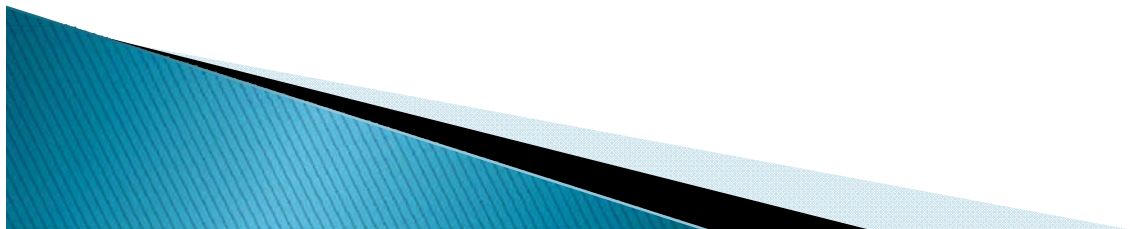


Building Science Summer Camp

Westford, Ma.

“The Coquitlam Experience”
August 2, 2011

Mark Gauvin



The Coquitlam Test Hut

A Building Enclosure Research Facility

Located at:

1140 Austin Avenue, Coquitlam, B.C.
(a suburb of the City of Vancouver)

Outline

Some History

- ▶ About myself and Company
- ▶ About Vancouver's Leaky Condo Disaster

The Coquitlam Test Hut

- ▶ Purpose
- ▶ Test Program
- ▶ Results

Introduction

Mark Gauvin, President
Gauvin 2000 Construction Ltd.
General Contractor

- ▶ Building residential and commercial buildings
- ▶ Now 38 years in business.
- ▶ About 4900 Residential Units (\$ ½ billion)
- ▶ Numerous offices, schools, churches and retail buildings.

Disclaimer

- ▶ Energy Efficiency is Important
 - Very Important!
- ▶ Insulation is Important and Necessary!
- ▶ Vapor Barriers (Retarders) are Necessary!

But,

- ▶ We need to use them correctly.

Leaky Condo Disaster

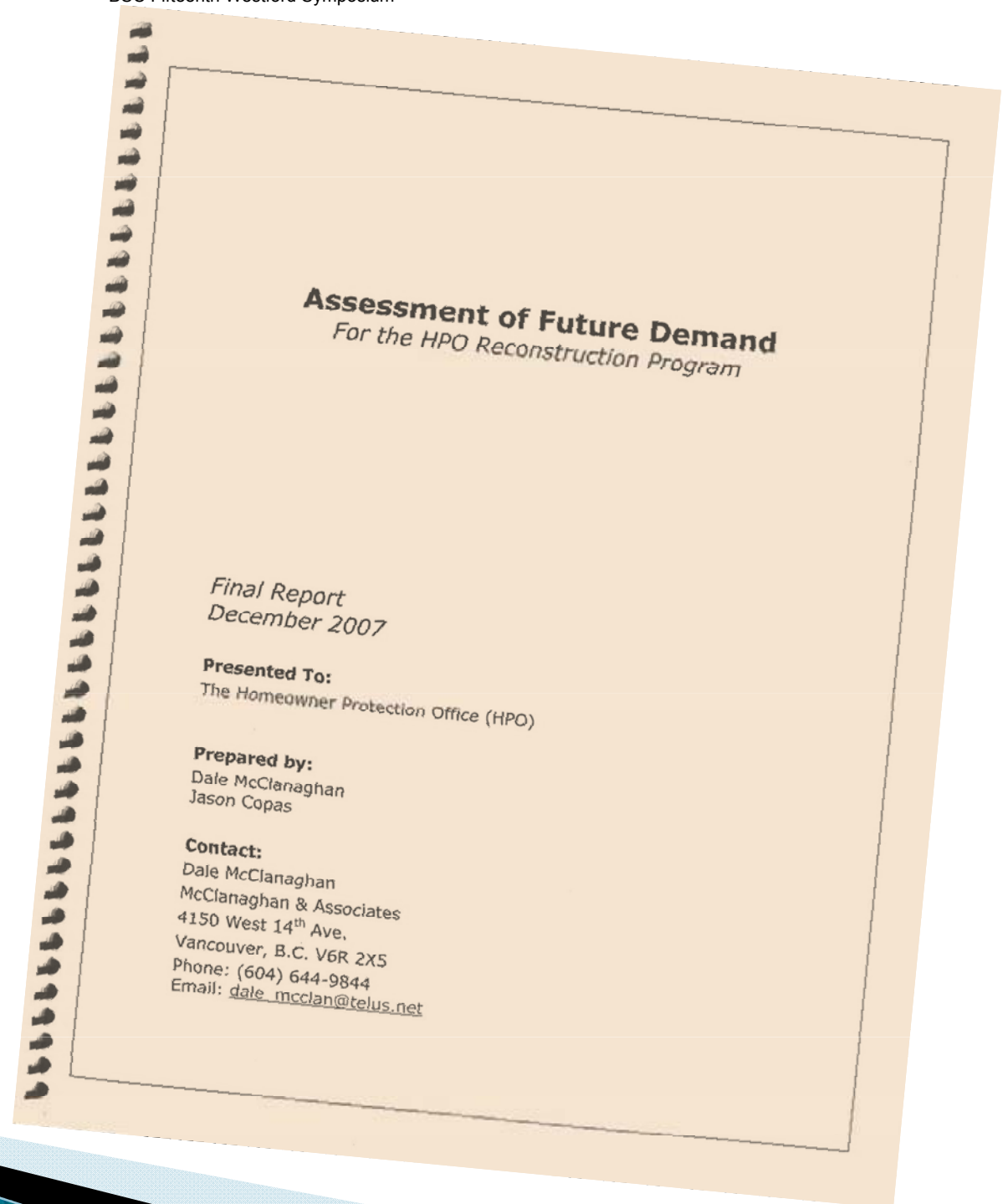


Problems started showing up in
early/mid 1990's.

Why was it a “Disaster” ?

- ▶ Affected a lot of buildings
- ▶ Cost a lot of money to remedy
- ▶ Devastated so many homeowners
- ▶ Devastated an industry
- ▶ Still ongoing

How Many Units Affected?



Coastal Climate Region of B.C.

Units BUILT 1982 – 1999

“Leaky Condo Period” Coastal Climate Region

- ▶ 85,627 Wood-frame Apartment Condos
- ▶ 43,409 Concrete Apartment Condos
- ▶ 30,943 Row/Townhouse (99.7% Wood-frame)

▶ 159,979 Total Units Built (10,346 Buildings)

▶ (of these, 79% in Greater Vancouver Region)

Apartment Condos

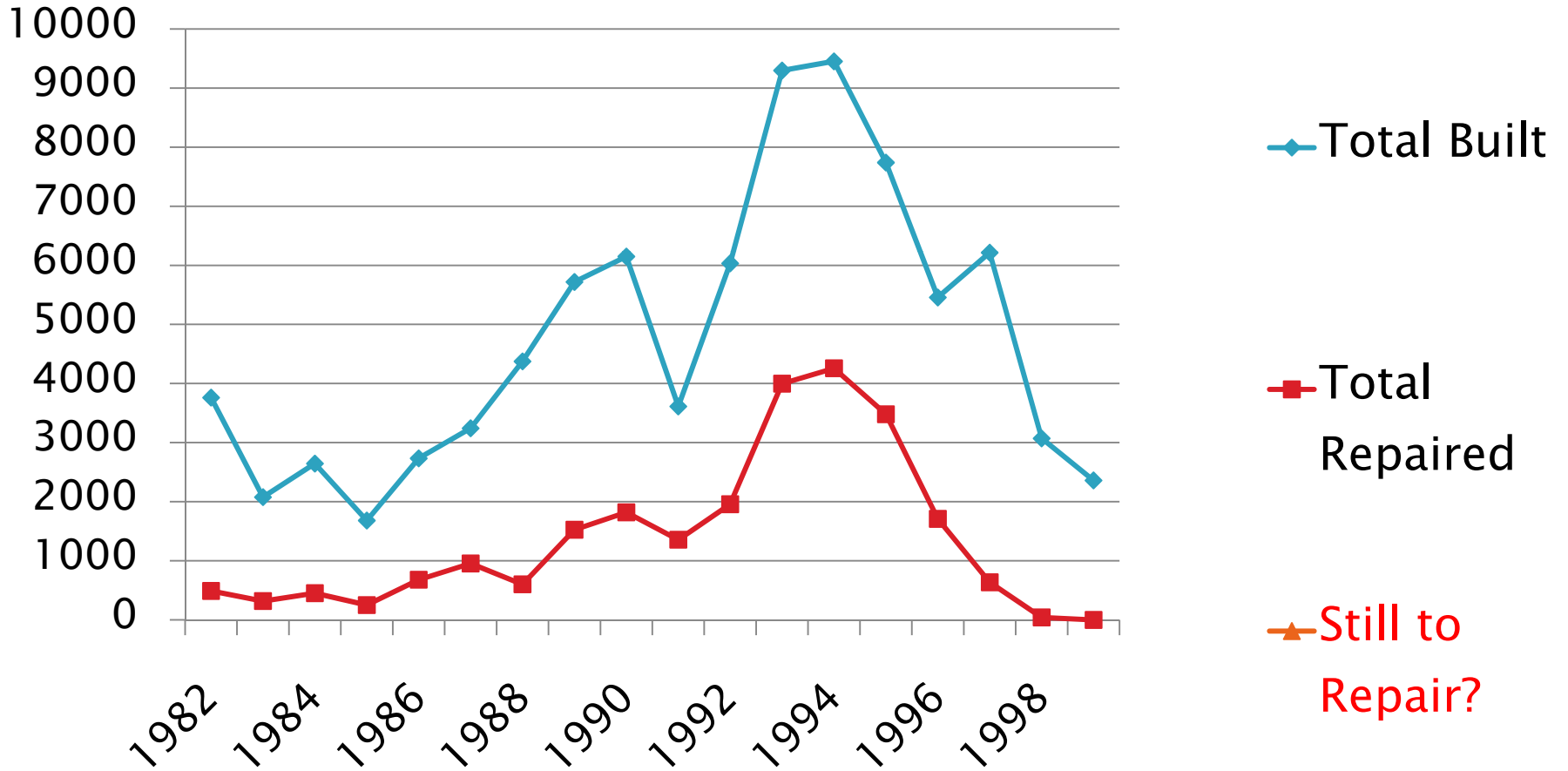
- ▶ Built: 85,627 Wood-frame Units
- ▶ Built: 43,409 Concrete Units

▶ Total Apartment Condos Built:	129,036
▶ Units Repaired to Dec. 2007:	30,664
▶ Estimated Still to Repair	41,529

▶ Total 'Failed' Units 72,193

▶ Failure rate = 56%

85,627 Wood-frame Apt Condos Failures by YEAR Built



Repair Costs to Homeowner

Apartment Condos only

- ▶ HPO Loan Amounts:
- ▶ average \$24,144 in 2000
- ▶ up to \$63,511 in 2007

'Contractor's Estimate'

72,193 Failed Units at \$45,000 per unit...

\$3.25 Billion

Repair loans for leaky condos average from \$62,000 to \$72,000

From A1

The HPO and the provincial government insisted for many years that no more than 65,000 strata apartments were damaged, including all the ones that had not been discovered yet.

The report said officials now realize they still don't know "the full extent of building envelope failure."

The consultants made no attempt to estimate the total cost of the damage, but concluded that early estimates of the repair cost per unit — \$10,000 to \$15,000 — were far too low.

