Structure, Fire & Acoustics Shouldn’t Exist in Separate Silos for Mid-Rise

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Structure and Fire & Life Safety

Can’t Live in Separate Bubbles
In any project, but particularly wood-frame mid-rise construction, efficiency in structural framing layout, assembly selection and detailing must also account for “architectural” requirements such as:

- Fire-resistance ratings
- Acoustics
- Materials permitted (construction type)

In other words, you’re not just an architect or engineer anymore.
Evolution of Mid-Rise

Through the lens of Type III and Type V mid-rise projects, we will take a look at a few common design & detailing issues and how to design holistically.
Type III Exterior Walls – FRT

Type III Construction - IBC Section 602.3:
Fire-retardant-treated wood framing complying with Section 2303.2 shall be permitted within exterior wall assemblies of a 2-hour rating or less

What does this FRTW requirement include?
• Wall Framing (Studs & Plates) – Yes
• Headers – Yes
• Wall Sheathing – Yes
• Floor sheathing - ?
• Rim Joist- ?
• Floor Joists- ?

Credit: WoodWorks
Type III Exterior Walls – FRT

Long Span Headers in Type III

When a multi-ply 2x is inadequate due to load and span, what are the options?

• FRT EWP availability?
• Non-FRT wood options?
• Non-combustible materials?

Credit: WoodWorks
Type III Exterior Walls – FRT

Structural Impacts of using FRTW
NDS 2.3.4: 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.
FRT Wood Design Values

FRT manufacturers provide reduction values in literature, ICC ESR’s, etc.

Example FRT manufacturer’s ESR reduction values:

### TABLE 2—DESIGN VALUE ADJUSTMENT FACTORS FOR PYRO-GUARD® TREATED LUMBER

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>PYRO-GUARD® WALL/FLOOR SERVICE TEMPERATURE TO 100°F/38°C</th>
<th>PYRO-GUARD® ROOF FRAMING, SERVICE TEMPERATURE TO 150°F/66°C,</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Douglas fir</td>
<td>Southern pine</td>
</tr>
<tr>
<td>Extreme fiber stress in bending, Fₚ</td>
<td>0.97</td>
<td>0.91</td>
</tr>
<tr>
<td>Tension parallel to grain Fₚ</td>
<td>0.95</td>
<td>0.88</td>
</tr>
<tr>
<td>Compression parallel to grain, Fₚ</td>
<td>1.00</td>
<td>0.94</td>
</tr>
<tr>
<td>Horizontal shear Fₛ</td>
<td>0.96</td>
<td>0.95</td>
</tr>
<tr>
<td>Modulus of elasticity, E</td>
<td>0.96</td>
<td>0.95</td>
</tr>
<tr>
<td>Compression perp. to grain Fₓ</td>
<td>0.95</td>
<td>0.95</td>
</tr>
<tr>
<td>Fasteners/connectors</td>
<td>0.90</td>
<td>0.90</td>
</tr>
</tbody>
</table>
FRT Wood Design Values

Shear wall capacity reduction typically handled by increasing sheathing thickness

When fire-retardant-treated plywood is used in a shear wall, the thickness must be one standard size thicker than that determined in the tabulated allowable shear values contained in Section 4.3 of ANSI/AWC Special Design Provisions for Wind and Seismic (SDPWS) or as shown in the tables referenced in Section 2306.3 of the IBC (2306.4 of the 2009 and 2006 IBC). Thickness to be used for FRT plywood compared to untreated plywood shear walls are shown below:

<table>
<thead>
<tr>
<th>FRT Plywood Thickness (inches)</th>
<th>Untreated Plywood Thickness (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\frac{3}{8}$</td>
<td>$\frac{5}{16}$</td>
</tr>
<tr>
<td>$\frac{1}{16}$</td>
<td>$\frac{3}{8}$</td>
</tr>
<tr>
<td>$\frac{15}{32}$</td>
<td>$\frac{1}{16}$</td>
</tr>
<tr>
<td>$\frac{1}{2}$</td>
<td>$\frac{15}{32}$</td>
</tr>
</tbody>
</table>
Accommodating Wood Shrinkage
2304.3.3 Shrinkage. Wood walls and bearing partitions shall not support more than two floors and a roof unless an analysis satisfactory to the building official shows that shrinkage of the wood framing will not have adverse effects on the structure or any plumbing, electrical or mechanical systems, or other equipment installed therein due to excessive shrinkage or differential movements caused by shrinkage. The analysis shall also show that the roof drainage system and the foregoing systems or equipment will not be adversely affected or, as an alternative, such systems shall be designed to accommodate the differential shrinkage or movements.
Shrinkage Design Considerations
Shrinkage Design Considerations

