

# How to Develop a CLT Project

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Project of the Canadian Wood Council



# CLT Project: Architectural Concepts

**Michael Green**

**MGA** | Michael Green Architecture

[www.mg-architecture.ca](http://www.mg-architecture.ca)



# CLT

## THE WONDER DRUG

TORONTO 11.2012

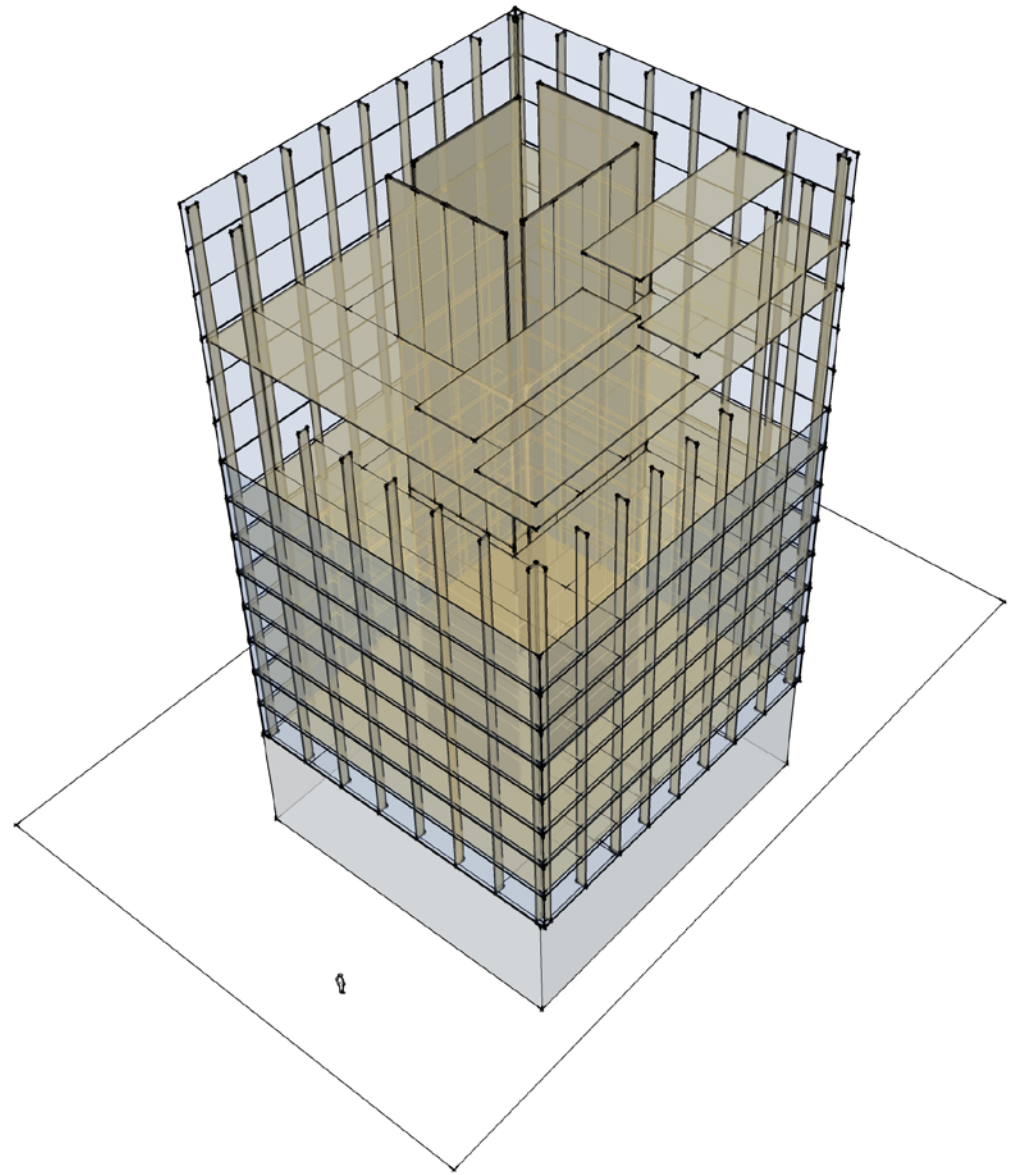
**MGA** | MICHAEL GREEN ARCHITECTURE  
VANCOUVER | NEW YORK





**CROSS LAMINATED TIMBER**  
CLT 40' x 10' (12 x 2.4)







# CLT

## THE OPPORTUNITIES

LARGE FORMAT  
FAST CONSTRUCTION  
EXCELLENT SPAN TO THICKNESS  
LOW WEIGHT  
REDUCED FOUNDATION COSTS  
SYSTEMS INTEGRATION  
PRE-FABRICATED APPROACH  
CARBON SEQUESTRATION  
COMPETITIVE WITH CONCRETE  
EXCELLENT FIRE PROPERTIES



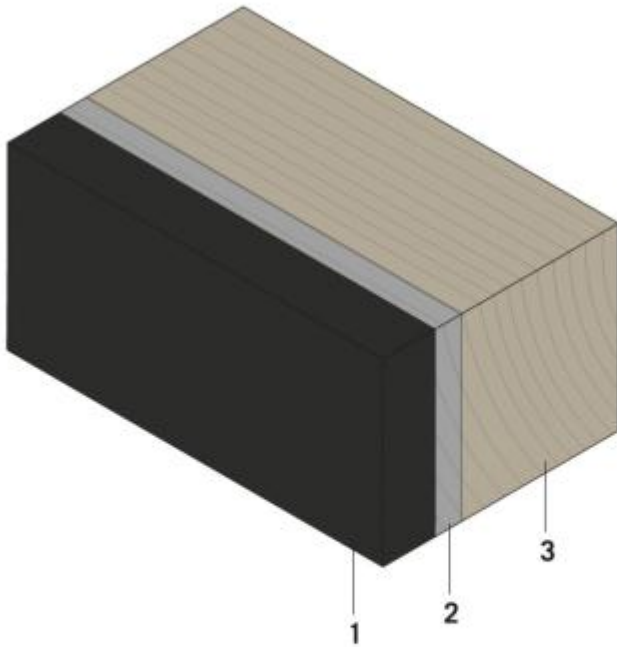
# CLT

## THE CHALLENGES

DETAILING  
FIRE RATINGS  
FLAME SPREAD RATINGS  
ACOUSTIC PERFORMANCE  
MOISTURE  
PENETRATIONS  
ENVELOPE DETAILING

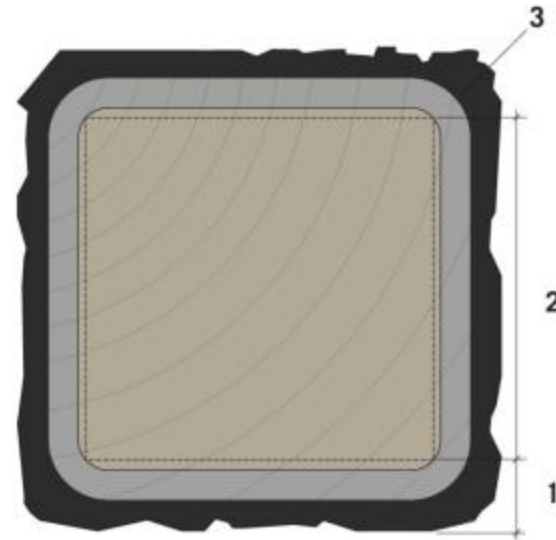


# Charring



**Charring Diagram**

- 1 Char layer
- 2 Pyrolysis zone
- 3 Normal wood

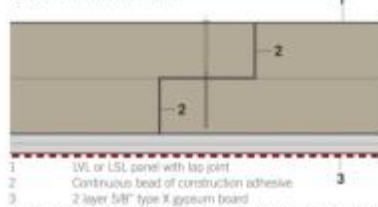


**Charring Structural Design Diagram**

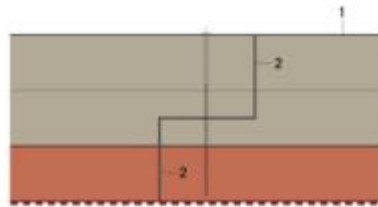
- 1 Sacrificial layer (char layer and pyrolysis zone; no structural capacity)
- 2 Residual section (structural capacity retained)
- 3 Rounded corner

# Charring and Encapsulation

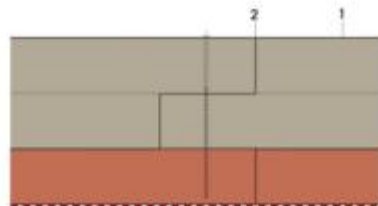
Typical Panel Joint Details



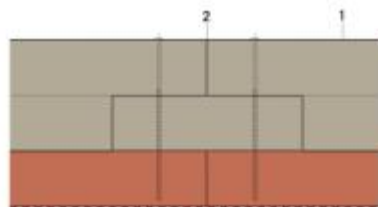
Assembly illustrating encapsulation concept with lap joint



1 VL or LSL panel with lap joint  
2 Continuous bead of construction adhesive  
3 2 layer 5/8" type X gypsum board



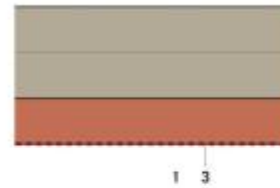
1 VL or LSL panel with lap joint  
2 Continuous bead of construction adhesive  
3 Sacrificial VL or LSL layer



1 Spline joint  
2 Bead of construction adhesive or gasket  
3 Sacrificial VL or LSL layer

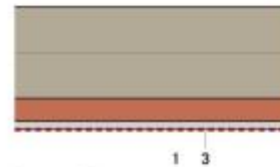
Assemblies illustrating charring concept with various joints

Hybrid Charring and Encapsulation Details



1 Fire exposed side  
2 2 layer VL or LSL  
3 \*\*\*\*Sacrificial VL or LSL layer (2HR FRR)

Assembly illustrating charring only concept



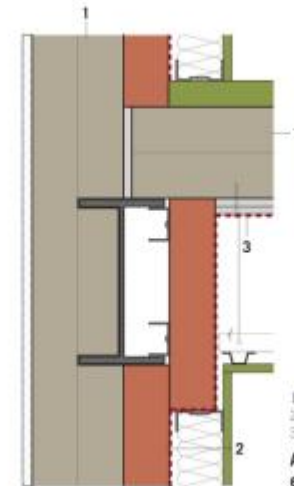
1 Fire exposed side  
2 2 layer VL or LSL  
3 \*\*Sacrificial VL or LSL layer + 1 layer 5/8" type X gypsum board (2HR FRR)

Assembly illustrating hybrid charring and encapsulation concept



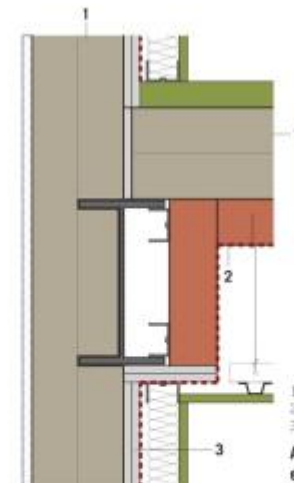
1 Fire exposed side  
2 2 layer VL or LSL  
3 2 layer 5/8" type X gypsum board (2HR FRR)

Assembly illustrating encapsulation only concept



1 2 layer VL or LSL  
2 \*\*Wall: sacrificial VL or LSL (2HR FRR)  
3 Ceiling: 2 layer 5/8" type X gypsum board (2HR FRR)

Assembly illustrating hybrid charring and encapsulation concept



1 2 layer VL or LSL  
2 \*\*Ceiling: sacrificial VL or LSL (2HR FRR)  
3 Wall: 2 layer 5/8" type X gypsum board (2HR FRR)

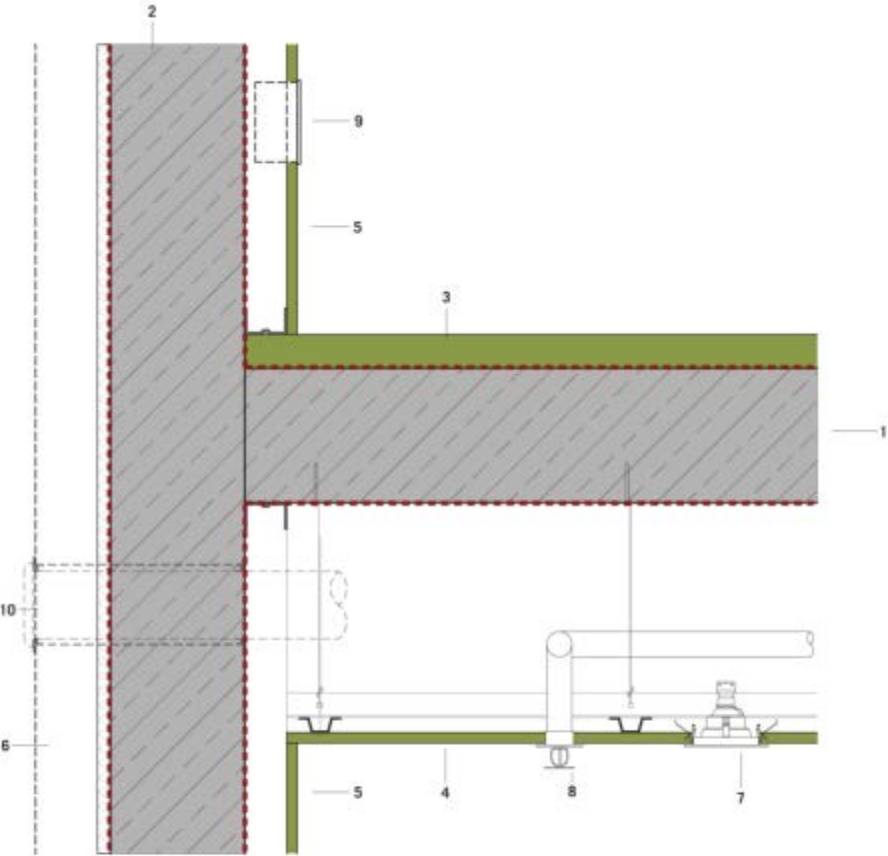
Assembly illustrating hybrid charring and encapsulation concept

\*\* Charring rates vary depending on moisture, density, species etc. The charring rate of 0.635mm/min is the generally accepted average. Refer to page XX for additional information on charring rate.