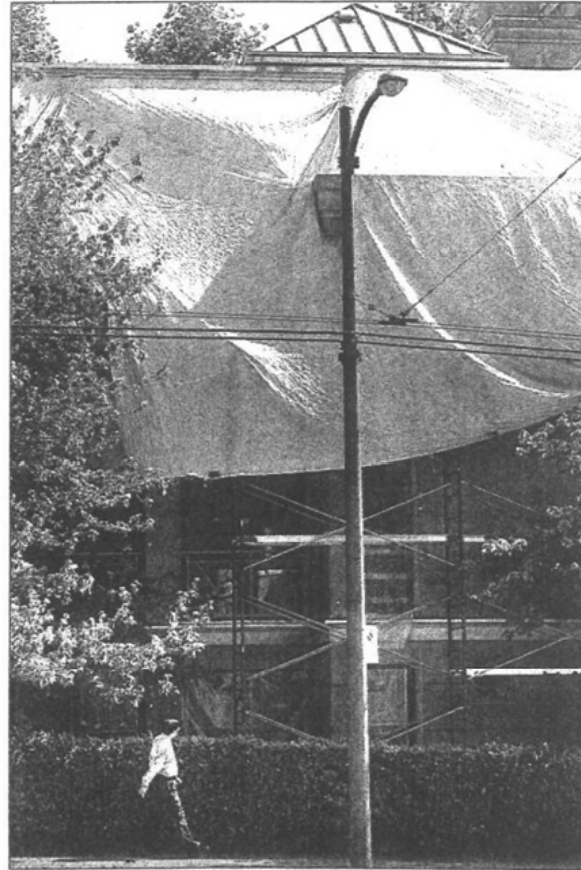
"Based on the HPO experience, it would appear that the actual average repair costs are approximately five times or six times higher," they said.

By last September, repair loans the HPO makes to leaky condo owners had grown to an average of \$62,000 for wood-frame apartments, and \$72,000 for those in concrete buildings.

The repair costs continue to escalate because of construction cost inflation, 10 per cent last year and expected to be eight per cent this year, the consultants added.

The report's findings were based in part on the HPO's repair loan statistics — it has been making repair loans since 1999 — and in part on B.C. Assessment Authority records of units that suffered a sudden drop in assessed value of 15 per cent or more, a likely sign of building envelope failure.

Nearly a decade ago, the HPO estimated that the 65,000 units it then said were damaged would cost \$1.5 billion to repair. The consultants did not provide a new number, but based on *The Sun's* extrapolations of their scenarios,



STEVE BOSCH/VANCOUVER SUN

Repair costs are skyrocketing because of construction cost inflation of 10 per cent last year and an expected eight per cent this year.

it appears the complete repair cost for strata apartments alone is in the range of \$3 billion to \$4 billion.

The consultants' report was presented to the HPO last December, but was not distrib-

uted to the media and not posted on the HPO's website, although an executive summary was posted. It took persistent requests from *The Vancouver Sun* to obtain a full copy of the report.

It said 159,979 strata units were built during the leaky condo period. Based on a moderate estimate of 72,000 leakers, 45 per cent of those units were defective.

The higher estimate of 87,500 problem units suggests 55 per cent of strata units built during the period suffered building envelope failure.

Some 30,000 homes have already been repaired, but at least 42,000 others still require major reconstruction, the report said. In the report's worst-case scenario, 68 per cent of leaky condos have not been repaired yet.

Concrete highrises have been slower to show water problems than wood-frame buildings, and the report said six to 10 highrises, often with 100 or more units per building, are being added to the leaky lists each year.

"A small increase in the number of buildings from this segment could have a significant impact on the HPO reconstruction program," it said. In a background paper, the HPO said it expected "demand for assistance will likely remain high for the foreseeable future."

The consultants' report said the percentage of units in leaky buildings whose owners need financial help to make repairs has risen in the last three years from just under 40 per cent to nearly 49 per cent. Eight-one per cent of HPO repair loans have been for units in wood-frame buildings, and the rest for concrete.

With files from Derrick Penner
bboei@png.canwest.com

All Types of Buildings Affected

- ▶ Apartment Condos
- ▶ Townhouses
- ▶ Single Family
- ▶ High-Rise
- ▶ Co-Op Housing
- ▶ Social Housing
- ▶ Private Rental Bldgs
- ▶ Institutional Bldgs
- ▶ Commercial Bldgs

A10 | NEWS | THEPROVINCE.COM

MONDAY, SEPTEMBER 8, 2008

Hundreds of leaky schools slated for repair: Minister

BY LORA GRINDLAY
STAFF REPORTER

Education Minister Shirley Bond said yesterday that hundreds of leaky schools need to be fixed.

She was responding to media reports that revealed that almost 400 B.C. schools built between 1985 and 2000 are leaking — or are being inspected for leaks.

Canadian Press reported it will cost nearly \$357 million to repair the schools.

Five engineering firms are said to be doing building-envelope-condition assessments on the schools, with Surrey School District hav-

ing 48 schools under assessment, the most in any district.

Bond issued the following written statement:

"In 2002, we created the school building envelope program to provide a coordinated and cost-effective repair strategy. We are working closely with school districts to move ahead with these repair projects and are not aware of any resulting health issues.

"Litigation settlement negotiations are under way in an effort to recover damages from the responsible parties."

lgrindlay@png.canwest.com

Government Response

June 16, 1998 “The Barrett Inquiry” submitted it’s report to government

Following recommendations of the Inquiry,

- ▶ Homeowner Protection Act passed July 28, 1998
- ▶ Homeowner Protection Office opened October 1, 1998,
 - ▶ – Mandatory residential builder/developer licensing,
 - ▶ – Mandatory Warranty backed by 3rd party insurers
 - ▶ – And a “no-interest loan” and “Sales Tax Relief program to assist owners of leaky homes

City of Vancouver = Rainscreen



...and flashings

Is it a Hole?



Or a Vapour Diffusion Port ??

Do
They
Work ?



Leaky Condo Disaster



Why
Problems
Now ?



Built 1996, Photo 2001

Early “causes” of the Disaster

- ▶ Shoddy Construction. Inferior workmanship.
 - Non-union trades
 - Building boom of the early 1990’s
 - Fly by Night contractors
 - Inexperienced Supervisors and Trades

- ▶ Greedy Developers
 - Cost cutting
 - Inferior materials

- ▶ Faulty Design
 - Inappropriate California style design

More Specifically

- ▶ Mis-lapped building paper
- ▶ Inadequate head flashings
- ▶ Missing sill/pan flashings
- ▶ Pipe/vent penetrations not flashed
- ▶ Backsloped flashings, lapped connections
- ▶ Backsloped decks, clogged drains

- ▶ Handrails too short – and any other code violation attributable to any innocent bystander with an insurance policy.

And...

- ▶ Leaking windows
- ▶ OSB sheathing (instead of plywood)
- ▶ “New growth” lumber (vs. “old growth”)
- ▶ “deadly combination” Housewrap and Stucco
- ▶ Stucco too thin.
- ▶ Stucco mix (less soap, more cement?)
- ▶ No overhangs
- ▶ Complicated design – corners, decks etc.
- ▶ Inadequate or no design details

No shortage of Problems... What did we do?

- ▶ By 1995 -1996
- ▶ Vinyl windows, welded corners
- ▶ Extended head flashings with end dams
- ▶ Peel & stick sill pans + sheet metal w/end dams
- ▶ Really good stucco
- ▶ Really good caulking
- ▶ Sloped flashings, w/standing seam joints
- ▶ Back to plywood sheathing
- ▶ Two layers 30 minute rated building paper

Problem Solved? Not yet...

- ▶ Problems still showing up, some worse than ever.
- ▶ The culprit: **CONSTRUCTION MOISTURE**
- ▶ The solution: Delmhorst Moisture Meters for all:
 - Consultants,
 - Superintendents
 - Framers

And there's more...



Maplewood Place, Burnaby



Corrosion of Galv. Steel Frame



Poly VB intact...

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SATURDAY, AUGUST 1, 2009 | BREAKING NEWS: VANCOUVERSUN.COM

GOVERNMENT POLICY

Leaky condo assistance dries up, Liberals say program is obsolete

Critics call the move 'a betrayal' of condo owners whose units haven't been fixed

BY DERRICK PENNER
VANCOUVER SUN

The provincial government is scrapping a program that for the past decade has provided leaky-condo owners with interest-free loans to pay for repairs.

Housing and Development Minister Rich Coleman said the loan program has more than run its course and is no longer sustainable.

The program was established as condo-owner advocates called on the government — whose building codes and regulatory programs were blamed by some for the problem — to foot the entire bill for the repairs, which is estimated at several billion dollars or more.

Critics called the move "a betrayal" of condo owners whose units have not been repaired yet.

Coleman said he has asked the government's Homeowner Protection Office, which administers the loan program, to review its operations and determine "what other programs may or may not be necessary."

His ministry confirmed that the HPO's chief executive, Ken Cameron, is leaving his job.

In addition to the loan program, the HPO runs education programs for the construction industry, sets standards for and licenses homebuilders, renovators and strata management companies, and monitors the homebuilding industry home warranty program that was brought in after the leaky-condo crisis collapsed the existing program.

Established by the then-NDP government in 1998, the program was initially envisioned as a 10-year, \$250-million effort to help owners repair leaky buildings built before 1999.

The HPO has loaned out almost \$670 million to the owners of 16,000 condo, primarily on the South Coast.

"I think the moral responsibility was

met by successive governments by continuing the program longer than it was intended to go, and by funding it at a much higher level than it was intended to be," Coleman said in an interview.

Opposition housing critic Shane Simpson called it a bad decision that leaves current owners of leaky condos high and dry.

"I think it's nothing short of a betrayal of leaky-condo owners by the premier, by the minister and the government," Simpson said in an interview.

"The government made a commitment some 10 years ago to help people to deal with these leaky condos, and they're now turning their backs on who knows how many people who are still facing this problem."

Simpson added that there is a continued demand for the loans.

The HPO will stop taking new applications immediately and process the 100 or so pending applications it has in hand, with a view to wrapping up the program by Dec. 31.

Coleman said the government will introduce legislation in the next session to officially end the program.

He added that the province topped up the loan program with \$9 million to make sure it could fund its pending obligations after the HPO hit the limit of its financing earlier this year and had to stop awarding loans.

The loan program was funded by a \$750-per-home levy on new construction, but the sharp drop in housing starts resulted in a drop in revenue to the program. Coleman said the levy will remain in place since loans are still outstanding.

He said the majority of applications the HPO now receives are from buildings that have leaked because of poor maintenance rather than construction failure.

"That's not what the program is for, so basically what we've done is said it's time to sunset this program," Coleman said.

However, more than a year ago the HPO received a report from consultants McClanaghan & Associates that estimated some 45 to 55 per cent of the 160,000 strata-owned apartments built in B.C. during the leaky-condo period — considered between 1982 and 1999 — had suffered "premature building envelope failure."

The report's authors estimated that between 45 and 68 per cent of the leaky units had not yet been repaired, and that by 2012, up to one-third of them would still need fixing.

Pierre Gallant, an architect with engineering consulting firm Morrison Her-shfield, said it is hard to estimate the number of buildings that still need repairing, but said the loan program was "hugely successful and very helpful" in encouraging homeowners to take action on their problems with leaky condos.

"Not all [buildings] have been repaired," Gallant said. "Probably the majority have been repaired, but what does that mean? Fifty-one per cent, or 90 per cent?"

Gallant's concern is that without the loan program, owners will be more reluctant to address their problems with leaks and buildings will go longer without repairs.

Coleman said the government would have to look at further evidence and determine if there was a "different problem that we need to address."

Advocates for leaky condo owners were outraged.

"I think it's atrocious," said James Balderson, a long-time advocate for leaky-condo owners. He said he could not understand why the provincial government can't extend a loan program when the government of Canada can bail out General Motors.

