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Design for Durability: Cross-Laminated Timber (CLT) Construction

CLT Building Envelope Design Guide

Objectives:

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

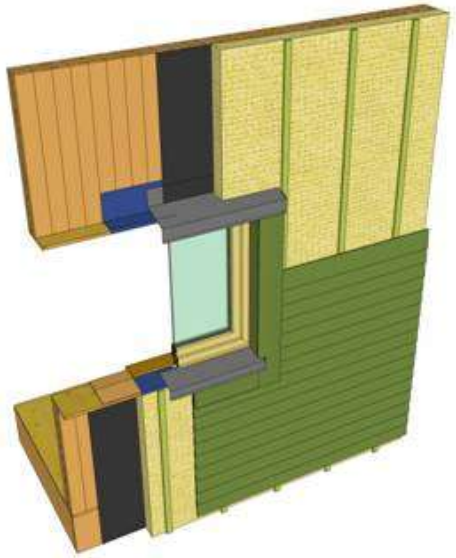

Photo courtesy: Vaxjo University

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General Principles of Design for Durability

CLT does not change basic wood characteristics

CLT does not change basic durability principles

- Keep wood dry wherever possible
  - Minimize wetting during shipment & construction
  - Prevent wetting in service
  - Allow drying in case wetting occurs
    - CLT may dry slowly due to the mass of wood
- Anticipate persistent wet conditions or other hazards
  - Preservative treatment
  - Use naturally durable wood

General Principles of Design for Durability

CLT does not change basic building physics

- Assess climatic load and control water, heat, air and vapour flow
- Use 4 **D**'s to protect assembly from water penetration
  - **D**eflection: Divert water off building
  - **D**rainage: Remove bulk water
  - **D**rying: Facilitate drying of wood
  - **D**urable material: Treated or naturally durable wood

General Principles of Durability by Design

- General guidelines on design for durability
  - Best Practice Guide for Wood-Frame Envelopes/ (in the Coastal Climate of BC) (CMHC 1999)
  - Building Enclosure Design Guide – Wood Frame Multi-Unit Residential Buildings (HPO 2011)
- Consult with building science professionals
  - Required in some jurisdictions
- Interface detailing critical

CLT Building Envelope Design Guide

- Focuses on unique aspects of CLT
- Tries to answer
  - Why important to prevent wetting during construction?
  - How to prevent rain penetration into envelopes?
  - How to meet envelope energy requirements?
  - How to place/choose insulation?
  - How to deal with “vapour retarder/barrier”?
  - How to build air tight?
  - How to make CLT more durable?
  - …

Construction Moisture Management

- CLT construction may reduce wetting potential
  - Prefabrication reduces construction time
- CLT may get wet and trap moisture when exposed to moisture
- Potential to absorb or trap moisture influenced by
  - Wood species
  - Amounts of permeable sapwood versus heartwood
  - Gaps within and between laminae
    - Use of edge gluing
  - Any water repellant/coating/membrane applied

