Multi-story Wood Frame Structures

Introduction to How to Build Bigger and Taller

Answering the most frequently asked questions about Mid-rise construction
Outline / Learning Objectives

• **Mid-rise Construction Overview**
  Evaluate examples of mid-rise wood buildings with an emphasis on configurations and site layouts

• **Maximizing Height and Area**
  Identify International Building Code (IBC) maximum height and associated allowable area of wood-frame structures including allowances from special provisions

• **Understanding Shrinkage**
  Calculate overall building shrinkage and understand how to minimize and compensated for its effects

• **Detailing Considerations**
  Recognize common detailing used for exterior wall to floor intersections across the country for multi-story structures
Outline

• Mid-rise Construction Overview
• Maximizing Height and Area
• Understanding Shrinkage
• Detailing Considerations
Mid-Rise Construction Overview
Urban Infill Development
Walk-up/ Tuck Under

First floor walk up units with private garage

Benefits:
• Eliminates need for S-2 parking garage
• Can be all wood
• Least expensive overall but lowest densification rates
Wrap-Around

Walk up units surround parking structure

Benefits:

• enhanced security
• Centralized access to parking
• Visual appeal from street
• More expensive than walk/up tuck-under
• 5 story yields 60-80 units/acre
Podium

Multiple stories of wood over an elevated concrete deck

Benefits:

• Increased number of stories
• Accommodates Mixed-use occupancies
• Most expensive but can allow increased density
Podium

4 stories of residential over podium (parking or retail)

• 60-80 units/acre

Inman Park Condos, Atlanta, GA
Davis & Church
Podium

5 stories over subterranean parking
5 stories over retail

• 100-120 units/acre
Podium

5 stories over residential podium

• 120-140 units/acre
Podium

5 stories with mezzanine + residential podium

• 125-145 units/acre

120 Union, San Diego, CA
Togawa Smith Martin
Sloped Sites

Fashion Valley, CA
AvalonBay Communities

Seattle, WA
PB Architects

Fashion Valley, CA
AvalonBay Communities
Sloped Sites

HEIGHT, BUILDING. The vertical distance from grade plane to the average height of the highest roof surface.

GRADE PLANE. A reference plane representing the average of finished ground level adjoining the building at exterior walls. Where the finished ground level slopes away from the exterior walls, the reference plane shall be established by the lowest points within the area between the building and the lot line or, where the lot line is more than 6 feet (1829 mm) from the building, between the building and a point 6 feet (1829 mm) from the building.

(2009 IBC)
Definition – IBC 202

If this dimension exceeds 75 feet, building is considered a high rise.

10’ floor to floor


FIGURE 6-6 Determination of high-rise building
Typical Mid-rise Occupancy

- Hotels (R-1)
- Apartments (R-2)
- Condominiums (R-2)
- Student housing (R-2)
- Live/work units (R-2)
- Assisted living (R-4)
- Nursing homes (I-2)

(A-2) Restaurants/cafeterias
(A-3) Workout facilities
(A-3) Meeting rooms
(B) Offices
(M) Shops
(S-2) Parking
(S-1) Storage
Maximizing Height and Area

• Mid-rise Construction Overview
• Steps to Maximizing Height and Area
  1. Tabulate Areas
  2. Allowable increases
  3. Maximum Building Area
• Understanding Shrinkage
• Detailing Considerations
Type I and II Construction

Building Elements are of noncombustible materials except as permitted by IBC 603

- Non combustible only
- Fire Retardant Treated
  - Non-bearing ext. walls w/ no fire rating
  - Roof EXCEPT in Type IA of 2 stories or more where roof is < 20’ from floor below
- Heavy Timber
  - Roof except IA where fire rating is 1hr or less
Type III Construction

Exterior walls are of noncombustible materials and interior building elements are of any material. FRT is permitted in exterior wall of 2hr fire rating or less.

- Non combustible
  - Exterior walls

- Fire Retardant Treated allowed
  - Exterior walls if fire rating is 2hr or less

- Heavy Timber
  - HT used in place of 1hr rating or less
  - Untreated Lumber
  - All interior elements
Heights and Areas – IBC Table 503

<table>
<thead>
<tr>
<th>GROUP</th>
<th>TYPE OF CONSTRUCTION</th>
<th>STORIES(S)</th>
<th>AREA (A)</th>
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Step 1 – Tabulated Height and Area

<table>
<thead>
<tr>
<th>Occupancy</th>
<th>II A</th>
<th>III A</th>
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<tbody>
<tr>
<td>R-1</td>
<td>24,000</td>
<td>24,000</td>
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<tr>
<td>R-2</td>
<td>24,000</td>
<td>24,000</td>
</tr>
</tbody>
</table>
Step 1 – Tabulated Height and Area

### Occupancy Table

<table>
<thead>
<tr>
<th>Occupancy</th>
<th>IIB</th>
<th>IIIB</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-1</td>
<td>16,000</td>
<td>16,000</td>
</tr>
<tr>
<td>R-2</td>
<td>16,000</td>
<td>16,000</td>
</tr>
</tbody>
</table>

- **Type IIB**: Occupancy R-1 and R-2 are both 16,000.
- **Type IIIB**: Occupancy R-1 and R-2 are both 16,000.
Step 1 – Tabulated Height and Area

<table>
<thead>
<tr>
<th>Occupancy</th>
<th>VA</th>
<th>VB</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-1</td>
<td>12,000</td>
<td>7,000</td>
</tr>
<tr>
<td>R-2</td>
<td>12,000</td>
<td>7,000</td>
</tr>
</tbody>
</table>
Height Modification – IBC 504

IBC 504.2 Where a building is equipped throughout with an approved sprinkler system...

- maximum height is increased by 20 feet
- maximum number of stories is increased by one.

Can be combined w/ frontage area increase - 506.2
Can be combined w/ sprinkler area increase - 506.3

• EXCEPT for I-2 occupancy of Type IIIB, III and V construction and H occupancies or where sprinklers are used as substitution for 1hr fire resistance.
Automatic Sprinkler Increase – 504.2

504.2 Automatic sprinkler system increase.

....For Group R buildings equipped throughout with an approved automatic sprinkler system in accordance with Section 903.3.1.2, the value specified in Table 503 for maximum building height is increased by 20 feet (6096 mm) and the maximum number of stories is increased by one, but shall not exceed 60 feet (18 288 mm) or four stories, respectively.