\*\*\* Interior finish: exposed wood paneling subject to flame-spread rating and smoke developed classification code requirements. Refer to page 106 for additional information on flamespread, smoke classification and interior finishes.

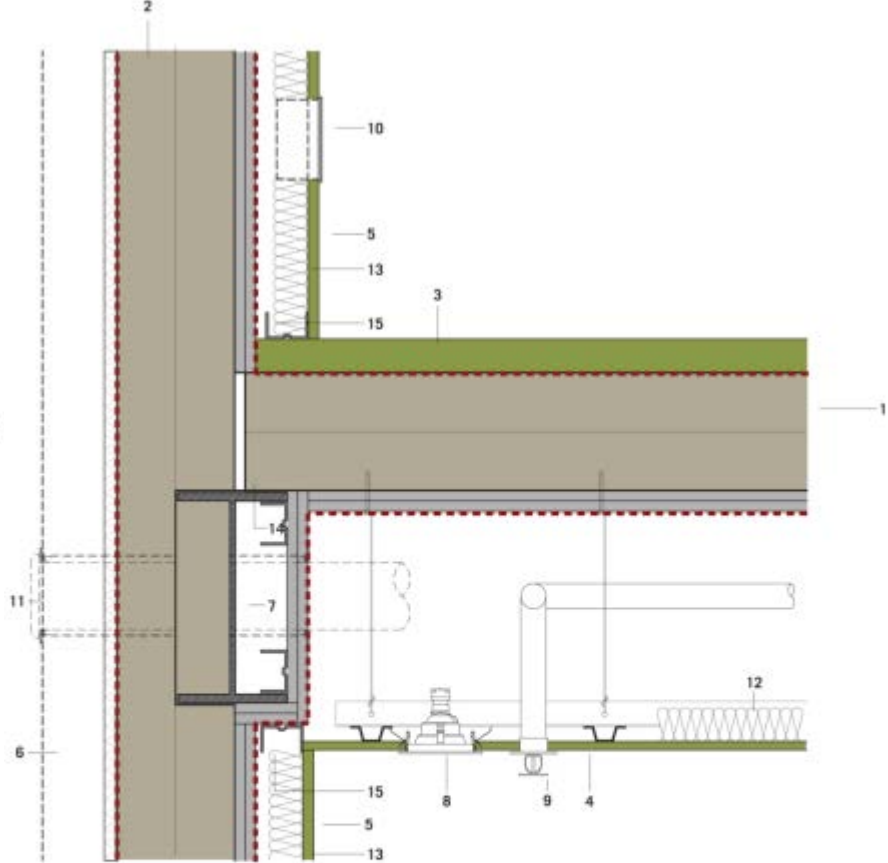


Typical Details



- 1 Cast in place concrete floor (ZHR FRR)
- 2 Cast in place concrete wall (ZHR FRR)
- 3 Finish floor
- 4 Finish ceiling
- 5 Finish wall
- 6 Facade (non-combustible)
- 7 Pot light
- 8 Sprinkler (plastic pipe)
- 9 Electrical outlet
- 10 Exhaust penetration with fire stopping

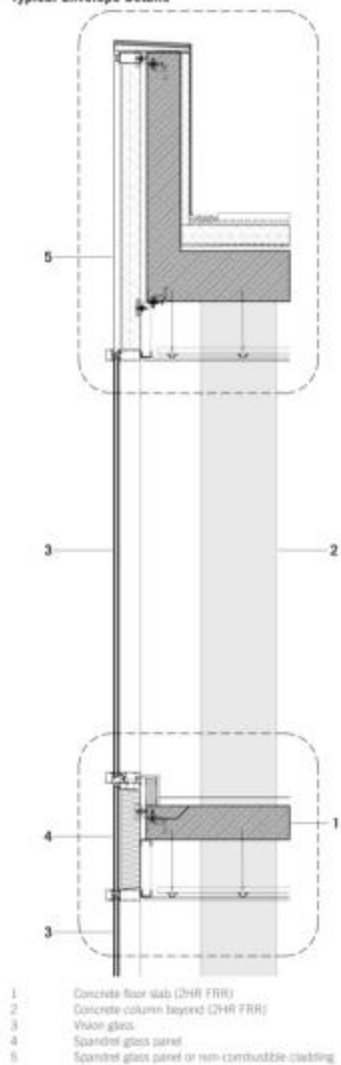
Typical concrete tower floor and wall section at exterior wall



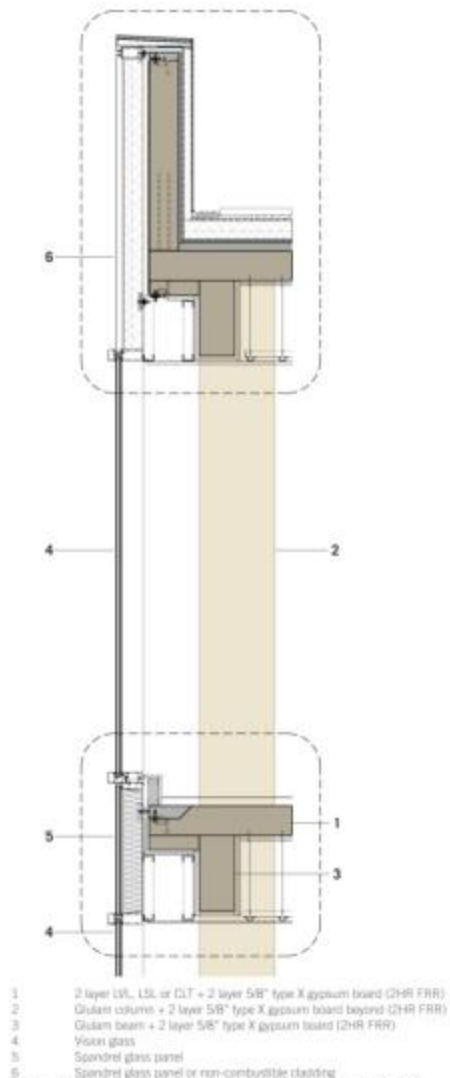
- 1 2 layer LVL or LSL + 2 Layer 5/8" type X gypsum board underside only (ZHR FFR)
- 2 2 layer LVL or LSL + 2 Layer 5/8" type X gypsum board interior side only (ZHR FFR)
- 3 Finish floor
- 4 Finish ceiling
- 5 Finish wall
- 6 Facade (non-combustible)
- 7 Pot light
- 8 Sprinkler (plastic pipe)
- 9 Electrical outlet
- 10 Exhaust penetration with fire stopping
- 11 Exhaust penetration with fire stopping
- 12 2" loose mineral wool insulation for sound absorption (ceiling)
- 13 2" loose mineral wool insulation for sound absorption (wall)
- 14 Airspace to reduce sound transmission between floor and wall
- 15 Gap between drywall and stud to reduce sound transmission

Tall wood case study floor and wall section at exterior wall

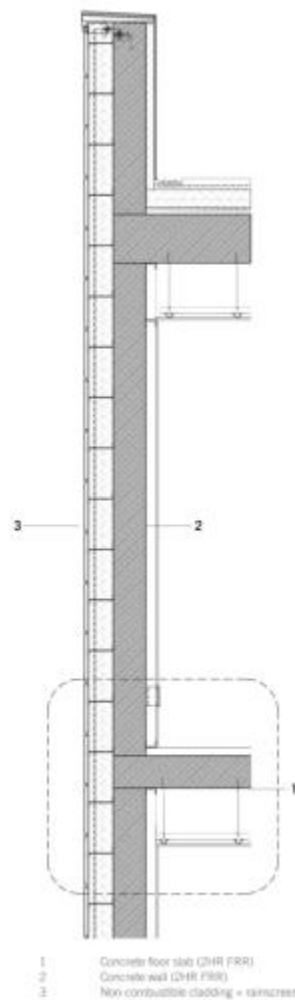
# Typical Envelope Details



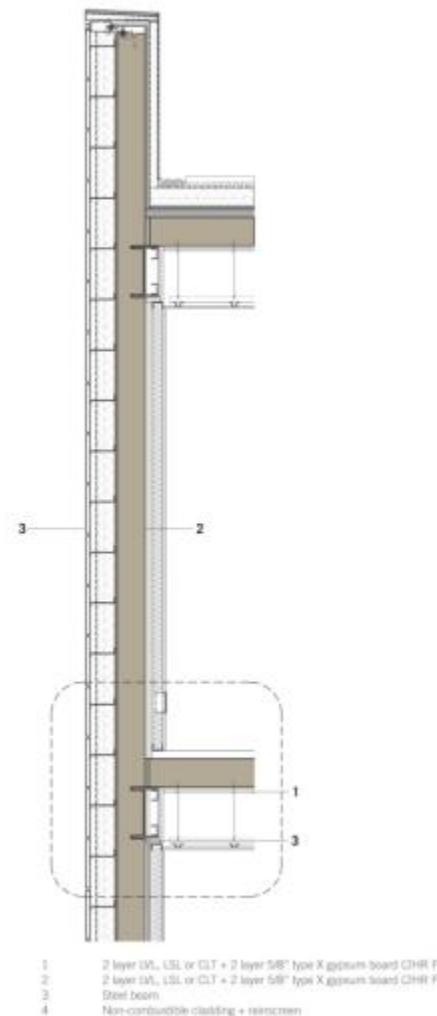
Typical concrete tower curtain wall facade section



Tall wood case study curtain wall facade section (option 1 + 2)