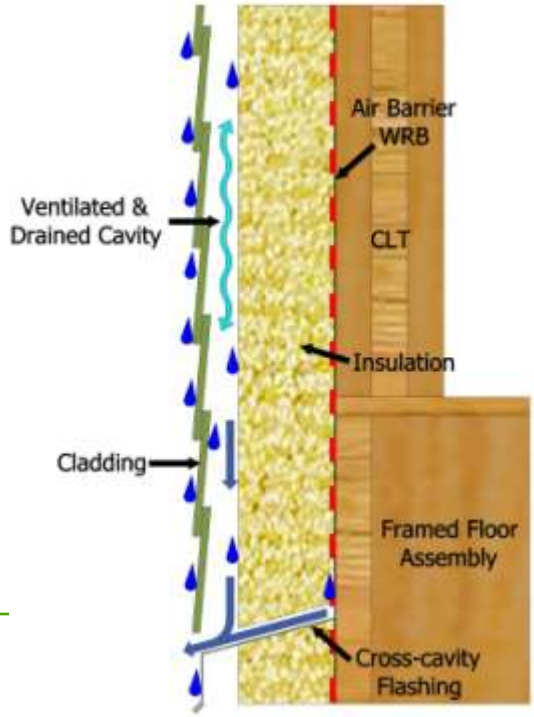
Construction Moisture Management

- On-site protection needed in most climates
  - Much attention paid in Europe: temporary roofs etc.
- Simple protection measures can make a difference
  - Temporary shelters etc.
- Consider season for construction
  - Try to avoid CLT installation in rain without protection
- Design assembly to
  - Allow drying in case wetting occurs

Photo courtesy: Vaxjo University

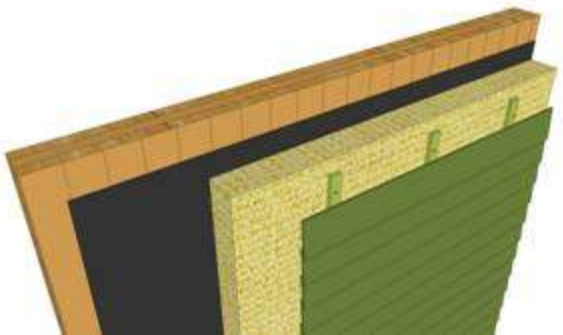
Enclosure: Rainwater Management

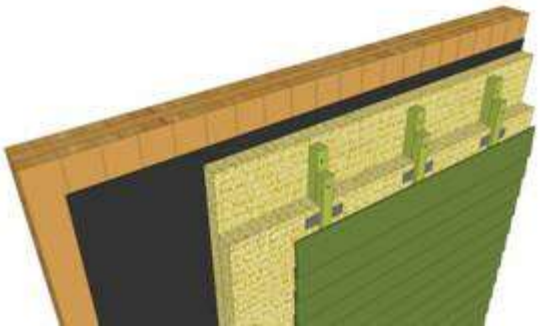
- Rain is usually the largest water source
- Building design important to reduce wetting
  - Overhangs and sloped roofs
- Rainscreen walls proved to be effective
  - Two drainage planes
    - Cladding and sheathing membrane
  - Air space
    - Capillary break
    - Pressure moderation
    - Ventilation
  - Provide redundancy for dry areas



Enclosure: Thermal Insulation Design

- CLT provides considerable insulation
  - Inherent R-value about R-1.2/per inch
    - R-4.2 for 3 ½” thick panel
  - Solid panel reduces convection in the assembly
- Exterior insulation helps keep wood warm and dry
  - Cladding attachment must meet structural requirements
  - Insulation permeance has impact on wall performance





Enclosure: Thermal Insulation Design

Required nominal insulation R-value (RSI)	CLT thickness inch (mm)	CLT insulation R-value (RSI)	Additional insulation thickness inch (mm), R-4/inch
20 (3.52)	2.0 (50)	2.4 (0.42)	4.5 (114)
	3.5 (89)	4.2 (0.74)	4 (102)
	5.5 (140)	6.6 (1.16)	3.5 (89)

Table 1, Building Enclosure Design, CLT Handbook

Enclosure: Vapour Flow Control

- Overall principle
  - Prevent vapour condensation and facilitate drying
  - Control layer on warm/high vapour pressure side
- CLT is a vapour retarder/barrier
  - 3 ½” solid wood: 3-30 ng/Pa·s·m^2 (0.05-0.5 US Perms)
  - No need for interior vapour retarder/barrier in cold climates

