
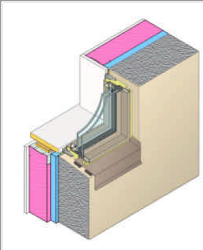


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### PERFORMANCE MONITORING OF RAINSCREEN WALL ASSEMBLIES IN VANCOUVER, BRITISH COLUMBIA

Sponsors

Brian Hubbs, P.Eng.  
RDH Building Engineering Ltd.

### Purpose

- To determine the in-situ performance of a rainscreen wall assembly on 5 buildings over a period of 5 years.
- To correlate wetting events with exposure, weather conditions, and building interior conditions.
- To determine if wetted walls dry quickly enough to resist damage, and under what conditions drying takes place.
- To provide baseline data that can be used to compare with the performance of other rainscreen buildings when they are investigated.

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### What We Need to Know:



What moisture content is acceptable or expected?  
For How long?  
How does it change with time of year? 8/2000

LEGEND: 0 - 10% (green triangle), 20 - 30% (yellow triangle), >30% (red triangle)

MOISTURE PROBE SURVEY RESULTS NORTH ELEVATION EAST SIDE

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### Methodology

- 5 Buildings, 3 wood frame and 2 concrete frame
- Continuous, automatic electronic system that records measurements from all sensors every 15 minutes
- 5 wall cavities on each building, each containing a minimum of 4 temperature, 4 wood Moisture Content, and 2 Relative Humidity sensors
- Site windspeed and direction, outdoor temperature and humidity, driving rainfall on walls, and pressure difference across walls

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### Methodology

MONITORED BUILDING LOCATIONS, VANCOUVER, BC

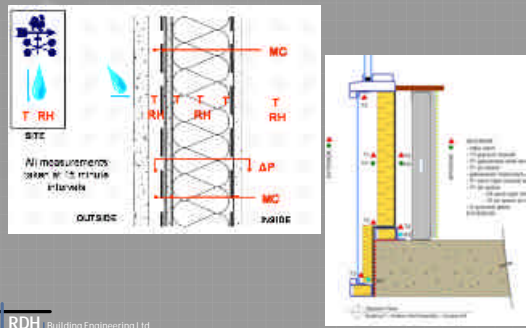


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<p><b>Building 1 – 4 storey wood frame</b> Project Type: New Construction Frame Type/Sheathing: Wood/Plywood Insulation: R19 Fiberglass Batt Moisture Barrier: 2 layers of BP Cladding: Vinyl on Wood Strapping</p>		
<p><b>Building 2 – 4 storey wood frame</b> Project Type: Cladding Rehabilitation Frame Type/Sheathing: Wood/Plywood Insulation: R19 Fiberglass Batt Moisture Barrier: Tyvek Cladding: Stucco on Wood Strapping</p>		
<p><b>Building 3 – 6 storey concrete frame</b> Project Type: Cladding Rehabilitation Frame Type/Sheathing: Concrete/Dens-glass Insulation: R8 Semi-rigid mineral w/ R8 fiberglass batt in the stud cavity. Moisture Barrier: Self adhered bitumen Cladding: Stucco on "Z" bars</p>		

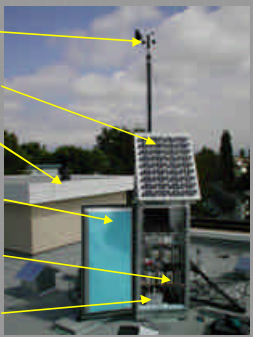
<p><b>Building 4 – 4 storey wood frame</b>                  Project Type: New Construction                  Frame Type/Sheathing: Wood/Plywood                  Insulation: R12 Fiberglass Batt                  Moisture Barrier: Building Paper                  Cladding: Fiber Cement Board on Wood Strapping</p>		
<p><b>Building 5 – 30 storey concrete frame</b>                  Project Type: New Construction                  Frame Type/Sheathing: Concrete/Dens-Glass                  Insulation: R10 Rigid Polystyrene on ext. of M.B.,                  Moisture Barrier: Self adhered bitumen                  Cladding: Stucco on "Z" bars and Aluminium Window Wall</p>		

### Typical Wall and Window Cavity



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### Monitoring Equipment



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### Nature of Monitoring System

- System is independent of building power – powered by battery and solar panel, provides data during severe storms when power might be interrupted
- Monitored wall locations chosen to be representative of locations most likely to be wetted during severe weather
- Interior conditions monitored to determine possible contribution to wetting due to high interior humidity

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### Status of Project

- Initial project Complete
- Moisture content data measured over past 6 years
- Minimum 1 consecutive year of full data for all buildings
- Minor problems with some sensors encountered, most sensors have provided complete information
- Delays in simultaneous data acquisition due to building construction schedules.

