Mass Timber in the Code and Alternative Solutions

ELEVATE: MASS TIMBER DESIGN SOLUTIONS
June 5, 2018 – Edmonton
June 6, 2018 - Calgary

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Senior Manager, Codes and Standards – Fire & Acoustics
Canadian Wood Council
Mass Timber
Solid-sawn timber / Heavy timber (CSA O86 → CSA O141):
Mass Timber

Nail-laminated Timber (NLT) (CSA O86 → CSA O141)
Mass Timber

Glued-Laminated Timber (Glulam) (CSA O86 → CSA O122 / CSA O177)
Mass Timber: Structural Composite Lumber (SCL) (CSA O86 → ASTM D5456)

Laminated Veneer Lumber (LVL)
Mass Timber: Structural Composite Lumber (SCL) (CSA O86 → ASTM D5456)

Laminated Strand Lumber (LSL)
Mass Timber: Structural Composite Lumber (SCL) (CSA O86 → ASTM D5456)
Parallel Strand Lumber (PSL)
Mass Timber
Cross-Laminated Timber (CLT)
(CSA O86 → ANSI/APA PRG 320)
Mass Timber

Dowel-laminated Timber (DLT)

Mass Plywood Panels (MPPs)
Objective-based Code – Structure

- **Division A**: Compliance, Objectives and Functional Statements
  - policy level
  - changes infrequently

- **Division B**: Acceptable Solutions
  - working level
  - updated regularly

- **Division C**: Administrative Provisions
Division A – Compliance Statement

1.2.1.1.(1) Compliance with this Code shall be achieved by:

(a) complying with the applicable acceptable solutions in Division B, or

(b) using alternative solutions that will achieve at least the minimum level of performance required by Division B …
Division B

Acceptable Solutions
Division A – Compliance Statement

Appendix Note:

A-1.2.1.1.(1)(a) Code Compliance via Acceptable Solutions. If a building design ... can be shown to meet all provisions of the applicable acceptable solutions in Division B ..., it is deemed to have satisfied the objectives and functional statements linked to those provisions and thus to have complied with that part of the Code. In fact, if it can be determined that a design meets all the applicable acceptable solutions in Division B, there is no need to consult the objectives and functional statements in Division A to determine its compliance.
Division B - Subsection 3.1.4

Combustible Construction:

3.1.4.1.(1) A building permitted to be of combustible construction is permitted to be constructed of combustible materials...
Division B - Subsection 3.1.5

Noncombustible Construction:

3.1.5.1.(1) ...a building [...] required to be of noncombustible construction shall be constructed with noncombustible materials.
Division A - Part 1

Combustible:

1.4.1.2 Combustible means that a material fails to meet the acceptance criteria of CAN/ULC-S114 Test for Determination of Non-Combustibility in Building Materials.
Division A - Part 1

Noncombustible:

1.4.1.2 Noncombustible means that a material meets the acceptance criteria of CAN/ULC-S114 Test for Determination of Non-Combustibility in Building Materials.
CAN/ULC-S114

• Heat specimens at 750°C for 15 min.
• Noncombustible, if:
  ▪ maximum temperature rise does not exceed 36°C;
  ▪ no flaming of any specimen during the test; and
  ▪ maximum mass loss of any specimen does not exceed 20%.
Division B – Subsection 3.2.2

• Building size (height in storeys and area) and construction relative to occupancy type

• 3.2.2.20 to 3.2.2.83

• Combustible Construction (3.1.4.) or Noncombustible Construction (3.1.5.)
## Division B – Subsection 3.2.2. Combustible Construction

<table>
<thead>
<tr>
<th>Occupancy Type</th>
<th>No. of storeys</th>
<th>Max. Allowable Building Area (m²) (unsprinklered)</th>
<th>Max. Allowable Building Area (m²) (sprinklered)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembly(^a) (Group A-1)</td>
<td>1</td>
<td>-</td>
<td>600</td>
</tr>
<tr>
<td>Assembly(^b) (Group A-2)</td>
<td>1</td>
<td>2 400</td>
<td>4 800</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1 200</td>
<td>2 400</td>
</tr>
<tr>
<td>Assembly(^c) (Group A-3)</td>
<td>1</td>
<td>3 600</td>
<td>7 200</td>
</tr>
</tbody>
</table>

\(^a\) Example: theatres (movie and live-performance)
\(^b\) Examples: art galleries, schools, restaurants, places of worship
\(^c\) Examples: arenas, indoor swimming pools
### Division B – Subsection 3.2.2. Combustible Construction

<table>
<thead>
<tr>
<th>Occupancy Type</th>
<th>No. of storeys</th>
<th>Max. Allowable Building Area (m²) (unsprinklered)</th>
<th>Max. Allowable Building Area (m²) (sprinklered)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment⁺⁻ (Group B-2)</td>
<td>1</td>
<td>-</td>
<td>2 400</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>-</td>
<td>1 600</td>
</tr>
<tr>
<td>Care⁻ (Group B-3)</td>
<td>1</td>
<td>-</td>
<td>5 400</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>-</td>
<td>2 700</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>-</td>
<td>1 800</td>
</tr>
</tbody>
</table>

- a. Examples: hospitals, nursing homes with treatment, care facilities with treatment
- b. Examples: nursing homes without treatment, group homes, children’s custodial homes
## Division B – Subsection 3.2.2. Combustible Construction

