Timber Office Buildings: Everything Old is New Again
Brock Commons
Vancouver, completed 2017
Acton Ostry
Fast+Epp

18 storeys (17 wood +1 concrete); 54 metres; 162,700 sqft.

Time for Canadian & U.S. Forests to grow the timber used: 6 minutes

Time to erect 17 floors: less than 70 days with a crew of 9 or 10

1,753 tonnes of CO₂ sequestered

Tallest modern timber tower until…
Mjøsa Tower
Brumunddal, Norway
18 storeys/85.4m
11,300 m² (121,570sqft.)
Offices, hotel and apartments
Wood as a resource

- Canada's forest cover (nearly ~350M hectares) represents about 10% of the global forest.
- Comprised of softwood, hardwood and mixed forests.
- In 2014, ~720,000 hectares were harvested (<0.2% of total).
- To compare, ~20.3M hectares were damaged by insects (2014), ~3.9M hectares burned in forest fires (2015).
- Forestry contributed ~$22.1B to GDP in 2015 and accounts for over 200,000 jobs.
- 7% of Canadian exports are from the forest industry.
- 94% of Canada's forests are Crown land; only 6% is privately owned.
Why wood?

- Grown by the sun
- Light weight relative to its strength
- Low carbon footprint
  - On a recent study for a 15 storey office building we estimate 3250 tonnes of CO$_2$ saved in switching from the steel to wood, roughly the annual output of 200 average Canadians
- Prefabricated – accelerated construction
- Aesthetically pleasing – exposed to view
Biophilia

- exposed wood has positive health and well-being benefits on occupants
  - Studies: D. Fell (UBC); Rice et al. (FPInnovation); Kelz et al. (Austria); Sakuragawa et al. (Japan)

In offices:
- Higher rental rates
- Faster to rent
- High profile tenants (i.e. knowledge economy)
- More likely to stay rented during economic downturns

In hospitals (Credit Valley Hospital Atrium):
- Notable reduction in cancer centre staff sick days

In barns:
- Cows produce more milk in barns with exposed wood
Mass Timber

Glulam (Glue Laminated Timber)
NLT (Nail Laminated Timber)
DLT (Dowel Laminated Timber)
CLT (Cross Laminated Timber)
LVL (Laminated Veneer Lumber)
LSL (Laminated Strand Lumber)
Plywood
Glulam
NLT (Nail Laminated Timber)
DLT (Dowel Laminated Timber)
CLT (Cross Laminated Timber)
LVL (Laminated Veneer Lumber)
LSL (Laminated Strand Lumber)
Plywood

Mass plywood: up to 300mm thick; 3.6m x 14.5m
Special design considerations for mass timber buildings

- Fire
- Water
- Dimensional stability
- Connections
• Rule #1: Wood burns; get over it

• Wood has an inherent fire rating and predictable char rate

• Research has shown sprinklers/alarm make a difference in fire outcomes, not type of construction

Photo: Forest Products Laboratory
• M-Building, Kanazawa City, Japan
  • Composite steel-timber structural system
  • Timber contributes to structure and protects steel

Fig. 3 Cross sections of column, beam, and brace

Images: Koshihara et al.
Water

Rule #2: Wood rots – keep it dry.
Other materials are not immune
Shrinkage
Wood Connections
### MEZZANINE LEVEL: SCHEDULE OF BEAMS AND BEAM DESIGN REACTIONS

<table>
<thead>
<tr>
<th>BEAM MARK</th>
<th>BEAM SECTION (w x d)</th>
<th>GRADE</th>
<th>REACTIONS</th>
<th>REMARKS</th>
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Wood Connections
Precedents

- Horyuji – Nara Japan, 700 AD, 37m
- 312 Adelaide West, Toronto – 1895, 8 Levels Post and Beam
St. Jacobs Farmers’ Market
(Architecture Incorporated)
Shoppers Drug Mart, Yonge St.
(Brook McIlroy)
Brock Commons, UBC (Acton Ostry)
18 Storeys, 2016
Terrace House (Shigeru Ban)
MEC Headquarters
(Proscenium Architecture)
UMass Design Building
(Leers Weinzapfel Associates)
Wood Innovations Centre – Prince George (MGA)
7 Levels, 2014
T3 Minneapolis (MGA)
7 stories
Residential