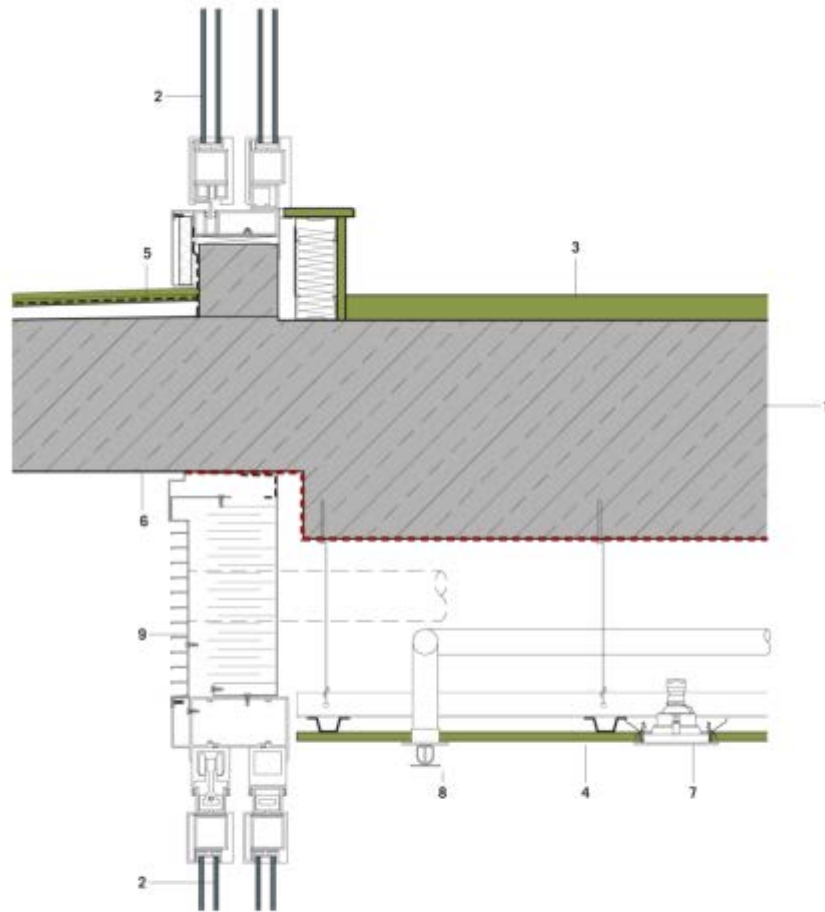


Typical concrete tower facade section



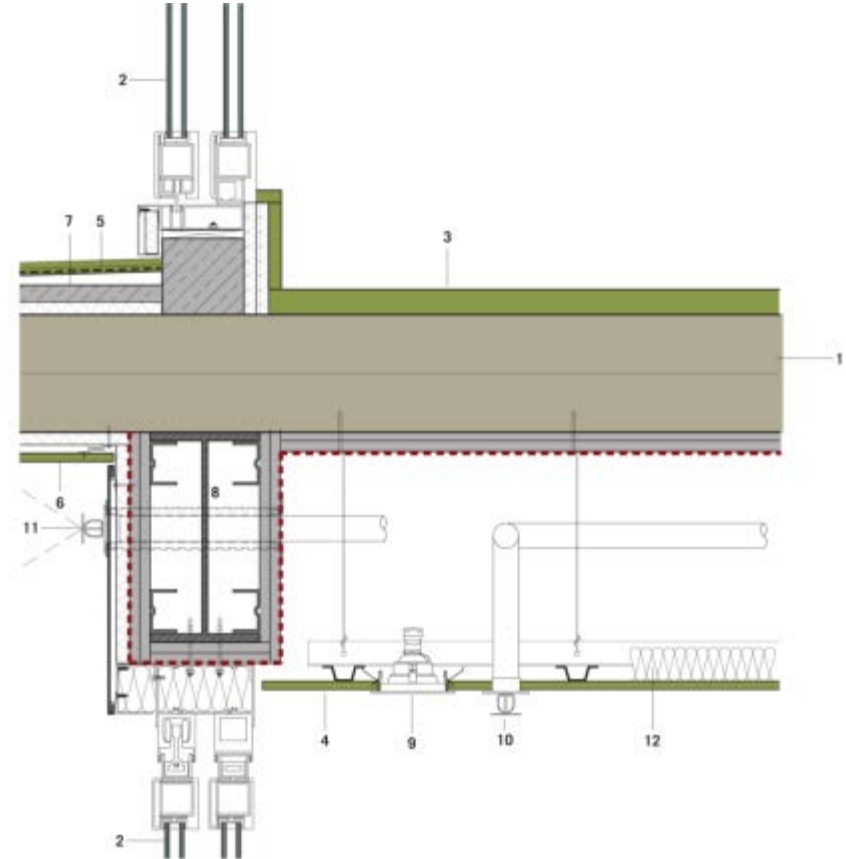
Tall wood case study facade section (option 3 + 4)

## Typical Details



- 1 Cast in place concrete floor (2HR FRR)
- 2 Balcony door
- 3 Finish floor
- 4 Finish ceiling
- 5 Finish floor balcony (sloping with waterproofing)
- 6 Exposed concrete
- 7 Pot light
- 8 Sprinkler
- 9 Spandrel panel + exhaust

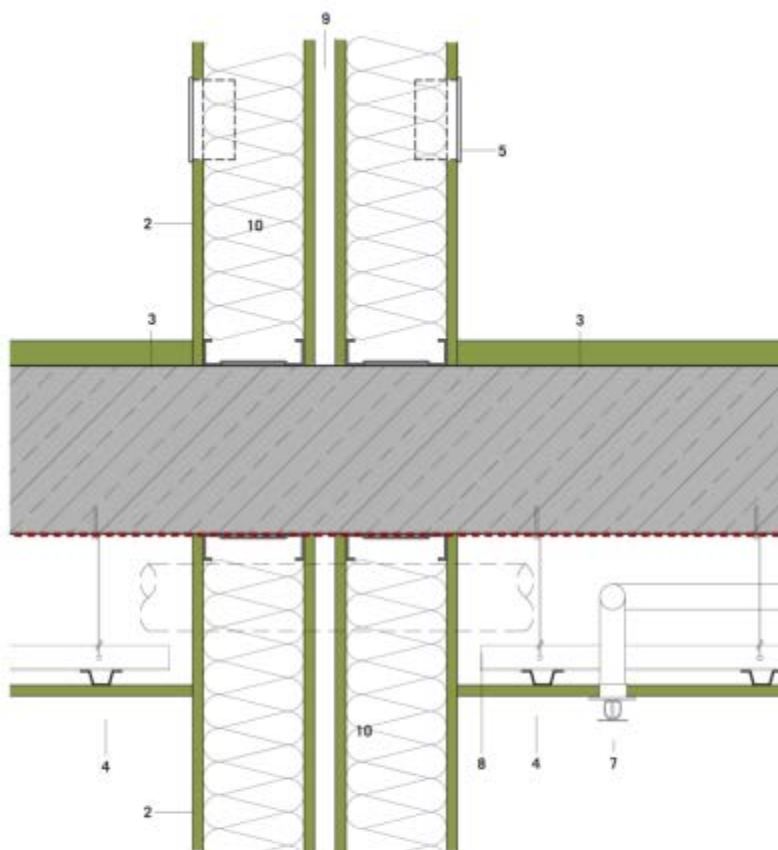
Typical concrete tower sliding door section at balcony



- 1 2 layer LVL or LSL + 2 Layer 5/8" type X gypsum board underside only (2HR FRR)
- 2 Balcony door
- 3 Finish floor
- 4 Finish ceiling
- 5 Finish floor balcony (sloping waterproofing)
- 6 Exterior soffit
- 7 Concrete topping and curb (2HR FRR)
- 8 Steel beam
- 9 Pot light
- 10 Sprinkler
- 11 Dryhead sprinkler with sleeved fire stopping (for balconies up to 10' outboard)
- 12 2" loose mineral wool insulation for sound absorption

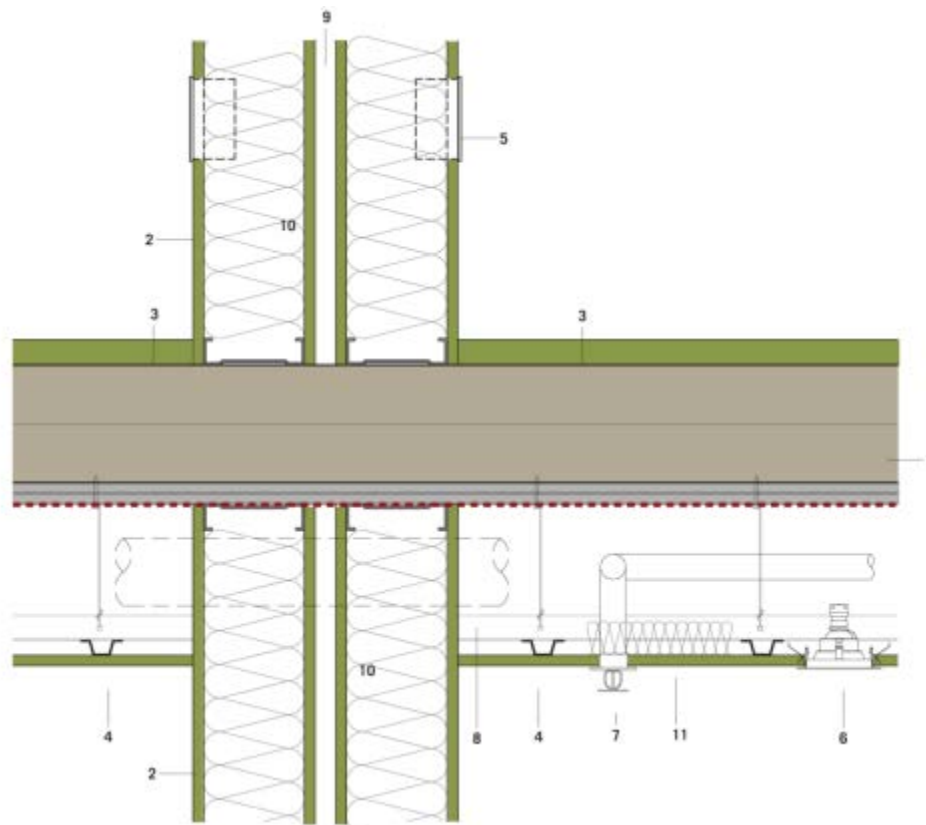
Tall wood case study sliding door section at balcony

## Typical Details



- 1 Cast in place concrete floor (2HR FRR)
- 2 Double steel stud wall with 5/8" gypsum board on both sides
- 3 Finish floor
- 4 Finish ceiling
- 5 Electrical outlet
- 6 Pot light
- 7 Sprinkler
- 8 Duct
- 9 Air space between walls to reduce sound transmission
- 10 Mineral wool insulation for sound absorption

Typical concrete tower typical non-load bearing interior partition between units



- 1 2 layer LVL or LSL + 2 Layer 5/8" type X gypsum board on underside only (2HR FRR)
- 2 Double steel stud wall with 5/8" gypsum board on both sides
- 3 Finish floor
- 4 Finish ceiling
- 5 Electrical outlet
- 6 Pot light
- 7 Sprinkler
- 8 Duct
- 9 Air space between walls to reduce sound transmission
- 10 Mineral wool insulation for sound absorption
- 11 2" loose mineral wool insulation for sound absorption

Tall wood case study typical non-load bearing interior partition between units

# HISTORY

FIRE MASS APPROACHES

VANCOUVER BC





WING SANG GALLERY



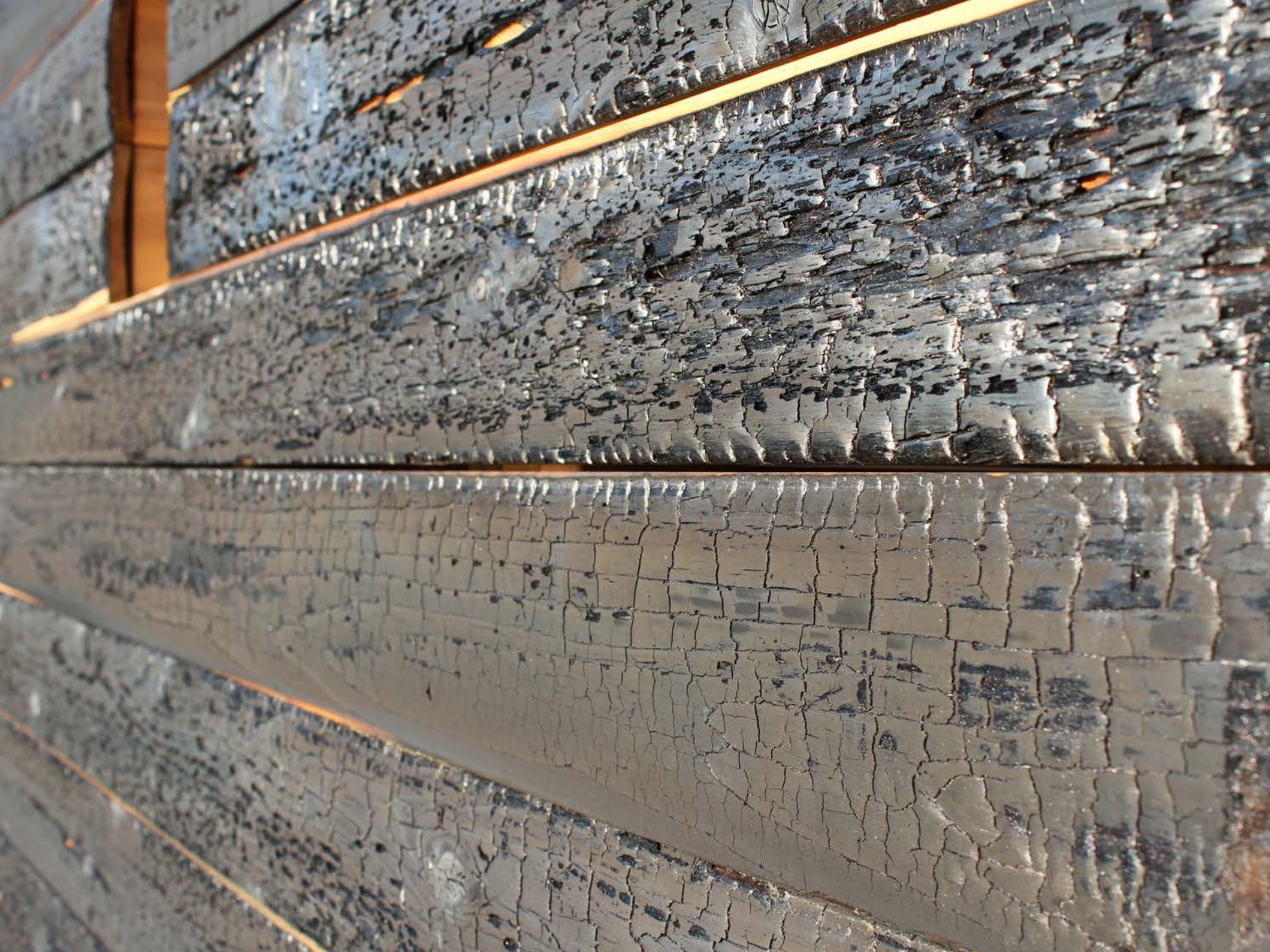
# 2 (OFFICE)

