Timber Skyline

The Rise of Tall Wood Buildings

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Course Description

In North America, the idea of high-rise wood construction using mass(ive) timber systems is getting a lot of attention. This presentation will provide examples of eight, nine and 10-story timber buildings recently completed in Sweden, Germany, Italy, Austria, the UK and Australia. It will also examine several concepts for timber hybrid buildings up to 40 stories, discussing both the architectural layouts and structural systems proposed. An introduction to the mass timber products and systems that are making these advances possible will also be provided.
Learning Objectives

- Review high-rise timber project examples from around the world.

- Evaluate the mass timber products and systems used in tall timber structures, including their availability and code applicability.

- Discuss the resources available for designing taller timber buildings.

- Introduce building layouts and structural systems proposed for high-rise wood and hybrid buildings up to 40 stories.

What do these Projects have in common?

![Building Images]
What do these Projects have in common?

1) They all use wood as the primary framing material
2) They all have been built

Stadhaus, London

Waugh Thistleton Architects
9 Story
97 Ft Tall Residential
Completed 2009

Photo credit: Waugh Thistleton Architects
Stadthaus–Tallest Modern Mixed Use Timber Structure

- London infill project
- 29 flats (mixed affordable and private)
- Ground floor office
- 4x less weight than precast concrete
- ~1/2 the construction time of precast concrete
- Saves 300 metric tons of CO₂
- 21 years of energy usage for the building
- 9 stories built in 9 weeks

Stadhaus, London, UK
Architect: Waugh Thistleton Architects
Photo credit: Waugh Thistleton Architects
Reduced Embodied Carbon

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume of wood used</td>
<td>950 m$^3$</td>
</tr>
<tr>
<td>Carbon sequestered and stored (CO$_2$e)</td>
<td>760 metric tons</td>
</tr>
<tr>
<td>Avoided greenhouse gases (CO$_2$e)</td>
<td>320 metric tons</td>
</tr>
<tr>
<td>Total potential carbon benefit (CO$_2$e)</td>
<td>1,080 metric tons</td>
</tr>
</tbody>
</table>

Carbon savings from the choice of wood in this one building are equivalent to:

- 1,615 passenger vehicles off the road for a year
- Enough energy to operate a home for 803 years

Stadhaus, London, UK
Architect: Waugh Thistleton Architects
Photo credit: Waugh Thistleton Architects

Bridport House, London

Karakusevic Architects
Peter Brett Associates
44 Unit Residential
8 stories
87 ft
Completed 2010
Forté, Melbourne, Australia

Forté
Melbourne, Australia
10 stories
105.5 ft
Developer: Lend Lease
Completed 2012

Via Cenni, Milan

4 residential buildings
9 story 92 ft tall
140k sq ft
Architect: Carron Group, Service Lengo
Completed 2013
Via Cenni

**Limnolgen, Vaxjo, Sweden**

4 residential buildings, 134 units
8 story
78 ft tall
> 115k sq ft
Completed 2008

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**H8, Bad Aibling, Germany**

Architect Arthur Schankula
13 unit residential/office
8 stories
82 ft tall
Completed 2011
Library Square, British Columbia

WIDC, Prince George, BC
Bullitt Center, Seattle, WA

250 YEAR STRUCTURE
HEAVY TIMBER, CONCRETE & STEEL

Architect: Miller Hull Partnership
6 Stories, 4 Heavy Timber
Living Building Challenge Building
Completed 2013

Photo Credit: Miller Hull Partnership

Mareslle, Seattle, WA

Mareslle
Seattle, WA
5 1/2 over 2 above grade
Architect: PB Architects
Photo: Matt Todd
Mareslle, Seattle, WA

Q: What is max number of stories can you build with wood in IBC?
A: 6 for offices, 5 for residential*

* Using prescriptive heights & areas limits. Possibly taller using alternative means of fire safety

Marselle
Seattle, WA
5 1/2 over 2 above grade
Architect: PB Architects
Photo: Matt Todd
Butler Brothers Building, Minneapolis MN

Built 1906  500,000 s.f.

