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| **0Client Name:** | **TVA Architects** | | |
| Project Number: | C53-006A | Date: | 4/30/2020 |
| Distribution: | Terry Whitehall, Jody Orrison – Portland BDS<br>Corey Stanley, Nate Takara – Portland Fire & Rescue<br>Bob Thompson, John Jamiel – TVA Architects<br>Carl Baldassarra, Garner Palenske – Wiss Janney, Elstner Associates | | |
| Subject: | Fire Analysis and Appeal of Type IV-B Interior Protection | | |
| Referenced Codes and Standards: | • 2019 Oregon Structural Specialty Code (OSSC)<br>• OSSC Appendix P, Tall Wood Buildings<br>• 2016 Portland Fire Code<br>• NFPA 13, Standard for the Installation of Sprinkler Systems, 2016<br>• NFPA 550, Guide to the Fire Safety Concepts Tree, 2017 | | |
| Building Name: | Flatworks Building – 234 SE Grand Avenue | | |
| Room Area Affected: | Whole Building | | |
| Appendix: | Appendix A – Code Excerpts<br>Appendix B – Background Discussion | | |

# 1 OVERVIEW

A new 8-story mass timber building in southeast Portland is proposed. The new building has a finished height of 103-ft, which exceeds the limit for Type IV-C construction in new OSSC Appendix P (2019). As such, construction of the new building is proposed to meet all of the requirements for Type IV-B construction except for the limitation the percentage of exposed timber on the ceiling surfaces.

The new mass timber requirements in OSSC Appendix P limit the exposed area of wood surfaces on walls and ceilings to limit the contribution of the wood elements in a compartment fire. Code Unlimited conducted a review of the large-scale, post-flashover tests conducted in support of the ICC Ad Hoc Committee on Mass Timber Construction's consideration of these new requirements. Fire science experts with experience testing various mass timber configurations advised Code Unlimited that exposed combustible linings play a very small, although not conclusively insignificant role in early fire growth and spread.

Based on the conditions presented by this project, Code Unlimited proposes enhancements to sprinkler density, coverage area, and water supply reliability to satisfy the intent of the code by alternate means. We believe the added protection satisfies the intent of the code with respect to safety and reliability by ensuring the automatic sprinkler system is capable of responding to any added contribution to the fire from the exposed combustible ceiling.

# 2 PROJECT OVERVIEW

TVA Architects is designing an eight-story, sprinkler-protected 103-foot-high, mass timber high-rise office building with automatic smoke detection and voice annunciation at 234 SE Grand Avenue in Portland, Oregon. The proposed occupancies include below-grade and at-grade parking, grade-level retail and above-grade business use groups. The building will conform to 2019 OSSC including special use and occupancy requirements governing high-rise buildings.

The building will comply with the requirements of Type IV-B construction of the OSSC Section P602.4.2, except that the exposed surface area of the wood ceilings and beams will exceed the 20 percent allowed by Section P604.2.2.3. The mass timber ceiling, including the beams, is proposed to be fully exposed. The design will include 3-hour fire-resistance-rated concrete columns and 3-hour fire-resistance-rated concrete load-bearing walls. All interior walls and partitions will be of non-combustible construction.

TVA Architects and Code Unlimited met with representatives of Portland BDS and Portland Fire & Rescue on December 17, 2019 to discuss approaches to evaluating the comparative performance of Type IV-B and Type IV-C construction as it relates to a possible appeal to permit more exposed CLT than otherwise allowed for Type IV-B construction.

As previously stipulated, the fire resistance ratings of the structural floor-ceiling assembly and the beams will be met. The proposed alternative is to the area of exposed wood ceilings and beams. The restriction on the percent area that is exposed is intended to limit fire growth and spread. The purpose of this requirement is to allow:

- Occupants to safely evacuate the building,
- Firefighters to respond, arrive, enter, and establish interior firefighting operations; and
- Firefighters to achieve fire control.

For the purpose of the analysis performed by Code Unlimited, these qualitative considerations are considered in the context of NFPA 550 and the “manage fire impacts” path to achieving fire safety objectives.

