



## Durability Considerations for Wood Construction

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### Presentation Outline

- General trends of wood construction
- Basic structure and wood-water relationship
- Durability considerations during design
- Related FPInnovations research
  - Differential movement
  - Cross-laminated timber (CLT) building enclosure
  - Infill wall application
  - Energy efficiency improvement
  - Assistance to university research on durability

## Newer Buildings Built Better?

- “Leaky condo crisis”-a lesson not to be forgotten
- More attention paid to moisture management
- Consultation with building science professionals
  - Has become a standard procedure during design
  - Required in some jurisdictions
- General guidelines on design for durability
  - Best Practice Guide for Wood-Frame Envelopes /in the Coastal Climate of BC (CMHC, 1999)
- Best practice guide updated
  - Building Enclosure Design Guide – Wood Frame Multi-Unit Residential Buildings (HPO, 2011)

## Trends of Wood Construction

- Modern wood buildings getting taller
  - Mid-rise started in Europe and a few American states
  - BCBC allows 5, 6 storey residential as of April 6, 2009
- Emergence of new wood/wood-hybrid systems
  - CLT construction
  - Wood infill walls
- Relevant new code requirements
  - Energy efficiency

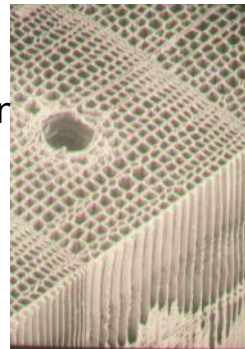
**Opportunities, but also durability challenges!**

## Wood-Water Relationship

- Trees cannot grow without water
- Wood and water get along most of the time
- Water affects properties and service performance
  - Strength, durability, dimensions...
- Wood achieves best performance when dry
  - Framing is expected to be “dry” ( $\leq 19\%$  based on NBCC)
  - Wood can tolerate certain amounts of water
  - But there is a limit
- Moisture impact must be considered in design

## Water Pathways into Wood

- Most rapidly through end grain
  - Exposed by end cuts, knots and cracks
- Much slowly through other surfaces
- Checking creates water traps
- Moisture not uniformly distributed
- Fungal infection increases absorption



## Conditions for Decay

- Favourable moisture contents: 40-80%
  - Threshold of MC: 26%
- Favourable temperature: 21-32°C
- Suitable food
  - Including non-durable wood
- Favourable competition over other micro-organisms
- Oxygen

## Decay Initiation Times under Marginal MC



- Tests done in conditioning chambers
  - Over 2000 samples
  - Various RH/MC
  - 20°C
- Inoculated fungi failed to establish
- Decay initiated in some samples by natural infection by spores

## Decay Initiation Times under Marginal MC

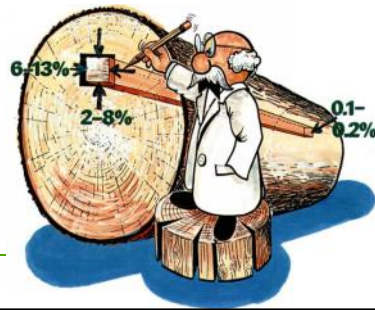
	90% RH	95% RH	~100% RH	40% MC
Hemlock	18%	24%	-	38% <b>(21 weeks)</b>
OSB	19%	25%	27% <b>(36 weeks)</b>	45% <b>(21 weeks)</b>
Plywood	22%	28%	-	45% <b>(&gt; 74 weeks)</b>

## Much More Than Marginal MC



## Shrinkage and Moisture

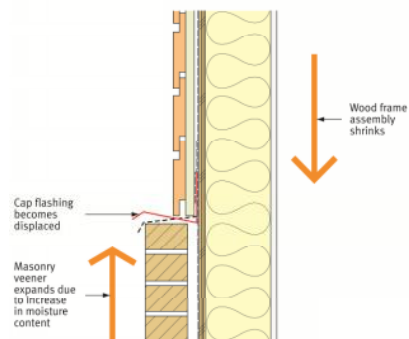
- Wood shrinks/swells with MC changes below 30%
- Shrinkage negligible longitudinal
- Mostly controlled by horizontal elements
- A rate of 0.2-0.25% per 1% change in MC usually recommended
- Coefficients being validated