Butler Square today...

St. Louis, MO
Architect: Harry W. Jones
Renovated 1974
9 Stories, 500,000 sf
What about even taller?

Life Cycle Tower System

Life Cycle Tower by Cree Gmbh
Engineering: Arup
Architect: Herman Kaufmann

www.creebyrhomberg.com
LifeCycle Tower

Hybrid Panelized Floor System

LifeCycle Tower

Slab Design

Bearing Posts

Up to 30 Stories
**LifeCycle Tower**

![LifeCycle Tower image]

**LCT One**

**OFFICE BUILDING**

**LCT ONE**

Dornbirn, Austria

Height: 9 stories

FA: app. 17,000 ft²

Completed Sept 2012

88.5 ft tall

![LCT One image]
LCT One

STRUCTURE Magazine
September 2013
ARUP investigated design variations targeted at US code requirements
**FFTT System**

**Tall Wood**
The Case for Tall Wood Buildings (2012)
Engineer: Eric Karsh
Equilibrium
Architect: Michael Green
Michael Green Architecture
30 Stories in Vancouver

[link](mg-architecture.ca/portfolio/tallwood/)

**FFTT System**

Designed for Vancouver, BC
Up to 30 Stories

![Diagram of FFTT System](Image)
FFT System
Finding the Forest Through the Trees

Option 1 Structural Core

Mass Timber Walls
Glulam Columns
Mass Timber Floors

FFT System

Glulam Perimeter Beams
Steel Interior Beams
CLT Floor Panels
FFTT System

Balloon Framed
Offsite Components
Tilt-Up
Construction Sequence

Strong-Column Weak-Beam System

CLT Walls
Steel Beams
### FFTT System

Proposed Tower Solutions: 3.4

Structural Section 3.6

Structural concept plans have been included for each option below, and the associated architectural floor plans, elevations and exploded 3D models can be found in the architectural report.

While we originally anticipated that both interior shear walls and perimeter frames would be required to achieve sufficient stiffness for the 30-storey case (Option 4), this did not prove necessary, as the layouts for Options 1 and 2 met the strength and serviceability criteria for 30 stories.

### SOM Timber Tower

Timber Tower Research Project

Skidmore, Owings, & Merrill LLP
May 2013

[www.som.com/publication/timber-tower-research-project](http://www.som.com/publication/timber-tower-research-project)
**SOM Timber Tower**

**Benchmark Building**

Dewitt-Chestnut Apartments:
- Designed by SOM
- Chicago, IL
- Completed in 1966
- 42 Stories
- 395 ft tall + parapets
- Concrete frame building