**MGA OFFICE**  
VANCOUVER BC

**MGA** | MICHAEL GREEN ARCHITECTURE  
VANCOUVER | NEW YORK







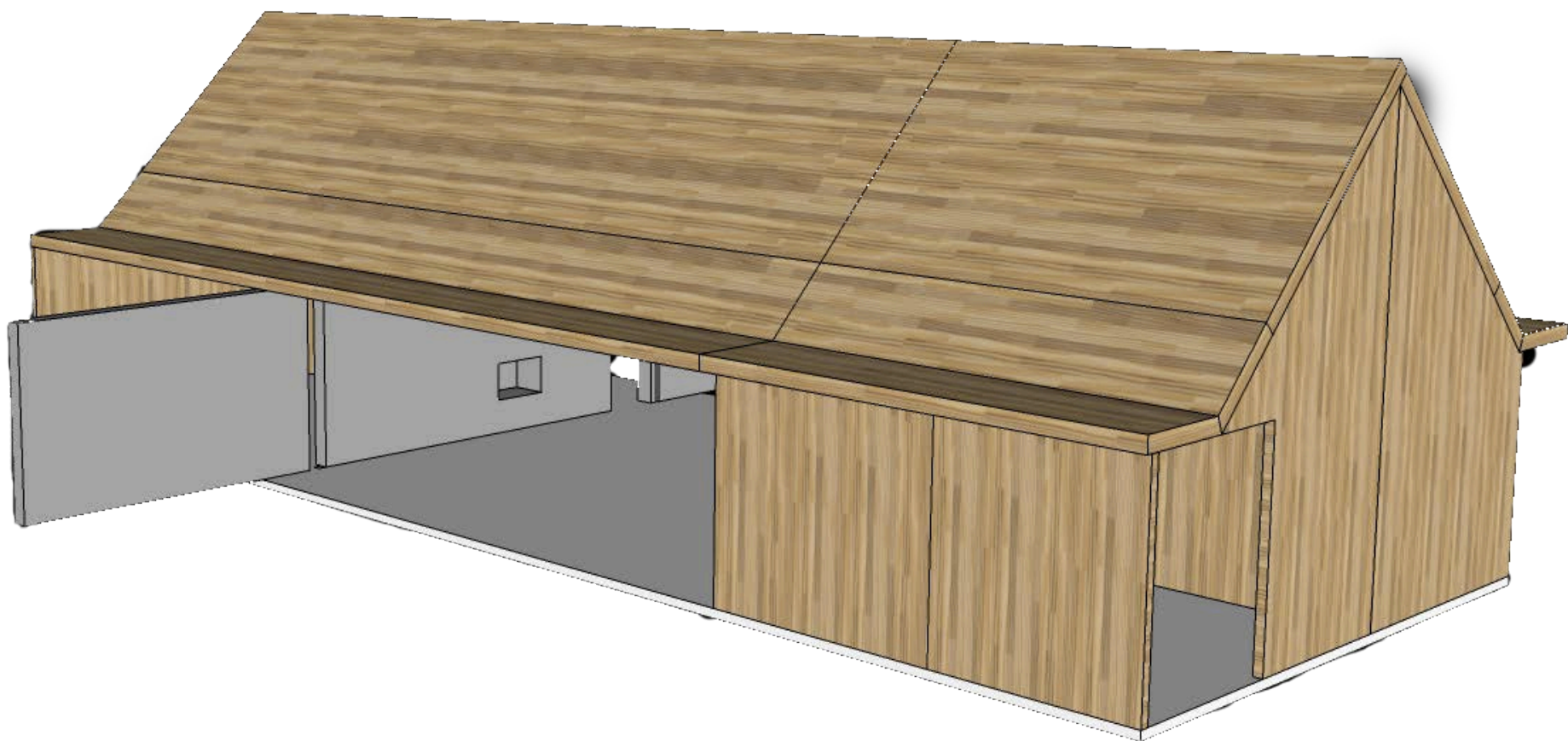


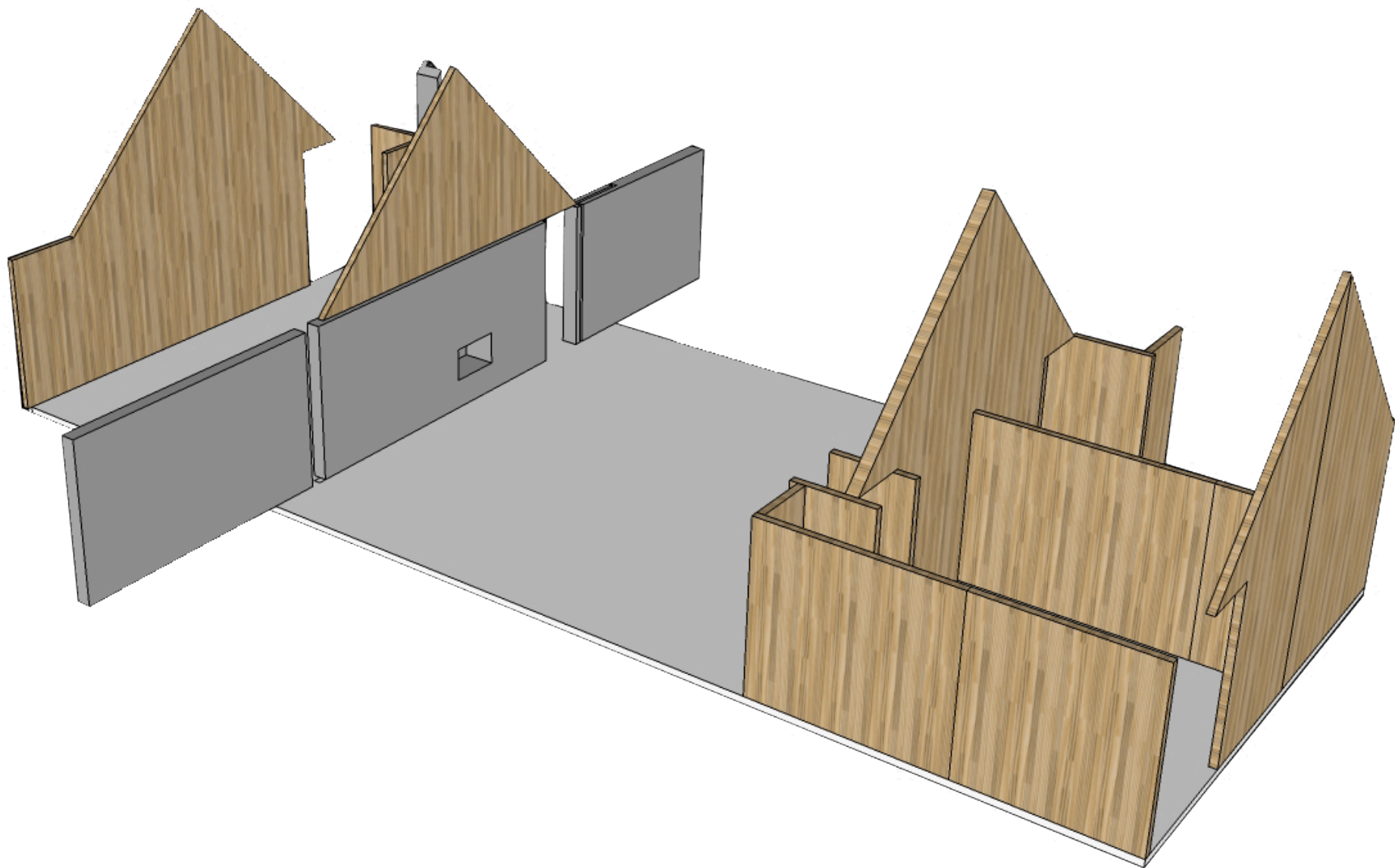
1+ (RES)

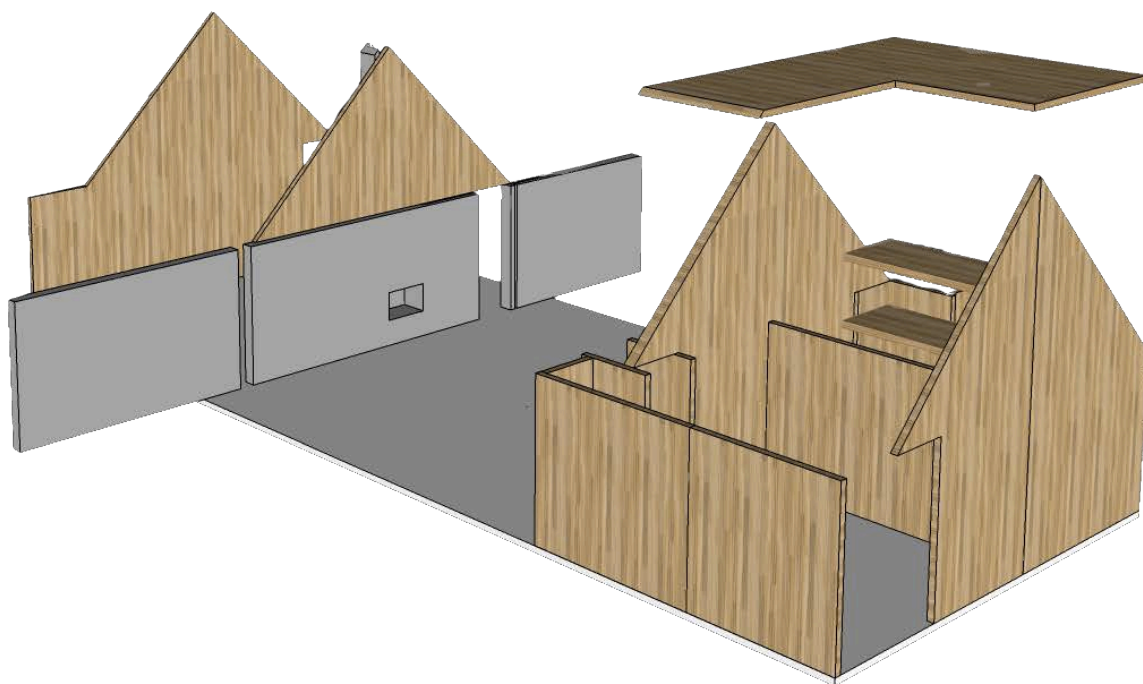
CANNON POINT HOUSE  
NEW YORK

MGA | MICHAEL GREEN ARCHITECTURE  
VANCOUVER | NEW YORK









# 2 (MOUNTAIN)

## RENDEZVOUS LODGE

WHISTLER BC

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VANCOUVER | NEW YORK





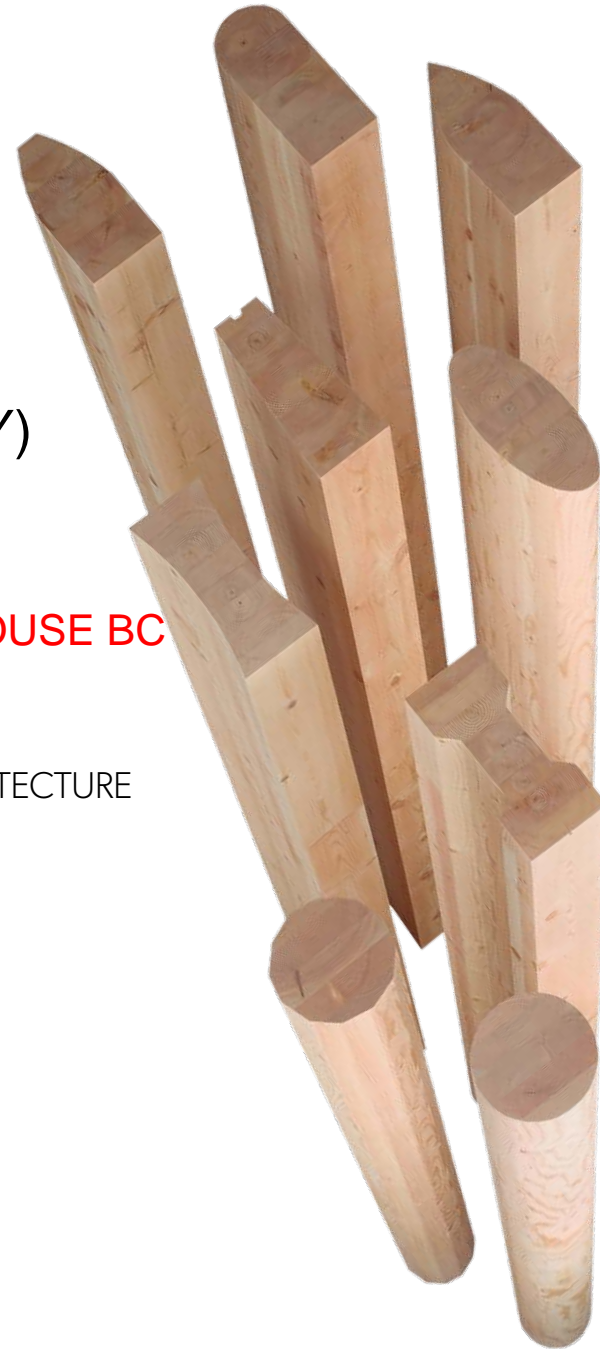
## RENDEZVOUS LODGE | WHISTLER BLACKCOMB



