WoodWorks
WOOD PRODUCTS COUNCIL

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

Bruce Lindsey

WoodWorks – Wood Products Council

Credit: Greg Folkins

Structure and Fire & Life Safety


Credit: Greg Folkins

Can’t Live in Separate Bubbles

Structure and Fire & Life Safety

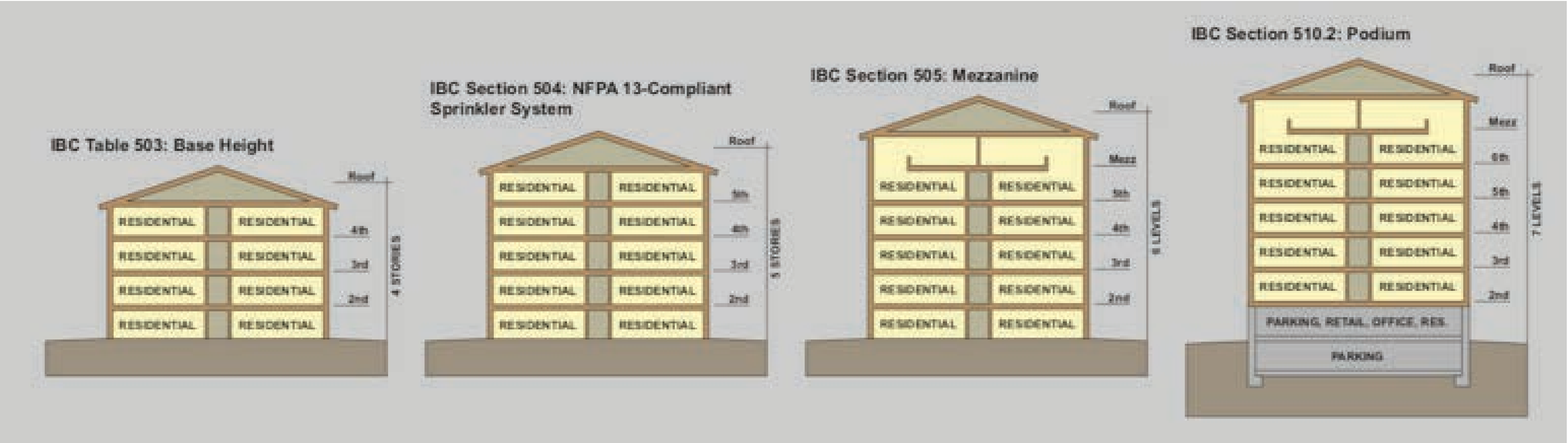
In any project, but particularly wood-frame mid-rise construction, efficiency in structural framing layout, assembly selection and detailing must also account for ”architectural” requirements such as:

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

In other words, you’re not just an architect or engineer anymore

Credit: Brett Drury

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?

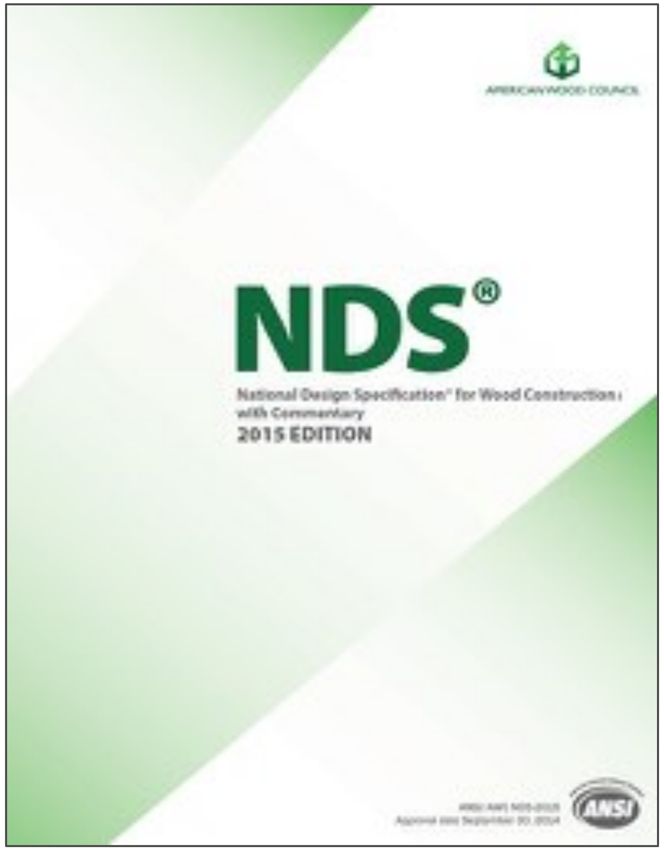
Credit: WoodWorks

Type III Exterior Walls – FRT

Structural Impacts of using FRTW

FRT Wood Design Values

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

PROPERTY	PYRO-GUARD® WALL/FLOOR SERVICE TEMPERATURE TO 100°F/38°C			PYRO-GUARD® ROOF FRAMING, SERVICE TEMPERATURE TO 150° F/66° C,					
	Douglas fir	Southern pine	Other species	Douglas fir Climate Zone			Southern pine Climate Zone		
				1A	1B	2	1A	1B	2
Extreme fiber stress in bending, F_b	0.97	0.91	0.88	0.90	0.93	0.96	0.80	0.85	0.89
Tension parallel to grain F_t	0.95	0.88	0.83	0.80	0.87	0.93	0.80	0.84	0.88
Compression parallel to grain, F_c	1.00	0.94	0.94	0.94	0.98	1.00	0.94	0.94	0.94
Horizontal shear F_v	0.96	0.95	0.93	0.95	0.95	0.96	0.92	0.93	0.94
Modulus of elasticity, E	0.96	0.95	0.94	0.96	0.96	0.96	0.95	0.95	0.95
Compression perp. to grain $F_{c\perp}$	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Fasteners/connectors	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90

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:

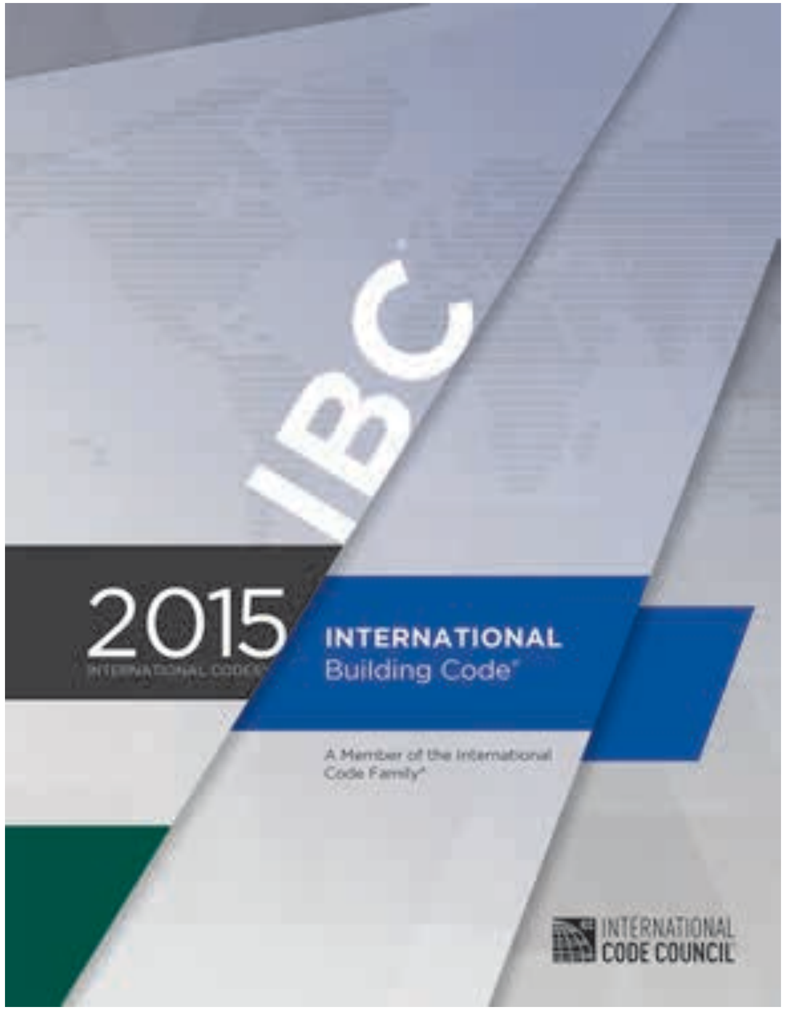
FRT Plywood Thickness (inches)	Untreated Plywood Thickness (inches)
3/8	5/16
7/16	3/8
15/32	7/16
1/2	15/32

Accommodating Wood Shrinkage

Credit: Greg Folkins

Shrinkage Code Requirements

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.



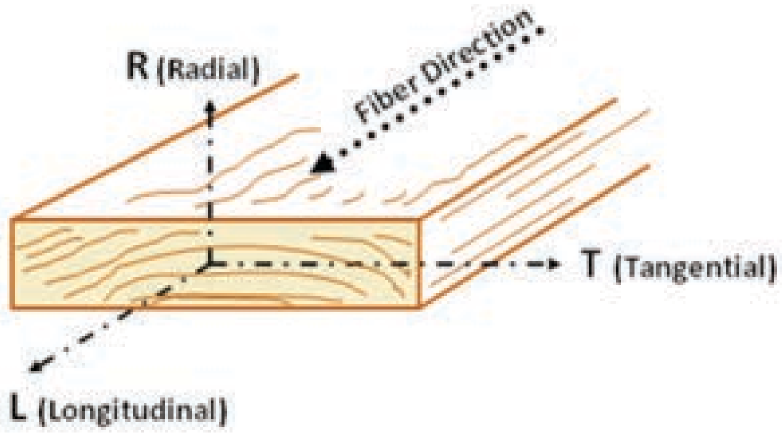
Shrinkage Design Considerations

Image: Schaefer

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



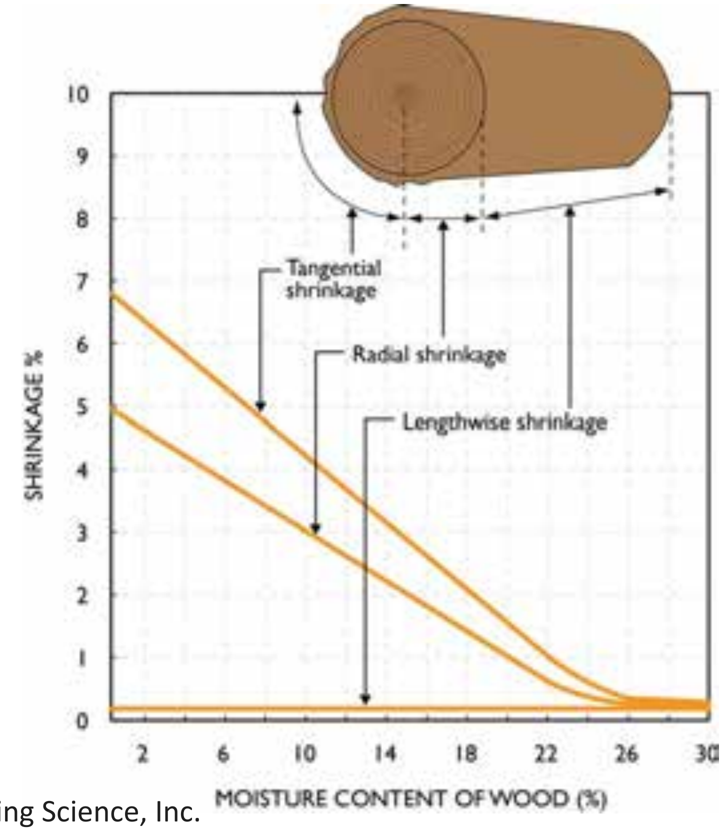


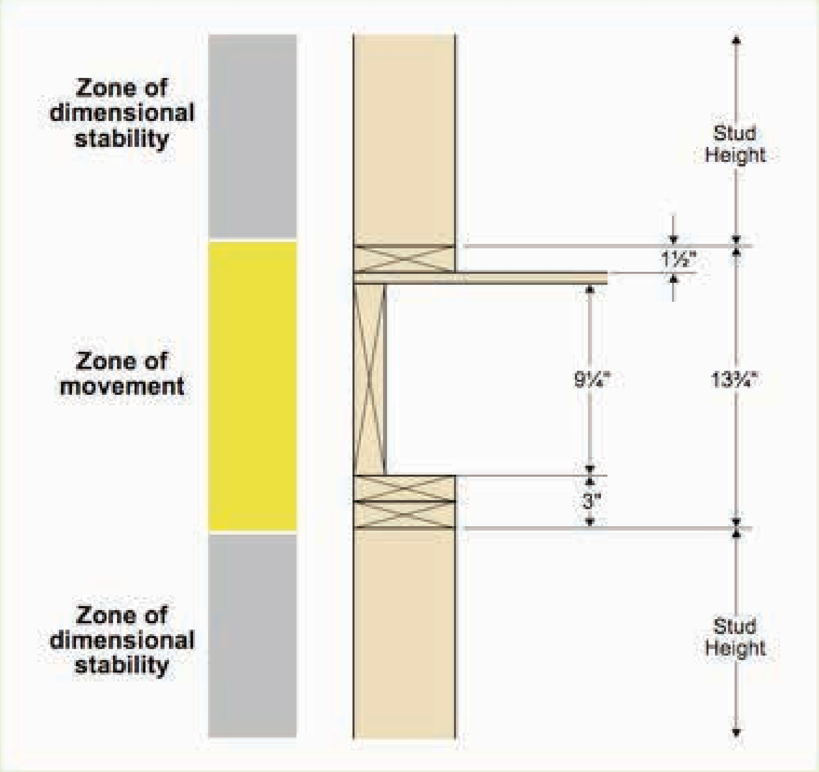
Image: RDH Building Science, Inc.

