WoodWorks™
WOOD PRODUCTS COUNCIL

# Sound Solutions:
## Designing for Acoustics in Wood Structures

Image: Haven at Avalon, Dwell Design Studios

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WoodWorks

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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

# Course Description

Noise control in buildings such as apartments, schools, and offices plays an important role in tenant satisfaction. Selecting an effective wall or floor/ceiling assembly is important—and necessary for proper design—but it's just one of several considerations. Covering both light wood-frame and mass timber structures, this presentation will provide a top to bottom approach to achieving sound acoustical performance. Topics will include code requirements and owner expectations, tested assemblies vs. calculated performance, exterior noise, interior noise reverberation, structural and fire-resistance related components, detailing to avoid flanking paths, and installation best practices.

# Learning Objectives

1. Consider code requirements for acoustical performance of building spaces compared to common owner expectations in occupancies such as multi-family.

2. Highlight best practice details to avoid noise flanking paths.

3. Explore options for minimizing exterior noise and interior reverberation issues in wood buildings including schools and offices.

4. Discuss the difference between acoustical performance of light-frame wood and mass timber assemblies and highlight successful acoustical design approaches for each.


Beyond the 50

# Acoustics Design Topics - Agenda

1. Principles of Acoustics Design
2. Code Requirements and Owner Expectations
3. Tested Assemblies & Calculated Performance
4. Interior Noise – Reverberation
5. Exterior Noise Control
6. Light-Frame Walls / Mass Timber Walls
7. Light-Frame Floors / Mass Timber Floors

# Acoustics Design Topics - Agenda

1. **Principles of Acoustics Design**
2. Code Requirements and Owner Expectations
3. Tested Assemblies & Calculated Performance
4. Light-Frame Floors & Walls
5. Mass Timber Floors & Walls

# Acoustical Design

## Types of noise to control:
## Exterior to interior

# Acoustical Design

## Types of noise to control:

# Acoustical Design

## Types of noise to control:
## Interior to interior

# Acoustical Design

## LOUDNESS COMPARISON CHART (dBA)

| Common Outdoor Activities | Noise Level (dBA) | Common Indoor Activities |
|---|---|---|
| Jet Fly-over at 1000 ft | 110 | Rock Band |
| | 100 | |
| Gas Lawn Mower at 3 ft | | |
| | 90 | Food Blender at 3 ft |
| Diesel Truck at 50 ft at 50 mph | 80 | Garbage Disposal at 3 ft |
| Noisy Urban Area, Daytime | | Vacuum Cleaner at 10 ft |
| Gas Lawn Mower at 100 ft | 70 | Normal Speech at 3 ft |
| Commercial Area | | |
| Heavy Traffic at 300 ft | 60 | Large Business Office |
| Quiet Urban, Daytime | 50 | Dishwasher Next Room |
| Quiet Urban, Nighttime | 40 | Theater, Large Conference Room (Background) |
| Quiet Suburban, Nighttime | | Library |
| | 30 | Bedroom at Night, Concert Hall (Background) |
| Quiet Rural, Nighttime | 20 | Broadcast/Recording Studio |
| | 10 | |
| Lowest Threshold of Human Hearing | 0 | Lowest Threshold of Human Hearing |

An increase of 3 dBA is barely perceptible to the human ear.

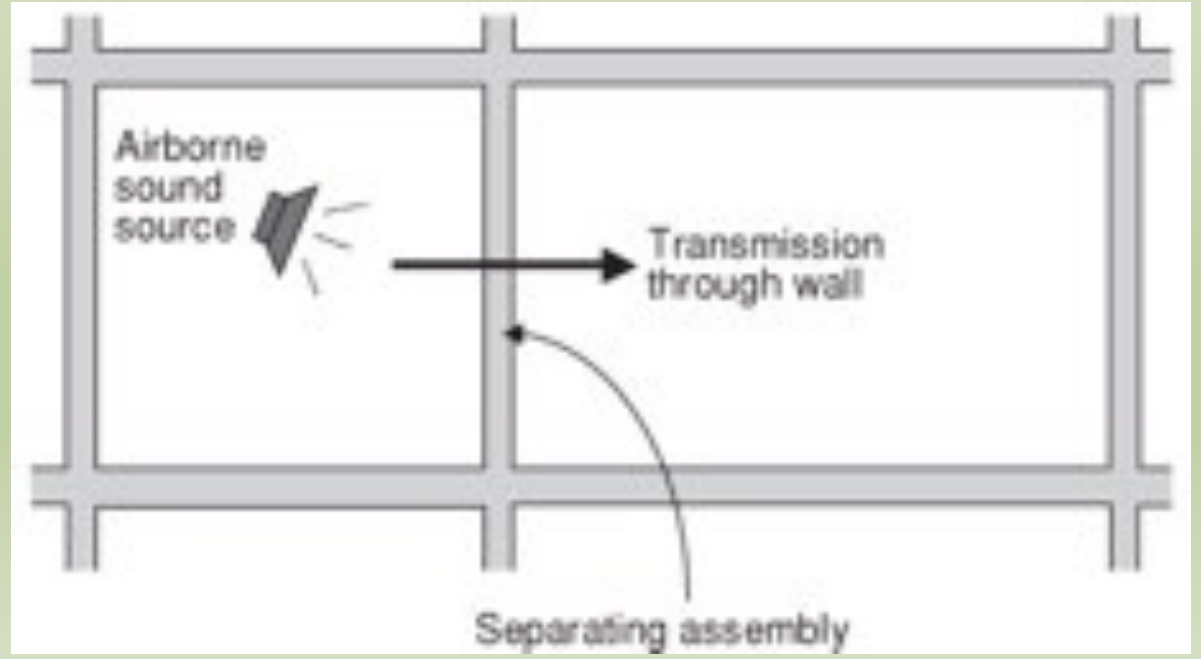
| Changes in STC Rating | Changes in Apparent Loudness |
|---|---|
| +/- 1 | Almost imperceptible |
| +/- 3 | Just perceptible |
| +/- 5 | Clearly noticeable |
| +/- 10 | Twice (or half) as loud |

# Acoustical Design

## 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

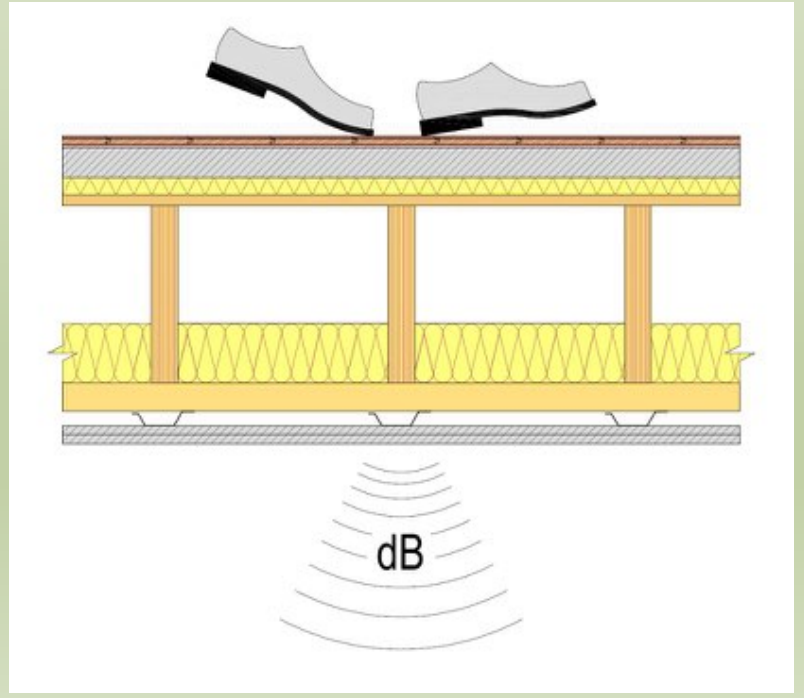



# Acoustical Design

**<u>Structure-borne sound:</u>**

**Impact Insulation Class (IIC)**

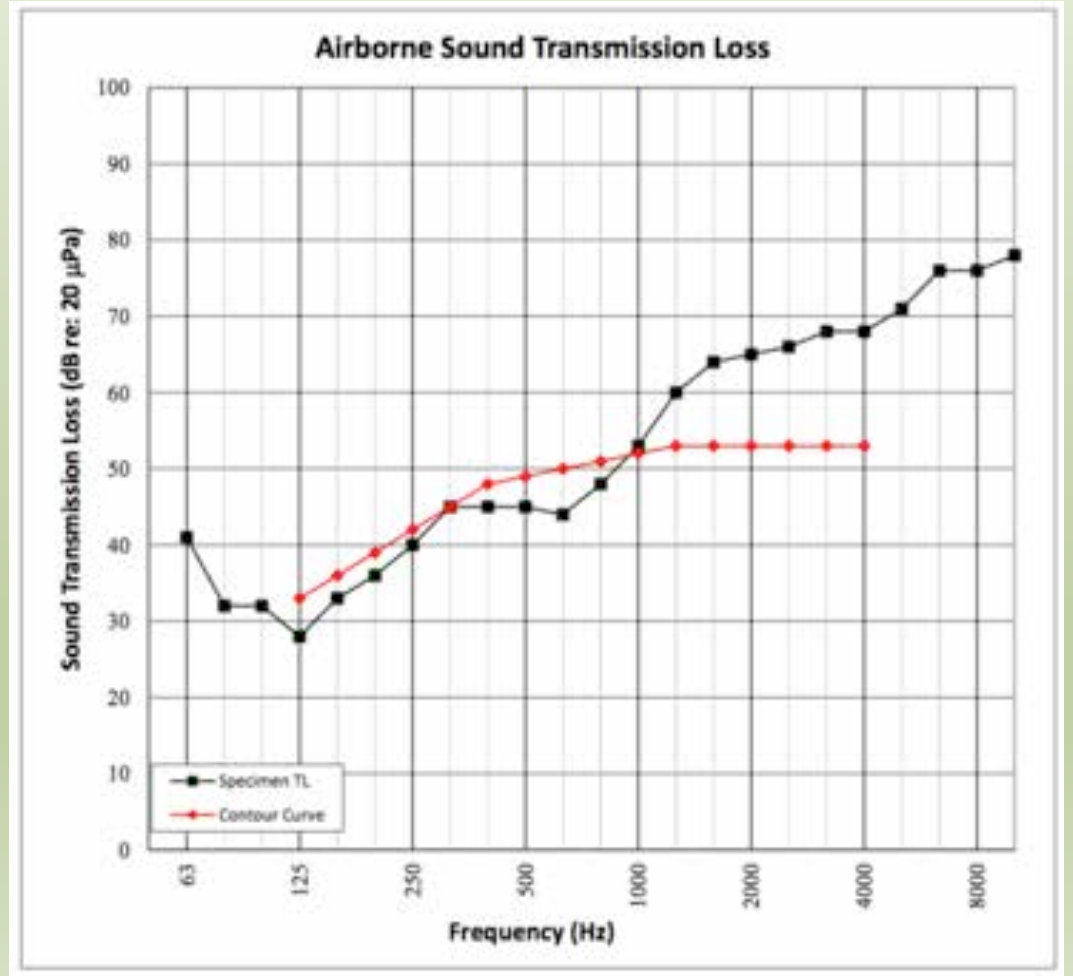
- Evaluates how effectively an assembly blocks impact sound from passing through it
- Only applies to floor/ceiling assemblies