Friday's decision also did not sit well with former premier Dave Barrett, who headed a commission that looked into B.C.'s leaky condo problem.

depenner@vancouver.sun.com

More Recent News

"Assessment of Future Demand"

2008



© Baird / Yacht-Images.com

Leaky Condo Disaster



Problem: Rainwater Penetration

31

North Vancouver



Built 1977



Why older buildings not affected?

- Vancouver always had rain
- Workmanship/materials ???

Kiwanis Village, Crescent Beach



Built early 1950's

Windows leak – immediately ?



Water Test Windows

Window installation ?



- ✓ Aluminum Window Frame
- ✓ Corners not welded/sealed
- ✓ Wall opening not papered
- ✓ No head flashing
- ✓ No sill pan or membrane
- ✓ No air seal around frame

Sheathing Paper Installation ?



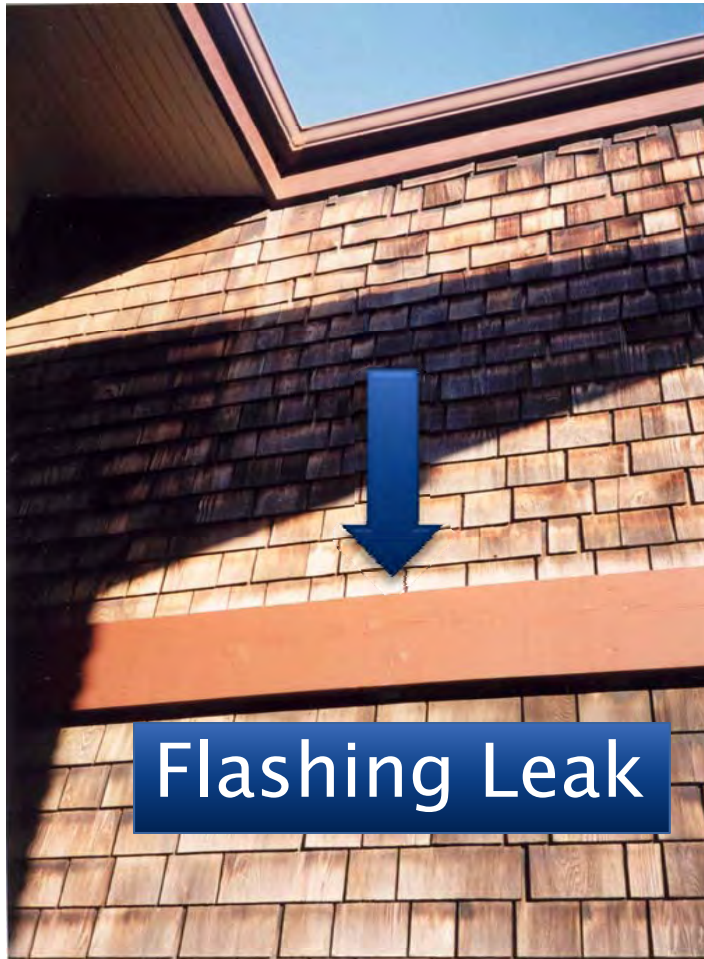
- ✓ Single layer
- ✓ Reverse lapped
- ✓ No window lap
- ✓ Holes all over

Lots of Water – but no rot... ?



Water stains below window

Clarendon Court, South Vancouver



Built 1950

Energy Efficiency – Comfort

- ▶ Increased R-Values
- ▶ Increased Air-Tightness
 - 1970's – R8 Paper Backed Batts
 - 1980's – R12/R14 Batts w/2 mil Poly
 - 1990's – R14/R20 Batts w/6 mil Poly,
...caulked and sealed

Changed Drying Ability?

- ▶ Higher Insulation Values
- ▶ Greater risk of interior condensation due to colder outer surfaces
- ▶ Therefore: better vapor barriers
- ▶ And: Better airtightness
- ▶ Polyethylene solved vapor barrier and airtightness problem

More Insulation = More Damage ?

Burnaby



Built 1992 R14

Coquitlam



Built 1996 R20

The Coquitlam Test Hut

Dr. Joseph Lstiburek

- ▶ **Principal of Building Science Corporation**
- ▶ **Located at Boston , Ma.**

For Building Science information/research:

- ▶ **Go to: <http://www.buildingscience.com/>**

The Coquitlam Test Hut



Dr. John Straube, PhD



Dr. Joseph Lstiburek, PhD

May 17, 2004 First Discussion of Test Hut

An Informal Partnership

- Gauvin 2000 Construction Ltd.
 - Construction and Maintenance

- Building Science Corporation
 - Expertise, Guidance, Analysis

- Balanced Solutions Inc./University of Waterloo
 - Instrumentation, Monitoring, Analysis

- And Dupont, Icynene and James Hardie
 - some “hands off” Funding & Materials

Waterloo BEG hut

University of Waterloo,
Building Engineering Group



Natural Exposure & Test Facility

In operation since 1990

Charleston Test Hut

Charleston, South Carolina



June 2004

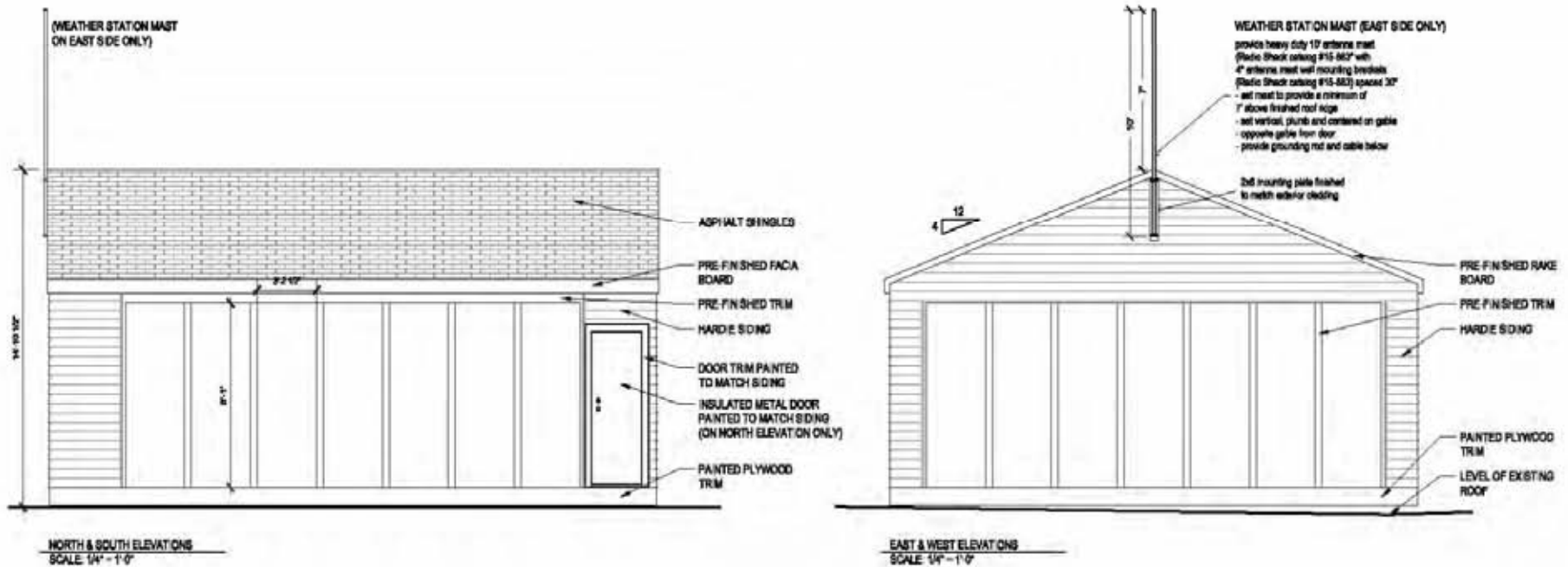
Building site



- ✓ Accessible
- ✓ Secure
- ✓ Power
- ✓ Water
- ✓ Internet
- ✓ FREE RENT

Roof Top at 1140 Austin Avenue,
Coquitlam

Plans – 2 weeks... Permits – 1 year



Phoenix Structural Designs Ltd.
Port Coquitlam, B.C.

Construction Underway



October, 2005

Test Panel Openings



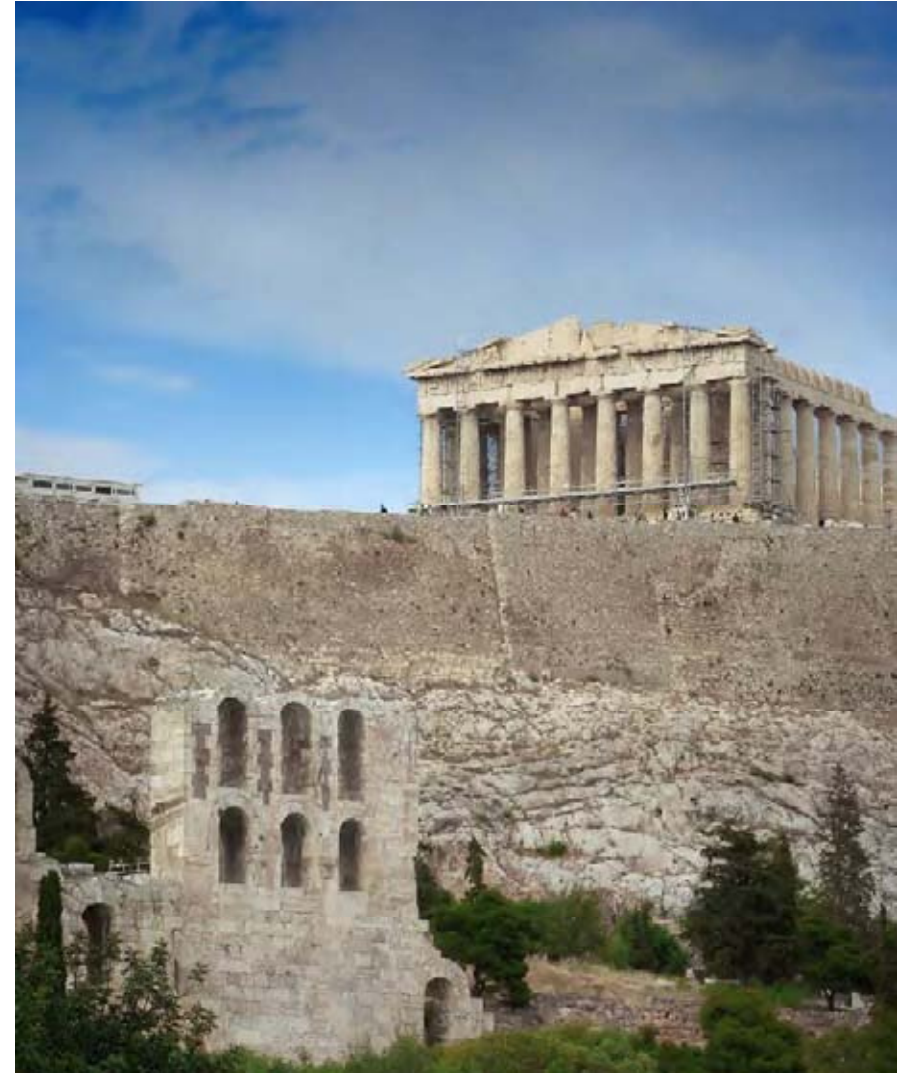
Nice work
Chris !

