





Moisture Safe High-R Walls

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Highly Insulated walls

- Biggest energy users in *new* Canadian houses
 - Space heating followed by
 - Domestic hot water
- Codes and Consumers demand more
 - Increasing Insulation
 - Increasing Airtightness
- Concerns about moisture risk
 - Any change comes with risk of unknown



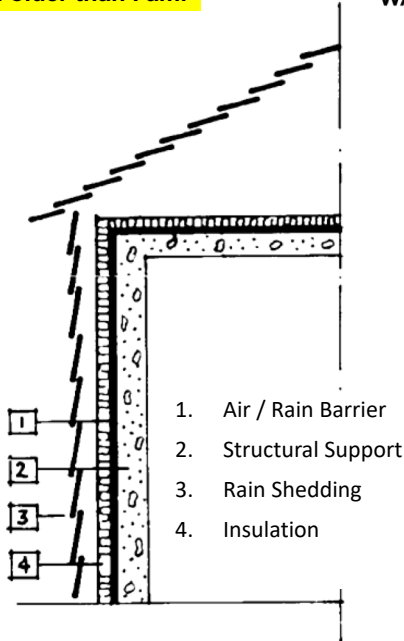
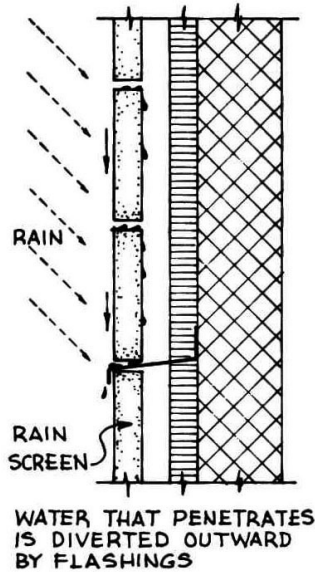
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Mom's Rules of Building Science

- “Close the window / door / fridge”
 - Airtightness matters
- “Wear a hat”
 - Overhangs = Sunshade, rain shelter
- “Don't tuck your pants into your boots”
 - Drainage and shingling
- “Wear your jacket, sweater, mittens”
 - Insulate on the outside

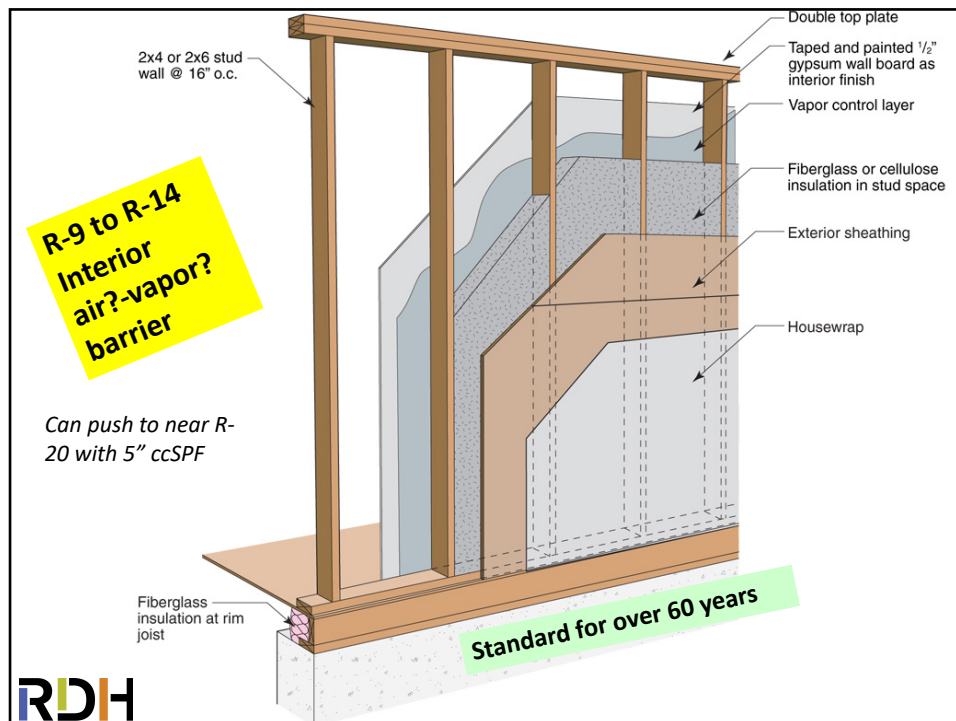
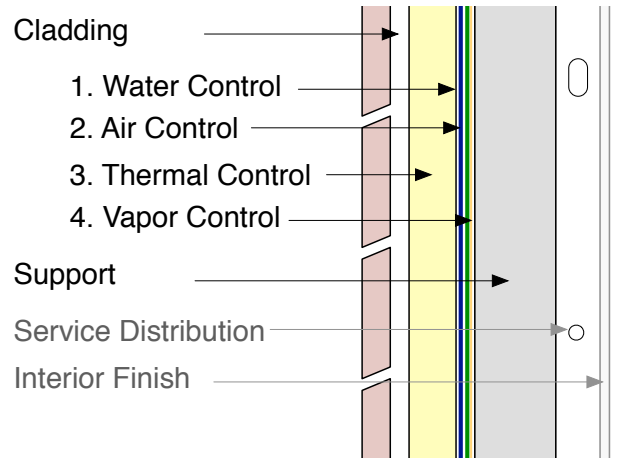


Design Information older than I am.



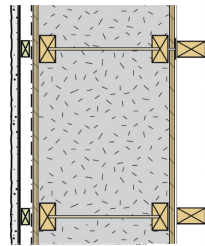
“Perfect Wall”

- Why perfect? Identify layers & Arrangement

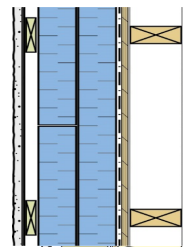


But we need more insulation

Stuff It?

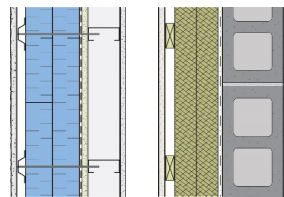
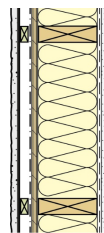


Wrap It?



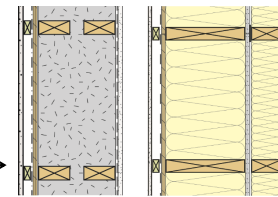
Achieving Higher Insulation Levels

Base 2x6
Framed Wall
<R-16 (wood)



Exterior Insulation
R-15 to R-60+

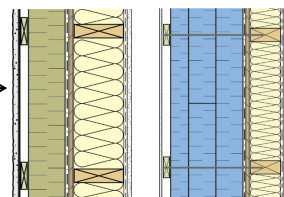
Issues: cladding attachment, thickness



Deep Stud,
Double
Stud,
SIPS
R-20 –
R-80+

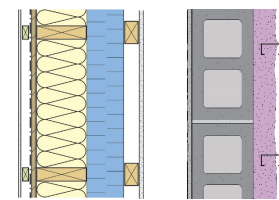
Issues: thermal bridging, thickness, durability

Split Insulation R-20
to R-60+

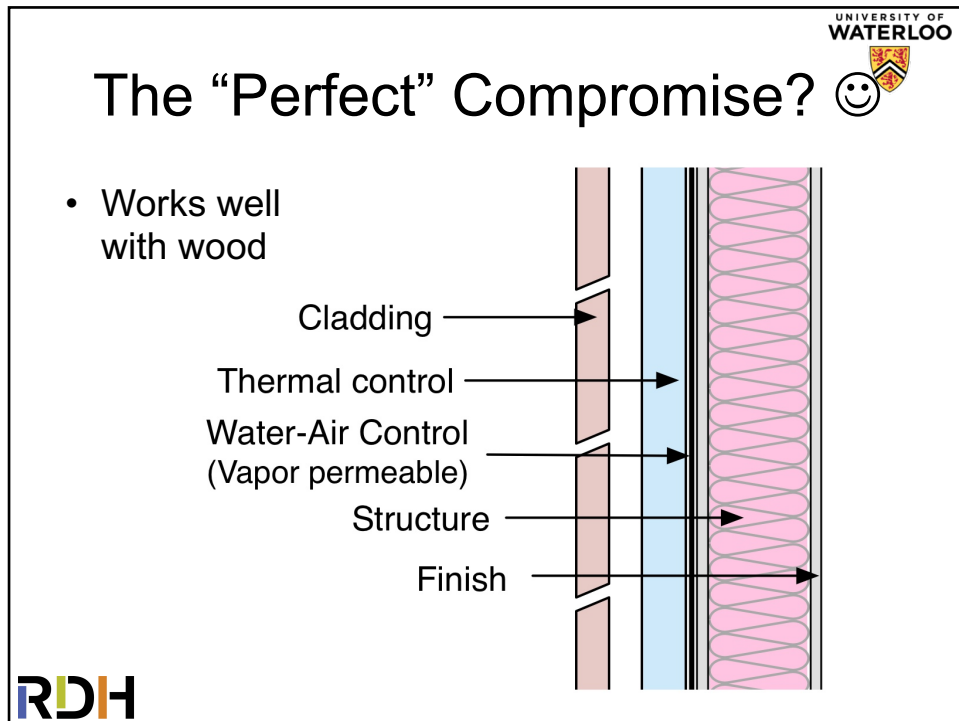
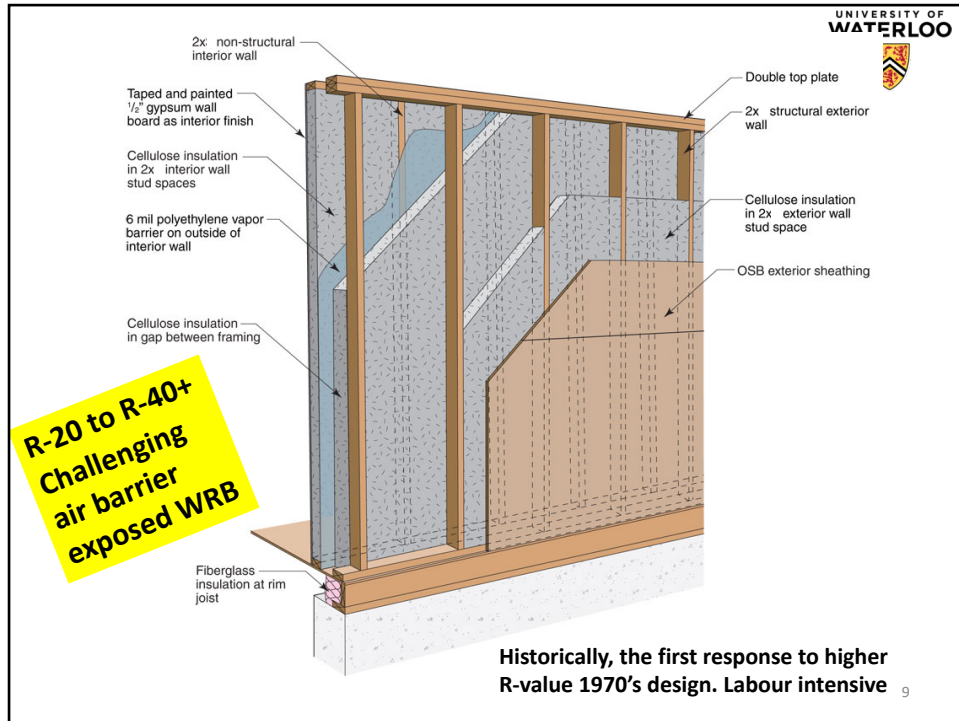