<table>
<thead>
<tr>
<th>Occupancy Type</th>
<th>No. of storeys</th>
<th>Max. Allowable Building Area (m²) (unsprinklered)</th>
<th>Max. Allowable Building Area (m²) (sprinklered)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residentiala (Group C)</td>
<td>1</td>
<td>3 600</td>
<td>7 200</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1 800</td>
<td>3 600</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>1 200</td>
<td>2 400</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>-</td>
<td>1 800</td>
</tr>
</tbody>
</table>

a. Examples: apartment buildings, hotels
## Division B – Subsection 3.2.2. Combustible Construction

<table>
<thead>
<tr>
<th>Occupancy Type</th>
<th>No. of storeys</th>
<th>Max. Allowable Building Area (m²) (unsprinklered)</th>
<th>Max. Allowable Building Area (m²) (sprinklered)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business and personal services&lt;sup&gt;a&lt;/sup&gt; (Group D)</td>
<td>1</td>
<td>7 200</td>
<td>14 400</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>3 600</td>
<td>7 200</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>2 400</td>
<td>4 800</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>-</td>
<td>3 600</td>
</tr>
</tbody>
</table>

<sup>a</sup> Examples: banks, dental and medical offices, radio stations, barber shops
## Division B – Subsection 3.2.2. Combustible Construction

<table>
<thead>
<tr>
<th>Occupancy Type</th>
<th>No. of storeys</th>
<th>Max. Allowable Building Area (m²) (unsprinklered)</th>
<th>Max. Allowable Building Area (m²) (sprinklered)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mercantile</strong>&lt;sup&gt;a&lt;/sup&gt; (Group E)</td>
<td>1</td>
<td>1 500</td>
<td>7 200</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1 500</td>
<td>3 600</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>1 500</td>
<td>2 400</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>-</td>
<td>1 800</td>
</tr>
<tr>
<td><strong>High-hazard industrial</strong>&lt;sup&gt;b&lt;/sup&gt; (Group F-1)</td>
<td>1</td>
<td>800</td>
<td>3 600&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>-</td>
<td>1 800&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>-</td>
<td>1 200&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

- **Examples**: Shops, supermarkets, exhibition halls
- **Examples**: spray painting operations, distilleries
- **Heavy timber construction** only
### Division B – Subsection 3.2.2. Combustible Construction

<table>
<thead>
<tr>
<th>Occupancy Type</th>
<th>No. of storeys</th>
<th>Max. Allowable Building Area (m²) (unsprinklered)</th>
<th>Max. Allowable Building Area (m²) (sprinklered)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium-hazard industriala</td>
<td>1</td>
<td>1500</td>
<td>9600</td>
</tr>
<tr>
<td>(Group F-2)</td>
<td>2</td>
<td>1500</td>
<td>4800</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>1500</td>
<td>3200</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>-</td>
<td>2400</td>
</tr>
<tr>
<td>Low-hazard industrialb</td>
<td>1</td>
<td>7200</td>
<td>14400</td>
</tr>
<tr>
<td>(Group F-3)</td>
<td>2</td>
<td>3600</td>
<td>7200</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>2400</td>
<td>4800</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>1800</td>
<td>3600</td>
</tr>
</tbody>
</table>

a. Examples: woodworking factories, repair garages  
b. Examples: storage garages
Division B – Subsection 3.2.2. Mid-rise Combustible Construction

3.2.2.50. Group C – Residential

- 1 storey: Unlimited, 7200 m²
- 2 storeys: 3600 m²
- 3 storeys - 12000 m²
- 1&2 storeys: Unlimited
- 3 storeys: 9000 m²
- 4 storeys: 4500 m²
- 5 storeys: 3000 m²
- 6 storeys: 2250 m²

Noncombustible Construction

- 4 storeys: 7200 m²
- 5 storeys: 6000 m²
- 6 storeys: 5400 m²
- 4 storeys: 1800 m²
- 5 storeys: 1800 m²
- 6 storeys: 1500 m²

ABC 2014 (NBCC 2015)
Division B – Subsection 3.2.2. Mid-rise Combustible Construction

3.2.2.58. Group D – Business and Personal Services
## Division B – Subsection 3.2.2. Mid-rise Combustible Construction

<table>
<thead>
<tr>
<th>Occupancy Type</th>
<th>No. of storeys</th>
<th>Max. Allowable Building Area (m²) (sprinklered)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembly(^a) (Group A-2)</td>
<td>1</td>
<td>4 800</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>2 400</td>
</tr>
<tr>
<td>Mercantile(^b) (Group E)</td>
<td>1</td>
<td>7 200</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>3 600</td>
</tr>
<tr>
<td>Group A-2 and Group E in Mid-rise Combustible Construction (on 1(^{st}) and 2(^{nd}) storey)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>9 000</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>4 500</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>3 000</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>2 250</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>1 800</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>1 500</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In Group C</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>18 000</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>9 000</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>6 000</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>4 500</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>3 600</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>3 000</td>
</tr>
</tbody>
</table>

\(^a\) Examples: art galleries, schools, restaurants, places of worship

\(^b\) Examples: Shops, supermarkets, exhibition halls
Heavy Timber Construction

Division A - Part 1

1.4.1.2.(1) Heavy timber construction means that type of combustible construction in which a degree of fire safety is attained by placing limitations on the sizes of wood structural members and on the thickness and composition of wood floors and roofs and by the avoidance of concealed spaces under floors and roofs.