Wood is orthotropic, meaning it behaves differently in its three orthogonal directions: Longitudinal (L), Radial (R), and Tangential (T)

- Longitudinal shrinkage is negligible
- Can assume avg. of radial & tangential or assume all tangential

Image: RDH Building Science, Inc.
Shrinkage occurs in cross-grain, but not longitudinal, wood dimensions

- Primarily in horizontal members
- Wall plates
- Floor/rim joists
- Engineering judgement required when determining what to include in shrinkage zone
- Should Sheathing, I-Joists, Trusses, other products manufactured with low MC be included?
Shrinkage Calculations – Cross Grain Wood

In parallel chord trusses, only chords contribute to shrinkage, vertical and diagonal webs don’t
Shrinkage Calculations – Running the Numbers

Simplified Method:

\[ S = 0.0025 \text{ in} \times \text{ inch of cross grain wood} \times \% \text{ MC change} \]

Example: 13.75” shrinkage zone
Installed MC = 19%
EMC = 12%

\[ S = (0.0025)(13.75”)(12-19) = -0.24” \]

(note: Negative value due to loss in cross section)
MEP main runs often start at base or top of structure, extend throughout height, with horizontal tees at each floor.

Horizontal tees often installed in wood stud partitions
Differential Movement - MEP

Wood framing shrinks, vertical MEP runs remain stationary or expand with thermal fluctuations

Differential movement should be allowed for

Helpful to wait as late as possible after wood framing is erected to install MEP

Note anticipated wood shrinkage at each level on construction documents – MEP contractor should provide methods of accommodating
Differential Movement - MEP

- Vertically slotted holes in studs allow differential movement
- Verify structural adequacy of studs

Image: Louisiana-Pacific Corporation
Image: Schaefer
Vertical Stacks – Compensation Devices Installed
Shrinkage Resource

Code provisions, detailing options, calculations and more for accommodating differential material movement in wood structures

Free resource at woodworks.org
**Acoustical Design**

Whatever you call it, it all comes down to one thing:

**Occupant Comfort**
Air-Borne Sound: 
Sound Transmission Class (STC)

- Measures how effectively an assembly isolates air-borne sound and reduces the level that passes from one side to the other
- Applies to walls and floor/ceiling assemblies
Aoustical Design

**Structure-borne sound:**
**Impact Insulation Class (IIC)**
- Evaluates how effectively an assembly blocks impact sound from passing through it
- Only applies to floor/ceiling assemblies
Acoustical Design

Code requirements only address residential occupancies:

For unit to unit or unit to public or service areas:

**Min. STC of 50 (45 if field tested):**
- Walls, Partitions, and Floor/Ceiling Assemblies

**Min. IIC of 50 (45 if field tested) for:**
- Floor/Ceiling Assemblies
Acoustical Design

When does structure impact the acoustical performance of a wall or floor assembly?

Regardless of the structural materials used in a wall or floor ceiling assembly, there are 3 effective methods of improving acoustical performance:

1. Add Mass
2. Add noise barriers
3. Add decouplers
Acoustical Design

What does this look like in typical wood-frame construction:

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Make sure that structural elements don’t defeat the purpose of these, especially decouplers
• My interior, acoustically rated wall also needs to be a shearwall (think unit demising wall)
• Can I add wood structural panels to an acoustically tested wall?

Yes, but placement is very important!
Acoustical Design

**FIGURE 6**
Effect of Sheathing Placement on Acoustical Performance (Plan View)

STC 58  STC 53  STC 48  STC 63
Acoustical Design

- For walls with resilient channels, put WSP on opposite side of wall
- For highly loaded shearwalls, can use double layer of sheathing on same side of wall
Acoustical Design

- Staggered stud wall condition:
- Blocking bridges finish on one side of wall to studs on opposite side, defeats purpose.
- Solution: use flat blocking in wall (wide face against WSP)
QUESTIONS?

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Credit: Brett Dury