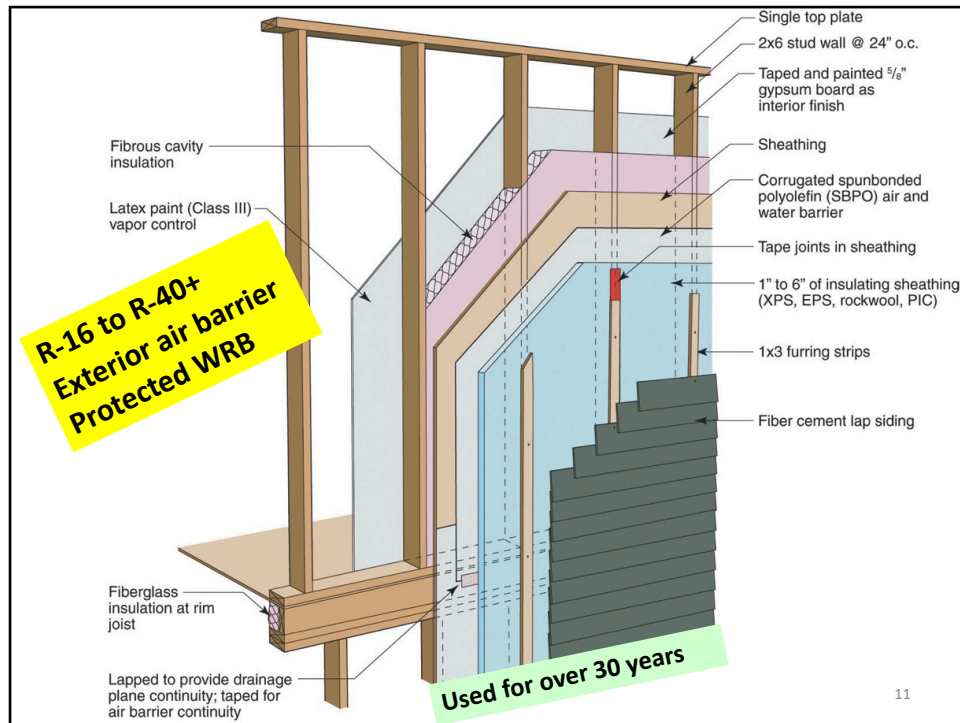
Issues: cladding attachment, material selection


Interior Insulation
R-20 to R-30+



Issues: thickness, durability, interior details








Exterior Insulation Practise

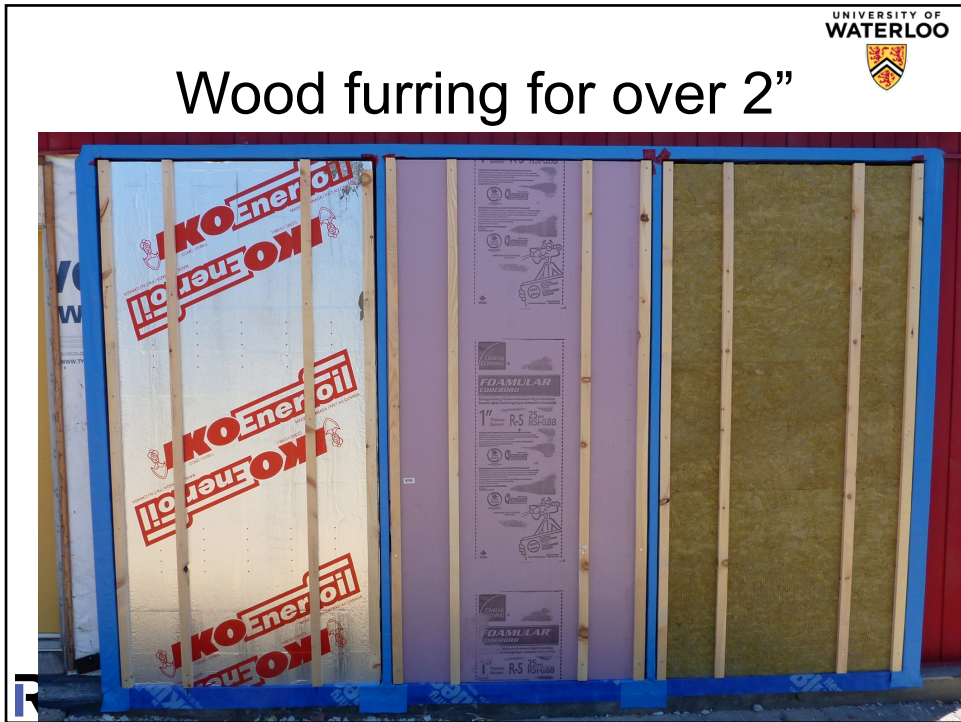
Issues

- Insulation choice
- Cladding Attachment
- Moisture concerns
- Window / door penetrations
- Decks and porches


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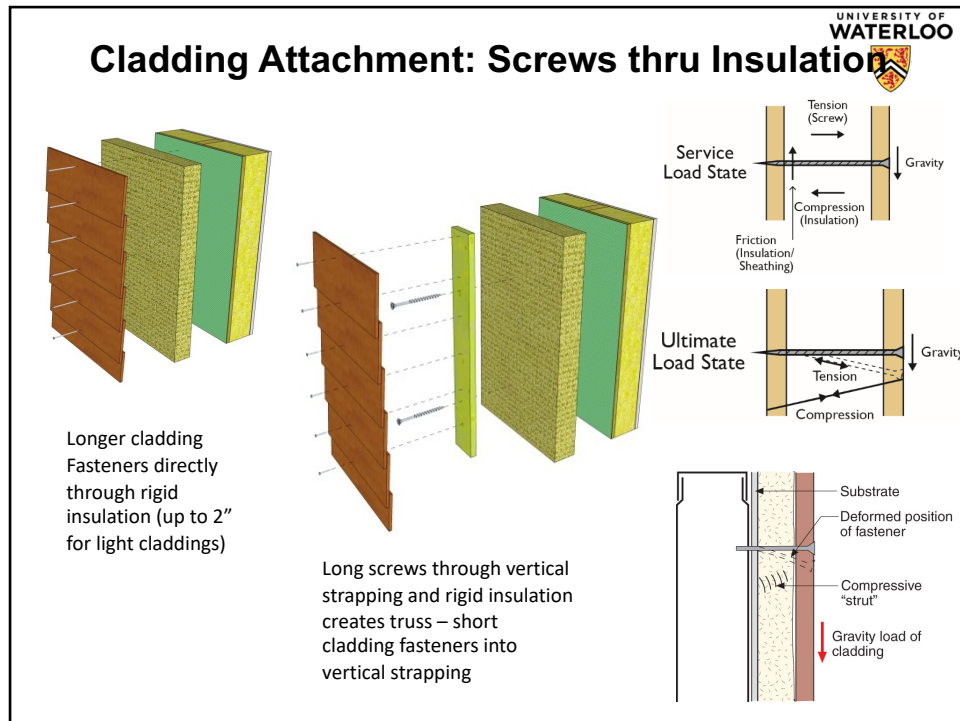


Experience with many insulations



Wood furring for over 2"





Failure modes

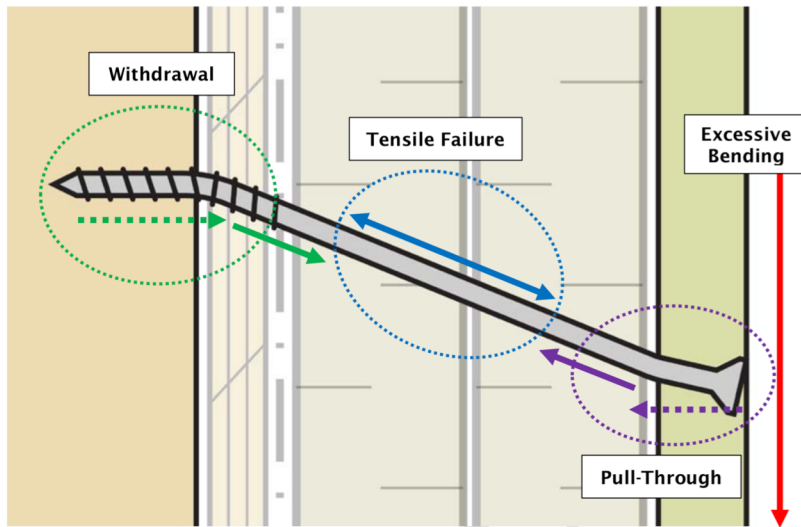


Figure 3.11 Illustration of possible mechanical failures relating to a screw securing a

