Building Enclosure Assemblies that Work for Taller Wood Buildings

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Outline

→ Building Enclosure Design Fundamentals
→ Building Enclosure Design Guidance
→ Some Lessons Learned from Larger & Taller Buildings
→ Case Study – Wood Innovation Design Centre
The Building Enclosure

Structure

Image Credit: MGA
- Wood Innovation Design Centre
The Building Enclosure
Primary function: Separate exterior & interior environments
- Manage environmental loads: outdoor/indoor climates & differences between
- Aesthetics & function
- Protect the structure & be durable

Accommodate building movement & structural loads: initial, seasonal, & long term
- Control heat, air, and moisture
- Control fire and sound
- Key passive design element in an energy efficient building
Building Enclosure Assemblies & Details

### Control Functions

- Water
- Air
- Heat
- Vapour
- Sound
- Fire

### Critical Barriers

- Building Form & Features
- Water Shedding Surface (WSS)
- Water-Resistive Barrier (WRB)
- Air Barrier System
- Thermal Insulation
- Vapour Retarder/Barrier

#### Primary Relationship

1. Water is defined here as precipitation (rain, snow, hail, etc.) and ground water

#### Secondary Relationship

2. Vapour is separately defined here as the water vapour in air, as well as condensate moisture
How does the Structural System Influence Building Enclosure Design?

Steel  Concrete  Wood
What is Unique about Larger Wood Buildings?

- Greater use of engineered heavier timber components (panels, beams, columns)
  - CLT, LSL, PSL, LVL, Glulam etc.
  - Alternate structural systems (post/beam, engineered panels, infill components)
- Unique connections, interfaces & details
- Longer & heightened exposure to rain and weathering during construction
- Codes dictate certain thermal insulation, fire performance & acoustic properties
- *Is not the same as stick built <6 storey wood-frame, but is also different from high-rise steel or concrete structures*
North American Energy Codes & Wood Buildings

### Climate Zone

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Based on Maximum Effective Assembly U-value Tables.

Residential Building R-values similar or in some cases slightly higher.

Some state by state & municipal differences depending on year of energy code adoption.
Building Enclosure Design Guidance

- 1999/2001 *Wood Frame Envelopes in the Coastal Climate of British Columbia - Best Practice Guide* (CMHC)
  - Emphasis on moisture control in Pacific Northwest
  - Emphasis on best practices, moisture and new energy codes
  - Currently being updated
Cross Laminated Timber Handbooks

→ Canadian & USA handbooks published by FPInnovations
→ Provides design guidance for Cross Laminated Timber (CLT) buildings in all North American climate zones
→ Building enclosure chapter focuses on durability and energy efficiency
Highly Insulated Wood-frame Guide

- 2013 Guide for Designing Energy-Efficient Wood-Frame Building Enclosures (FP Innovations)
  - Focus on highly insulated wood-frame assemblies to meet current and upcoming energy codes
  - Strategies, assemblies & many building enclosure details provided for passive design and “green” buildings
  - Sequential detailing for windows and other complicated details
2014 *Tall Wood Buildings Guide* (FPInnovations) – high-rise wood and hybrid wood buildings

Building enclosure chapter #6 focuses on design fundamentals for durable and energy efficient high-rise mass timber buildings

- Moisture management & control
- Heat flow & thermal bridging
- Condensation control
- Air flow control & air barrier systems
- Noise & Fire control
- Assemblies & Details
- Claddings, Roofing
- Wood Durability
Wall Design for Taller Wood Buildings

→ **Key Considerations:**
  Durability, Airtightness &
  Thermal Efficiency

→ **Strategies:**
  → Exterior or split-insulated wood walls
  → Thermally efficient cladding attachments through exterior insulation
  → Non-combustible & moisture tolerant cavity insulation
  → Non-combustible rainscreen claddings
Wall Design for Taller Wood Buildings

- Taller 4 storey stick frame & heavy timber panel buildings
  - less room for stud frame insulation
- Challenges to meeting prescriptive R-value requirements without exterior insulation in walls
Getting to Higher Effective R-values

**Baseline**
2x6 w/ R-22 batts = R-16 effective

- **Exterior Insulation**: R-20 to R-40+ effective
  - Constraints: cladding attachment, wall thickness
  - Good durability

- **Deep/Double Stud**: R-20 to R-40+ effective
  - Constraints wall thickness
  - Fair durability