*Source: SOM Timber Tower Research Project, May 2013*

**SOM Timber Tower**

**Prototype Building**

SOM Timber Tower
- Redesign of same building
- CLT and Glu-Lam framing and walls

*Source: SOM Timber Tower Research Project, May 2013*
SOM Timber Tower

Typical Floor Structure

Steel Bearing Plates
Glulam Column
R.C. Beam

Steel Erection Element
Exterior Column at Spandrel Beam
SOM Timber Tower

Concrete Jointed Timber Frame

<table>
<thead>
<tr>
<th>Material</th>
<th>Benchmark Concrete Building</th>
<th>Prototype Timber Tower</th>
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</thead>
<tbody>
<tr>
<td>Structure</td>
<td>-</td>
<td>0.80 cu ft/sf</td>
</tr>
<tr>
<td>Wood</td>
<td>0.98 cu ft/sf</td>
<td>0.25 cu ft/sf</td>
</tr>
<tr>
<td>Concrete</td>
<td>0.98 cu ft/sf</td>
<td>1.05 cu ft/sf</td>
</tr>
<tr>
<td>Wood + Conc</td>
<td>0.98 cu ft/sf</td>
<td>1.05 cu ft/sf</td>
</tr>
<tr>
<td>Reinforcement</td>
<td>5.9 psf</td>
<td>1.7 psf</td>
</tr>
<tr>
<td>Structural steel</td>
<td>-</td>
<td>0.3 psf</td>
</tr>
<tr>
<td>Foundations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete</td>
<td>0.14 cu ft/sf</td>
<td>0.09 cu ft/sf</td>
</tr>
<tr>
<td>Reinforcement</td>
<td>0.1 psf</td>
<td>0.1 psf</td>
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<tr>
<td>Dead Weight</td>
<td>18 lb/ft³</td>
<td>7 lb/ft³</td>
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</table>

Bill of Materials
**SOM Timber Tower**

Embodied Carbon

![Embodied Carbon Graphs](chart)

Standard Materials: 100% Construction, 41% Total

Sustainable Materials: 77% Construction, 20% Total

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**40 Storey Office Building of the Future**

CEI Architecture
RJC Consulting Engineers
2012

[www.ceiarchitecture.com/project/naiop-design-competition-2012/](http://www.ceiarchitecture.com/project/naiop-design-competition-2012/)
Flexible Office Shell and Core

150 ft x 90 ft open floor plan

Hybrid Floor and Framing

Hybrid Concrete over Wood Floor

Perimeter Wood Trusses

Concrete Core and Columns
Unique Floor Framing

Courtesy CEI Architecture
Modular Design, Sky Gardens

Courtesy CEI Architecture

Additional Information

- Cree by Rhomberg & ARUP, Life Cycle Tower
  - www.creebyrhomberg.com
  - www.arup.com/Projects/Life_Cycle_Tower.aspx
- Michael Green & Eric Karsh at Equilibrium, FFTT Tall Wood
  - www.mg-architecture.ca
  - www.eqcanada.com
- Benton Johnson at SOM for Timber Tower
  - www.som.com/publication/timber-tower-research-project
- Nick Bevanda at CEI Architecture for the 40 Storey Office Tower
  - www.ceiarchitecture.com/project/naiop-design-competition-2012
Observations

- Timber High-Rises look feasible!
- Prototype timber designs not 100% wood.
- Mass timber products a key enabler

Additional Tall Wood Resources

http://www.fpinnovations.ca/

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

90% DRAFT
“Mass”ive Timber

Cross Laminated Timber (CLT)

Photos by FPInnovations
Structural Flexibility

75% Lighter Weight Than Concrete
Reduced Construction Time

**Stadhaus, London UK**
- 8 stories of CLT over 1 story concrete podium
- 9 stories built in 9 weeks (~1/2 the time of precast concrete)

**Norwich Academy, Norwich UK**
- 102,300 ft² 3 story secondary school
- 27 weeks to construct

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CLT has an ANSI/APA Product Standard
APA Product Standard

APA/ANSI PRG 320
- 7 stress classes
- Quality assurance testing
- Identification marking

<table>
<thead>
<tr>
<th>CLT Thickness (in)</th>
<th>1/2</th>
<th>3/8</th>
<th>1/4</th>
<th>5/32</th>
<th>1/8</th>
<th>3/16</th>
<th>1/16</th>
<th>1/32</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laminaion Thiccnes (in)</td>
<td>1/2</td>
<td>3/8</td>
<td>1/4</td>
<td>5/32</td>
<td>1/8</td>
<td>3/16</td>
<td>1/16</td>
<td>1/32</td>
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<tr>
<td>E1</td>
<td>4,825</td>
<td>115</td>
<td>0.46</td>
<td>160</td>
<td>3.1</td>
<td></td>
<td></td>
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<tr>
<td>E2</td>
<td>5,255</td>
<td>162</td>
<td>0.53</td>
<td>165</td>
<td>3.6</td>
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</tbody>
</table>

Is CLT recognized by the building Code?

