INTRO:
CLEVELAND

Kristina Miele, PE
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Disclaimer: This presentation was developed by a third party and is not funded by WoodWorks or the Softwood Lumber Board
Cleveland's First 9-Story Timber Tower
Where We Work

- Vancouver | Canada
- Edmonton | Canada
- Calgary | Canada
- Seattle | USA
- New York | USA
- Darmstadt | Germany
Who We Are

- Structural engineers
- Founded in 1985
- 85 global staff
- Work in all materials
- Mass Timber expertise
Design Team:
Key Features
Key Features

- Cantilevered Slab Edges
- Long Span Structure
- Heavy Live Load
- Steel Structure at Pool
- Repeatable Structure
- Steel Transfer Beams
- Below Grade / Parking
### ALLOWABLE BUILDING HEIGHT

**Table 504.3**

<table>
<thead>
<tr>
<th>OCCUPANCY CLASSIFICATION</th>
<th>TYPE I</th>
<th>TYPE II</th>
<th>TYPE III</th>
<th>TYPE IV</th>
<th>TYPE V</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>NS'</td>
<td>UL</td>
<td>166</td>
<td>56</td>
<td>65</td>
<td>55</td>
</tr>
<tr>
<td>S13D</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>S13R</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>S</td>
<td>UL</td>
<td>180</td>
<td>85</td>
<td>75</td>
<td>85</td>
</tr>
</tbody>
</table>

**Table 504.4**—continued

<table>
<thead>
<tr>
<th>OCCUPANCY CLASSIFICATION</th>
<th>TYPE I</th>
<th>TYPE II</th>
<th>TYPE III</th>
<th>TYPE IV</th>
<th>TYPE V</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>R-1'</td>
<td>NS'</td>
<td>UL</td>
<td>11</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>S13R</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>S</td>
<td>UL</td>
<td>12</td>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>R-2'</td>
<td>NS'</td>
<td>UL</td>
<td>11</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>S13R</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>S</td>
<td>UL</td>
<td>12</td>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>
AED

alternatively engineered design required

CLT not a recognized material

Accepted Based On:

• language adopted by
  ICC Ad Hoc Committee on Tall Wood Buildings for 2021 IBC
• Data from USDA tests
• Additional code compliance for fire protection
2021 IBC
Tall Wood Provisions

Breneman, S; Timmers, M; Richardson, D; Tall Wood Buildings in the 2021 IBC Up to 18 Stories of Mass Timber, 2019; Woodworks Wood Products Council
Image Courtesy atelierjones, LLC
What is the required fire rating (mins) or the building type?

How much timber can be exposed / how much must be covered?

What satisfies the coverage requirement?

To Note:

IBC tables that are most often referenced typically call out Allowable Building Height, # of Stories, and Allowable Area,
The new 2021 code also has some key information for engineers to be aware of when looking into type 4 construction.
602.4.2.2.2 Protected area. All interior faces of all mass timber elements shall be protected in accordance with Section 602.4.2.2.1, including the inside face of exterior mass timber walls and mass timber roofs.

Exceptions: Unprotected portions of mass timber ceilings and walls complying with Section 602.4.2.2.4 and the following:

1. Unprotected portions of mass timber ceilings, including attached beams, shall be permitted and shall be limited to an area equal to 20% of the floor area in any dwelling unit or fire area; or

2. Unprotected portions of mass timber walls, including attached columns, shall be permitted and shall be limited to an area equal to 40% of the floor area in any dwelling unit or fire area; or

3. Unprotected portions of both walls and ceilings of mass timber, including attached columns and beams, in any dwelling unit or fire area shall be permitted in accordance with section 602.4.2.2.3.

4. Mass timber columns and beams which are not an integral portion of walls or ceilings, respectively, shall be permitted to be unprotected without restriction of either aggregate area or separation from one another.