Subsection 3.1.4. sets out the requirements that must be conformed to for code-defined heavy timber construction.
Division B - Article 3.1.4.6.

Heavy Timber Construction Alternative:

3.1.4.6.(1): If combustible construction is permitted and is not required to have a fire-resistance rating of more than 45 min, heavy timber construction is permitted to be used.
3.1.4.7. Heavy Timber Construction

2) Except as permitted by Sentences (3) to (6) and (12), the minimum dimensions of wood elements in heavy timber construction shall conform to Table 3.1.4.7.

<table>
<thead>
<tr>
<th>Supported Assembly</th>
<th>Structural Element</th>
<th>Solid Sawn (width × depth), mm × mm</th>
<th>Glued-Laminated (width × depth), mm × mm</th>
<th>Round (diam), mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roofs only</td>
<td>Columns</td>
<td>140 × 191</td>
<td>130 × 190</td>
<td>180</td>
</tr>
<tr>
<td></td>
<td>Arches supported on the tops of walls or abutments</td>
<td>89 × 140</td>
<td>80 × 152</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Beams, girders and trusses</td>
<td>89 × 140</td>
<td>80 × 152</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Arches supported at or near the floor line</td>
<td>140 × 140</td>
<td>130 × 152</td>
<td>—</td>
</tr>
<tr>
<td>Floors, floors plus roofs</td>
<td>Columns</td>
<td>191 × 191</td>
<td>175 × 190</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>Beams, girders, trusses and arches</td>
<td>140 × 241 or 191 × 191</td>
<td>130 × 228 or 175 × 190</td>
<td>—</td>
</tr>
</tbody>
</table>
3.1.4.7. Heavy Timber Construction

3) Where splice plates are used at splices of roof arches supported on the tops of walls or abutments, roof trusses, roof beams and roof girders in heavy timber construction, they shall be not less than 64 mm thick.

4) Floors in heavy timber construction shall be of glued-laminated or solid sawn plank not less than
   a) 64 mm thick, splined or tongued and grooved, or
   b) 38 mm wide and 89 mm deep set on edge and well spiked together.

5) Floors in heavy timber construction shall be laid
   a) so that no continuous line of end joints will occur except at points of support, and covered with
      i) tongued and grooved flooring not less than 19 mm thick laid crosswise or diagonally, or
      ii) tongued and grooved phenolic-bonded plywood, strandboard or waferboard not less than 12.5 mm thick, and
   b) not closer than 15 mm to the walls to provide for expansion, with the gap covered at the top or bottom.
3.1.4.7. Heavy Timber Construction

6) Roofs in *heavy timber construction* shall be of tongued and grooved phenolic-bonded plywood, strandboard or waferboard not less than 28 mm thick, or glued-laminated or solid sawn plank that is
   a) not less than 38 mm thick, splined or tongued and grooved, or
   b) not less than 38 mm wide and 64 mm deep set on edge and laid so that no continuous line of end joints will occur except at the points of support.

7) Wood columns in *heavy timber construction* shall be continuous or superimposed throughout all storeys.

8) Superimposed wood columns in *heavy timber construction* shall be connected by
   a) reinforced concrete or metal caps with brackets,
   b) steel or iron caps with pintles and base plates, or
   c) timber splice plates fastened to the columns by metal connectors housed within the contact faces.
3.1.4.7. Heavy Timber Construction

9) Where beams and girders in *heavy timber construction* enter masonry, wall plates, boxes of the self-releasing type or hangers shall be used.

10) Wood girders and beams in *heavy timber construction* shall be closely fitted to columns, and adjoining ends shall be connected by ties or caps to transfer horizontal loads across the joints.

11) In *heavy timber construction*, intermediate wood beams used to support a floor shall be supported on top of the girders or on metal hangers into which the ends of the beams are closely fitted.

12) Roof arches supported on the top of walls or abutments, roof trusses, roof beams and roof girders in *heavy timber construction* are permitted to be not less than 64 mm wide provided
   a) where two or more spaced members are used, the intervening spaces are
      i) blocked solidly throughout, or
      ii) tightly closed by a continuous wood cover plate not less than 38 mm thick secured to the underside of the members, or
   b) the underneath of the roof deck or sheathing is *sprinklered*.
### Division B – Subsection 3.2.2. Combustible Construction

<table>
<thead>
<tr>
<th>Occupancy Type</th>
<th>No. of storeys</th>
<th>Max. Allowable Building Area (m²) (unsprinklered)</th>
<th>Max. Allowable Building Area (m²) (sprinklered)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercantile(^a) (Group E)</td>
<td>1</td>
<td>1 500</td>
<td>7 200</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1 500</td>
<td>3 600</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>1 500</td>
<td>2 400</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>-</td>
<td>1 800</td>
</tr>
<tr>
<td>High-hazard industrial(^b) (Group F-1)</td>
<td>1</td>
<td>800</td>
<td>3 600(^c)</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>-</td>
<td>1 800(^c)</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>-</td>
<td>1 200(^c)</td>
</tr>
</tbody>
</table>

\(^a\) Examples: Shops, supermarkets, exhibition halls
\(^b\) Examples: spray painting operations, distilleries
\(^c\) Heavy timber construction only
Heavy Timber Roof Permitted

3.2.2.16.(1):
• For building up to 2 storeys
• Sprinklered throughout
• Regardless of building area or construction type required
Heavy Timber Roof Permitted

3.2.2.16.(2) - Structural members in storey immediately below permitted to heavy timber construction
Division B - Subsection 3.1.5. Noncombustible Construction

Wood Partitions (3.1.5.13.)