• Section 903.3.1.2 references NFPA 13R sprinkler system.
• This limitation does not apply when using NFPA 13 Sprinkler System
Area Modification – IBC 506

(Equation 5-1)

\[ A_a = A_t + [A_t \times l_f] + [A_t \times l_s] \]

\( A_a \) = Allowable area per story (sq. ft.)
\( A_t \) = Tabular area per story (sq. ft.)
\( l_f \) = Area increase factor due to frontage

(IBC 506.2) \( l_{f\text{max}} = .75 \)

\( l_s \) = Area increase factor due to sprinkler protection

(IBC 506.3) \( l_s = 3 \) for 1 story, \( l_s = 2 \) for > 1 story
In 2012 code, there is further clarification between “W” for area increases and Fire Separation Distance for purposes of fire resistance ratings of walls and openings.

Bldg. 1

W ≠ FSD

Bldg. 2
Frontage Increases – IBC 506.2.1

For two buildings on DIFFERENT lots
Frontage Increases – IBC 506.2.1

For two buildings on the SAME lot
Frontage Increases – IBC 506.2.1

Buildings near public right of ways:

Bldg. 1

lot line

W

FSD

Bldg. 2

centerline of public way

W

FSD
**Step 2 – Increased Height & Story Area**

<table>
<thead>
<tr>
<th>Occupancy</th>
<th>IIA (ft²)*</th>
<th>IIIA (ft²)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-1</td>
<td>72,000 +18,000 (max frontage)</td>
<td>72,000 +18,000 (max frontage)</td>
</tr>
<tr>
<td>R-2</td>
<td>72,000 +18,000 (max frontage)</td>
<td>72,000 +18,000 (max frontage)</td>
</tr>
</tbody>
</table>

*Areas reflect PER STORY max. Total building max may limit area further.

**ASCE7 12.2-1 limits wood shear wall seismic systems to 65’ in height in SDC D,E,F
Step 2 – Increased Height & Story Area

<table>
<thead>
<tr>
<th>Occupancy</th>
<th>IIB ((\text{ft}^2))*</th>
<th>IIIB ((\text{ft}^2))*</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-1</td>
<td>48,000 +12,000(max frontage)</td>
<td>48,000 +12,000(max frontage)</td>
</tr>
<tr>
<td>R-2</td>
<td>48,000 +12,000(max frontage)</td>
<td>48,000 +12,000(max frontage)</td>
</tr>
</tbody>
</table>

*Areas reflect PER STORY max. Total building max may limit area further.
... Horizontal assemblies separating dwelling units in the same building and horizontal assemblies separating sleeping units in the same building shall be a minimum of 1-hour fire-resistance-rated construction.

**EXCEPTION**

Dwelling unit and sleeping unit separations in buildings of Type IIB, IIIB and VB construction shall have fire-resistance ratings of not less than 1/2 hour in buildings equipped throughout with an automatic sprinkler system in accordance with Section 903.3.1.1.
Step 2 – Increased Height & Story Area

<table>
<thead>
<tr>
<th>Occupancy</th>
<th>VA (ft²)*</th>
<th>VB (ft²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-1</td>
<td>36,000 +9,000(max frontage)</td>
<td>21,000 +5,250(max frontage)</td>
</tr>
<tr>
<td>R-2</td>
<td>36,000 +9,000(max frontage)</td>
<td>21,000 +5,250(max frontage)</td>
</tr>
</tbody>
</table>

*Areas reflect PER STORY max. Total building max may limit area further.
**ASCE7 12.2-1 limits wood shear wall seismic systems to 65’ in height in SDC D,E,F
Opportunity for Office Occupancy (B)

<table>
<thead>
<tr>
<th>Occupancy</th>
<th>IIIA (ft²)*</th>
<th>IV (ft²)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>85,500 + 21,375 (max frontage)</td>
<td>108,000 + 27,000 (max frontage)</td>
</tr>
</tbody>
</table>

*Areas reflect PER STORY max. Total building max may limit area further.

**ASCE7 12.2-1 limits wood shear wall seismic systems to 65’ in height in SDC D,E,F
# Summary of Building Heights

## Building Heights and Stories by Building Type With NFPA 13 Sprinklers

<table>
<thead>
<tr>
<th>Occupancy</th>
<th>IIIA</th>
<th>IIIB</th>
<th>VA</th>
<th>VB</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-1/R-2/R-4</td>
<td>85 ft</td>
<td>75 ft</td>
<td>70 ft</td>
<td>60 ft</td>
</tr>
<tr>
<td>A-2/A-3</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>B</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>M</td>
<td>6</td>
<td>4</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>S-2</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>S-1</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

**ASCE7 12.2-1 limits wood shear wall seismic systems to 65’ in height in SDC D, E, F**
Maximum Building Area – 506.4

Single Occupancy Area determination

- Two stories above grade:
  - Maximum Building Area = $A_a \times 2$
- Three stories or more above grade:
  - Maximum Building Area = $A_a \times 3$
- No Story shall exceed $A_a$

Exceptions

- Unlimited area buildings
- Buildings with NFPA 13R sprinkler system

$A_a$ – Allowable Area PER STORY
**Step 3 – Max Building vs. Story Areas**

<table>
<thead>
<tr>
<th>Occupancy</th>
<th>IIIA</th>
<th>VA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Story Area</td>
<td>72,000 +18,000 (max frontage)</td>
<td>36,000 +9,000 (max frontage)</td>
</tr>
<tr>
<td>Building Area</td>
<td>216,000 +54,000 (max frontage)</td>
<td>108,000 +27,000 (max frontage)</td>
</tr>
</tbody>
</table>

**NFPA13**

**ASCE7 12.2-1** limits wood shear wall seismic systems to 65’ in height in SDC D,E,F
### Step 3 – Max Building vs. Story Areas

**Type IIIA**

- **Occupancy**: IIIA (NFPA 13)
- **Story Area**: 72,000 (3x tabulated)
- **Building Area**: 216,000 (3x story)