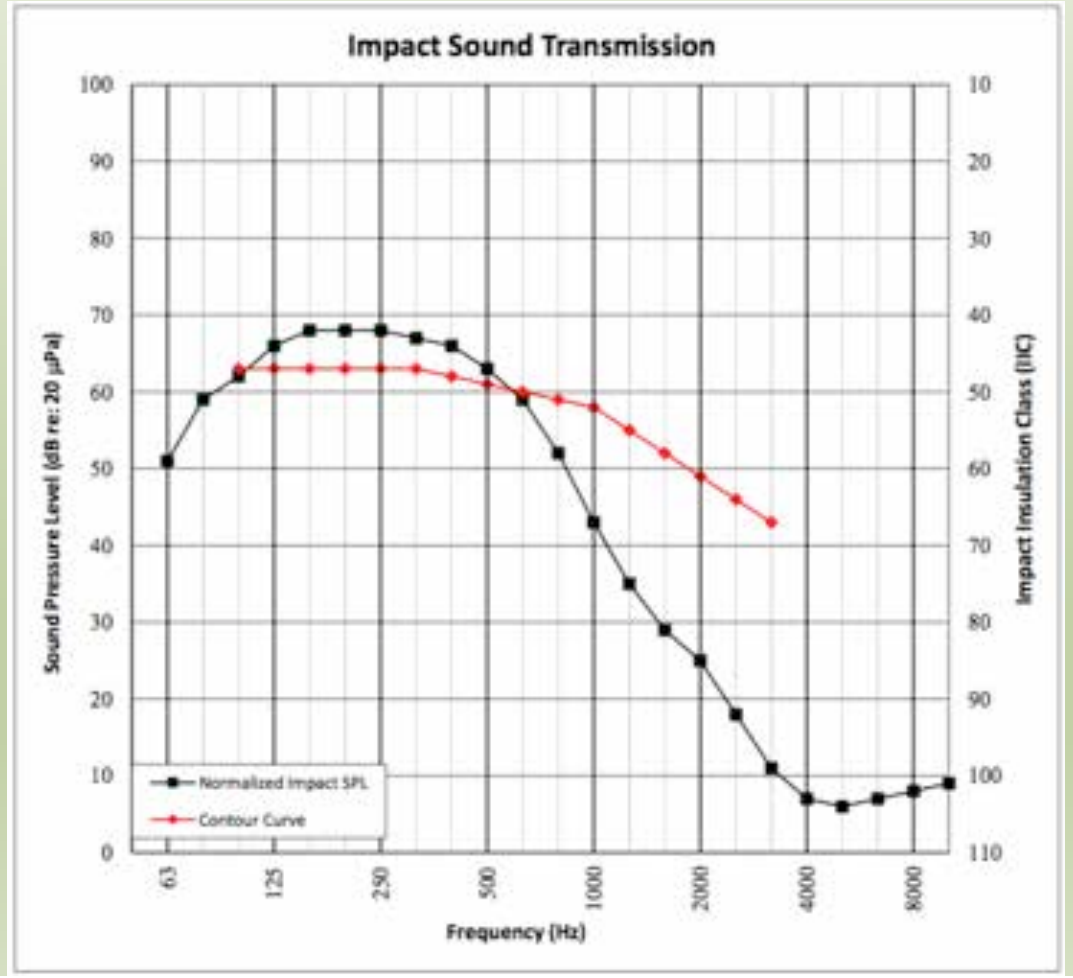



# Acoustical Design

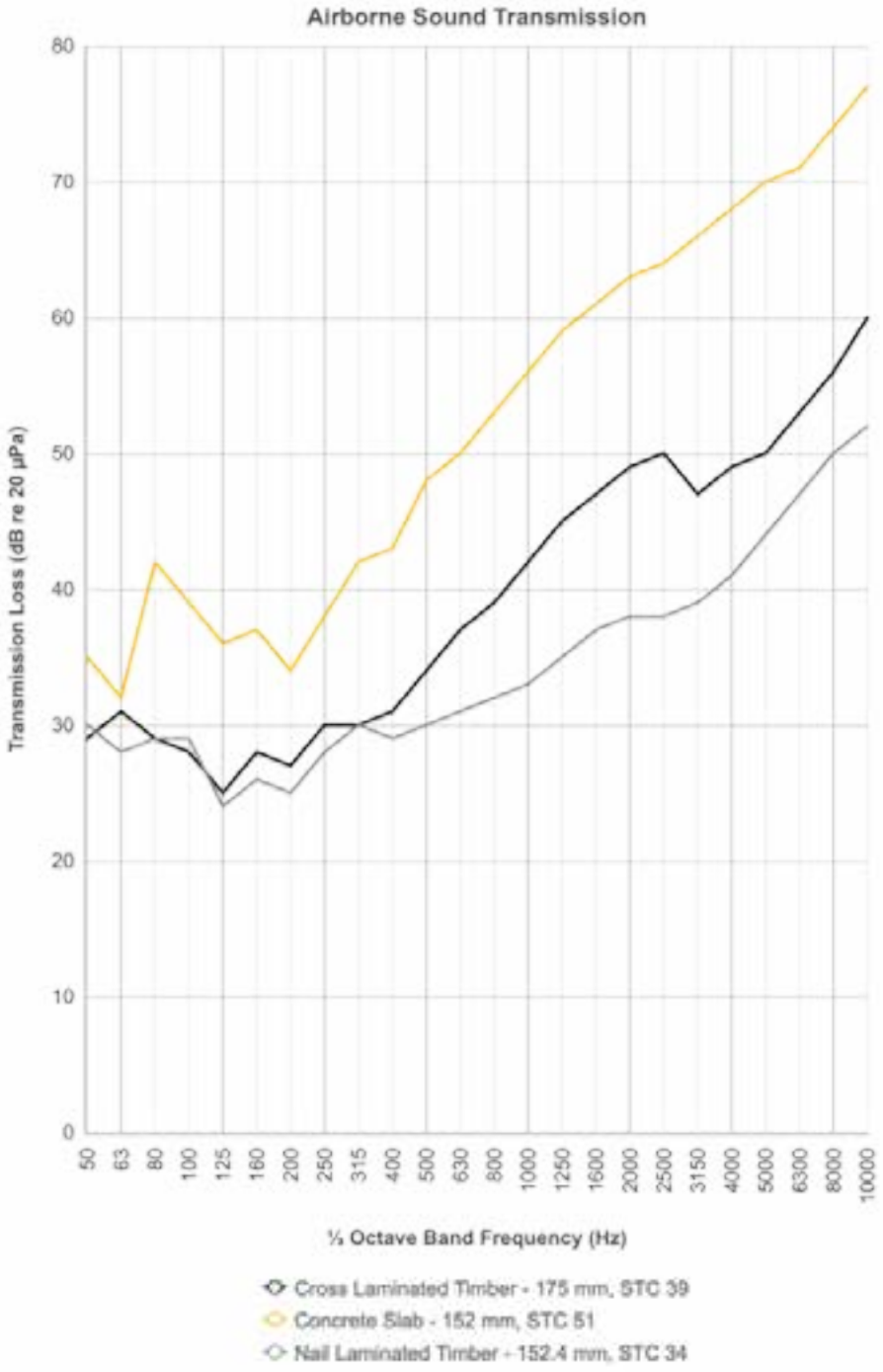
# Acoustical Design

**STC and IIC Tests: Utilize 1/3 Octave Band Data, measured at 16 frequencies from 125 to 4000 Hz**



# Acoustical Design




**STC/IIC determined by plotting actual tested data against standardized contours, paired to contour that meets criteria for deviation from actual tested data (at any given frequency and the sum of all)**

**Due to single number rating over a series of frequencies, can have assemblies with same STC/IIC – one can perform well at a given frequency while the other doesn't**

Image Credit: Pliteq

# Acoustics Design Topics - Agenda

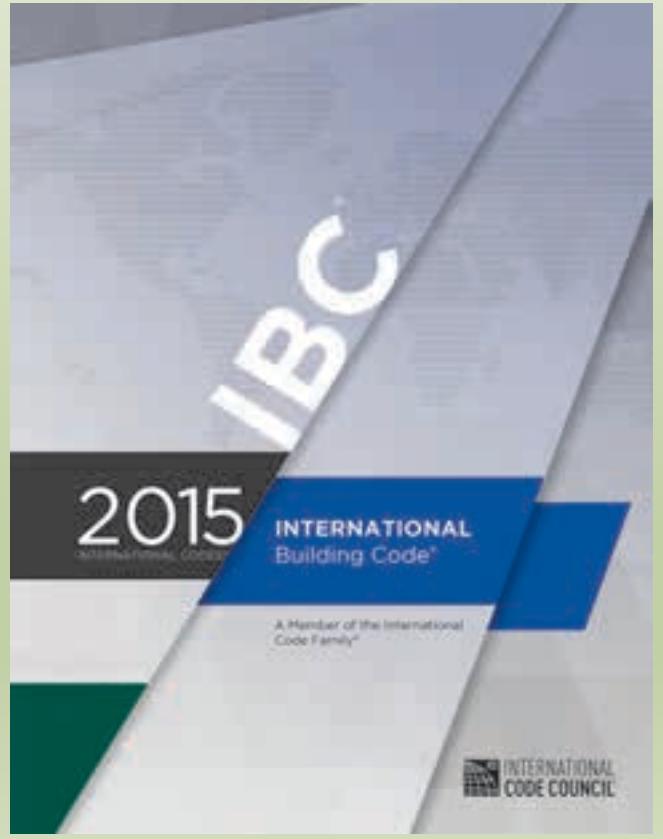
1. Principles of Acoustics Design
2. **Code Requirements and Owner Expectations**
3. Tested Assemblies & Calculated Performance
4. Light-Frame Floors & Walls
5. Mass Timber Floors & Walls

# Acoustical Criteria

## IBC 1207

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 Criteria

| STC | What can be heard |
|---|---|
| 25 | Normal speech can be understood quite easily and distinctly through wall |
| 30 | Loud speech can be understood fairly well, normal speech heard but not understood |
| 35 | Loud speech audible but not intelligible |
| 40 | Onset of "privacy" |
| 42 | Loud speech audible as a murmur |
| 45 | Loud speech not audible; 90% of statistical population not annoyed |
| 50 | Very loud sounds such as musical instruments or a stereo can be faintly heard; 99% of population not annoyed. |
| 60+ | Superior soundproofing; most sounds inaudible |

# Acoustical Criteria

Acoustical Isolation Between Units – Airborne (STC) / Impact (IIC)

| Class Designation | Airborne Sound Isolation (STC) | Floor Ceiling Impact Isolation (IIC) |
|---|---|---|
| **Entry level** | 50 | 50 |
| **Market rate** | 55 | 55 |
| **Luxury** | 60 | 60 |

# Acoustical Criteria

LEED has acoustics criteria for specific occupancies:

Schools:

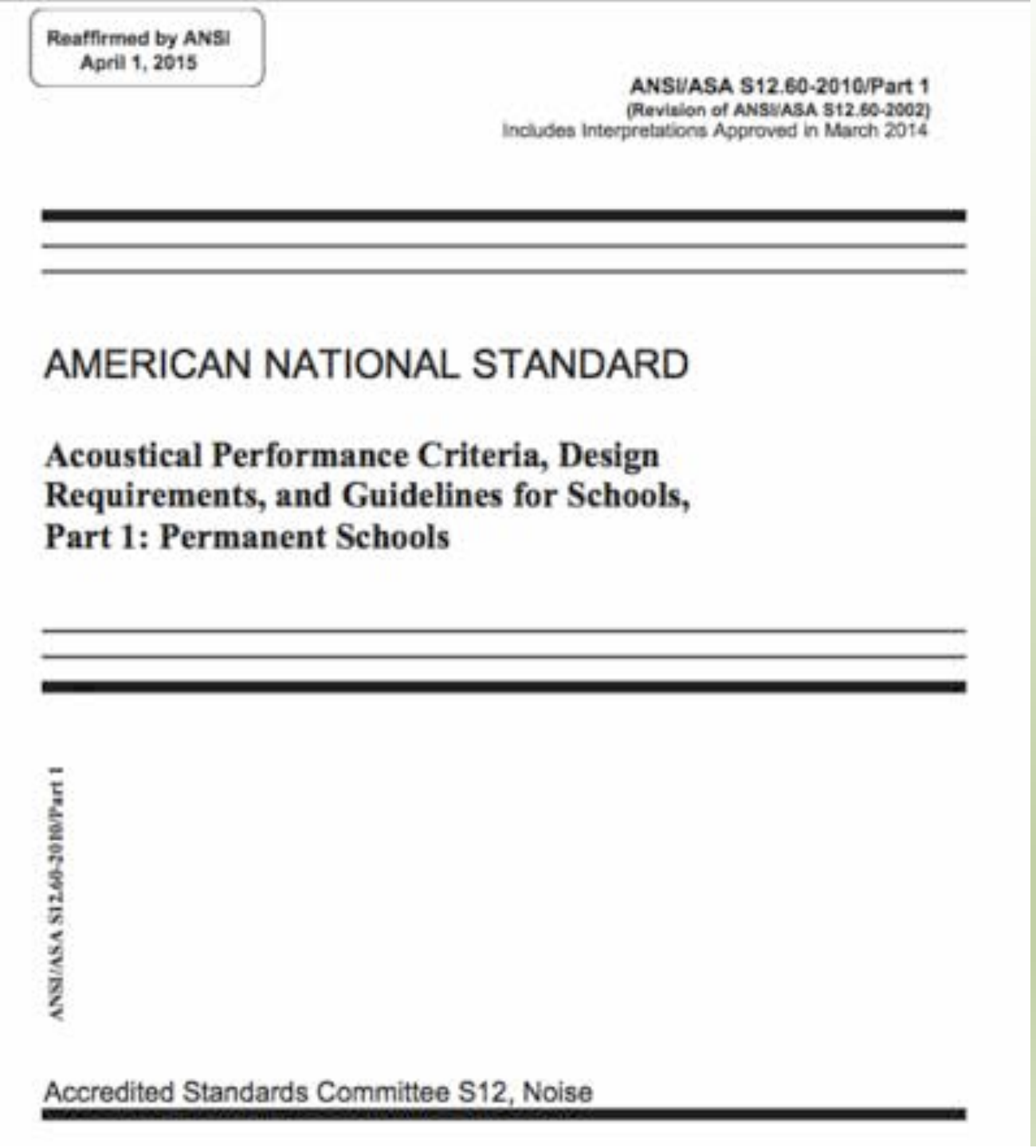

Addresses items such as:

- HVAC background noise
- Exterior noise
- Reverberation time

Healthcare:


Addresses items such as:

- Speech privacy
- Background noise


Reaffirmed by ANSI
April 1, 2015

ANSI/ASA S12.60-2010/Part 1
(Revision of ANSI/ASA S12.60-2002)
Includes Interpretations Approved in March 2014

AMERICAN NATIONAL STANDARD

**Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools, Part 1: Permanent Schools**

ANSI/ASA S12.60-2010/Part 1

Accredited Standards Committee S12, Noise

# Acoustical Criteria

No code requirements for education buildings, but many owners require minimum level of performance

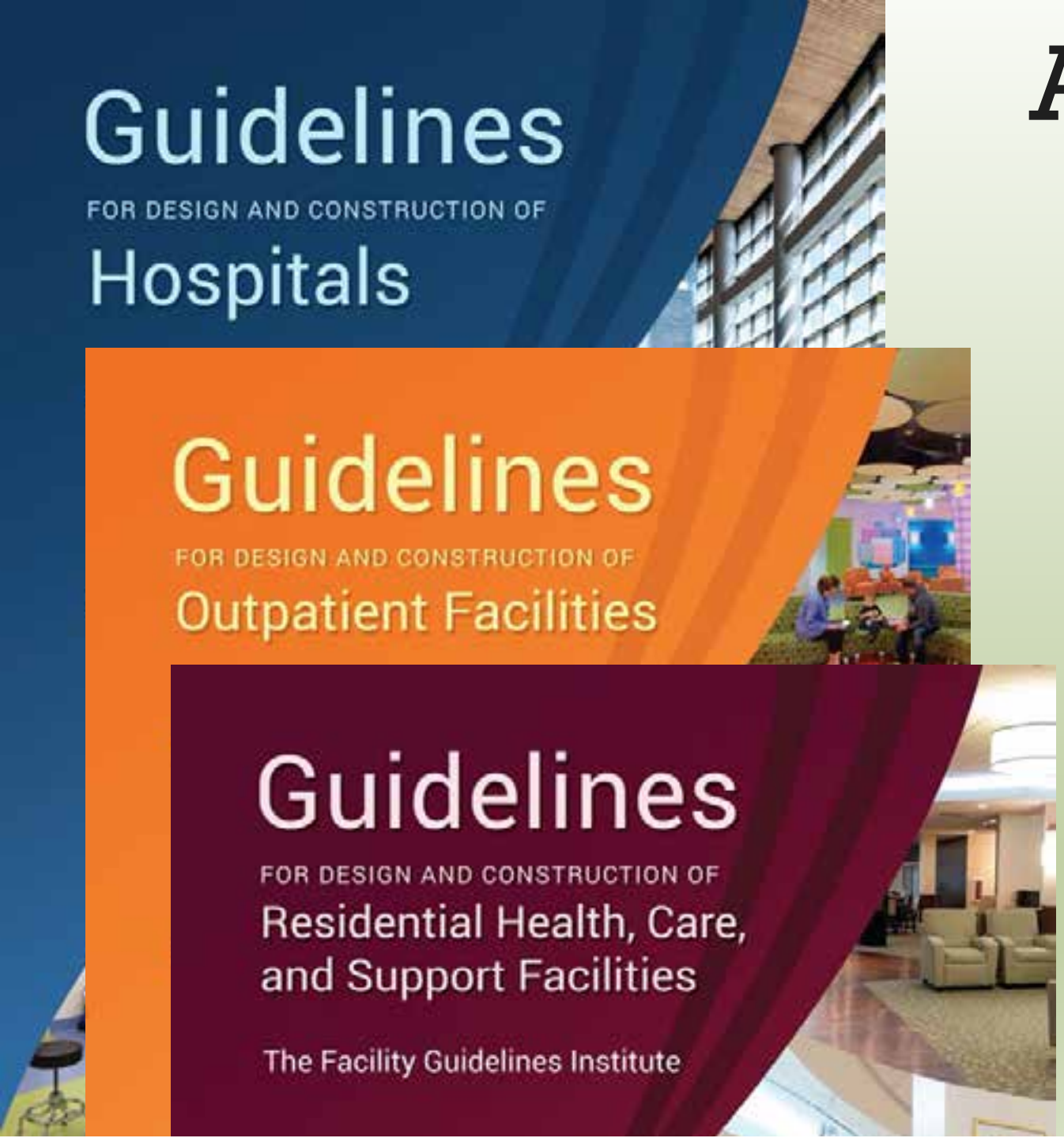
**ANSI S12.60:**

Optional acoustics criteria for schools

Examples:

- Floor/wall separating learning space from corridor: STC 45
- Floor/wall separating learning space from music room: STC 60

# Acoustical Criteria




Referenced in LEED for Healthcare:

The Facilities Guidelines Institute produces documents that address acoustics design considerations and guidelines for hospitals, outpatient facilities and residential health, care and support facilities