Installing Sensors in Test Panel



David
Hill

Chris
Schumacher



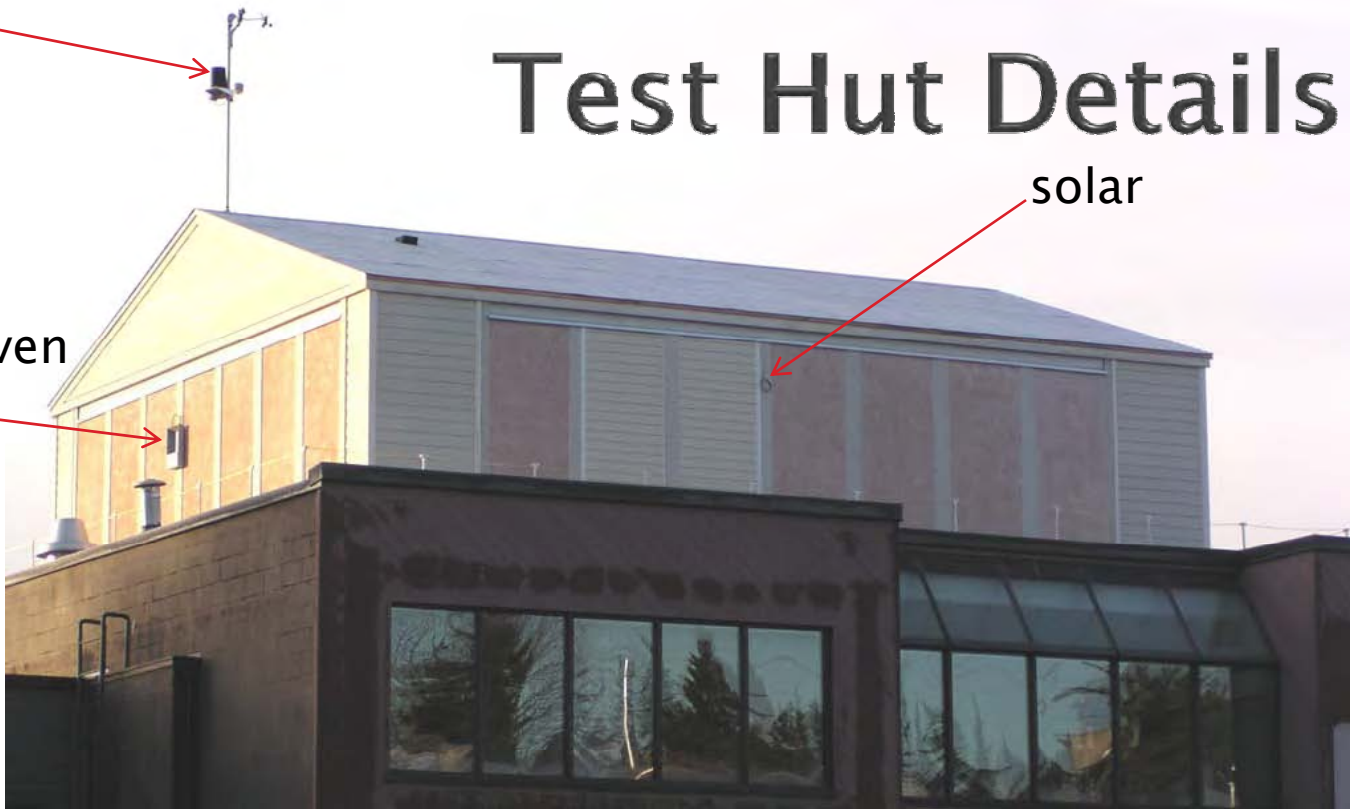
The beginnings of building science?

Weather

Test Hut Details

solar

Wind-driven
Rain



- ▶ 7 Wall assemblies each orientation (x4)
- ▶ 3 Roof assemblies each orientation (x2)
- ▶ Full weather station

Field Trip – March, 2006

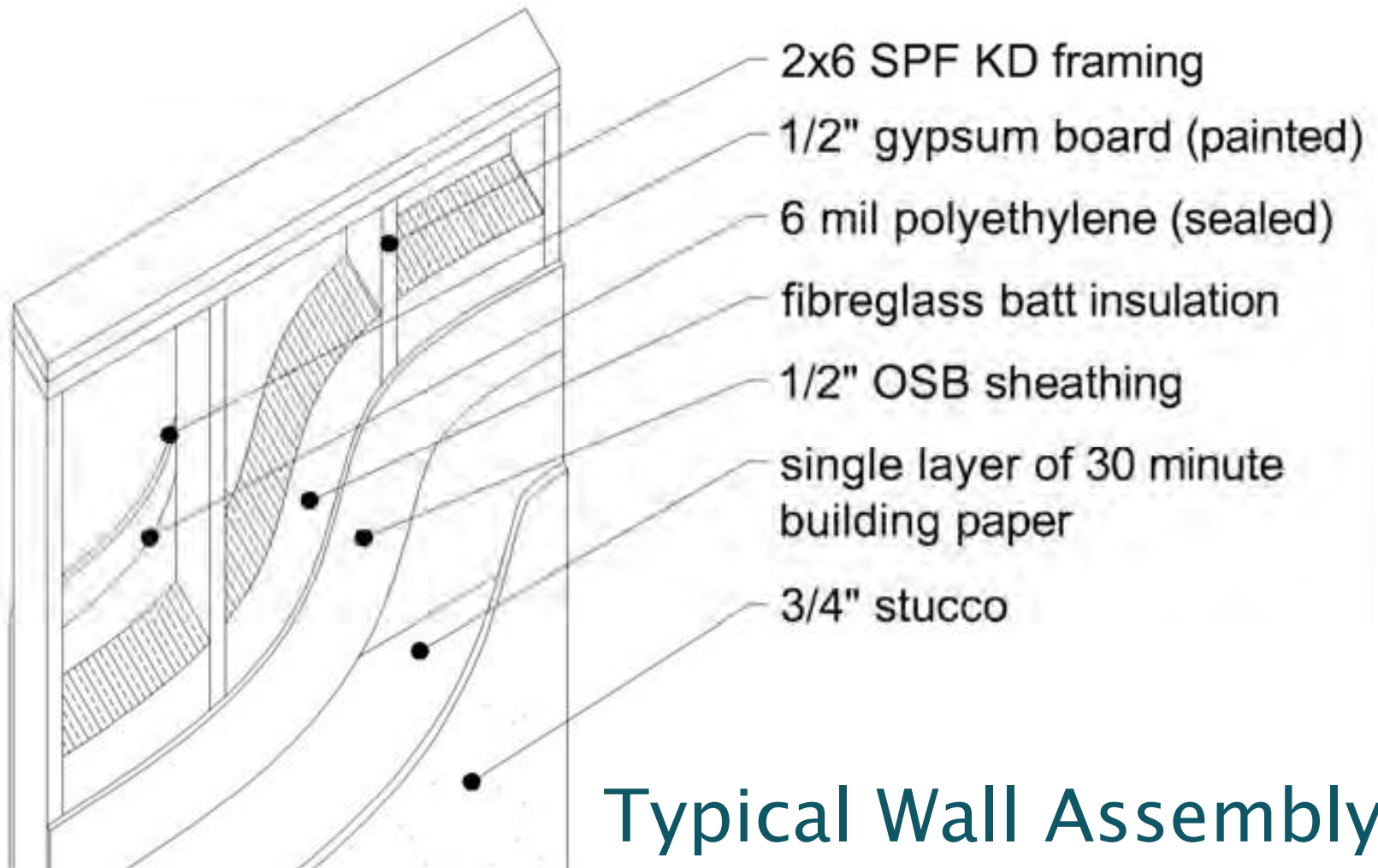


Gauvin

Observation Port



1980s Energy Efficient 2x6 (airtight w/poly)



Wall Assemblies (typical)

70's	90's	90's	USA	Rain/Screen	Foam	
1	2	3	4	5	6	7
2x4	2x6	2x6	2x6	2x6	2x6	2x6
paper	Poly	Paint	Paint	Poly	Paint	Paint
R8	R20	R20	R20	R20	R20	R20+5
3/8 ply	½ OSB	½ OSB	½ OSB	½ OSB	½ OSB	*½ OSB
1 paper	1 paper	1 paper	Drain-wrap™	House wrap™	House wrap™	Drain-wrap™
Stucco	Stucco	Stucco	Stucco	*Stucco	*Stucco	Stucco

* Variation on N. & S. Walls

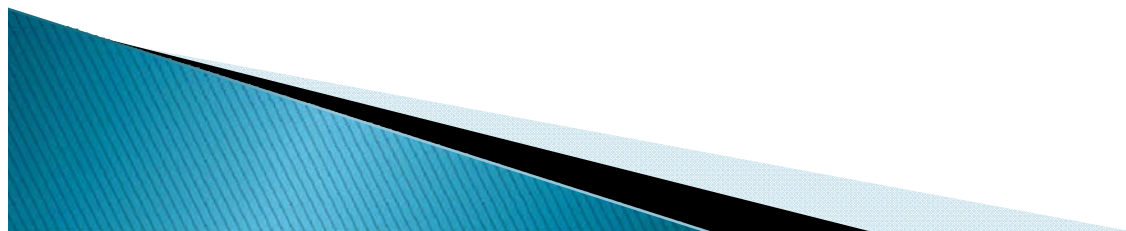
Instrumentation

Sensors – Walls and Roof

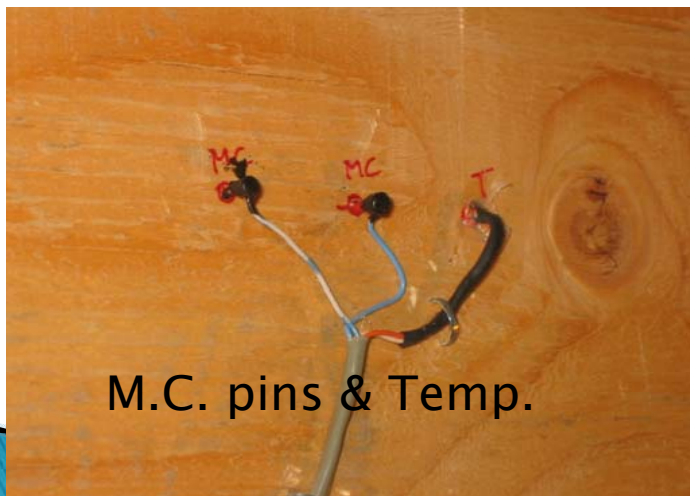
- Temperature
- Wood moisture content – EMC
- Relative Humidity

Located;

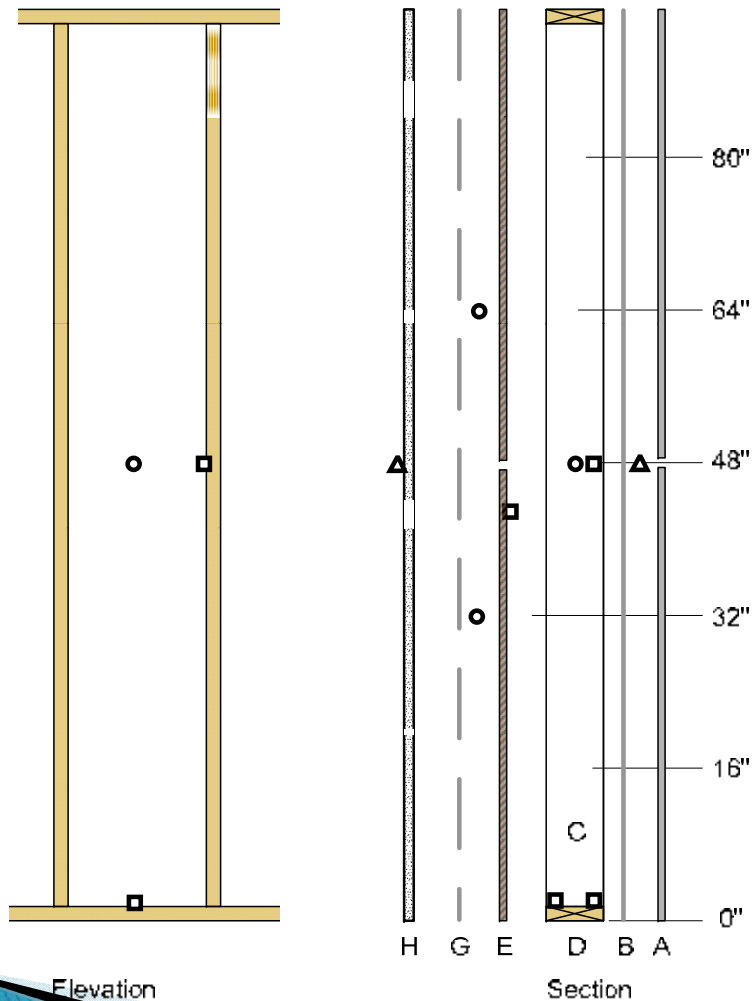
- Bottom and mid–height each wall
- Inside, middle, outside each wall



