Mass Timber & Tall Wood Buildings

XXII WESTFORD SYMPOSIUM - SUMMER CAMP, AUGUST 8, 2018

GRAHAM FINCH, MASC, P.ENG – PRINCIPAL, SENIOR BUILDING SCIENCE SPECIALIST

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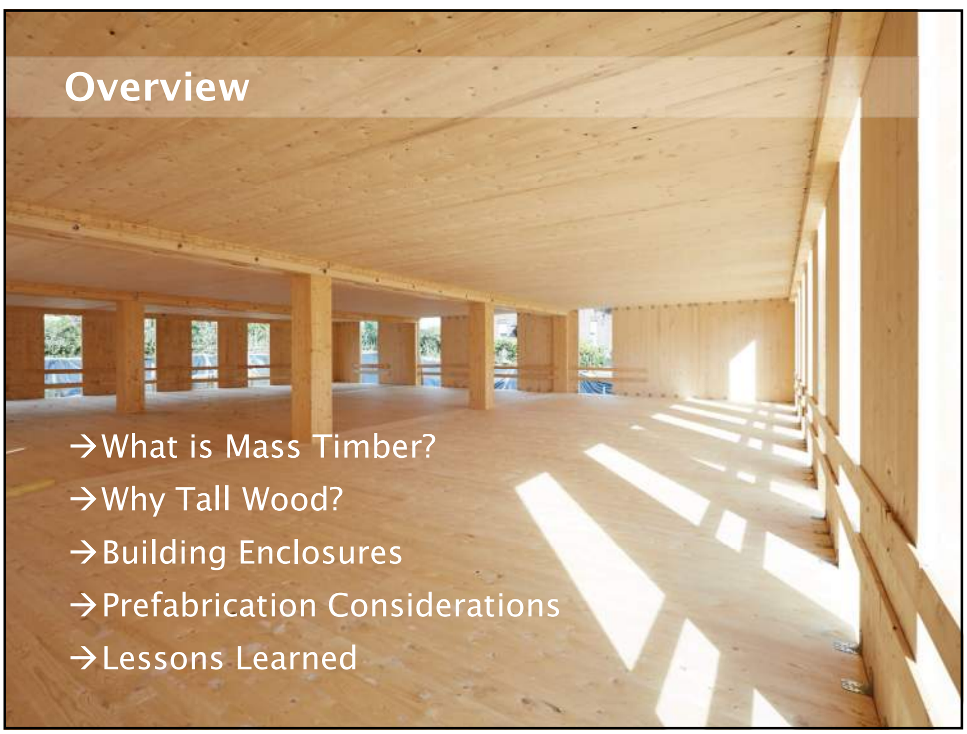
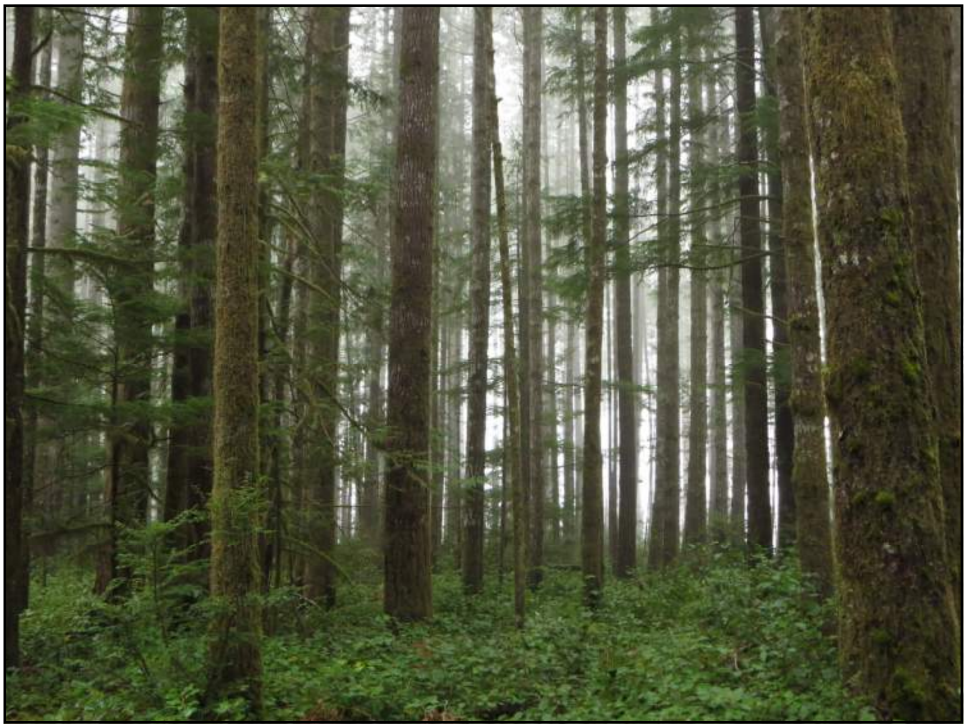
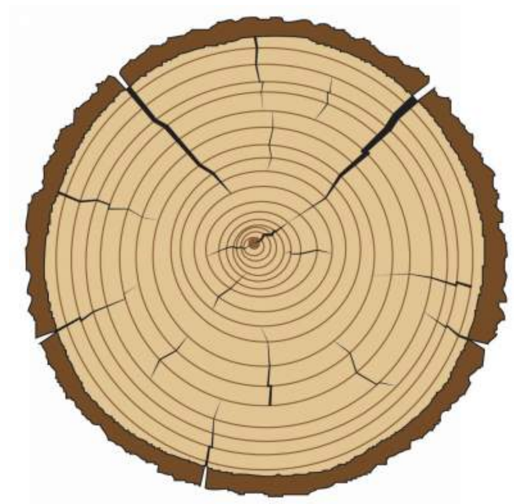
Overview

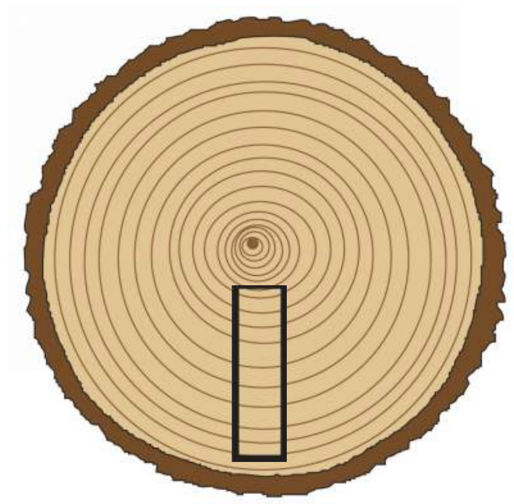


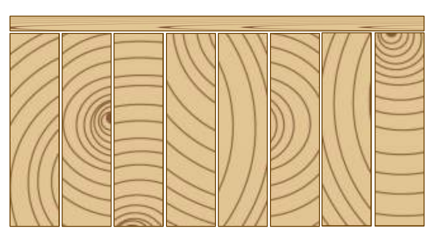
- →What is Mass Timber?
- →Why Tall Wood?
- →Building Enclosures
- →Prefabrication Considerations
- →Lessons Learned

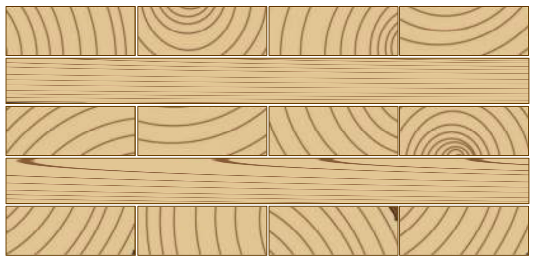




- “Wood Is Good But Strange” – Joe Lstiburek







Engineered Wood is Better? But Also Stranger…

The Cast of Characters

CLT GLULAM NLT DLT

LVL LSL PSL MPP

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Cross Laminated Timber (CLT)

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Not All CLT Quality is the Same

Structural non-finish grade (Canadian product)

Custom clear finish interior tongue & groove with wood dowels (Canadian)

High quality interior finish grade (European product)

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Glulam & Glue Laminated Timber (GLT) Panels

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Nail Laminated Timber (NLT)

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Many Historical Examples – Heavy Timber Framing with NLT Floors

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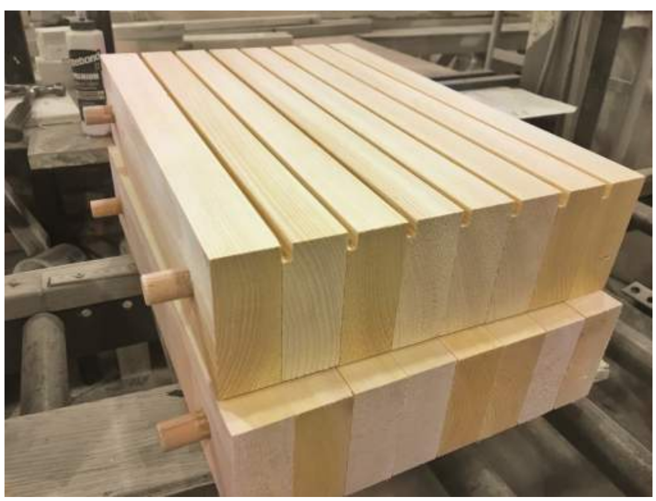
Dowel Laminated Lumber (DLT)



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Laminated Strand Lumber (LSL) & Parallel Strand Lumber (PSL)