**Type IIIA or Type VA**

- **Occupancy**: IIIA (NFPA 13R)
- **Story Area**: 24,000 (4x tabulated)
- **Building Area**: 96,000 (4x story)

- **Occupancy**: VA (NFPA 13R)
- **Story Area**: 12,000 (4x tabulated)
- **Building Area**: 48,000 (4x story)

**Notes**:

- **ASCE7 12.2-1** limits wood shear wall seismic systems to 65’ in height in SDC D, E, F.
Case Study: Innovations in Wood

Emory Point

Location: Atlanta, GA

3 buildings complete - Luxury Apt., retail, restaurants

- (1) 5 story Type III wood frame over slab on grade
- (2) 4 stories of wood over 1 story concrete podium

35% savings

- $14/sf (wood concept)
- $22/sf (PT conc. Slab and frame)
Mixed Use Occupancy

Located at woodworks.org – design tools – online calculators – Heights and Areas Calculator
Mixed Use Occupancy

Located at woodworks.org – design tools – online calculators – Heights and Areas Calculator
Step 4—Addition of Mezzanine

An intermediate level or levels between the floor and ceiling of any story and in accordance with IBC Section 505.

<table>
<thead>
<tr>
<th>Occupancy</th>
<th>IIIA (NFPA 13)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Story Area</td>
<td>72,000 (3x tabulated)</td>
</tr>
<tr>
<td>Building Area</td>
<td>216,000 (3x story area)</td>
</tr>
</tbody>
</table>

*Areas reflect PER STORY max. Total building max may limit area further.

**ASCE7 12.2-1 limits wood shear wall seismic systems to 65’ in height in SDC D,E,F
Mezzanines – IBC 505

Not counted toward building area** or height if:

- Maximum 1/3 floor area of room or space where located
- Special egress provisions apply
- Must be open and unobstructed to room in which it’s located (walls ≤ 42” allowed)
- Several exceptions
- Slightly different for equipment platforms

**Does count toward fire area with regard to fire protection in Chapter 9
Case Study: Maximizing View and Value With Wood

Marselle Condominiums
Location: Seattle WA
Type IIIA condo complex
5 -1/2 stories of wood over 2 stories of concrete
mezzanine added $250K cost but $1M in value
30% cost savings over concrete
Time savings over steel

Architect: PB Architects
Engineer: Yu & Trochalakis
Contractor: Norcon, NW
Completed: 2009
Photo Credit: Matt Todd Photography
Step 4 - Horizontal Building Separation

Horizontal Assembly = a fire-resistance-rated floor or roof assembly of materials designed to restrict the spread of fire in which continuity is maintained.

**Type IIIA**

**ASCE7 12.2-1 limits wood shear wall seismic systems to 65’ in height**
Considered separate buildings above and below for purposes of area calculations if:

- overall height is still limited to min of either building
- 3hr rated horizontal assembly
- Building below is one story above grade
- Building below is Type 1A with sprinklers
- Enclosures penetrating horizontal assembly are 2hr rated
- occupancy above is A, B, M, R or S
- occupancy below is A, B, M, R or S-2
Case Study: Wood Buildings Aim High

AvalonBay Stadium
Location: Anaheim, CA
251 Apts., 13K sf retail/restaurant
Type III modified
50% of their projects are podium
Semi-balloon framed with 16” I-joist at exterior walls

Architect: Withee Malcolm Architects
Engineer: VanDorpe Chou Associates
Developer/Contractor: AvalonBay Communities
Photo credit: Arden Photography
Carbon Case Study: High Density

Climate Change Advantage

- Volume of wood used: 5,200 cubic meters / 183,600 cubic feet of lumber and sheathing
- U.S. and Canadian forests grow this much wood in: 15 minutes
- Carbon stored in the wood: 3,970 metric tons of CO₂
- Avoided greenhouse gases: 8,440 metric tons of CO₂
- Total potential carbon benefit: 12,410 metric tons of CO₂

Equivalent to:
- 2,370 cars off the road for a year
- Energy to operate a home for 1,050 years
Parking Beneath Group R – IBC 510.4

Possibility of a Type IV podium where number of stories starts above parking when:

• Occupancy above is R and below is S-2
• Lower floor is open Type IV parking with grade entrance
• Horizontal assembly between 1st and 2nd floor shall be
  • Type IV
  • Have 1 hr fire resistance rating when sprinklered
  • Have 2 hr fire resistance rating when not sprinklered
• overall height is still limited to occupancy
APA- N110: Parking beneath Group R

Galt Place
Location: Galt, CA
Architect: Michael Malinowski

Oceano at Warner Center
Location: Woodland Hills, CA
Architect: RC AlleyIII
All-wood Podiums in Mid-rise Construction

Michelle Kam-Biron, S.E.
WoodWorks
Newbury Park, CA

Karyn Beebe, P.E., LEED AP
APA
San Diego, CA

Abstract

Concern for the environment and climate change as well as the economic downturn of the past few years have created a demand for sustainable multi-family housing. According to the Washington, D.C.-based National Association of Home Builders Multi-Family Production Index (MPI), a leading indicator for the multi-family market, the apartment and condominium housing market has shown steady improvement for six consecutive quarters. However, today’s economic and environmental realities have led the building industry to re-evaluate the way we design and build multi-story buildings.

Mid-rise podium construction, consisting of two to four stories of wood framing above a concrete first story (the "podium") and often incorporating additional subterranean concrete levels, is common throughout North America and in levels of residential units built on top of one or two levels of parking or other non-residential occupancies below. In this paper, we are defining wood podiums as the level (or some level between the two or more stories of wood-framed residential occupancy and the lower non-residential occupancy which is traditionally constructed of concrete. An article titled, "What to Build Now," by Michael P. Dan Wilbes, AIA, LEED AP, and partner with W. Malcolm Architects LLP in Torrance, CA states, "The podium is basically tack-under apartments on steroids."