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### RESULTS

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### Moisture Content

Category	Wood	Gypsum	Typical Description
Low (Green)	MC<20	RML<40	Normal
Elevated (Yellow)	20-MC<28	40-RML<80	Caution Elevated moisture level.
Wet (Red)	MC>28	RML>80	Danger Sample is wet. Long term exposure will result in deterioration or strength loss

\*- Sheathing is fiberglass faced gypsum board. Result is expressed as 0-100 moisture reference scale, Delmhorst BD-10/2100

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### Yellow Category

Percent of Time Moisture Content (MC) of Plywood Sheathing is Above 20% or Relative Moisture Level (RML) of Gypsum Sheathing is Above 40%

Category	Cavity	Percent of Time That Moisture Content (wood) is Above 20% or Relative Moisture Level (Gypsum) is above 40%											
		2001			2002			2003			2004		
		Control	Detail	Sheathing	SB Panel	Control	Detail	Sheathing	SB Panel	Control	Detail	Sheathing	SB Panel
1	1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	3	4.86%	2.51%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	4	2.16%	7.86%	0.00%	0.00%	1.36%	7.86%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2	1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	3	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	4	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
3	1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	3	81.62%	59.79%	88.87%	88.78%	79.92%	81.12%	72.02%	45.84%	58.31%	54.72%	73.01%	58.31%
	4	72.02%	74.81%	72.02%	74.81%	67.22%	61.22%	67.22%	58.81%	67.22%	67.22%	67.22%	67.22%
4	1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	3	0.00%	0.24%	0.24%	0.00%	0.00%	0.00%	0.00%	0.00%	14.21%	0.00%	0.00%	1.47%
	4	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
5	1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	3	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	4	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