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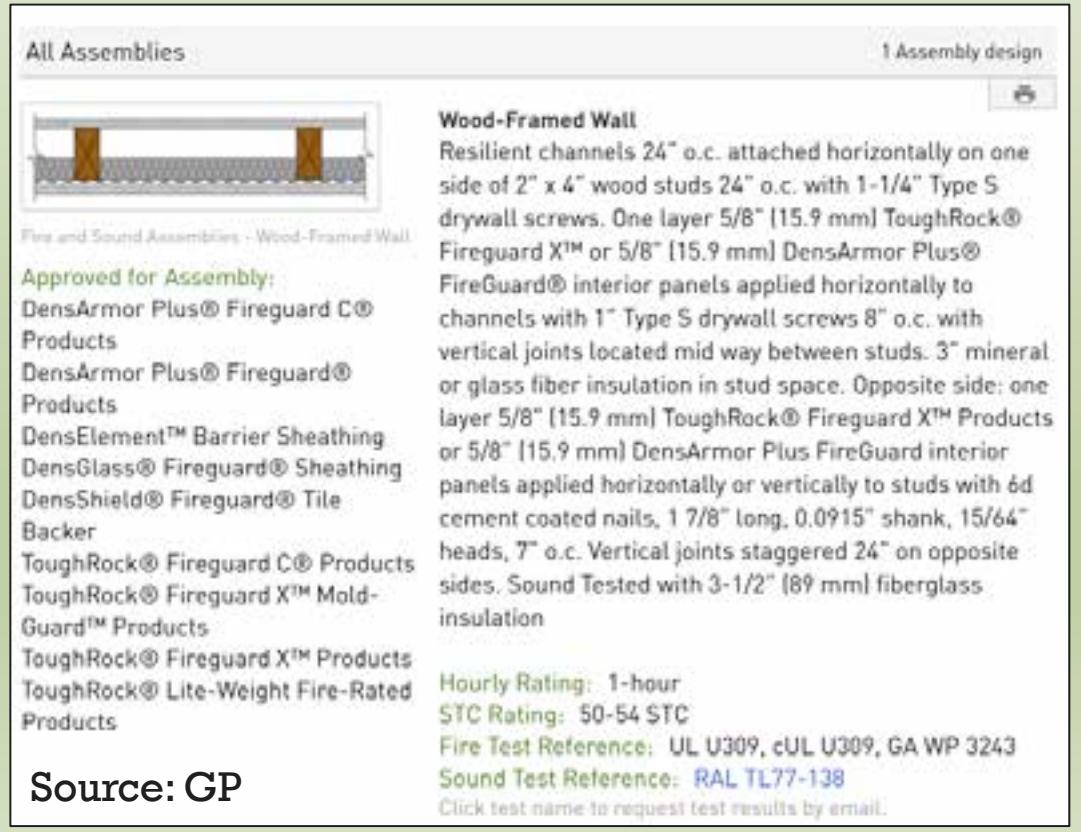
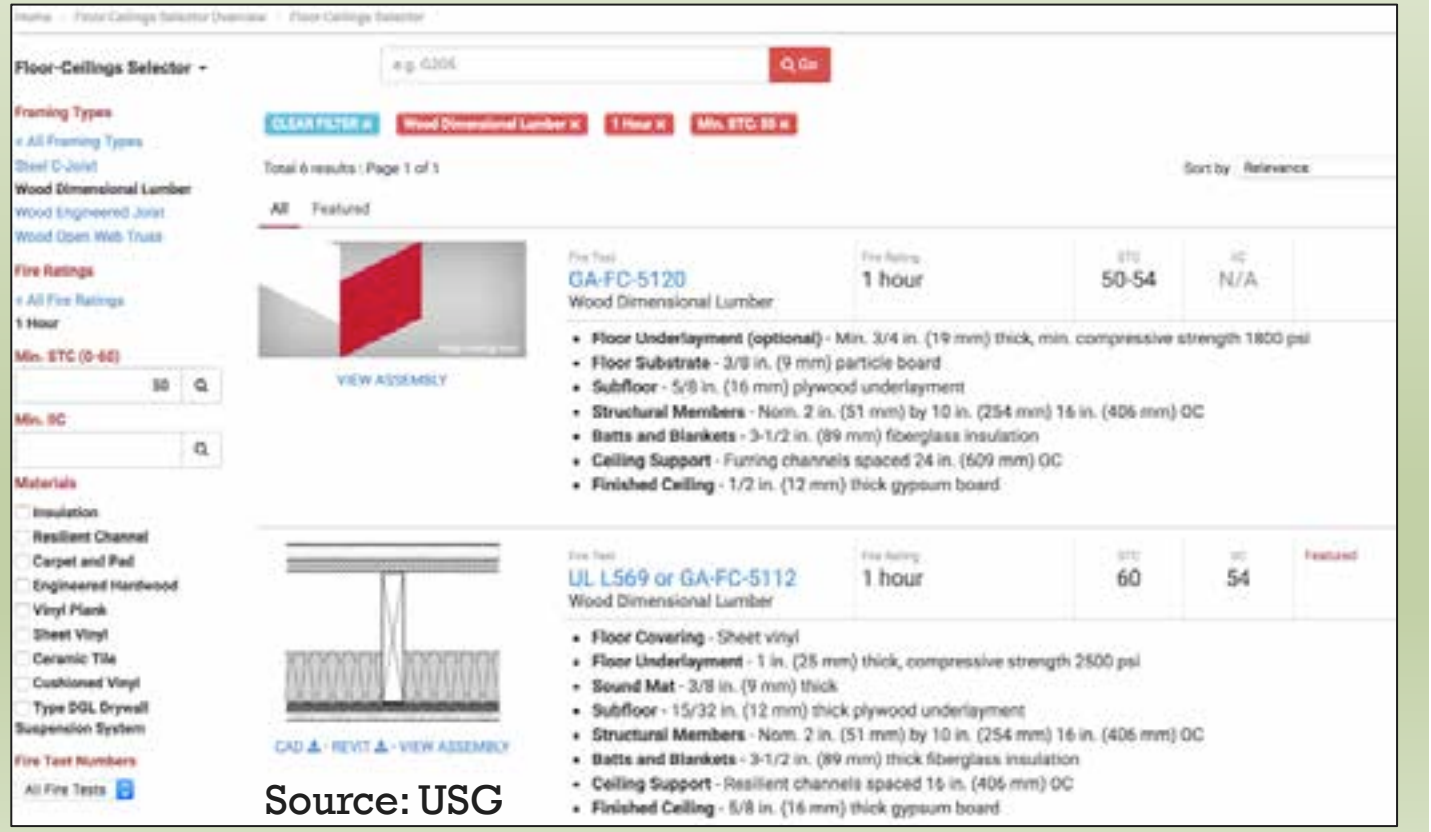
# Acoustical Detailing

Sources of acoustically tested assemblies:

- Gypsum product manufacturers literature




Source: GP



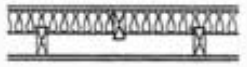

Source: USG

# Acoustical Detailing

Sources of acoustically tested assemblies:

- Insulation product manufacturers literature

## Staggered Wood Stud Wall System

| STC | STC Test No. | Construction Description | | Fire Rating | Fire Test |
|---|---|---|---|---|---|
| 46 | W5769 | Staggered wood studs 16" o.c.; single layer 5/8" type "x" gypsum drywall each side; one thickness, 3½" thick *QuietZone* Acoustic Batts |  | 1 hr.[1] | UL U305 |
| 51 | W01486 | Staggered wood studs 16" o.c.; single layer ½" type "x" gypsum drywall each side; one thickness, 3½" thick *QuietZone* Acoustic Batts |  | N.A. | — |
| 51 | OC5FC | Staggered wood studs 16" o.c.; single layer ½" type "x" gypsum drywall each side two thicknesses, 3½" thick *QuietZone* Acoustic Batts | | | |
| 53 | W4769 | Staggered wood studs 24" o.c.; double layer ½" type "x" gypsum drywall one sid single layer other side; one thickness, 3½" thick *QuietZone* Acoustic Batts | | | |
| 55 | W4869 | Staggered wood studs 24" o.c.; double layer ½" type "x" gypsum drywall each si one thickness, 3½" thick *QuietZone* Acoustic Batts | | | |

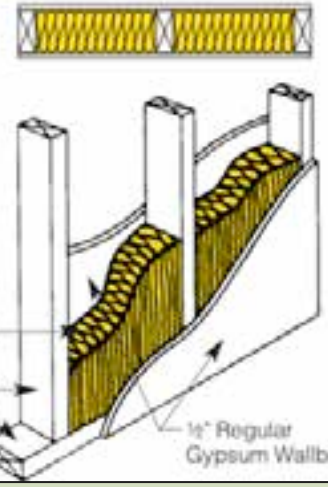
[1]Rating is estimated from tests using thinner assemblies of fewer layers of gypsum drywall. Specific test referer

Source: Owens Corning

## Building Insulation Assemblies

1

2x4 Wood Stud Partition



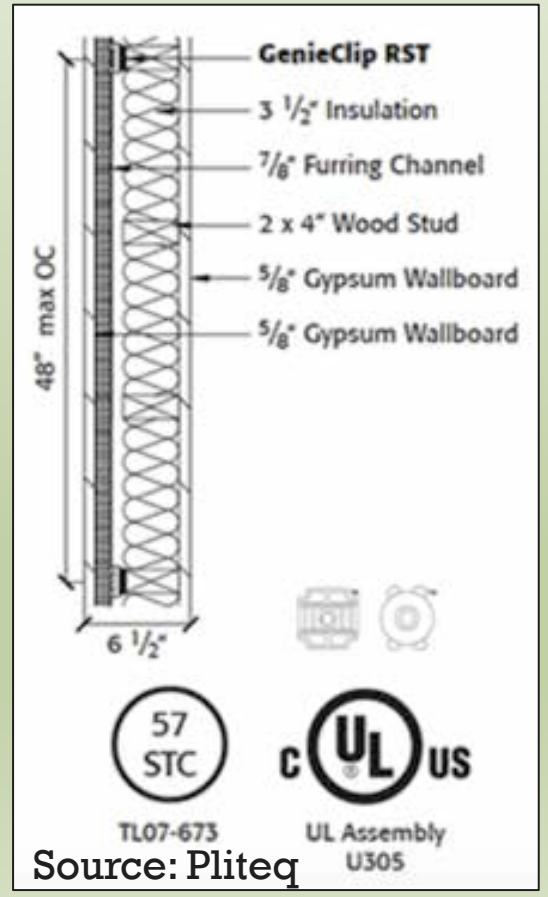

| Sound Rating | Construction Details |
|---|---|
| STC | 39 |
| Test No. | RAL-TL94-305 |
| STC | 34 (no insulation) |
| Test. No. | RAL-TL94-275 |
| Materials | 2 x 4 Wood Studs 16" o.c. |
| | 2 x 4 Wood Plates |
| | 3½" Fiber Glass Insulation |
| | ½" Regular Gypsum Wallboard |

Source: CertainTeed

# Acoustical Detailing

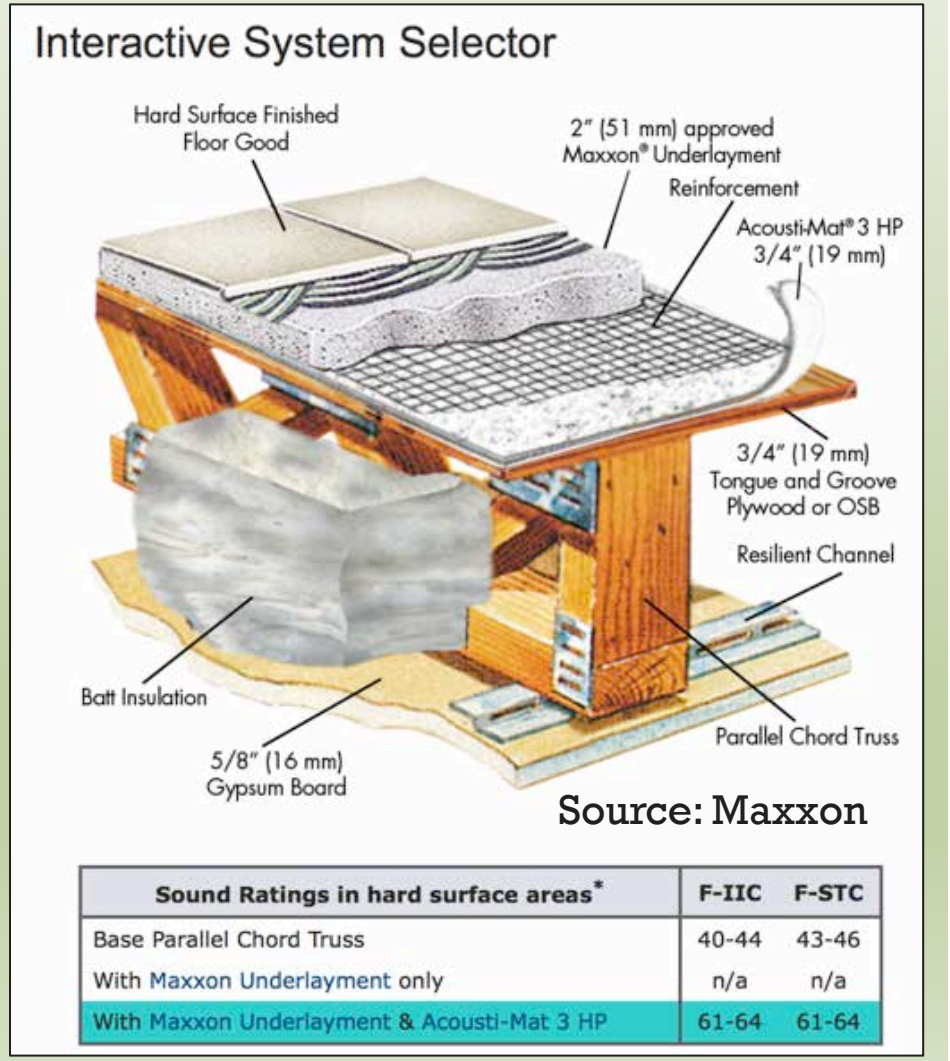
Sources of acoustically tested assemblies:

- Acoustical product manufacturers literature




Source: Pliteq


Source: AcoustiTech




Source: Maxxon

| Sound Ratings in hard surface areas* | F-IIC | F-STC |
|---|---|---|
| Base Parallel Chord Truss | 40-44 | 43-46 |
| With Maxxon Underlayment only | n/a | n/a |
| With Maxxon Underlayment & Acousti-Mat 3 HP | 61-64 | 61-64 |

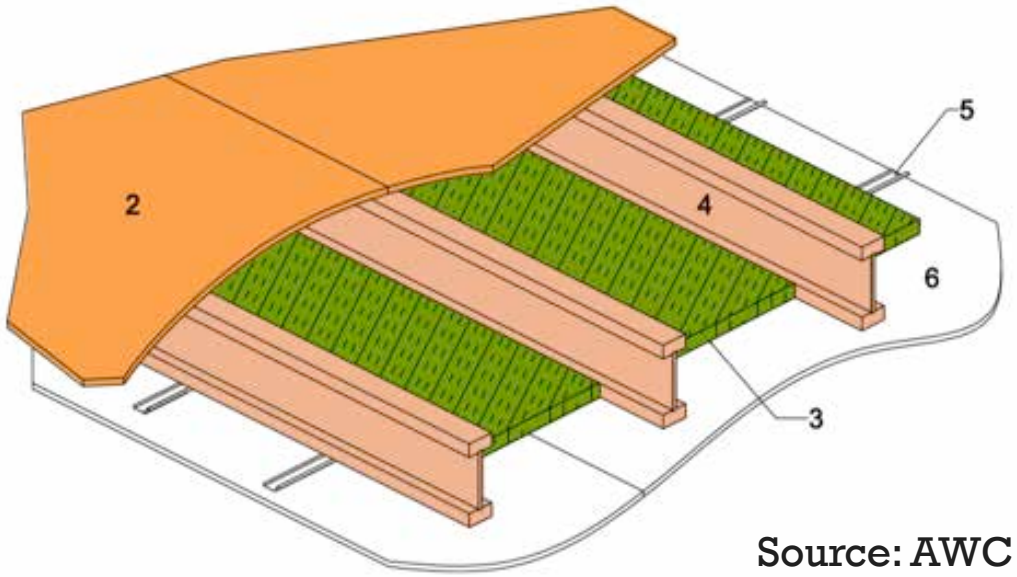
# Acoustical Detailing

Sources of acoustically tested assemblies:

- Industry associations: AWC, APA, others

**WIJ-1.2 One-Hour Fire-Resistance-Rated Ceiling Assembly**

Floor[a]/Ceiling - 100% Design Load - 1 Hour Rating - ASTM E 119 / NFPA 251

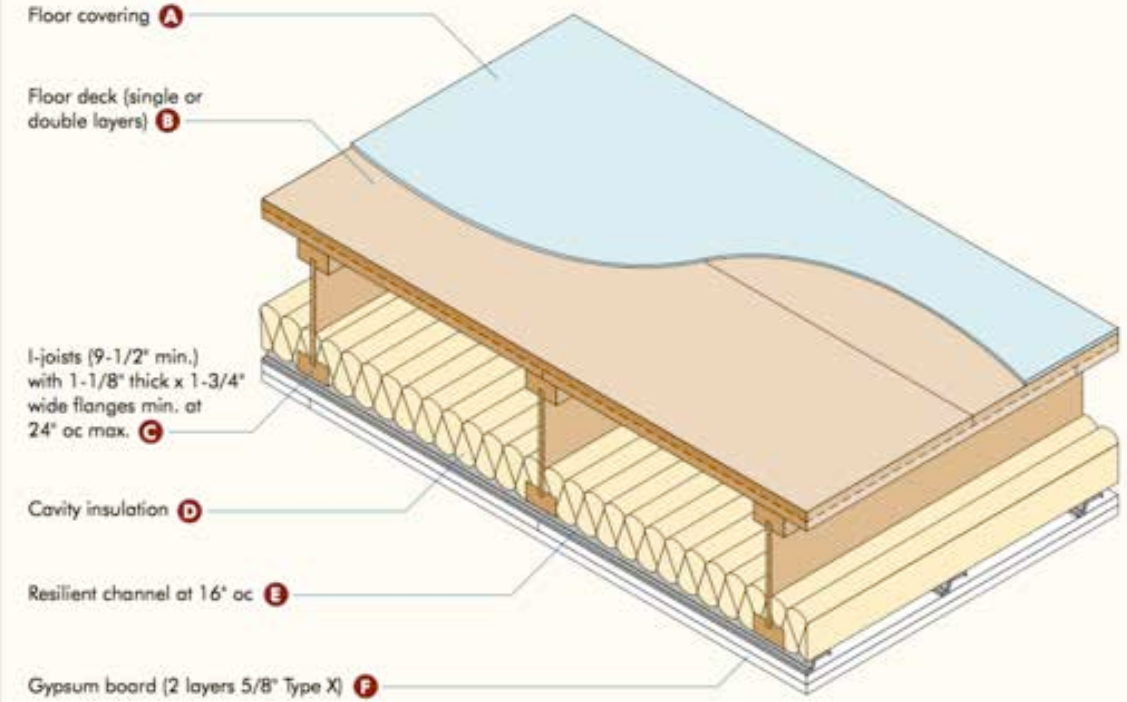



Source: AWC

| STC and IIC Sound Ratings for Listed Assembly | | | | | | | |
|---|---|---|---|---|---|---|---|
| Without Gypsum Concrete | | | | With Gypsum Concrete | | | |
| Cushioned Vinyl | | Carpet & Pad | | Cushioned Vinyl | | Carpet & Pad | |
| STC | IIC | STC | IIC | STC | IIC | STC | IIC |
| 51[b] | 46[b] | 51[b] | 64[b] | 60[b] | 50[b] | 60[b] | 65[b] |

FIGURE 1

**CROSS-SECTION OF ALL-WOOD FLOOR ASSEMBLY**

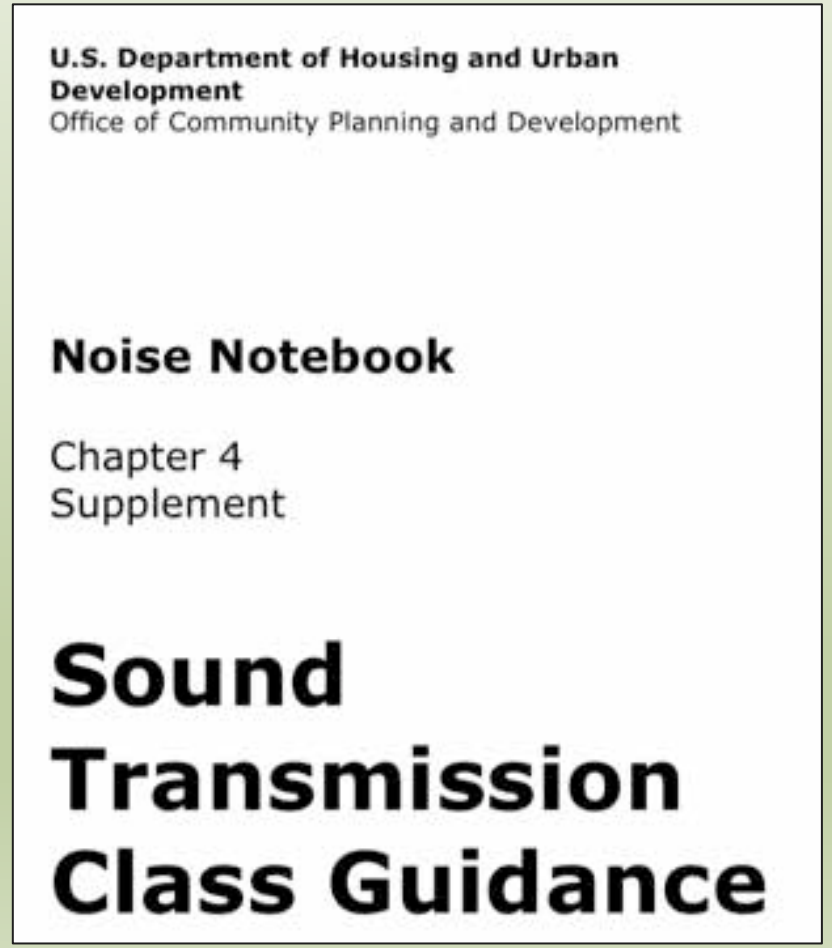



Source: APA

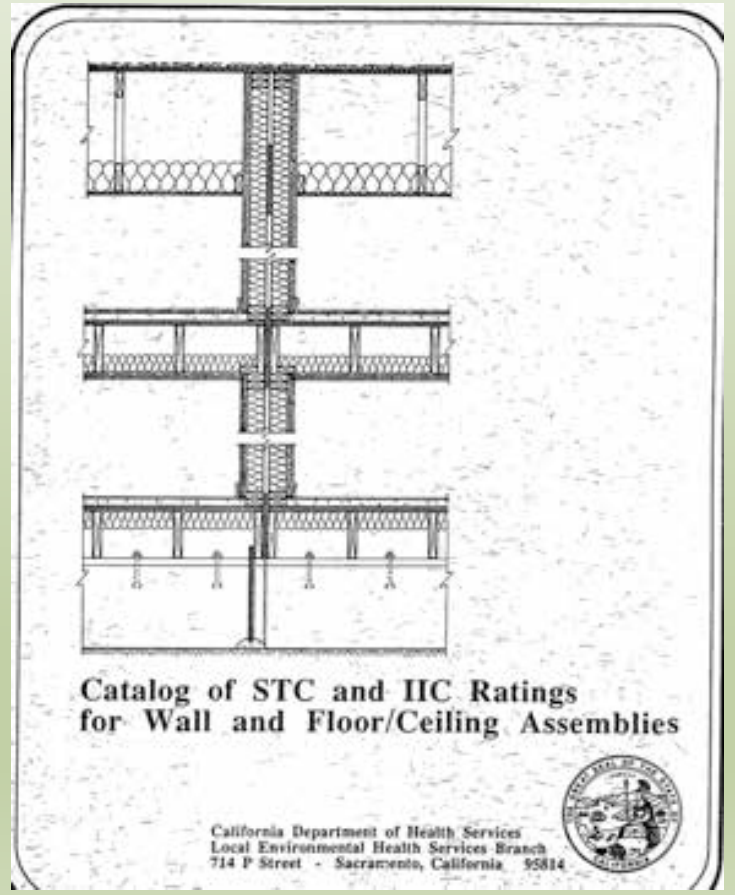
# Acoustical Detailing

Sources of acoustically tested assemblies:

- Other industry associations



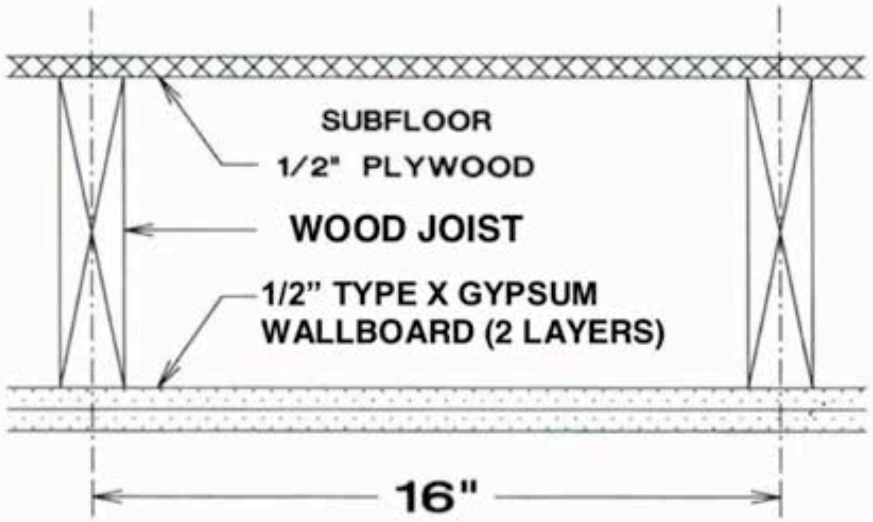

Source: HUD




Source: CA DoH


Source: GA

# Acoustical Detailing




| | | |
|---|---|---|
| 1/2 inch Type X Gypsum wallboard | = | 25 minutes |
| 1/2 inch Type X Gypsum wallboard | = | 25 minutes |
| Wood joists | = | 10 minutes |
| Combined Assembly Fire Resistance Rating | = | 60 minutes |

**Figure 2 Floor/Ceiling Assembly**

| Description | STC | IIC |
|---|---|---|
| Carpet & Pad | 0 | 20 |
| 3/4" Gypcrete® | 7 | 1 |
| Wood I-joist Floor | 36 | 33 |
| Resilient Channel | 10 | 8 |
| ***Total*** | ***53*** | ***62*** |

Table 18.1.3. Example calculation.

Source: SBCA

Can I acoustically rate individual components in an assembly and then add them up for the system rating?

It depends…

# Acoustical Detailing

2018 IBC now allows engineering analysis based on comparisons

**1206.2 Airborne sound.**

Walls, partitions and floor-ceiling assemblies separating *dwelling units* and *sleeping units* from each other or from public or service areas shall have a sound transmission class of not less than 50, or not less than 45 if field tested, for airborne noise where tested in accordance with ASTM E90. Alternatively, the sound transmission class of walls, partitions and floor-ceiling assemblies shall be established by engineering analysis based on a comparison of walls, partitions and floor-ceiling assemblies having sound transmission class ratings as determined by the test procedures set forth in ASTM E90. Penetrations or openings in construction assemblies for piping; electrical devices; recessed cabinets; bathtubs; soffits; or heating, ventilating or exhaust ducts shall be sealed, lined, insulated or otherwise treated to maintain the required ratings. This requirement shall not apply to entrance doors; however, such doors shall be tight fitting to the frame and sill.

**1206.2.1 Masonry.**

The sound transmission class of concrete masonry and clay masonry assemblies shall be calculated in accordance with TMS 0302 or determined through testing in accordance with ASTM E90.

**1206.3 Structure-borne sound.**

Floor-ceiling assemblies between *dwelling units* and *sleeping units* or between a *dwelling unit* or *sleeping unit* and a public or service area within the structure shall have an impact insulation class rating of not less than 50, or not less than 45 if field tested, where tested in accordance with ASTM E492. Alternatively, the impact insulation class of floor-ceiling assemblies shall be established by engineering analysis based on a comparison of floor-ceiling assemblies having impact insulation class ratings as determined by the test procedures in ASTM E492.

# Acoustical Detailing

2018 IBC now allows engineering analysis based on comparisons

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120

The through

test

1206.3 S

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Alternatively, the **sound transmission class** of walls, partitions and floor-ceiling assemblies **shall be established by engineering analysis based on a comparison** of walls, partitions and floor-ceiling assemblies having sound transmission class ratings as determined by the test procedures set forth in ASTM E90.

# Acoustics Design Topics - Agenda

1. Principles of Acoustics Design
2. Code Requirements and Owner Expectations
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4. **Light-Frame Floors & Walls**
5. Mass Timber Floors & Walls

# Understanding Acoustical Detailing

# Acoustical Detailing

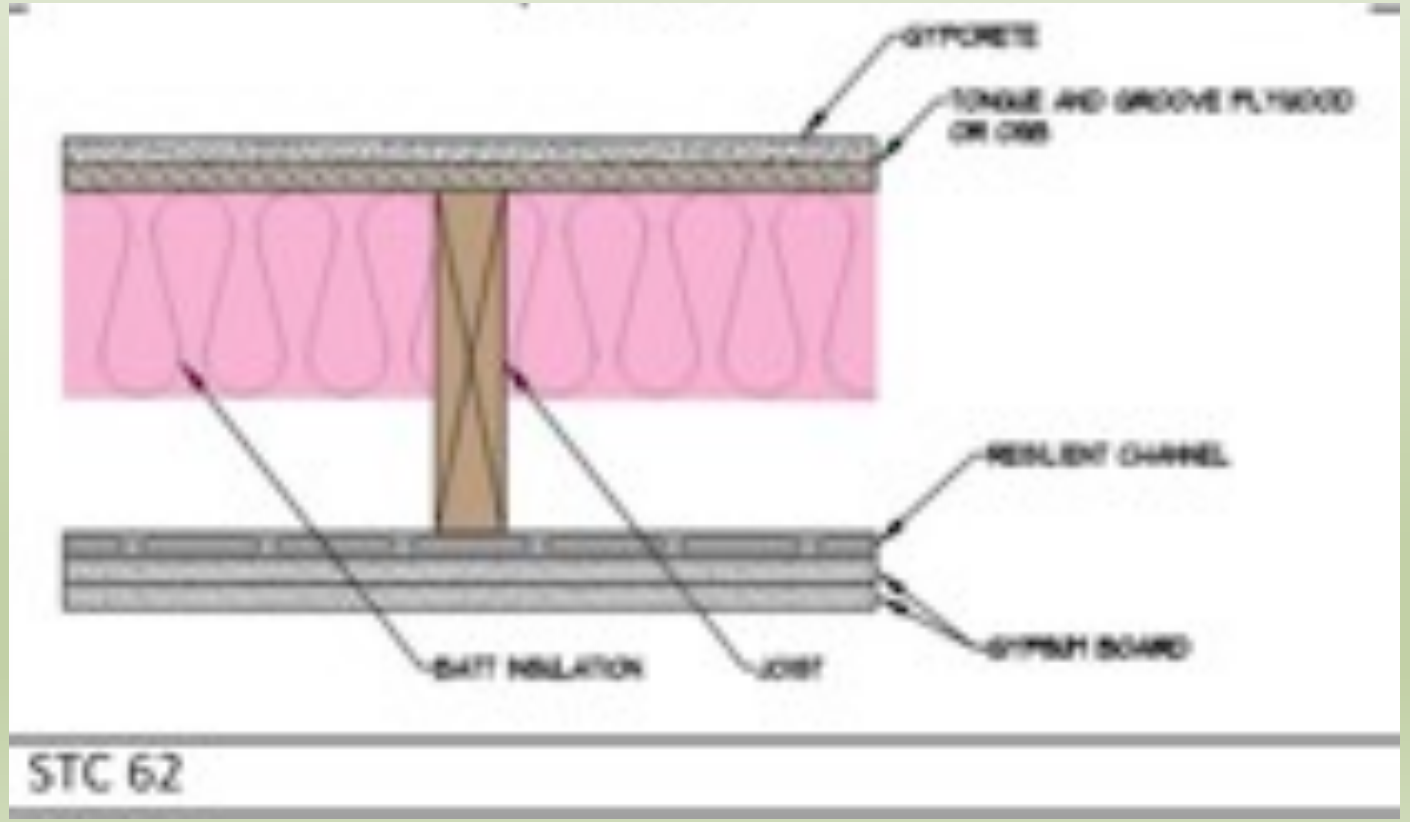
**Regardless of the structural materials used in a wall or floor ceiling assembly, there are 3 effective methods of improving acoustical performance:**