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Laminated Veneer Lumber (LVL)

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Mass Plywood Panel (MPP)

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Mass Timber is Beyond Stick Framing

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It Borrows a Lot from Heavy Timber Framing

And Borrows a Bit from Pre-Cast & Tilt-Up Concrete

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And Combines Pre-fabrication Modular & Panelization

Will Always Utilize Concrete & Steel Components

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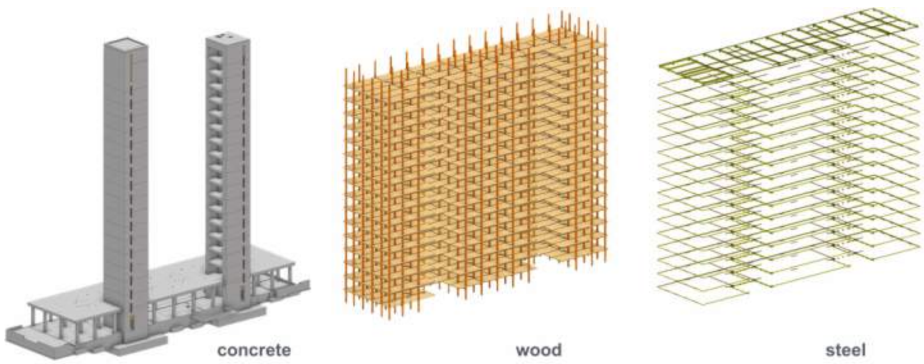
And Use Wood Where Wood Makes Sense



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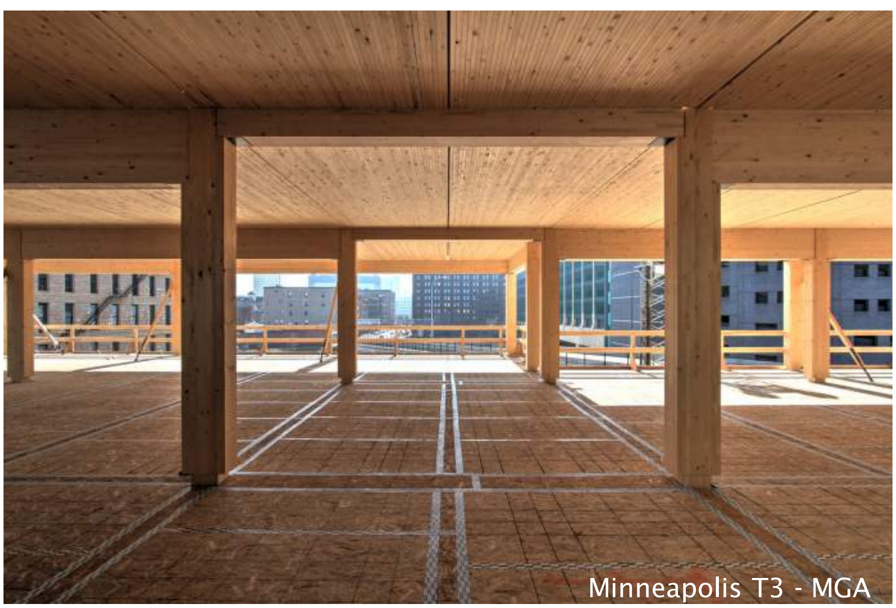
Post & Beam



Post & Beam

Post & Plate (Panels)

Solid Wood Panels

Origine – Nordic Structures

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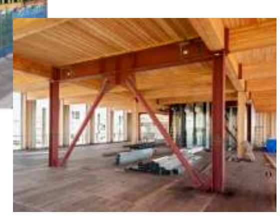
What Makes Mass Timber Buildings Unique?

- → Use of engineered mass timber components
  - → Alternate structural systems (post/beam, engineered panels, infill components)
  - → Unique & new connections, interfaces & details
  - → Hybrid steel-wood-concrete components & connections
- → Longer & heightened exposure of large wood components to rain and weathering during construction
- → *Is not the same as stick built mid-rise wood-frame, but is also different from high-rise steel or concrete structures*



Why Taller Wood – Why Now?

- → Building codes are rapidly changing to allow both larger and taller wood buildings across North America
  - → 5&6 storey wood-frame (stick-built) now allowed in many N.A. jurisdictions
  - → Even taller & larger mass timber buildings being constructed as alternate code solutions (Canada and the US)
  - → Many precedents in Europe and AUS/NZ
- → Significant research, testing, and current interest in taller wood buildings
- → Wood seen as a sustainable and renewable resource with bonus carbon storage
- → Cost & speed of construction benefits?

1900s era Tall Wood Buildings Across North America

2016 – UBC Brock Commons, Student Residence – Currently the Tallest Wood Building in the World, 18 storeys, 53m

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The Carbon Argument for More Wood in Buildings

- → **Operating** Carbon
  - → Carbon equivalent emitted as part of operation and maintenance
  - → Reduced with *energy efficiency measures*
- → **Embodied** Carbon
  - → Cumulative equivalent emitted carbon from acquisition, manufacture, transport, and installation of material
  - → Reduced with *low carbon* or *carbon sequestering* materials
- → **Trend** – In jurisdictions with low carbon energy grids and energy efficient building standards – embodied carbon really starts to become important (i.e. the likely future)

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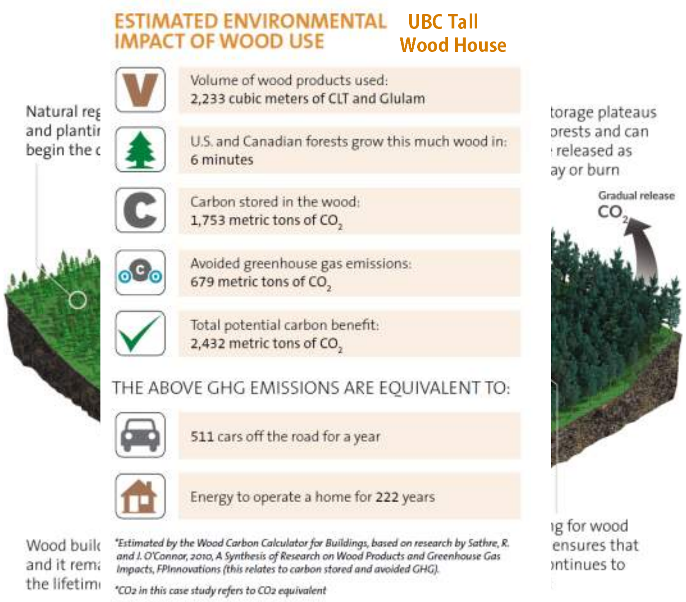
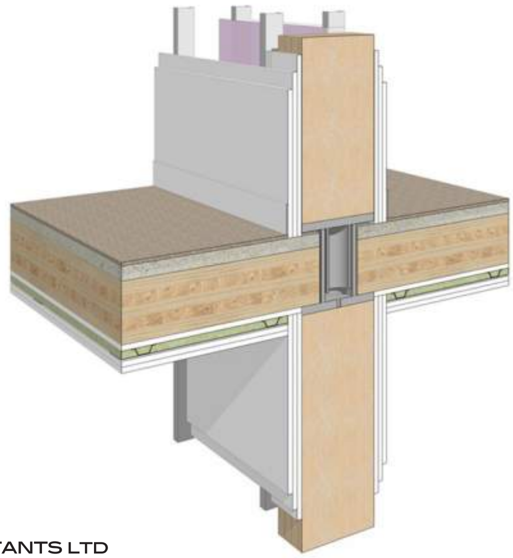
The Carbon Argument for Tall Wood Buildings



Worldwide Tall Wood Building Evolution

Challenges: Fire Code Solutions – Encapsulation



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Challenges: Fire Code Solutions – Charring

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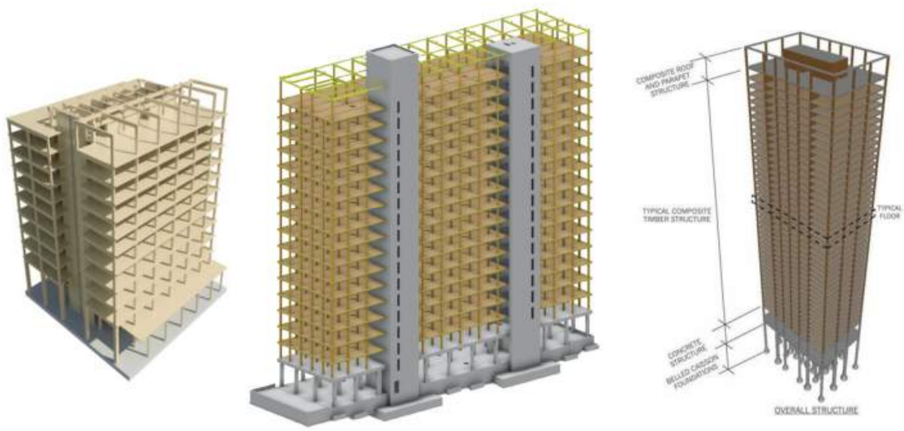
Challenges: Structural Solutions



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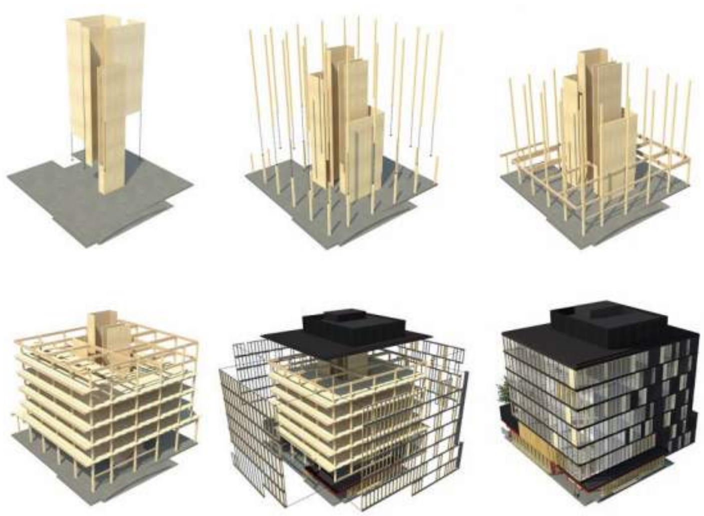
Challenges: Structural Movement?