<table>
<thead>
<tr>
<th>BUILDING ELEMENT</th>
<th>TYPE I</th>
<th>TYPE II</th>
<th>TYPE III</th>
<th>TYPE IV</th>
<th>TYPE V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary structural frame (see Section 202)</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3/2</td>
<td>3/2</td>
</tr>
<tr>
<td>Bearing walls Exterior</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Interior</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Required fire resistance rating of Building Element</th>
<th>Required Noncombustible Protection Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.50 inch Type X Gypsum Board</td>
<td>50</td>
</tr>
<tr>
<td>1/2 inch Type X Gypsum Board</td>
<td>30</td>
</tr>
</tbody>
</table>

IBC 2021
LATERAL DESIGN

FIRE PROTECTION
SCHEMATIC DESIGN

- MATERIAL AND SUPPLY
- FIRE DESIGN
- GRID SPACING
- VOLUME ANALYSIS
WOOD SPECIES
European Spruce

PANEL SIZE
4' Width
40' Length

SHIPPING
Barge
St. Lawrence Seaway
To Port of Cleveland

APPROVALS
PRG 320

SEAGATE - INSTALLER
Supplier and Material

**EC5 Characteristic Values:**

<table>
<thead>
<tr>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$f_{m,k}$</td>
<td>30 N/mm²</td>
</tr>
<tr>
<td>$f_{t,0,k}$</td>
<td>24 N/mm²</td>
</tr>
<tr>
<td>$f_{t,90,k}$</td>
<td>0.5 N/mm²</td>
</tr>
<tr>
<td>$f_{c,0,k}$</td>
<td>30 N/mm²</td>
</tr>
<tr>
<td>$f_{c,90,k}$</td>
<td>2.5 N/mm²</td>
</tr>
<tr>
<td>$f_{v,k}$</td>
<td>3.5 N/mm²</td>
</tr>
<tr>
<td>$f_{f,k}$</td>
<td>1.2 N/mm²</td>
</tr>
</tbody>
</table>

**NDS2015 Reference Design Values:**

\[
F_{ND5} = 145 \times f_{EC5,k} \times k_{mod} / Y_M / \phi_{ND5} / K_f
\]

\[
k_{mod} = 1.00
\]

<table>
<thead>
<tr>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$F_b$</td>
<td>1550 psi</td>
</tr>
<tr>
<td>$F_t$</td>
<td>1239 psi</td>
</tr>
<tr>
<td>$F_{tL}$</td>
<td>26 psi</td>
</tr>
<tr>
<td>$F_c$</td>
<td>1549 psi</td>
</tr>
<tr>
<td>$F_{cL}$</td>
<td>186 psi</td>
</tr>
<tr>
<td>$F_y$</td>
<td>181 psi</td>
</tr>
</tbody>
</table>
Fire Design

Table 16.2.1A  Char Depth and Effective Char Depth (for $\beta_n = 1.5$ in./hr.)

<table>
<thead>
<tr>
<th>Required Fire Resistance (hr.)</th>
<th>Char Depth, $a_{\text{char}}$ (in.)</th>
<th>Effective Char Depth, $a_{\text{eff}}$ (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Hour</td>
<td>1.5</td>
<td>1.8</td>
</tr>
<tr>
<td>1½-Hour</td>
<td>2.1</td>
<td>2.5</td>
</tr>
<tr>
<td>2-Hour</td>
<td>2.6</td>
<td>3.2</td>
</tr>
</tbody>
</table>

Table 16.2.1B  Effective Char Depths (for CLT with $\beta_n = 1.5$ in./hr.)