*Figure 1: North-south section facing east.*

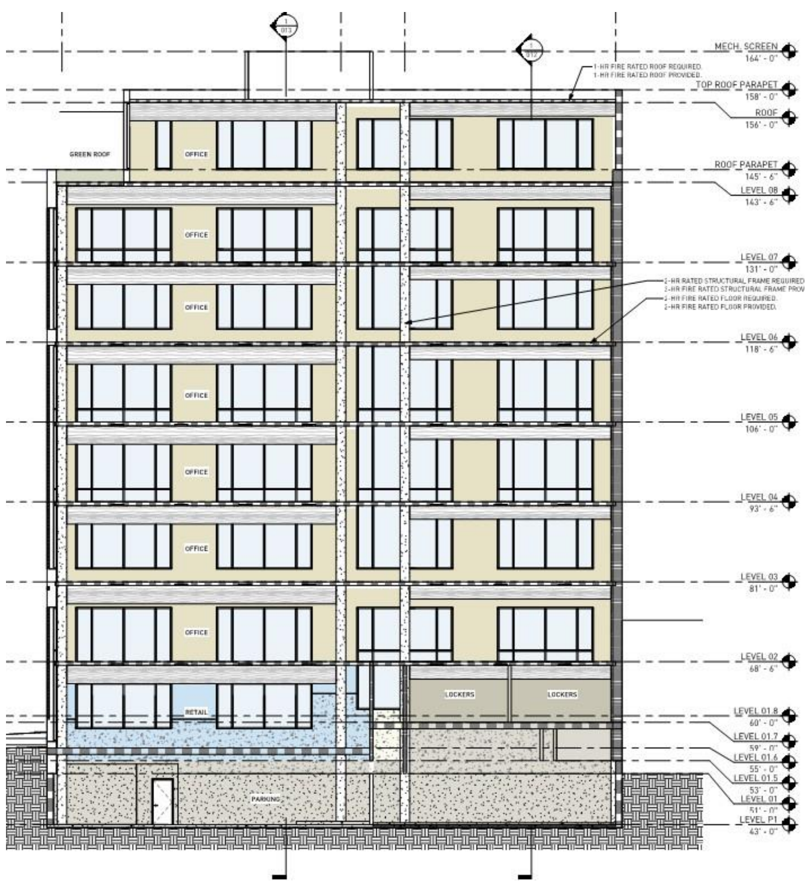


*Figure 2: East-west building section.*

# 3 BUILDING DESCRIPTION

The structural design for the building proposed by KPFF includes the following:

- Columns and load-bearing walls – reinforced concrete columns and load-bearing walls with 3-hour fire-resistance ratings are provided to support the glulam beams
- Beams – 12.25 × 25.5-inch for 33-ft span and 12.25 x 33-inch for 41-ft span glulam beams, spaced 10 feet on center, extend east-west from wall-to-wall except for a section identified for mechanical system laterals running north-south from the core.
- Floor – A 4⅛-inch thick CLT panel with at least 3-inch minimum concrete topping slab is designed to span between the glulam beams using the reduced 1.2DL+0.5LL load combination per ASCE 7-10 Section 2.5 overlay.
- No floor openings such as atria, exit access stairs, communicating stairs, escalators, or other unprotected vertical openings are planned.
- The interior partitions of this building beyond the common core areas will be undefined in the Shell-Core design permit package but the structural design, including beam depth and spacing, and the provision of other draft stops will be known and materially unchanged during tenant improvement.
- Draft stops will be provided about mid-building, which will separate the beam bays into two compartments to restrict lateral spread of the ceiling jet produced by a fire and limit smoke transport.

KPFF determined the fire resistance rating for glulam timber beams in accordance with the 2015 National Design Standard (NDS), Chapter 16 - Fire Design of Wood Members and the 2018 AWC Technical Report 10 – Calculating the Fire Resistance of Wood Members and Assemblies. Effective char depths are applied to the exposed faces of the beams, and the induced stresses on the reduced sections are verified to not exceed the allowable member stresses with appropriate modification factors applied. Additional tension zone laminations on the bottom faces of beams are also provided as required per ANSI 117 section 3.7. In addition, connections for glulam beams are to be designed and detailed to provide a fire resistance rating matching the beam.

