Fire Retardants and Truss Design

Overview
Introduction

• Fire retardant treatments (FRT) were developed to be applied to building materials, such as dimension lumber (FRTW) and plywood, to reduce the ability of the wood to fuel a fire.

• This treatment can allow FRT materials to be used as an acceptable alternative for building code requirements that specify noncombustible material in specific applications.
Introduction

- This treatment does not make wood a noncombustible material as defined by the building codes but it does reduce the ability of the treated wood to contribute significantly to the growth of a fire.
- The treatments must be carefully applied according to applicable standards.
Introduction

• While reducing the flammability of the wood, the fire retardant treatments may also cause degradation of the structural properties of the wood.

• Depending on the treatment, constructing buildings with FRTW may require:
  – A reduction in the design values of the wood materials, and/or
  – A reduction in the capacity of connectors used
Introduction

• There are FRT treatments for both interior and exterior use.
• The focus of this presentation is on interior use of FRTW, specifically when and how FRTW is permitted to be used in Truss design.
Introduction

• The wood or product is impregnated with a mineral salt or water insoluble organic retardant, generally a resin polymer or graft polymer that reduces the temperature of thermal degradation, which results in more charring and a decrease of flammable volatiles.
Introduction

• The Structural Building Components Association (SBCA) has developed this presentation to provide a clear perspective on the use of fire retardant materials used in construction.

• The analysis is based on code requirements developed by the International Code Council within the 2012 and 2015 *International Building Code (IBC)*, *ANSI/TPI I* as well as other industry resources.
Key Definitions

• **Building** - Any structure used or intended for supporting or sheltering any use or occupancy.

• **Building Code** - As it applies to a Building, any set of standards set forth and enforced by a Jurisdiction for the protection of public safety.

• **Combustible Material** - A material that does not qualify as noncombustible.

• **Noncombustible Material** - A material that, under the conditions anticipated, will not ignite or burn when subjected to fire or heat. Materials that pass ASTM E136 are considered noncombustible materials.
Key Definitions

• **Fire Retardant-treated Wood (FRTW)** - Wood products that, when impregnated with chemicals by a pressure process or other means during manufacture, exhibit reduced surface-burning characteristics and resist propagation of fire.

• **Truss** - Individual metal-plate-connected wood component manufactured for the construction of a Building.

• **Truss Designer** - Person responsible for the preparation of the Truss Design Drawings.
Key Definitions

- **Truss Manufacturer** - Person or organization engaged in the fabrication of Trusses.

- **Truss Design Drawings (TDD)** - The written, graphic and pictorial depiction of each individual truss shall be provided to the building official for approval prior to installation. Truss design drawings shall also be provided with the shipment of trusses delivered to the job site. Truss design drawings shall include, at a minimum, the information specified below: [2303.4.1.1]
Background

• Code requirements related to fire-retardant-treated wood are located in two places in the *IBC*.
  – Chapter 6 of the *IBC* details under what circumstances fire retardant treated wood is permitted, and the acceptable exceptions to these rules.
  – Chapter 23 governs the materials, design, construction and quality of wood members and their fasteners, including FRTW.
Background

- Requirements related to fire retardant materials specific to trusses are located in *ANSI/TPI 1 – Design Standard for the Manufacture of Metal Plate Connected Wood Trusses*.
  - Chapter 3 of *ANSI/TPI 1* stipulates that lumber treated with fire retardant chemicals must be identified and clearly marked by the manufacturer.
  - Chapter 6 of *ANSI/TPI 1* details the appropriate reductions for both lumber design values and metal connector plate values, including FRTW.
Background

- **AWC NDS** includes fire-retardant-treatment reductions for the material in Chapter 2 and connections in Chapter 11:
  - **2.3.4 Fire Retardant Treatment** The effects of fire retardant chemical treatment on strength shall be accounted for in the design. Adjusted design values, including adjusted connection design values, for lumber and structural glued laminated timber pressure-treated with fire retardant chemicals **shall be obtained from the company providing the treatment and redrying service**. Load duration factors greater than 1.6 shall not apply to structural members pressure-treated with fire retardant chemicals (see Table 2.3.2).
  - **11.3.5 Fire Retardant Treatment** Adjusted design values for connections in lumber and structural glued laminated timber pressure-treated with fire retardant chemicals **shall be obtained from the company providing the treatment and redrying service** (see 2.3.4). The impact load duration factor shall not apply to connections in wood pressure-treated with fire retardant chemicals (see Table 2.3.2).
Background

• *IBC* Chapter 6 addresses types of construction and includes information on when and where fire-retardant-treated wood may be used.
  – Fire retardant materials are permitted in non-bearing walls with low fire-resistance ratings and in roof construction and decking.
• *IBC* Chapter 23 Wood includes information regarding fire-retardant-treated wood.