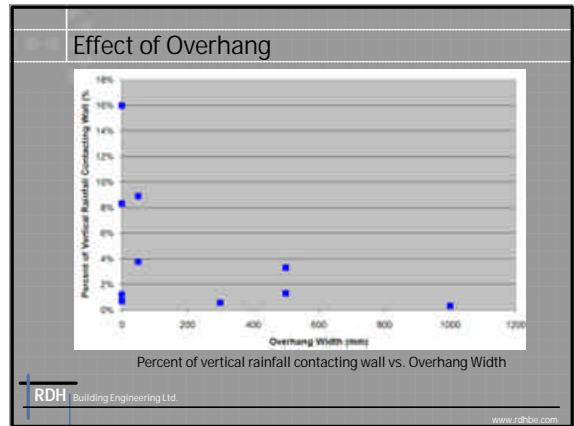
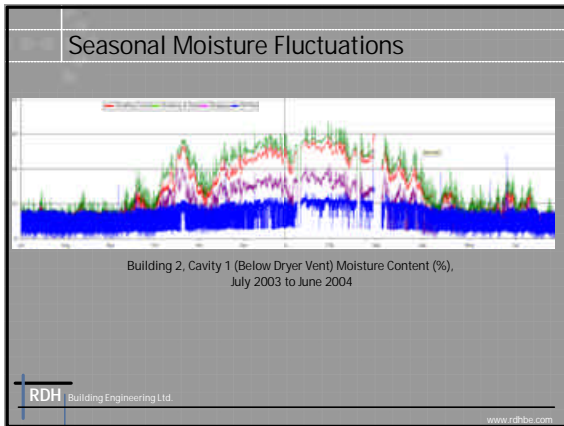
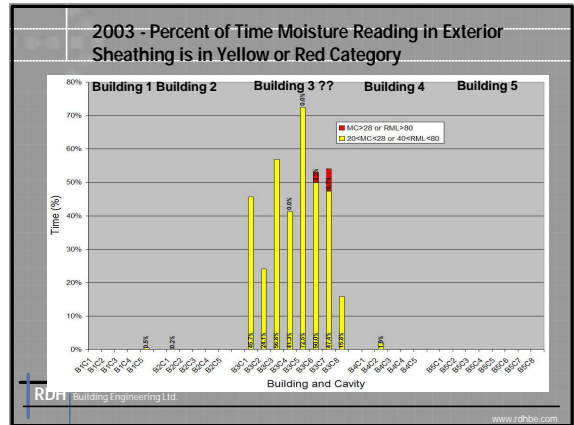
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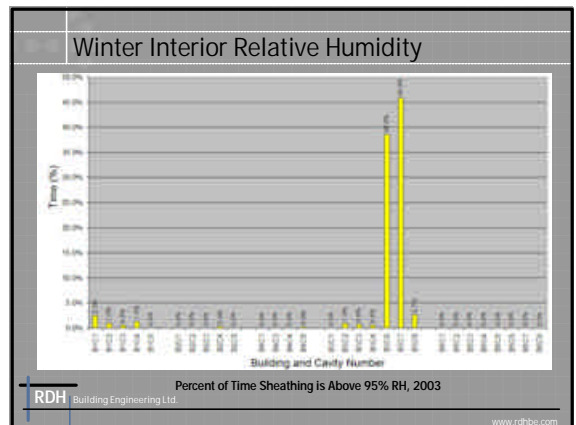
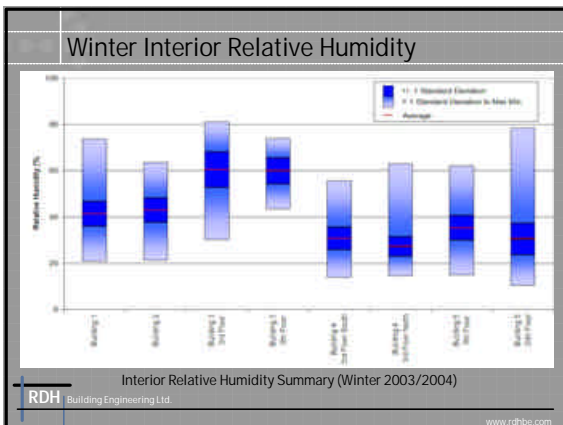
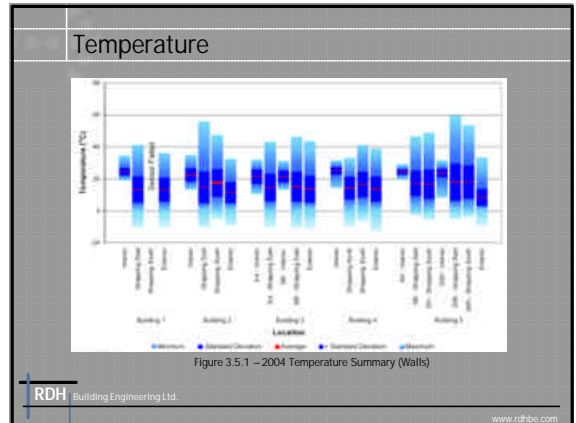
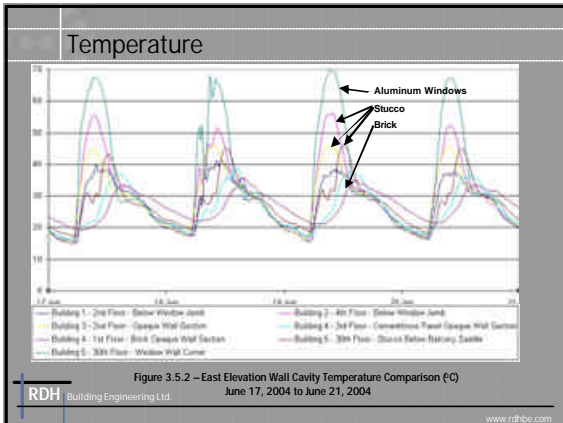
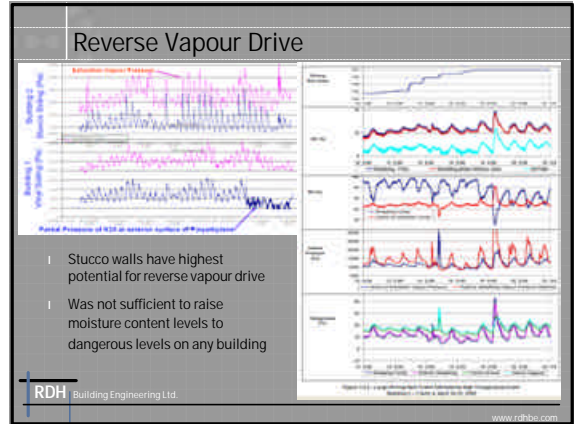
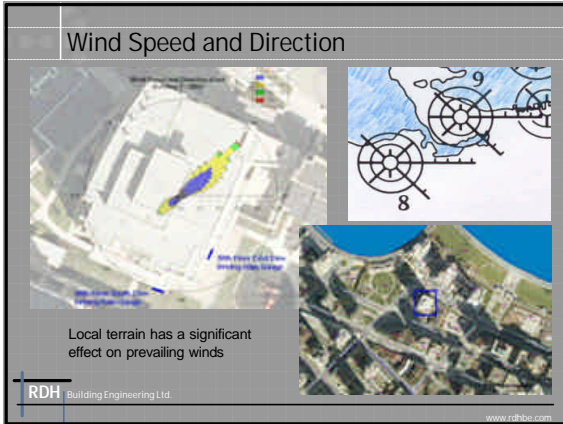
### Typical RED Category