FPIinnovations 2010

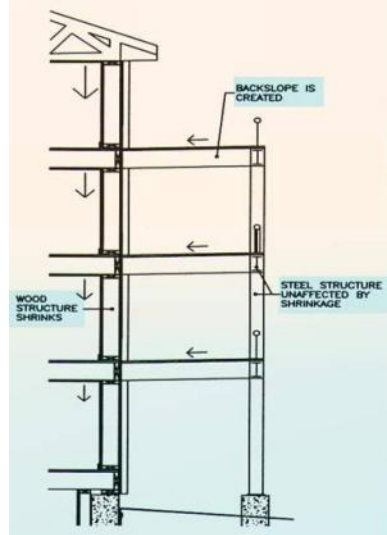
## Differential Movement Is the Issue

- Detailing important



## Differential Movement Is the Issue

- Detailing important



## Improve Durability – Three Choices

### Keep wood dry



#### Durability by Design:

Protect the wood from biodeterioration through good design and construction practice

### Make wood unappealing to organisms



#### Durability by Treatment:

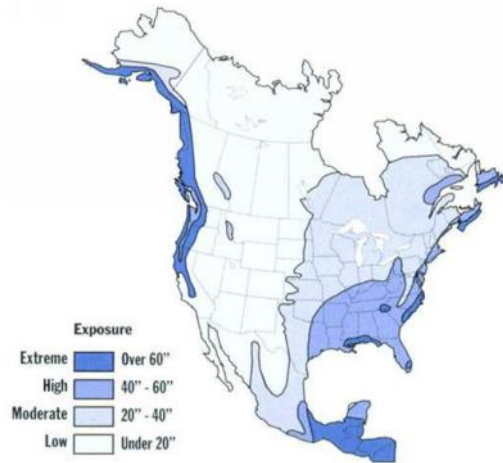
Protect the wood from biodeterioration through application of chemicals



#### Durability by Nature:

Use wood species that have their own protection against biodeterioration

# Rain usually the Largest Water Source



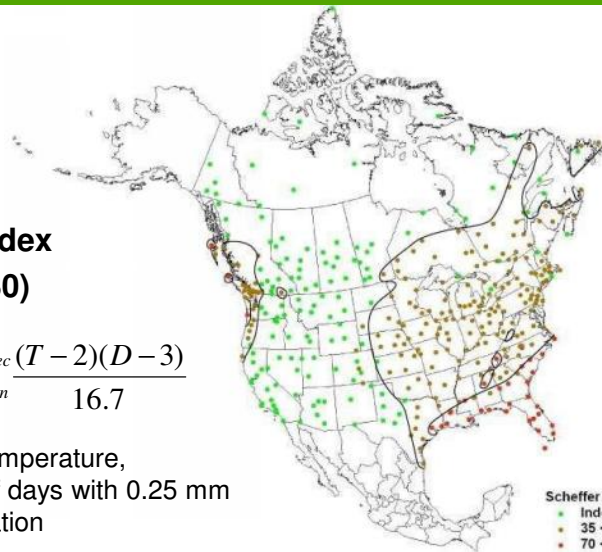
Building Science Corporation 2001

# Decay Potential of Above-Ground Exterior

## Scheffer Index (1951-1980)

$$\text{Climate Index} = \sum_{\text{Jan}}^{\text{Dec}} \frac{(T - 2)(D - 3)}{16.7}$$

T: mean monthly temperature,  
D: mean number of days with 0.25 mm  
or more of precipitation