Wood Innovation Design Centre – 6 tall storeys, ~98’

Michael Green Architecture (MGA)

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Wood Movement at WIDC – Monitored & Measured

- → Overall building height ~98 ft – continuous glulam columns/CLT core walls with glulam beams/CLT floor panels
  - → Glulam columns 6 tall floors – total ~ ½" (0.04%) longitudinal shrinkage/compression
  - → CLT core walls 6 tall floors – total ~ ¾" (0.06%) longitudinal shrinkage/compression
  - → 5 ply CLT floor panels (6.5") ~3/16" shrinkage in thickness (3%) each floor – **but separate from load path**

Initial wood moisture content of 14% dried down to a low of ~ 4%

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Many Precedents – Europe, Australia & North America

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Next World's Tallest Wood Building – HoHo, Vienna

Rüdiger Lainer+ Partner RLP

A few of Our Past & Current Mass Timber Projects

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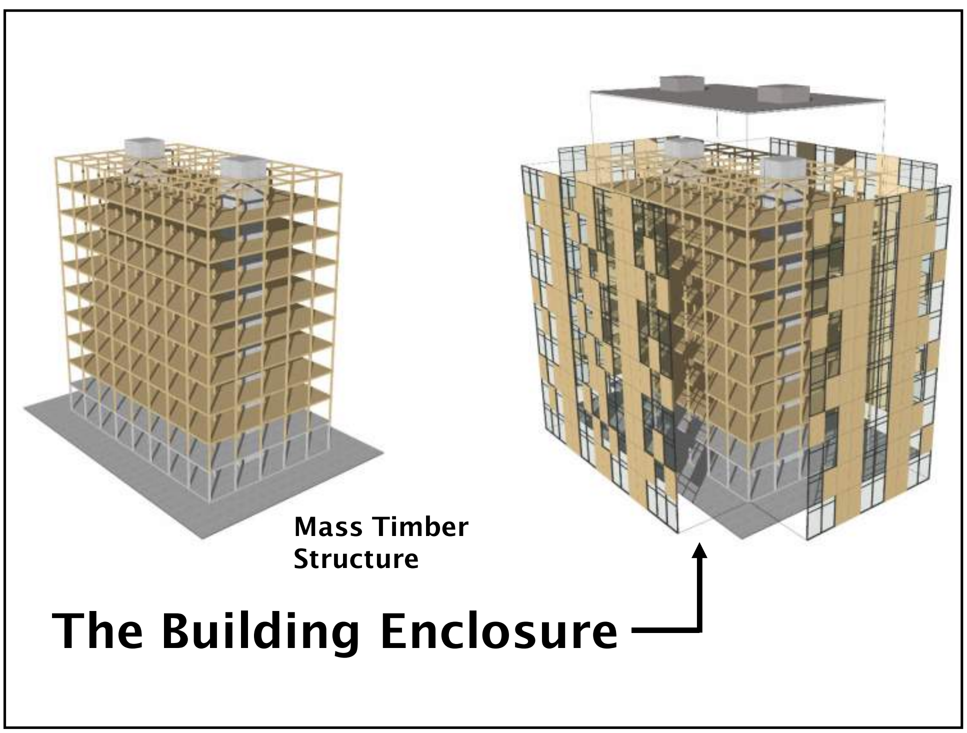
Mass Timber Building Enclosures


Mass Timber
Structure
The Building Enclosure

Mass Timber Integrated into Building Enclosures

→ Mass timber elements often a part of the building enclosure
  - → Above Grade Walls & Roofs
  - → Wood or parts of wood desired to be left exposed – serves both functional and aesthetic purpose
  - → Requires protection from moisture during construction & in-service
  - → Assemblies with wood, membranes, insulation, accessories control heat, air, and moisture transfer along with noise and fire
  - → Designed to accommodate building movement, structural loads, initial & seasonal wood movement

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Taller Wood Building Structures

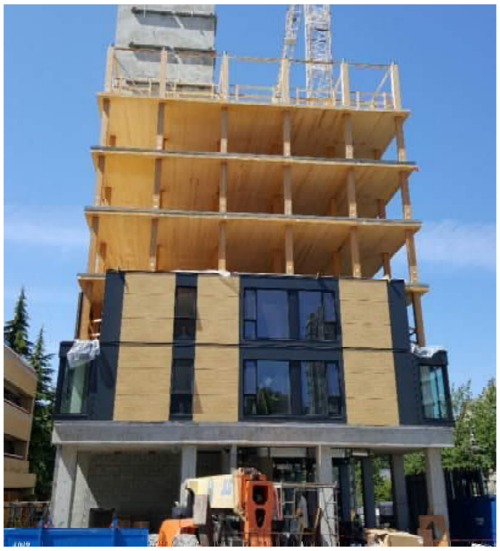
→ Potentially fast

→ Sensitive to moisture

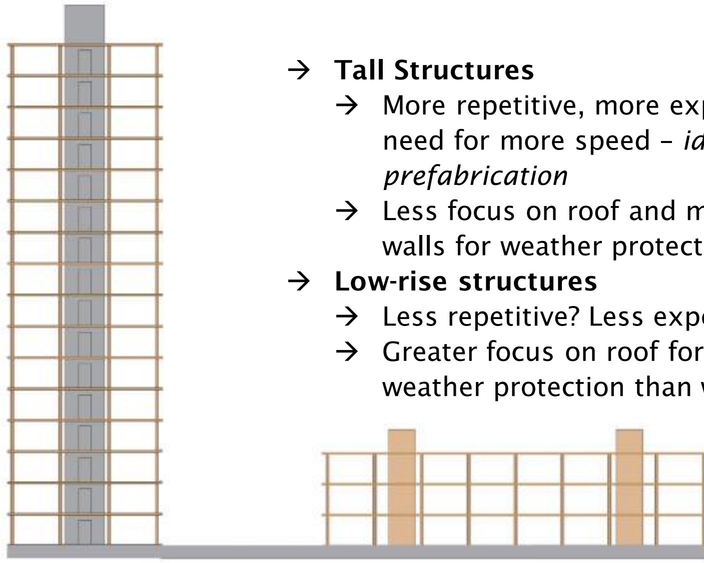
→ Greater movement (shrinkage & drift)

→ Fire code challenges

→ Mixed steel, concrete & wood components & connections



Building Enclosures for Mass Timber Structures



- → **Tall Structures**
  - → More repetitive, more exposed, need for more speed – *ideal for prefabrication*
  - → Less focus on roof and more on walls for weather protection
- → **Low-rise structures**
  - → Less repetitive? Less exposed
  - → Greater focus on roof for weather protection than walls

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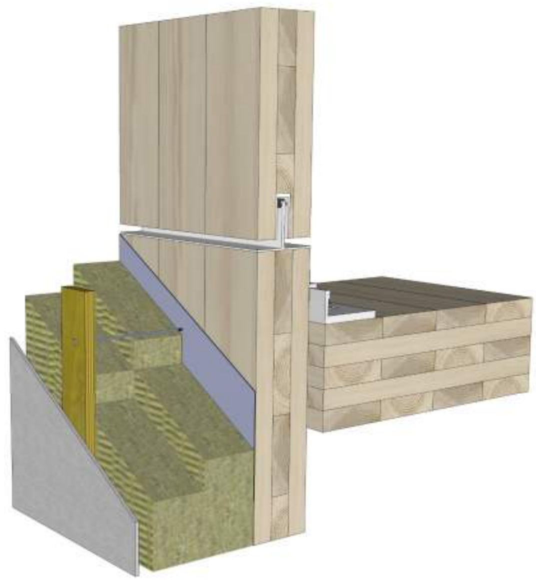
Tall Wood Building Enclosures

- → **Need for Speed**
  - → Erect and seal as fast as possible to protect the wood structure
  - → Preference for offsite prefabrication & minimal site preparation
  - → Be accommodating of inclement weather
- → **Ensure Durability**
  - → Robust materials – high-rise appropriate
  - → Be more tolerant of movement
  - → Thermally efficient
  - → Non-combustible

Facades for Tall Wood Buildings?