Cladding Attachment: Screws through Insulation

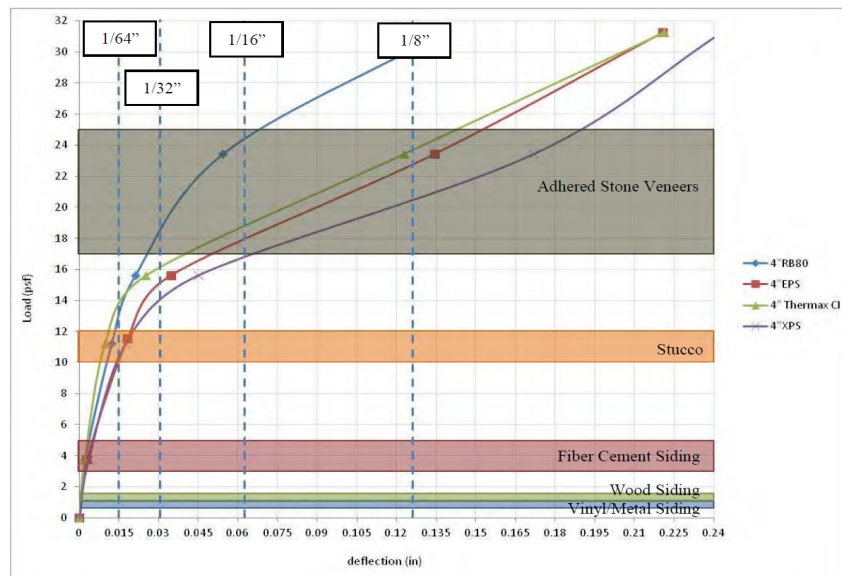
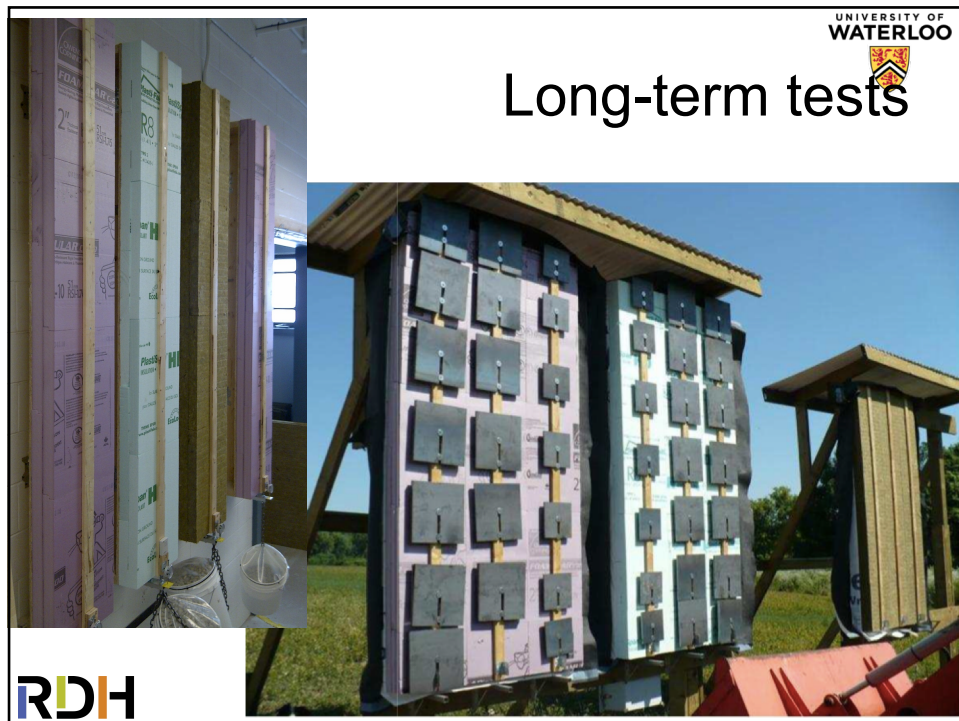
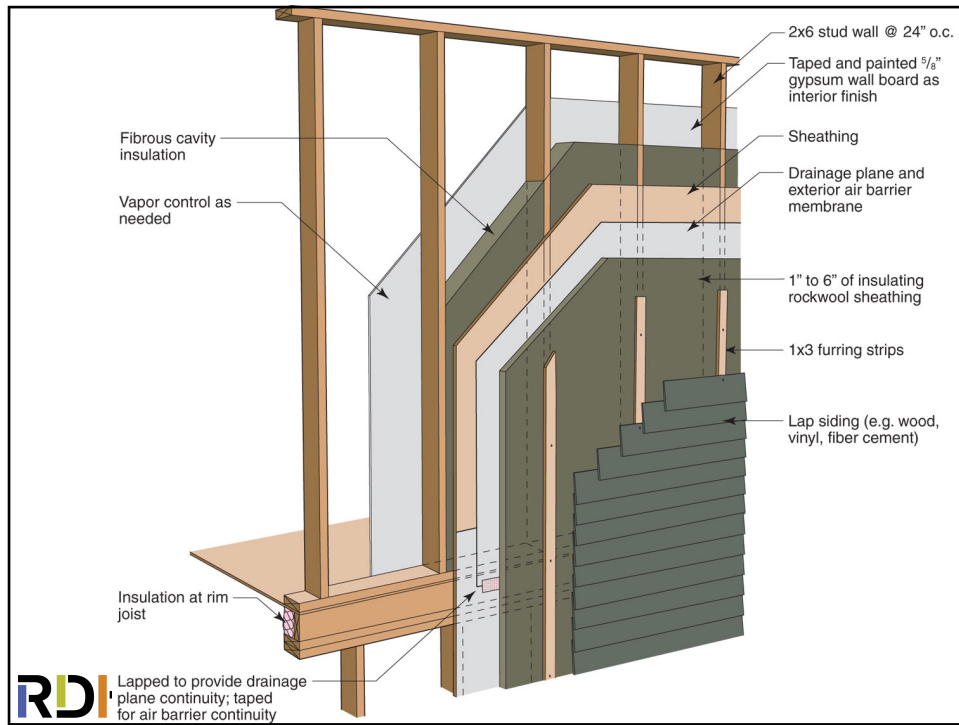
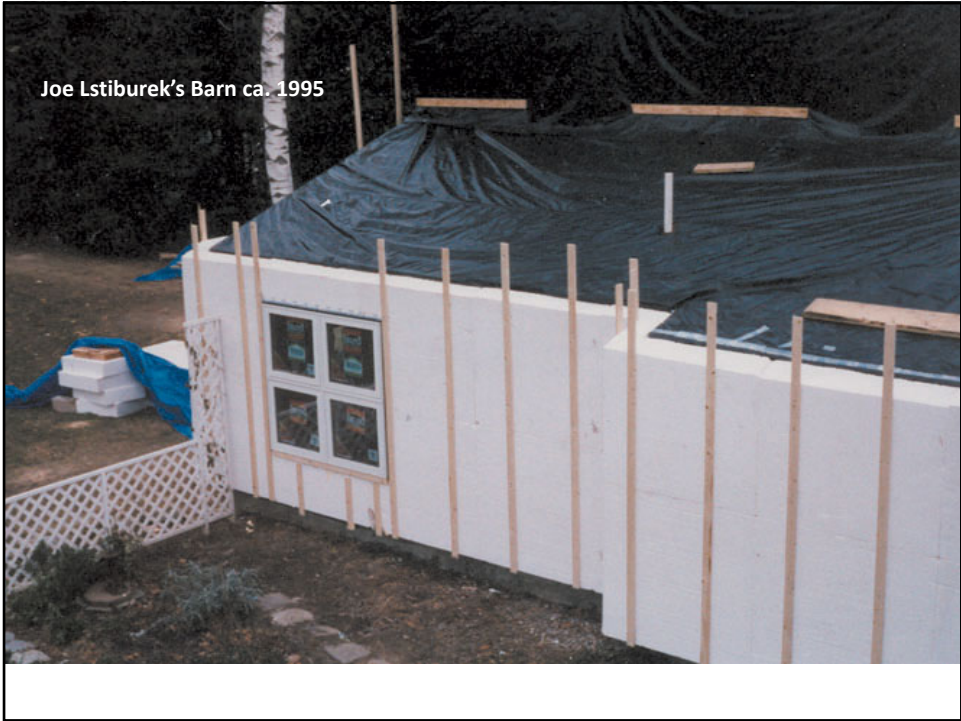


Figure 9: Short term deflection testing results (4" thick insulation)

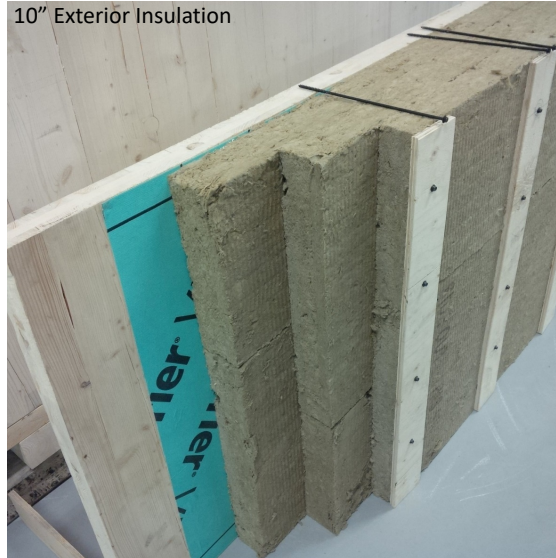




Really Thick Insulation = Really Long Screws



10" Exterior Insulation



Moisture and exterior insulation

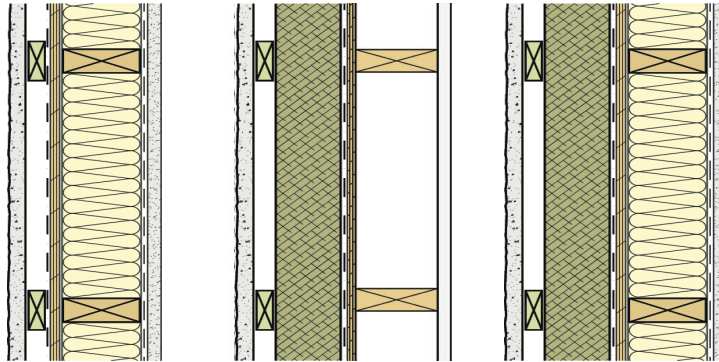


- Exterior insulation *reduces condensation*
 - Fewer hours per year
 - Lower quantity
- Exterior insulation *slows outward drying*
 - Drainage and ventilation enhance drying

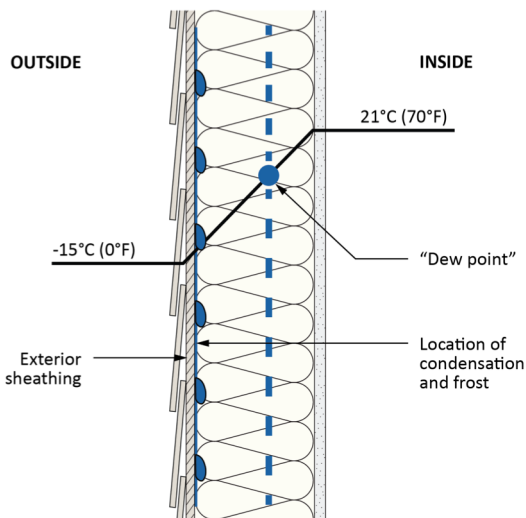
Consider Vapor Diffusion through ALL Layers