Enclosure: Vapour Flow Control

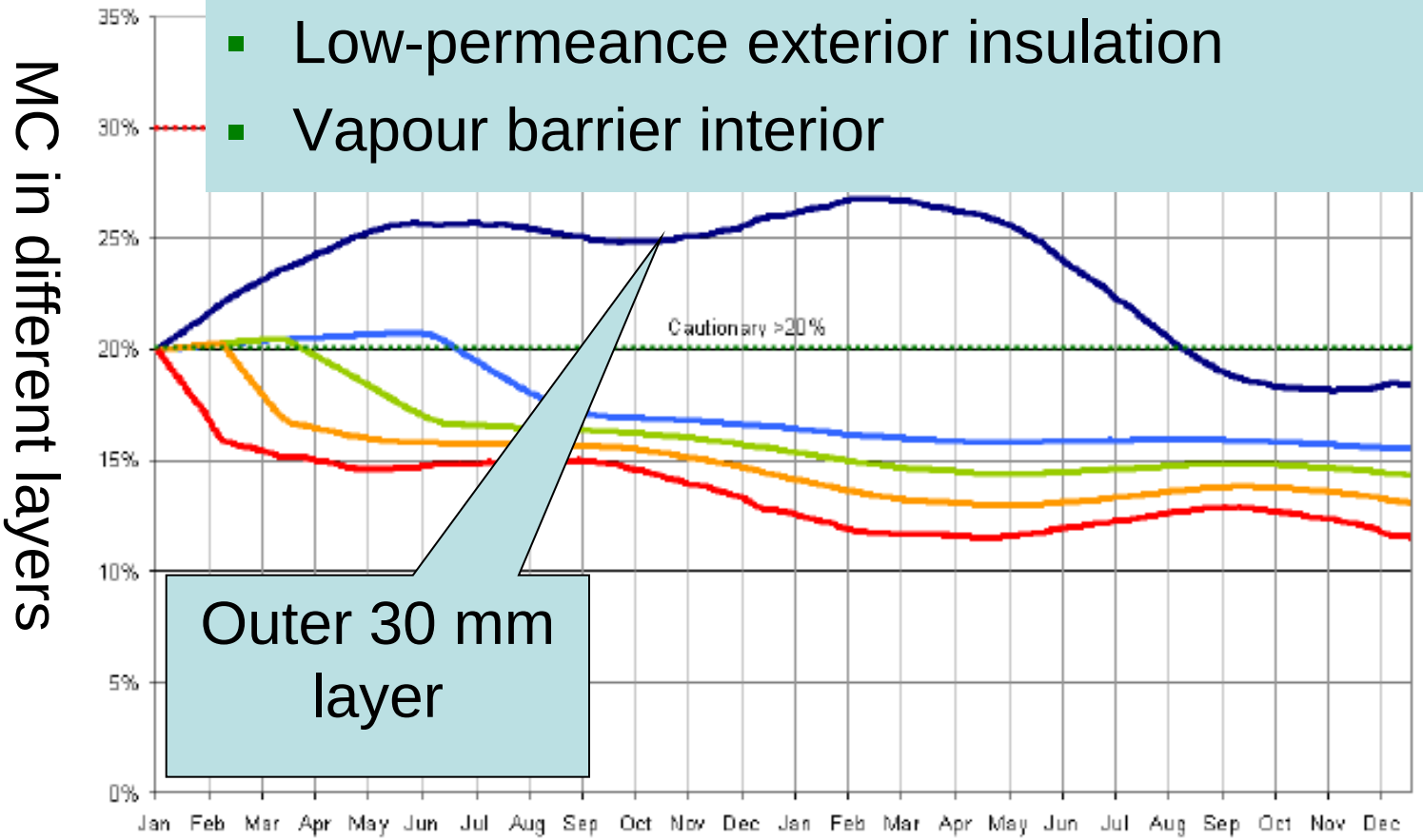
- Assemblies should be “breathable”
  - Based on simulation study by Paolo Baldracchi (U. Trento) and RDH
  - Dry out from initial wetting
  - Present lower risk if building envelope leaks occur

Enclosure: Vapour Flow Control

- Risk increases when impermeable materials used
  - May not dry out when initially wetted/wetted in service
  - Moisture level may exceed the margin of safety
- Don’t place potential vapour barriers/retarders both sides

Enclosure: Vapour Flow Control

- Climate in Vancouver
- CLT with an initial MC of 20%
- Low-permeance exterior insulation
- Vapour barrier interior