Sensors & Wetting Systems



Typical Sensor Layout



Assembly		
Layer	Function	Description
A	Interior Finish	gypsum wall board
B	Vapor Control	poly
C	Studspace	fiberglass batt
D	Framing	2x6
E	Sheathing	1/2" OSB
F	Sheathing Membrane	#15 felt
G	Drainage Gap	none
H	Cladding	stucco

Sensor Package		
Layer	Code	Location
A	taem	Interior finish, exterior face, 48"
C	r/tcnm	Studspace, interstitial, 48"
D	m/tdem	Framing, interior edge, middle
D	m/tdem	Framing, exterior edge, bottom plate
D	m/dib	Framing, interior edge, bottom plate
E	m/tenm	Sheathing, interstitial, 48"
G	r/tgnw	Drainage space, interstitial, 32"
G	r/tgnc	Drainage space, interstitial, 64"
H	them	Cladding, exterior surface, 48"

- Relative Humidity and Temperature Sensor Package
- Moisture Content Pins and Temperature Sensor Package
- △ Temperature Sensor
- ▨ Moisture Content Wafer and Temperature Sensor Package
- Moisture Content Pins

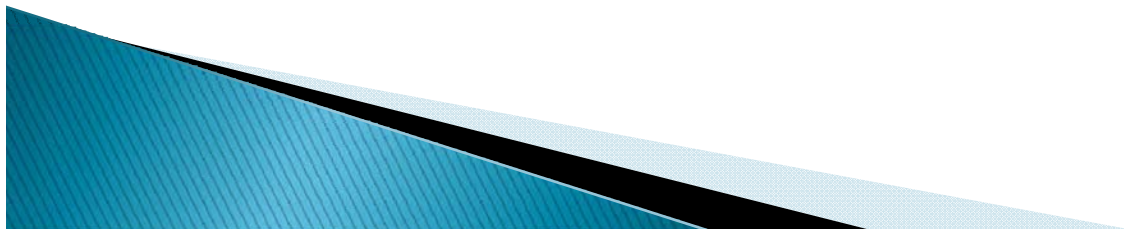
Instrumentation



by Chris Schumacher

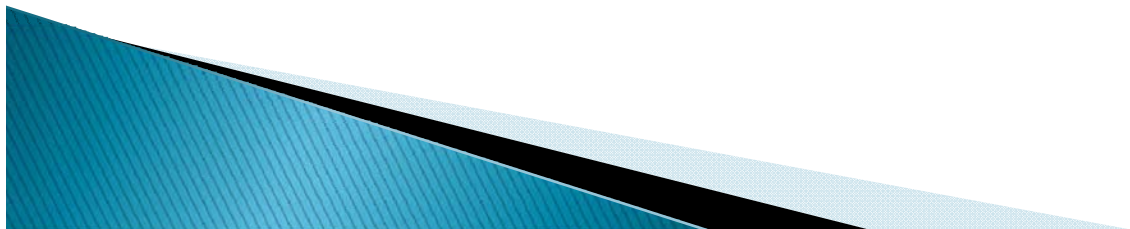
Phase One First Year

- ▶ Indoor Temperature constant at 20° C.
- ▶ Indoor R.H. not controlled.
(Indoor Relative Humidity allowed to fluctuate naturally – lower in winter, higher in summer)
- ▶ Leak Simulation – **Controlled wetting** at interior face of sheathing.



Phase Two 2nd – 3rd Year

- ▶ Indoor temperature constant at 20° C.
- ▶ Indoor R.H. constant at 50%
- ▶ Leak Simulation – Controlled wetting of the interior face of the sheathing.

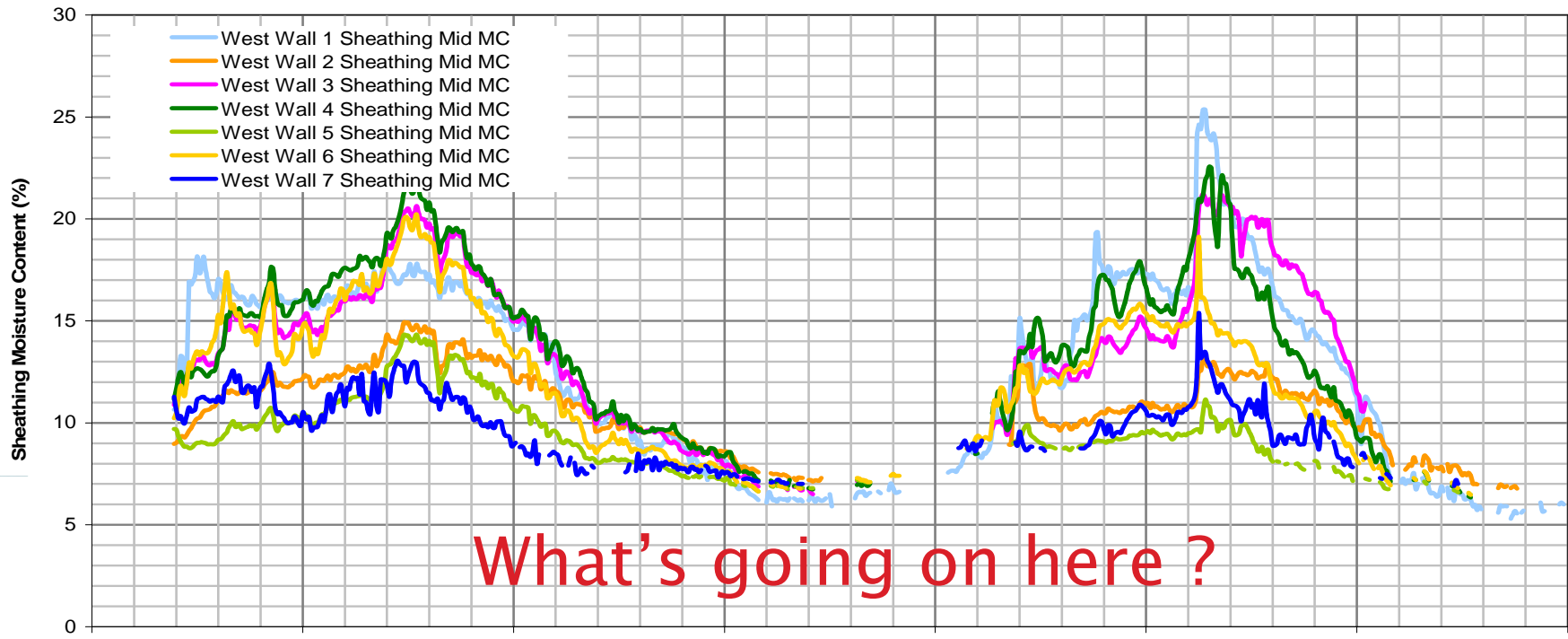
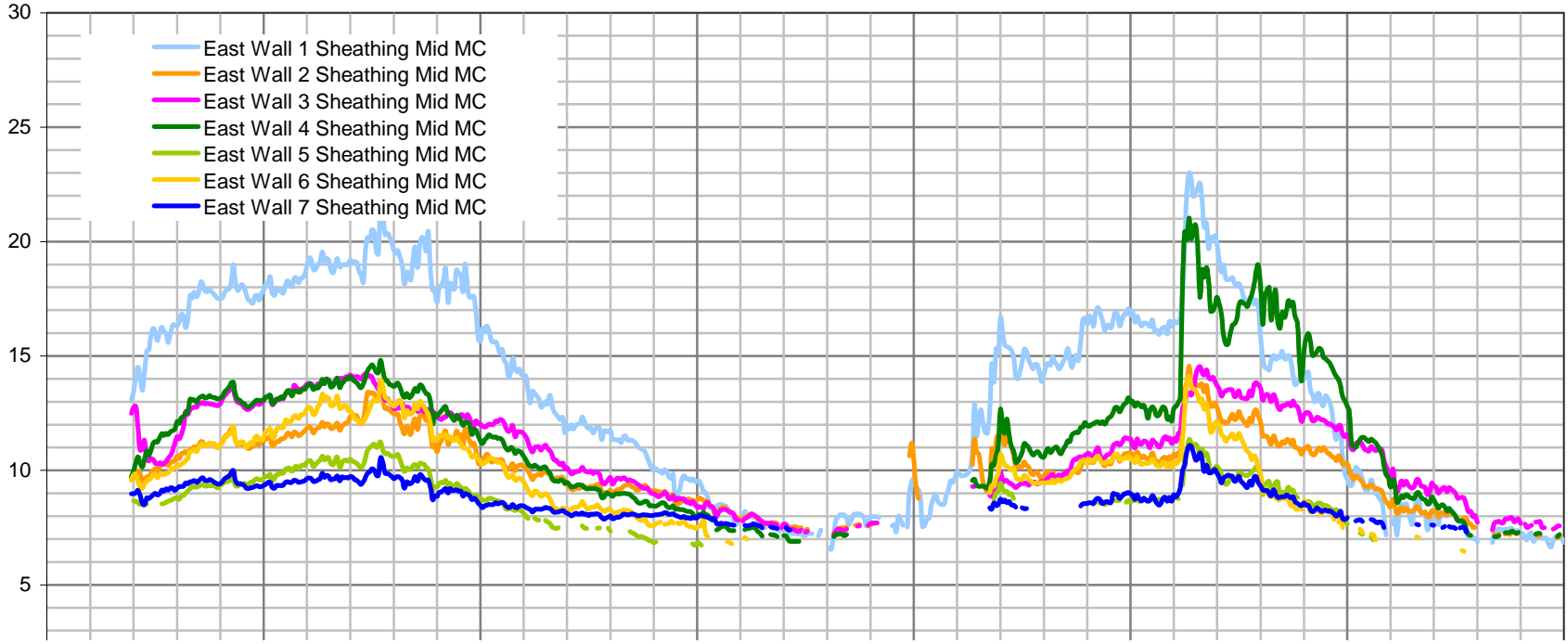


Phase Three 4th – 5th Year

- ▶ Indoor Temperature constant at 20° C.
- ▶ Indoor R.H. constant at 40%
- ▶ Controlled wetting of the Exterior and Interior face of the sheathing.
- ▶ Underway now – started November 2009

What Have I Learned?

- ▶ There is a lot going on inside a building enclosure.
- ▶ The laws of physics apply to Enclosures.
- ▶ Observation is a very useful tool.
- ▶ To understand, you must Measure what you can't see.
- ▶ Everything affects something else!



What's going on here ?

North Side
- No Sun

Which wall looks to be the driest?



After a rain...



Which wall looks to be the wettest?