- **Split Insulation**: R-20 to R-40+ effective
  - Constraints: cladding attachment
  - Good durability with proper design

**New vs Retrofit Considerations**
Cladding Attachment Options

*Thermally Efficient Clip & Rail Systems*
Cladding Attachment Options

*Screws through Exterior Insulation*
Thermal Efficient Masonry over CLT
→ **Strategies (continued)**
  
  → Robust air-tight, water resistant & breathable wall membrane (AB/WRB)
  
  → Membrane compatibility with glazing, roofing, and other assembly materials
  
  → Simple integration with glazing systems & other penetrations
  
  → Watch details at interfaces with mass timber structure
Air Barriers for Taller Wood Buildings

- Air Barrier Systems need to:
  - Be Continuous
  - Be Durable
  - Resist Structural Loads – Sufficient Stiffness & Strength for Full Wind
  - Be Airtight
  - Not negatively affect durability or vapor diffusion drying ability
- Traditional loose sheet applied house-wrap products are challenging for larger wood buildings
- Adhered/liquid applied membranes preferred
Air Barriers for Taller Wood Buildings

- **Loose sheet applied membrane** – taped joints & strapping
- **Sealed gypsum sheathing** – sealant filler at joints
- **Liquid applied membrane over wood sheathing** – sealants at joints
- **Sealed plywood sheathing** – sealant/membrane at joints
- **Liquid applied over gypsum sheathing** – sealant at joints
- **Self-adhered vapor permeable membrane over sheathing**
- **Plywood sheathing with taped joints (good tape)**
Air Barrier Challenges – Mass Timber Walls

- CLT panel structural connections interfere with air-barrier membrane installation/sequencing and sharp parts can damage materials (applied before or after)
- Consideration for both building enclosure & smoke/fire separation
→ Structural protrusions add to air-barrier complexity
→ Better to pre-strip air barrier membrane prior to attachment of panels instead of wrapping around them
→ Construction sequencing of this will be a challenge with trades
Air Barrier Challenges – CLT Panel Gaps
Air is able to bypass many common CLT interfaces at gaps in lumber which open up as wood shrinks.

Requires attention for building enclosure & smoke/fire separation to stop this bypass leakage.
→ CLT panels can be air-tight as a material, but not easily as a system

→ Recommend use of vapor permeable self-adhered sheet air barrier membranes on exterior of panels (exterior air-barrier approach)

→ Use of loose-applied sheets (Housewraps) generally not recommended – very difficult to make airtight, perforating attachment, billowing, flanking airflow behind membrane
Air Barrier/WRB Material Selection

Vapor permeable self-adhered sheets

Liquids

Liquids
Other Solutions to Some Challenges

→ Need for higher grade CLT Panels with higher quality lumber & moisture control without edge checking in-service

Photos courtesy AHC Derix
Considerations & Detailing for Wood Movement

- Wood shrinks as it dries and swells when it gets damp (both liquid water & humidity fluctuations)
- Mass timber assemblies introduce unique details & shrinkage can often be greater than anticipated (more wood to shrink)
  - Building height & differential movement between assemblies/floors
- Manufacturing of CLT/Glulam
  - ~12-14% MC for adhesives to bond
- Watch in-service wetting/high RH, drying in service (low RH) and seasonal fluctuations in RH
Wood shrinkage is 0.20% to 0.25% in dimension per 1% change in MC.
Materials for Taller Wood Buildings

- Watch use of vapor impermeable materials over wood that is wet or could get wet
  - Self adhered membranes
  - Foam plastic insulations

- Vapor diffusion *wetting & drying* ability for assemblies & details should always be assessed – ensure balance
Materials for Taller Wood Buildings

→ Many new synthetic self-adhered sheet & liquid applied membranes in the market (moisture & air control layers)
→ Not all created equal – each have strengths & weaknesses
  → Need to match compatible sealants, tapes, & membranes with each
  → Choice will depend on substrate, field conditions & tie-in details etc.
Roof Design for Larger Wood Buildings

→ **Key Considerations:** Keep dry, allow to dry, robustness of assemblies, sloping strategy

→ **Strategies:**
  → Protect wood roof from getting wet during construction
  → Design assembly with redundancy for in-service drying
  → Slope structure where possible
  → Insulation on top - conventional or protected membrane assemblies
  → Question the need for heavy timber panels up here?
Lessons Learned from Construction of Larger Wood Roofs