2015 IBC
CLT Product Accepted for IBC 2015

SECTION 202
DEFINITIONS

CROSS-LAMINATED TIMBER. A prefabricated engineered wood product consisting of at least three layers of solid-sawn lumber or structural composite lumber where the adjacent layers are cross-oriented and bonded with structural adhesive to form a solid wood element.

Add new text as follows:

2303.1.4 Structural glued cross-laminated timber. Cross-laminated timbers shall be manufactured and identified as required in ANSI/APA PRG 320-2011.

Add new standard to Chapter 35 as follows:

ANSI


Application – Construction Type IV

602.4 Type IV. Type IV construction (Heavy Timber, HT) is that type of construction in which the exterior walls are of noncombustible materials and the interior building elements are of solid or laminated wood without concealed spaces. The details of Type IV construction shall comply with the provisions of this section. Fire retardant treated wood framing complying with Section 2303.2 shall be permitted within exterior wall assemblies with a 2-hour rating or less. Exterior walls complying with Section 602.4.1 or 602.4.2 shall also be permitted. Minimum solid sawn nominal dimensions are required for structures built using Type IV construction (HT). For glued-laminated members the equivalent net finished width and depths corresponding to the minimum nominal width and depths of solid sawn lumber are required as specified in Table 602.4. Cross-laminated timber (CLT) dimension used in this section are actual dimensions.

602.4.1 Fire retardant treated wood framing complying with Section 2303.2 shall be permitted within exterior wall assemblies with a 2-hour rating or less.

602.4.2 Cross-laminated timber complying with Section 2303.1.4 shall be permitted within exterior wall assemblies with a 2-hour rating or less, provided the exterior surface of the cross-laminated timber is protected by (1) fire retardant treated wood sheathing complying with 2303.2 and not less than 15/32 inch thick, or (2) gypsum board not less than ½ inch thick, or (3) a noncombustible material.
How does CLT work?

www.masstimber.com

US CLT Handbook

1. Introduction
2. Manufacturing
3. Structural
4. Lateral
5. Connections
6. DOL and Creep
7. Vibration
8. Fire
9. Sound
10. Enclosure
11. Environmental
12. Lifting
North American CLT Production

Nordic Engineered Wood
Structurlam
Guardian Bridge
Smartlam

- Both located in Canada near the US border; one on the east coast and one on the west
- SMARTLAM is in Montana and producing CLT for oil rig mats and is not intended for building applications
- Guardian Bridge produces a CLT product for specific use in bridge decks and can not support US distribution for building applications

Code Approvals – Product Reports

Structured CrossLam
Structured Products LP

APA PRODUCT REPORT
PR-L314
Issued May 23, 2013

Nordic X-Lam
Nordic Engineered Wood

APA PRODUCT REPORT
PR-L306
Revised May 23, 2013
North American CLT Distribution

Storaenso
MetsaWood (formerly Finforest)
KLH
Binderholz

• Several European producers have the ability and are willing to source product to the US
• Access is restrained by US physical presence (i.e.. No sales force or good web presence)
• Transportation costs can effect competitive pricing
• For improved economic and sustainable performance, North American producers are recommended.

US CLT Distribution & Production

Innovative Timber Systems (ITS)
Crosslam Solutions

• Several US based companies are currently sourcing material from Europe and providing a coordination service
• Their intent is to eventually manufacture panels in the US
• There are others working on manufacture in the US
In Conclusion

- 8, 9, 10 Story wood buildings are being built around the world
- Taller building systems are being thought out
- Mass Timber and CLT are enabling products to help achieve these heights
- We have the know-how, let’s go make it happen.

What can be done?

The “Tree”
Bergen Norway
14 story, ~145 feet all wood
62 units.
Architect: Artec
Engineer: Swenco

You can buy a condo @ http://treesameie.no/
Questions?

This concludes The American Institute of Architects Continuing Education Systems Course

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