<table>
<thead>
<tr>
<th>Required Fire Resistance (hr.)</th>
<th>Effective Char Depths, $a_{\text{eff}}$ (in.)</th>
<th>Required Fire Resistance (hr.)</th>
<th>Lamination thicknesses, $b_{\text{lam}}$ (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Hour</td>
<td>2.2</td>
<td>3/8</td>
<td>1/2</td>
</tr>
<tr>
<td>1½-Hour</td>
<td>3.4</td>
<td>3/4</td>
<td>1/3</td>
</tr>
<tr>
<td>2-Hour</td>
<td>4.4</td>
<td>7/8</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1-1/3</td>
<td>1-1/3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1-1/2</td>
<td>1-3/4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1-3/4</td>
<td>2</td>
</tr>
</tbody>
</table>

NDS – National Design Specification for Wood
### Table 16.2.2 Adjustment Factors for Fire Design

<table>
<thead>
<tr>
<th>Material Property</th>
<th>Symbol</th>
<th>ASD 2.03</th>
<th>Design Factor to Member Strength Factor</th>
<th>Volume Factor</th>
<th>Flat Use Factor</th>
<th>Bending Stability Factor</th>
<th>Column Stability Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bending Strength</td>
<td>$F_b$</td>
<td>x</td>
<td>2.85</td>
<td>$C_F$</td>
<td>$C_V$</td>
<td>$C_{bf}$</td>
<td>$C_{bf}$</td>
</tr>
<tr>
<td>Beam Buckling Strength</td>
<td>$F_{be}$</td>
<td>x</td>
<td>2.03</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>$F_t$</td>
<td>x</td>
<td>2.85</td>
<td>$C_F$</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Compressive Strength</td>
<td>$F_c$</td>
<td>x</td>
<td>2.58</td>
<td>$C_F$</td>
<td>-</td>
<td>-</td>
<td>$C_P$</td>
</tr>
<tr>
<td>Column Buckling Strength</td>
<td>$F_{ce}$</td>
<td>x</td>
<td>2.03</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

### Table 5.3.1 Applicability of Adjustment Factors for Structural Glued Laminated Timber

<table>
<thead>
<tr>
<th>Condition</th>
<th>ASD only</th>
<th>ASD and LRFD</th>
<th>LRFD only</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load Duration Factor</td>
<td>$F_B$</td>
<td>$C_D$, $C_M$, $C_L$, $C_V$, $C_{bf}$, $C_{bf}$</td>
<td>$K_{bf}$</td>
</tr>
<tr>
<td>Wet Service Factor</td>
<td>$F_B$</td>
<td>$C_D$, $C_M$, $C_L$, $C_V$, $C_{bf}$, $C_{bf}$</td>
<td>$K_{bf}$</td>
</tr>
<tr>
<td>Temperature Factor</td>
<td>$F_B$</td>
<td>$C_D$, $C_M$, $C_L$, $C_V$, $C_{bf}$, $C_{bf}$</td>
<td>$K_{bf}$</td>
</tr>
<tr>
<td>Beam Stability Factor</td>
<td>$F_B$</td>
<td>$C_D$, $C_M$, $C_L$, $C_V$, $C_{bf}$, $C_{bf}$</td>
<td>$K_{bf}$</td>
</tr>
<tr>
<td>Volume Factor</td>
<td>$F_B$</td>
<td>$C_D$, $C_M$, $C_L$, $C_V$, $C_{bf}$, $C_{bf}$</td>
<td>$K_{bf}$</td>
</tr>
<tr>
<td>Flat Use Factor</td>
<td>$F_B$</td>
<td>$C_D$, $C_M$, $C_L$, $C_V$, $C_{bf}$, $C_{bf}$</td>
<td>$K_{bf}$</td>
</tr>
<tr>
<td>Corrosion Factor</td>
<td>$F_B$</td>
<td>$C_D$, $C_M$, $C_L$, $C_V$, $C_{bf}$, $C_{bf}$</td>
<td>$K_{bf}$</td>
</tr>
<tr>
<td>Shear Reduction Factor</td>
<td>$F_B$</td>
<td>$C_D$, $C_M$, $C_L$, $C_V$, $C_{bf}$, $C_{bf}$</td>
<td>$K_{bf}$</td>
</tr>
<tr>
<td>Column Stability Factor</td>
<td>$F_B$</td>
<td>$C_D$, $C_M$, $C_L$, $C_V$, $C_{bf}$, $C_{bf}$</td>
<td>$K_{bf}$</td>
</tr>
<tr>
<td>Bearing Stress Factor</td>
<td>$F_B$</td>
<td>$C_D$, $C_M$, $C_L$, $C_V$, $C_{bf}$, $C_{bf}$</td>
<td>$K_{bf}$</td>
</tr>
<tr>
<td>Resistance Factor</td>
<td>$F_B$</td>
<td>$C_D$, $C_M$, $C_L$, $C_V$, $C_{bf}$, $C_{bf}$</td>
<td>$K_{bf}$</td>
</tr>
<tr>
<td>Time Effect Factor</td>
<td>$F_B$</td>
<td>$C_D$, $C_M$, $C_L$, $C_V$, $C_{bf}$, $C_{bf}$</td>
<td>$K_{bf}$</td>
</tr>
</tbody>
</table>