- All occupancies other than care, treatment or detention (Group B)
- Non-loadbearing
- Solid lumber (or wood-frame construction)
Division B - Subsection 3.1.5. Noncombustible Construction

Wood Partitions (3.1.5.13.)

• If not required to be fire separation:
  ▪ Sprinklered floor area, unlimited area
  ▪ Unsprinklered floor area, 600 m² fire compartment area limit
Division B - Subsection 3.1.5. Noncombustible Construction

Wood Partitions (3.1.5.13.)

• No limits on compartment size and unsprinklered:
  ▪ not more than 3 storeys
  ▪ not used to enclose exits or vertical services spaces
  ▪ can be used in most fire separations
Division B - Subsection 3.1.5. Noncombustible Construction

Wood Partitions (3.1.5.13.)

- No limits on compartment size or storeys, sprinklered:
  - not used to enclose exits or vertical services spaces
  - can be used in most fire separations
Division B - Subsection 3.1.5. Noncombustible Construction

Combustible Components for Exterior Walls (3.1.5.6.)
• \( \leq 3 \) storeys OR sprinklered
• CAN/ULC-S134
• Loadbearing or non-loadbearing
• >10\% of unprotected openings (spatial separation requirements)
Division B - Subsection 3.1.5. Noncombustible Construction

Combustible Components for Exterior Walls (3.1.5.6.)

Division B - Subsection 3.1.5. Noncombustible Construction

Combustible Components for Exterior Walls (3.1.5.6.)

Division A

Alternative Solutions
Division A – Compliance Statement

1.2.1.1.(1) Compliance with this Code shall be achieved by:

(a) complying with the applicable acceptable solutions in Division B, or

(b) using alternative solutions that will achieve at least the minimum level of performance required by Division B …
Division A – Compliance Statement

Appendix Note

A-1.2.1.1.(1)(b) Code Compliance via Alternative Solutions:

• Where a design differs from the acceptable solutions (Div. B), should be treated as an “alternative solution”

• Must make effort to demonstrate that it addresses the same issues as well as the applicable acceptable solutions and their attributed objectives and functional statements
NBC Preface
Objective-based Code Structure

Each code provision in Division B (Acceptable Solutions) is linked to:
- objectives
- functional statements
- specific intents
- application statements
Objectives

• every code requirement has at least one objective attributed to it – often more
• describe the overall goals that code provisions serve to fulfill
• are very broad
Division A, Part 2 - Objectives

**OS - SAFETY**
- OS1 Fire Safety
- OS2 Structural Safety
- OS3 Safety in Use
- OS4 Resistance to Unwanted Entry
- OS5 Safety at Construction and Demolition Sites

**OH - HEALTH**
- OH1 Indoor Conditions
- OH2 Sanitation
- OH3 Noise Protection
- OH4 Vibration and Deflection Limitation
- OH5 Hazardous Substances Containment

**OA - ACCESSIBILITY**
- OA1 Barrier-Free Path of Travel
- OA2 Barrier-Free Facilities

**OP - FIRE & STRUCTURAL PROTECTION OF BUILDINGS**
- OP1 Fire Protection of the Building
- OP2 Structural Sufficiency of the Building
- OP3 Protection of Adjacent Buildings from Fire
- OP4 Protection of Adjacent Buildings from Structural Damage
Division A, Part 2 - Objectives

OS1 Fire Safety
An objective of this Code is to limit the probability that, as a result of the design or construction of the building, a person in or adjacent to the building will be exposed to an unacceptable risk of injury due to fire. The risks of injury due to fire addressed in this Code are those caused by —

OS1.1 – fire or explosion occurring
OS1.2 – fire or explosion impacting areas beyond its point of origin
OS1.3 – collapse of physical elements due to a fire or explosion

...
Division A, Part 2 - Objectives

OP1 Fire Protection of the Building

An objective of this Code is to limit the probability that, as a result of its design or construction, the building will be exposed to an unacceptable risk of damage due to fire. The risks of damage due to fire addressed in this Code are those caused by —

OP1.1 – fire or explosion occurring
OP1.2 – fire or explosion impacting areas beyond its point of origin
OP1.3 – collapse of physical elements due to a fire or explosion

...
Functional Statements

• every code requirement has at least one functional statement attributed to it – often more
• describe the conditions to be achieved in more detail than objectives
• are qualitative
Division A, Part 3 - Functional Statements

3.2.1.1.(1) The objectives of this Code are achieved by measures, such as those described in the acceptable solutions, intended to allow the building to perform the following functions:

F01 To minimize the risk of accidental ignition.
F02 To limit the severity and effects of fire or explosions.
F03 To retard the effects of fire on areas beyond its point of origin.
F04 To retard failure or collapse due to the effects of a fire.

...
Division A, Part 3 - Functional Statements

F01 To minimize the risk of accidental ignition.
F02 To limit the severity and effects of fire or explosions.
F03 To retard the effects of fire on areas beyond its point of origin.
F04 To retard failure or collapse due to the effects of a fire.

... Prescriptive Provisions:

• Walls and floors must have a fire-resistance rating of not less than 45 minutes...