Since the effective char depth for a 2-hour fire exposure on a CLT panel with 1 3/8” laminations is 3.8” per the NDS Table 16.2.1B and the CLT-3 panels are 4 1/8” thick, we will neglect any strength provided by the CLT panel and will design the concrete topping to have adequate strength to span between glulam beams. The concrete topping will be designed using ACI-318 and the LRFD load combination for extraordinary events of 1.2D + 0.5L per ASCE 7-16

# 4 CODE REQUIREMENTS

OSSC Appendix P incorporates new provisions governing tall wood buildings, also known as mass timber. These provisions expand recognition and acceptance of construction beyond the limitations formerly imposed on Type IV (heavy timber) buildings. Prior to consideration by the International Code Council's code change committee, the proposed materials and methods of construction were subjected to extensive large-scale fire testing.[1]

The tests performed by the U.S Department of Agriculture under the guidance of the National Research Council of Canada and conducted at the U.S. Bureau of Alcohol, Tobacco, Firearms, and Explosives fire test laboratory in Greenbelt, MD assessed the fire resistance of mass timber construction with and without automatic sprinkler protection. The unsprinklered tests assessed the performance of the completed construction under post-flashover conditions and did not specifically quantify other properties of such construction, such as contributions of exposed CLT panels to fire growth and spread. Likewise, these tests evaluated the proposed construction under exposure to residential fuel loads, with fast fire growth rates and fuel concentrations typically greater than those encountered in business occupancies.

In each of the fire tests, the extent of exposed CLT was varied in accordance with specifications provided by the Ad Hoc Committee on Mass Timber Construction. The variations in the percentage of exposed wall and ceiling areas were selected to limit potential damage to the test facility yet became the benchmarks for the categories of Type IV construction subsequently established.

Although covering CLT with a minimum of two layers of 5/8-in gypsum wallboard reduces the contribution of mass timber elements to combustion, it also limits the rate at which these elements char and as such increases the relative fire resistance of protected elements compared to unprotected elements. The contribution of exposed surfaces to flame spread as it relates to fire growth is addressed by the requirements of OSSC §803, not the provisions of Appendix P or other requirements specific to mass timber construction.

OSSC Appendix P establishes three new subcategories of mass timber construction, each corresponding to different area/height limitations and additional limitations on the proportion of exposed (unprotected) mass timber elements allowed for interior wall and ceiling construction. OSSC Table AP104.3 limits the height of buildings of Type IV-C construction to 85-ft. The allowable number of stories varies depending upon intended use. OSSC Section P602.4.3.2 does not limit the areas of interior exposed mass timber elements for buildings of Type IV-C construction.

[1] Of interest, the National Building Code of Canada (NBCC), developed in partnership with and published by the National Research Council of Canada, neither defines mass timber construction types by the degree of exposed surface area nor does it limit the exposed interior surface area beyond the requirements associated with interior finish flame spread, which appear similar to those in OSSC §803.

Because the proposed design height is 103-ft, construction of Type IV-B would be required to satisfy the allowable height limits of OSSC Table AP104.3. This type of construction permits building heights up to 180-ft and the allowable number of stories varies depending upon intended use. For Type IV-B construction, OSSC Section P602.4.2.2.2 restricts the area of exposed (unprotected) interior mass timber elements to 20 percent of the ceiling (including beams) or 40 percent of the walls (including columns), or a combination of ceilings and walls using a sum of the ratios calculation, in any dwelling or fire area. Areas in excess of this must be protected by a noncombustible thermal barrier for 80 minutes consisting of two (2) layers of 5/8 inch gypsum wallboard or a material having an equivalent degree of thermal resistance. OSSC Section P602.4.2.2.3 allows for the proportional distribution of exposed wall and ceiling areas.