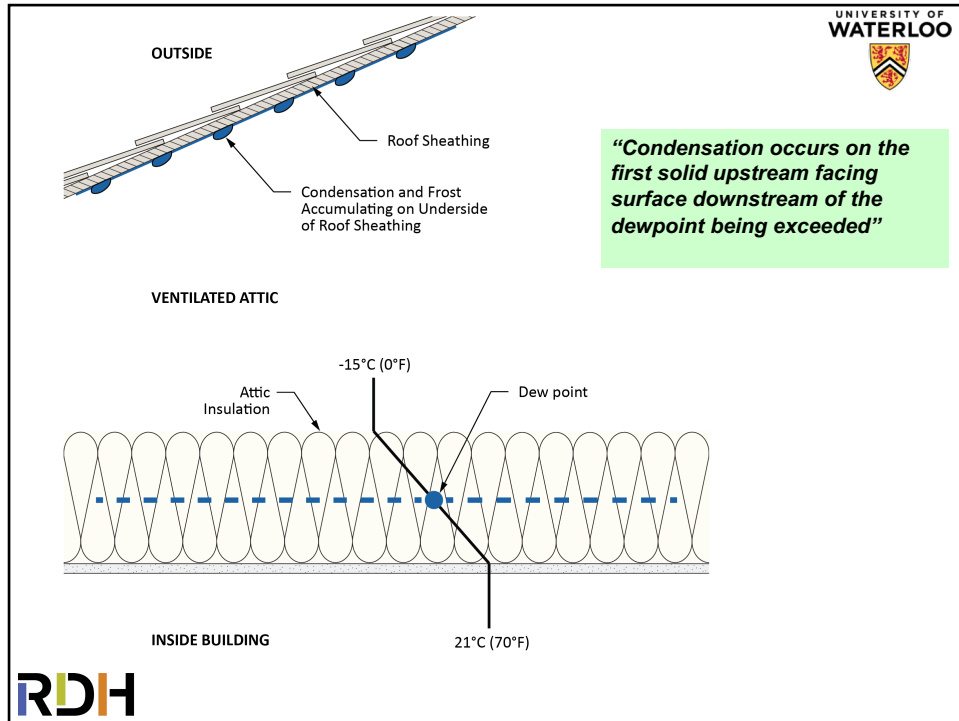


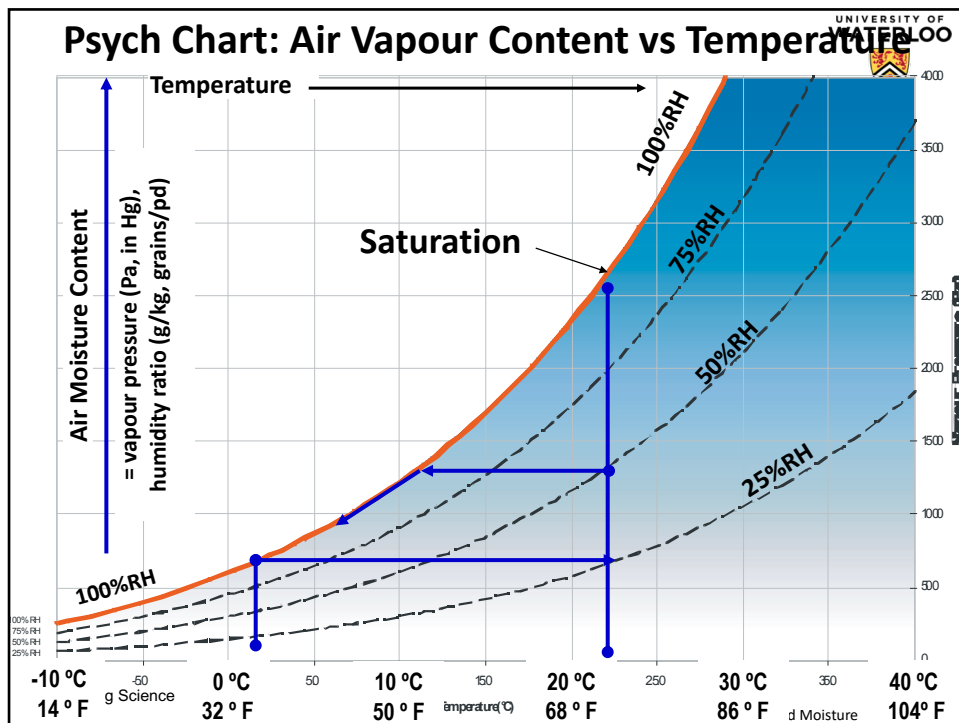
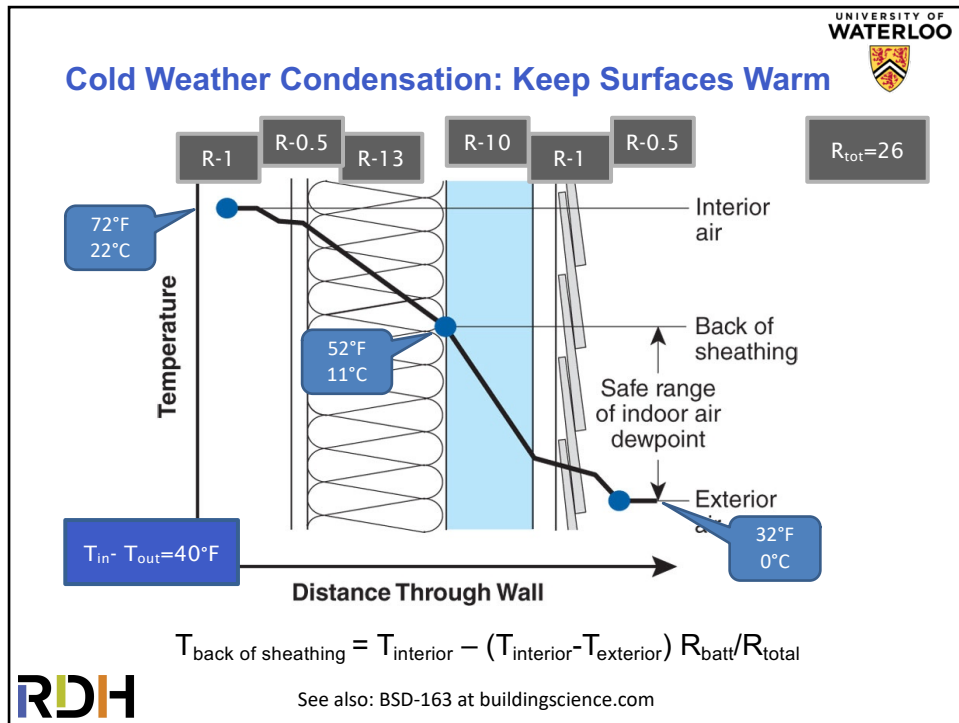
- Must consider the whole assembly, not only the properties of the Air (Water Vapor) Barriers
- Sheathing, exterior finishes can have significant resistance
- Don't be tricked by labels... low perm layers are vapor barriers

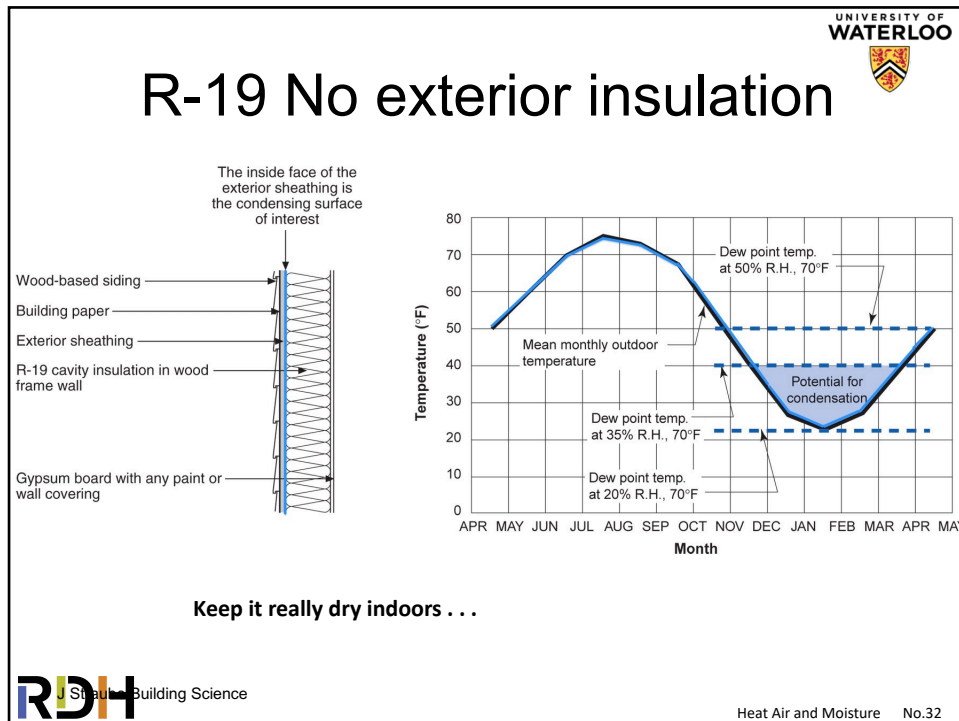
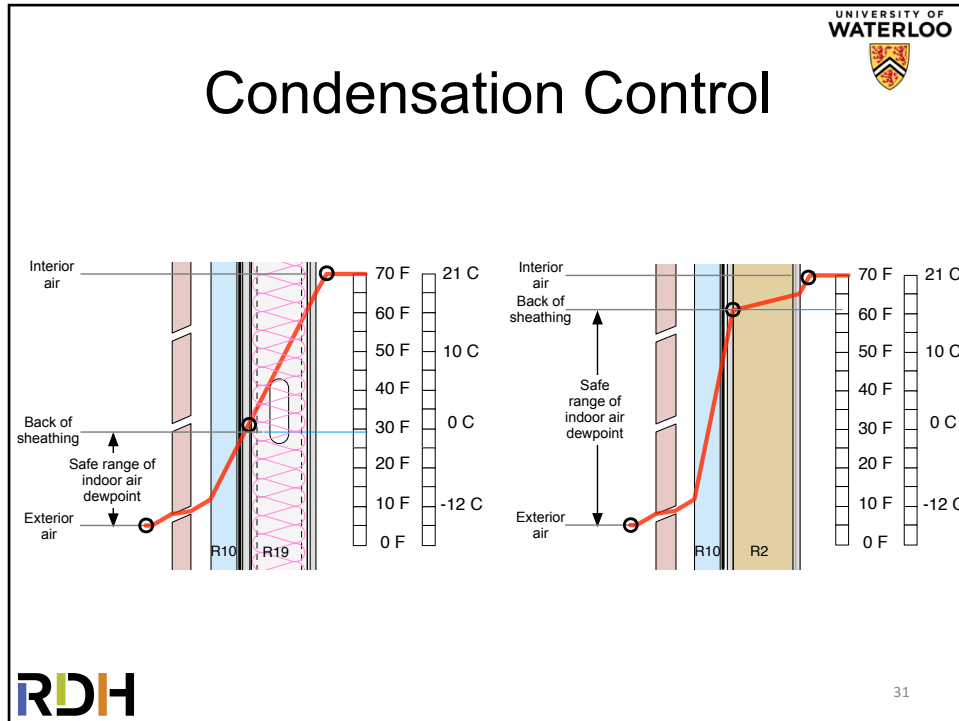