• The building shall be sprinklered throughout...
Intent Statements

• at least one for every code provision
• explains the thinking behind specific code requirements in plain language
• helps codes users apply the code, assess equivalent/alternate solutions
• only published electronically
Application Statements

- at least one for every code provision
- describe the situations to which the code provision applies and does not apply
- only published electronically
Application & Intent Statements

• Clarify what undesirable results each provision seek to preclude
• Not a legal component of the Code
• Advisory in nature
• Can help establish performance targets for alternative solutions
Division A – Compliance Statement

Appendix Note - A-1.2.1.1.(1)(b) Code Compliance via Alternative Solutions:

• **Level of Performance**
  
  Among a number of possible designs satisfying acceptable solutions in Div. B, the design providing the lowest level of performance is generally considered to establish minimum acceptable level of performance in evaluation of alternative solutions.
Division A – Compliance Statement

Appendix Note - A-1.2.1.1.(1)(b) Code Compliance via Alternative Solutions:

• Areas of Performance
  Some acceptable solutions may provide some benefits that could be related to objectives and/or functional statements not attributed to them; however, an alternative solution need only demonstrate that it satisfies acceptable levels of performance in those areas defined by the objectives and functional statements attributed to the acceptable solutions.
Appendix Note - A-1.2.1.1.(1)(b) Code Compliance via Alternative Solutions:

• Applicable Acceptable Solutions

  All applicable acceptable solutions should be taken into consideration in demonstrating the compliance of an alternative solution; e.g. innovative sheathing material
Division C
Administrative Provisions

2.3.1. Documentation of Alternative Solutions

• Code analysis
  • Identify applicable objectives, functional statements and acceptable solutions
  • Identify any assumptions, limiting factors, testing procedures, engineering studies or building performance parameters
  • Include qualifications, experience, background of designer(s)

• Information concerning any special maintenance or operational requirements
Documentation

• NBC or Provincial Code, Division C, 2.3.1. Documentation of Alternative Solutions

• Provincial legislation
e.g. Alberta: Safety Codes Act – Section 38, Variances

• Municipal requirements and guidance
e.g. City of Calgary:
  - Request for Specific Variance Form
  - Variance Manual
Division B - Subsection 3.1.5

Noncombustible Construction:

3.1.5.1.(1) ...a building [...] required to be of noncombustible construction shall be constructed with noncombustible materials.

Attributed Objectives and Functional Statements: F02 – OS1.2, F02 – OP1.2
Division B - Subsection 3.2.2

e.g. Group A, Division 1, Any Height, Any Area, Sprinklered:

3.2.2.20.(2) ... the building referred to in Sentence (1) shall be of noncombustible construction...

Attributed Objectives and Functional Statements: F02 – OS1.2, F02 – OP1.2
Division A, Part 3 - Functional Statements

3.2.1.1.(1) The objectives of this Code are achieved by measures, such as those described in the acceptable solutions, intended to allow the building to perform the following functions:

- **F01** To minimize the risk of accidental ignition.
- **F02** To limit the severity and effects of fire or explosions.
- **F03** To retard the effects of fire on areas beyond its point of origin.
- **F04** To retard failure or collapse due to the effects of a fire.

...
Division A, Part 2 - Objectives

OS1 Fire Safety
An objective of this Code is to limit the probability that, as a result of the design or construction of the building, a person in or adjacent to the building will be exposed to an unacceptable risk of injury due to fire. The risks of injury due to fire addressed in this Code are those caused by —

OS1.1 – fire or explosion occurring
OS1.2 – fire or explosion impacting areas beyond its point of origin
OS1.3 – collapse of physical elements due to a fire or explosion

...
Division A, Part 2 - Objectives

OP1 Fire Protection of the Building
An objective of this Code is to limit the probability that, as a result of its design or construction, the building will be exposed to an unacceptable risk of damage due to fire. The risks of damage due to fire addressed in this Code are those caused by —
OP1.1 – fire or explosion occurring
OP1.2 – fire or explosion impacting areas beyond its point of origin
OP1.3 – collapse of physical elements due to a fire or explosion

...
3.1.5.1.(1)

<table>
<thead>
<tr>
<th>OS1</th>
<th>OP1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>OS1 Fire Safety</td>
</tr>
<tr>
<td>Attribution</td>
<td>[F02-OS1.2]</td>
</tr>
</tbody>
</table>

**Intent**

**Intent 1:** To clarify what constitutes noncombustible construction.

**Intent 2:** To limit the probability that construction materials will contribute to the growth and spread of fire, which could lead to harm to persons.

Top of Page
Intent Statements

NBC 2010 - intent statements

Expand All   Collapse All

3.1.5.1.(1)

<table>
<thead>
<tr>
<th>OS1</th>
<th>OP1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>OP1 Fire Protection of the Building</td>
</tr>
<tr>
<td>Attribution</td>
<td>[F02-OP1.2]</td>
</tr>
</tbody>
</table>

Intent

Intent 1:
To clarify what constitutes noncombustible construction.