FPInnovations 2008/2011

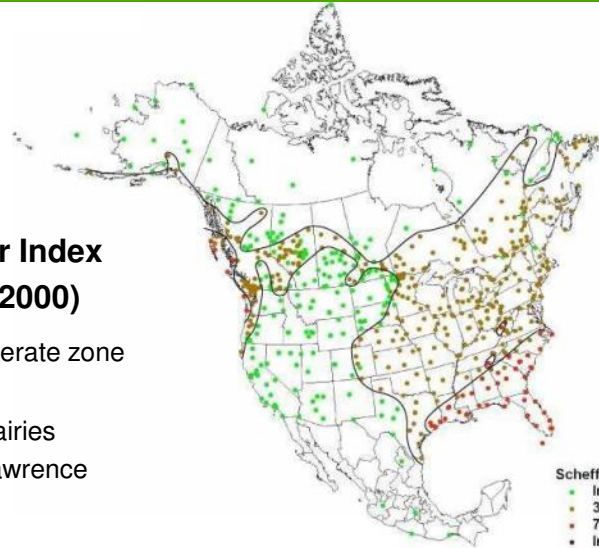


## Decay Potential of Above-Ground Exterior

### Scheffer Index (1971-2000)

Expansion of moderate zone

- Interior BC
- Northern Prairies
- Gulf of St. Lawrence



Scheffer Climate Index  
 ● Index < 35  
 ● 35 <= Index < 70  
 ● 70 <= Index <= 150  
 ● Index > 150

FPInnovations 2008/2011



## Moisture Management Principles

- Traditional durability measures still relevant
  - Pitched roofs and generous overhangs
- 4 “D”s effectively protect assemblies from moisture
  - Rain deflection, drainage, drying and durable materials
- Rainscreen concept important (drainage/drying)
  - “Perform adequately” in Vancouver (RDH study)
  - Important for increasing levels of insulation
- Interface detailing

RDH, 2007, Performance monitoring of rainscreen wall assemblies



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## 4 Ds also Apply to Outdoor Structures

- Deflection:
  - Post cap
  - Cap rail (could be wider)
- Drainage:
  - Staggered boards create gaps
  - Gravel
- Drying:
  - Open to the air
- Durable Wood:
  - Naturally durable boards
  - Treated wood posts



## Beam/Column: Overhang

- Best
  - Generous overhang



## Beam: Overhang

- Good, but could have been better
  - With a slightly wider canopy



## Column Base

- Good
  - Drainage
  - Ventilation
  - Clearance from soil
  - Separation from other wicking material



## Column Base

Durability by Design

- Extreme exposure
  - Metal boots
  - Eliminate drainage and drying



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## Column Base

Durability by Design

- Extreme exposure
  - Unless preservative-treated wood



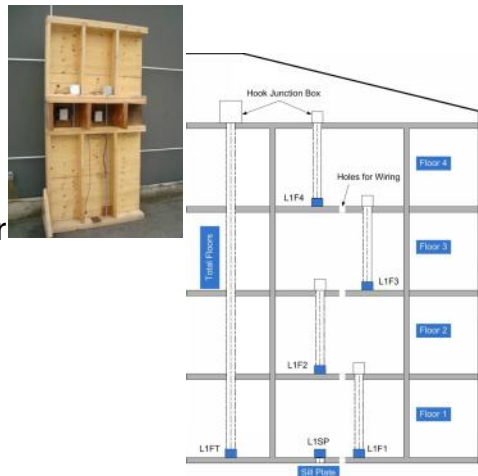
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## Related FPInnovations Research

- **General objective**
  - Identify research needs and provide solutions by working with the design and construction community
    - Building scientists, designers, developers, builders...
    - BC Housing/HPO, CMHC, schools, NRC...
- **Project examples**
  - Differential movement
  - CLT building enclosure design
  - Wood infill wall
  - Durable and energy-efficient assemblies
  - Assistance to NSERC NEWBuildS projects

## Differential Movement

- Literature and survey carried out
- Mock up test
  - Sensor selection
  - Sensor installation
- Real building
  - Movement of each floor
  - Different locations
  - Wood MC
  - Construction