• *IBC* Chapter 6 (2015)
• *IBC* Chapter 23 (2015)
Background

- **ANSI/TPI Chapter 3 – Quality Criteria for the Manufacture of Metal-Plate-Connected Wood Trusses** includes the requirement that fire retardant treated lumber must be clearly identified and marked.

- **3.4.4 Preservative Treatment Identification.**
- **3.4.5 Fire Retardant Identification**
- **§3.4.4 Preservative Treatment & §3.4.5 Fire Retardant Identification.**
  - § = commentary
Background

- ANSI/TPI Chapter 6 – Materials and General Design Considerations covers acceptable conditions for the FRTW before installation as well as possible design value reductions.
- Reductions may depend on ambient conditions at the building site.
  - Design values must be approved by local authorities.
- Truss engineering software can apply FRTW plate and lumber reductions

- 6.4.9.1 Fire Retardant Treated (FRT) Lumber.
- 6.4.9.2 Metal Connector Plates Installed in FRT
- §6.4.9 Chemically Treated Lumber.
- §6.4.9.2 Metal Connector Plates Installed in FRTW.
- § = commentary
### 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></td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Primary structural frame&lt;sup&gt;1&lt;/sup&gt; (see Section 202)</td>
<td>3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Bearing walls</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Exterior&lt;sup&gt;6,1&lt;/sup&gt;</td>
<td>3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Interior</td>
<td>3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Nonbearing walls and partitions</td>
<td></td>
<td></td>
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<tr>
<td>Exterior</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Nonbearing walls and partitions</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Interior&lt;sup&gt;6&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Floor construction and associated secondary members (see Section 202)</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Roof construction and associated secondary members (see Section 202)</td>
<td>1&lt;sup&gt;1/2,h&lt;/sup&gt;</td>
<td>1&lt;sup&gt;h,e&lt;/sup&gt;</td>
<td>1&lt;sup&gt;h,e&lt;/sup&gt;</td>
<td>0&lt;sup&gt;e&lt;/sup&gt;</td>
<td>1&lt;sup&gt;h,e&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

For SI: 1 foot = 304.8 mm.

<sup>a</sup> Roof supports: Fire-resistance ratings of primary structural frame and bearing walls are permitted to be reduced by 1 hour where supporting a roof only.

<sup>b</sup> Except in Group F-1, H, M and S-1 occupancies, fire protection of structural members shall not be required, including protection of roof framing and decking where every part of the roof construction is 20 feet or more above any floor immediately below. Fire-retardant-treated wood members shall be allowed to be used for such unprotected members.

<sup>c</sup> In all occupancies, heavy timber shall be allowed where a 1-hour or less fire-resistance rating is required.

<sup>d</sup> Not less than the fire-resistance rating required by other sections of this code.

<sup>e</sup> Not less than the fire-resistance rating based on fire separation distance (see Table 602).

<sup>f</sup> Not less than the fire-resistance rating as referenced in Section 704.10.
Analysis – Allowable Uses

• Type I: Fire-Resistive
  – High and mid rise buildings
  – Exterior and interior must be non-combustible

• Type II: Non-Combustible
  – New commercial buildings and remodels
  – Exterior and interior must be non-combustible

• 602.2 Types I and II
Analysis – Allowable Uses

- In Types I and II FRTW may be used:
  - In nonbearing partitions rated 2 hours or less.
  - In nonbearing exterior walls where fire rating is not required.
  - In roof construction, including girders, trusses, framing and decking.
  - **Exception:** In type IA over 2 stories, FRTW is not permitted in roofs when the vertical distance from the upper floor to the roof is <20 feet

- **603.1 Allowable materials.**
Analysis – Allowable Uses

– Type III: Ordinary (Combustible)
  • Exterior must be noncombustible
  • Interior may be any permitted by code
Analysis – Allowable Uses

• In Type III, FRTW may be used:
  – In place of non-combustible materials within exterior wall assemblies of a 2-hour rating or less.
  – In other building elements, FRTW is permitted (though not required) if the construction meets the specific fire-resistance rating given in Table 601.