Intent 2:
To limit the probability that construction materials will contribute to the growth and spread of fire, which could lead to damage to the building.
Resource:

Ontario’s Tall Wood Building Reference:
October, 2017

Tall Wood Buildings


Height: up to 30 storeys

Prepared by:
mgb ARCHITECTURE + DESIGN
Equilibrium Consulting
LMDG Ltd
BTY Group
Tall Wood Buildings

Cree by Rhomburg: The LifeCycle Tower, 2012

Height: up to 30 storeys (100 m / 328 ft)

LifeCycleTower
Sustainable, resource-efficient, profitable: the facts.

factbox

DIMENSION
High: up to 100 m
Grid: 1.35 m
Slab range: 8.10 m or 9.45 m column-free

MATERIALS
Basement, 1st and 2nd floor: reinforced concrete
Slab from 2nd floor up to: composite slab (wood/concrete)
Facade columns 2nd floor up: timber/wood
Tall Wood Buildings

*SOM Timber Tower Research Project, 2013 (1st Phase)*

Project by:
Skidmore, Owings, and Merrill

Height: 42 storeys (120 m / 395 ft)
Canadian Codes – Historical Study


www.cwc.ca

Building Solutions

Mid-rise Buildings/Tall Buildings

Research

Canadian Wood Council  Conseil canadien du bois
Proposed Changes for the 2020 NBC: Prescriptive Tall Wood Buildings
Division B – 2020 NBC: Prescriptive Tall Wood Buildings

- Code Change Request package submitted by Canadian Wood Council
- Standing Committee on Fire Protection → Task Group → 5 Sub-Task Groups
- List of 25 potential issues/concerns developed
- Draft Proposed Code Changes submitted to public consultation in Fall 2017
Division B – 2020 NBC: Prescriptive Tall Wood Buildings

Current Code:

• “Noncombustible construction means that type of construction in which a degree of fire safety is attained by the use of noncombustible materials for structural members and other building assemblies.”

• “Combustible construction means that type of construction that does not meet the requirements for noncombustible construction.”
Division B – 2020 NBC: Prescriptive Tall Wood Buildings

Any building that does not follow all the requirements for “noncombustible construction”, including

- 3.1.5.1. to 3.1.5.24.
- 3.1.11.3. (fire blocking)
- 3.1.13.8. (flame-spread ratings)
- 3.2.3.19. (connected walkways)
- 3.6.4.3. (plenums)
- 3.6.5.5. (insulation and coverings on piping)

is considered “combustible construction”
Division B – 2020 NBC: Prescriptive Tall Wood Buildings

Tall buildings in current Codes:

• “noncombustible construction”
• fire-resistance rating of structural members of 2 h
• automatic fire sprinklers
• unlimited height, unlimited area
“Noncombustibility is an elemental concept, but ‘noncombustible construction’ is only a standard that has proved satisfactory for tall buildings and some other situations. When construction using combustible materials is developed that satisfies the conditions, the standard should be changed to permit it.... Noncombustibility will always be one, but not necessarily the only, solution.”

R.S. Ferguson, The Problem of “Noncombustible”
Technical Note No. 428
National Research Council of Canada
1964
General Premise:

Develop a set of provisions that achieves the current level of fire safety when wood structural elements are substituted for structural elements of noncombustible materials.
Division B – 2020 NBC: Prescriptive Tall Wood Buildings

General Premise

“Noncombustible Construction”
(i.e. all the current material restrictions and fire safety provisions required for NC)

Structural elements currently required to be of noncombustible material replaced with wood elements

Additional requirements - ??
Division B – 2020 NBC: Prescriptive Tall Wood Buildings

Objectives and Functional Statements attributed to requirement for “noncombustible construction”: F02 – OS1.2

F02 To limit the severity and effects of fire or explosions.

OS1 Fire Safety
OS1.2 To limit the probability that, as a result of the design or construction of the building, a person in or adjacent to the building will be exposed to an unacceptable risk of injury due to fire caused by fire or explosion impacting areas beyond its point of origin.
Division B – 2020 NBC: Prescriptive Tall Wood Buildings

Objectives and Functional Statements attributed to requirement for “noncombustible construction”: F02 – OP1.2

F02 To limit the severity and effects of fire or explosions.

OP1 Fire Protection of the Building
OP1.2 To limit the probability that, as a result of its design or construction, the building will be exposed to an unacceptable risk of damage due to fire caused by fire or explosion impacting areas beyond its point of origin.
Division B – 2020 NBC: Prescriptive Tall Wood Buildings

Question:

• What performance aspects may be different when using combustible structural materials versus noncombustible structural materials, with respect to the impact of a fire beyond its point of origin?

Potential Answers:

1) Combustible structural materials may be additional fuel load for a fire

2) An increase in surface flammability may increase rate of fire spread
Division B – 2020 NBC: Prescriptive Tall Wood Buildings

1) Combustible structural materials may be additional fuel load for a fire

A. Mass Timber:
   • Different fire performance characteristics from lightweight, small-dimensioned wood elements
   • Reduced ignition propensity
   • Reduced average rate of fuel contribution
Division B – 2020 NBC: Prescriptive Tall Wood Buildings

A. Mass Timber:

- Minimum size requirements for structural timber elements to be considered “mass timber”

<table>
<thead>
<tr>
<th>Structural timber elements</th>
<th>Type of Dimension</th>
<th>Minimum Dimensions (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall, floor and roof assemblies</td>
<td>thickness/depth</td>
<td>96</td>
</tr>
<tr>
<td>Beams, columns and arches with 2-sided or 3-sided fire exposure</td>
<td>cross-section</td>
<td>192 x 192</td>
</tr>
<tr>
<td>Beams, columns and arches with 4-sided fire exposure</td>
<td>cross-section</td>
<td>224 x 224</td>
</tr>
</tbody>
</table>