1. Add Mass
2. Add noise absorbers
3. Add decouples

# Acoustical Detailing

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

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



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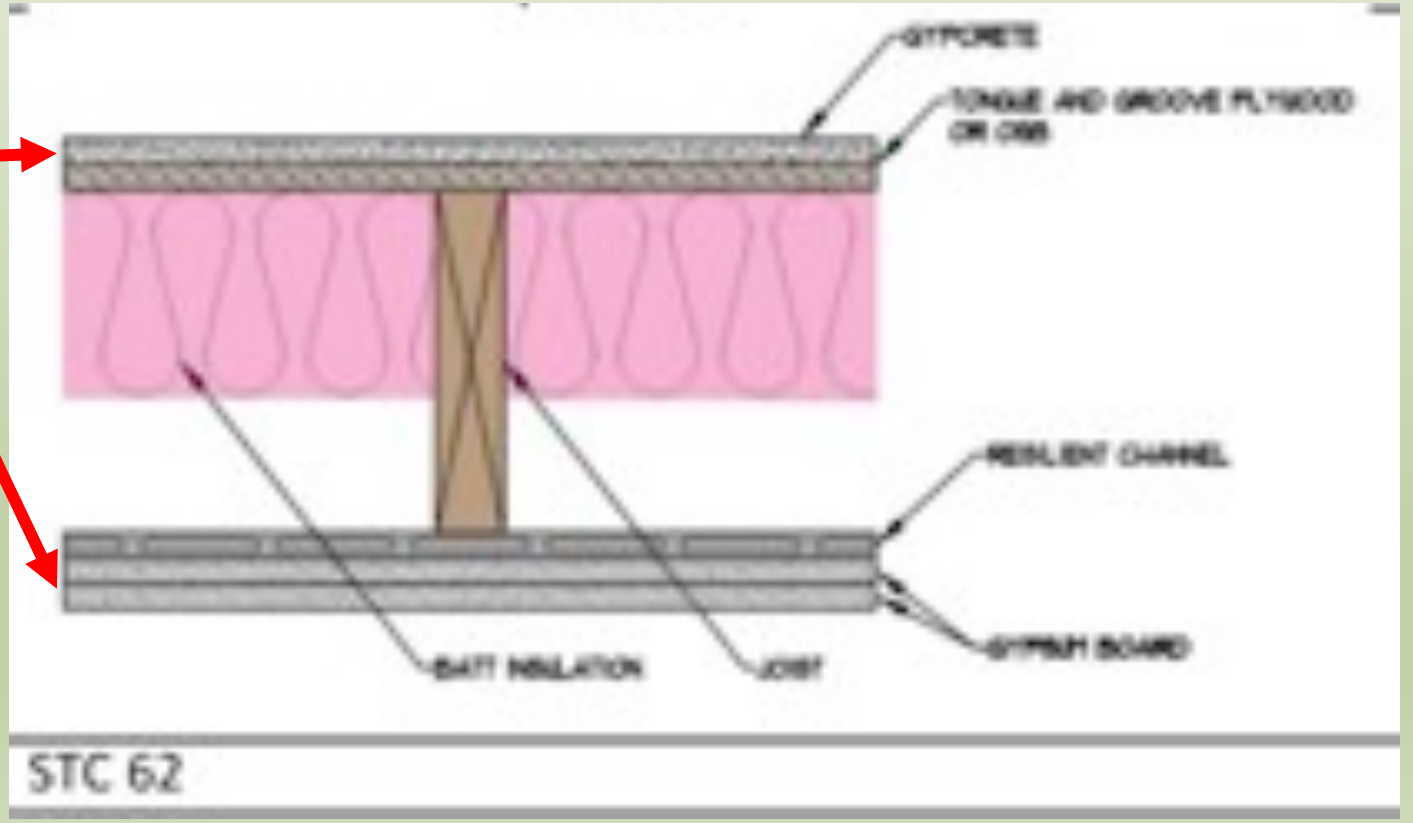

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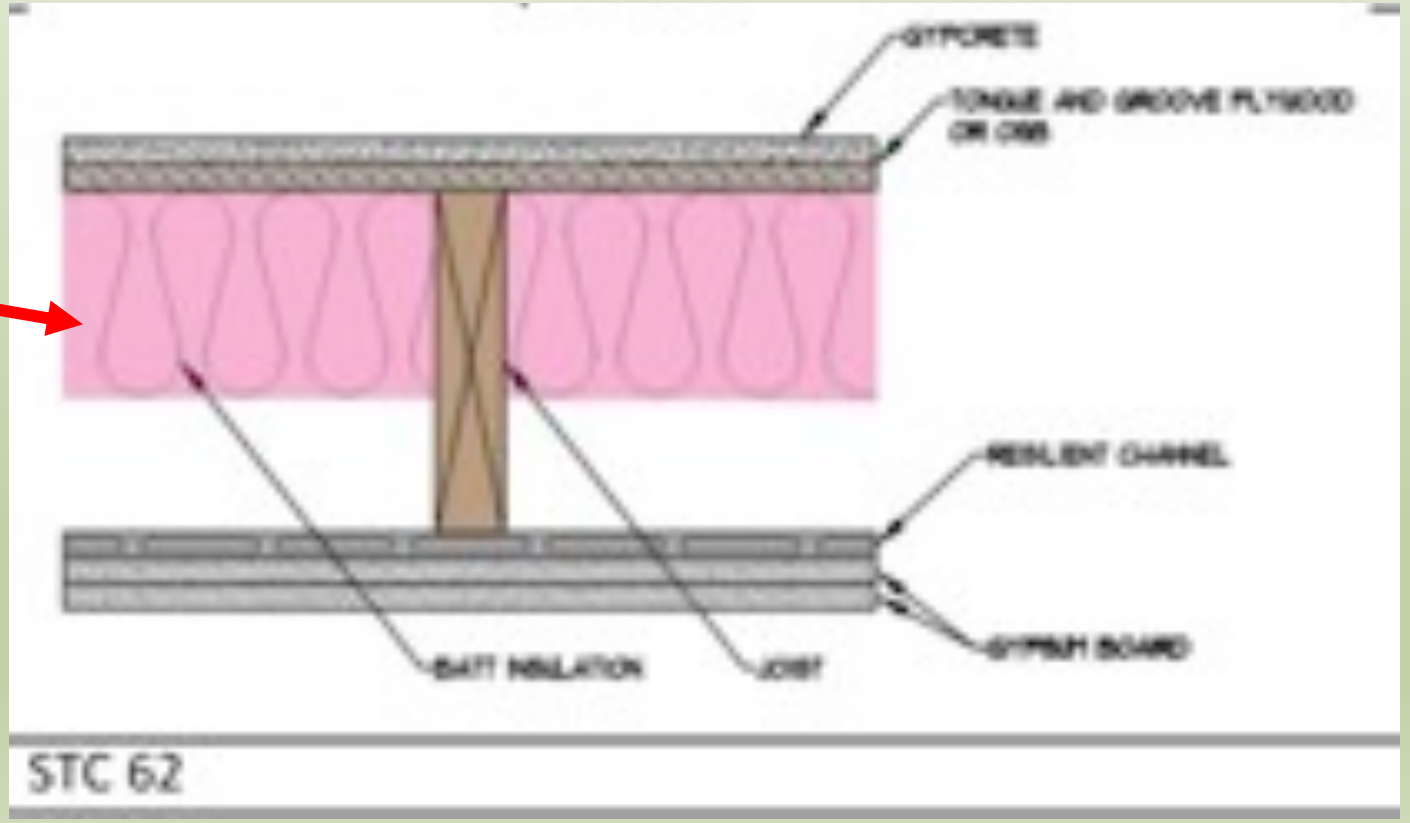

# Acoustical Detailing

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

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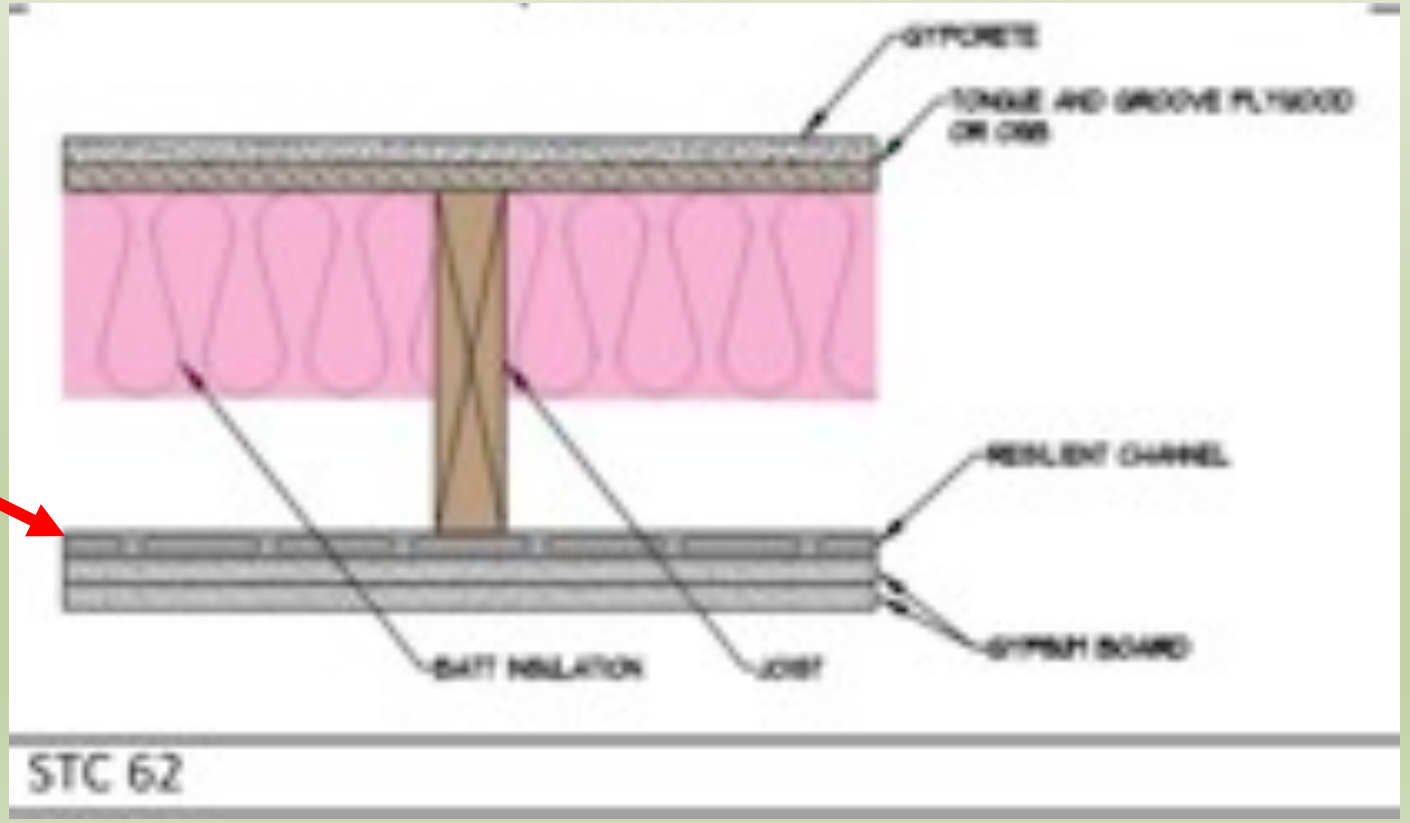


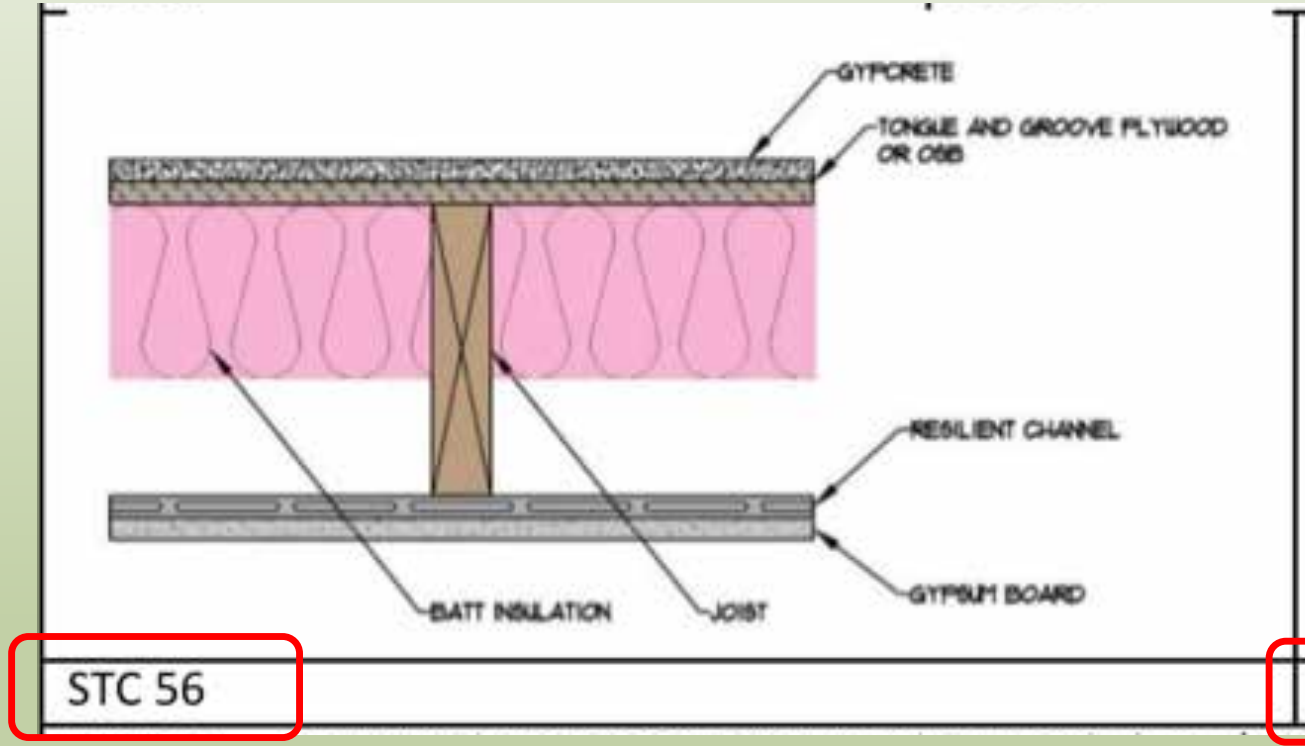
# Acoustical Detailing

**Light-frame wood floor acoustics – STC & IIC**

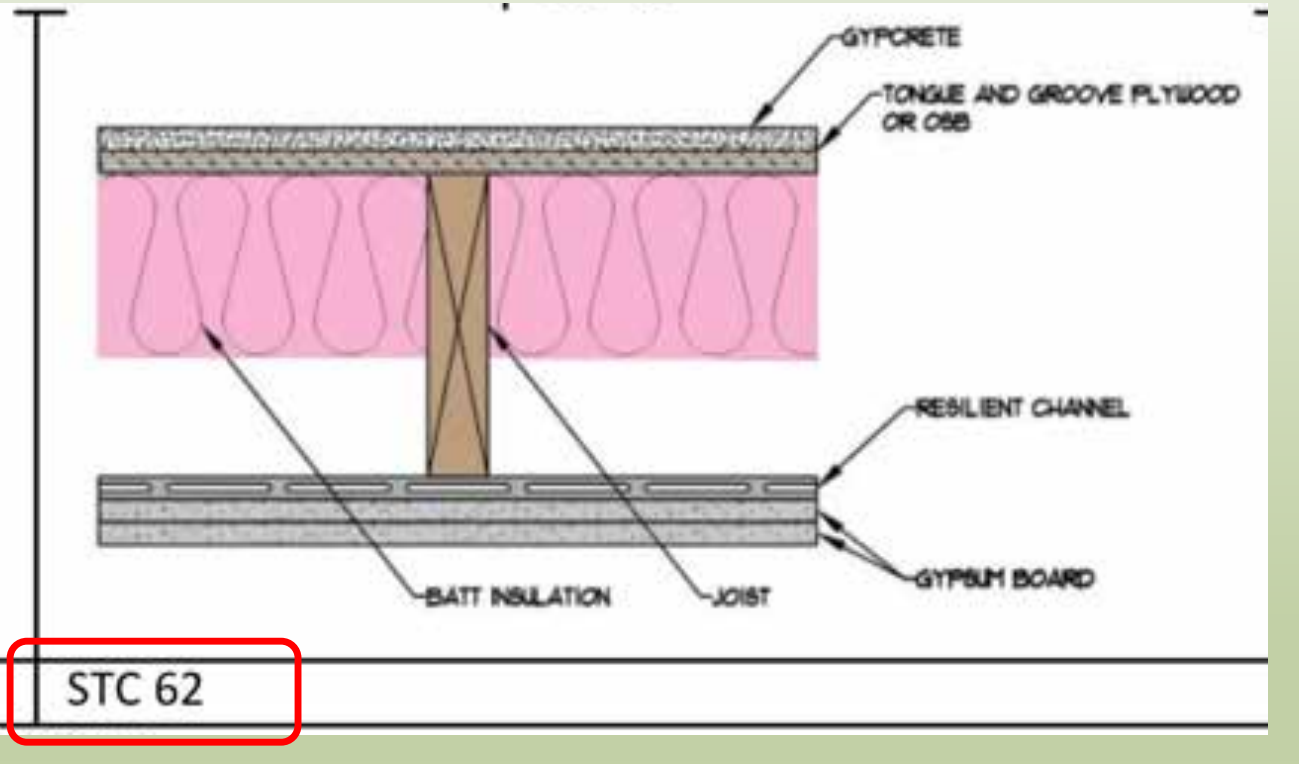
# Acoustical Detailing

**Adding Mass:**

Gypsum Wall Board




1 Layer Ceiling




2 Layer Ceiling

# Acoustical Detailing

Lightweight concrete topping or other similar materials can provide improved acoustical performance, increased durability