# 4 (CLT | MASONRY)

**RONALD MCDONALD HOUSE BC**  
VANCOUVER BC

**MGA** | MICHAEL GREEN ARCHITECTURE  
VANCOUVER | NEW YORK







RONALD MCDONALD HOUSE















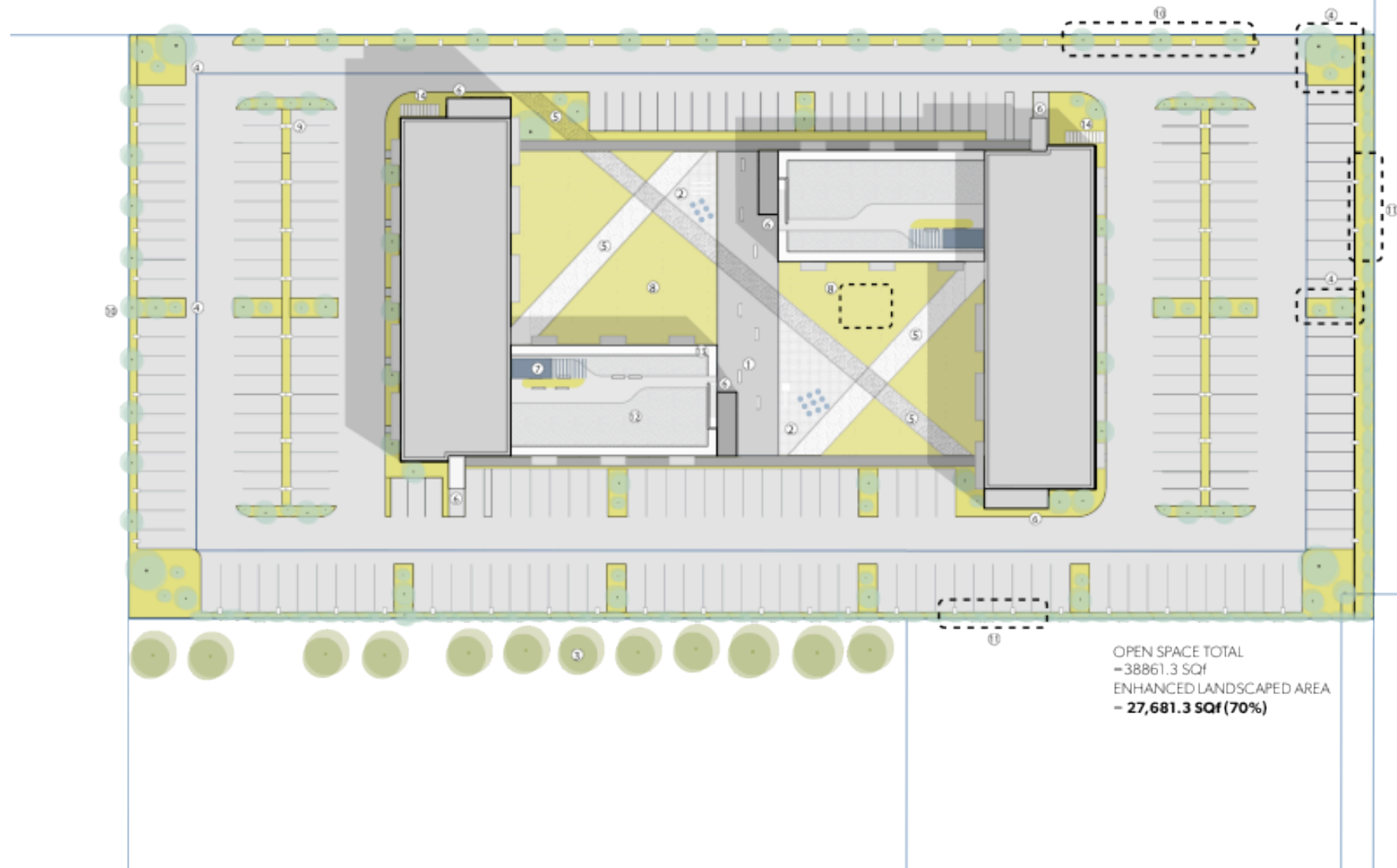


6 (RES)

**HILLCREST**  
FORT ST JOHN BC

**MGA** | MICHAEL GREEN ARCHITECTURE  
VANCOUVER | NEW YORK





HILLCREST VILLAGE 2012-030

**MGA**

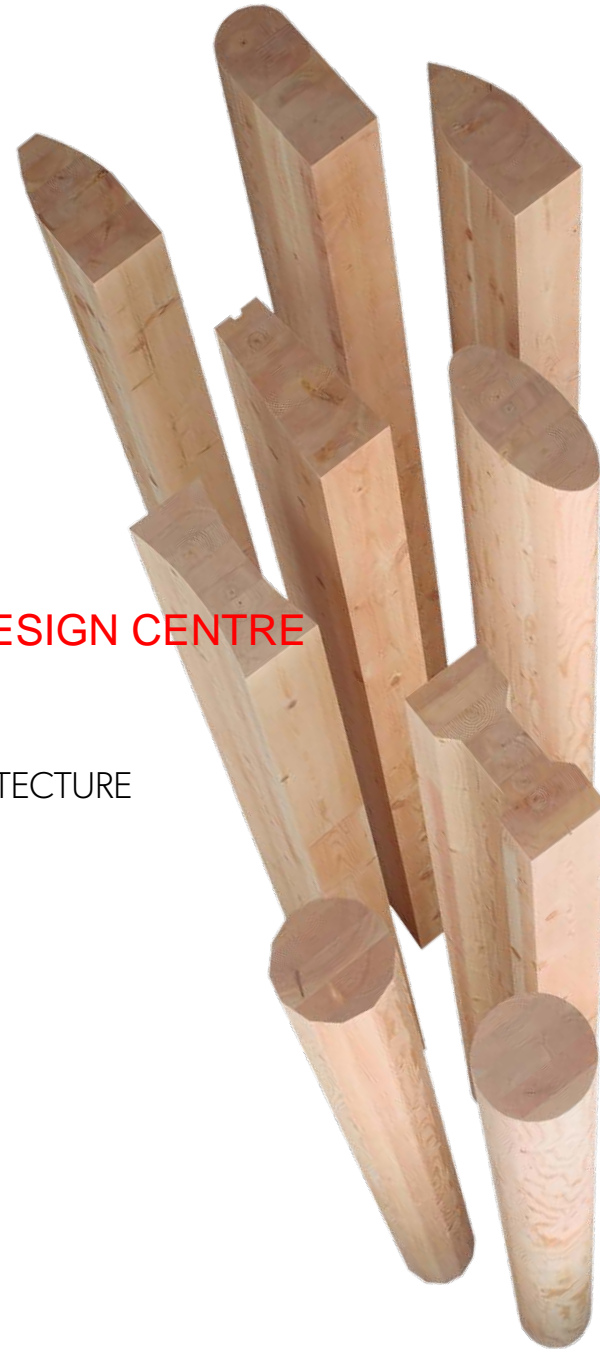




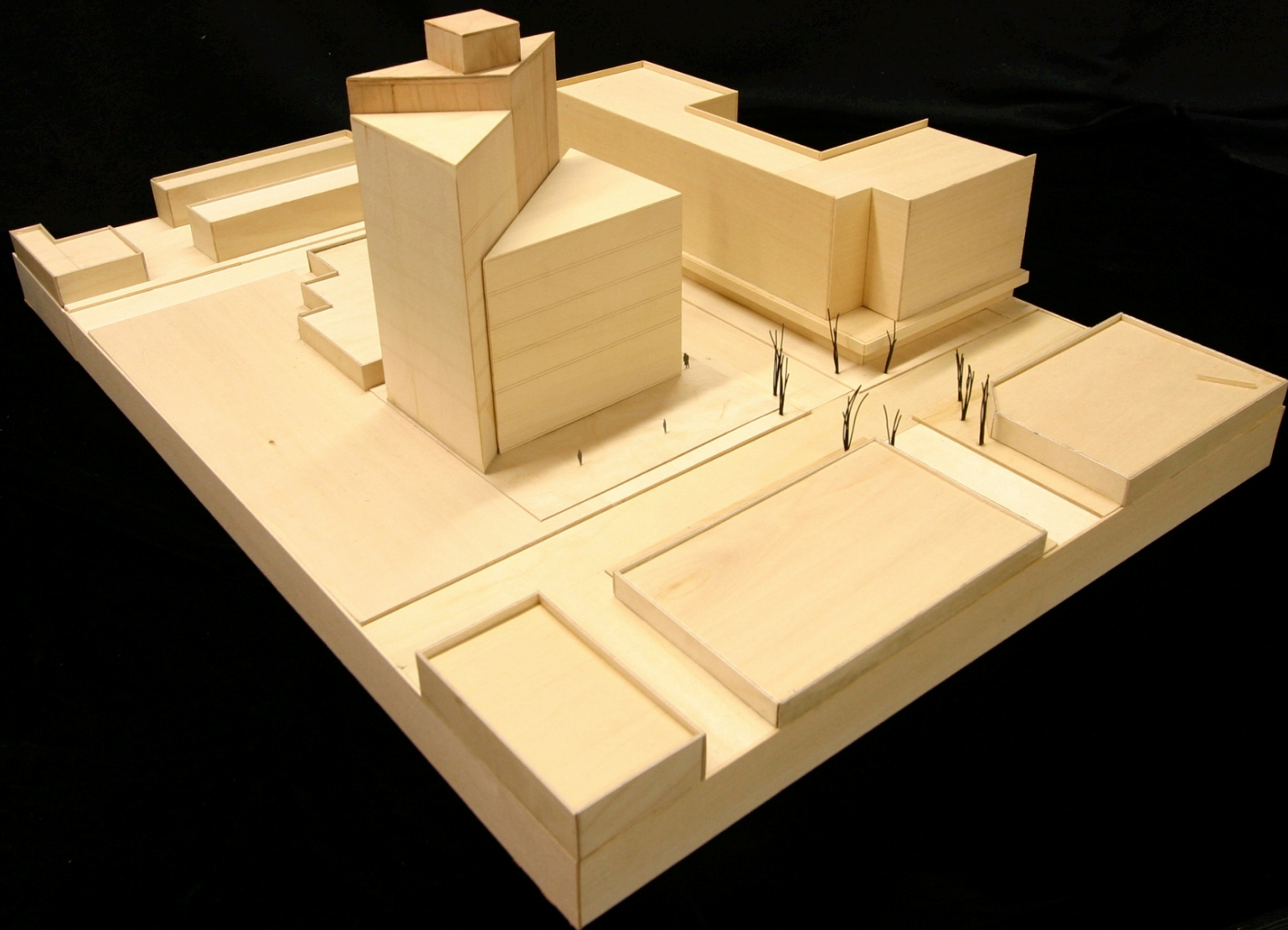
6 (NON RES)

