Mass Timber & Tall Wood Buildings

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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
Cross Laminated Timber (CLT)

Not All CLT Quality is the Same

Structural non-finish grade (Canadian product)

High quality interior finish grade (European product)

Custom clear finish interior tongue & groove with wood dowels (Canadian)
Glulam & Glue Laminated Timber (GLT) Panels

Nail Laminated Timber (NLT)
Many Historical Examples – Heavy Timber Framing with NLT Floors

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

Laminated Veneer Lumber (LVL)
Mass Plywood Panel (MPP)

Mass Timber is Beyond Stick Framing
It Borrows a Lot from Heavy Timber Framing

And Borrows a Bit from Pre-Cast & Tilt-Up Concrete
And Combines Pre-fabrication Modular & Panelization

Will Always Utilize Concrete & Steel Components
And Use Wood Where Wood Makes Sense

Post & Beam

Minneapolis T3 - MGA
Post & Beam

WIDC - MGA

Post & Plate (Panels)

UBC Tall Wood House - AOA
Solid Wood Panels

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
- 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?

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)
The Carbon Argument for Tall Wood Buildings

**Estimated Environmental Impact of Wood Use**

- **Volume of wood products used**: 2,233 cubic meters of CFI and Glulam
- **Carbon stored in the wood**: 1,753 metric tons of CO₂
- **Avoided greenhouse gas emissions**: 679 metric tons of CO₂
- **Total potential carbon benefit**: 2,432 metric tons of CO₂

**The above GHG emissions are equivalent to:**

- 0.1% runs off the road for a year
- Energy to operate a home for 222 years


UBC Tall Wood House

Worldwide Tall Wood Building Evolution

- **Height (metres)**
- **174 ft**
- **275 ft**

Challenges: Fire Code Solutions – Encapsulation

Challenges: Fire Code Solutions – Charring
Challenges: Structural Solutions

Challenges: Structural Movement?

Wood Innovation Design Centre - 6 tall storeys, ~98'
Michael Green Architecture (MGA)
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%

Many Precedents – Europe, Australia & North America
Next World’s Tallest Wood Building – HoHo, Vienna

A few of Our Past & Current Mass Timber Projects
Mass Timber Building Enclosures

The Building Enclosure

Mass Timber Structure
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

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

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?

Load Bearing versus Hung “Curtain-wood” Exterior Enclosure Walls
**Good vs Bad Use of Mass Timber**

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

**Bad** – exposed to weathering

**CLT Wall Considerations**

Best Placement & Insulation Type? – It Depends!
CLT Walls

CLT Wall Considerations - Movement
CLT Panel Interface Air Tightness?

CLT Interface Air Barrier Detailing Considerations
Air Barrier/WRB Membranes for CLT Panels

Vapor permeable self-adhered sheets

Liquids

Roofs – Exterior Insulated (Conventional or PMR)
CLT Roof Considerations

Venting Above Mass Timber Panels in Roofs
Why Prefabrication & Mass Timber Fit

LCT One, Vienna, Hermann Koffman
UBC Tall Wood Structure – Prefabricated & Fast
UBC Tall Wood House – Façade Challenge

Fast installation – 1 floor/day & water tight to protect structure

Durable & High-performance

Thermally Efficient, >R-16 effective walls

Resistant to water & able to install in rain

Inexpensive, <$50/sqft installed & finished

Pre-installed cladding & windows

Installed without access to exterior – no sealing or finishing

UBC Tall Wood House - Façade Design Criteria
Façade Prefabrication - Small Panel with Separate Windows

Façade Prefabrication - Large Panel with Pre-installed Windows
UBC Tall Wood - Prefabricated Panel Competition
Wall Panel Laboratory Mockup & Physical Testing
Wall Panel Prefabrication

Site Installation
Site Installation – at Pace with Structure – 2 floors/week
Mass Timber Building Lessons Learned

CLT is Not Airtight - Don’t Forget the Membrane
CLT is Not Airtight - Don’t Forget the Membrane
NLT Panel Shrinkage Considerations

Lamination expansion due to swelling

Lamination position after NLT has returned to lower moisture

NLT Considerations – Design for Movement
The Biggest Challenge with NLT Overhangs

NLT Panel Air Sealing in Factory
The Biggest Challenge – Managing Water Effectively During Construction

Keep Wood Dry & Use Appropriate Materials in Contact with Damp Wood
Take Care with Impermeable Roof Membranes – Can Be Double Edged Sword

Protect NLT from Excessive Wetting But Not Too Late
...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
**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

**Lots of Protection Options for Mass Timber Panels During Construction**
Wetted NLT Panels Can Move a Lot!

Swelling Wood Is an Almost Unstoppable Force
Pick the Right Wood Product for the Application

Know the Wood You Are Using
CLT Is Not Watertight During Construction

Try to Avoid Drywall Until You Have A Roof or Water-tight Floor Overhead
Sanding & Site Finishing Is Often Required

Protection of CLT During Construction

- End grain is very absorptive
- Water repellants can help reduce uptake into wood
- 5 ply CLT - ½ Untreated & ½ Treated with water repellant
- Splits, checks & joints that allow water past top layer can be problematic
- Erect & roof as fast as possible to protect from rain to avoid delays
A Little Protection Goes a Long Way

No Coating

Water Repellent Stain

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

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 the 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

Discussion & Questions

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