Table 3.1.18.3. Minimum Dimensions of Structural Timber Elements in Encapsulated Mass Timber Construction Forming Part of Sentence 3.1.18.3.(2)-2020
Division B – 2020 NBC: Prescriptive Tall Wood Buildings

1) Combustible structural materials may be additional fuel load for a fire

B. Encapsulation: a method of covering or enclosing something
   • 2 layers of 12.7-mm-thick Type X gypsum board,
   • 38-mm-thick gypsum-concrete topping,
   or
   • Other material or assembly of materials that provides an “encapsulation rating” of at least 50 minutes
Division B – 2020 NBC: Prescriptive Tall Wood Buildings

B. Encapsulation:

- ENCAPSULATION RATING determined via new test method
Division B – 2020 NBC: Prescriptive Tall Wood Buildings

B. Encapsulation:
Draft test method ULC S146-XX -

- Standard time-temperature curve from CAN/ULC-S101
- Horizontal configuration (fire from underside)
- Minimum size of assembly: 3.66 m x 3.66 m
- Maximum average temperature increase of 250°C
- Maximum temperature increase at any individual point of 270°C
Division B – 2020 NBC: Prescriptive Tall Wood Buildings

2) An increase in surface flammability may increase rate of fire spread

Current provisions for “noncombustible construction”:

- combustible wall interior finishes ≤ 25 mm thick with FSR ≤ 150
- combustible ceiling interior finishes ≤ 25 mm thick with FSR ≤ 25, except ≤ 10% area with FSR ≤ 150
- “cut-through” requirement
Division B – 2020 NBC: Prescriptive Tall Wood Buildings

- Encapsulation of mass timber elements
- Mass timber elements to be protected from adjacent spaces, including concealed spaces
- Some mass timber surfaces permitted to remain exposed
Division B – 2020 NBC: Prescriptive Tall Wood Buildings

Additional Requirements:

• Limited height: 12 storeys & 42 m
• Main occupancy types – Group C & Group D
• Limited maximum building area (for any height):
  • Group C: 6,000 m²
  • Group D: 7,200 m²
Division B – 2020 NBC: Prescriptive Tall Wood Buildings

Additional Requirements:

• Limited occupancy combinations:
  • Group C and Group D – all/any floors;
  • Group E – 1st & 2nd storeys
  • Group A, Division 2 – 1st, 2nd & 3rd storeys
  • storage garages – below 5th storey
  • In Group D buildings only: Group F, Division 2 or 3 – 1st & 2nd storeys
Division B – 2020 NBC: Prescriptive Tall Wood Buildings

Additional Requirements:

• Subsection 3.2.6. (Additional Requirements for High Buildings) applicable to all EMTC buildings over 18 m

• increased fire-resistance ratings for some separations between permitted major occupancies

• additional NFC Subsection 5.6.3. on construction site fire safety to be applied
So, proposing 3rd “type” of construction -

• “Noncombustible construction means that type of construction in which a degree of fire safety is attained by the use of noncombustible materials for structural members and other building assemblies.”

• “Encapsulated mass timber construction means that type of construction in which a degree of fire safety is attained by the use of mass timber elements for structural members and other building assemblies in combination with meeting requirements for noncombustible construction, the use of encapsulation ratings and minimum dimensions for the structural timber members and other building assemblies, and limitations on combustible concealed spaces.”

• “Combustible construction means that type of construction that does not meet the requirements for noncombustible construction or encapsulated mass timber construction.”
Fire Resistance
Fire Resistance

fire resistance, n—the ability of a material, product, or assembly to withstand fire or give protection from it for a period of time.

(ASTM E 176-15 Standard Terminology of Fire Standards)
Division A - Part 1
“Fire-resistance rating”

1.4.1.2: "...the time in minutes or hours that a material or assembly of materials will withstand the passage of flame and the transmission of heat when exposed to fire under specified conditions of test and performance criteria, or as determined by extension or interpretation of information derived from that test and performance as prescribed in this Code."
Division B
3.1.7. Fire-resistance Ratings

Sentence 3.1.7.1.(1): CAN/ULC-S101 - Fire Endurance Tests of Building Construction and Materials
CAN/ULC-S101
Horizontal Furnace
CAN/ULC-S101
Loading – Horizontal Furnace
CAN/ULC-S101
Vertical Furnace
CAN/ULC-S101
Temperature Exposure
CAN/ULC-S101
Standard Fire-resistance Test Failure Criteria

• Structural Failure

• Insulation Failure

• Integrity Failure
Structural Failure

CLT wall assembly has buckled under applied load
Insulation Failure
Integrity Failure

Flame penetrating the subfloor at failure time
Fire-resistance Ratings

• Generic Listings
• Proprietary Listings
• Empirical Calculation Methods
Generic Listings

ABC: Appendix D

• Part 2 Fire-Resistance Ratings
• Section 2.4 Solid Wood Walls, Floors and Roofs
## Generic Listings:
### ABC - Appendix D-2.4.