WOOD INNOVATION + DESIGN CENTRE  
PRINCE GEORGE BC

MGA | MICHAEL GREEN ARCHITECTURE  
VANCOUVER | NEW YORK







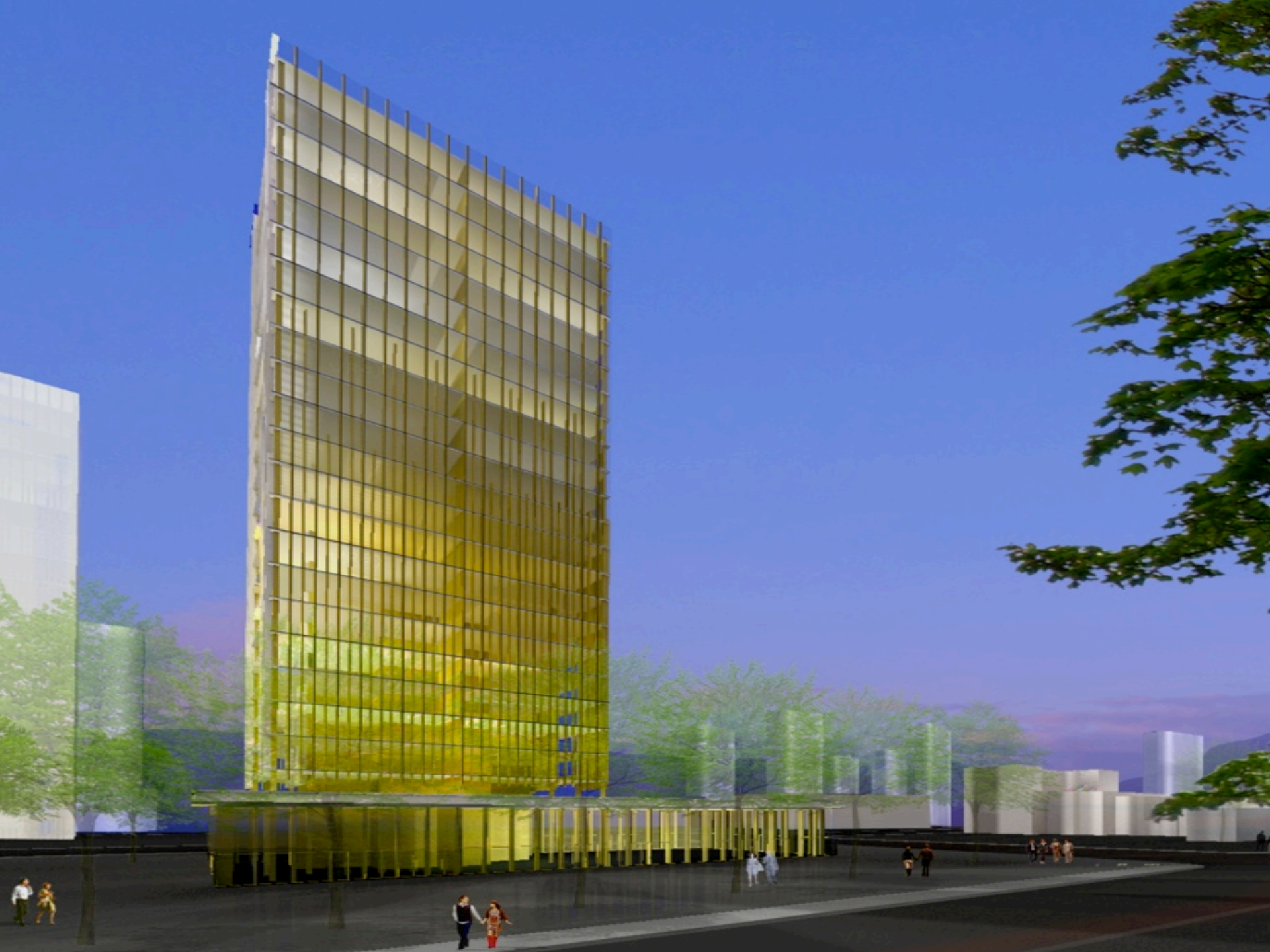
20+ (STUDENT HOUSING)

**WORLD'S TALLEST**  
VANCOUVER BC

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VANCOUVER | NEW YORK







# CLT: Engineering Concepts

**David Moses, Principal**

PhD, PEng, PE, LEED® AP

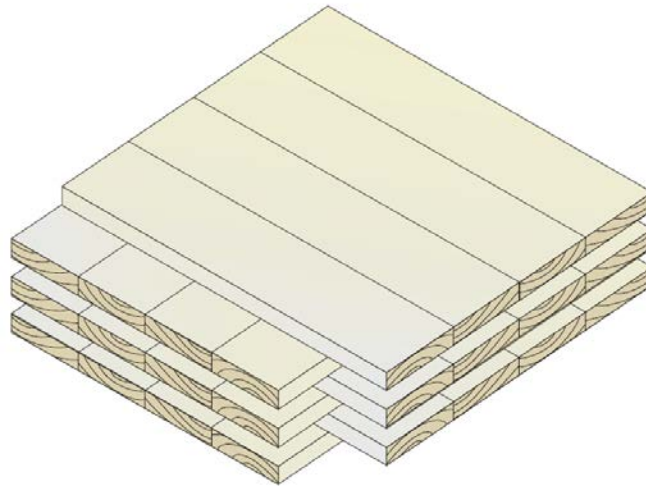
Moses Structural Engineers Inc.



# Cross-laminated Timber (CLT)

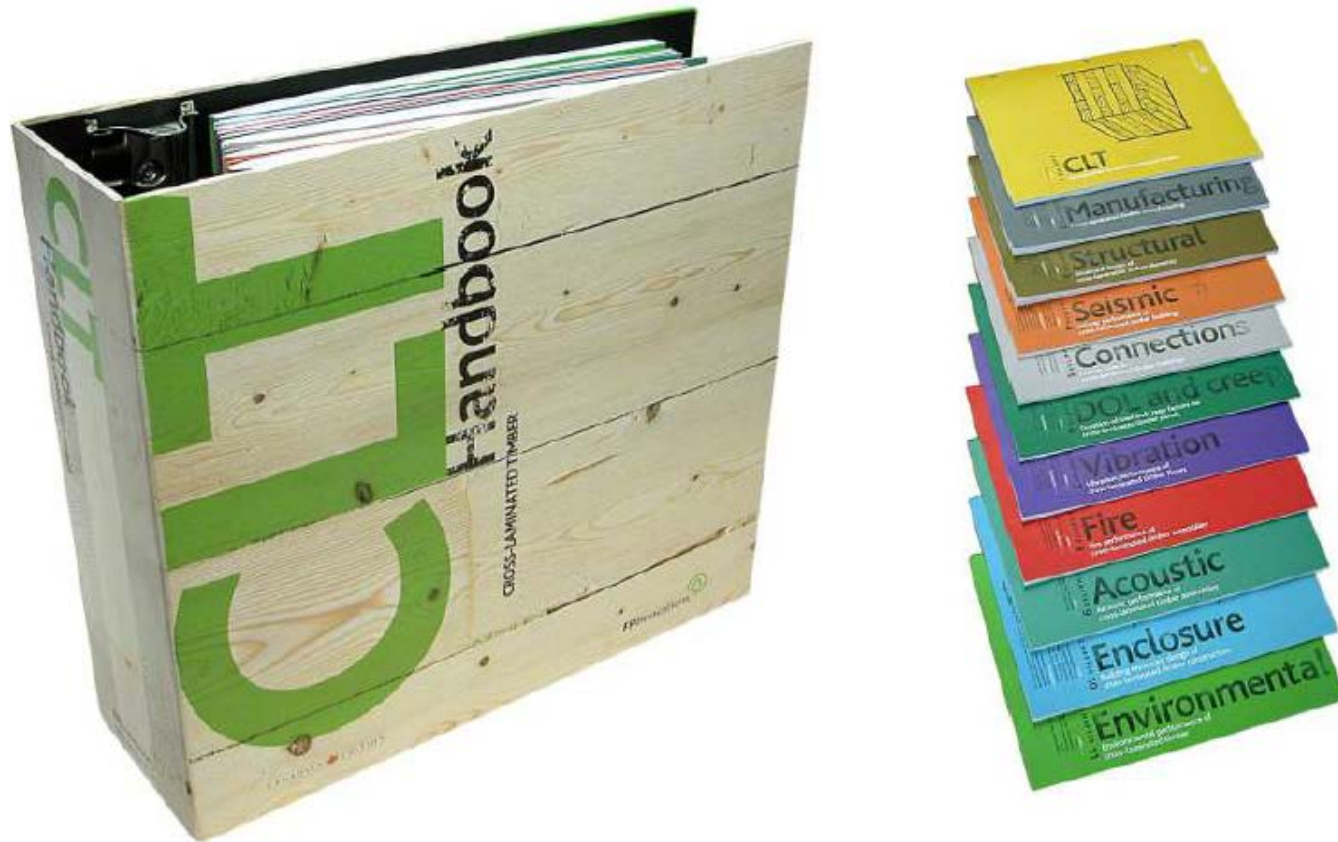
Introductory Article (pdf) at:

[www.mosesstructures.com](http://www.mosesstructures.com)



Source: FPInnovations

# CLT Handbook



[www.FPInnovations.ca](http://www.FPInnovations.ca)

# APA Standard PRG-320

- Standard for Performance-rated Cross-laminated timber
- Released in 2011
- Deals with tolerance, wood and adhesives, layups, manufacturing, quality assurance

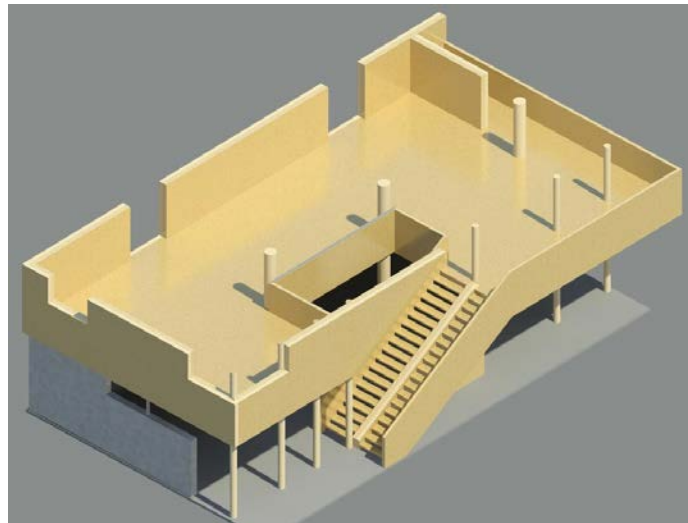
# Canadian Codes and Standards

Not yet



# Things to consider when designing

- Available panel sizes, layups, thicknesses
- Looks for opportunities to maximize panel size (2-span, 3-span)



Moses Structural Engineers, R&D

# Things to consider when designing

- Available panel sizes, layups, thicknesses
- Looks for opportunities to maximize panel size (2-span, 3-span)
- Mix systems: concrete, steel, masonry, wood, glulam

# Design

- Roofs: Deflections tend to control design
- Floors: Vibration and deflections tend to control
- Walls: full CLT, glulam posts, CLT infill

# Connections

- Beam pockets on CLT walls
- Screws: different manufacturers (see trade show)
- Configurations: CLT Handbook examples





# Rules of Thumb

Courtesy: Equilibrium Consulting Inc., Vancouver  
CLT Symposium 2011

- CLT design has the 'feel' of concrete
- Floor span-to-depth ratios 20-30
- Roof span-to-depth ratios 30-40
- Deflection and vibration control design(not strength)
- Engineers must consider creep and rolling shear
- Effective stiffness increases for longer spans

# CLT: Installation Concepts

**Michael Krans**

Timmerman Timberworks

[www.timmermantimberworks.com](http://www.timmermantimberworks.com)

# From Paper to Panel

## **A Brief Summary of the CLT Installation Process**

- Introduction
- The Shop Drawing process
- The Site Survey process
- Notes on Logistics



# Shop Drawing Process

- Receipt of IFCs
- Decision: preliminary layout submittal vs. submittal of full, sealed shop drawings
- Factors: complexity of project and detail of IFC set
- Pros & Cons: preliminary layout submittal reduces re-engineering time, covers off issues of liability/responsibility, but consumes time and resources
- Shop drawings vs. individual panel drawings—the manufacturing difference

# The Shop Drawing Process

- The proliferation of BIM/3 dimensional modeling software—and its effect on pre-fabrication
- Revit, AutoCAD, Solidworks, CADworks
- Interchange of models via FTPs, dropboxes etc
- A “Brave New World” in every sense of the phrase