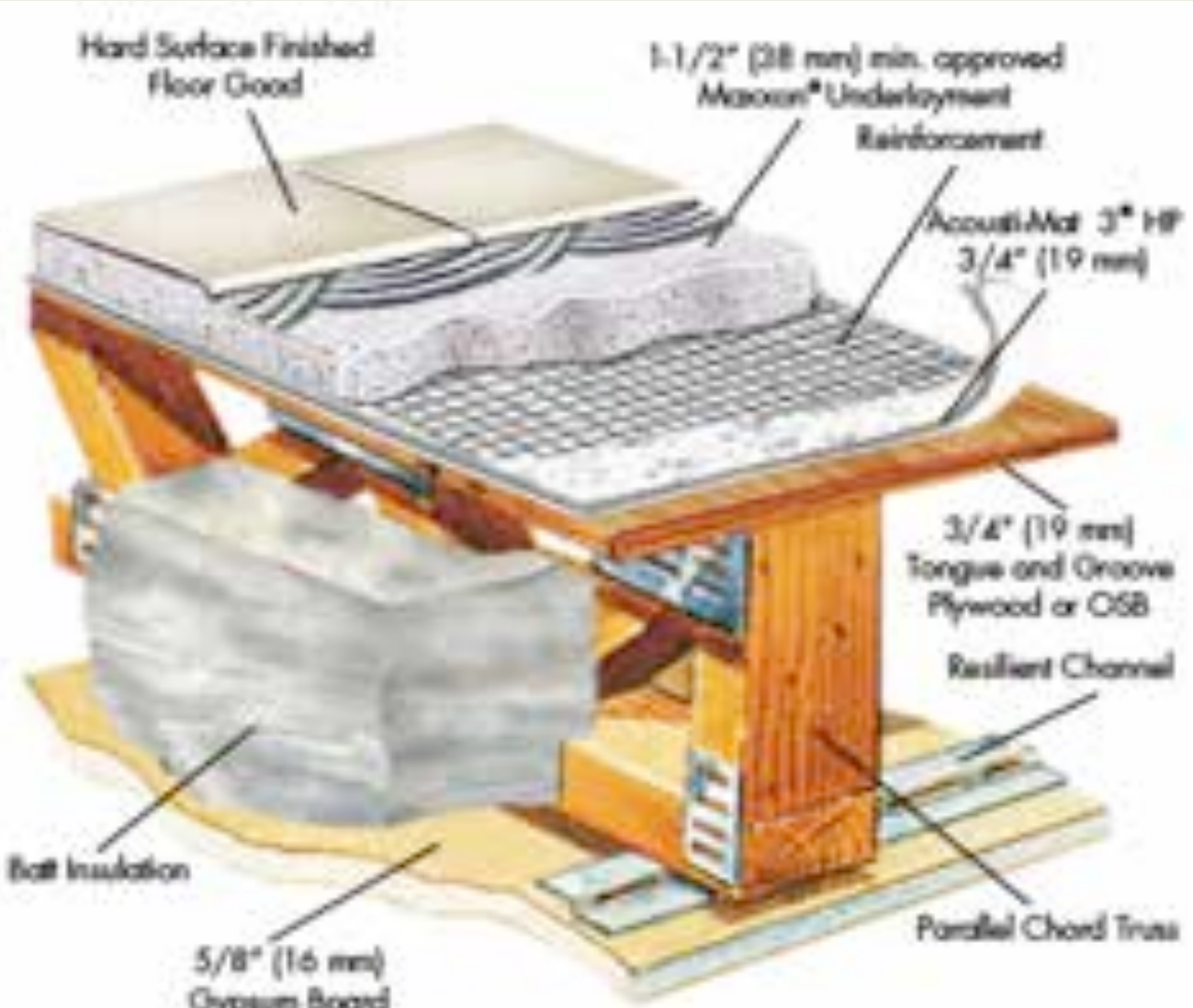
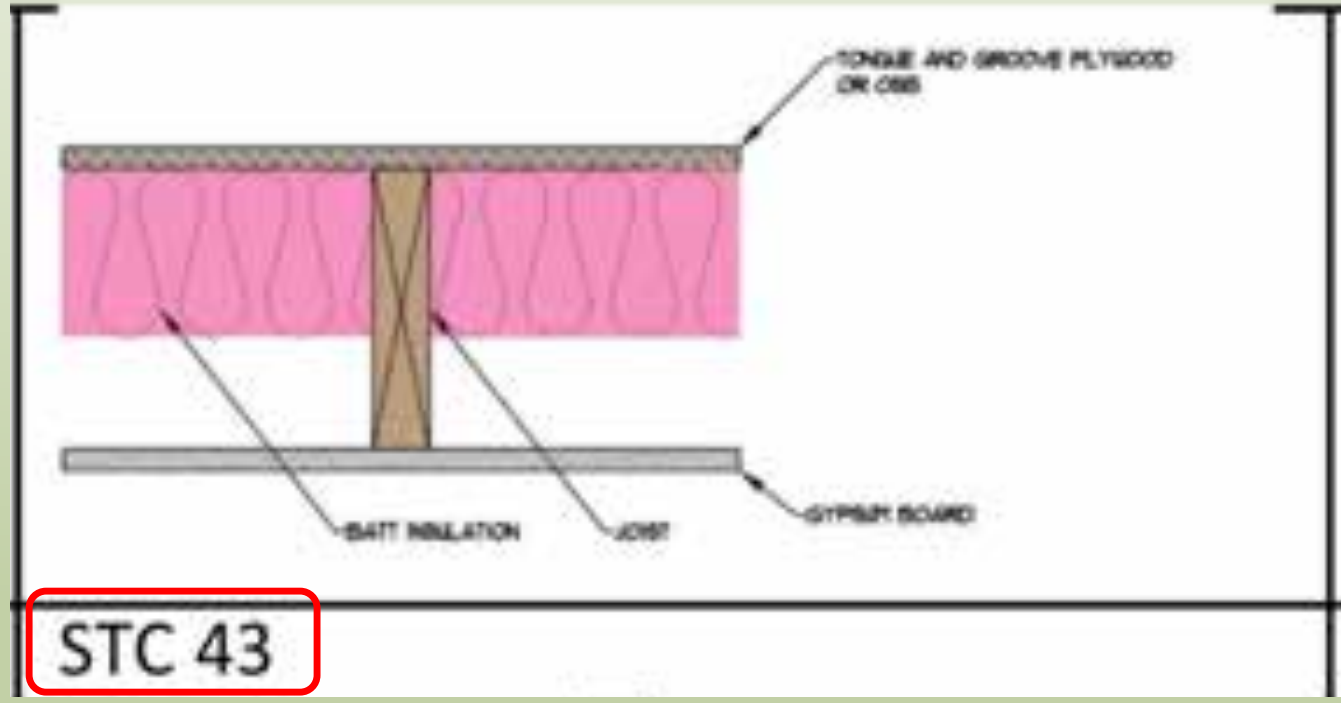