NDS – National Design Specification for Wood
16.2.1.3 For cross-laminated timber manufactured with laminations of equal thickness, the char depth, $\alpha_{\text{char}}$, shall be calculated as follows:

$$\alpha_{\text{char}} = n_{\text{lam}} h_{\text{lam}} + \beta_{i} \left( t - \left( n_{\text{lam}} t_{y} \right) \right)^{0.833}$$  \hspace{1cm} (16.2-3)
Bay Studies
DETAILED DESIGN

• VIBRATION
• LATERAL
• CONNECTIONS
• COORDINATION
COLUMN: SEE PLAN
(4) 5/8″ Ø GLUED-IN HILTI HAS-E RODS (8″ EMBED) IN 3/4″Øx6.5″ LG HOLES C/W NUT & WASHER
CUT CLT PANEL LOCALLY TO FACILITATE INSTALLATION; PER CLT SUPPLIER, 6″ MAX
CLT PANEL: SEE PLAN

CONCRETE TOPPING: SEE PLAN

ASSY SCREWS (SEE SCHEDULE)

3/4″ BUILT-UP HANGER PLATE (TYP): SEE SCHEDULE FOR SIZE
BEAM: SEE PLAN
WxH 1 1/8″ PLATE; WxH TO MATCH COLUMN DIMENSIONS
COLUMN: SEE PLAN

HSS: SEE SCHEDULE

PROVIDE SHIM AS REQ'D

(4) 3/4″Ø BOLT W/ SLOTTED HOLES @ HANGER PLATE AND COLUMN TOP PLATE

SECTION A-A

SECTION B-B
MEP
MEP COORD

CENTRAL BEAM PENETRATIONS

CLT HOLES
Full thread SWG ASSY® Screws as Reinforcement

Effect of Large Diameter Horizontal Holes on the Bending and Shear Properties of Structural Glued Laminated Timber
Cleveland's First 9-Story Timber Tower
THANK YOU!
Ascent

Alejandro Fernandez
Senior Project Engineer
Woodworks

Disclaimer: This presentation was developed by a third party and is not funded by WoodWorks or the Softwood Lumber Board
WHO ARE WE?

1500 ENGINEERS, ARCHITECTS, SCIENTISTS AND OTHER PROFESSIONALS

PROJECTS IN 50 COUNTRIES

50+ OFFICES

5 CONTINENTS
WHO ARE WE?

Sustainability

Weidlinger
Transportation

Weidlinger
Applied
Science

Renewal

Property Loss
Consulting

Facade
Engineering

Protection
Design

Construction
Engineering

Structural
Engineering

Forensics
MASS TIMBER SOLUTIONS

WWW.THRNTONTOMASETTI.COM/CAPABILITY/MASS-TIMBER-CONSTRUCTION
RIVER BEECH
Chicago
COORDINATION

© CD Smith/CAD Makers/Swinerton//Korb/TT
ARCHITECTURAL EXPRESSION
TYPICAL FLOOR PLANS