<table>
<thead>
<tr>
<th>Type of Construction</th>
<th>Fire-Resistance Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30 min</td>
</tr>
<tr>
<td>Solid wood floor with building paper and finish flooring on top&lt;sup&gt;(3)&lt;/sup&gt;</td>
<td>89</td>
</tr>
<tr>
<td>Solid wood, splined or tongued and grooved floor with building paper and finish flooring on top&lt;sup&gt;(4)&lt;/sup&gt;</td>
<td>64</td>
</tr>
<tr>
<td>Solid wood walls of loadbearing vertical plank&lt;sup&gt;(3)&lt;/sup&gt;</td>
<td>89</td>
</tr>
<tr>
<td>Solid wood walls of non-loadbearing horizontal plank&lt;sup&gt;(3)&lt;/sup&gt;</td>
<td>89</td>
</tr>
<tr>
<td>Column 1</td>
<td>2</td>
</tr>
</tbody>
</table>
Proprietary Listings

Louisiana-Pacific Corporation
Design No. LPO13PSW 00-02
Laminated Strand Lumber and Laminated Veneer Lumber Wall Stud
ULS Solidlarts L3 and LVL
ASTM E118, CANULC-S101
Rating: 1 hour restricted load-bearing 77% for LVL and 63% for LVL

1. CERTIFIED MANUFACTURER: Louisiana-Pacific Corporation
2. GYPSUM BOARD: 5/8 in. Type X gyspum wallboard installed horizontally, and fastened with 2-1/4 in. Type 2 drywall screws located 7 in. on center from horizontal board meeting edges.
3. INSULATION: Min. 2.5 pcf density, 3-1/2 in. thickness, 2-1/2 in. Type X gyspum wallboard installed horizontally, and fastened with 2-1/4 in. Type 2 drywall screws located 7 in. on center from horizontal board meeting edges.

Design No. V329
March 03, 2017
Bearing Wall Rating - 2 Hr.
Restricted Load Condition — Axial loading restricted to 30% of allowable compressive load parallel to grain.
* Indicates such products shall bear the UL or cUL Certification Mark for jurisdictions employing the UL or cUL Certification (such as Canada), respectively.

1. Structural Wood Members — close to horizontal/over panels, with 2-1/2 in. lag joint, Panels screwed together with #8 ASTM 3.5 screws at 12 in. OC, length as specified in table below. Fasten screws 2-1/2 in. from panel ends.

LENDO LEASE (US) PUBLIC PARTNERSHIPS LLC — Nordic X-Lam CLT 100-Bo. 131-Bs. 175-Bo. 220-75 and 220-75 (53-55)

Nordic X-Lam Panel Construction (Nessence) Panel Fastener Length
355 mm 100 mm
351 mm 120 mm
119 mm 150 mm

- Validated by test results
- For FRRs greater than 45 min

Figure D-2.11.2-B
Full dimensions of glued-laminated beams and columns

\[
FRR = 0.1fB \left[ 4 - \frac{2B}{D} \right]
\]
for beams exposed to fire on 4 sides,

\[
FRR = 0.1fB \left[ 4 - \frac{B}{D} \right]
\]
for beams exposed to fire on 3 sides,

\[
FRR = 0.1fB \left[ 3 - \frac{B}{D} \right]
\]
for columns exposed to fire on 4 sides,

\[
FRR = 0.1fB \left[ 3 - \frac{B}{2D} \right]
\]
for columns exposed to fire on 3 sides,

- \( f = \text{load factor shown in Figure 2.11.2.A} \)
- \( B = \text{dimension of the smaller side} \)
- \( D = \text{dimension on the larger side} \)
Empirical FRR Calculation Method:
Appendix D-2.11. Glued-Laminated Timber Beams and Columns

2) The factored resistance of a beam or column shall be determined by using the specified strengths in CAN/CSA-O86, "Engineering Design in Wood."

\[ K = \text{effective length factor (CAN/CSA-O86)} \]
\[ L = \text{unsupported length of column} \]

*K = \text{effective length factor (CAN/CSA-O86)}
\[ L = \text{unsupported length of column} \]

*In the case of beams, use bending moment in place of load."
Empirical FRR Calculation Methods: Mass Timber Beams and Columns

Additional Information:

• American Wood Council (www.awc.org)
  • \textit{DCA 2 - Design of Fire-Resistive Exposed Wood Members}
  • \textit{TR10 - Calculating the Fire Resistance of Exposed Wood Members}
Empirical FRR Calculation Methods: CSA O86-2014
Large Cross-section Wood Elements (Mass Timber)

5.6 Fire resistance
Where applicable, design for fire resistance shall be in accordance with the NBCC.

Note: See Annex B for a methodology that provides useful information in the development of a proposal for an alternative solution to meet the objectives of the NBCC.
Empirical FRR Calculation Methods: CSA O86-2014
Large Cross-section Wood Elements (Mass Timber)

Annex B (informative)
Fire resistance of large cross-section wood elements

Notes:
(1) This informative (non-mandatory) Annex has been written in normative (mandatory) language to facilitate adoption where users of the Standard or regulatory authorities wish to adopt it formally as additional requirements to this Standard.

(2) When this informational (non-mandatory) Annex is not otherwise adopted formally by building regulatory authorities as additional requirements to this Standard, the methodology presented provides information that may be useful to users of the Standard in the development of a proposal for an alternative solution to meet the objectives of the National Building Code of Canada (NBCC).

Materials:
- Solid-sawn timber
- Glued-laminated timber (glulam)
- Structural composite lumber (SCL)
- New (2017): Cross-laminated timber (CLT)
Additional Resources:


Thank You