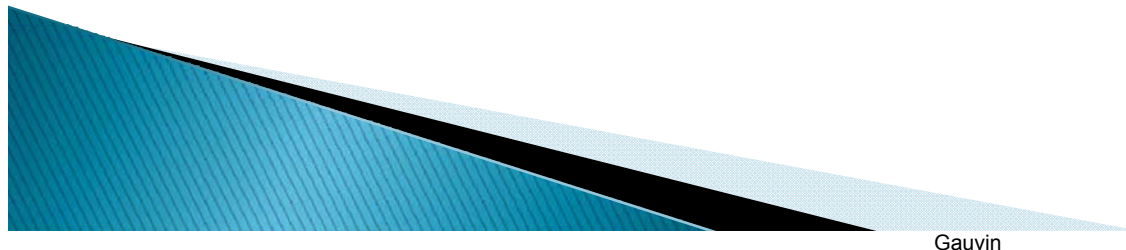
To understand, measure what you can't see.



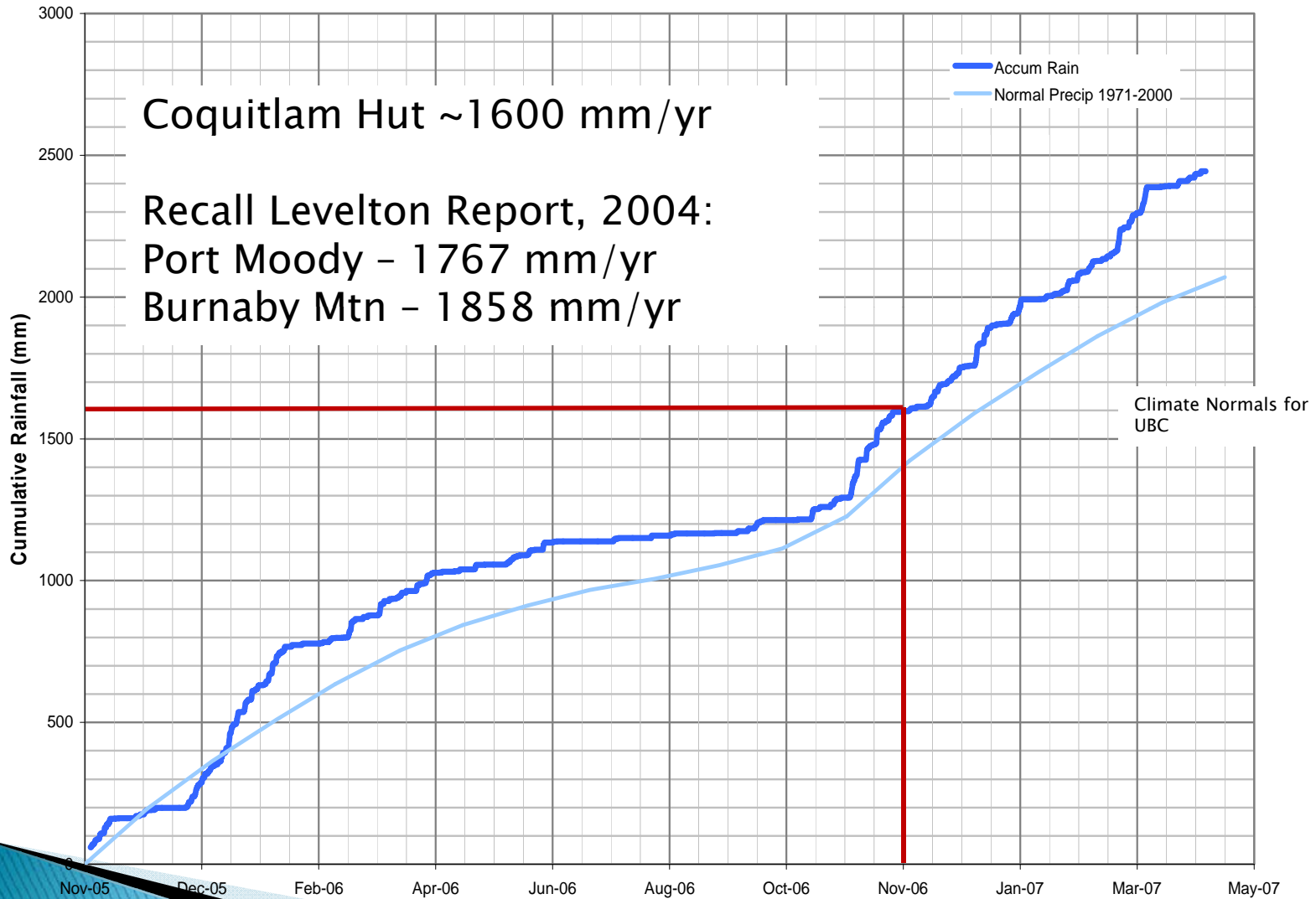
▶ Everything affects something else

Let's look at:

- ▶ **OUTDOOR CLIMATE and Wood Moisture Content (EMC)...**

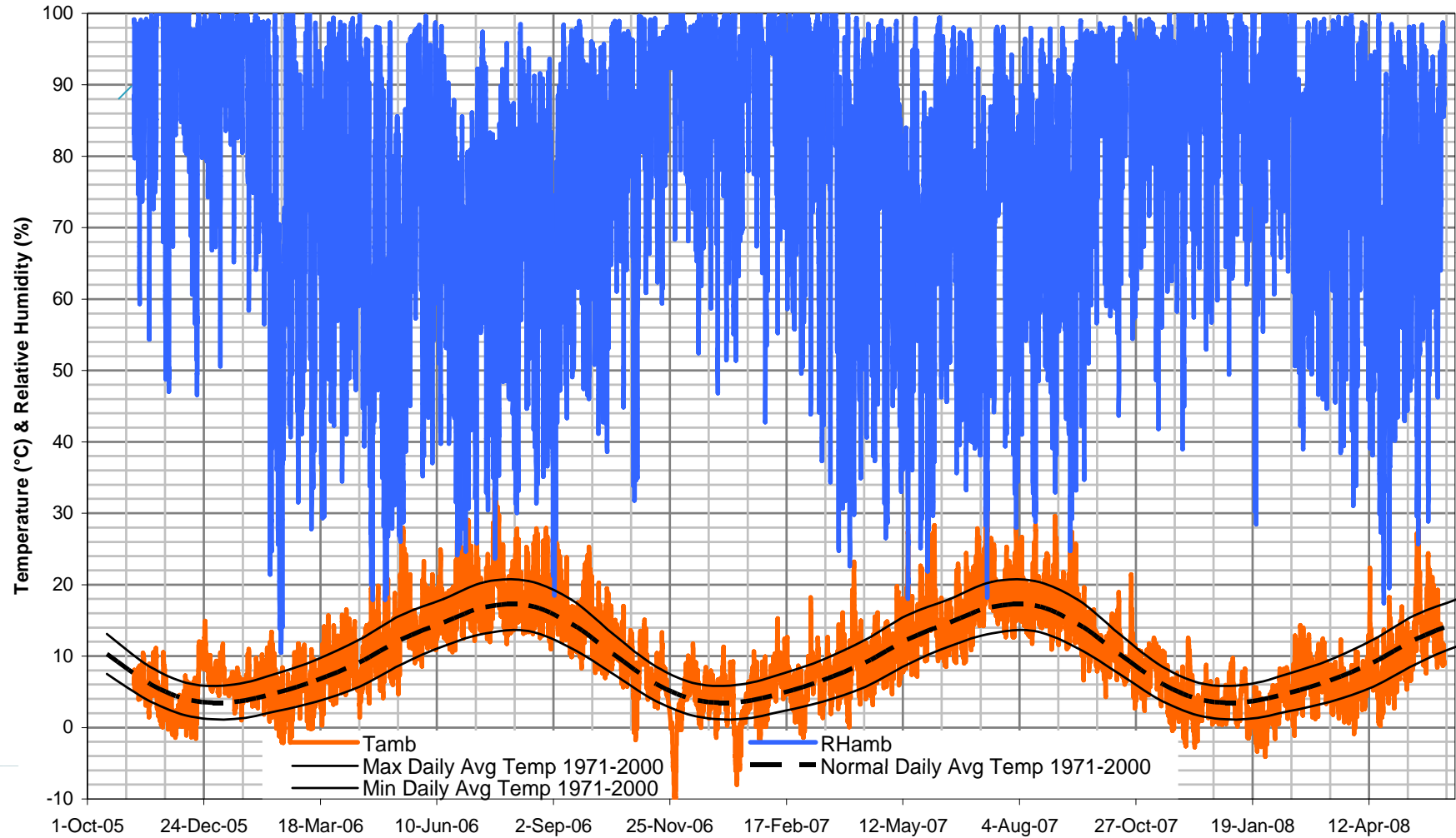


Cumulative Rainfall

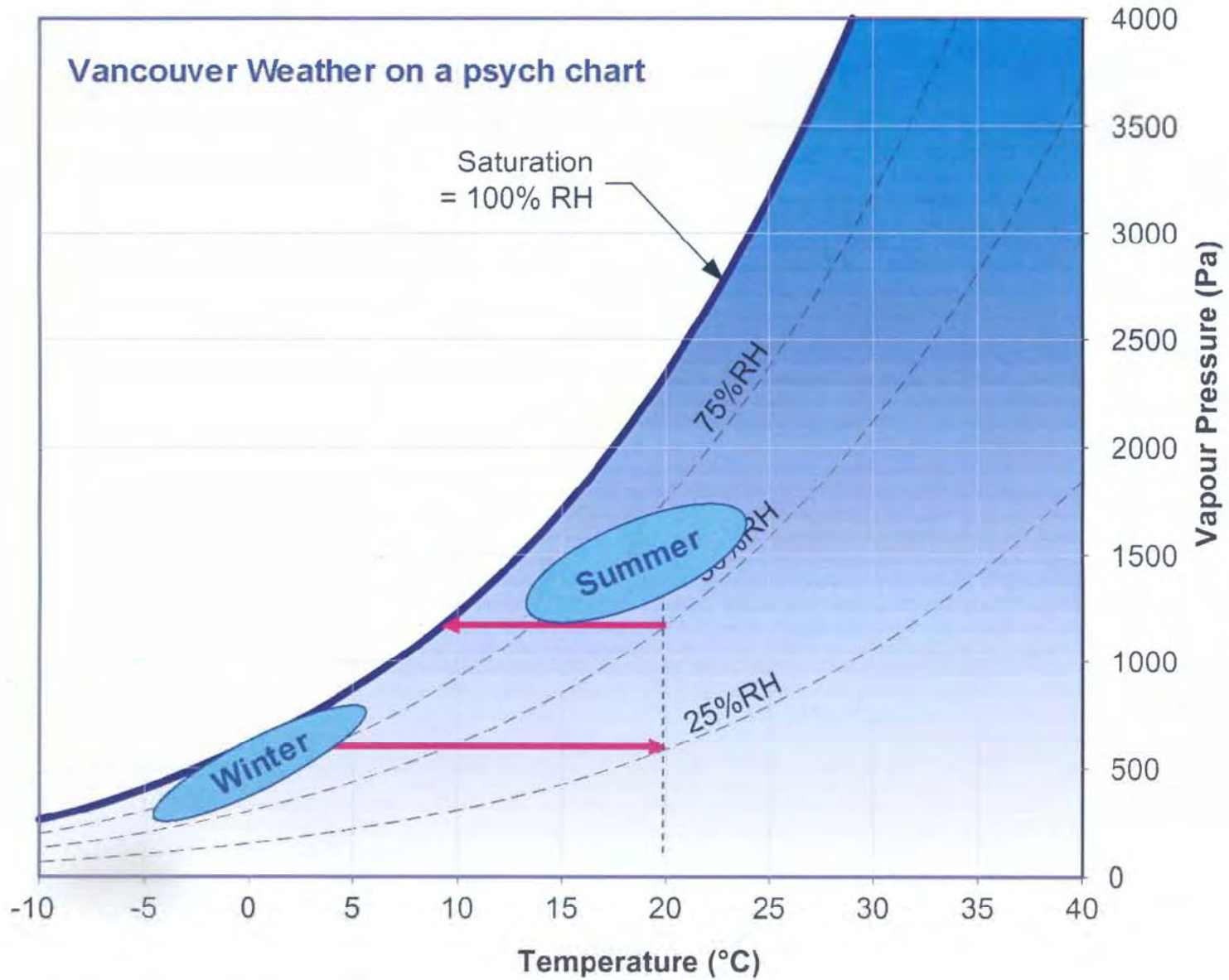


Outdoor Temp. & RH

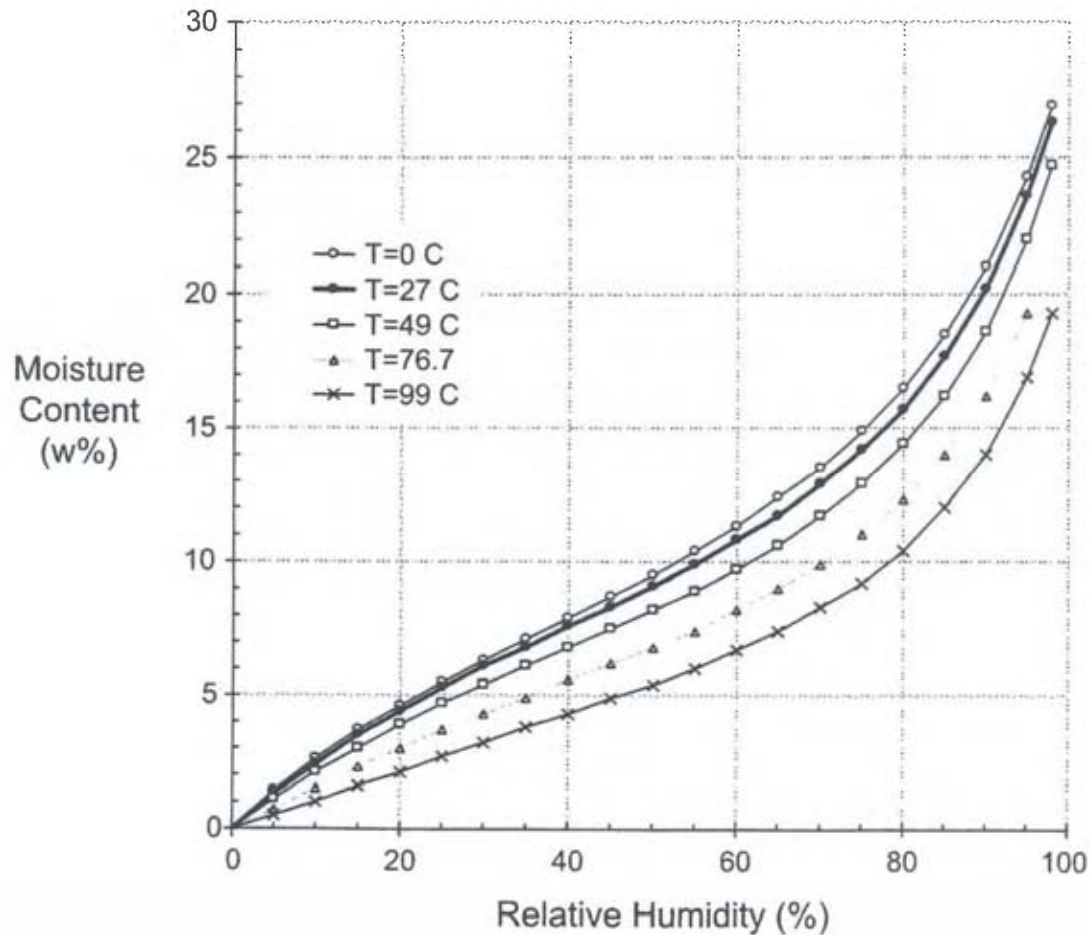
Outdoor Temperature & Relative Humidity - Coquitlam Test Hut



High Wintertime Humidity



Wood Moisture Content is a function of Relative Humidity

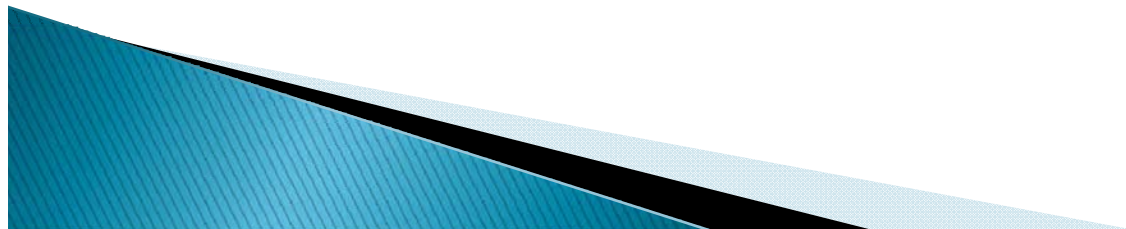


Average sorption isotherm for wood as a function of temperature.

US FPL Wood Handbook [1999]

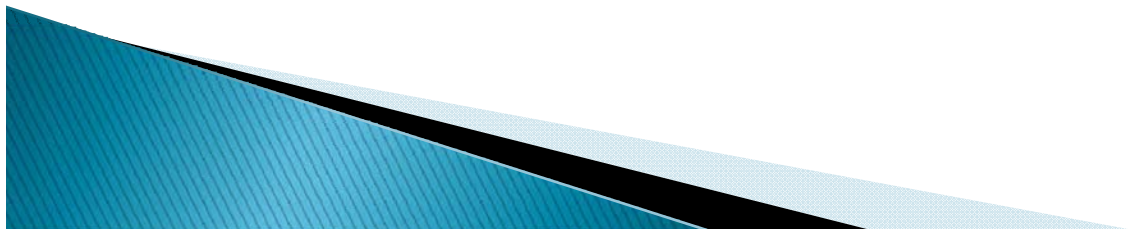
Lower Temperature = Higher EMC

- ▶ Better Insulation in stud space
- ▶ Sheathing closer to outdoor (colder) temperature
- ▶ Colder sheathing sees (high) outdoor RH
- ▶ Therefore sheathing Moisture Content raised
- ▶ Less capacity to store and redistribute moisture
- ▶ Sheathing more susceptible to damage with any additional moisture – such as rain water



More insulation = Less Energy

- ▶ Drying water requires change of state
 - Liquid water to water vapor
- ▶ Change of state requires energy
 - Latent Heat of Vaporization
- ▶ Does not require change in temperature
- ▶ More insulation means less heat (energy) flow
- ▶ Less energy = Less drying



So Far...

More Insulation gives us:

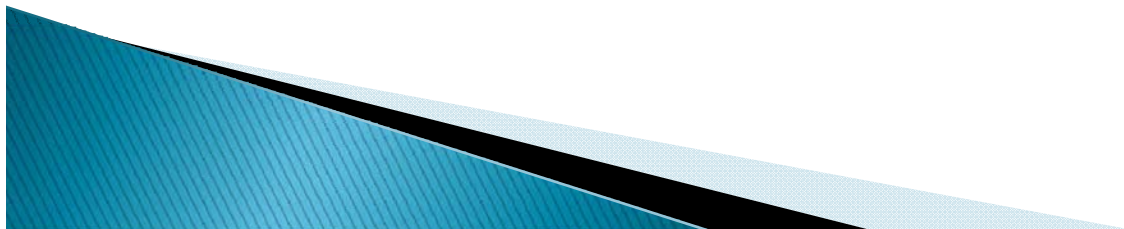
- Lower sheathing temperatures, Higher EMC
- Higher EMC, reduced storage capacity
- Less energy for drying

Did we know this 20 years ago?

Next: Poly Vapor Barriers

Poly very effective for intended purpose:

- Stops diffusion – of moist indoor air thru wall
- Stops air leakage:
 - ✓ To prevent moist indoor air reaching cold surfaces
 - ✓ To control heat (energy) loss to exterior
- ▶ Protects wall from condensation on cold outer surfaces



Poly

No poly



Poly wins! ...but?

1970's Wall – No Poly

- Stucco, 2x4, R10 Paper Back Batt, Plywood
- Thick frost inside plywood (melting as wall opened up)
- OAT minus 8° C.

What Happened??



Photo taken 9:00 AM
December 20, 2008

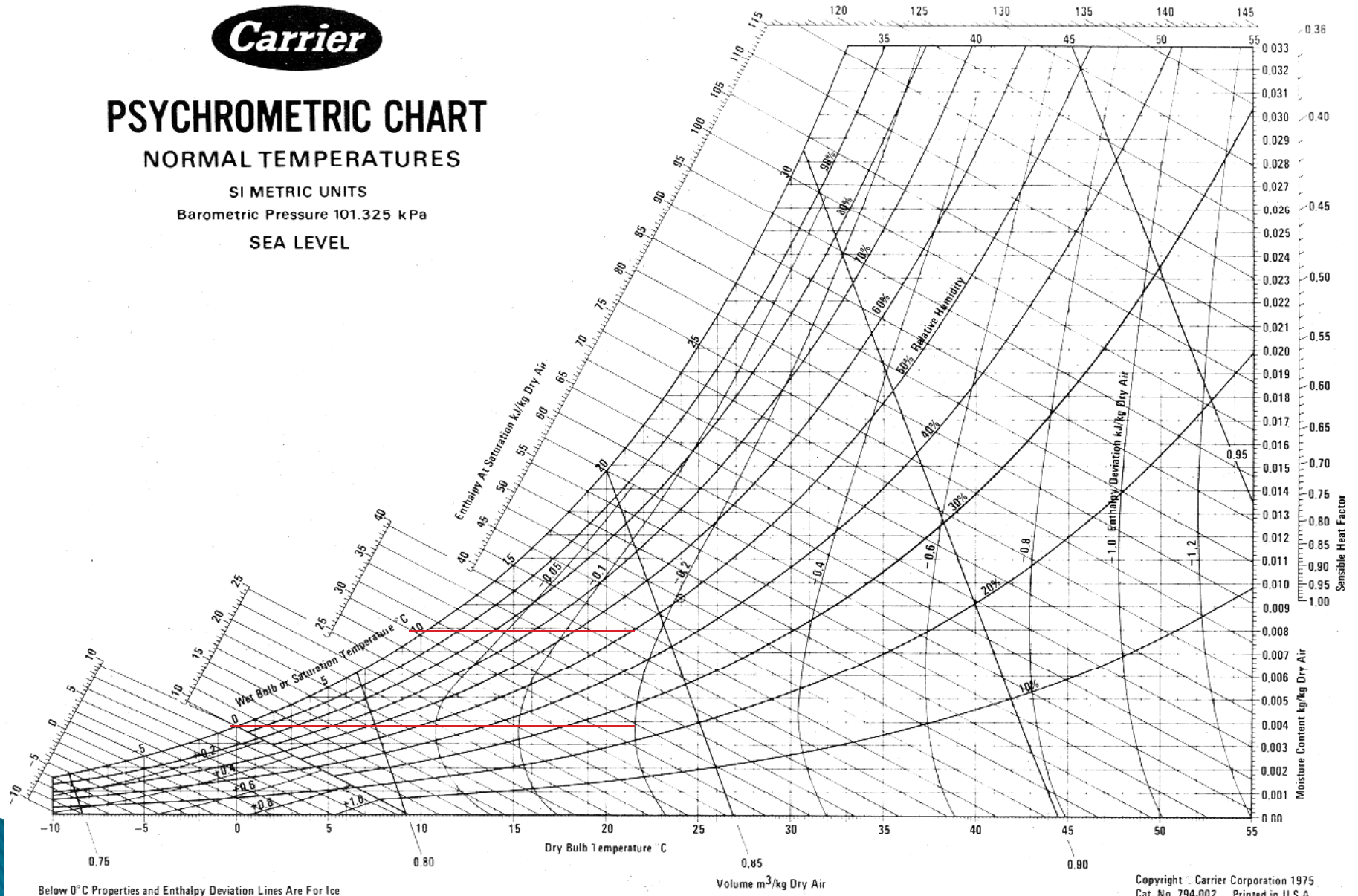
C.