RDH simulation results

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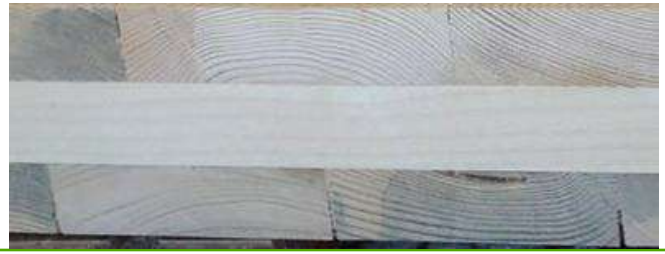
Enclosure: Air Flow Control

Air tightness of CLT depends on

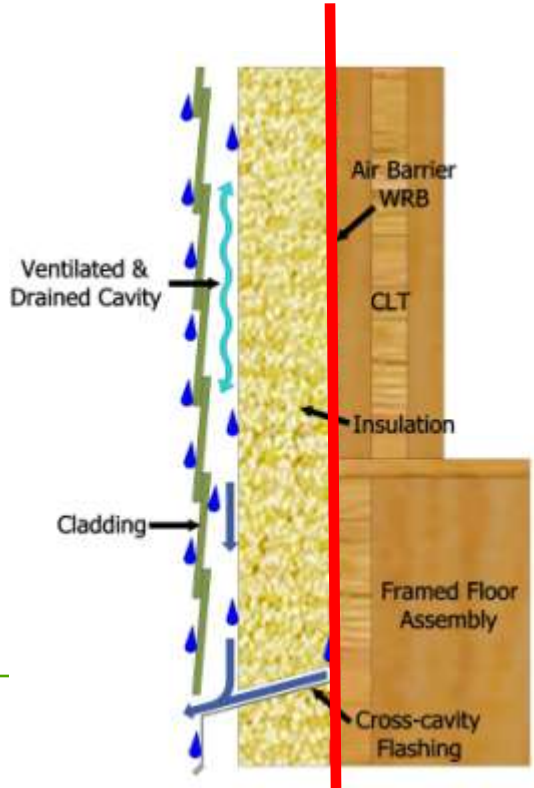
- Joints between boards and layers
- Edge gluing and staggered layers help
- With wood moisture changes
  - Gaps between boards may increase or decrease
  - Wood surfaces may form “checks” or cracks
- Interface between panels

CLT may not be relied on as a primary air barrier



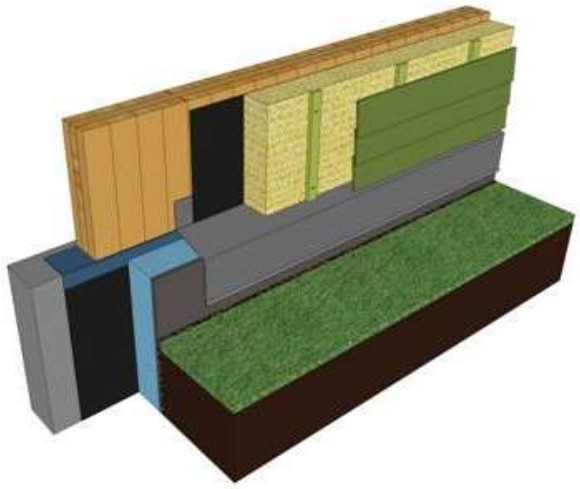
Enclosure: Air Flow Control

- Recommend use of a primary air barrier
  - Preferred to use water-resistive barrier
  - Other approaches may also work: interior drywall
  - Continuity at interfaces critical



