Proper fire protection can increase the allowable size of wood-frame buildings. In fact, the International Building Code (IBC) allows larger wood-frame structures than designers may think possible.

The IBC allows designers to increase the allowable size of wood-frame buildings through larger floor areas and building heights with sprinkler systems and use of open spaces around the building. By using sprinklers and fire-resistance-rated wood wall and floor/ceiling assemblies, allowable area can be increased dramatically or an additional floor can be added. Open frontage around the building also allows increased building size. For some building types, provisions in the IBC allow for unlimited building area when an automatic sprinkler system and minimum setbacks are provided.

Materials and assemblies used for fire-resistance-rated construction and separation of adjacent spaces are covered in Chapter 7 of the IBC.

**Fire Protection and Building Size**

Among the techniques used to increase allowable building size, designers may add sprinklers, break up the area with fire-resistance-rated walls, increase property line setbacks and/or specify a building assembly with more fire resistance.

For most building occupancies, sprinklers allow an area increase of 200 percent for multi-story buildings and 300 percent for single-story structures. Type III buildings can be up to five stories when sprinklers are included. In addition, open frontage allows an increase of 75 percent to the baseline tabulated area.

If designers use fire-retardant-treated (FRT) wood in exterior bearing walls, Type V structures can be increased to over 50,000 and Type III structures can be more than 100,000 square feet per floor.

Designers can use IBC Section 507, unlimited building size provisions, to gain further advantage.

- For example, the allowable area of a two-story Group B, F, M or S building is unlimited when the building is equipped throughout with an automatic sprinkler system, and surrounded and adjoined by open space of at least 60 feet.
- The IBC includes additional provisions for one-story buildings. One-story Group B, F, M or S buildings or one-story Group A-4 buildings (except Type V construction) allow unlimited size when a 60-foot spatial separation to the property line is provided and the building is sprinklered. Additional exceptions apply; they are listed in Section 507.3 of the 2006 IBC.
Wood Is Allowed in Noncombustible Construction

It’s important to note that wood can be used in noncombustible construction and in structures that require noncombustible exterior walls.

- Type I and II construction require noncombustible materials, but Section 603.1 of the IBC permits use of fire-retardant-treated (FRT) wood in Type I and II structures for a number of applications.
- While Type III requires noncombustible materials for exterior walls, Section 602.3 permits FRT wood framing within exterior wall assemblies with a two-hour rating or less.
- Type IV (Heavy Timber) uses noncombustible materials for exterior walls and heavy timber for interior framing. Again, Section 602.3 allows FRT wood framing within exterior wall assemblies with a two-hour rating or less.
- Type V construction allows any material permitted by code, including untreated wood.

Wood Meets Fire Resistance Requirements Inside and Out

Heavy Timber (Type IV) construction offers an effective design option. Since large wood members char when exposed to fire, surface char insulates the member so it can continue to support its load, increasing the amount of time before the member fails.

The IBC requires that wood used as an interior finish material meet flame-spread requirements. Many wood species are appropriate for applications requiring low flame-spread ratings.

In addition, the State of California requires that wood products used on building exteriors in Wildland-Urban Interface (WUI) areas, which cover much of the state, pass specific fire ignition tests. Many wood products meet the requirements of California Building Code Chapter 7A for construction in WUI areas, and are accepted in the California State Fire Marshal WUI Products Handbook.

Fire-Retardant-Treated Wood

Fire-retardant treatment limits flame spread and prevents progressive combustion over time. FRT wood, covered under IBC Section 2303.2, can be used in Type I and II roof assemblies, which are otherwise considered to be noncombustible types of construction. According to Section 603.1, Type II construction allows the use of FRT lumber and plywood in non-bearing exterior walls where fire rating is not required or in non-bearing partitions where required fire rating is two hours or less. Type III and IV buildings permit the use of FRT wood within exterior walls with required fire ratings of two hours or less.

Manufacturers use stabilizers to ensure longevity of fire retardant chemicals. In addition, changes in formulation now allow some FRT lumber to be exposed to moisture. These applications are covered under ASTM D 2898 (Standard Practice for Accelerated Weathering of Fire-Retardant-Treated Wood for Fire Testing) and ASTM ES 20 (Test Method for Evaluating the Mechanical Properties of Fire-Retardant Treated Softwood Plywood Exposed to Elevated Temperatures).

Rated Wall/Ceiling Assemblies

Rated assemblies consist of specific wall/floor/ceiling component combinations that are used to prevent the spread of fire for a specific time period—typically one or two hours. Scientists determine assembly ratings through tests that approximate actual fire conditions. The standard for measuring fire resistance is ASTM Test Method E-119, Standard Test Methods for Fire Tests of Building Construction and Materials. The IBC also permits determination of fire-rated wood-frame floors, roofs and load-bearing and non-bearing walls by calculation, described below, as an alternate to tested assemblies.