# 5 COMPLIANCE SUMMARY

The following table compares minimum requirements with the proposed design:

| ***Code Requirement*** | ***Type IV-B*** | ***Proposed Design*** |
|---|---|---|
| Building Height | 180 feet | 103 feet |
| **Fire resistive rating for building elements** | | |
| Primary Structural Frame | 2 hours (allowed to be combustible) | 3 hours (noncombustible concrete columns)<br>2 hours glulam beams |
| Bearing Walls | 2 hours | 3 hours (noncombustible concrete) |
| Floor Construction | 2 hours with 1” non-combustible topping | 2 hours with at least 3” noncombustible topping. |
| **Interior protection requirements** | | |
| Unprotected portion of mass timber ceiling including beams | Up to 20%* | Up to 100% (Allowed for Type IV-C but not IV-B. See performance design criteria.) |
| Unprotected walls including attached columns | Up to 40%* | 0% |
| *Limit for ceilings and walls cannot exceed the sum of the ratio of 1.0. | | |
| Draft stop ceiling design | None | 25.5 and 33-inch deep beams form natural draft stops that limit lateral fire growth and a framed sheetrock (or equal) draft stop to breach each beam bay into two sections. (see detailed discussion below). |
| **Unprotected vertical opening between floors** | | |
| Unenclosed exit access stairs | Allowed | Not proposed |
| Escalators | Allowed | Not proposed |
| Floor openings between two stories | Allowed | Not proposed |

| | | |
|---|---|---|
| Atrium | Allowed | Not proposed |
| **Automatic sprinkler system – Office Space** | | |
| Coverage per sprinkler | 225-ft² | 120-ft² |
| Design density | 0.10 gpm/ft² | 0.125 gpm/ft² |
| Remote demand area | 940-ft² | 1,500-ft² |
| **Fire protection water supply** | | |
| Secondary water supply | Not required | Two feeds and redundant fire pumps provided |
| On site water storage tank | Required | Single 22,500-gal tank provided |

# 6 FIRE GROWTH MECHANISMS

Discussions with prominent fire scientists and code experts[2] regarding the fire tests conducted to support new mass timber regulations in the IBC and other codes revealed important considerations that guided Code Unlimited's assessment of this project.

- First, Dr. Joseph Su and others confirmed the tests were designed and conducted first and foremost to assess the properties of the proposed construction under fully developed fire conditions and does not provide sufficient evidence to determine the specific contributions of individual elements of exposed CLT to fire growth and spread during the fire.
- Second, assessments of the potential size, scope, and speed of the fires in each test scenario were performed to ensure the test scenarios did not overwhelm or damage the test equipment. As such, the contributions of individual elements to fire growth at any single point in the fire development and spread process were not considered apart from the contribution each had on the test as a whole.
- Finally, experience conducting tests beyond those associated with the Ad Hoc Committee process suggest individual exposed elements may contribute to fire growth and spread in the earliest stages of fire development but these effects are quickly overwhelmed if not inundated by the growing and spreading fire itself and any ventilation limits or other features or controls that may inhibit fire development or spread.

[2] Code Unlimited staff conducted interviews with Dr. Joseph Su of the National Research Council of Canada, Dr. Kevin McGrattan of the U.S. National Institute of Science and Technology, and Dr. Michael Spearpoint, formerly of BRE and the University of Canterbury and presently chief research officer with OFR Fire Consultants in Manchester, UK, during the course of this project to obtain advice regarding the application of fire modeling tools, namely the Fire Dynamics Simulator (FDS), to the assessment of exposed mass timber elements. Their advice included important insights into prior testing and ongoing work to validate applications of FDS to fire spread and development.

This final point is particularly salient in relation to this project. An incipient fire could expose the unprotected ceiling and beams to sufficient radiant and convective heat to induce pyrolysis.

However, with autoignition temperatures of approximately 450°F, these elements are extremely unlikely to ignite before quick-response automatic sprinklers with an operating temperature between 155 and 175°F operate.

# 7 PROPOSED ALTERNATE

The activation and operation of automatic sprinklers is crucial to achieve successful fire outcomes in all high-rise buildings regardless of construction. The height of this building will have no effect on possible fire outcomes or fire service intervention strategies. However, variations in construction to satisfy client requirements, that is, the percentage of exposed combustible wall and ceiling linings, warrant additional measures to ensure performance equivalent to that required for buildings of this height. As such, it is worth noting that in the absence of automatic sprinkler protection, uncontrolled fires pose a significant threat to building occupants and firefighters alike regardless of construction type.

All high-rise construction under current building codes is predicated upon reliable automatic sprinkler system performance. Consequently, the building code incorporates additional requirements for these structures to ensure the sprinkler systems have dependable water supplies, remain unimpaired during construction and building alterations, and are sufficiently independent of standpipes to ensure firefighters can manage any fires that do occur. Likewise, certain requirements that might otherwise be relaxed or waived due to the installation of automatic sprinklers in other situations remain mandatory in high-rise construction.