• 602.3 Type III
• Table 601
Analysis – Allowable Uses

– Type IV (Heavy Timber)
  • Exterior must be noncombustible
  • Interior must be solid or laminated wood without concealed spaces

• 602.4 Type IV
Analysis – Allowable Uses

- In Type IV (Heavy Timber), FRTW may be used:
  - In place of non-combustible materials within exterior wall assemblies of a 2-hour rating or less.

- 602.4.1 Fire-retardant-treated wood in exterior walls.
Analysis – Allowable Uses

– Type V construction
  • Exterior and interior walls may be any permitted by code

• 602.5 Type V
Analysis – Allowable Uses

• In Type V, FRTW may be used:
  – In all building elements, FRTW is permitted (though not required)
  • Note: in Type V-A major building elements must be protected by a 1-hour fire resistant rating.
Analysis – Allowable Uses

• FRTW use is also permitted in accordance with the footnotes to Table 601 as applicable to Roof Construction in Type IA, 1B, IIA, IIIA and VA as follows (emphasis added):

• b. Except in Group F-1, H, M and S-1 occupancies, fire protection of structural members shall not be required, including protection of roof framing and decking where every part of the roof construction is 20 feet or more above any floor immediately below. Fire-retardant-treated wood members shall be allowed to be used for such unprotected members.
Analysis – Allowable Uses

• FRTW is advantageous in some cases related to sprinklering.

• Per Section 8.15.1.2.11 of NFPA 13 Standard:
  – Concealed spaces in which the exposed materials are constructed entirely of fire-retardant treated wood as defined by NFPA 703 ... shall not require sprinkler protection.

• This means that if FRTW is used in concealed spaces, sprinklers are not required, saving time and money.
Analysis – Material Requirements

- Since FRTW is allowed in some applications where noncombustible materials are otherwise required, it is important that these products meet rigorous requirements.

- IBC Section 2303.2 requires the material to be tested in accordance with ASTM E84, with the test duration increased by 20 minutes.
Analysis – Material Requirements

• Using this procedure, a flame spread index is established during the standard test period.
• The test is continued for an additional 20 minutes.
• During this added time period, there must not be any significant flame spread and at no time can the flame spread more than $10^{1/2}$ feet (3200 mm) past the centerline of the burners.
Analysis – Material Requirements

• What is meant by impregnation? *(IBC 2303.2)*
  – Impregnation does not mean the chemical penetrates all the way through the lumber.
  – The penetration depth may vary with lumber species and treatment method.
  – There is no definition of how much penetration is needed to be called “impregnated”.
Analysis – Material Requirements

• Section 2303.2.2 requires that FRTW must be a permanent protection of all surfaces.
• Treatments that stay on the lumber surface and can be chipped off or lose their bond to the lumber are not FRTW.
• Those products would need to be qualified as an alternative material under IBC Section 104.11 or IRC section R104.11.
Analysis – Material Requirements

• Treatment by other than a pressure process is addressed in Section 2303.2.3.
• Here equivalent performance is required from all sides of the FRTW product, so that orientation of the product is not an issue.
• The intent is that all sides of the material is protected.
• The requirement in this code section is that the product must be tested on all sides.
Analysis – Material Requirements

• This is problematic from a testing perspective.
• How does one determine what is the front or back side of a piece of lumber?
• If I test one side of a sample, I cannot use that same sample for the next test. A new sample must be used.
• How do I then determine which side to test? What is the front side? What is the back side?
• Meeting this requirement is not typically possible so some judgement on the part of the testing facility is necessary.
Analysis – Material Requirements

• Specifics related to design value adjustments are discussed below, but *IBC* Section 2303.2.6 also requires consideration of situations when FRTW may be exposed to the weather or may be used in damp or wet locations.