The projects described in this paper have parking, retail, and restaurant space on their first level. The podium is comprised of gypcrete (or lightweight concrete) topping over structural panels supported by I-joints and glued laminated glulam beams. Both design teams made a conscious effort to not utilize concrete or steel framing.
2012 Code Conforming Wood

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4. Establishing Fire Resistance
5. Wood Use in “Noncombustible” Construction
6. Wood Features
7. Precautions During Construction
8. Resources
9. Building Area Tables

Available for Free Download: www.awc.org
Overview

• Mid-rise Construction Overview
• Maximizing Height and Area
• Understanding Shrinkage
  • Concepts
  • Calculations
  • Recommendations
• Detailing Considerations
IBC 2009 on 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.
Key Factors Influencing Shrinkage

- Pre-construction moisture content (MC)
- In-service EMC
- Cumulative thickness of cross-grain wood contributing to shrinkage

(Wood species has relatively little impact since most species used in commercial construction have similar shrinkage properties.)
Basic Wood Theory

Moisture changes cause dimensional changes perpendicular to grain

Growing tree is filled with water

As wood dries, it shrinks perp. to grain

Basic Wood Theory

Shrinkage in lumber expected **ACROSS** the grain.

Longitudinal shrinkage is negligible.

Wider & Thicker --- NOT Taller
Basic Wood Theory

Figure 2. Average shrinkage properties
Zone of Movement

Shrinkage occurs primarily in horizontal members
- wall plates
- Floors

Be aware of cumulative shrinkage.
## Pre-Construction Moisture Content

<table>
<thead>
<tr>
<th>Product</th>
<th>Moisture Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lumber – S-Dry</td>
<td>19% or less</td>
</tr>
<tr>
<td>Lumber – S-Green</td>
<td>Usually over 19%</td>
</tr>
<tr>
<td>Panel products (OSB, plywood)</td>
<td>4-8%</td>
</tr>
<tr>
<td>I-Joists</td>
<td>4-16%</td>
</tr>
</tbody>
</table>

- $M_i = 19\%$
- $M_i = 28\%$
Minimize Pre-Construction Moisture Content

1. Minimize storage of material on site where rain and standing water can increase moisture content.
2. Keep unused framing material covered
3. Inspect pre-built wall panels prior to installation for proper material and quality of mechanical fasteners.
4. “Dry-in” the structure as quickly as possible.
5. Immediately remove any standing water from floor framing after rain showers.
Shrinkage Calculations for Multistory Wood Frame Construction

Lack of affordable housing is an important issue affecting all major industrialized cities. Multistory/multifamily wood frame construction offers one cost-effective solution. Wood frame construction has advantages over steel, masonry and concrete in speed of construction and material cost in buildings ranging from one to five stories in height.

How wood acclimates to its surrounding environment is an important design consideration. Wood, as a natural material, shrinks and swells with changes in moisture content. Accommodating for the effects of shrinkage of wood frame members is one of the key considerations in designing and building these structures. Proper design and construction contribute to the performance of multistory wood frame structures over time.

Moisture in Solid-Sawn Lumber
Standard moisture content designations are used to indicate the moisture content (MC) of lumber at time of manufacture. The designations are as follows:

- WWPA Lumber Shrinkage Estimator

Right click on the button above or here to begin downloading. If you have Microsoft Excel loaded, the program will open in your browser window.

Features easy-to-use form to estimate shrinkage by selecting the Western species group, starting moisture content, ending moisture content and product size from 1x2 to 24x24. Comparisons can be made between two Western species groups.

Minimum requirements:
In-service EMC (Average EMC- July)

Map courtesy of US Forest Products Laboratory
In-service EMC (Average EMC- January)

Map courtesy of US Forest Products Laboratory
Calculating Shrinkage

For MC **between 6 to 14%** the formula is:

\[ S = D_i \left[ C_T (M_F - M_i) \right] \]

- \( S \) = shrinkage (in inches)
- \( D_i \) = initial dimension (in inches)
- \( C_T / C_R \) = dimension change coefficient, tangential/radial direction
  - \( C_T = 0.00319 \) for Douglas Fir-Larch
  - \( C_T = 0.00323 \) for Hem-Fir
  - \( C_T = 0.00263 \) for Spruce-Pine-Fir
  - \( C_T = 0.00263 \) for Southern Pine
- \( M_F \) = final moisture content (percent)
- \( M_i \) = initial moisture content (percent)
Calculating Shrinkage

For MC outside the range of 6 to 14%:

\[
S = \frac{D_i \left( M_F - M_i \right)}{30(100) S_T} - 30 + M_i
\]

- \( S \) = shrinkage (in inches)
- \( D_i \) = initial dimension (in inches)
- \( S_T / S_R \) = tangential/radial shrinkage (%) from green to oven dry
- \( M_F \) = final moisture content (percent)
- \( M_i \) = initial moisture content (percent)
Calculating Shrinkage – Resources

Wood Handbook: [www.fpl.fs.fed.us](http://www.fpl.fs.fed.us)
- Chapter 13 – $C_T$, $C_R$
- Chapter 4 – $S_T$, $S_R$

**Table 13–5. Dimensional change coefficients ($C_R$, radial; $C_T$, tangential) for shrinking or swelling within moisture content limits of 6% to 14%**