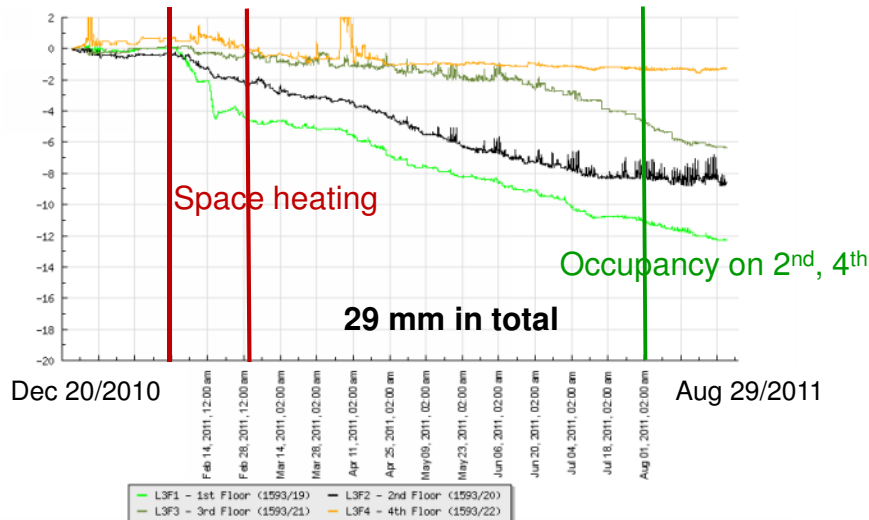


## Differential Movement Field Monitoring

- Movement closely related with wood MC changes
  - Lumber MC remains around 19% in winter
  - Space heating and ventilation dry wood efficiently
  - Much less wetting on construction site in summer
- Movement affected by local loads
  - Vary with floors and locations
- Time is an important factor
- Good construction sequence reduces movement and impact

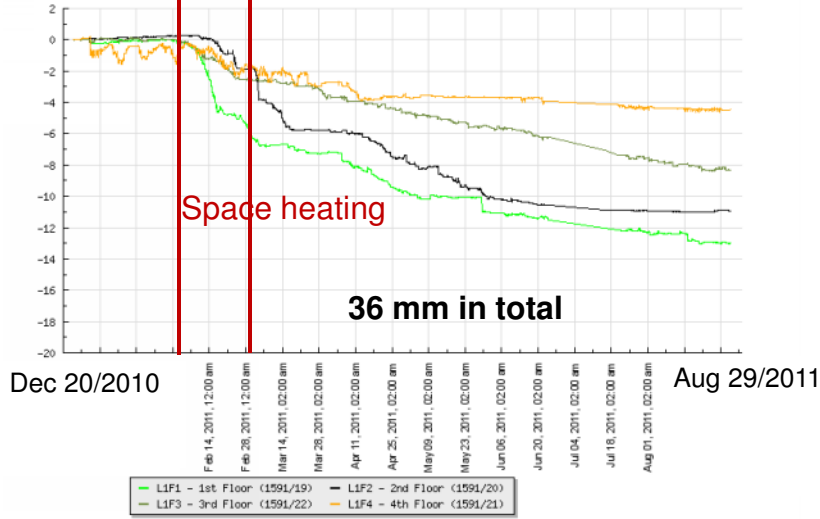
FPInnovations 2010; In collaboration with BC Housing-HPO, developers, SMT

## Vertical Movement in a 4-Storey Building



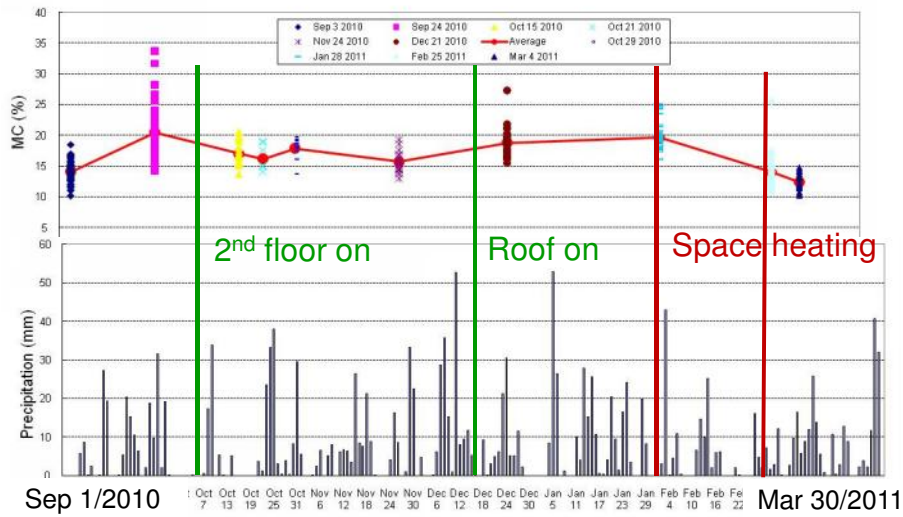
Exterior wall, construction started September 2010