There are numerous fire-rated assemblies suitable for non-residential building which combine wood-frame construction with protective materials such as gypsum wallboard—including one- and two-hour-rated wood-frame wall and floor/ceiling systems. These assemblies are listed in the Underwriters Laboratories’ Fire Resistance Directory, the Intertek Testing Services’ Directory of Listed Products, the Gypsum Association’s Fire Resistance Design Manual and other sources, and are accepted as rated construction by the IBC. Other proprietary systems are also recognized by the IBC under individual evaluation reports.

Rated wall, roof and floor assemblies are also detailed in APA – The Engineered Wood Association’s Fire-Rated Systems and the American Wood Council’s Fire-Rated Wood Floor and Wall Assemblies. Prescriptive fire-resistance-rated building elements are listed in IBC Tables 720.1(1), Minimum Protection of Structural Parts Based on Time Periods for Various Noncombustible Insulating Materials; 720.1(2), Rated Fire-Resistance Periods for Various Walls and Partitions; and 720.1(3), Minimum Protection for Floor and Roof Systems.

Component Additive Method

The other method used to determine an assembly’s fire resistance is the Component Additive Method, also covered in Chapter 7 of the IBC. This method allows engineering analysis based on comparison of building element designs having fire-resistance ratings set forth in ASTM E-119, Standard Test Methods for Fire Tests of Building Construction and Materials. It describes the fire resistance (in minutes) provided by individual components and structural members. While total resistance may vary, depending on dimensions, spacing and other attributes, the overall fire resistance is cumulative; the resistance of each component in an assembly is added together to determine total resistance.
**Designing for Fire Protection**

**Component Minutes of Resistance**

- 2x4 wood studs, 16 inches on center: 20 minutes each or one layer 5/8-inch Type X gypsum board: 25 minutes
- Total: 40 minutes

**Time Assigned to Protective Membranes**

<table>
<thead>
<tr>
<th>Description of Finish</th>
<th>Time, min.</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8-inch Douglas fir plywood, phenolic bonded</td>
<td>5</td>
</tr>
<tr>
<td>1/2-inch Douglas fir plywood, phenolic bonded</td>
<td>10</td>
</tr>
<tr>
<td>5/8-inch Douglas fir plywood, phenolic bonded</td>
<td>15</td>
</tr>
<tr>
<td>3/8-inch gypsum board</td>
<td>10</td>
</tr>
<tr>
<td>1/2-inch gypsum board</td>
<td>15</td>
</tr>
<tr>
<td>5/8-inch gypsum board</td>
<td>20</td>
</tr>
<tr>
<td>1/2-inch Type X gypsum board</td>
<td>25</td>
</tr>
<tr>
<td>5/8-inch Type X gypsum board</td>
<td>40</td>
</tr>
<tr>
<td>Double 3/8-inch gypsum board</td>
<td>25</td>
</tr>
<tr>
<td>1/2 + 3/8-inch gypsum board</td>
<td>35</td>
</tr>
<tr>
<td>Double 1/2-inch gypsum board</td>
<td>40</td>
</tr>
</tbody>
</table>

**Time Assigned to Wood-Frame Components**

<table>
<thead>
<tr>
<th>Description of Frames</th>
<th>Time, min.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood studs, 16 inches on center</td>
<td>20</td>
</tr>
<tr>
<td>Wood joists, 16 inches on center</td>
<td>10</td>
</tr>
<tr>
<td>Wood roof and floor truss assemblies, 24 inches on center</td>
<td>5</td>
</tr>
</tbody>
</table>


**Example of Component Additive Analysis**

- Assume the building requires a one-hour rated wall.
- A 2x4 stud wall provides 20 minutes of resistance.
- A single layer of 5/8-inch gypsum board would be insufficient.
- Use two layers of 5/8-inch gypsum board or one layer of 5/8-inch Type X gypsum board to get a one-hour wall.

<table>
<thead>
<tr>
<th>Component</th>
<th>Minutes of Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>2x4 wood studs, 16 inches on center</td>
<td>20</td>
</tr>
<tr>
<td>Two layers of 5/8-inch gypsum board (20 minutes each) or one layer 5/8-inch Type X gypsum board</td>
<td>40</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>60</strong></td>
</tr>
</tbody>
</table>

**Fireblocking**

Fireblocking forms an effective barrier between floors and between a top story and roof or attic space, and is used to slow the passage of flames and hot gases through a structure. According to IBC Section 717.2, fireblocking is required in combustible construction to cut off vertical and horizontal concealed draft openings.