TYPICAL PARKING LEVEL

TYPICAL RESIDENTIAL LEVEL

AMENITIES LEVEL (L25)
CONNECTION TO NATURE
PERMITTING

Dates indicate approved permit year

Framework (2017)
Portland, OR

Ascent (2020)
Milwaukee, WI

12 stories

25 stories
## PERMITTING

### TABLE 601

**FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (HOURS)**

<table>
<thead>
<tr>
<th>BUILDING ELEMENT</th>
<th>TYPE I</th>
<th>TYPE II</th>
<th>TYPE III</th>
<th>TYPE IV</th>
<th>TYPE V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary structural frame, see Section 202</td>
<td>32</td>
<td>21</td>
<td>10</td>
<td>00</td>
<td>00</td>
</tr>
<tr>
<td>Bearing walls, see Section 202, Exterior</td>
<td>32</td>
<td>21</td>
<td>10</td>
<td>00</td>
<td>00</td>
</tr>
<tr>
<td>Bearing walls, see Section 202, Interior</td>
<td>32</td>
<td>21</td>
<td>10</td>
<td>00</td>
<td>00</td>
</tr>
<tr>
<td>Nonbearing walls and partitions, Exterior</td>
<td>00</td>
<td>00</td>
<td>00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonbearing walls and partitions, Interior</td>
<td>00</td>
<td>00</td>
<td>00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Floor construction and associated secondary members</td>
<td>22</td>
<td>10</td>
<td>00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roof construction and associated secondary members</td>
<td>11</td>
<td>00</td>
<td>00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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### Chapter SPS 361

**ADMINISTRATION AND ENFORCEMENT**

**Subchapter I — Scope and Application**

(6) Alternatives. Nothing in chs. SPS 361 to 366 is intended to prohibit or discourage the design and utilization of new building products, systems, components, or alternate practices, provided written approval from the department is obtained first.

**Voluntary approval.**

(a) Materials, equipment, and products regulated under chs. SPS 361 to 366 may receive a written approval from the department indicating code compliance.

(b) 1. Approval of materials, equipment, and products shall be based on sufficient data, tests, and other evidence that prove the material, equipment, or product is in compliance with the standards specified in chs. SPS 361 to 366.

2. Tests, compilation of data, and calculations shall be conducted by a qualified independent third party.

**Alternate approval.**

(a) Materials, equipment, and products that meet the intent of chs. SPS 361 to 366 and which are not approved under sub. 11 shall be permitted if approved in writing by the department.

(b) 1. Approval of materials, equipment, and products shall be based on sufficient data, tests, and other evidence that prove the material, equipment, or product meets the intent of the standards specified in chs. SPS 361 to 366.

2. Tests, compilation of data, and calculations shall be conducted by a qualified independent third party.
PERMITTING


Milwaukee's 25-Story Ascent Stacks Up as Tall Timber Role Model

Fire officials accept the unprecedented use of the sustainable material in a 284-ft-tall wood and concrete frame

Approvals took two years for Ascent, an unprecedented 284-ft-tall wood and concrete tower under way in Milwaukee since September.

Montage by Scott Hilling for ENR—rendering by Thornton Tomasetti, photo courtesy C.D. Smith
FIRE

Determining Fire Ratings:

- Char
  - Calculations (Char Method)
  - Full Scale (Global) Testing
  - Element (Member) Testing
  - Connection Testing
- Product Certificates
- Concealment
- Intumescent Paint (connections only)
FIRE
3 HOURS TEST
CONNECTIONS

STEEL CONNECTOR
SCREWED TO GLULAM COLUMN

GLULAM BEAM
ROUTED TO CONCEAL CONNECTION

INFIL BLOCK

GLULAM COLUMN
FOUNDATION
FOUNDATION

STATIC TESTING
ASCENT
TYPICAL PARKING LEVEL
ASCENT
TRANSFER LEVEL
ASCENT
TYPICAL TIMBER LEVEL
This concludes The American Institute of Architects Continuing Education Systems Course
THANK YOU
Contact info
afernandez@ThorntonTomasetti.com