Minimising floor-to-floor height and assembly thickness is desirable

- Smaller rooms /demising walls result in smaller spans and can result in modest structural depth
- Frequently fire rating is achieved through gypsum in residential applications
Minimising floor assembly thickness is desirable

Mechanical requirements are more significant – adds to depth of assembly

Long spans are preferred – 9m± is gold standard for office space

Exposed timber is preferred

• Beam depth increases with span
• Fire-rating may drive up timber sizes in order to expose structure
Systems for long spans
Composite vs. Non-composite

- Less Timber
- Shear Transfer (Cost & Complication)
- Heavier

- More Timber
- Floating Topping (if used)
- Lighter Weight (if no topping)
- Faster
SFS Holz-Beton-Verbundsystem
**Figure 9.3**
Details of wood-concrete interface
(See Clause 9.22.4.)

**Figure 9.4**
Alternative details of wood-concrete interface
(See Clauses 9.22.3.3 and 9.22.4.)
Hybrid assembly

Photo: PEIKKO
Prototype office comparison

- Generic office scheme
  - 5 storeys (top floor at 18m meets current code for combustible construction)
  - Baseline: hollowcore supported by steel frame
  - Comparison case: 2x8NLT, glulam beams and columns
  - 1 hour fire rating
Prototype office comparison

Results:

• Costs normalized to ~85,000sqft timber option

• Mostly “apple to apple” comparison
  • Did not consider schedule impact
  • Did not consider mechanical impact (exposed vs. concealed ducts)
  • Included ceiling and fireproofing for precast/steel option

• Timber option ~10% higher than precast-steel option
  • Only considered costs related to structure – not total construction costs
7 Storey office, Toronto

Image: Bogdan Newman Caranci Inc.
8.8m bays
Loading: 2.4kPa + partitions
2 hour fire rating
STC: approaching 50 based on slab alone; IIC to be addressed through finishes

— PEIKKO DELTABEAM
Alternative Solution Strategy

- Above 6 storeys but not a tall building
- 2 hour rating required for structure
- Provision of firefighter’s elevator and isolated elevator lobbies
- Pressurized exit stairs
- Total area, and area per compartment is lower than that allowed by code for 6-storey
- ~20% of soffit will be non-combustible; flame spread of combustible material ~1/3 of that allowed by code (49 for Black Spruce vs. 150)
- Emergency power provided for 1 hour instead of 30min.
- Sprinkler reliability will be increased – 2 standpipes
14 Storeys, 80m

- Foundations previously installed, structure complete for lower floors
- To achieve tower program, lightweight structure required
- Exterior braces required to distribute load evenly to foundations
- South, East and West face trusses required to support cantilever with open south programming

Entirely wood from Level 5, up
Academic Wood Tower

- Post and beam floor plans
- Simple connections throughout
- Columns 265x266 – 532x845
Academic Wood Tower

- Optimal design optimizes deck.
- Bay spacing designed to maximize slab span
  - 175 Glulam slab required for inherent 2 hr fire resistance
- Mid span columns required to maintain floor to floor heights
Academic Wood Tower

- Comparison with steel sizes
  - Typical beam depth:
    - Timber - 570
    - Steel - 460
    \[ \Delta = 110 \]
  - Typical structural floor assembly
    - Timber - 795
    - Steel - 560
    \[ \Delta = 235 \]
Lateral System

- Wind controls design
- Seismic to be addressed through time-history analysis - strategy to reduce the need for ductility in compression/bearing connections
Code compliance

- Current Canadian building codes only recognize up to 6 storeys (Quebec has special provisions for up to 12 storeys)
- Encapsulation is effective in pursuing alternative solution submission to meet objectives of code
  - 2020 NBCC will have provisions for 12-storey mass timber
- But if exposed timber is preferred, need to pursue alternate means
  - Enhanced sprinkler reliability/redundancy
  - Fire-fighting lobby/non-combustible core
  - Comparison with combustible material allowances in current non-combustible building code provisions
- FRR: NBCC vs. O86-14 Annex B
Design Resources

Technical Guide for the Design and Construction of Tall Wood Buildings in Canada

Ontario’s Tall Wood Building Reference

CLT Handbook

Nail Laminated Timber Design Guide

National Lumber
Tallest multi-storey wood building in the world:
Fogong Temple Pagoda
circa 1056
67.3m