Shrinkage Calculations – Cross Grain Wood

Shrinkage occurs in cross-grain, but not longitudinal, wood dimensions

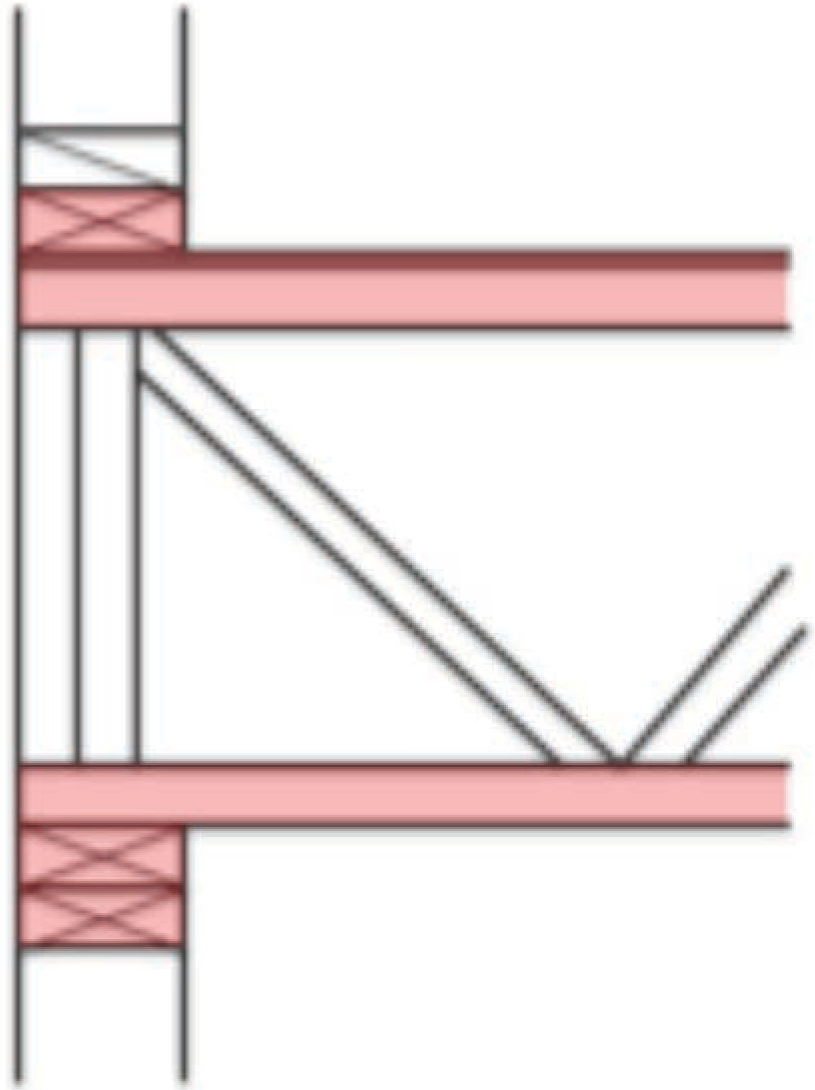
- Primarily in horizontal members
- Wall plates
- Floor/rim joists
- Engineering judgement required when determining what to include in shrinkage zone
- Should Sheathing, I-Joists, Trusses, other products manufactured with low MC be included?

FIGURE 5:
Shrinkage zone in platform-framed detail



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:

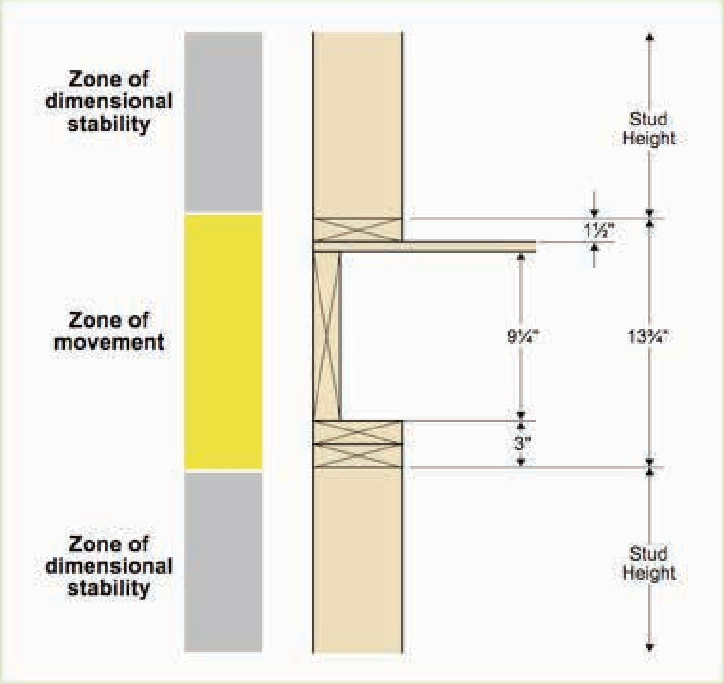
S = 0.0025 in * inch of cross grain wood * % MC change

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)