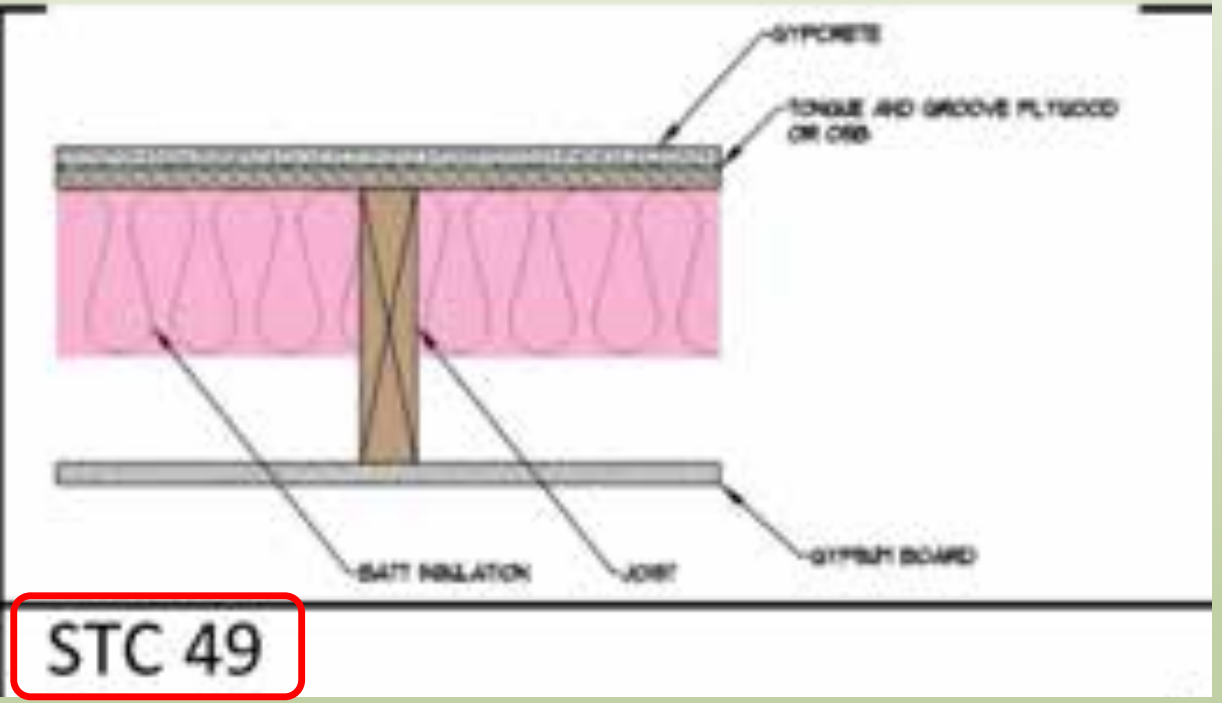

Image credit: Maxxon

# Acoustical Detailing

**Adding Mass:**

Concrete or gypsum topping



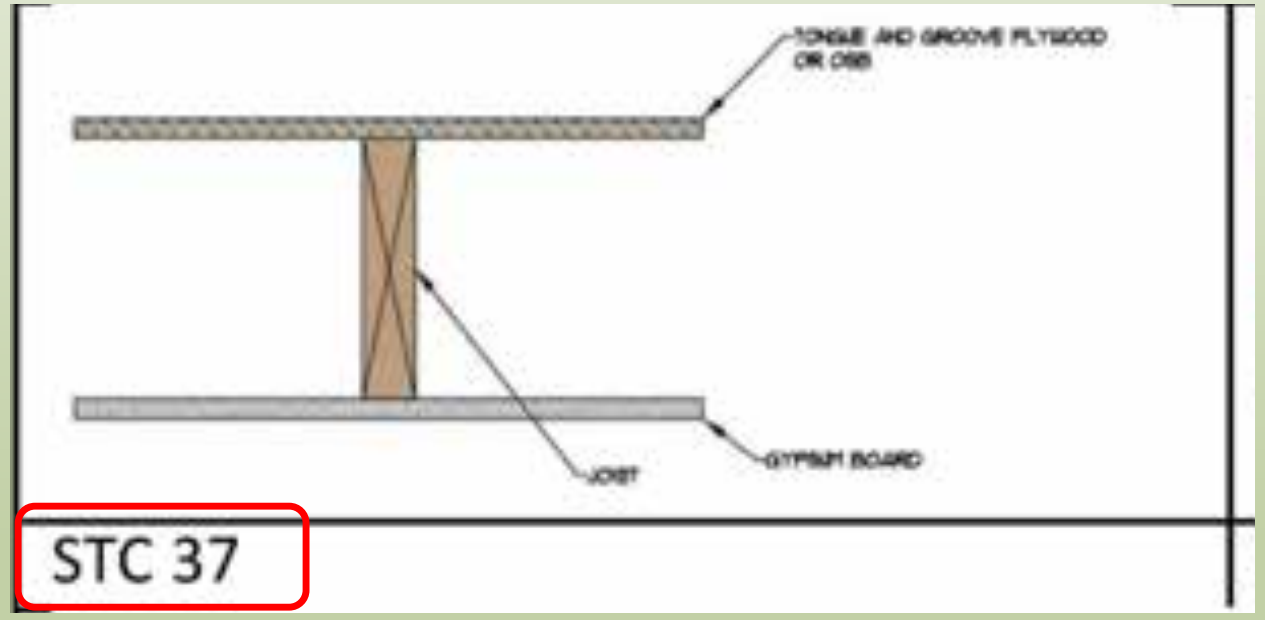

Without concrete topping

With concrete topping

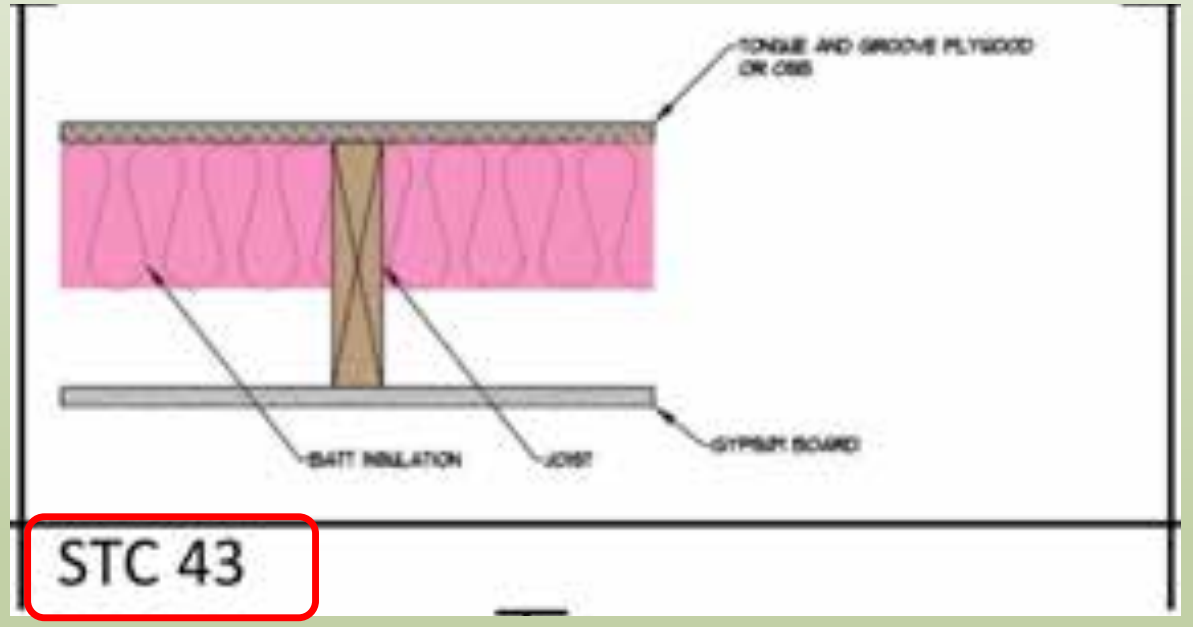
# Acoustical Detailing

**Adding Noise Absorbers:**

Batt Insulation




Without insulation




With insulation

# Acoustical Detailing

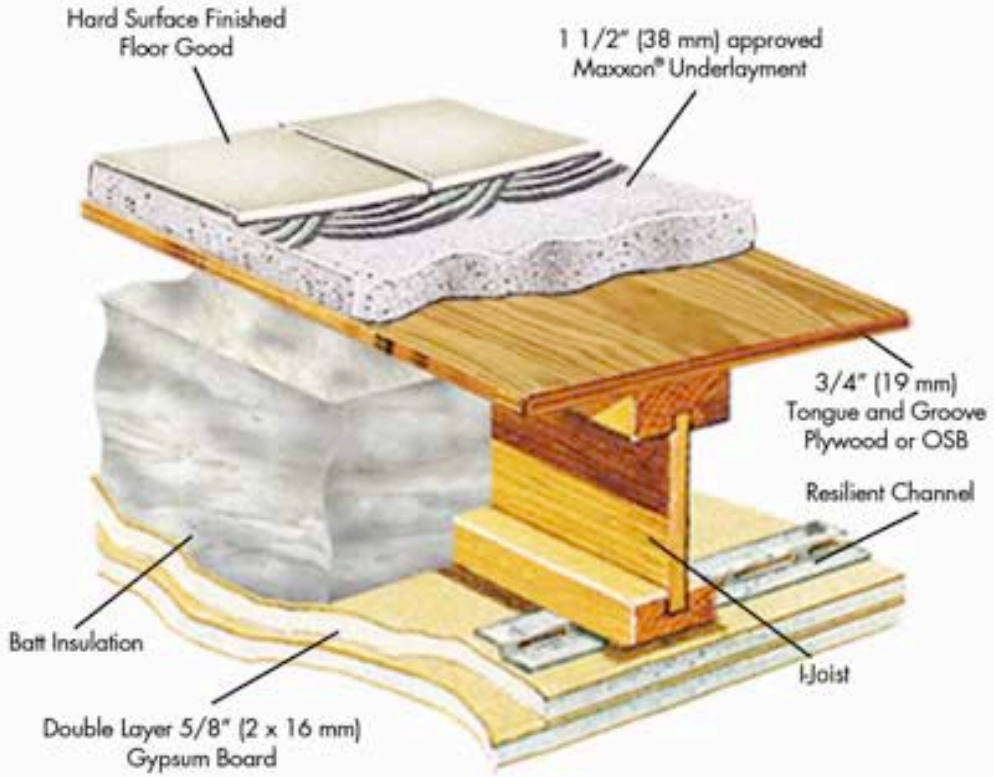
**Add Decouplers:**

Acoustical mat - typically installed between subfloor and topping or flooring. Can use multiple decoupling layers in sandwich assembly

Image credit: Pliteq

# Acoustical Detailing

Image credit: Maxxon




Start over

Project Details:

| | |
|---|---|
| Project Type: | Multifamily-Condos |
| Assembly: | I-Joist |
| Sound Mat: | None |
| Maxxon Underlayment: | 1-1/2" |

**W/O acoustical mat**

Selections:

| | |
|---|---|
| Project Type: | Multifamily-Condos |
| Assembly: | I-Joist |
| Sound Mat: | None |
| Maxxon Underlayment: | 1-1/2" |

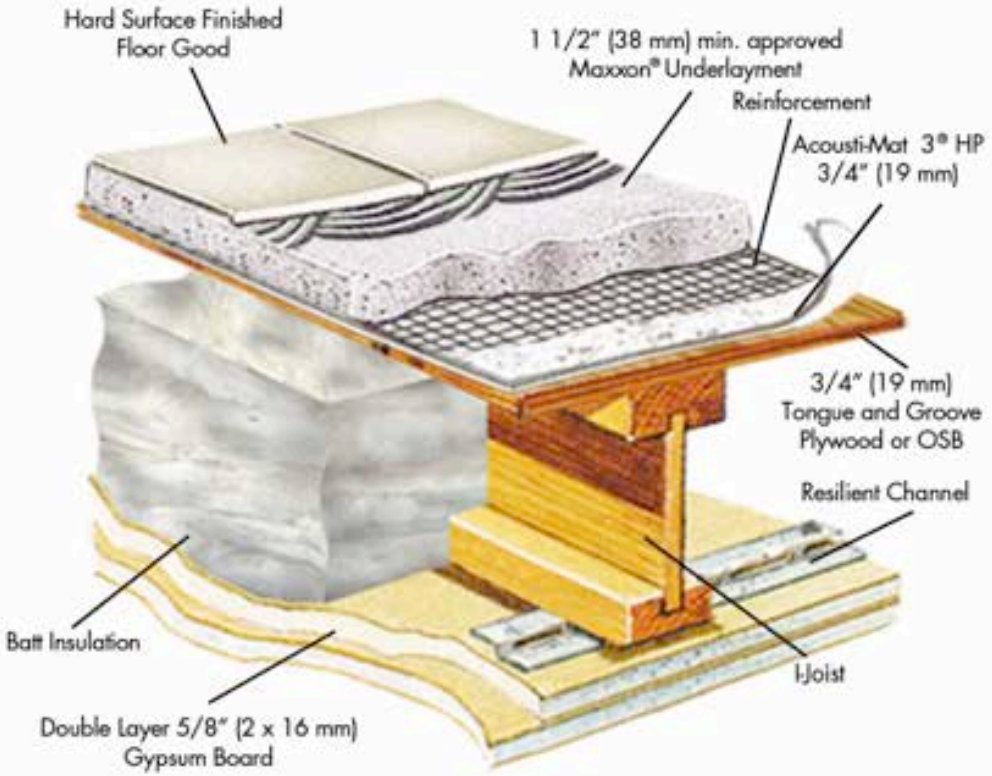
| Sound Ratings in hard surface areas* | F-IIC | F-STC |
|---|---|---|
| Base I-Joist | 40-44 | 43-46 |
| With Maxxon Underlayment only | 40-45 | 59-62 |
| With Maxxon Underlayment & (sound mat) | n/a | n/a |

| Typical UL Fire Rated Design | Design |
|---|---|
| I-Joist | L589 |

* The UL Fire Design listed above is a common design for the specified assembly. Maxxon Underlayments are listed in over 100 UL Fire Designs. To request a copy of Maxxon's Fire & Sound Manual or for assistance in determining the right UL Design for your project, contact your Regional Representative at (800) 356-7887 or by

Start over

Image credit: Maxxon


## Project Details:

| | |
|---|---|
| Project Type: | Multifamily-Condos |
| Assembly: | I-Joist |
| Sound Mat: | Acousti-Mat 3 HP |
| Maxxon Underlayment: | 1-1/2" |

## Selections:

| | |
|---|---|
| Project Type: | Multifamily-Condos |
| Assembly: | I-Joist |
| Sound Mat: | Acousti-Mat 3 HP |
| Maxxon Underlayment: | 1-1/2" |

# W/ acoustical mat

| Sound Ratings in hard surface areas* | F-IIC | F-STC |
|---|---|---|
| Base I-Joist | 40-44 | 43-46 |
| With Maxxon Underlayment only | 40-45 | 59-62 |
| With Maxxon Underlayment & Acousti-Mat 3 HP | 61-64 | 60-63 |

| Typical UL Fire Rated Design | Design |
|---|---|
| I-Joist | L589 |

* The UL Fire Design listed above is a common design for the specified assembly. Maxxon Underlayments are listed in over 100 UL Fire Designs. To request a copy of Maxxon's Fire & Sound Manual or for assistance in determining the right UL Design for your project, contact your Regional Representative at (800) 356-7887 or by

| Sound Ratings in hard surface areas* | F-IIC | F-STC |
|---|---|---|
| Base I-Joist | 40-44 | 43-46 |
| With Maxxon Underlayment only | 40-45 | 59-62 |
| With Maxxon Underlayment & (sound mat) | n/a | n/a |

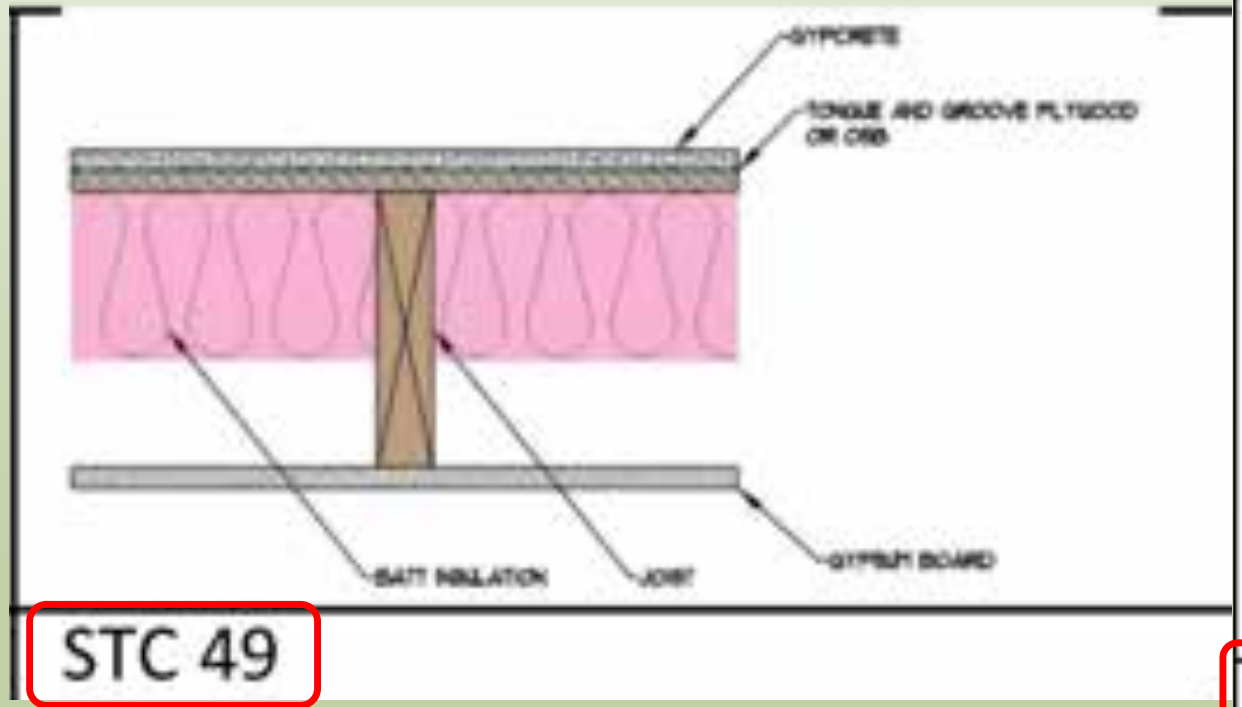
| Typical UL Fire Rated Design | Design |
|---|---|
| I-Joist | L589 |

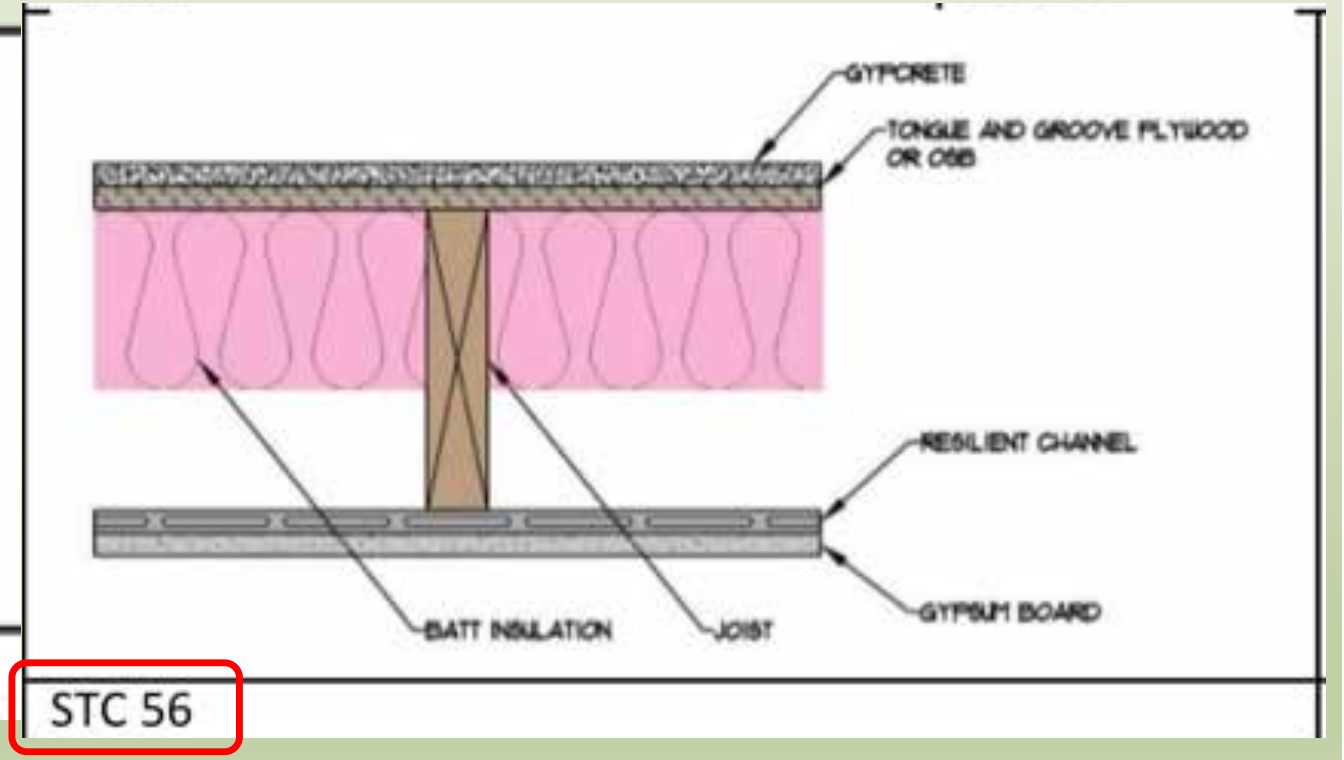
* The UL Fire Design listed above is a common design for the specified assembly. Maxxon Underlayments are listed in over 100 UL Fire Designs. To request a copy of Maxxon's Fire & Sound Manual or for assistance in determining the right UL Design for your project, contact your Regional Representative at (800) 356-7887 or by

