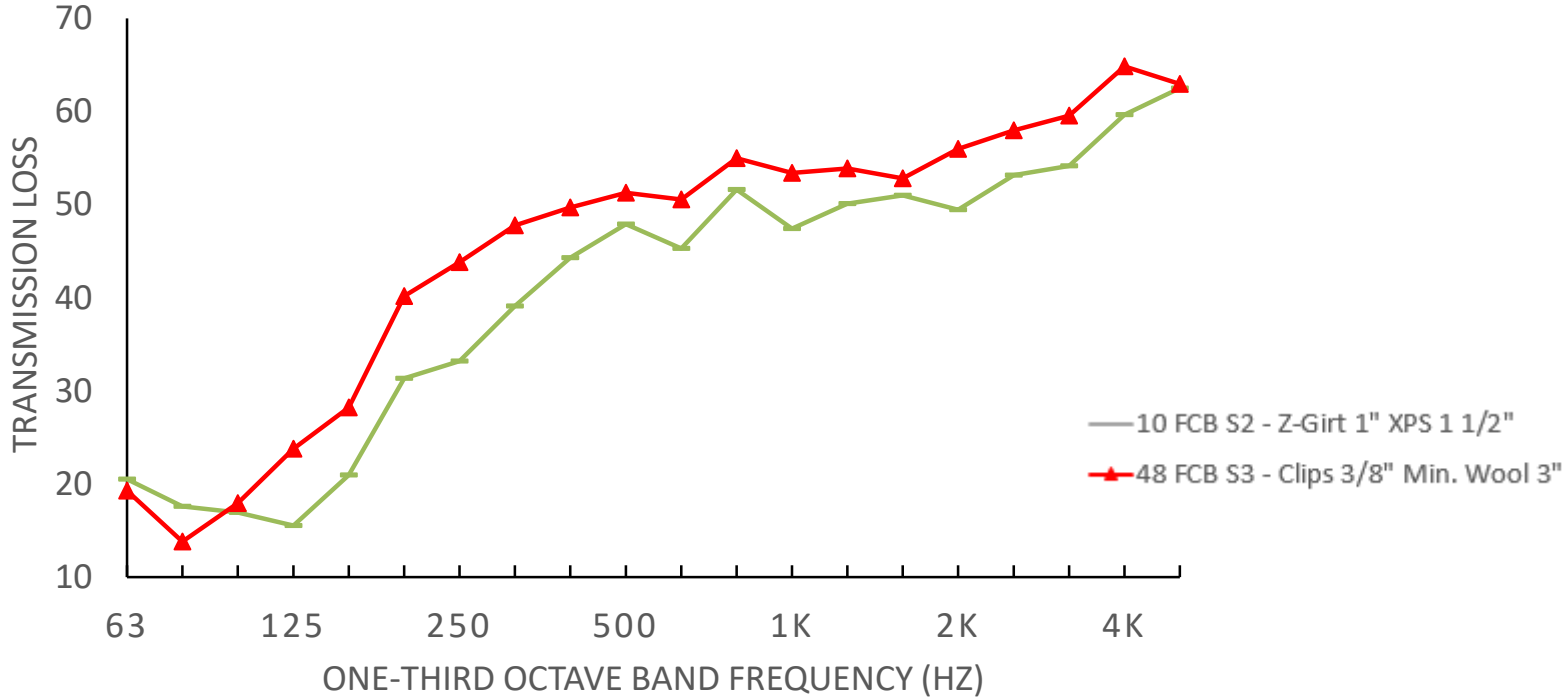


Given FCB Cladding

Top performer: S3 attachment and 3” mineral wool insulation

Then: S2/S3 resilient attachment and 3” XPS

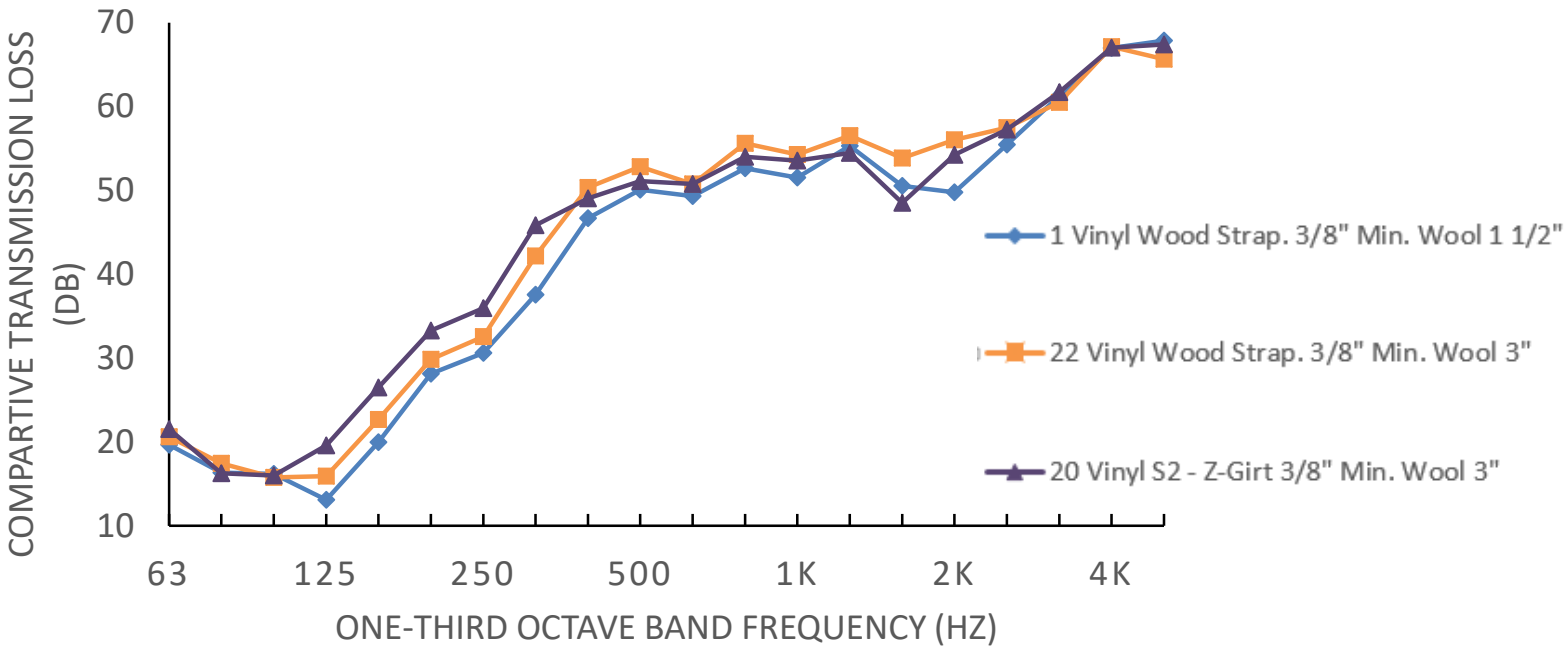
Then: 1-1/2” insulation



Given Stucco Cladding

If Stucco (where only S1 wood strapping was evaluated)

Most important: type of exterior insulation or thickness



Proposed candidates for E-90 Evaluation

Reconstruct wall at IRC/NRC for E90 evaluation: higher level of accuracy and consistency in patterns, so we can draw acoustical reason.

Cladding and insulation thickness are reasonably understood, cavity width does not seem to be dominate

Relationship between type of insulation and type of cladding attachment is of interest, in association with cladding

1, 1.1	Vinyl	S1	3/8"	Min. Wool	1 ½" and 3"
2	Vinyl	S2/3		Min. Wool	3"
3	Vinyl	S1		XPS	3"
4	Vinyl	S2/3		XPS	3"
5, 5.1	FCB	S1	3/8"	Min. Wool	1 ½" and 3"
6	FCB	S2/3		Min. Wool	3"
7	FCB	S1		XPS	3"
8	FCB	S2/3		XPS	3"

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THANK YOU

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