<table>
<thead>
<tr>
<th>Species</th>
<th>$C_R$</th>
<th>$C_T$</th>
<th>Species</th>
<th>$C_R$</th>
<th>$C_T$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baldcypress</td>
<td>0.00130</td>
<td>0.00216</td>
<td>Pine, eastern white</td>
<td>0.00071</td>
<td>0.00212</td>
</tr>
<tr>
<td>Cedar, yellow-</td>
<td>0.00095</td>
<td>0.00208</td>
<td>Pine, jack</td>
<td>0.00126</td>
<td>0.00230</td>
</tr>
<tr>
<td>Cedar, Atlantic white-</td>
<td>0.00099</td>
<td>0.00187</td>
<td>Pine, loblolly</td>
<td>0.00165</td>
<td>0.00259</td>
</tr>
<tr>
<td>Cedar, Eastern Red</td>
<td>0.00106</td>
<td>0.00162</td>
<td>Pine, pond</td>
<td>0.00148</td>
<td>0.00234</td>
</tr>
<tr>
<td>Cedar, incense</td>
<td>0.00112</td>
<td>0.00180</td>
<td>Pine, lodgepole</td>
<td>0.00148</td>
<td>0.00234</td>
</tr>
<tr>
<td>Cedar, northern white-</td>
<td>0.00101</td>
<td>0.00229</td>
<td>Pine, Jeffrey</td>
<td>0.00148</td>
<td>0.00234</td>
</tr>
<tr>
<td>Cedar, Port-Orford-</td>
<td>0.00158</td>
<td>0.00241</td>
<td>Pine, longleaf</td>
<td>0.00176</td>
<td>0.00263</td>
</tr>
<tr>
<td>Cedar, western red-</td>
<td>0.00111</td>
<td>0.00234</td>
<td>Pine, ponderosa</td>
<td>0.00133</td>
<td>0.00216</td>
</tr>
<tr>
<td>Douglas-fir, Coast-type</td>
<td>0.00165</td>
<td>0.00267</td>
<td>Pine, red</td>
<td>0.00130</td>
<td>0.00252</td>
</tr>
<tr>
<td>Douglas-fir, Interior north</td>
<td>0.00130</td>
<td>0.00241</td>
<td>Pine, shortleaf</td>
<td>0.00158</td>
<td>0.00271</td>
</tr>
<tr>
<td>Douglas-fir, Interior west</td>
<td>0.00165</td>
<td>0.00263</td>
<td>Pine, slash</td>
<td>0.00187</td>
<td>0.00267</td>
</tr>
<tr>
<td>Fir, balsam</td>
<td>0.00099</td>
<td>0.00241</td>
<td>Pine, sugar</td>
<td>0.00099</td>
<td>0.00194</td>
</tr>
</tbody>
</table>
Example Shrinkage Calculation

Assume: S-Dry lumber
Find: 4x4 shrinkage
Example Shrinkage Calculation

Again assuming the initial MC ($M_i$) is 19 percent and the final MC ($M_F$) is 12 percent

Our approximated shrinkage is:
For Doug Fir Larch:

\[ S = CD_i (M_F - M_i) = 0.00319 \times 3.5 (12 - 19) = -0.078 \text{ inch} \]

For Southern Pine:

\[ S = CD_i (M_F - M_i) = 0.00263 \times 3.5 (12 - 19) = -0.064 \text{ inch} \]
Minimizing Shrinkage

Balloon framing
• minimizes inter-floor shrinkage from the wall assembly
• limited in height
• Complicated connections
• limited floor loads

Typically not used in projects over 2 stories in height.
Minimizing Shrinkage

Semi-balloon framing
• incorporates floor framing hanging from top plates
• Eliminates tangential shrinkage in zone of movement
• Floor framing doesn’t contribute to overall building shrinkage

Non-standard stud lengths and increased hardware requirements are a result.
Case Study: Wood Buildings Aim High

Inman Park Condominiums
Location: Atlanta, GA
Architect: Brown Doane Architects
Engineer: Davis & Church

4 stories of wood over 2 stories of concrete parking
11 7/8” I-joists to maximize headroom and not exceed building height (10’ plate)
Drop ceilings for MEP at perimeter of some rooms
Differential Movement

Movement between wood frame elements and other materials that...

• do not shrink at all
• shrink much less
• expand
Finish Considerations

Large expanses of interior and exterior drywall, paneling and siding need to be looked at specifically.

Employ expansion joint and slip-type detailing.
Solution 1- Plain Unreinforced Brick-h>30’

Design must be in strict conformance with ACI 530 section 6.2.1-Alt. design method (engineered)

Design to section 2.2 (ASD) or 3.2.2 (strength)
Unreinforced masonry

Brick veneer must be self supporting and not supported off of the wood framing

- Joints must allow for all differential movement (lateral drift and vertical shrinkage of wood Framing Etc.). Weight of brick must not be supported by wood Framing
- Requires steel lintel at openings
- Brick goes into flexure when wall studs deflect
- Anchors/ties to be spaced a maximum of 32” o.c. horiz. And 18” o.c. vert. (except seismic)
- Veneer must be designed per ACI 530 section 2.2 as plain unreinforced masonry
- Allows for vertical shrinkage of wood framing

Wood backer studs
Brick units are similar to CMU’s where vertical and horizontal reinforcing can be installed

- Veneer spans floor to floor without transferring loads to walls.
- Loads are dumped directly into floor diaphragms.
- Steel lintels over openings are not required.
- Intermediate anchors/ties are not required.
- Wall spans vert. & horiz. Between spaced anchors

Spaced anchors must allow for all differential movement (lateral drift, vertical shrinkage of wood Framing, etc.). Weight of brick must not be supported by wood Framing.

Veneer acts as complete unit, not as individual segments. Supports self weight plus out-of-plane loads.

Wood backer studs
- Reinf. horizontal bond beam or lintel units over openings
- Reinforcement reduces expansion and cracking

Heavier anchors are not as prone to fire damage

Spaced anchors must allow for all differential movement (lateral drift, vertical shrinkage of wood Framing, etc.). Weight of brick must not be supported by wood Framing.

Veneer acts as complete unit, not as individual segments. Supports self weight plus out-of-plane loads.

#3 or #4 rebar (typ.)

Anchors/ties are tied directly into floor diaphragms

4” nom. or greater
Façade Considerations - Resources

Brick Industry Association – www.gobrick.com

**Brick Veneer/Wood Stud Walls**

Abstract: This Technical Note deals with the prescriptive design of anchored brick veneer over wood stud backing in new construction. The properties of the brick veneer/wood stud system are described, which lead to design considerations. Selection of materials, construction details and workmanship techniques are also included.

Key Words: air space, anchors, brick, flashing, foundations,

**SUMMARY OF RECOMMENDATIONS:**
- **Support:** Provide a noncombustible foundation to support veneer.
- Where vertical support is provided by wood construction, provide steel angles properly attached to or supported by wood framing.
- **Veneer Height Limitations:**
  - For residential construction (IRC), do not exceed height listed in Table
  - For commercial construction (IBC) see “Additional Requirements for Buildings Covered by the IBC” and the “Wood” chapter of IBC
- **Air Space:** Maintain a minimum 1 in. (25 mm) air space.
- Where corrugated anchors are used, maintain a maximum 1 in. (25 mm) air space.
- Do not exceed 4% in. (114 mm) between back of brick and sheathing unless anchors are rhythmically distributed.
- Completely fill the air space below wall base flashing with grout or mortar.
- Where continuous insulation is placed between the veneer and backing, maintain 1-1/2 in. (25 mm) between the back of the brick and the face of the insulation.
- An air space is allowed to be 1 in. (25 mm) normal dimension in the IRC and 1 in. (25 mm) specified air space in the IBC to account for construction tolerances.
- **Flashing:** Install above grade at the wall base and extend to or beyond face of brickwork.
- Extend base flashing at least 8 in. (203 mm) vertically below finished floor level.