→ Don’t use organic (paper) faced insulation in contact with damp wood

→ Drying of a wetted roof by natural means through more than one layer of plywood can be very slow
Lessons Learned from Construction of Larger Wood Roofs

→ Nail laminated timber roofs get really wet when rained on and are very hard to dry out in-service

→ Careful with selection of temporary *waterproofing* membranes – assume it will be exposed *roofing* for a while. Need for water-tight laps/details
Lessons Learned from Construction of Larger Wood Roofs

→ Protect large wood roofs from rain – but not too late

→ Mechanical drying of wetted roofs is slow & causes costly construction delays
Lessons Learned from Construction of Larger Wood Roofs

→ Design for the inevitable to keep roofing and project on schedule

→ Design roof assemblies for redundancy and in-service drying where possible
Lessons Learned from Construction of Larger Wood Roofs

→ Care with porous wood panels as horizontal surfaces and roofing substrates

→ Assume that the wood will get damp/stained during construction and site sanding and finishing will be necessary
Industry Lessons - Wetting of Exposed CLT

End grain is very absorptive

5 ply CLT – ½ Untreated & ½ Treated with water repellent

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

Water repellants can help reduce uptake into wood
Case Study:
Wood Innovation Design Centre – Tall Wood Building Enclosure
Located in Prince George, BC @ UNBC Campus - North America’s Tallest Wood Building
- 6 ‘tall’ storeys (equivalent to 8 storey, 98’ tall)
- CLT shear walls, glulam columns with glulam beams and staggered CLT floor & roof structure
- Thermal performance design targets (effective R-values)
  - R-40 roof
  - R-25 walls
  - R-5 wood curtainwall glazing
- Pre-fabricated design for curtain wall & infill walls

Michael Green Architecture (MGA) – Contractor: PCL Construction
Design & Architectural Renders: Michael Green Architecture (MGA)
Building Enclosure Under Construction
Wood Veneer Curtainwall/Windows

→ Aluminum veneer curtainwall framing over LVL mullions
  → Installed as individual window units, ground bearing
→ Stick built/site glazed with triple glazed IGUs, argon filled, dual low-e coatings (U-0.15)
→ R-5 (U-0.20) overall thermal performance
  (vs. ~R-3.5 for aluminum system)
Wood Veneer Curtainwall/Windows
WIDC Infill Wall Assembly Design

→ Designed for prefab light-frame wall assemblies between curtainwall units
→ Target R-25 effective R-value
→ Structurally Insulated Panels (SIPs) proved cost effective, fast & easy to install
→ Robust silicone WRB/AB membrane on exterior surface (applied in factory) ties nicely into curtainwall assembly
→ Sealed joints
Curtainwall to SIPS Interface

- Aluminum Curtainwall Veneer Framing
- Silicone Transition Strip AB/WRB attached with silicone to curtainwall and wall membrane
- Interior Air Seal at Joints
- Silicone Applied Liquid AB/WRB
- LVL Framing Backup
- SIPS
- Charred fire-treated cedar cladding attached to plywood backup & cleat system over drained & ventilated rainscreen cavity
Charred Fire-Treated Cedar Panelized Cladding

John Boys, Nicola Log-works
Conventional Roof Assembly

R-40+ Conventional Roof Assembly – 2 ply SBS, 4" Stonewool, 4" Polyiso, Protection board, Tapered EPS (0-8"), Torch applied Air/Vapor Barrier (Temporary Roof), ¾” Plywood, Ventilated Space (To Indoors), CLT Roof Panel Structure (Intermittent)

Construction Photos by PCL/MGA/RDH
Conventional Roof Assembly

Construction Photos by PCL/MGA/RDH
Conventional Roof Assembly

Construction Photos by PCL/MGA/RDH
→ Key Building Enclosure Considerations: Assemblies & Details
  → Design to be durable, air-tight, & thermally efficient
  → Design for initial and long-term wood movement
  → Combustibility will drive many material choices & assemblies
→ Material Selection
  → Need for more robust and compatible materials, consider tie ins & details
  → Vapor permeable generally preferred to facilitate drying
  → Careful with new many materials on market
→ Construction
  → Keep wood dry during construction – allow it to dry if it gets wet
  → Incorporate contingencies for moisture protection during construction
  → Care with the materials & means for temporary moisture protection
  → Design for redundancy if materials get wet
→ Lessons learned from past from existing buildings apply to larger and taller buildings of the future
Questions & Discussion

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