FIGURE 5:
Shrinkage zone in platform-framed detail



Differential Movement – MEP

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

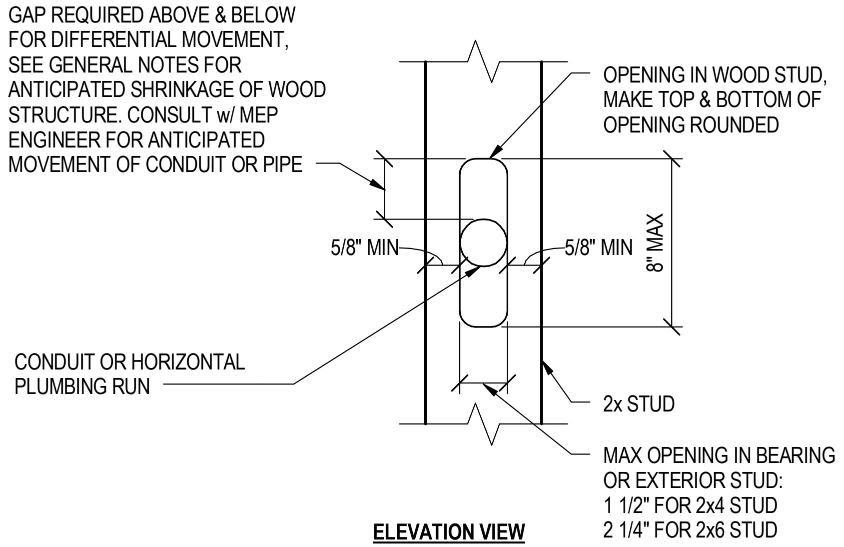


Image: Schaefer

Image: Louisiana-Pacific Corporation

NOTE: ENGINEER SHALL REVIEW LOADING CONDITIONS ON WALL FOR ALLOWABLE SIZE OF PENETRATION

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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Accommodating Shrinkage in Multi-Story Wood-Frame Structures

Wood Science & Shrinkage

Acoustical Design

Noise | **Acoustics** | **Sound Pollution**

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

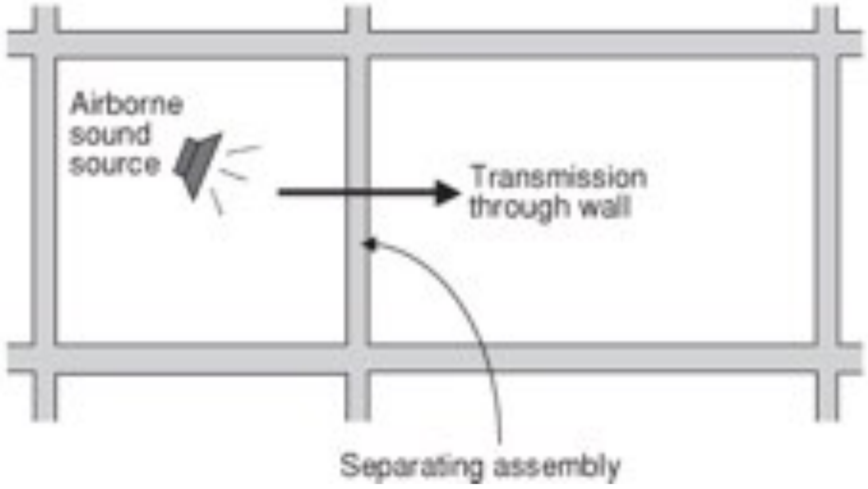
Occupant Comfort

Acoustical Design

<u>Air-Borne Sound:</u>

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

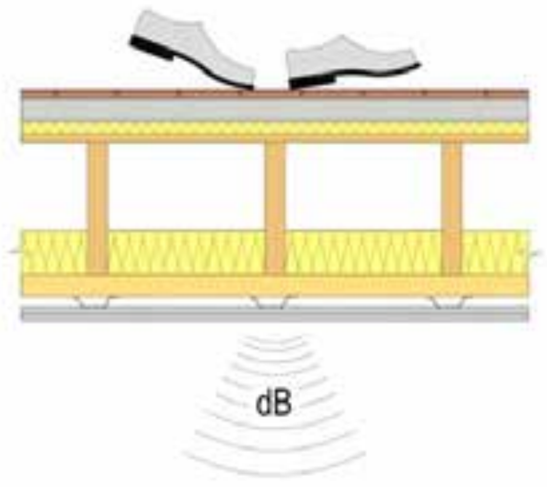


Acoustical Design

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:

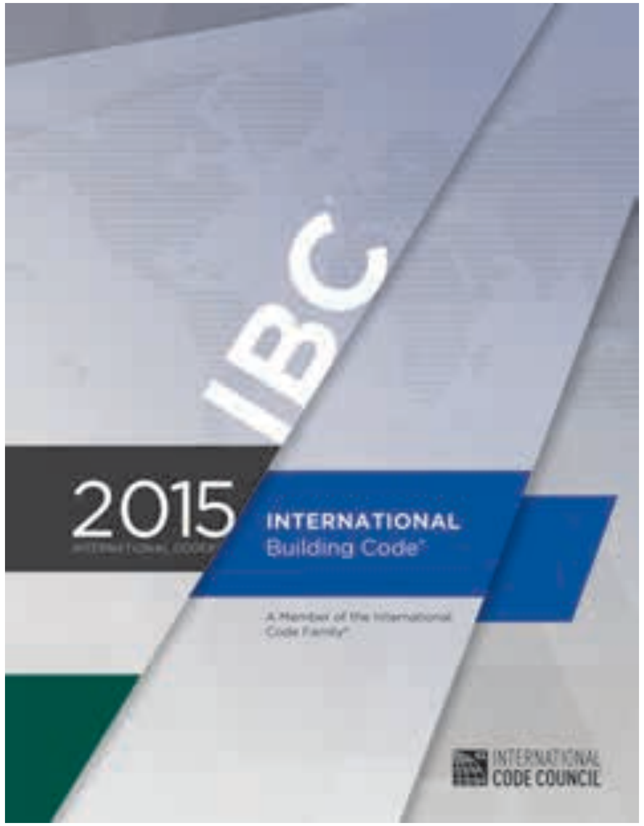
For unit to unit or unit to public or service areas:

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

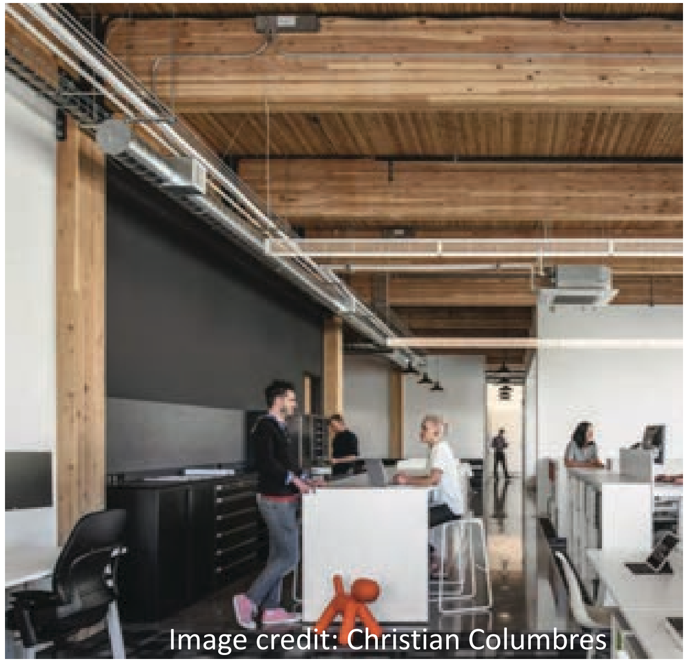
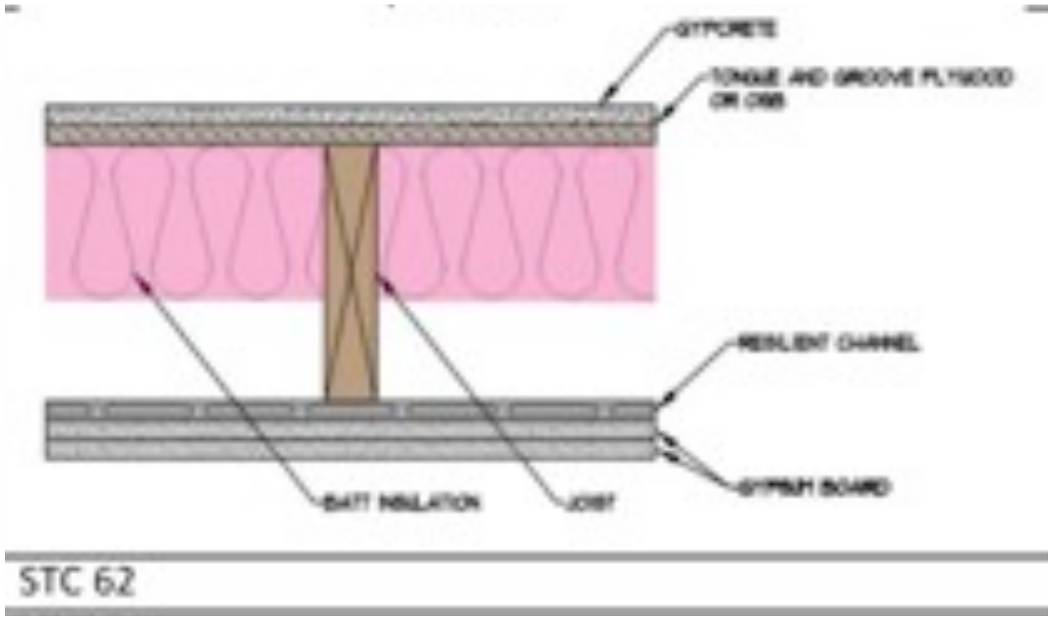


Image credit: Christian Columbres

Acoustical Design

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

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



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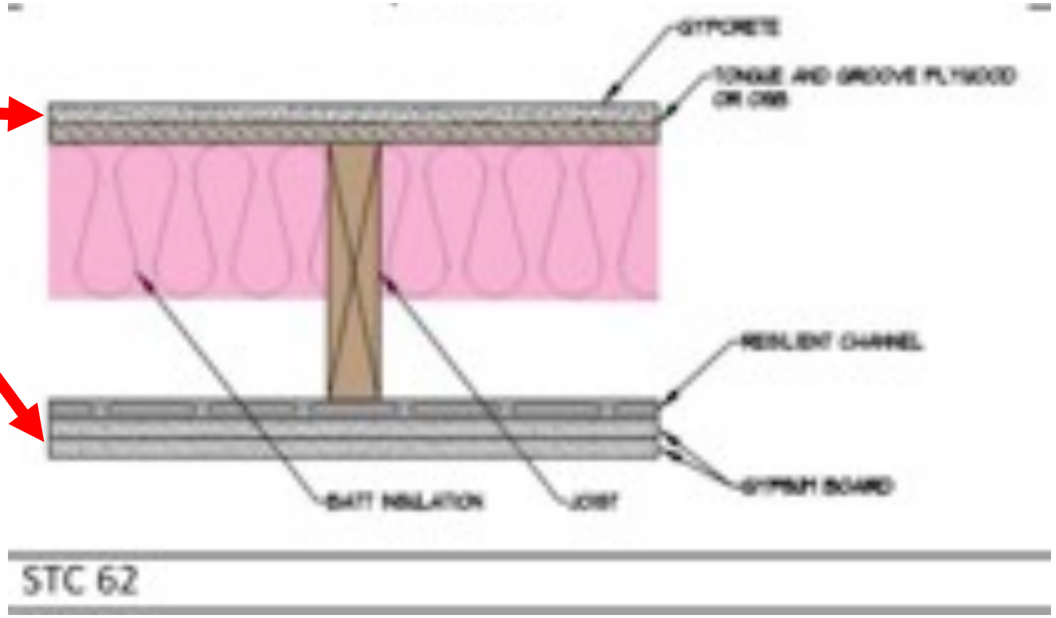

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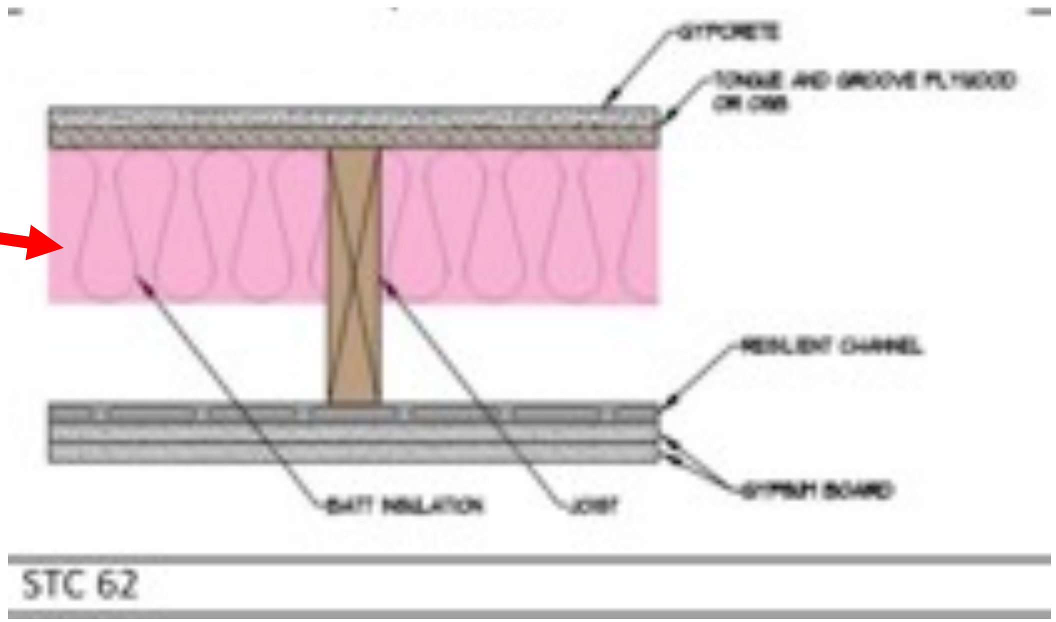