**Volume Changes - Analysis and Effects of Movement**

Abstract: This Technical Note describes the various movements that occur within buildings. Movements induced by changes in temperature, moisture, elastic deformations, creep, and other factors develop stresses if the brickwork is restrained. Restraining of these movements may result in cracking of the masonry. Typical crack patterns are shown and their causes identified.

Key Words: corrosion, cracks, creep, differential movement, elastic deformation, expansion.

**SUMMARY OF RECOMMENDATIONS:**
- Use the following coefficients to calculate movements of brick veneer:
  - Thermal expansion: $4 \times 10^{-6}$ in./in.°F (7.2 x 10^{-6} mm/mm°C)
  - Moisture expansion: $5 \times 10^{-5}$ in./in. (mm/mm)
  - Creep: $0.7 \times 10^{-5}$ in./ln. per psi

- Consider coefficients of movements for other materials in contact with brickwork.
- Consider elastic deformation and movement of structural elements supporting and connected to brickwork.

**ACCOMMODATING EXPANSION OF BRICKWORK**

Abstract: Expansion joints are used in brickwork to accommodate movement and to avoid cracking. This Technical Note describes and gives guidance regarding their placement. The theory and a given showing proper placement of expansion joints to avoid cracking, act of expansion joints. Also includes information about joint breaks, flexible anchorage, movement, sealants.

**INSTRUCTIONS:**
- Brickwork Without Shelf Angles:
  - Place expansion joints around elements that are rigidly attached to the frame and project into the veneer, such as windows and door frames.
  - Installing metal caps or copings that allow independent vertical movement of wythes.
  - Installing jamb receptors that allow independent movement between the brick and window frames.
  - Installing adjustable anchors or ties.

- Expansion Joint Sealants:
  - Comply with ASTM C 920, Grade NS, Use M.
  - Class 50 minimum extensibility recommended; Class 25 alternate.
  - Consult sealant manufacturer’s literature for guidance regarding use of primer and backing materials.

- Bond Breaks:
  - Use building paper or flashing to separate brickwork from dissimilar materials, foundations and slates.

- Loadbearing Masonry:
  - Use reinforcement to accommodate stress concentrations, particularly in parapets, at applied loading points and around openings.
  - Consider effect of vertical expansion joints on brickwork stability.
Door and Window Considerations

[1/4” per floor]
wide sealant joint
sized to allow
shrinkage of wood
frame and
expansion of brick
MEP Considerations

Fully compress wall framing by completing all dead load potential PRIOR to mechanical installations.

Avoid rigid vertical piping in mechanical and plumbing systems. Flexible members allow for shrinkage between floors.
MEP Considerations

Vertical vent stacks should not be installed prior to full completion of framing.

Vent stacks require special attention and must be designed to allow for vertical movement due to shrinkage between floors.
Facade Considerations

Panels should not extend across the zone of movement if platform framed.

Allow for up to ½” gap between abutting panel edges to prevent panel buckling when using platform framing and sawn lumber joists.
Structural Considerations

Strap holdowns will buckle with too much accumulated movement.

Anchor type holdowns should be re-tightened before installing finishes.

Threaded rod holdowns with shrinkage compensating devices work well for 4 sorties and above with stacking units.
Deck Considerations

Table 1. Summary of measured deck slopes.

<table>
<thead>
<tr>
<th>Summary of Deck Slopes for:</th>
<th>Story</th>
<th>Measured Locations</th>
<th>Average</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free Ledger Condition</td>
<td>4</td>
<td>23</td>
<td>-2.38</td>
<td>-0.70</td>
<td>-2.50</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>23</td>
<td>-1.22</td>
<td>-0.50</td>
<td>-2.20</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>23</td>
<td>-0.81</td>
<td>-0.20</td>
<td>-1.60</td>
</tr>
<tr>
<td>Fixed Ledger Condition</td>
<td>4</td>
<td>24</td>
<td>-0.26</td>
<td>0.70</td>
<td>-0.90</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>24</td>
<td>-0.19</td>
<td>1.00</td>
<td>-1.10</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>24</td>
<td>-0.27</td>
<td>1.20</td>
<td>-1.60</td>
</tr>
</tbody>
</table>

Note: Negative slopes drain to building wall; positive slopes drain away from building wall.

White Paper:
Multi-Story Wood-Frame Shrinkage Effects on Exterior Deck Drainage: A Case Study  by Zeno Martin, Wood Design Focus Fall 2010
Detailing Tips

Mitigate distress to finishes arising from cumulative differential movement:

• Be acutely aware of the fact that there will be differential movement
• Address it in detailing and specifications
• Consider where distress will occur
• Provide details to relieve or avoid it
Outline

• Mid-rise Construction Overview
• Maximizing Height and Area
• Understanding Shrinkage
• Detailing Considerations
Platform Framing

Structural
• Direct bearing/ no add’l hardware

Constructability
• Framing can be completed before drywall and insulation are installed
• Common length studs
Semi-balloon Framing

Structural
• Additional hardware/no direct bearing

Rated Assemblies
• May accommodate continuity in exterior walls in Type III construction

Constructability
• Framing can be completed before drywall and insulation are installed
• Custom length studs
• Can help minimize building shrinkage
Case Study: University of Washington

UW West Campus Student Housing

Location: Seattle, WA

1700 beds in 3 halls and 2 apt bldgs

$177/sf

4/5 bldgs met 2030 challenge (60% reduction in energy consumption)

Architect: Mahlum Architects
Engineer: Coughlin Porter Lundeen
Contractor: Walsh Construction
Detailing for Fire Resistance