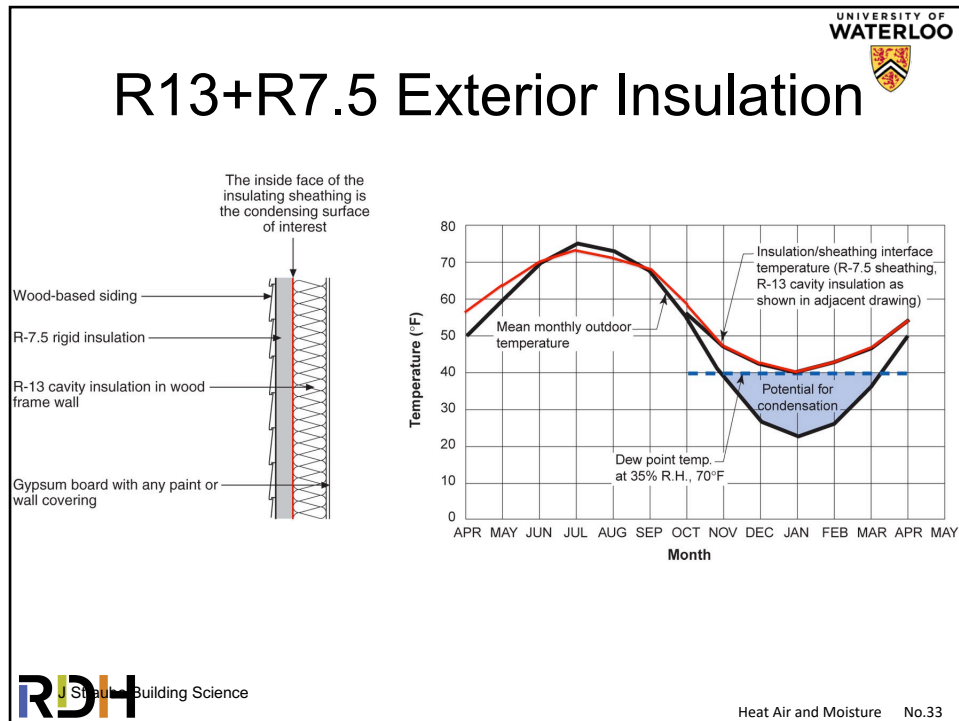
Where does condensation occur? Diffusion or Air Leakage (Convection)











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Drying

- Adding low-permeance sheathing reduces outward drying
- Low-perm increases risk
- The lower the perm, the greater the R-value

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Vapor tight and thin = bad



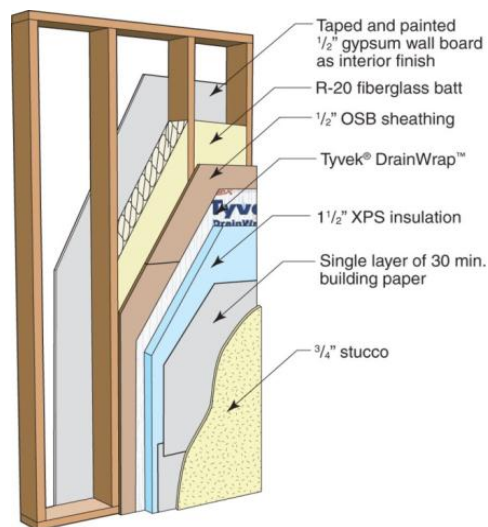
Vancouver test hut sponsored by Dow/Dupont/Hardie
NRCan-sponsored research at University of Waterloo

FIELD MOISTURE STUDIES

Field Testing & Demonstration



Field Testing & Demonstration



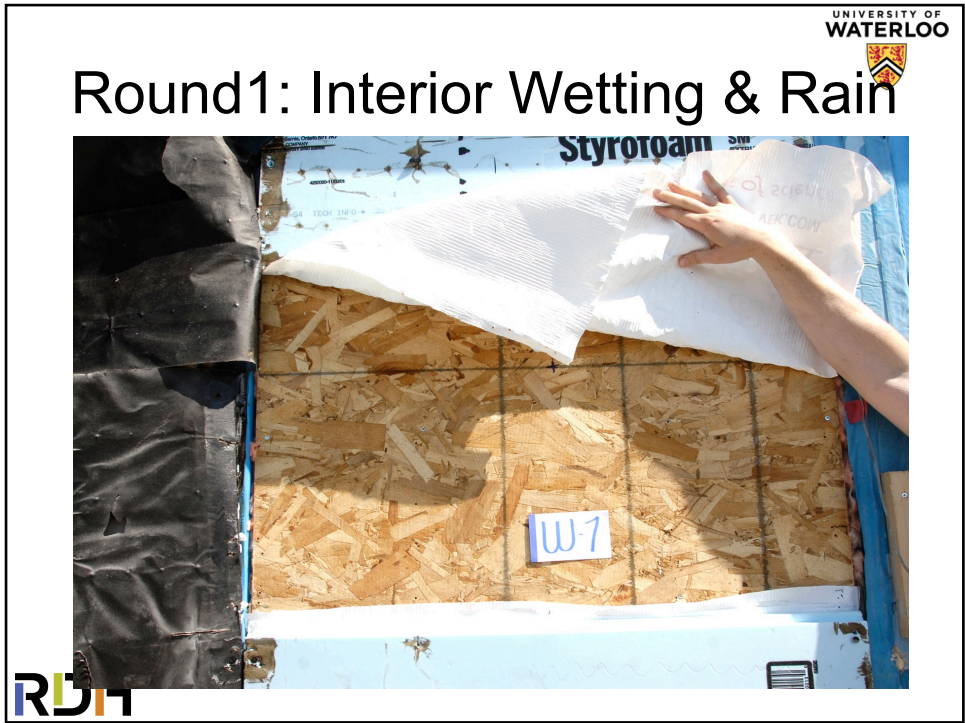


Round1: Interior Wetting & Rain

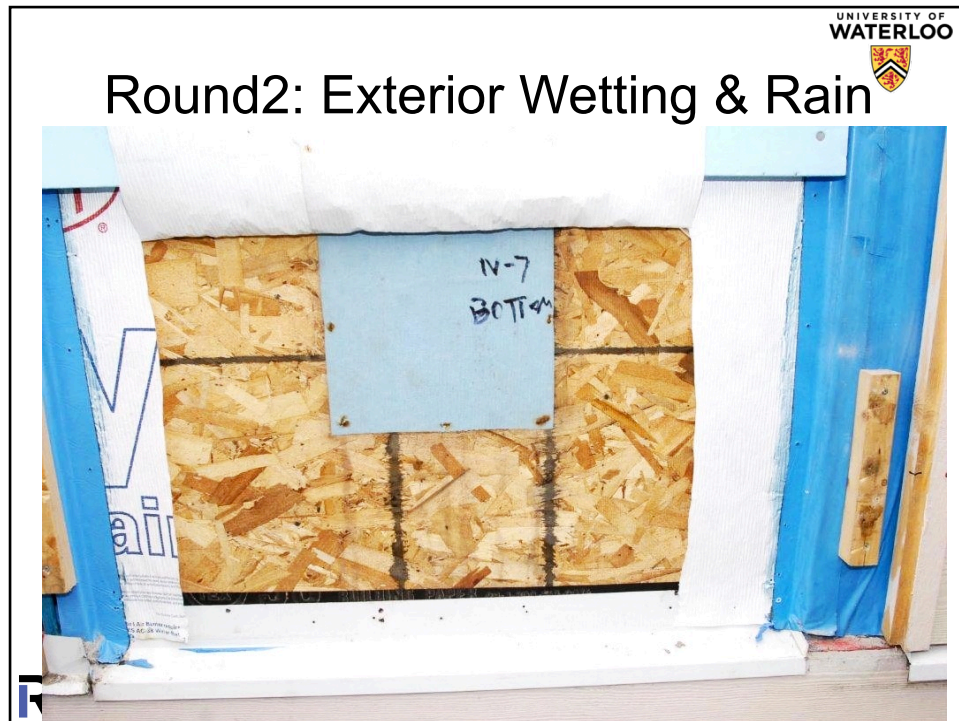


Round1: Interior Wetting & Rain









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Summary

- **Vancouver** climate
 - 1" XPS insulation outperforms standard 2x6
 - Imposed leaks dried out (in), *usually* more quickly than standard 2x6

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NSERC/ NRCan -> U Waterloo

- **Objective:** Assess high R-value walls of future
 - Target: About 50% less heat flow
 - Thus .. over R-30 effective
- Moisture performance:
 - Risk of condensation?
 - Slower drying?
- XPS, Polyiso, EPS, Stonewool

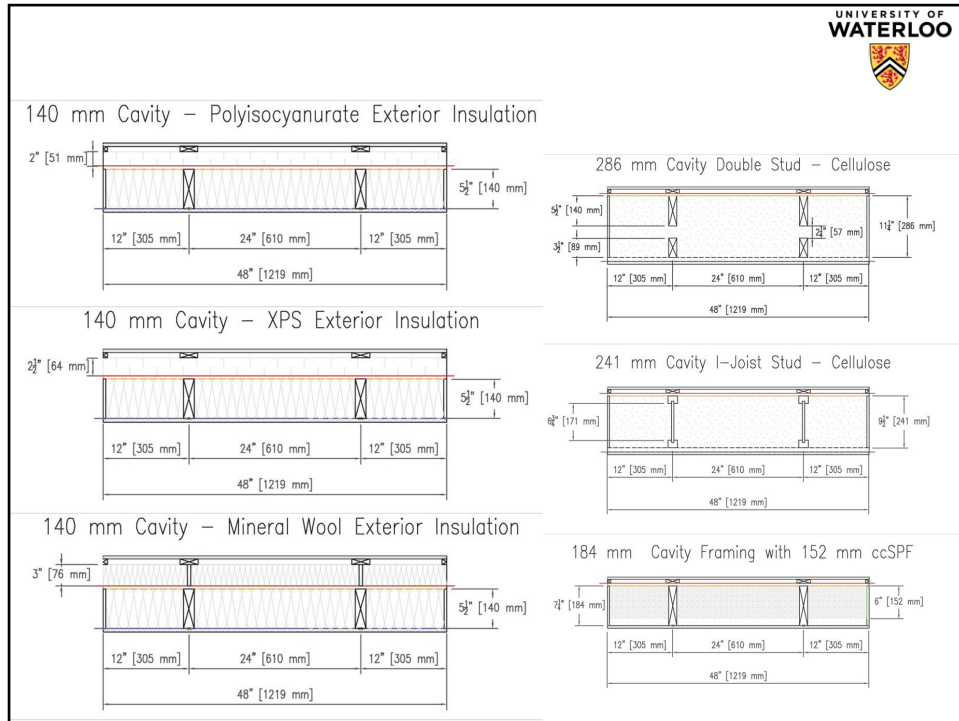


Trevor Trainor



7 Test Walls





Effective R-values

- 2x8 with ccSPF (max of R28)
- Others R-32ish
- Test Walls 5 & 6 with no 6 mil poly

Wall	R effective
1. Double Stud R44	32?
2. I-Joist R44	30?
3. 2x6 Datum	17.7
4. 2x8 ccSPF R40	27.7
5. 2x6 PIC R22 batt	32.4
6. 2x6 2.5" XPS	32.9
7. 2x6 3" MFI	33.0

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Walls isolated from each other