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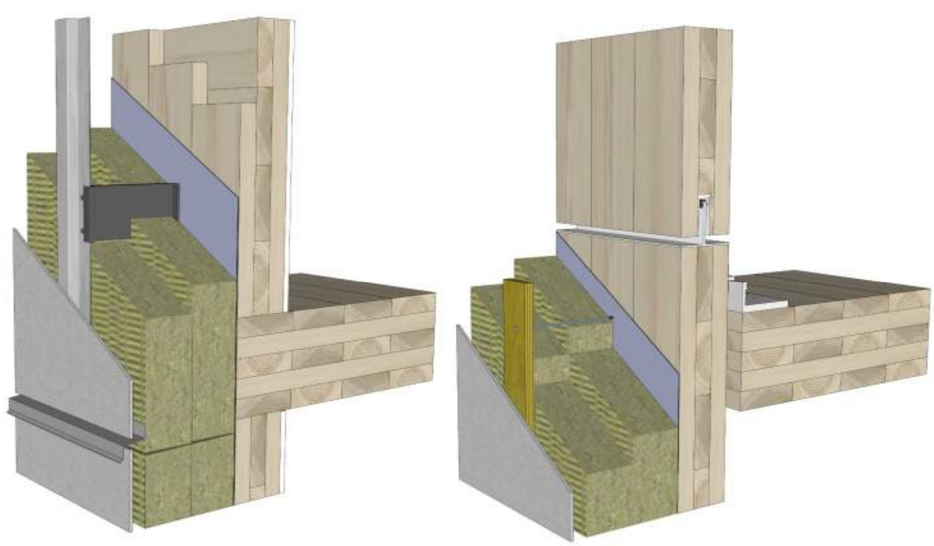
Load Bearing versus Hung "Curtain-wood" Exterior Enclosure Walls



Good vs Bad Use of Mass Timber

Bad – exposed to weathering ☹

Good – Warm, dry and protected by the building enclosure ☺

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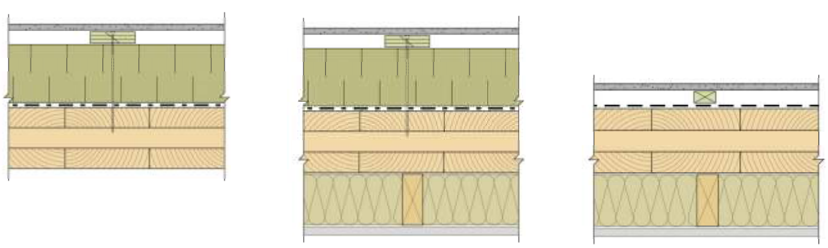
CLT Wall Considerations



Best Placement & Insulation Type? – It Depends!

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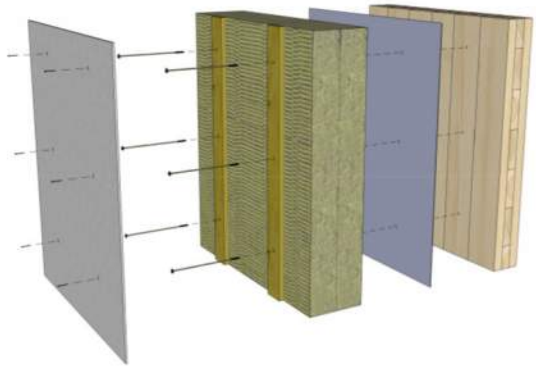
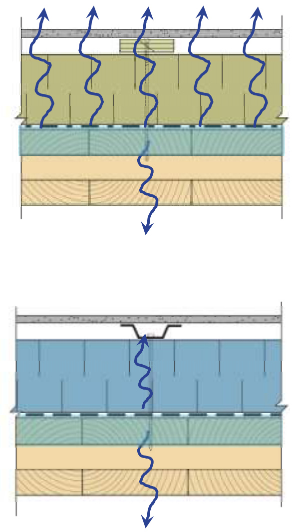
CLT Walls





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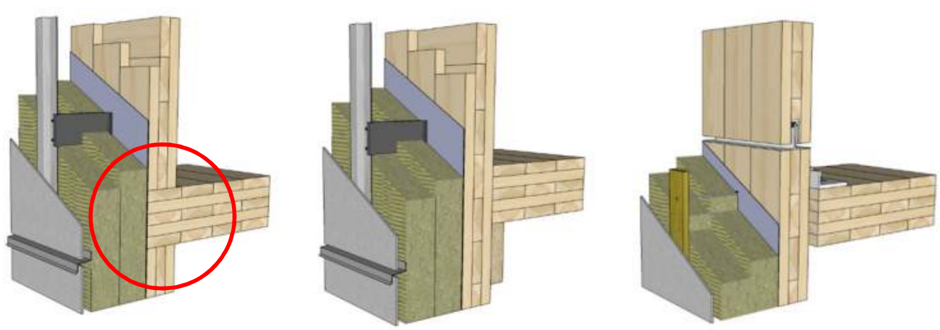
CLT Wall Considerations - Movement



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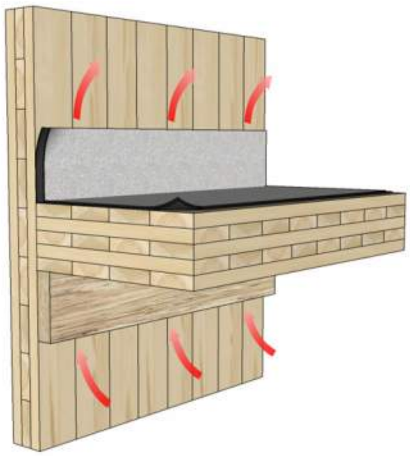
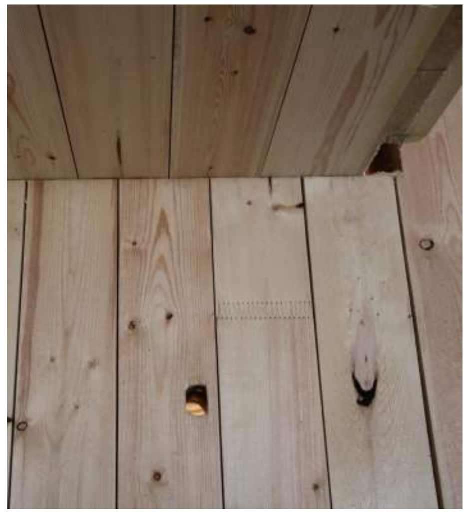
CLT Panel Interface Air Tightness?





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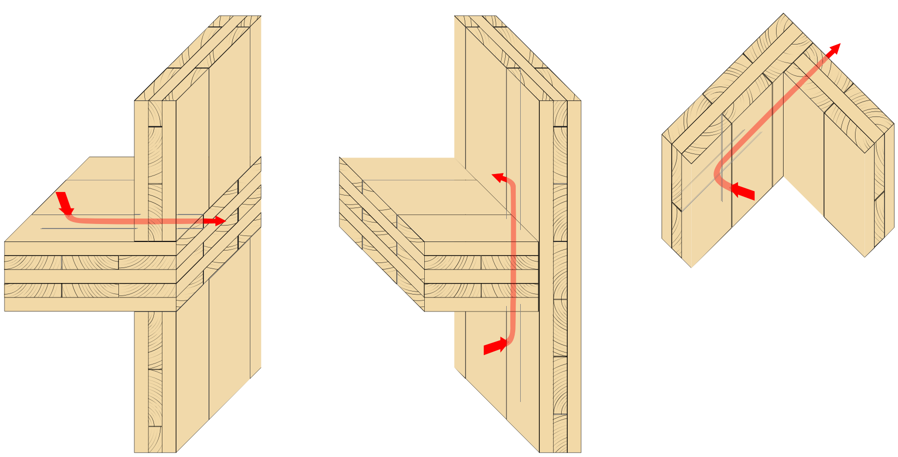
CLT Interface Air Barrier Detailing Considerations



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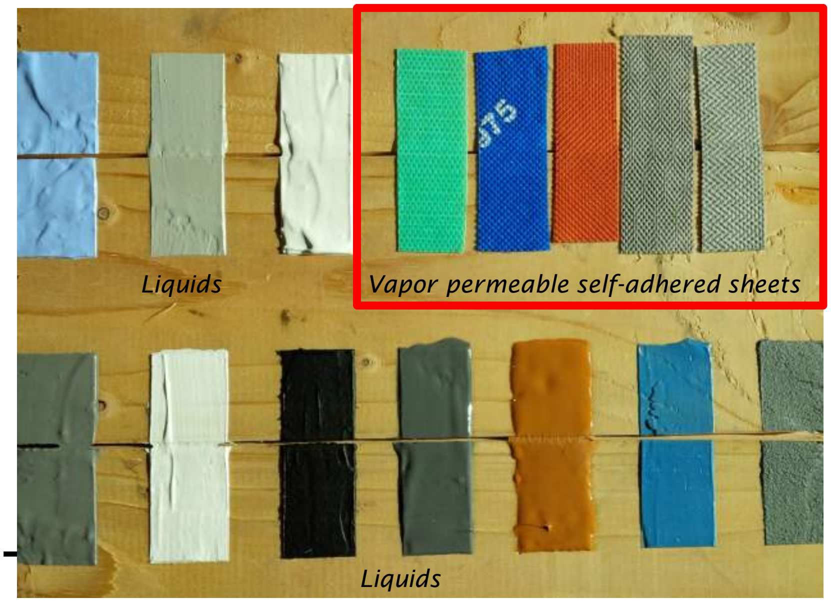
Air Barrier/WRB Membranes for CLT Panels