**Different** areas of fire design:
- Combustibility
- Fire resistance
- Fire Class
- Fire Protection

<table>
<thead>
<tr>
<th></th>
<th>IIIA</th>
<th>IIIB</th>
<th>VA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exterior wall framing</td>
<td>FRT</td>
<td>FRT</td>
<td>non-FRT</td>
</tr>
<tr>
<td>Exterior wall fire rating</td>
<td>2 hr</td>
<td>2 hr</td>
<td>1 hr</td>
</tr>
<tr>
<td>Floor assembly fire rating</td>
<td>1 hr</td>
<td>0 hr</td>
<td>1 hr</td>
</tr>
<tr>
<td>Fire wall rating</td>
<td>3 hr</td>
<td>3 hr</td>
<td>2 hr</td>
</tr>
</tbody>
</table>
Fire Resistance Rating

Basic assumption is that fires begin at the interior and rated wall assemblies are not required \textit{from} the exterior unless close to another structure.
# Fire Resistance Rating - IBC Table 601

**TABLE 601**

FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (hours)

<table>
<thead>
<tr>
<th>BUILDING ELEMENT</th>
<th>TYPE I</th>
<th></th>
<th>TYPE II</th>
<th></th>
<th>TYPE III</th>
<th></th>
<th>TYPE IV</th>
<th></th>
<th>TYPE V</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>A&lt;sup&gt;d&lt;/sup&gt;</td>
<td>B</td>
<td>A&lt;sup&gt;d&lt;/sup&gt;</td>
<td>B</td>
<td>HT</td>
<td>A&lt;sup&gt;d&lt;/sup&gt;</td>
<td>B</td>
</tr>
<tr>
<td>Primary structural frame&lt;sup&gt;9&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>1</td>
<td>0</td>
<td>HT</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>(see Section 202)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bearing walls</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exterior&lt;sup&gt;7,9&lt;/sup&gt;</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>0</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>0</td>
<td>1</td>
<td>0</td>
<td>1/HT</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Nonbearing walls and partitions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exterior</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonbearing walls and partitions</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Interior&lt;sup&gt;8&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Floor construction and secondary members (see Section 202)</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>HT</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Roof construction and secondary members (see Section 202)</td>
<td>1&lt;sup&gt;t, b&lt;/sup&gt;</td>
<td>1&lt;sup&gt;b,c&lt;/sup&gt;</td>
<td>1&lt;sup&gt;b,c&lt;/sup&gt;</td>
<td>1&lt;sup&gt;b,c&lt;/sup&gt;</td>
<td>1&lt;sup&gt;b,c&lt;/sup&gt;</td>
<td>0&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1&lt;sup&gt;b,c&lt;/sup&gt;</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>
**Fire Resistance Rating – IBC 705.5**

**Exterior Walls**

*Fire Separation > 10’* – shall be rated for exposure from the inside in accordance with 601 and 602.

*Fire Separation < 10’* – shall be rated for exposure to both sides in accordance with 601 and 602.

*Fire Protection on Exterior Walls When < 30’*

*Table 601 & 602*
Fire Resistance Rating – IBC Table 602

Exterior Fire Resistance Rating
- Table 601
- Table 602 establishes requirements
- structures separated by 10’-30’ they are typically 0 or 1 hour rated

**Table 602**

<table>
<thead>
<tr>
<th>FIRE SEPARATION DISTANCE = X (feet)</th>
<th>TYPE OF CONSTRUCTION</th>
<th>OCCUPANCY GROUP 1, M, S-1</th>
<th>OCCUPANCY GROUP A, B, E, F-2, I, R, S-2, U&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>X &lt; 5&lt;sup&gt;c&lt;/sup&gt;</td>
<td>All</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>5 ≤ X &lt; 10</td>
<td>IA</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Others</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>10 ≤ X &lt; 30</td>
<td>IA, IB</td>
<td>2</td>
<td>1&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>IIB, VB</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Others</td>
<td>1</td>
<td>1&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>X &gt; 30</td>
<td>All</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

For SI: 1 foot = 304.8 mm.

a. Load-bearing exterior walls shall also comply with the fire-resistance rating requirements of Table 601.
b. For special requirements for Group U occupancies see Section 406.1.2
c. See Section 705.1.1 for party walls.
d. Open parking garages complying with Section 406 shall not be required to have a fire-resistance rating.
e. The fire-resistance rating of an exterior wall is determined based upon the fire separation distance of the exterior wall and the story in which the wall is located.
Choosing Fire Rated Assemblies

Tested assemblies (ASTM E119) per IBC703.2:
• UL: http://database.ul.com
• Gypsum Catalog: www.gypsum.org
• Other tools: www.usgdesignstudio.com
• AWC DCA3
• APA Fire Rated Systems: http://www.apacad.org/cad_detail.cfm?id=2

Alternate Methods per IBC703.3
• Deemed to comply tables per IBC721
• Calculated Fire Resistance per IBC722
2 HR Exterior Wall Assembly – Type III

Common issues with tested assemblies:

• Assembly Asymmetry-
  separate assemblies for each side
Adding lateral resistance

Common issues with tested assemblies:

• Inclusion of wood structural panel – ESR2586
• FRT may also be substituted for untreated wood
Fire Wall Assemblies

**TABLE 706.4**

<table>
<thead>
<tr>
<th>GROUP</th>
<th>FIRE-RESISTANCE RATING (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A, B, E, H-4, I, R-1, R-2, U</td>
<td>3^a</td>
</tr>
<tr>
<td>F-1, H-3^b, H-5, M, S-1</td>
<td>3</td>
</tr>
<tr>
<td>H-1, H-2</td>
<td>4^b</td>
</tr>
<tr>
<td>F-2, S-2, R-3, R-4</td>
<td>2</td>
</tr>
</tbody>
</table>

a. In Type II or V construction, walls shall be permitted to have a 2-hour fire-resistance rating.

b. For Group H-1, H-2 or H-3 buildings, also see Sections 415.6 and 415.7.

**IBC 706.3** – Fire walls shall be of any approved non-combustible materials.

**Exception:** Buildings of Type V construction
2 HR Fire Wall– Type V

2 1/2" METAL STUDS AT 24" O.C.