**Draftstopping**

Draftstopping prevents the flow of hot air and smoke through a structure. It is used to subdivide floor/ceiling assemblies according to IBC Sections 717.3 and 717.4. Draftstopping is installed so that horizontal floor areas do not exceed 1,000 square feet, and attics or concealed roof spaces are 3,000 square feet or less. Therefore, it is installed in dropped ceilings, plated floor trusses and roof framing.

**Typical draftstopping materials include:**

- 1/2-inch gypsum board
- 3/8-inch wood structural panels or particleboard
- 1-inch dimension lumber
- Other adequately supported materials, including fiberglass insulation, cement fiberboard, etc.

Draftstopping is not required in buildings equipped throughout with an automatic sprinkler system, in accordance with IBC Section 903.3.1.1. However, it may be required for compartmentalization.

**IBC Section 717.2.3** requires fireblocking at connections between horizontal and vertical spaces. In these instances, fireblocking must be provided at interconnections between concealed vertical stud wall or partition spaces and concealed horizontal spaces created by an assembly of floor joists or trusses, and between concealed vertical and horizontal spaces such as at soffits, drop ceilings, cove ceilings and similar locations. Fireblocking is also required where openings for penetrations occur, such as for plumbing, electrical or HVAC.

**Typical fireblocking materials include:**

- Nominal 2-inch lumber or two layers of 1-inch lumber
- 23/32-inch wood structural panels or 3/4-inch particleboard lapped at seams
- 1/2-inch gypsum
- Mineral wool or fiberglass insulation
- Some engineered rim boards
COMPARTMENTALIZATION OF FLOORS USING NFPA 13

Guidelines of NFPA 13, Standard for the Installation of Sprinkler Systems, allow non-residential building designers to take advantage of larger allowable heights and areas when the structure is sprinklered. However, concealed spaces enclosed wholly or partly by exposed combustible construction must be protected.

According to 2007 NFPA 13 Section 8.15.1.2.6, sprinklers may be required in concealed floor spaces if the area is larger than 160 cubic feet. To eliminate the need for sprinklers in concealed spaces, insulate the space with noncombustible insulation and use draftstopping to compartmentalize the area to less than 160 cubic feet.

Fire Walls

Non-residential building designers use fire walls to separate structures and occupancies, such as in multi-family structures. If a building exceeds the allowable size for wood-frame construction, designers may add an interior wall of the required fire-resistance rating (hours) to divide the space into smaller areas; each smaller area can then be considered a separate unit to meet code requirements. When fire walls are used, IBC Section 705.3 requires them to be of noncombustible material unless the building is of Type V construction.

Allowable Wood Use by Building Type

For more information on wood use by building type, see the following tables in the 2006 IBC.

<table>
<thead>
<tr>
<th>BUILDING TYPE</th>
<th>WOOD PERMITTED FOR USE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Heavy Timber</td>
</tr>
<tr>
<td>Type I and II</td>
<td>603.1, item 16</td>
</tr>
<tr>
<td>Type III</td>
<td>602.3</td>
</tr>
<tr>
<td>Type IV</td>
<td>602.4</td>
</tr>
<tr>
<td>Type V</td>
<td>602.5</td>
</tr>
</tbody>
</table>

Summary

Wood-frame construction offers the ideal choice in terms of cost, design versatility and ease of building. When fire protection must be considered, the IBC allows larger wood-frame structures than designers may think possible. Designers have many options when additional fire protection is required. Plus, wood has proven to outperform non-combustible materials in direct comparison fire tests, making it an ideal building material for non-residential construction.

SOURCES AND OTHER MATERIALS

APA—the Engineered Wood Association, www.apawood.org
  • Fire-Rated Systems

  • Fire-Rated Wood Floor and Wall Assemblies
  • Component Additive Method (CAM) for Calculating and Demonstrating Assembly Fire Endurance
  • Design of Fire Resistant Exposed Wood Members
  • Fire Design for Code Acceptance
  • Fireblocking and Draft Stopping
  • Fire Rated Wood Floor and Wall Assemblies
  • ANSI/AF&PA NDS-2005 – National Design Specification® (NDS®) for Wood Construction
  • ASD/LRFD Manual for Engineered Wood Construction

Western Wood Products Association, www.wwpma.org
  • Flame-Spread Ratings & Smoke-Developed Indices: Conformance with Model Building Codes
  • Tech Notes: California Fire Standards and Exterior Wood Products

FPInnovations – Forintek Division, www.forintek.ca
  • Fire Safety: A Wood-Frame Building Performance Fact Sheet (with the Canadian Mortgage and Housing Corporation)

Materials are also available via the WoodWorks Web site, in the sections titled Key Issues/Fire Protection and Publications and Resources/Presentations, www.woodworks.org

WoodWorks is an initiative of the Wood Products Council, which includes all of the major North American wood associations.