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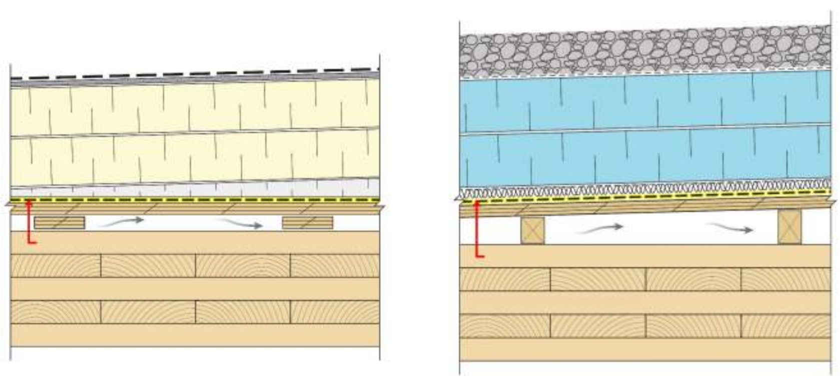
Roofs – Exterior Insulated (Conventional or PMR)



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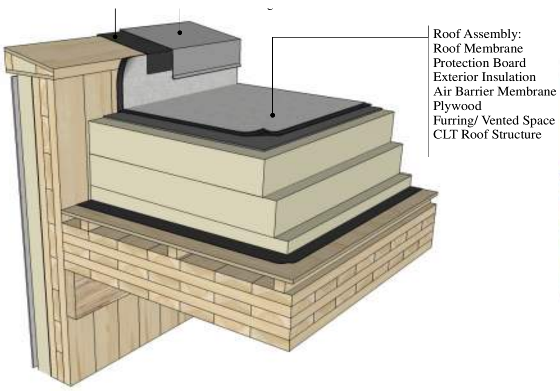
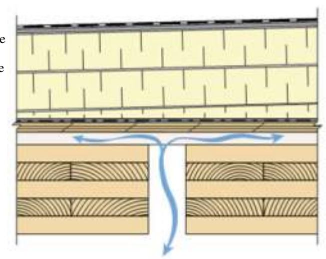
CLT Roof Considerations





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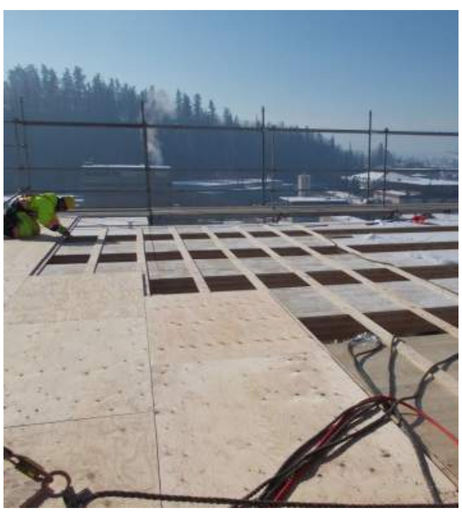
Venting Above Mass Timber Panels in Roofs



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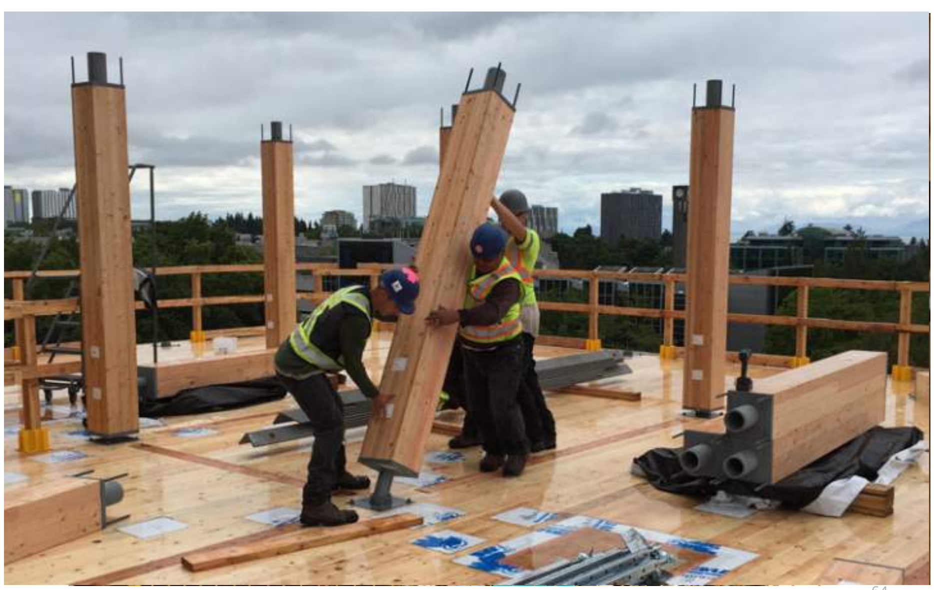
LCT One, Vienna, Hermann Koffman 62

UBC Tall Wood Structure – Prefabricated & Fast



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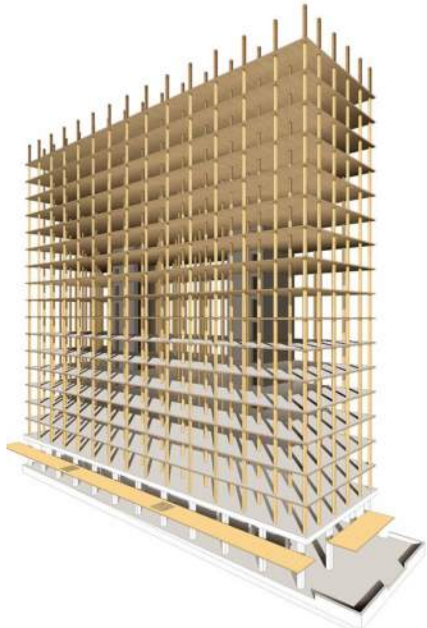
UBC Tall Wood House – Façade Challenge



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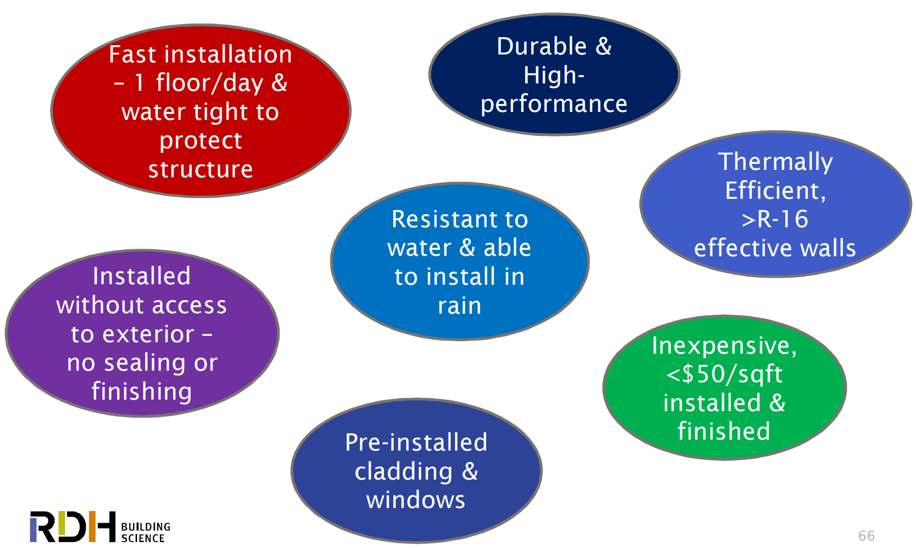
UBC Tall Wood House - Façade Design Criteria