# The Site Survey Process

- The reality interface—wood meets world
- Survey as state-of-the-art ***and*** seat of the pants
- State-of-the art: robotic Total Station c/w Bluetooth technology
- Next: 3 dimensional scanning systems (Faro etc)?
- Seat of the pants—get up there and measure . . .
- Last but not least, the survey as survey
- Putting the survey to paper—incorporating results, soliciting approvals



# Notes on Logistics

- Typical sizes—and weights
- Measure twice cut once
- Movement is money
- Movement means damage
- Integration of Logistics Chain from glue up, to fabrication, to delivery, to installation
- Implementation of tools, tricks, and strategies to make it look easy

# CLT: Supply Concepts

**Patrick Chouinard**  
Structurlam Products Ltd.  
[www.structurlam.com](http://www.structurlam.com)

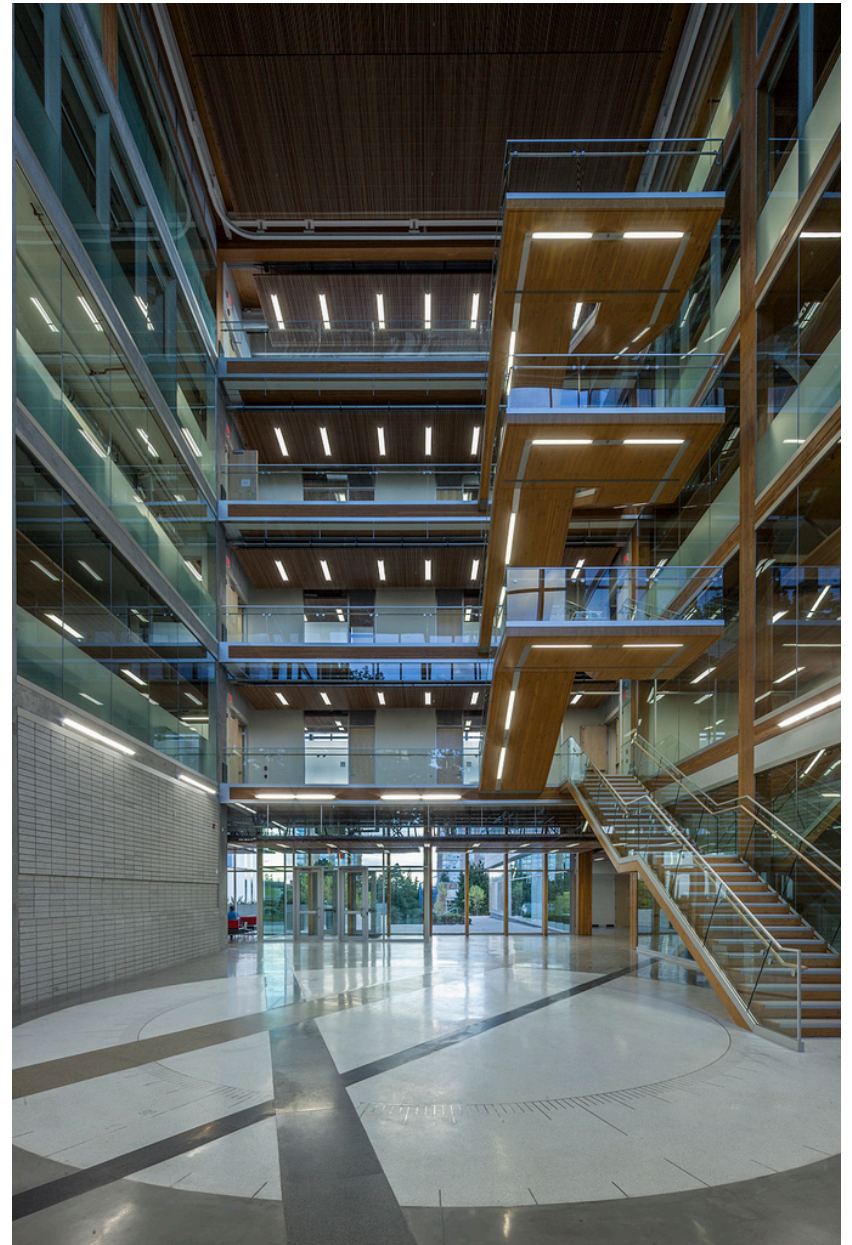


**UBC Earth Science Building**



**UBC Earth Science Building Canopy**





**UBC Earth Science Building**





**Elkford Community Centre**





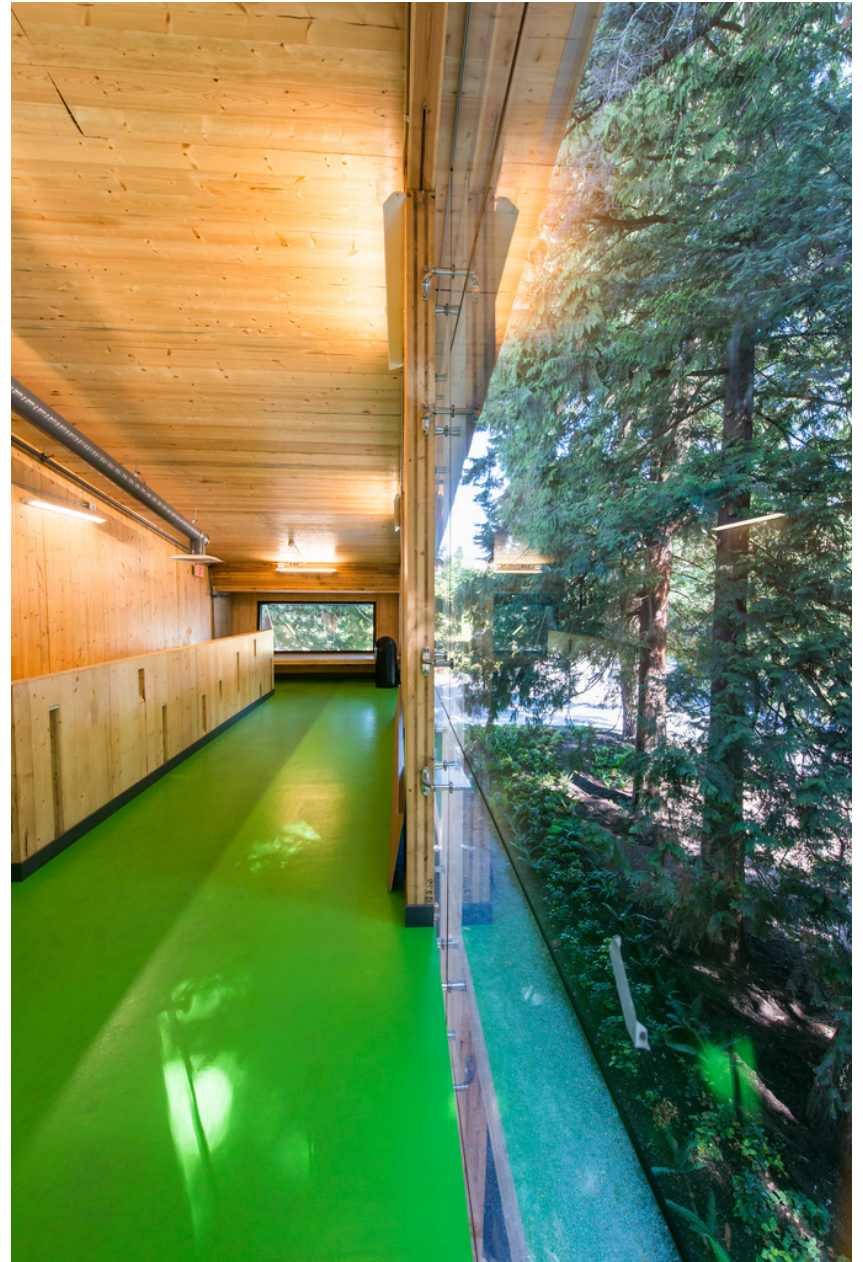
**Elkford Community Centre**





**UBC Bioenergy Research & Demonstration Facility**





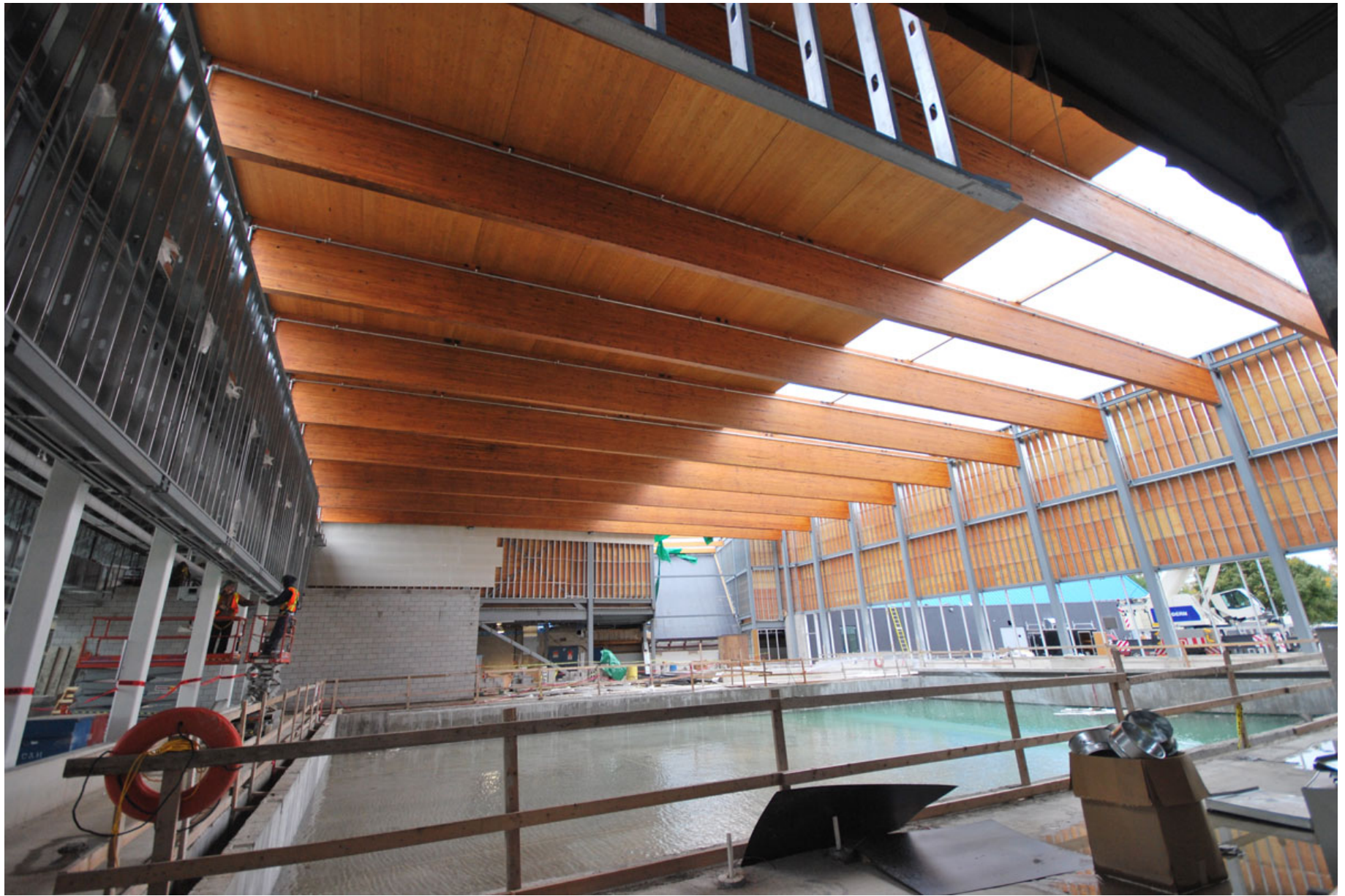
**UBC Bioenergy Research & Demonstration Facility**





**Wayne Gretzky Sports Centre**





**Wayne Gretzky Sports Centre**

# CrossLam (CLT) Basics

- 2 x 6 SPF (Standard)
- Two types: Visual and Non-Visual
- Max sizes: 8' x 40' (V) 10' x 40' (NV)
- Available in 3,5,7,9 laminate layers
- Thicknesses from 99 – 309 mm (3.9" – 12.17")
- CLT ANSI/APA PRG 320 Compliant
- Optional D. Fir Visual layer