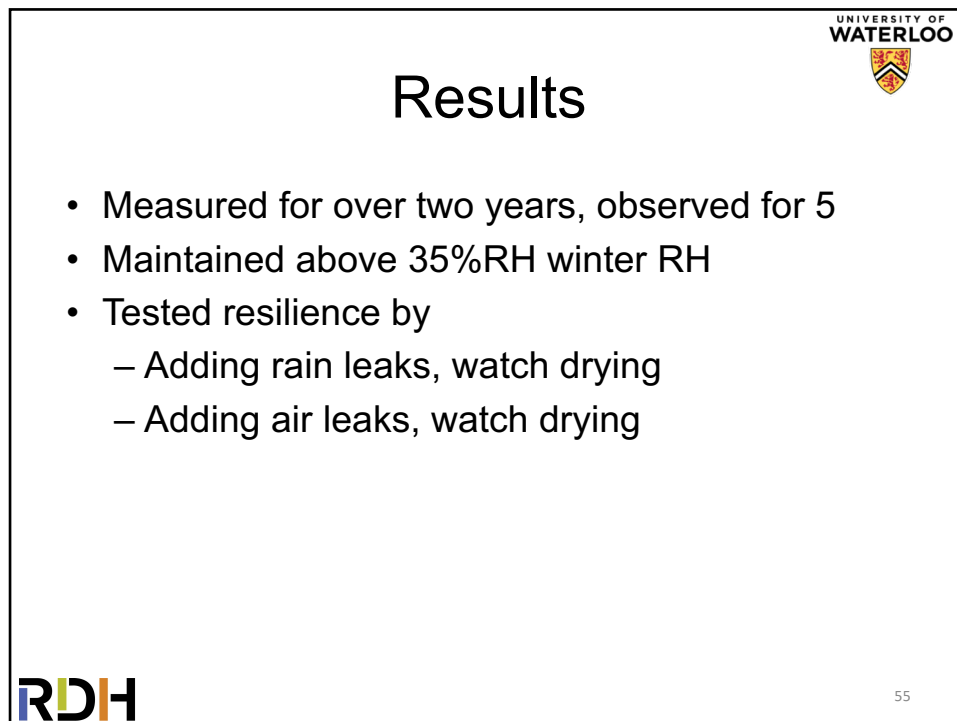
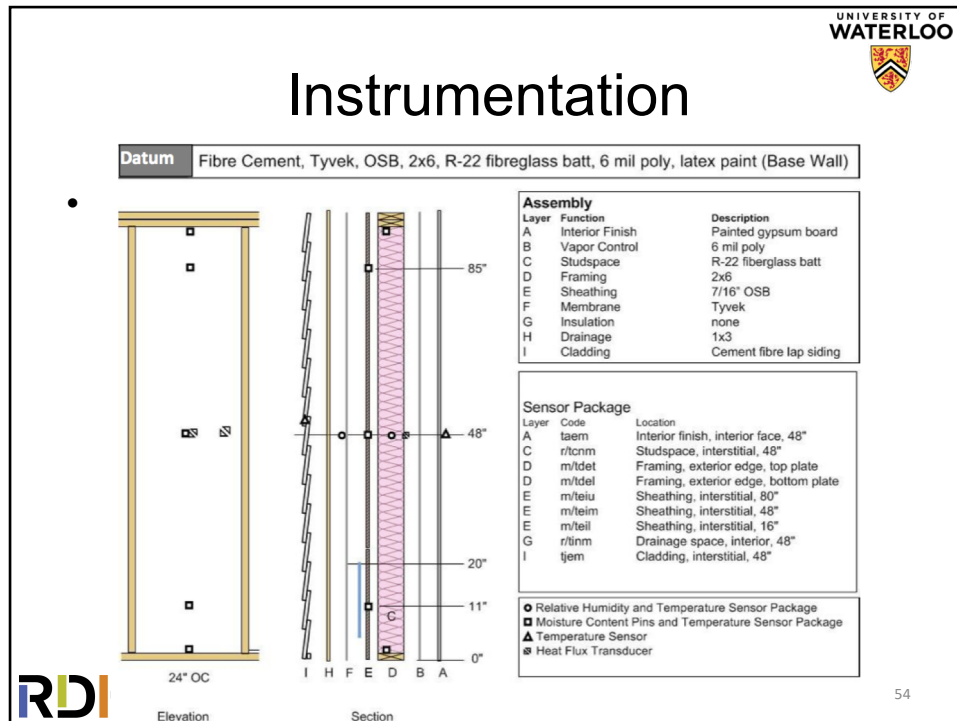
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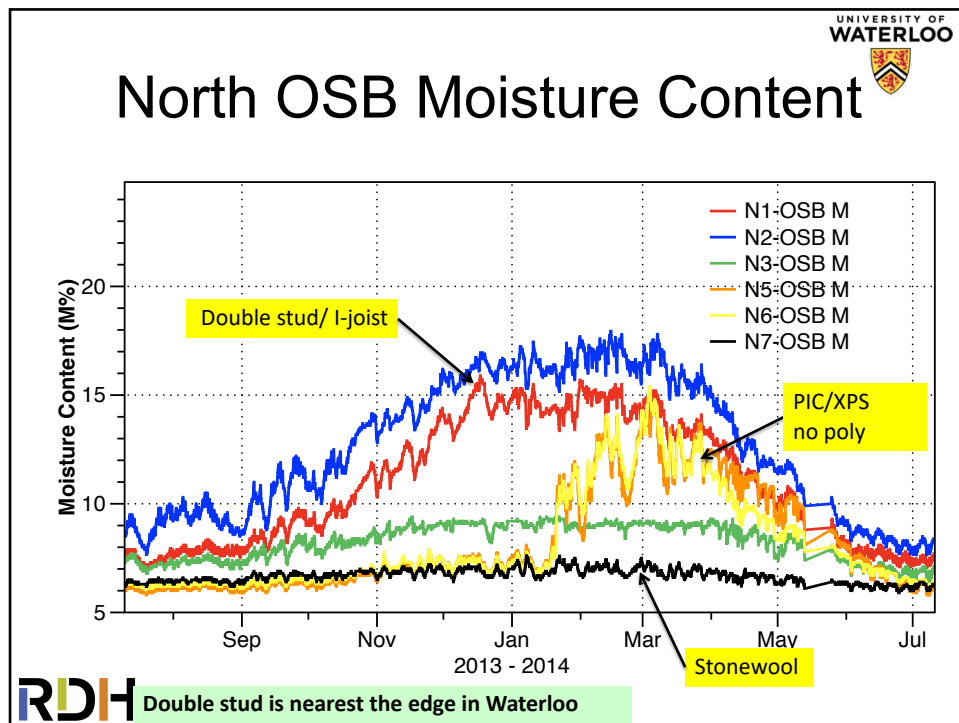
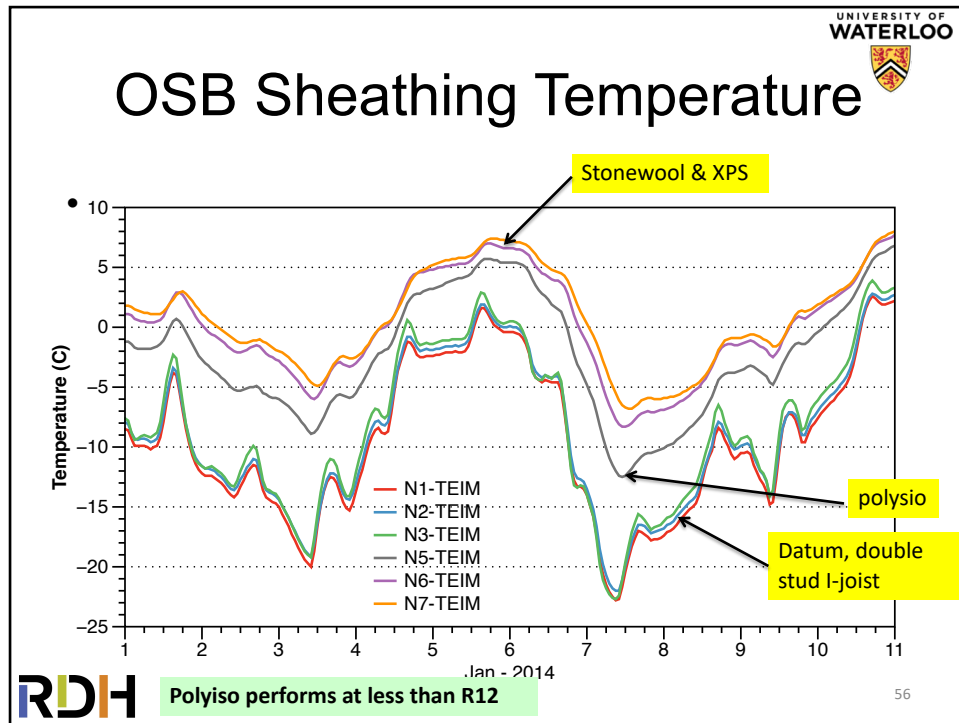
Calibrated leaks being installed

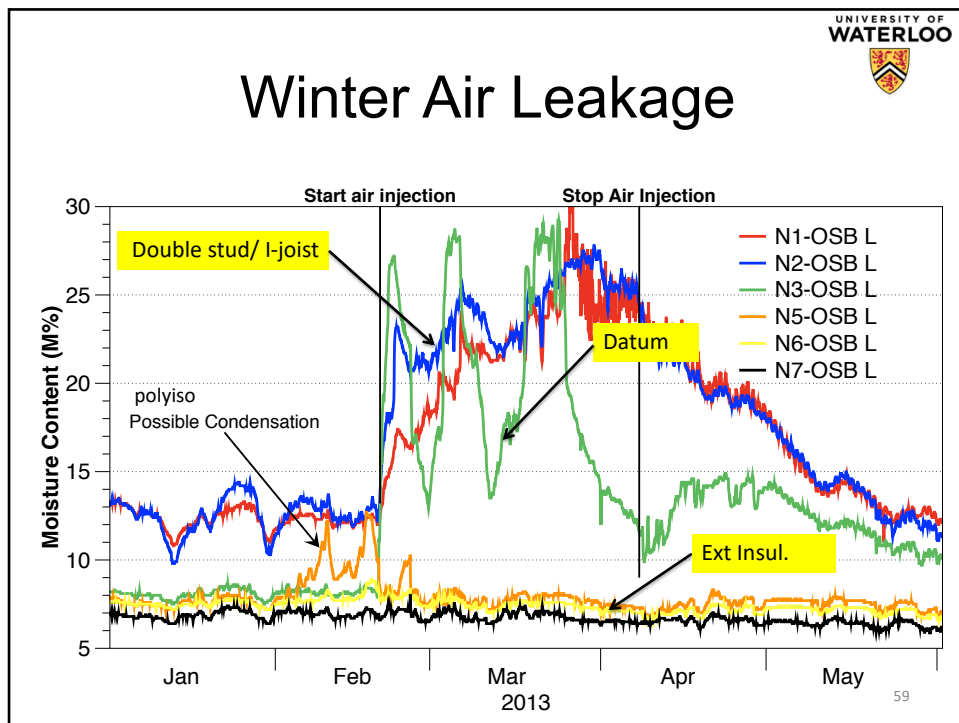
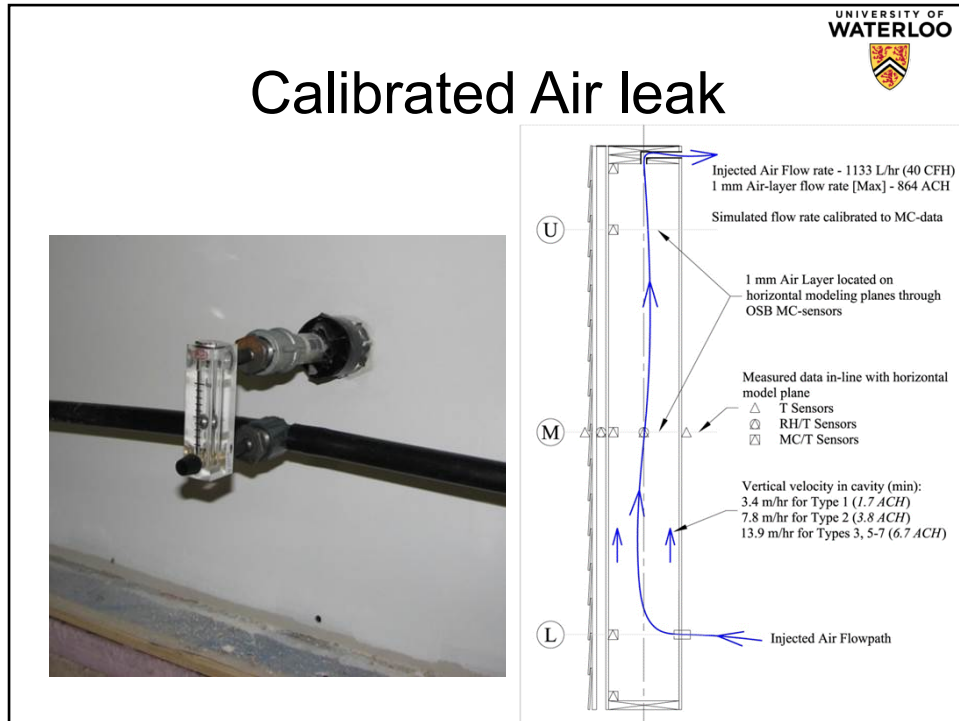