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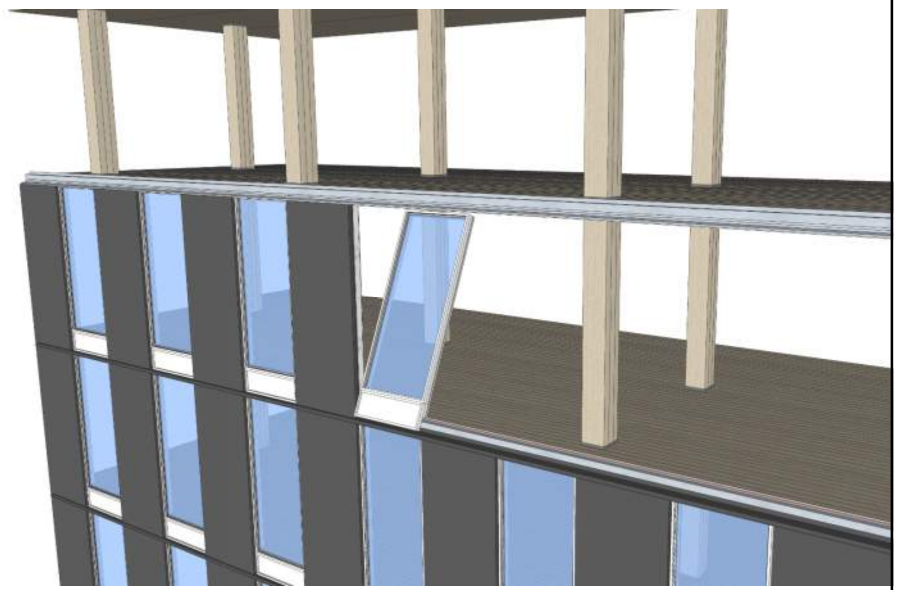
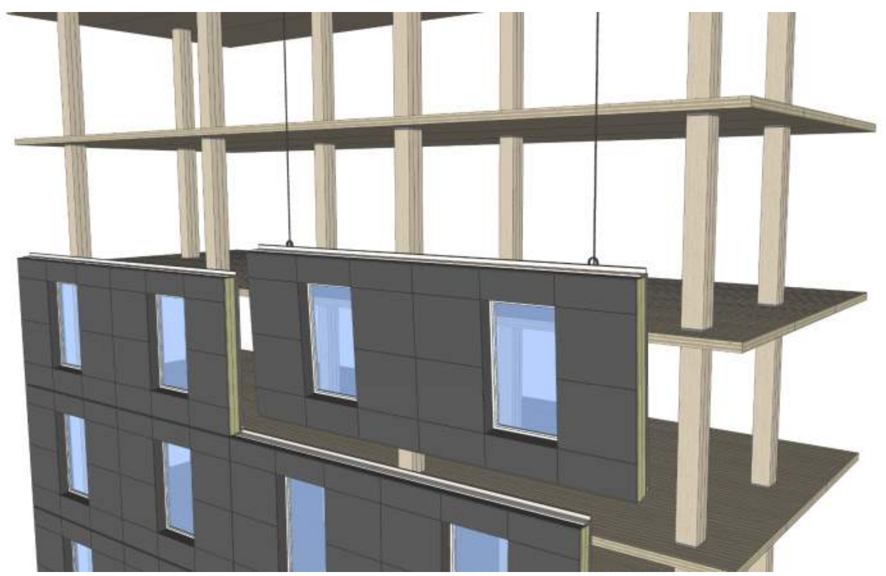
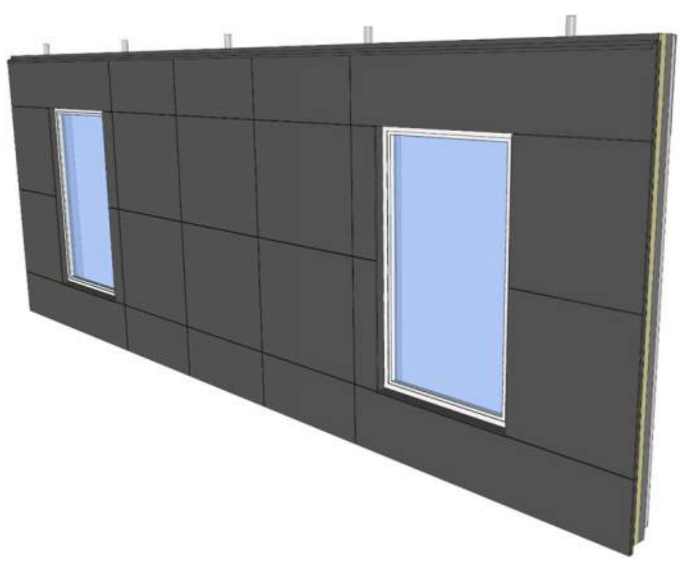
Façade Prefabrication - Small Panel with Separate Windows



Façade Prefabrication - Large Panel with Pre-installed Windows



UBC Tall Wood - Prefabricated Panel Competition



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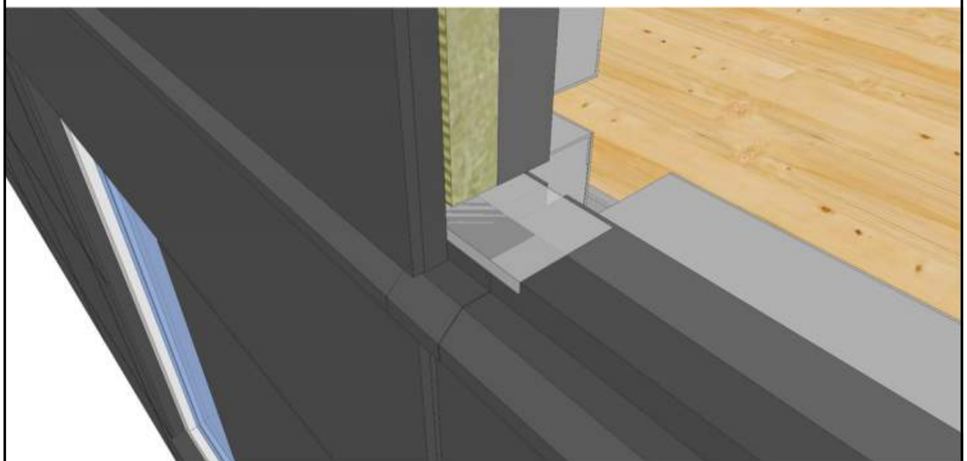

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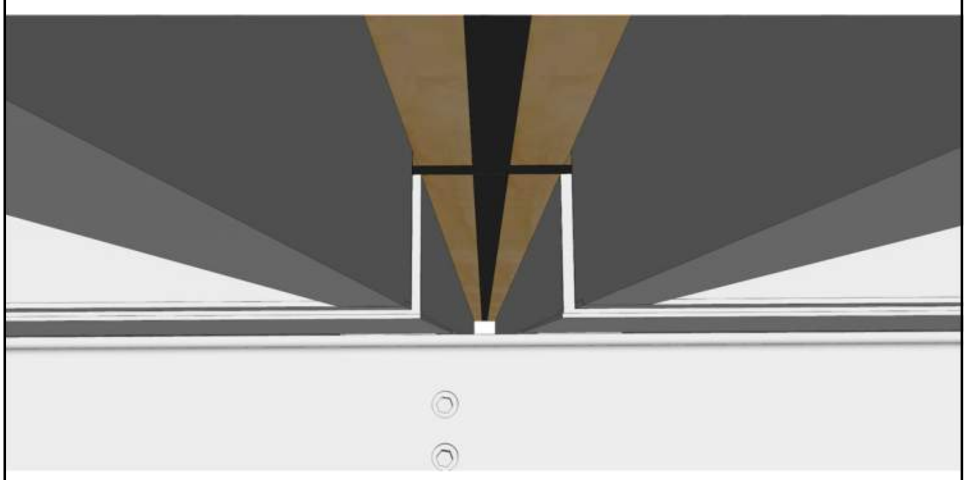