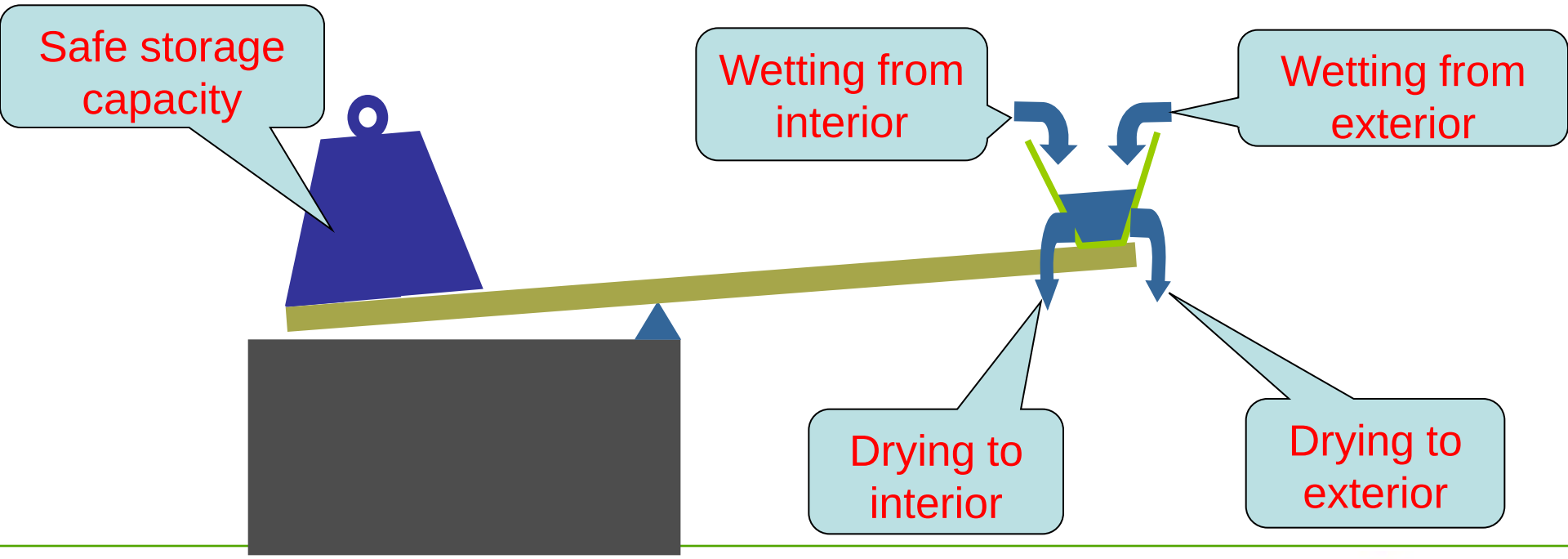
CLT at Grade

- Important to provide a clearance between wood and soil
  - A minimum of 8” (200 mm) recommended
  - Consider podium structures with CLT on elevated concrete decks for residential over commercial
- Separation between wood and concrete in contact with moisture important
- Detailing at the base critical



A Balance of Wetting, Drying and Storage

- CLT has a large moisture storage & buffering capacity, but …
  - There is a limit to amount that can be safely handled
  - Moisture may get trapped locally such as at end grain



Adapted from a slide by Dr. John Straube and RDH

Further Increase CLT Durability

- Select wood with low water permeability
  - Reduce potential for water absorption
- Select heartwood of naturally durable wood
  - Unlikely to be a practical approach
- Use preservative treated lamina for panel base
  - For parts of CLT likely to be exposed to moisture
- Use on-site diffusible treatment
  - Borate/glycol on surface + boron rods inside
- Consider making CLT from treated laminae

Summary

- CLT assemblies can be durable/energy efficient
- Minimize moisture exposure during construction
- Design assemblies to keep CLT dry and warm
- “Breathable” assemblies are more durable
- A primary air barrier is recommended
- Interface detailing is critical

Ongoing Research

- Laboratory and field testing of wall assemblies
  - NSERC Forest Sector Initiative (“NEWBuildS”)
  - Ryerson University and University of Waterloo
- Characterization of hygrothermal properties
  - In collaboration with National Research Council

General Durability Information on

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

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Questions?

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