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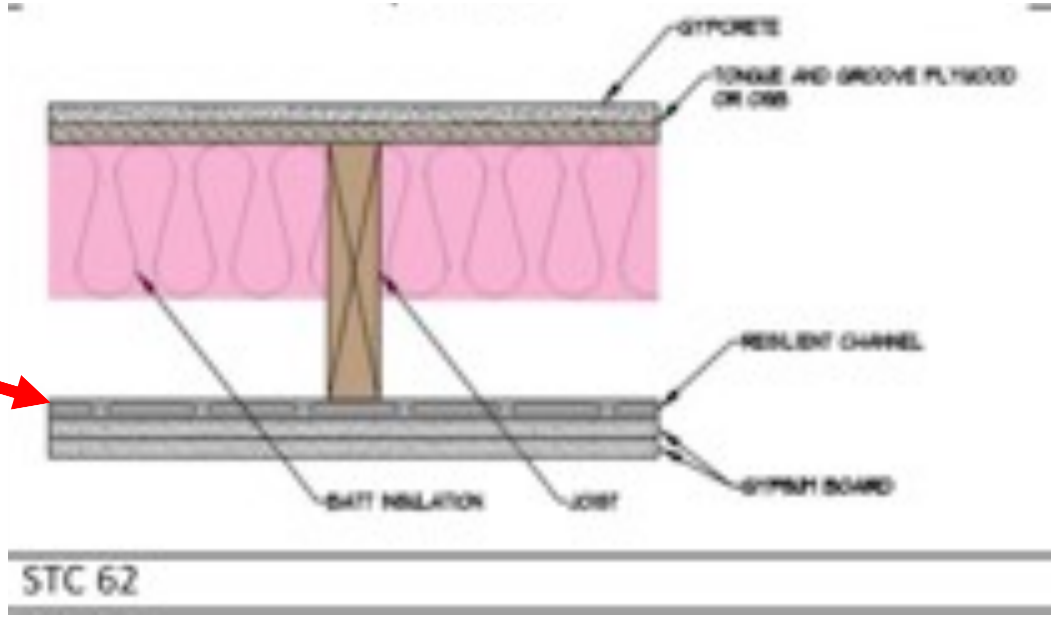

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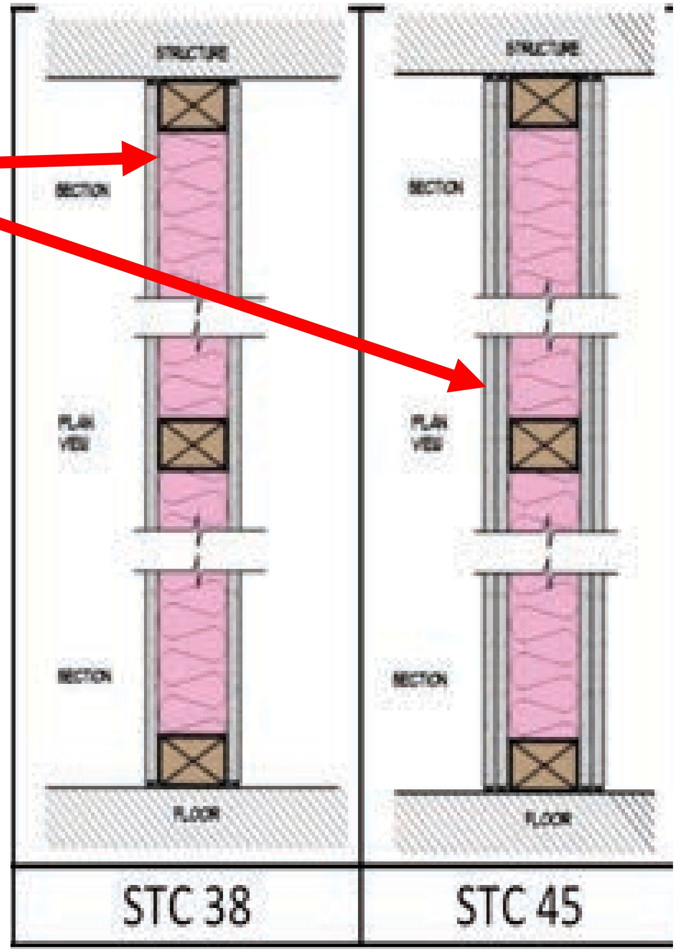

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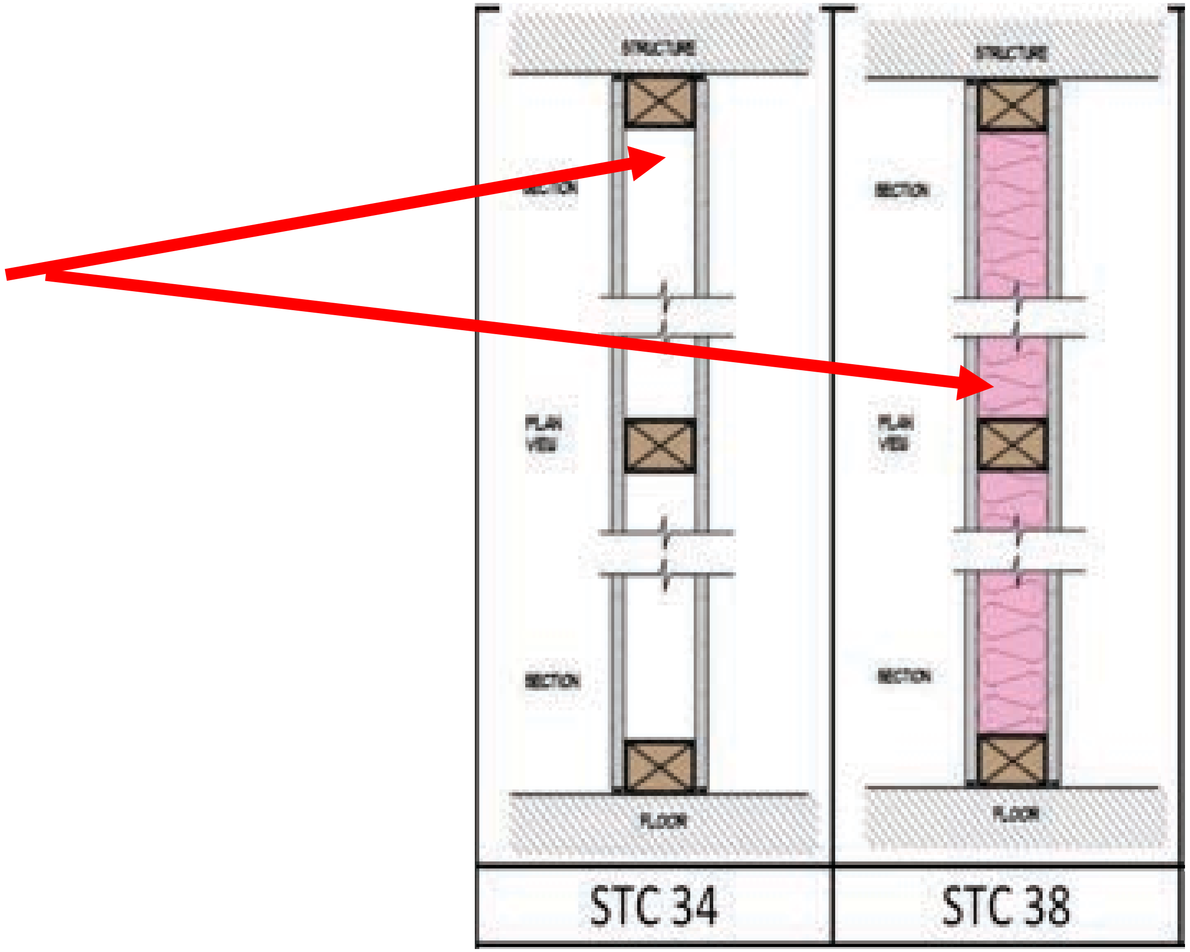