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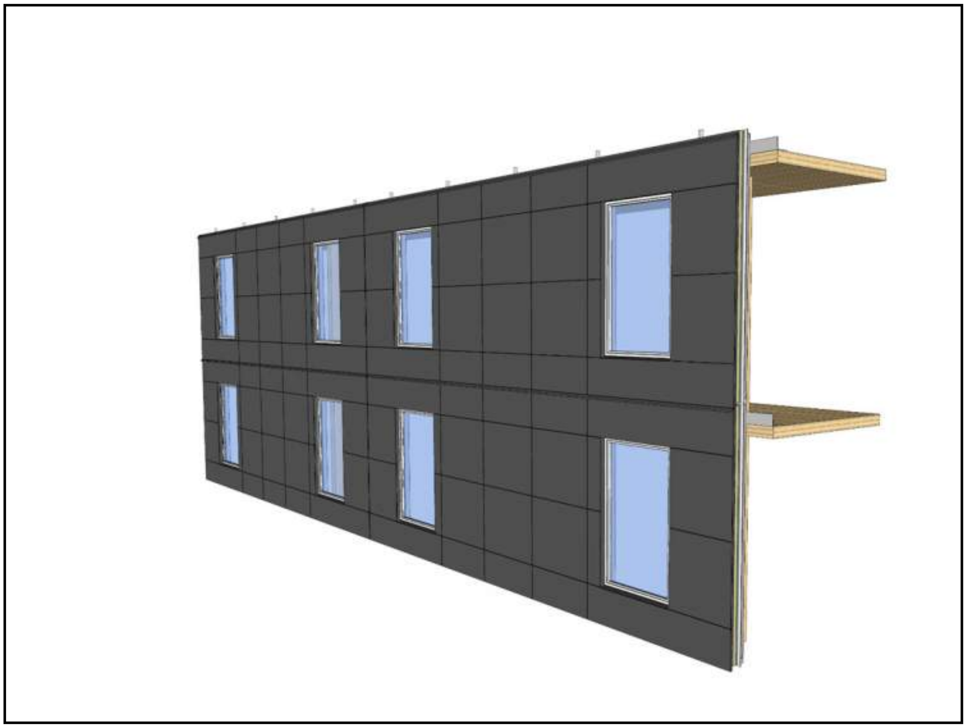
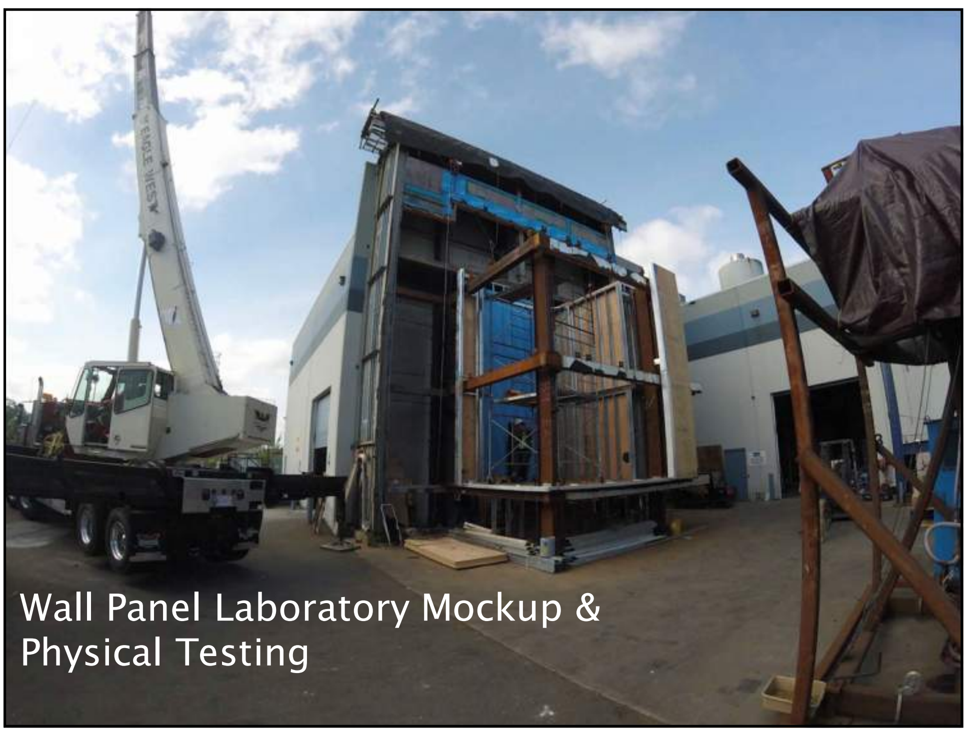
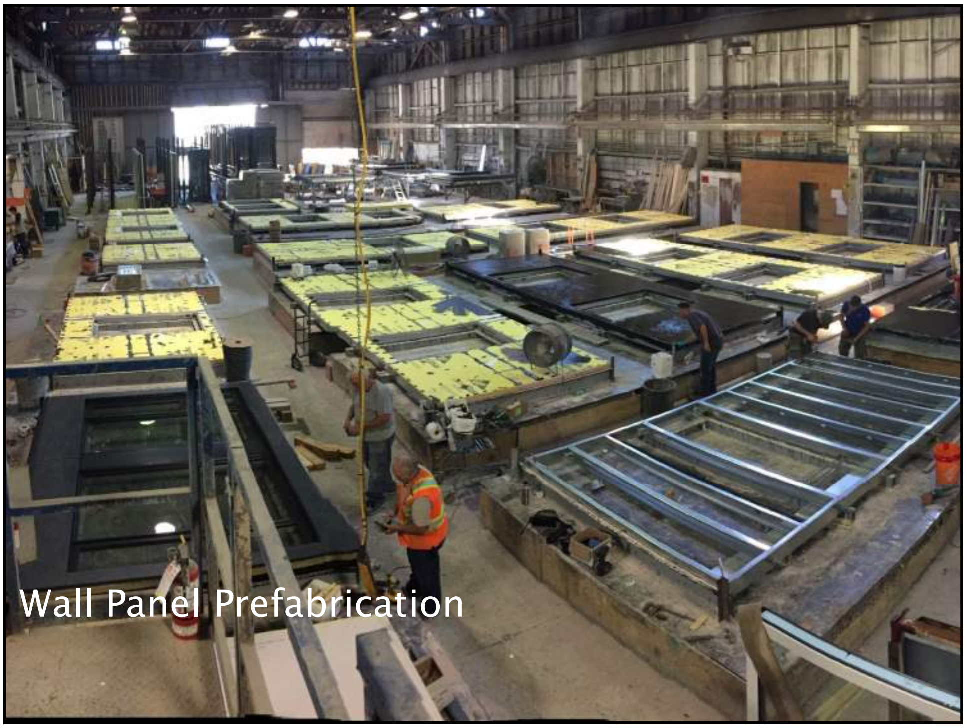



Wall Panel Laboratory Mockup &
Physical Testing



Site Installation

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Site Installation – at Pace with Structure – 2 floors/week
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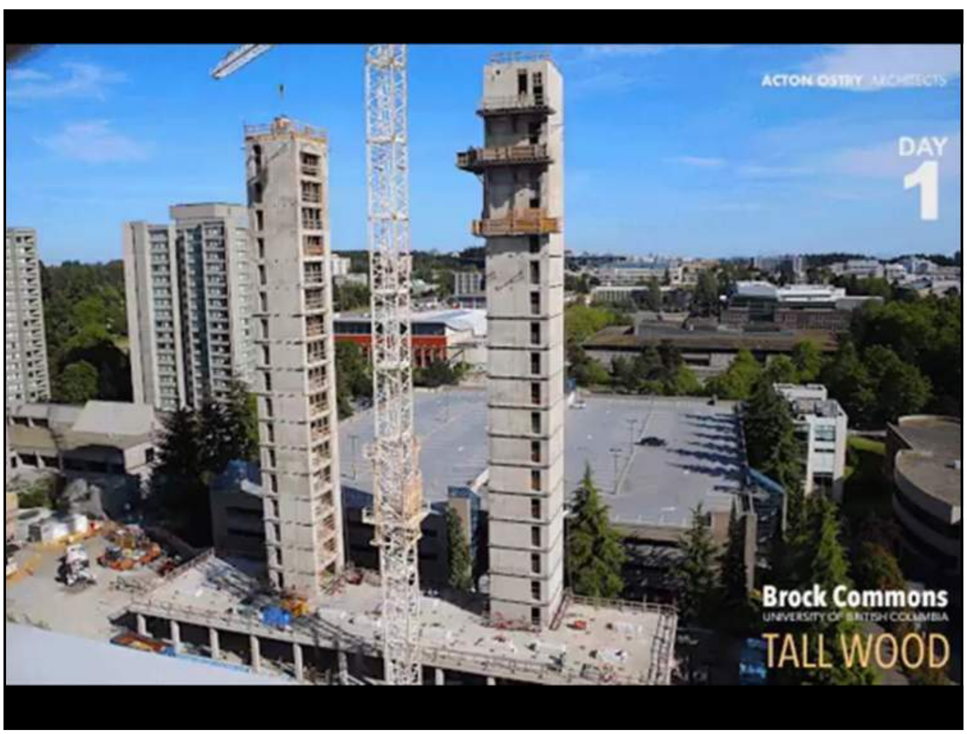
ACTON OSTRY ARCHITECTS
DAY
1
Brock Commons
UNIVERSITY OF BRITISH COLUMBIA
TALL WOOD

CLT is Not Airtight - Don’t Forget the Membrane

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CLT is Not Airtight - Don't Forget the Membrane

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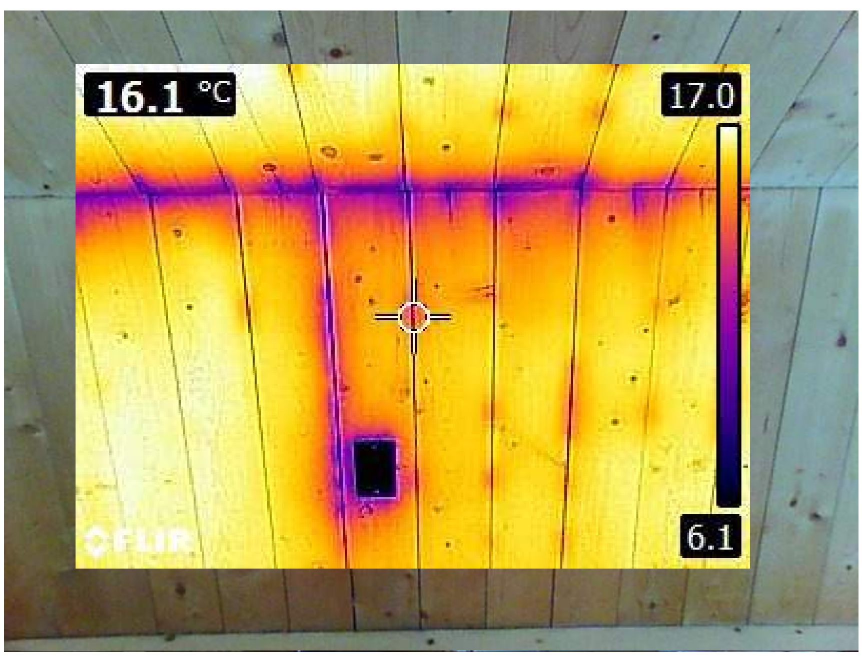
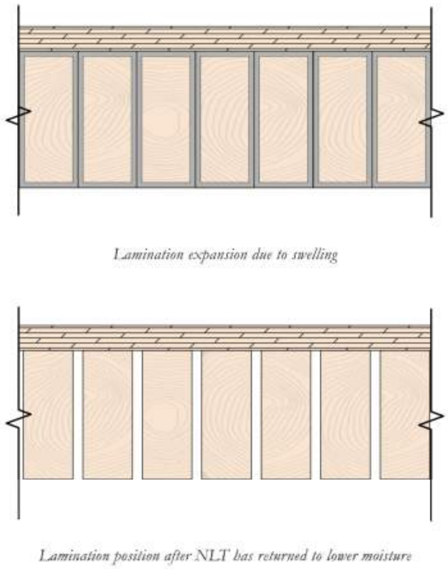


NLT Panel Shrinkage Considerations



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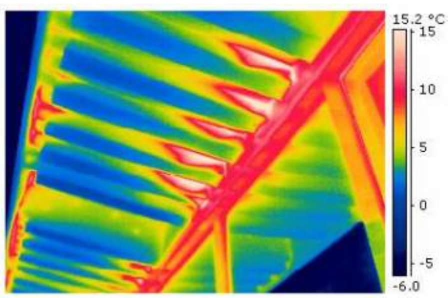
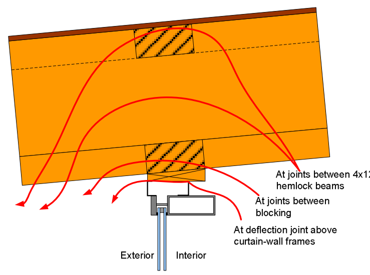
NLT Considerations – Design for Movement