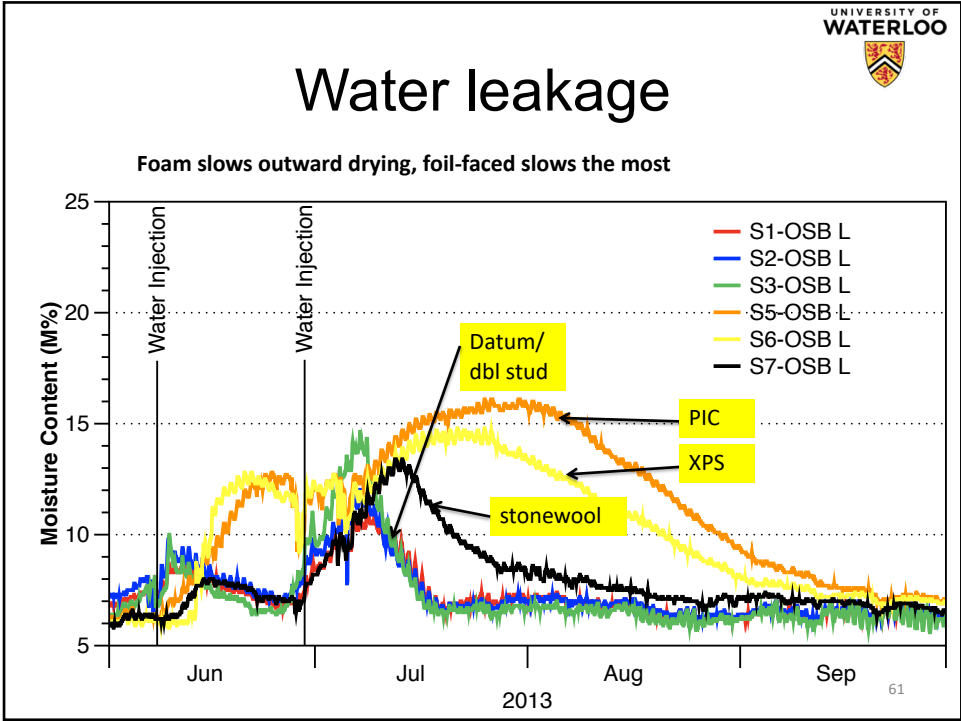
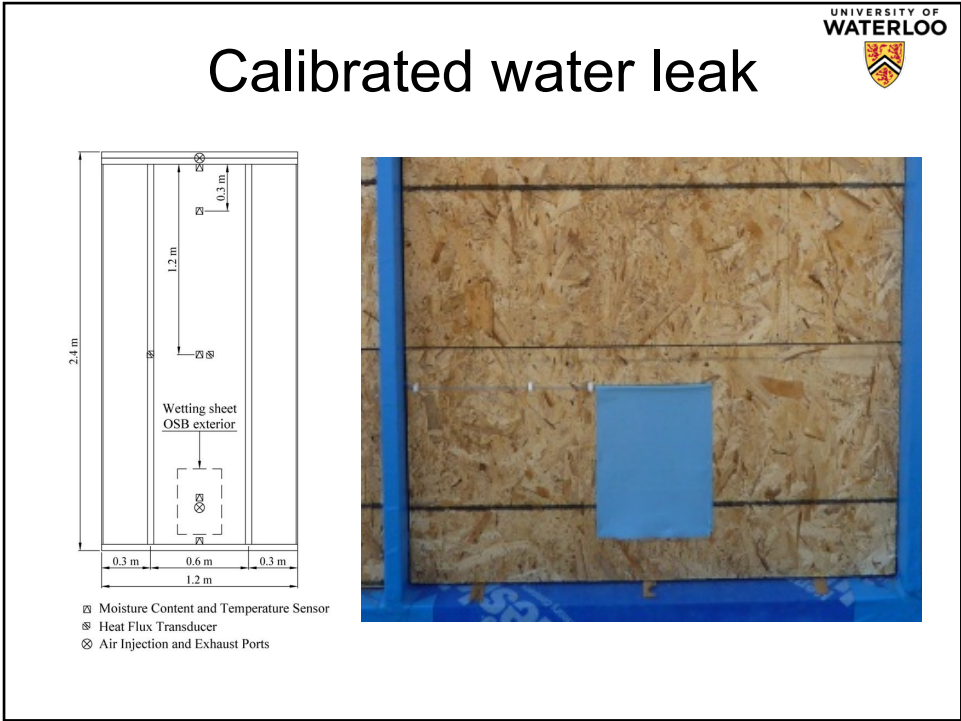
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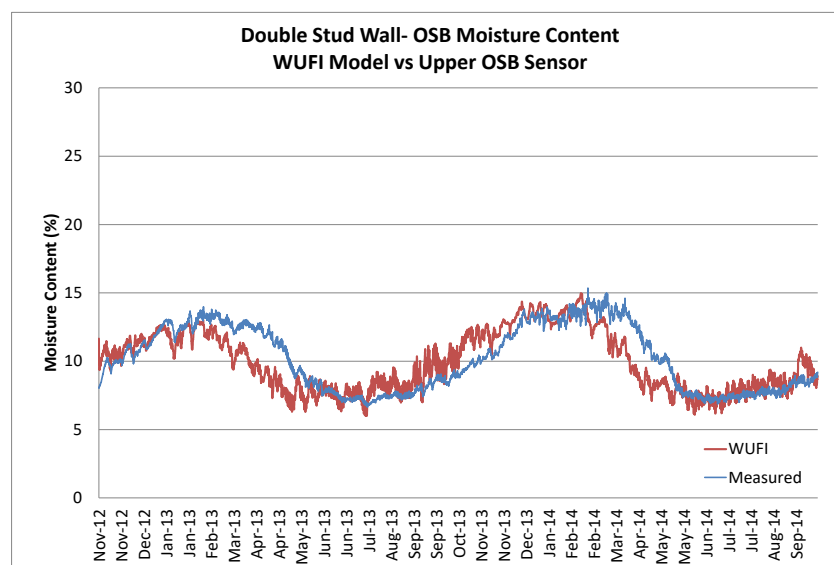


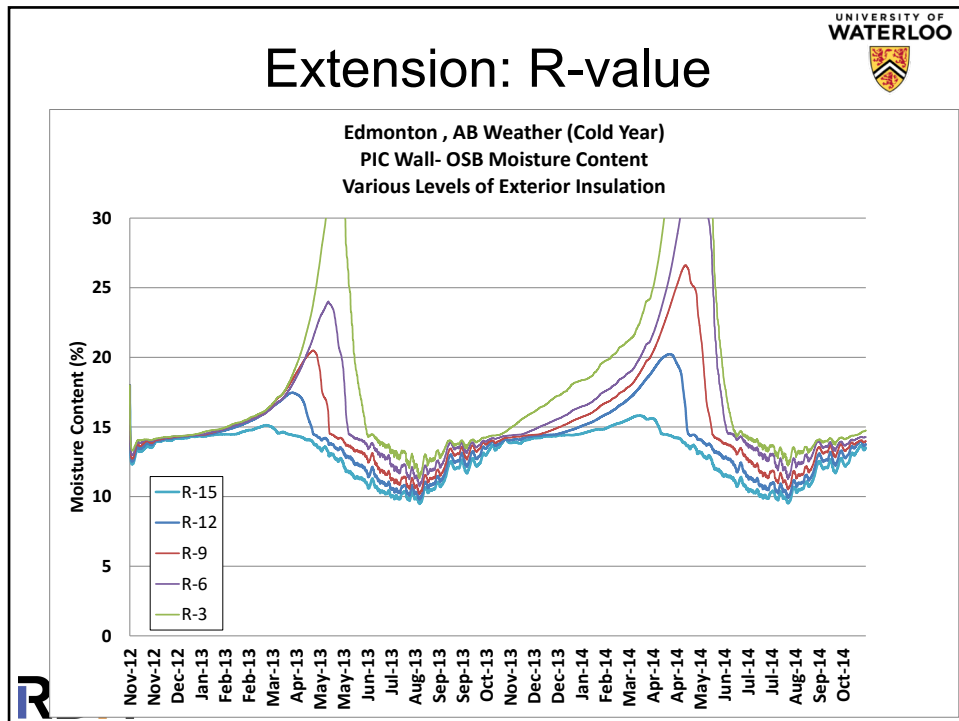
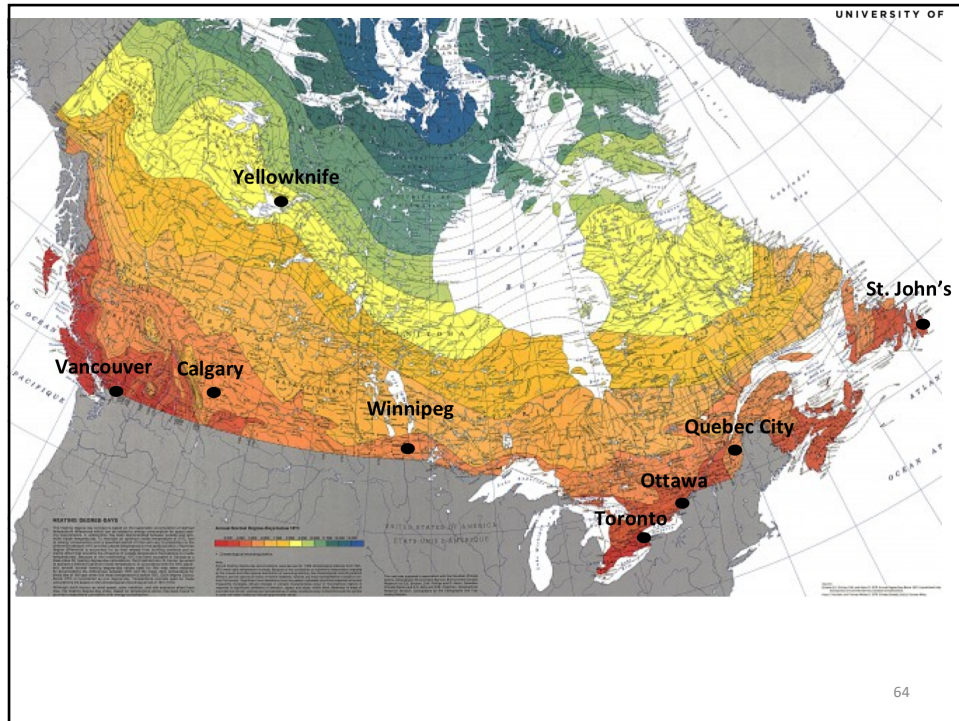