## 7.1 Increased Design Density

The use of mass timber elements in the fashion proposed will require a sprinkler system design suitable for obstructed construction as described in NFPA 13, §8.5.5, §8.6.4.1.2, and §8.6.5.2. This will reduce the spacing between branch lines, which will prevent sprinklers from being spaced to achieve the maximum coverage area per sprinkler usually allowed for light hazard occupancies such as offices. The dimensions of the proposed structural bays will limit the coverage area per sprinkler to less than 120-ft². Even at the minimum end-head pressure permitted by NFPA 13, §23.4.4.11.1 (7 psi) for a ½-inch (k=5.6) QR-SSU sprinkler, this will result in a design density at least 25 percent higher than that required for a light hazard occupancy.

$$q_s = k\sqrt{p}$$

Where: $q_s$ = flow from a single sprinkler
k = orifice coefficient
p = pressure

At a minimum design pressure of 7-psi, a single sprinkler will flow 15-gpm (see equation above). At this pressure, a sprinkler with a coverage area of 225-ft² will deliver a density less than that required for light hazard occupancies – 0.10 gpm/ft². The minimum required flow rate at the maximum allowable coverage area would require a minimum pressure of 16.1 psi at each sprinkler. At the proposed coverage area of 120-ft² per sprinkler, this pressure would yield a density of 0.19 gpm/ft²; at the minimum pressure of 7-psi a minimum density of 0.125 gpm/ft² would be achieved. Consequently, the design basis for the proposed sprinkler system exceeds that required by at least 25 percent.

## 7.2 Increased Sprinkler Discharge Pressure

The requirement to size the water supply and fire pump for the greater of the standpipe or automatic sprinkler demand will ensure the combined water supply is designed to deliver not less than 750-gpm at 100-psi. As such, the pressure available at individual sprinklers in the most remote area is likely to be much higher than the minimum required to satisfy the minimum design density for the control-mode density/area (CDMA) design method. At a discharge pressure of 30-psi, each sprinkler would discharge 30-gpm for an effective density of 0.25 gpm/ft².

## 7.3 Increased Design Demand Area

Code Unlimited proposes that the design of the automatic sprinkler system in the building be based on a minimum density of 0.125 gpm/ft² over the most remote 1,500-ft² demand area with no reduction for the use of quick-response sprinklers as permitted by NFPA 13, §11.2.3.2.3.1. (A design area reduction of approximately 37 percent is allowed based on ceiling height.) Notwithstanding the absence of direct evidence that exposed ceiling linings contribute to fire growth and spread in the early stages of fire development, the added sprinkler density and area of operation provide an added measure of safety.

## 7.4 Secondary Water Supply

OSSC §403.3.3 requires a secondary water supply for high-rise buildings in areas designated as seismic categories C, D, E, or F. As such, the proposed design incorporates a water storage tank with a capacity not less than 22,500-gal with an automatic refill from two separate connections to the municipal water distribution system sized to satisfy the design demand of the automatic sprinkler system plus inside hose allowance.

| Design Basis | Density (gpm/ft²) | Area (ft²) | Hose Stream (gpm) | Duration (mins) | Capacity (gals) |
|---|---|---|---|---|---|
| Sprinkler (LH-CDMA minimum) | 0.10 | 1,500 | 100 | 30 | 7,500 |
| Sprinkler (LH-design density) | 0.125 | 1,500 | 100 | 30 | 8,625 |
| Sprinkler (LH- density at 30-psi) | 0.25 | 1,500 | 100 | 30 | 14,475 |
| Sprinkler (OH1 – parking/retail <8-ft) | 0.15 | 1,500 | 100 | 60 | 19,500 |
| Standpipe | N/A | N/A | 750 | 30 | 22,500 |

A storage tank of this capacity will supply the anticipated sprinkler system demand (at 30-psi discharge pressure) plus inside hose stream allowance for a period not less than 45-mins for office levels which exceeds the requirements for light hazard occupancies by 50 percent. It will also satisfy the requirement for parking and retail spaces.