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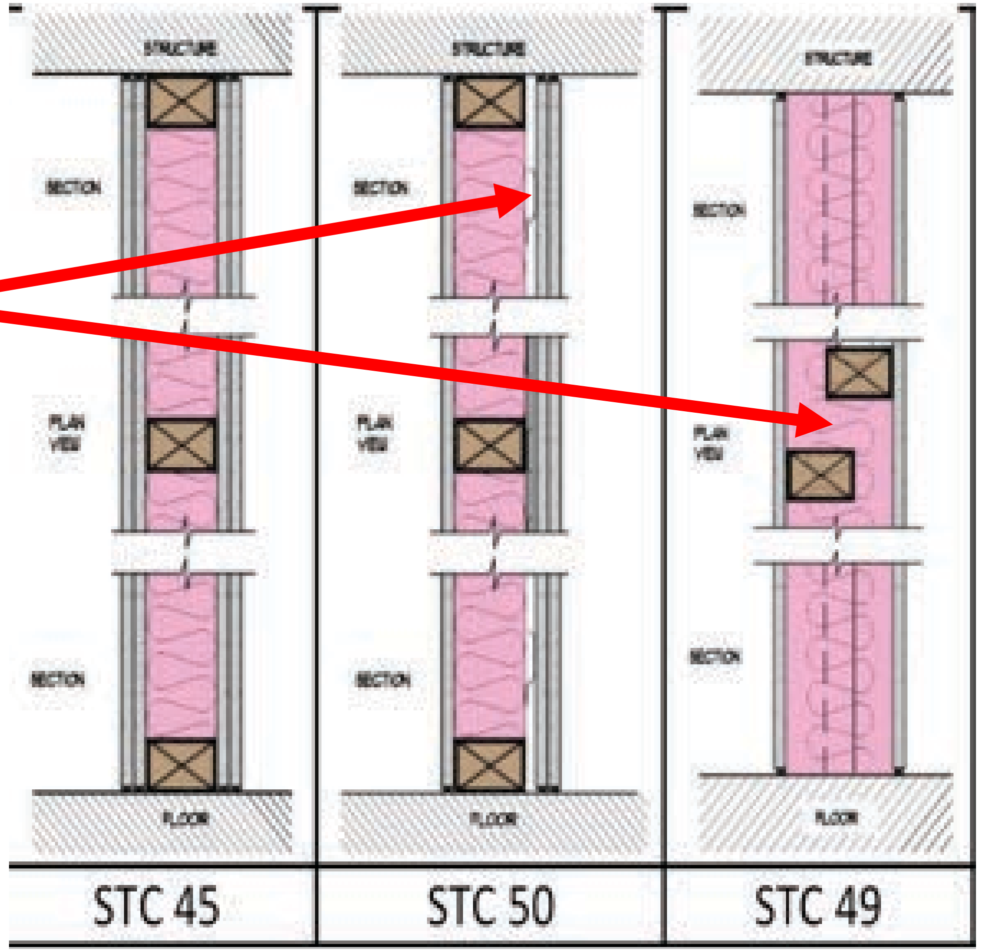

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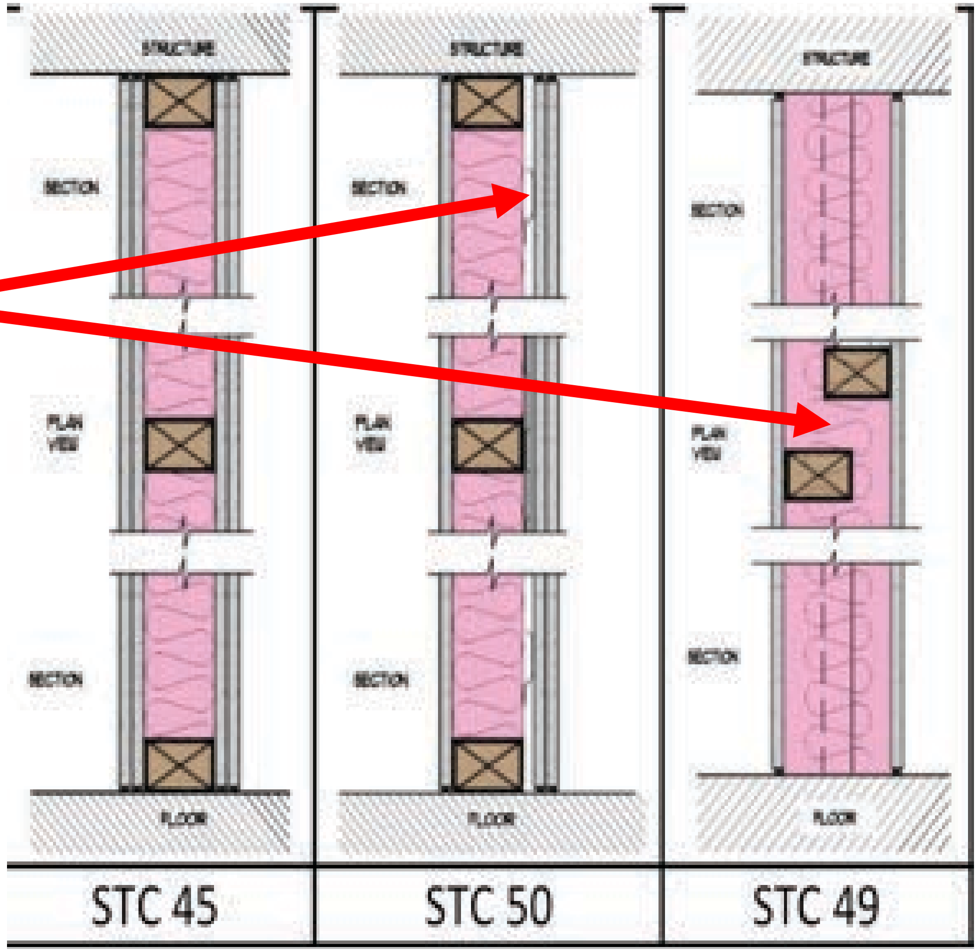