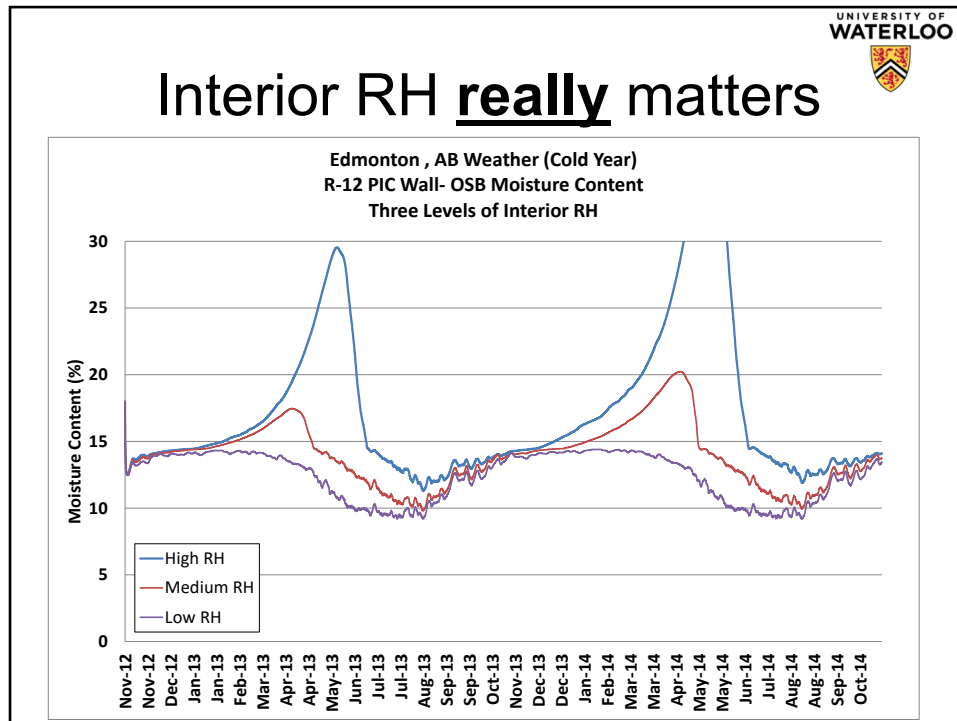
Modeling

- Computer model: WUFI
 - Calibrate to measured walls
- Extrapolate to
 - Different climates
 - Varying Interior RH
 - Different insulation levels

Model vs Measure








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Real walls

- Real assemblies fail if
 - air leakage is too much (and RH is high)
 - Too much rain wetting (often windows)
- Re-run models..
 - Account for some leakage of air and rain

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Proper conditions: no leaks

*Poly needed in cold
Prairie provinces*

■ = MC < 20%, no mold growth
 ■ = MC is 20 to 28%, potential for mold growth
 ■ = MC > 28%, moisture problems expected, this design is NOT recommended

Wall Construction		Vancouver		St. John's		Toronto		Ottawa		Quebec City		Calgary		Winnipeg		Yellowknife							
		HDD 2910		HDD 4881		HDD 3800		HDD 4440		5080		HDD 5000		HDD 5670		HDD 8170							
Wall	Cavity Insulation	Cavity Depth	Exterior Insulation	Ext. Insul. Thickness	Vapour Control	Low RH 30/55%	Med. RH 40/60%	Low RH 30/55%	Med. RH 40/60%	Low RH 30/55%	Med. RH 40/60%	Low RH 30/55%	Med. RH 40/60%	Low RH 20/50%	Med. RH 30/55%	Low RH 20/50%	Med. RH 30/55%						
Datum	Fiberglass	5.5"	none	0	Polyethylene sheet	10%	11%	11%	11%	10%	10%	11%	11%	8%	8%	10%	10%	11%	11%	12%			
PIC	Fiberglass	5.5"	polyisocyanurate	2"	Latex paint+primer	10%	11%	12%	15%	11%	13%	12%	18%	13%	19%	14%	21%	12%	20%	30%	15%	30%	35+%
					Polyethylene sheet																		
XPS	Fiberglass	5.5"	extruded polystyrene	2.5"	Latex paint+primer	10%	11%	12%	15%	11%	13%	12%	14%	13%	19%	14%	21%	12%	20%	30%	15%	30%	35+%
					Polyethylene sheet																		
EPS	Fiberglass	5.5"	expanded polystyrene	3.0"	Latex paint+primer	10%	11%	12%	17%	11%	14%	13%	20%	14%	20%	15%	24%	12%	21%	34%	17%	34%	35+%
					Polyethylene sheet																		
RW	Fiberglass	5.5"	rockwool insulated sheathing	3.0"	Latex paint+primer																		
					Polyethylene sheet																		
Double Stud	Cellulose	11.25"	none	0	Polyethylene sheet	8%	9%	8%	8%	9%	9%	8%	8%	9%	9%	7%	7%	7%	8%	8%	7%	7%	8%

General Notes:
 a. 2.5% Design Temperature and Heating Degree Days (HDD) from NBCC 2010
 b. Walls are residential wood frame with light-colored, thin cladding facing north; this is a worse-case scenario for cold-weather diffusion wetting
 c. Results are for OSB sheathing. Plywood sheathing values will be equal or lower. OSB permeance is always over 60 ngPa·s·m² in exterior sheathing applications.
 d. Sheathings of DensGlas, FiberBoard, and Gypsum Board are all very vapor permeable and hence will have lower moisture contents
 e. Thicker exterior insulation will always result in lower wintertime sheathing moisture contents
 f. Effective Air Barrier is assumed to be installed, as is proper rain control
 g. MC values are for inner 3 mm OSB sheathing




Response to Rain & Air leak

■ = MC < 20%, no mold growth
 ■ = MC is 20 to 28%, potential for mold growth
 ■ = MC > 28%, moisture problems expected, this design is NOT recommended

Wall Construction		Vancouver			Toronto				St. John's						
		Ave. Annual Temp 9 °C			Ave. Annual Temp 7 °C				Ave. Annual Temp 4 °C						
Wall	Cavity Insulation	Cavity Depth	Exterior Insulation	Ext. Insul. Thickness	Vapour Control	HDD 2910, 304 mm Driving Rain			HDD 3800, 77 mm Driving Rain				HDD 4881, 291 mm Driving Rain		
						No Leakage	1% Rain leak	2% Rain leak	No Leakage	1% Rain leak	2% Rain leak	5% Rain leak	No Leakage	1% Rain leak	2% Rain leak
Datum	Fiberglass	5.5"	none	0	Polyethylene sheet	11%	15%	22%	11%	11%	12%	15%	11%	15%	22%
PIC	Fiberglass	5.5"	polyisocyanurate	2"	Latex paint+primer	11%	16%	24%	13%	13%	17%	23%	15%	25%	35+%
					Polyethylene sheet										
XPS	Fiberglass	5.5"	extruded polystyrene	2.5"	Latex paint+primer	11%	16%	24%	13%	13%	17%	23%	15%	25%	35+%
					Polyethylene sheet										
EPS	Fiberglass	5.5"	expanded polystyrene	3.0"	Latex paint+primer	11%	17%	27%	14%	15%	18%	25%	17%	26%	35+%
					Polyethylene sheet										
RW	Fiberglass	5.5"	rockwool insulated sheathing	3.0"	Latex paint+primer										
					Polyethylene sheet										
Double Stud	Cellulose	11.25"	none	0	Polyethylene sheet	9%	12%	18%	9%	9%	9%	13%	8%		20%

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Rain & Air Leak Cold

■ = MC < 20%, no mold growth
 ■ = MC is 20 to 28%, potential for mold growth
 ■ = MC > 28%, moisture problems expected, this design is NOT recommended


Wall Construction		Winnipeg						Yellowknife								
		R-12 (RSI 2.1)		R-18 (RSI 3.1)		R-24 (RSI 4.2)		R-12 (RSI 2.1)		R-18 (RSI 3.1)		R-24 (RSI 4.2)				
		HDD 5777		HDD 5777		HDD 5777		HDD 8166		HDD 8166		HDD 8166				
Wall	Cavity Insulation	Cavity Depth	Exterior Insulation	Ext. Insul. Thickness	Vapour Control	Low RH 30/55%	Med. RH 40/60%	Low RH 30/55%	Med. RH 40/60%	Low RH 30/55%	Med. RH 40/60%	Low RH 30/55%	Med. RH 40/60%	Low RH 30/55%	Med. RH 40/60%	
PIC	Fiberglass	5.5"	polyiso-cyanurate	2.0"	Latex paint+primer	20%	30%	15%	23%	18%	30%	35+%	15%	30%	12%	15%
				3.0"	Polyethylene sheet	8%	8%	8%	7%	7%	7%	7%	7%	7%		
XPS	Fiberglass	5.5"	extruded polystyrene	2.5"	Latex paint+primer	20%	30%	15%	23%	18%	30%	35+%	15%	30%	12%	15%
				3.5"	Polyethylene sheet	8%	8%	8%	7%	7%	7%	7%	7%			
EPS	Fiberglass	5.5"	expanded polystyrene	3.0"	Latex paint+primer	21%	34%	17%	24%	19%	34%	35+%	17%	34%	12%	17%
				4.5"	Polyethylene sheet	8%	8%	8%	7%	7%	7%	7%	7%			
RW	Fiberglass	5.5"	rockwool insulated sheathing	3.0"	Latex paint+primer	17%	25%	12%	19%	14%	25%	35+%	13%	25%	10%	13%
				4.5"	Polyethylene sheet	8%	8%	8%	7%	7%	7%	7%	7%	7%		

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Study Conclusions

- Increasing exterior insulation R-value
 - Safer wall
 - **IF enough exterior insulation used**
- Control interior RH in winter
 - 35%RH max when $t_{out} < -5^{\circ}C$
- Poly can cause drying problems with foam + rain leak
- Poly can be removed if enough insulation exterior to 2x6 (about R15 in Winnipeg)


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