# Vertical Movement in a 4-Storey Building



Shear wall at hallway, construction started September 2010

# Lumber MC Changes on Site in Winter

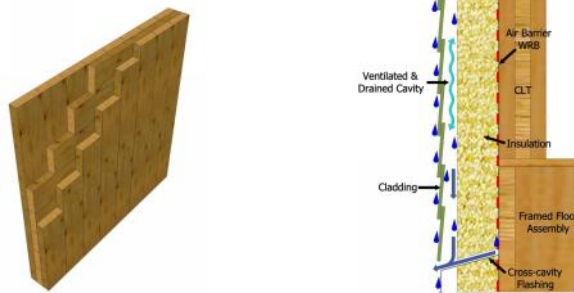


Changes of MC, chest height of studs, first floor

## CLT Building Enclosure Design Guide

### Objectives:

- Provide designers with guidance on CLT building envelope design
- Remind designers of durability considerations



CLT Handbook, 2010, FPInnovations , in collaboration with RDH, Associated Engineering, RJC, Morrison Hershfield, Patenaude-Trempe Inc.

## CLT Building Enclosure Design Guide

- Focuses on unique aspects of CLT envelope
- Emphasizes minimizing on-site wetting
- Assembly must allow drying in case wetting occurs
  - “Breathable” assemblies promote drying
  - CLT is a vapour retarder/barrier
    - No need for interior vapour retarder/barrier in cold climates
- Exterior insulation helps keep wood warm and dry
- A primary air barrier is recommended
  - Although CLT panel may provide good air tightness

CLT Handbook, 2010, FPInnovations , in collaboration with RDH, Associated Engineering, RJC, Morrison Hershfield, Patenaude-Trempe Inc.



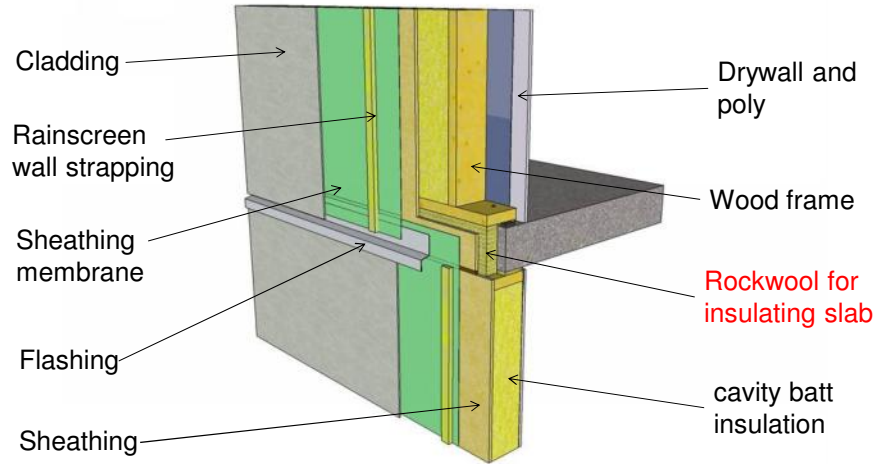
## Non-bearing Wood-Frame Exterior Wall

- For brevity, called “wood infill wall”
- Hybrid use in concrete and steel structures
- Originated in the Nordic countries in the 1950’s
- Technology spread to other European countries
  - The Netherlands, France, Austria, Germany, UK
- Interest in North America
- Building envelope design and detailing important