The Biggest Challenge with NLT Overhangs





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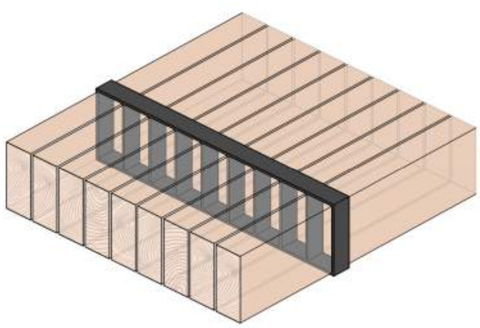
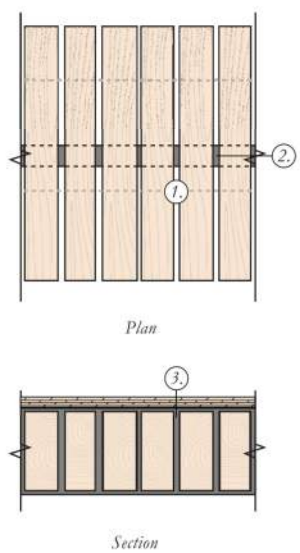
NLT Panel Air Sealing in Factory





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The Biggest Challenge – Managing Water Effectively During Construction

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Keep Wood Dry & Use Appropriate Materials in Contact with Damp Wood

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Take Care with Impermeable Roof Membranes – Can Be Double Edged Sword

Protect NLT from Excessive Wetting But Not Too Late

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…Or Just Plan Ahead & Take Advantage of the Protection

Finland – use of climbing roof and overhead cranes – high degree of modular moisture sensitive components

Mass Timber Can Be Dried Out… Albeit Slowly

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Protection of Mass Timber Panels During Construction

- → Pre-applied torch applied roofing membranes applied to horizontal panels in factory
- → Laps torched onsite immediately after installation

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Lots of Protection Options for Mass Timber Panels During Construction

Wetted NLT Panels Can Move a Lot!

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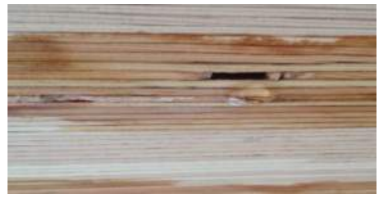
Swelling Wood Is an Almost Unstoppable Force

Pick the Right Wood Product for the Application



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Know the Wood You Are Using

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CLT Is Not Watertight During Construction

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Try to Avoid Drywall Until You Have A Roof or Water-tight Floor Overhead

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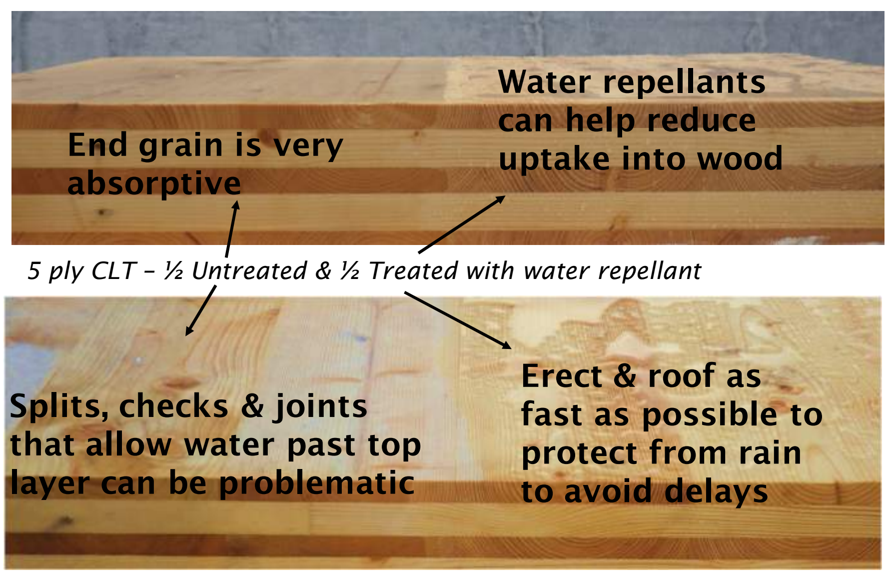
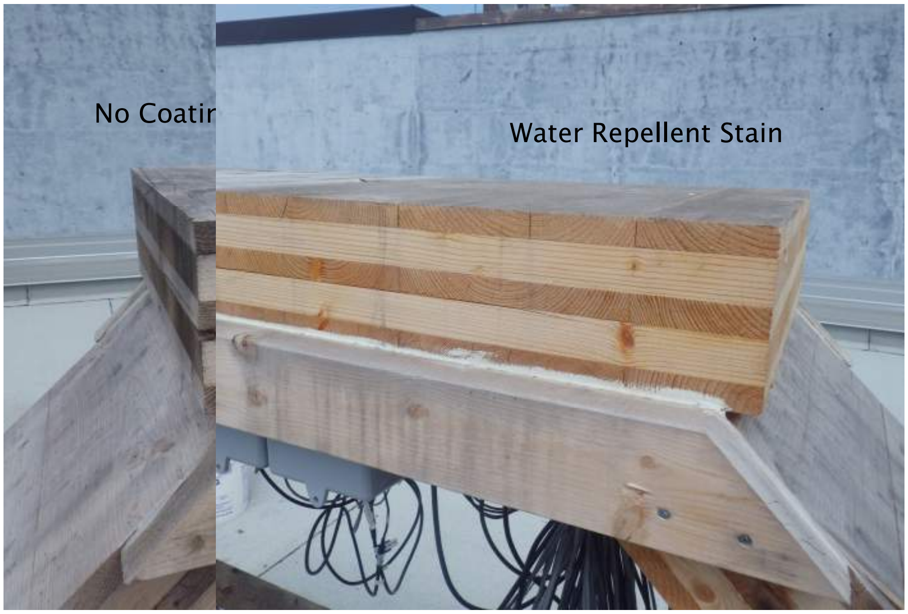
Sanding & Site Finishing Is Often Required

Protection of CLT During Construction



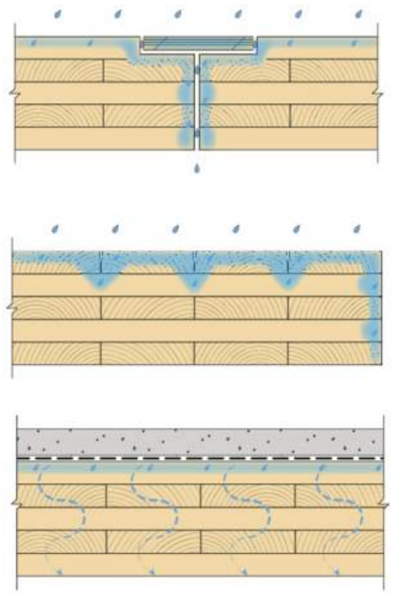
A Little Protection Goes a Long Way



But the Wrong Protection Can be A Mess..

Coating Lessons - CLT

- → Primary purpose for temporary moisture protection to reduce wetting to avoid drying and keep construction on schedule
- → Factory Coatings
  - → CLT end grain/panel edge coatings are effective
  - → CLT surface coatings are useful though not always needed
- → CLT will benefit with a coating below wet concrete floor toppings



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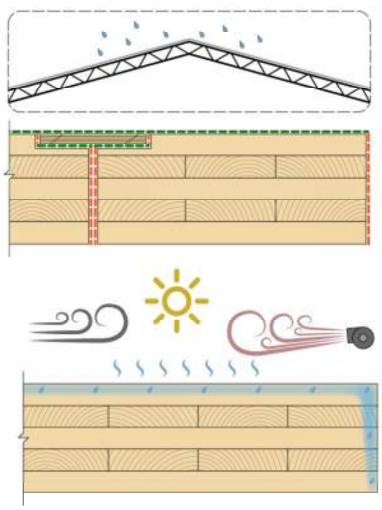
Key Takeaway – Have a Moisture Management Plan

- → Step 1: Risk Evaluation - Consider Climate, Rainfall, Construction Schedule, Length of exposure of all mass timber floors/roof etc.
- → Step 2: Factory applied coatings
- → Step 3: Pre-applied or field applied temporary or permanent membrane protection?
- → Step 4: Active water management team onsite to reduce uptake (small tarps, squeegees/vacuums etc.)
- → Step 5: Whole building tarping & protection systems
- → Step 6: Environmental drying
- → Step 7: Mechanical drying contingency



The Future of Tall Wood Facades/Enclosures

- → Facades/enclosures erected at same pace as structural systems for tall wood buildings
- → Growing local market opportunities for various prefabricated wall & window assemblies
  - → Will see a combination of steel, concrete, wood framing or wood panel structural systems used
  - → Systems will borrow technology from precast concrete and aluminum curtainwall industry, evolve and adapt for mass timber structures
  - → Use of hung "curtainwall" facades instead of load-bearing exterior walls

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Discussion & Questions

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