## 7.5 Water Supply Reliability

Although not required for high-rise buildings less than 16 stories per the City of Portland Fire Design Manual or buildings less 420-ft in height per the OSSC, the City has expressed concerns about water supply reliability in light of the dependence on automatic sprinkler performance to achieve equivalent fire safety outcomes. As such, Code Unlimited proposes two fire service feeds and two fire pumps. Both feeds will supply the water storage tank, which in-turn will supply the two fire pumps.

One fire service feed will come from the public main in SE Ash and the other from the public main in SE Pine. Both feeds will supply the secondary water storage tank with supply at a rate not less than the rate of flow required to supply the standpipe system demand and provide two independent sources of city water to the fire pumps at all times. A normally closed bypass will also be provided around the fire water tank from the city supplies to both fire pumps. The 22,500-gallon tank includes 15% of additional capacity to account for sprinkler system overflow (22,500/19,500 = 1.15).

Both fire pumps will be 750-gpm electric motor-driven and sized to deliver a minimum of 100-psi at the top-most standpipe outlet. Both pumps will be connected to emergency power from the standby generator. The fire pump controller will be arranged to prevent both pumps from running simultaneously when supplied with emergency power from the standby generator so that the generator may be sized to serve one pump.

# 8 SUMMARY AND CONCLUSIONS

The use of mass timber for high-rise construction has proven controversial due to concerns about the combustibility of primary structural elements. These concerns have focused attention on the fire-resistant properties of mass timber but have not fully quantified the specific contribution of these elements themselves to the scope or scale of fires in buildings. Nevertheless, concerns about the contribution of exposed combustible linings to fire development have been taken seriously with respect to this project.

Previous testing in support of the code changes that resulted in the adoption of OSSC Appendix P indicate that the structural performance of Types IV-B and IV-C construction is the same. Likewise, they suggest the exposed surface area of mass timber elements contribute little to the fire performance of these structures. Nevertheless, these new code requirements allow for different building heights depending upon the exposed (unprotected) surface area of mass timber elements. The observations of experts familiar with large-scale fire testing of mass timber construction elements have led Code Unlimited to conclude the exposed surface area of combustible linings have a marginal influence on fire development.

Code Unlimited is confident that the enhanced automatic sprinkler protection and other features proposed in this report are at least equivalent in safety and reliability to the limitations on exposed ceiling area for Type IV-B construction and as such satisfy the intent of the code. Therefore, we seek approval of the proposed conditions consistent with the authority granted to the building official by OSSC §104.11.

*timber* elements shall be protected in accordance with Section P602.4.1.2.

**P602.4.2 Type IVB.** Building elements in Type IVB construction shall be protected in accordance with Sections P602.4.2.1 through P602.4.2.6. The required *fire-resistance rating* of noncombustible elements or *mass timber* elements shall be determined in accordance with Section 703.2 or 703.3 of the *Building Code*.

**P602.4.2.1 Exterior protection.** The outside face of exterior walls of *mass timber* construction shall be protected with *noncombustible protection* with a minimum assigned time of 40 minutes, as determined in Section P722.7.1(1). All components of the *exterior wall* covering shall be of noncombustible material except water-resistive barriers having a peak heat release rate of less than 150 $kW/m^2$, a total heat release of less than 20 $MJ/m^2$ and an effective heat of combustion of less than 18 MJ/kg, as determined in accordance with ASTM E1354, and having a flame spread index of 25 or less and a smoke-developed index of 450 or less, as determined in accordance with ASTM E84 or UL 723. The ASTM E1354 test shall be conducted on specimens at the thickness intended for use, in the horizontal orientation and at an incident radiant heat flux of 50 $kW/m^2$.

**P602.4.2.2 Interior protection.** Interior faces of all *mass timber* elements, including the inside face of exterior *mass timber* walls and *mass timber* roofs, shall be protected, as required by this section, with materials complying with Section 703.5 of the *Building Code*.

**P602.4.2.2.1 Protection time.** *Noncombustible protection* shall contribute a time equal to or greater than times assigned in Table P722.7.1(1), but not less than 80 minutes. The use of materials and their respective protection contributions listed in Table P722.7.1(2) shall be permitted to be used for compliance with Section P722.7.1.