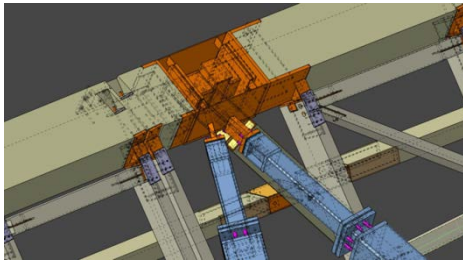
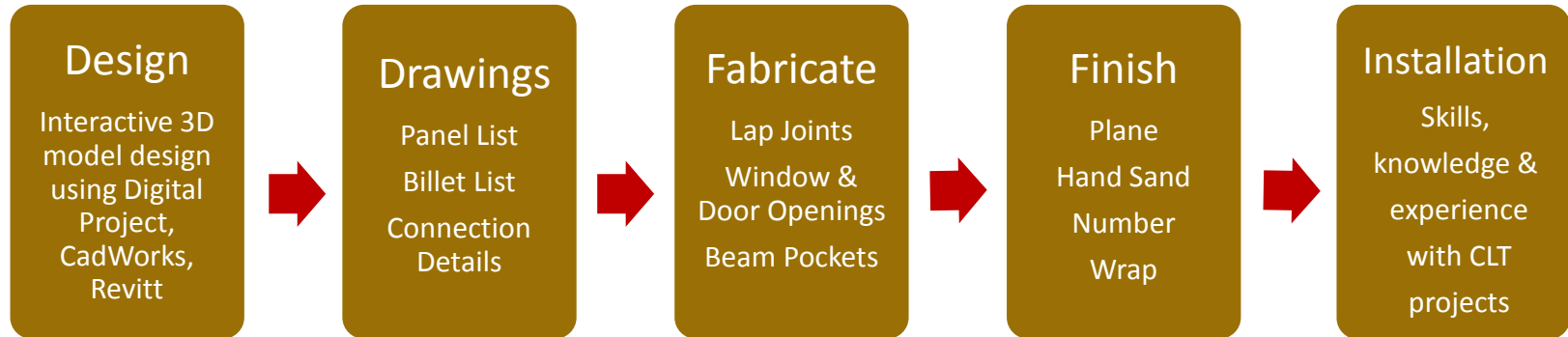






**Douglas Fir Visual Layer**

# The process for acquiring CrossLam







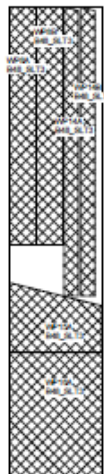
B48\_SLT3  
BILLET: 320.00  
PANELS: 277.25



B47\_SLT3  
BILLET: 320.00  
PANELS: 231.72



B48\_SLT3  
BILLET: 320.00  
PANELS: 274.15



B49\_SLT3  
BILLET: 320.00  
PANELS: 295.52



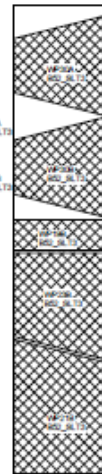
B50\_SLT3  
BILLET: 320.00  
PANELS: 248.13



B51\_SLT3  
BILLET: 320.00  
PANELS: 180.57



B52\_SLT3  
BILLET: 320.00  
PANELS: 272.00



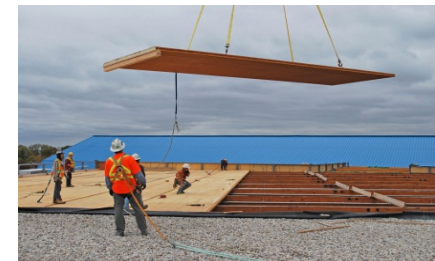
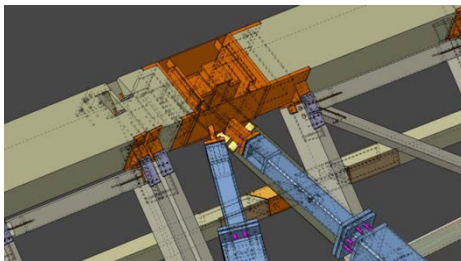
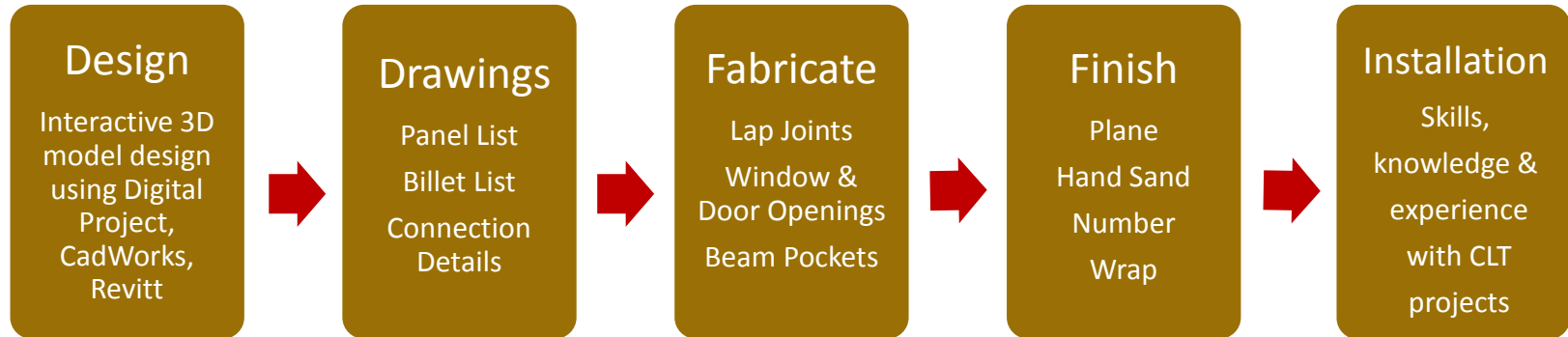
B53\_SLT3  
BILLET: 320.00  
PANELS: 181.05



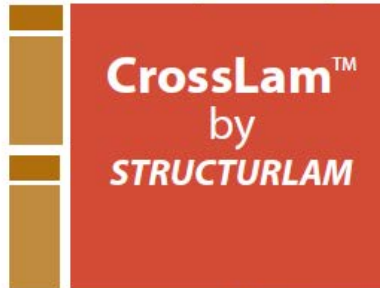
BILLET AREA: 2560.00  
PANEL AREA: 1961.82  
WASTE: 23.37%

Panel and Billet Drawings - Courtesy of Timmerman Timberworks

# The process for acquiring CrossLam







## Cross Laminated Timber Design Guide

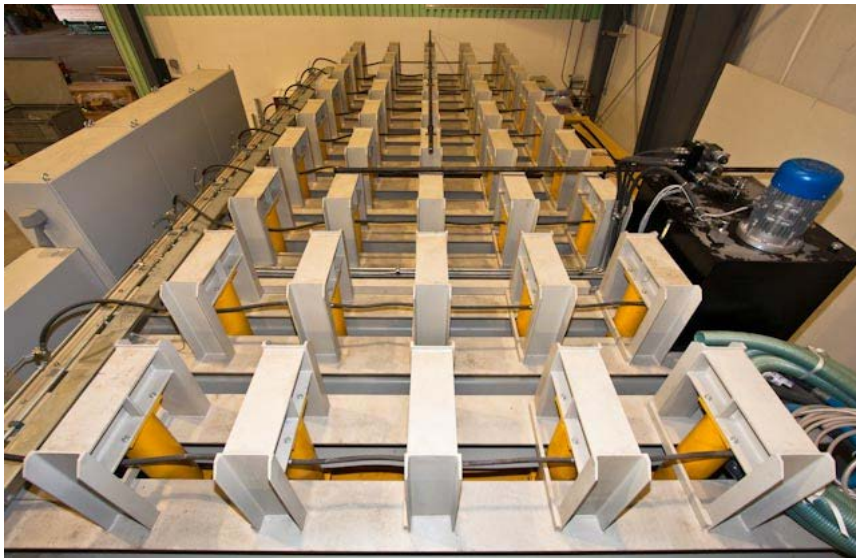
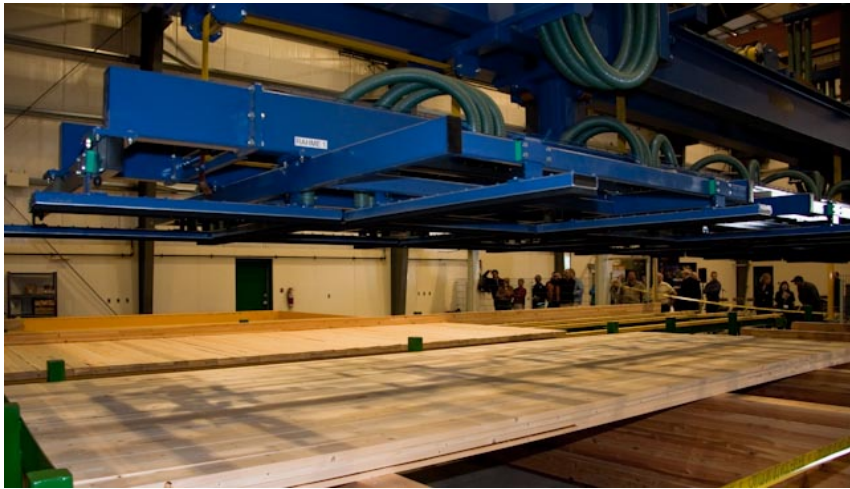


## Cross Laminated Timber Design Guide

**Structurlam Products Ltd Budget Pricing for CrossLam (Cross Laminated Timber Panels) CDN\$**

			1	2	3			
Panel	# of	Panel	Blank Panel	Hand Framing (Floor/Roof)	5 Axis Robotic Framing (Walls)	Fastener, Hardware, Shop Drawings		Visual Grade
Type	Laminations	Thickness	\$/Sq. Ft	\$/Sq. Ft	\$/Sq. Ft	Floor/Roof \$/Sq. Ft.	Walls \$/Sq. Ft.	\$/Sq. Ft
SLT3	3	99mm	5.80	6.05	7.02	2.50	3.00	1.00
SLT5	5	169mm	9.68	9.93	11.21	2.50	3.00	1.00
SLT7	7	239mm	13.77	14.02	15.93	3.00	3.50	1.00
SLT9	9	309mm	17.53	17.97	19.90	3.00	3.50	1.00

**Note:** it's columns 1 or 2 or 3... not 1 + 2 or 1 + 3 or 1 + 2 + 3





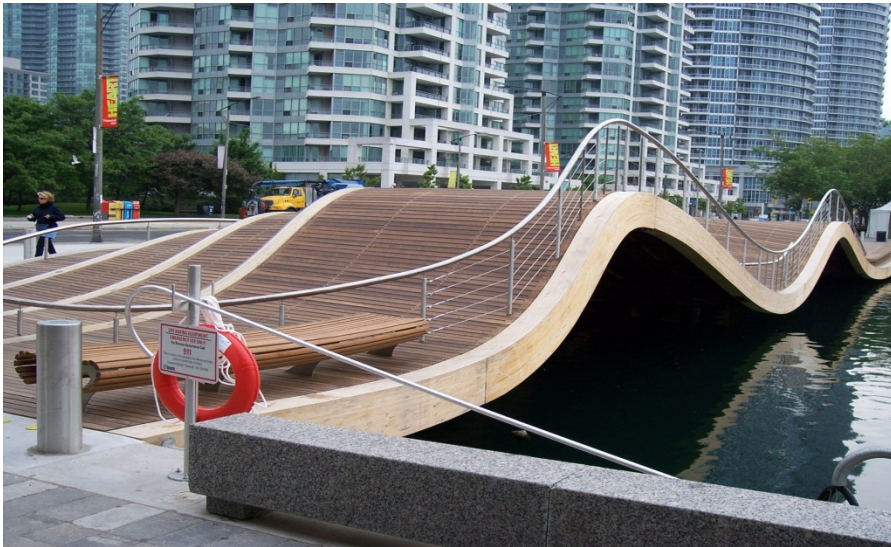


**13,000 sq. ft. South Plant CLT Extension**





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# Questions/ Comments?

This concludes the:

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*American Institute of Architects*  
*Ontario Association of Architects*

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Continuing Education Systems Program

How to Develop a CLT Project

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# Full-scale Fire Test Results

## Walls

- 3-plys (114 mm) protected + 2 x ½" Drywall : **106 min**
- 5-plys (105 mm) unprotected : **57 min**
- 5-plys (175 mm) unprotected : **113 min**

## Floors

- 3-plys (114 mm) protected + 2 x ½" Drywall : **>77 min\***
- 3-plys (105 mm) + ⅝" Drywall : **86 min**
- 5-plys (175 mm) unprotected : **96 min**
- 5-plys (175 mm) + ⅝" Drywall : **124 min (≈ 2 hrs !!!)**
- 7-plys (245 mm) unprotected : **178 min (≈ 3 hrs !!!)**

\* Test has been stopped due to safety concerns. Failure has not been reached.