Make sure that structural elements don't defeat the purpose of these, especially decouplers

Acoustical Design

- 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?

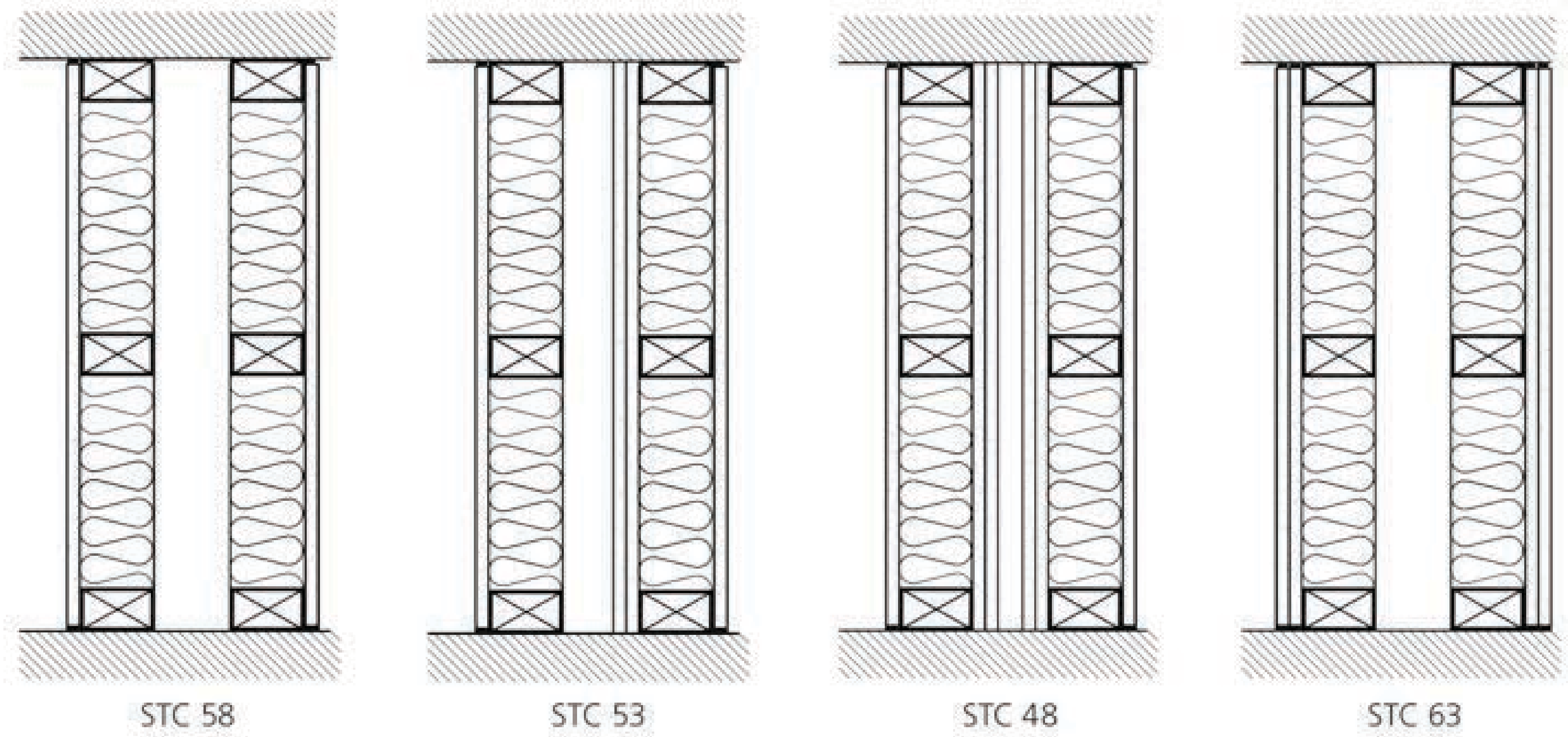
Yes, but placement is very important!


Credit: WoodWorks

Acoustical Design

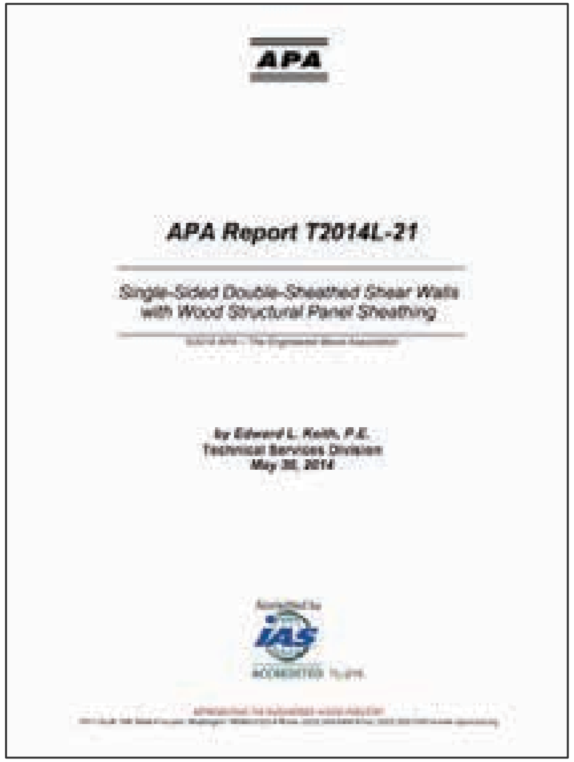
FIGURE 6

Effect of Sheathing Placement on Acoustical Performance (Plan View)



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



APA

APA Report T2014L-21

Single-Sided Double-Sheathed Shear Walls with Wood Structural Panel Sheathing

by Edward L. Keith, P.E.
Technical Services Division
May 30, 2014

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

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