**P602.4.2.2.2 Protected area.** All interior faces of all *mass timber* elements shall be protected in accordance with Section P602.4.2.2.1, 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 P602.4.2.2.4 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 percent of the floor area in any dwelling unit or fire area.
2. Unprotected portions of *mass timber* walls, including attached columns, shall be permitted and shall be limited to an area equal to 40 percent of the floor area in any dwelling unit or fire area.
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 P602.4.2.2.3.
4. *Mass timber* columns and beams that 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.

**P602.4.2.2.3 Mixed unprotected areas.** In each dwelling unit or fire area, where both portions of ceilings and portions of walls are unprotected, the total allowable unprotected area shall be determined in accordance with Equation P6-1.

$$(U_{tc}/U_{ac}) + (U_{tw}/U_{aw}) \leq 1 \qquad \textbf{(Equation P6-1)}$$

where:

$U_{tc}$ = Total unprotected *mass timber* ceiling area.

$U_{ac}$ = Allowable unprotected *mass timber* ceiling area conforming to Section P602.4.2.2.2, Exception 1.

$U_{tw}$ = Total unprotected *mass timber* wall areas.

$U_{aw}$ = Allowable unprotected *mass timber* wall area conforming to Section P602.4.2.2.2, Exception 2.

**P602.4.2.2.4 Separation distance between unprotected mass timber elements.** In each dwelling unit or fire area, unprotected portions of *mass timber* walls and ceilings shall be not less than 15 feet from unprotected portions of other walls and ceilings, measured horizontally along the ceiling and from other unprotected portions of walls measured horizontally along the floor.

**P602.4.2.3 Floors.** The floor assembly shall contain a noncombustible material not less than 1 inch in thickness above the *mass timber*. Floor finishes in accordance with Section 804 of the *Building Code* shall be permitted on top of the noncombustible material. The underside of floor assemblies shall be protected in accordance with Section P602.4.1.2.

**P602.4.2.4 Roofs.** The interior surfaces of roof assemblies shall be protected in accordance with Section P602.4.2.2 except in nonoccupiable spaces, they shall be treated as a concealed space with no portion left unprotected. Roof coverings in accordance with Chapter 15 of the *Building Code* shall be permitted on the outside surface of the roof assembly.

**P602.4.2.5 Concealed spaces.** Concealed spaces shall not contain combustibles other than electrical, mechanical, fire protection, or plumbing materials and equipment permitted in plenums in accordance with Section 602 of the *Mechanical Code* and shall

## Appendix B – Background Discussion

Limitations on the exposed interior surface area of mass timber walls and ceilings seek to provide additional insulation to protect combustible structural elements exposed to uncontrolled (post-flashover) compartment fires. The testing conducted to support the adoption of these code provisions was performed by the U.S. Department of Agriculture, Forest Products Laboratory.[1] These tests showed little correlation between the percentage of exposed mass timber and peak heat release rates (PHRR) or total heat release rates (THRR) when the percentage of these elements exposed was changed from test to test.

These results are consistent with the understanding that the main source of combustibles in building fires are the contents, rather than the structure. Only during the later stages of a structure fire, when the contents have been consumed, does the combustibility of the structure become a significant source of fuel for the fire.

Communication with Susan Jones of Atelier Jones Architects, who served on the Tall Wood Buildings Ad Hoc Committee, indicates the 20 and 40 percent limits for exposed mass timber in ceilings and walls were originally conceived as a means of gaining acceptance of the concept in early negotiations over the code change proposal, before the final test report was published and publicly available. The limits were based on the observation of acceptable performance in early fire tests, which only coincidentally exposed 20 percent of the ceiling and 40 percent of the walls.

The final report indicates mass timber construction performed better than expected when the test protocols were developed. Researchers noted that even if the entire mass timber surface was exposed, the tests would have performed acceptably and met the test objectives for burn-through resistance. This suggests such limits may be modified or rescinded in future editions of the code.

REGISTERED PROFESSIONAL ENGINEER
94607PE
OREGON
MAR 12, 2019
MARK DANIEL MURRAY
EXPIRES: 12/31/20

[1]Zelinka, SL and others (2018). Compartment Fire Testing of a Two-Story Mass Timber Building, General Technical Report FPL-GTR-247. Madison, WI: U.S. Department of Agriculture, Forest Products Laboratory