PSYCHROMETRIC CHART

NORMAL TEMPERATURES

SI METRIC UNITS
Barometric Pressure 101.325 kPa
SEA LEVEL



Below 0°C Properties and Enthalpy Deviation Lines Are For Ice

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Vapour Barriers (Retarders)

- ▶ Indoor (RH) matters – **ventilation**
- ▶ Surface Temperatures matter
- ▶ Diffusion matters

All these increasingly important as we move away from poly vapor barriers

De-Construction August, 2009



East Walls

Great Stucco!



Off to the lab for testing...

Phase 3 Testing – Changes

Changes:

- All New Walls
- All New Instrumentation

Plus:

- Walls will be wetted Exterior and Interior
- Interior R.H. will run at 40% (was 50%)
- Top of walls instrumented (to monitor convective looping and condensation)

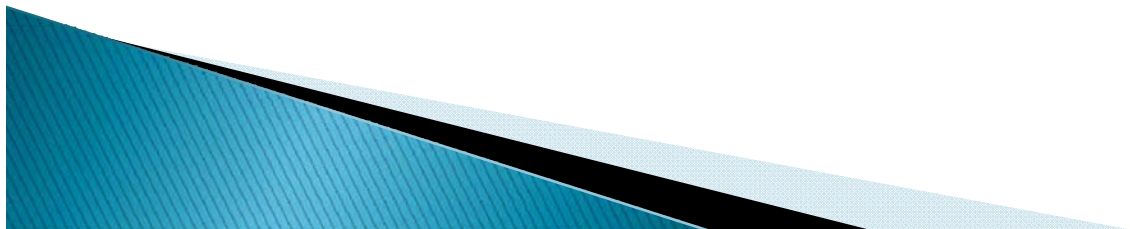
Phase 3 Testing – Questions

- ▶ Does poly vapor barrier inhibit drying (to interior)?
- ▶ Outside Wetting – how do rain water “leaks” affect performance?
- ▶ Is solar drive a factor – wetting, drying or both?
- ▶ Effect of lower (controlled) indoor RH

Rain Screen Walls

Do They Work? Yes!

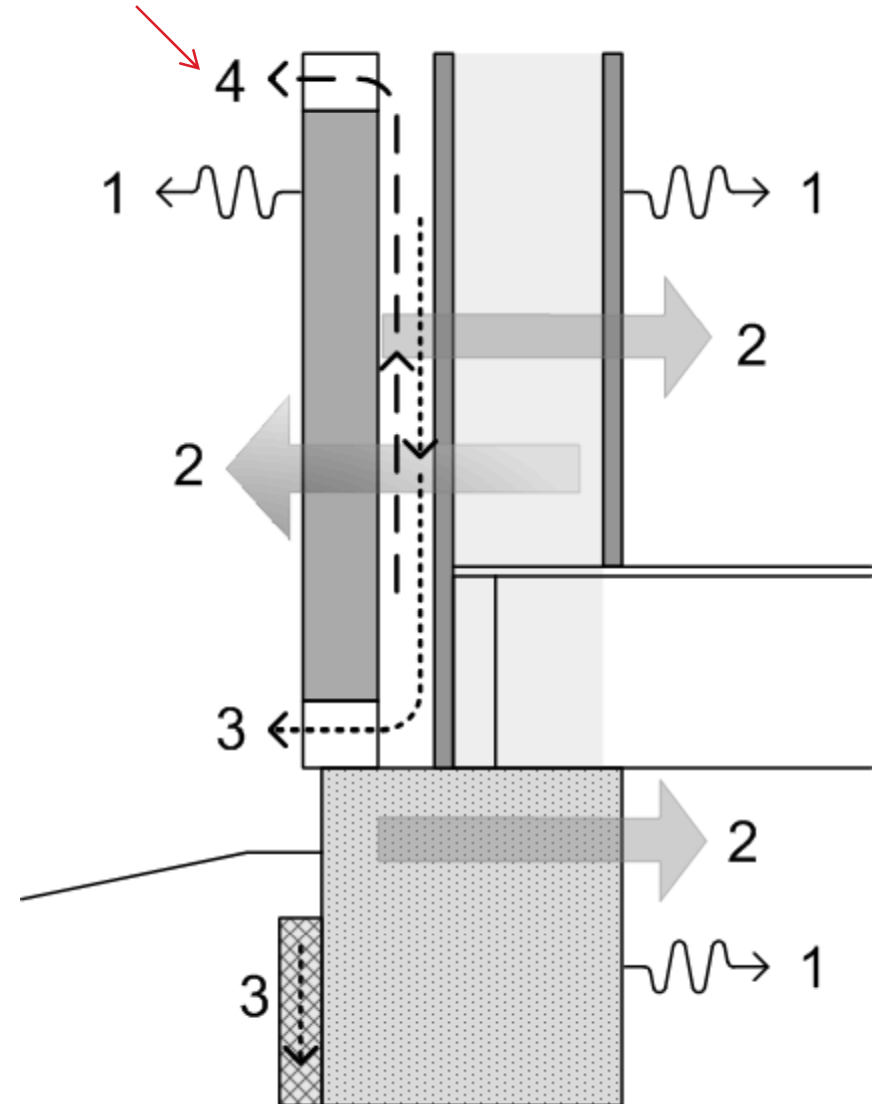
- Capillary Break
- Drainage Space
- Pressure Equalization
- AND Ventilation



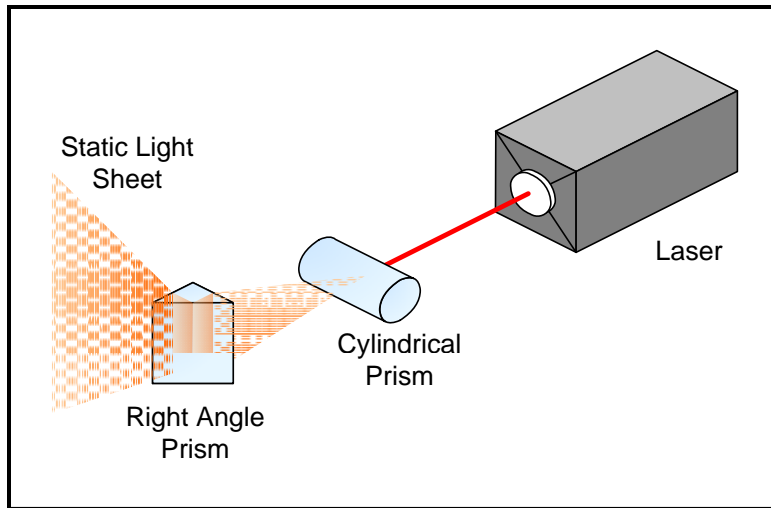
Recall drying mechanisms

1. Surface Evaporation
2. Vapor movement by
 - i) Diffusion
 - ii) Convection
3. Drainage by gravity
4. Ventilation
(Intentional convection)

Ventilation



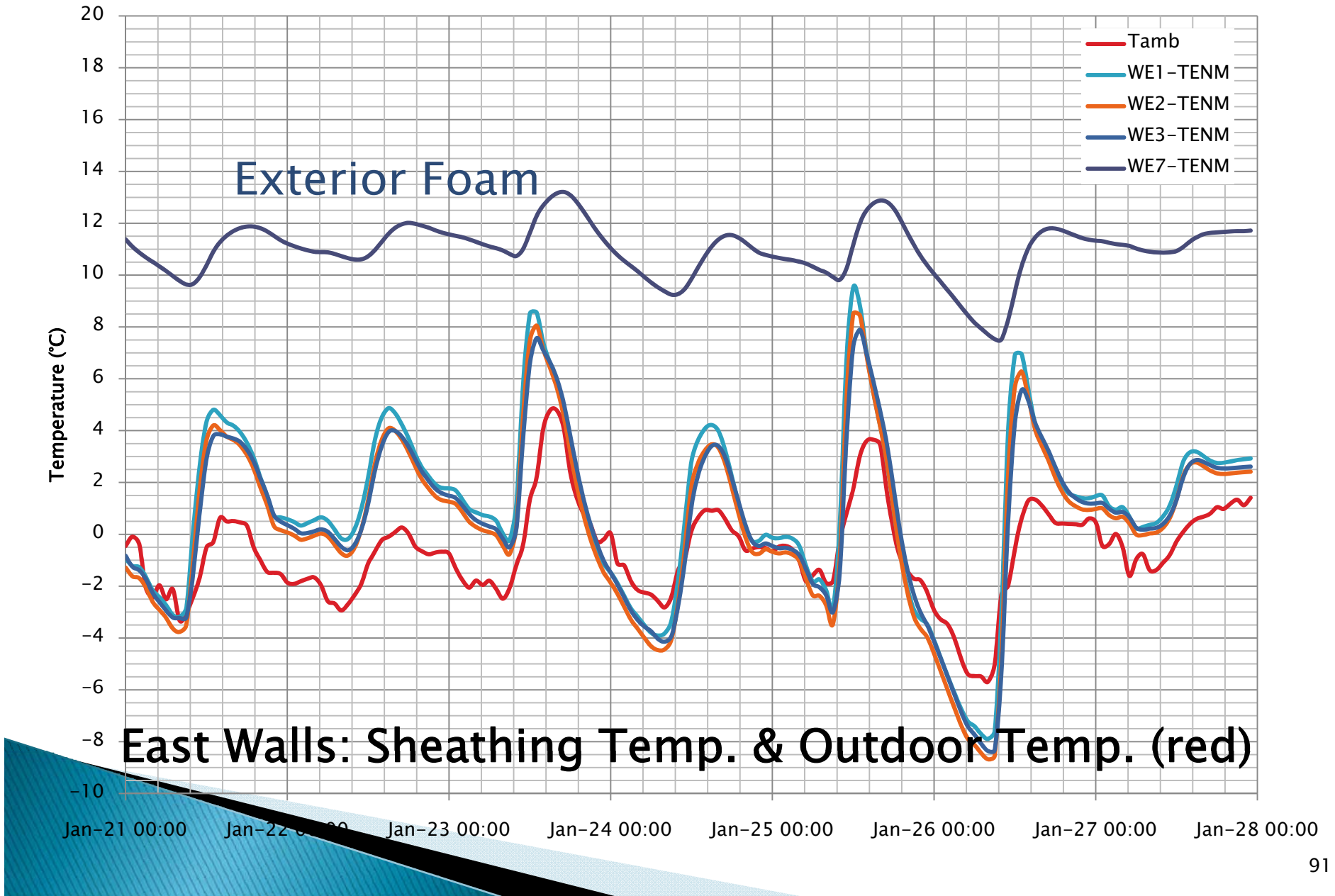
Flow Visualization (U of Waterloo 2004)



Flow Visualization (U of Waterloo 2004)



Exterior Insulation



Exterior Insulation

- ▶ Keeps wood warm
- ▶ Keeps wood dry
- ▶ Reduces condensation potential
- ▶ Reduce thermal bridging
- ▶ Reduces heat (energy) loss
- ▶ **BUT...**



Some Conclusions...

- ▶ High Energy Performance is compatible with Durability
- ▶ Research and Testing is Good
- ▶ Institutionalized Thinking is Bad
- ▶ Building Science needs to Reach Industry

Thank You! Come visit...

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▶ <http://vancouver.buildingscience.com/>
- ▶ **Building Science Corporation**
▶ <http://www.buildingscience.com/>
- ▶ **Building and Safety Standards – Gov't of B.C.**
▶ <http://www.housing.gov.bc.ca/building/>