• This requires evaluation of the flame spread index when tested in accordance with *ASTM D2898, Standard Practice for Accelerated Weathering of Fire-Retardant-Treated Wood for Fire Testing.*
Analysis – Material Requirements

• This test is applicable only to pressure treated material and simulates effects of leaching, drying, temperature and, in one method, ultraviolet light.

• If the FRTW product might be subject to these environmental concerns, the FRTW manufacturer must state that testing to ASTM D2898 has been completed for their product.

• IBC Section 2303.2.8 requires that FRTW drying temperatures are not to exceed those typically used for non-FRTW.
Analysis – Design Requirements

• *IBC* Section 2303.2.5 & 2303.2.5.2 state that FRTW must be tested to determine applicable adjustment factors in accordance with *ASTM D5664*, taking into account both the impact of the chemical treatment and the environment in which the FRTW product is to be used.
Analysis – Design Requirements

• *NDS* and *TPI 1* are all clear that applicable adjustments to design values are to be provided by the FRTW material supplier.

• All of the FRTW material suppliers do provide reductions for design values based on their chemical and process applicable to specific wood species.
Analysis – Design Requirements

• The adjustment values should be based on current product information and typically include reductions to the following material properties:
  – Compression Parallel to Grain
  – Horizontal Shear
  – Tension Parallel to Grain
  – Bending – Modulus of Elasticity
  – Bending – Extreme Fiber Stress
  – Fasteners/Connectors
Analysis – Design Requirements

• There may also be additional design value adjustment factors for FRTW used in high temperature applications.

• However, since most FRTW material suppliers do not stock the higher grades of lumber typically used in trusses, the truss manufacturer may have to take into account sending material out to be treated.
Conclusion

- Fire retardant treated materials can be incorporated into Buildings to reduce the ability of lumber products to contribute to a fire.
- The *IBC* requirements dictate where, and under what circumstances, fire retardant materials are allowed.
- When designing trusses with fire retardant lumber, *ANSI/TPI 1* should be followed as a guide for the appropriate drying conditions for the lumber after treatment.
- In addition, appropriate design values reductions for the lumber or metal connector plate should be taken following the FRT manufacturer’s specifications.
References

• ANSI/AWC National Design Specification® (NDS®) for Wood Construction
• ANSI/TPI-1 National Design Standard for Metal Plate Connected Wood Truss Construction
• International Building Code (IBC), International Code Council
• International Residential Code (IRC), International Code Council
• NFPA 13 Standard for the Installation of Sprinkler Systems
• United States Department of Agriculture, Forest Products Laboratory (U.S.), *Wood Handbook*, Wood as an Engineering Material, Chapter 18, 2010,
References

- ASTM D2898 - Standard Practice for Accelerated Weathering of Fire-Retardant-Treated Wood for Fire Testing
- ASTM D3201 - Standard Test Method for Hygroscopic Properties of Fire-Retardant Wood and Wood-Based Products
- ASTM D5516 - Standard Test Method for Evaluating the Flexural Properties of Fire-Retardant Treated Softwood Plywood Exposed to Elevated Temperatures
- ASTM D5664 - Standard Test Method for Evaluating Dowel-Bearing Strength of Wood and Wood-Based Products
- ASTM D6841 - Standard Practice for Calculating Design Value Treatment Adjustment Factors for Fire-Retardant-Treated Lumber
- ASTM E136 - Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C
Truss Design With Fire Retardant Materials

1) Select appropriate building material in accordance with the provisions of the IRC and/or local building code which corresponds to the structure to be built.
2) Find the fire retardant material’s engineering report as provided by the manufacturer in order to ascertain proper lumber and fastener design values.

- Note: Some engineering reports will report these values as reductions from published design values as shown in ANSI/TPI 1 and NDS.
3) Verify building material requirements as given by manufacturer for special installation or fastener requirements.

-Note: Some fire retardant lumber products require the use of specialized connector plates and fasteners.
Truss Design With Fire Retardant Materials

4) Carefully input design values and plate reductions as provided by the manufacturer into the design software’s database.
Truss Design With Fire Retardant Materials

5) Provide any additional required notes as to special installation or fastener requirements for the fire resistant truss assembly on the truss design drawing.
6) Provide information regarding the safe handling or health considerations (i.e. MSDS) as provided by material manufacturer to truss manufacturer and truss installation personnel.