Percent of Time Moisture Content (MC) of Plywood Sheathing is Above 28% or Relative Moisture Level (RML) of Gypsum Sheathing is Above 80%

Building	Cavity	Percent of Time That Moisture Content (wood) is Above 28% or Relative Moisture Level (Gypsum) is above 80%											
		2001			2002			2003			2004		
		Control	Detail	Sheathing	SB Panel	Control	Detail	Sheathing	SB Panel	Control	Detail	Sheathing	SB Panel
1	1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	3	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	4	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2	1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	3	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	4	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
3	1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	3	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	4	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
4	1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	3	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	4	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
5	1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	3	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	4	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

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### Conclusions

- | The moisture content in the sheathing and strapping on the woodframed buildings generally stayed below levels that can accelerate deterioration and promote fungi growth and decay. This indicates that wall systems currently being utilized in the Lower Mainland can perform successfully.
- | Use caution when using exterior insulated wall assemblies with a waterproof membrane on the exterior of the sheathing, in conjunction with conventional insulation in the stud cavity.
- | When remediating existing building enclosures, the mechanical ventilation strategy must consider the anticipated air and vapour tightness of the new wall assembly to ensure adequate supply and exhaust is provided in order to maintain reasonable RH levels post construction.
- | Condensation at the interior poly vapour retarder from inward vapour drive during hot clear days in the summer was not observed.
- | Condensation from inward vapour drive was measured at the exterior sheathing following some heavy rain events in the winter and spring.
- | Outward vapour drive in the winter has a significant effect on the moisture content of the exterior sheathing.

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### Conclusions

- | Wind driven rain increases moisture content of strapping quickly but takes longer to affect sheathing. In some cases when storm duration is small, sheathing moisture content is unaffected.
- | Dryer exhaust air can significantly increase the moisture content of the sheathing if it is allowed to enter behind the cladding.
- | Rainscreen cladding systems alone will not prevent wood moisture contents from reaching levels capable of supporting fungal growth if interface details allow bulk water or dryer exhaust air to infiltrate behind the exterior cladding over a prolonged period.
- | Caution must be used when assessing the performance of existing buildings using moisture readings of the exterior sheathing along with the risk categories commonly used in the industry. When conducting moisture content surveys, the analyst must consider the moisture regime that the building has been under for some time preceding reading.

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### Future Work

- | Graham Finch /John Straube, University of Waterloo
  - Field Validation of the results from the monitoring with a commercial software applications such as WUFI.
  - Research Hygrothermal behavior of fiberglass faced gypsum sheathing.
  - Further investigation of high moisture readings in building 3
  - Modeling of wall assemblies with an emphasis on improving hygrothermal performance
- | Mark Lawton, Morrison Hershfield Ltd.
  - Modeling interior environmental conditions in building 3 to examine the impact of ventilation on interior humidity.
  - Design of a mechanical HVAC solution to the high interior humidity levels on building 3.

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### Future Work

- | BCIT
  - Monitoring equipment donated to BCIT
  - Continue monitoring all 5 buildings indefinitely
  - Compare results with data from a non-rainscreen building with active water infiltration problems during the same time period.
  - Perform simultaneous wetting (water testing) on all buildings (stucco, vinyl and hardboard claddings) to examine and compare wetting and drying response times.
  - Compare real building results with Test Hut results

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### Questions and Discussion

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