WOOD STUD WALLS ON EITHER SIDE OF FIRE WALL

WOOD STRUCTURAL PANELS WHERE REQUIRED FOR SHEAR

INTERIOR OR EXTERIOR FINISH AS REQUIRED

2 LAYERS 5/8" TYPE 'X' GYP. BD. ON EACH SIDE OF METAL STUDS

BATT INSULATION (OPTIONAL)

http://www.usgdesignstudio.com/wall-selector.asp?framingType=18708&bldgSystem=18620

CAD & Revit Details: www.woodworks.org

CAD & Revit Details: www.woodworks.org
3hr Fire Wall Assemblies – Type III

Other options:
• NFPA 221 6.5.1
3-HOUR FIRE WALL AT FLOOR/CEILING

3-HR. ASSEMBLY: 1 5/8" METAL STUDS WITH 3 LAYERS 1/2" TYPE 'X' GYP. BD. EACH SIDE

CONTINUOUS STRUCTURAL WOOD PANELS - USE FIRE-TREATED PANELS THROUGH WALL CAVITY

CONTINUOUS 13 1/2" WIDE 14 GA. GALV. SHT. METAL
CONTINUOUS 16 GA. TRACK TOP AND BOTTOM
FIRE SAFING
CONTINUOUS 16 GA. COMP. CHANNEL

RIM JOIST WITH SOLID BLOCKING

RESILIENT CHANNELS

3-HOUR FIRE CAULKING

1" AIR GAP

2 X 4 STUD WALL EACH SIDE, WITH STRUCTURAL WOOD PANELS AS REQUIRED FOR SHEAR AND 1 LAYER 5/8" TYPE 'X' GYP. BD.

"CONSULT LOCAL JURISDICTION HAVING AUTHORITY FOR ACCEPTANCE OF FIRE-TREATED WOOD PANELS RUNNING THROUGH 3-HOUR ASSEMBLY IN THIS APPLICATION.

3-HOUR FIRE WALL AT FLOOR/CEILING

I-JOIST FRAMING WITH WOOD PANEL DIAPHRAGM RUNNING THROUGH FIRE WALL

WOOD TRUSS FRAMING WITHOUT WOOD PANEL DIAPHRAGM RUNNING THROUGH FIRE WALL

CAD & Revit Details: [www.woodworks.org](http://www.woodworks.org)
1hr rated floor assemblies – Type IIIA/VA

Common issues with UL approved assemblies:

- Shallow Floor depth
  - Use prescriptive assemblies - IBC 721.1(2) assembly 14-1.1
  - Or use the CAM method in IBC 722
# Acoustic Detailing

<table>
<thead>
<tr>
<th>Class Designation</th>
<th>Housing Type</th>
<th>STC Minimum For Most Stringent Wall Adjacency For Each Grade</th>
<th>IIC Minimum For Most Stringent Floor-Ceiling Adjacency For Each Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade I</td>
<td>&quot;Luxury&quot; units, units above the eighth floor and all buildings in “quiet” locations with nighttime background noise 40dB (A) or lower.</td>
<td>59 STC Bathroom to Bedroom</td>
<td>59 IIC Family Room Above Living Room</td>
</tr>
<tr>
<td>Grade II</td>
<td>Locations with “average” nighttime background noise of 40-45 dB.</td>
<td>56 STC Bathroom to Bedroom</td>
<td>54 IIC Family Room Above Living Room</td>
</tr>
<tr>
<td>Grade III</td>
<td>Minimal recommendations for urban housing in “noisy” nighttime background environments of 55 dB (A) or higher.</td>
<td>52 STC Bathroom to Bedroom</td>
<td>52 IIC Family Room Above Living Room</td>
</tr>
<tr>
<td>Townhouses</td>
<td>All Townhouses</td>
<td>60 STC All Party Walls</td>
<td>Not Applicable</td>
</tr>
</tbody>
</table>

Source: "HUD TS-24"
Acoustic Detailing

Figure 1 - Acoustical Progression in Wood Framed Walls
Acoustic Detailing

Figure 1 - Acoustical Progression in Wood Framed Floor / Ceilings
Type V Construction Detail Examples
Type III Construction

- 5/8” Type X GWB
  - 1 layer for 1hr rating
  - 2 layers for 2hr rating

- Fire Retardant Treated
  - Wall studs, plates and sheathing

- Untreated Lumber
  - Floor framing (solid sawn or engineered)
  - Floor sheathing
Continuity of FRT

- 5/8” Type X GWB
  - 1 layer for 1hr rating
  - 2 layers for 2hr rating

- Fire Retardant Treated
  - Wall studs, plates and sheathing

- Untreated Lumber
  - Floor framing (solid sawn or engineered)
  - Floor sheathing

No Scale
Type III Construction Detail Example

- 5/8” Type X GWB
  - 1 layer for 1hr rating
  - 2 layers for 2hr rating

- Fire Retardant Treated
  - Wall tuds, plates and sheathing
  - [2x Blocking (counts for 1hr fire protection per NDS 16.2.1)]
  - [Floor sheathing 4’-8’ in]

- Untreated Lumber
  - Floor framing (solid sawn or engineered)
  - Floor sheathing
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  - Studs, plates and sheathing
  - [Floor sheathing 4’-8’ in]

- Untreated Lumber
  - Floor framing (solid sawn or engineered)
  - Floor sheathing
Type III Construction Detail Example

What is being enforced in jurisdictions you are working in?
Balconies – IBC 1406.3

Balconies of combustible construction and not FRT shall be:

• Rated in accordance w/ Table 601 for floors
• Or be of Type IV
• And shall not exceed 50% of bldg perimeter

Exceptions

• Balconies in Type III, IV and V can be of type V const and shall not have fire resistance rating if sprinkler protection provided
• Untreated wood is permitted for rails and guardrails
Balconies – IBC 1406.3

So...

For Type III or V balcony options are:

1. Non-combustible – no sprinklers/no fire rating
2. FRT – no fire sprinklers/no fire rating
3. Type IV – no fire sprinklers/no fire rating
4. Non treated – fire sprinkler/no fire rating
5. Non treated – fire rated per 601 & 602/ no sprinkler
Balconies
Outline

• Mid-rise Construction Overview
• Maximizing Height and Area
• Understanding Shrinkage
• Detailing Considerations
Questions?

This concludes The American Institute of Architects Continuing Education Systems Course

Speaker Name
Speaker organization
Speaker email address