## Application in Mid- and High-rises

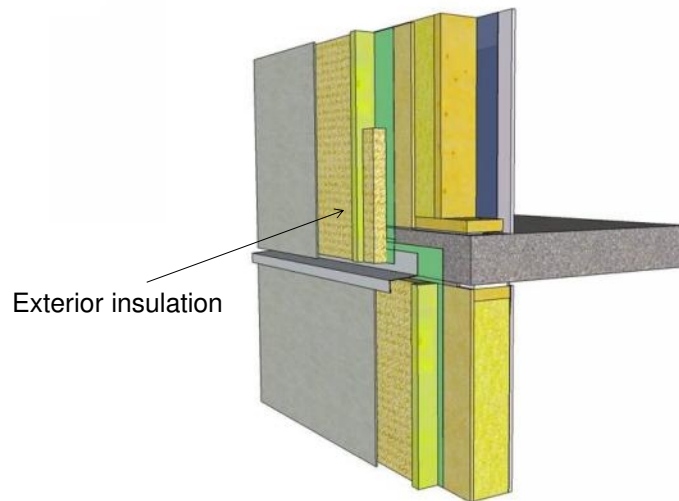


## Semi-Embedded Wood Frame



In collaboration with RDH Building Engineering

## Fully-Embedded Frame + Exterior Insulation



In collaboration with RDH Building Engineering

## Intersection Treatment Critical

- Decide to use semi-embedded or fully-embedded wood frame
  - Semi-embedded good to insulate concrete slab
  - Fully-embedded easier for installing panel etc.
- Decide gap between concrete and wood frame
  - Consider concrete slab tolerances
  - Gaps make it easier to install wall panels
  - Usually 20-30 mm in Europe
- Air tightness important
  - For both durability and energy efficiency
  - Strong air barrier required
  - Gaps must be sealed

## Durable and Energy Efficient Assemblies

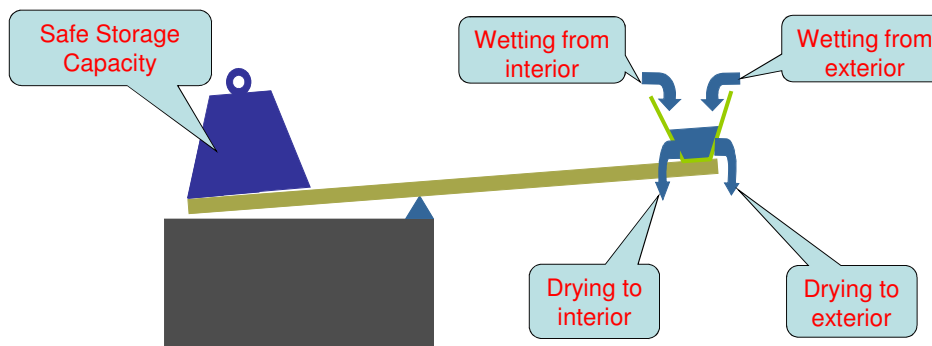
- Society and building codes call for energy efficiency
- Research to help meet new requirements
- Research to ensure durability and other aspects
- Literature on condensation potential reviewed
- Guidelines being developed on viable assembly options to meet code requirements
- Your feedback and advice appreciated

## Assistance to Schools on Durability

- Work to support NSERC NEWBuildS
- CLT: develop data to improve assembly design
  - Lab testing of wetting and drying behaviour finished
  - Field testing of CLT wall assemblies started
  - Hygrothermal property testing underway at NRC
- Mid-rise buildings
  - Wind-driven rain quantification in different climates
  - Further quantification of impact of overhangs
- Building energy efficiency
  - Field testing of durability performance of highly insulated assemblies

## Moisture Management Fundamental

- A balance of wetting, drying and moisture storage



## Key to Wood Durability

- Keep wood dry
- Prevent excessive moisture in service
  - Wood in both building envelope and exterior structure
  - Minimize wetting and moisture entrapment
  - Facilitate drainage and drying
- Anticipate wet conditions
  - Preservative-treated wood
  - Naturally durable wood

## For More Details on

- Durability by Design
- Durability by Nature
- Durability by Treatment

Check out the durability website

[WWW.DURABLE-WOOD.COM](http://WWW.DURABLE-WOOD.COM)

Suggestions and comments? Contact Jieying Wang:

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