# Acoustical Detailing

**Decouple:**

Resilient Channels




Without resilient channels

With resilient channels

# Acoustical Detailing

## STC ratings – low to mid 60's achievable

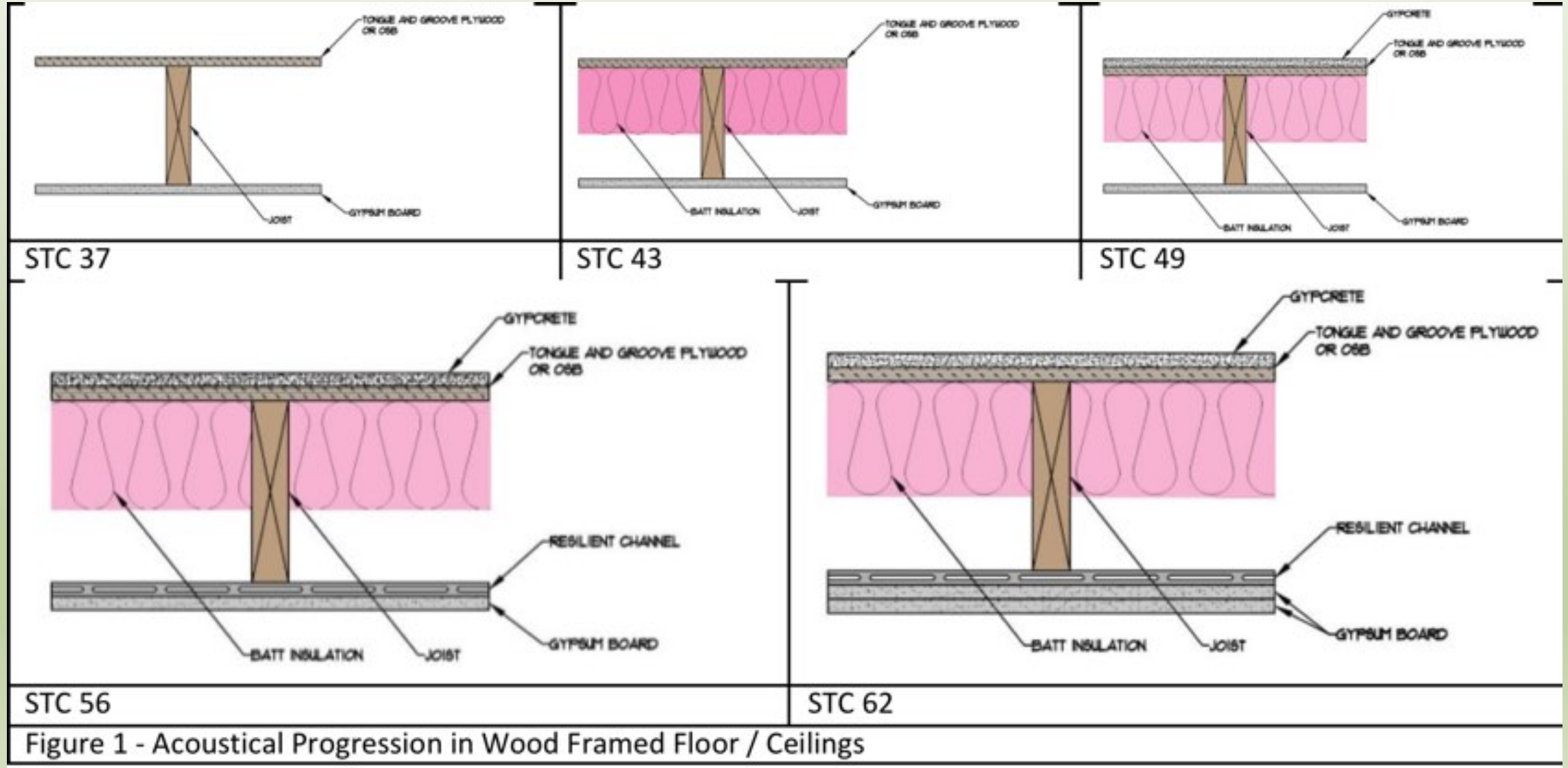
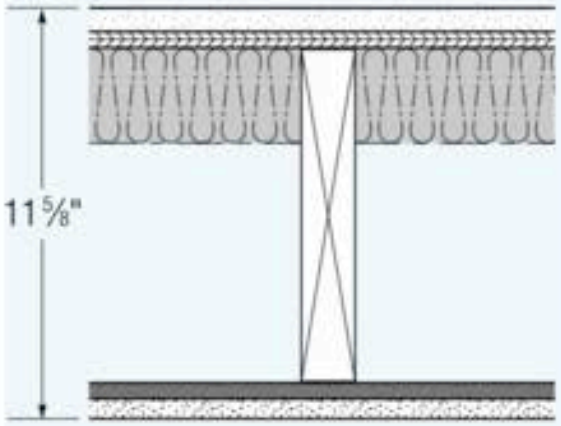



Figure 1 - Acoustical Progression in Wood Framed Floor / Ceilings

# Acoustical Detailing

**Dimensional Lumber**

| Construction Detail | Description | Acoustical Performance STC | IIC | Test Number |
|---|---|---|---|---|
| clg. wt. 3<br>  <br> | • 5/8" SHEETROCK Brand FIRECODE C Core Gypsum Panels<br>– 2x10" wood joist 16" o.c.<br>– RC-1 channel or equivalent 16" o.c.<br>– Insulation held up under subfloor by lightning clips<br>– 19/32" T&G wood subfloor<br>• 3/4" LEVELROCK Brand Floor Underlayment | 59 | 54 | **RAL-IN04-006/TL04-033**<br>Cushioned vinyl floor, SRM-25, 1" LEVELROCK |
| | | 58 | 55 | **RAL-IN04-007/TL04-034**<br>Engineered wood-laminate floor SRM-25, 1" LEVELROCK |
| | | 59 | 77 | **RAL-IN04-005/TL04-032**<br>Carpet with SRM-25, 1" LEVELROCK |
| | | 59 | 52 | **RAL-IN04-009/TL04-067**<br>Ceramic tile with crack-isolation membrane, SRM-25, 1" LEVELROCK |
| | | 58 | 50 | **RAL-IN04-013/TL04-100**<br>Cushioned vinyl floor, SRB board |
| | | 58 | 51 | **RAL-IN04-012/TL04-099**<br>Engineered wood-laminate floor, SRB board |
| | | 58 | 73 | **RAL-IN04-010/TL04-097**<br>Carpet with SRB board |

**Floor finish has a significant impact on IIC rating**

# Acoustical Detailing

## Light-frame wood wall acoustics - STC

# Acoustical Detailing

STC ratings – low to mid 60's achievable

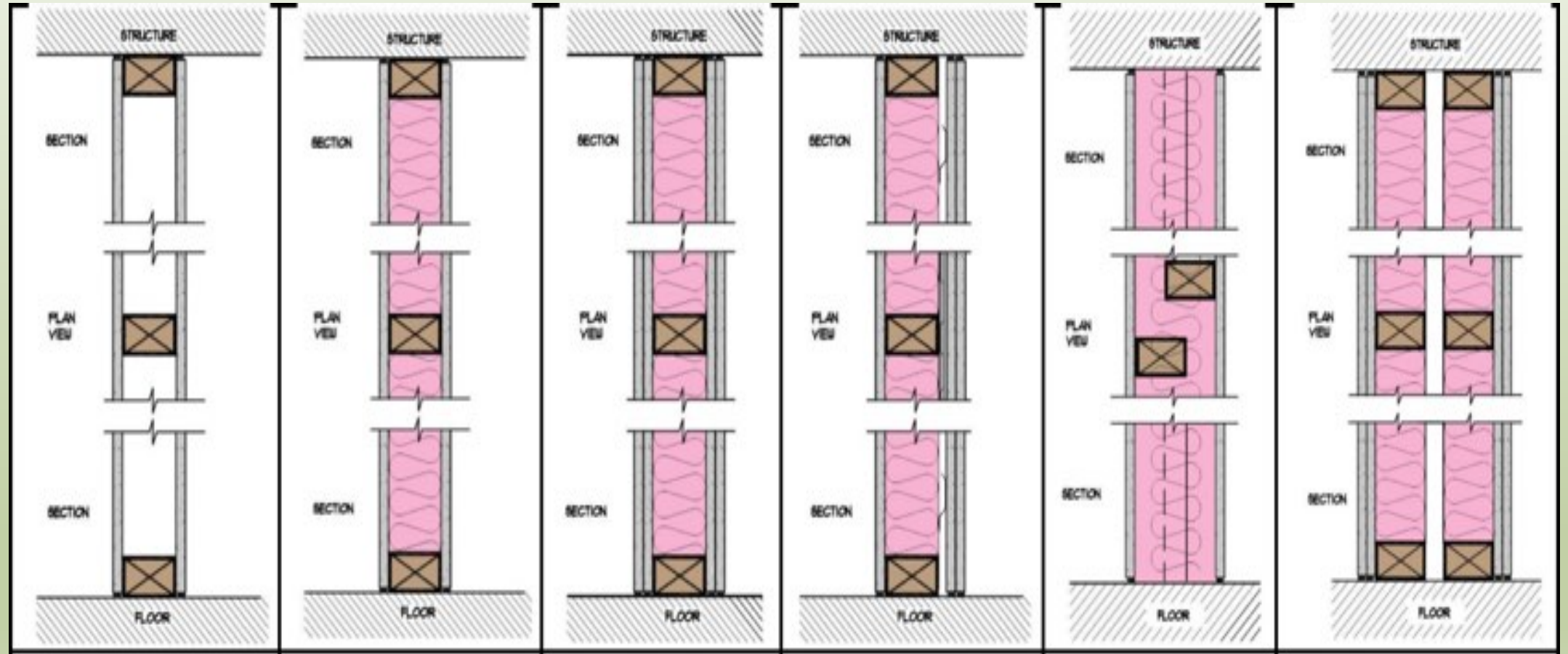
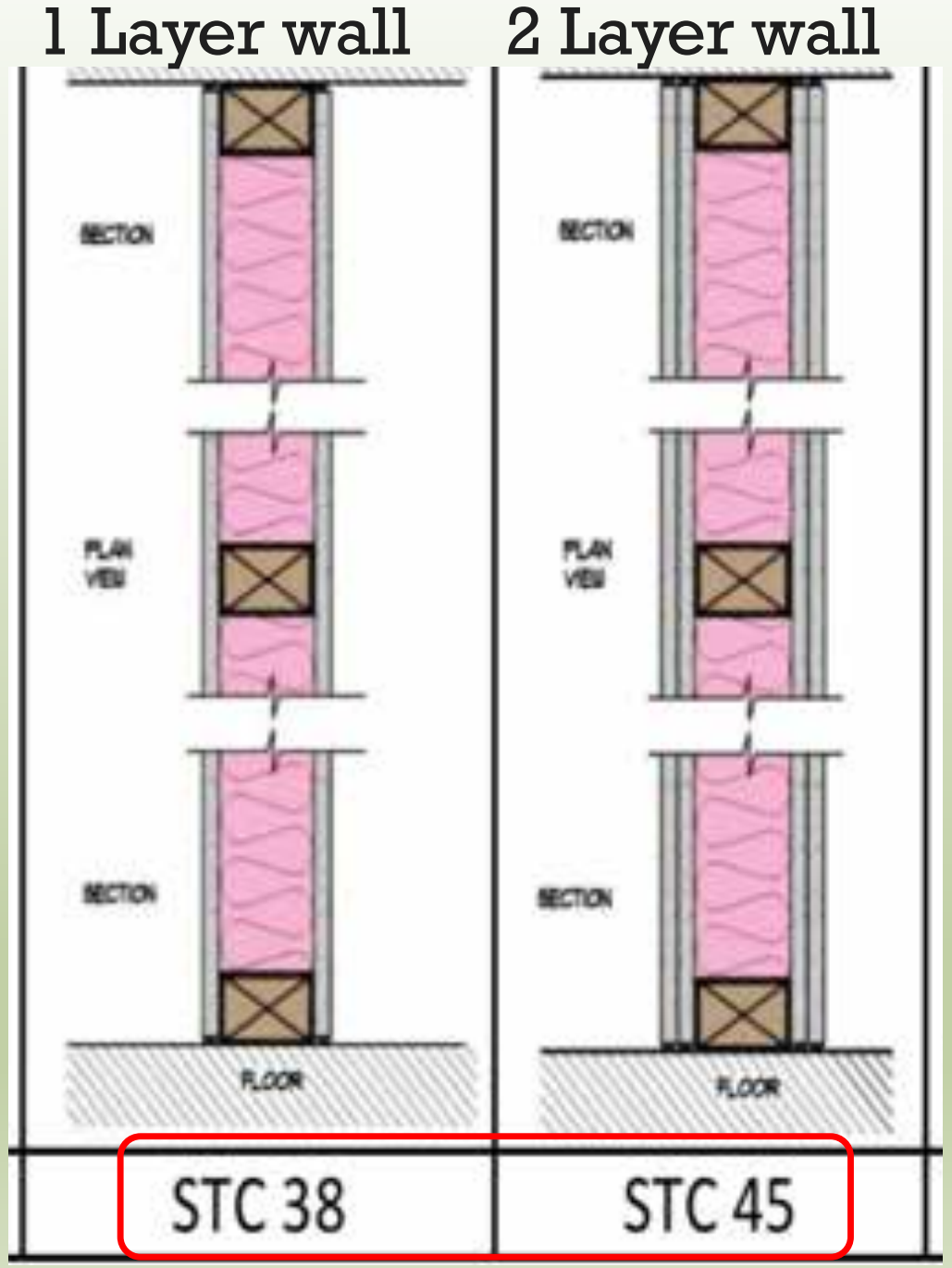



Figure 1 - Acoustical Progression in Wood Framed Walls

# Acoustical Detailing

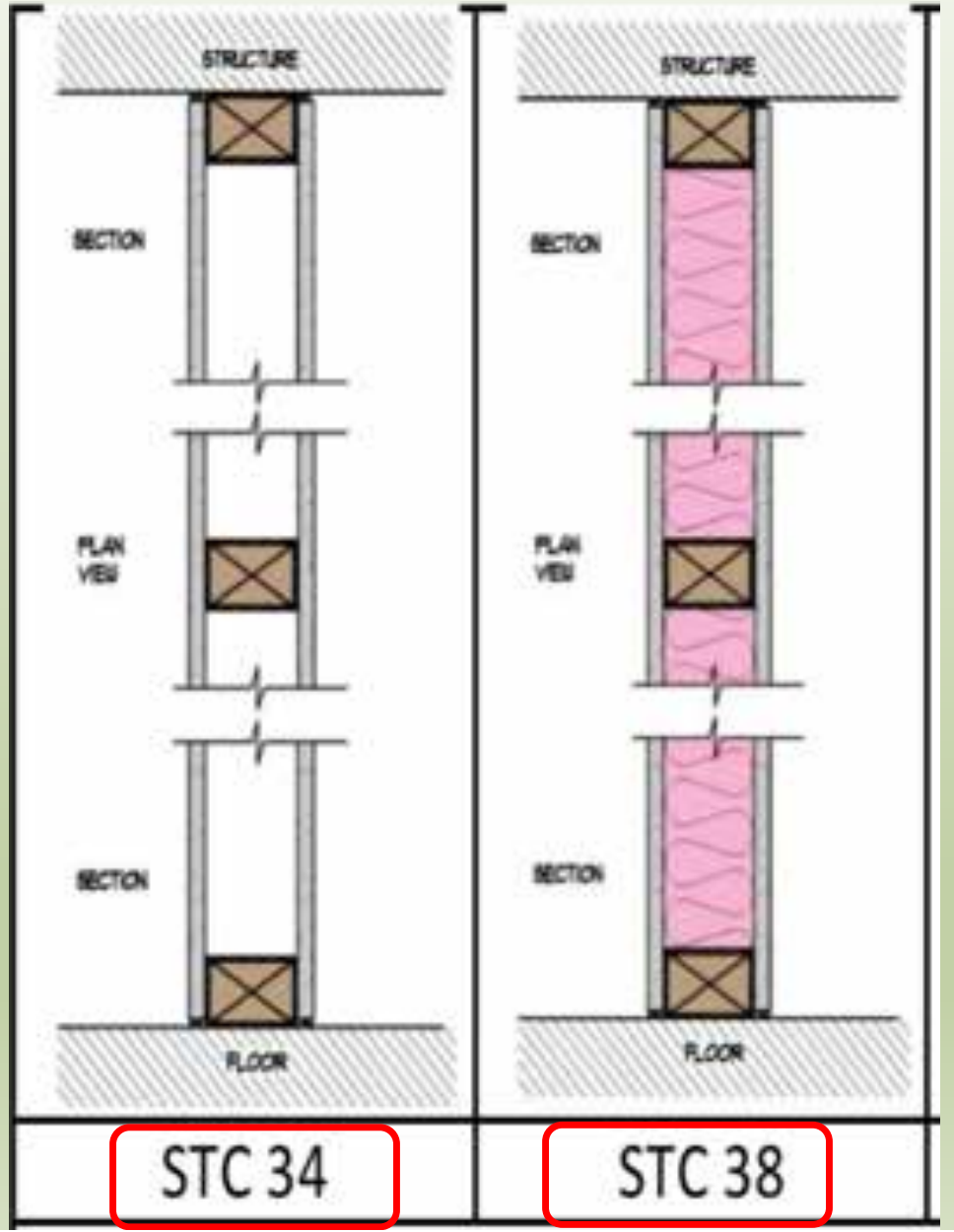



**Adding Mass:**

**Gypsum wall Board**

# Acoustical Detailing

## Adding Noise Absorbers: Batt Insulation



# Acoustical Detailing

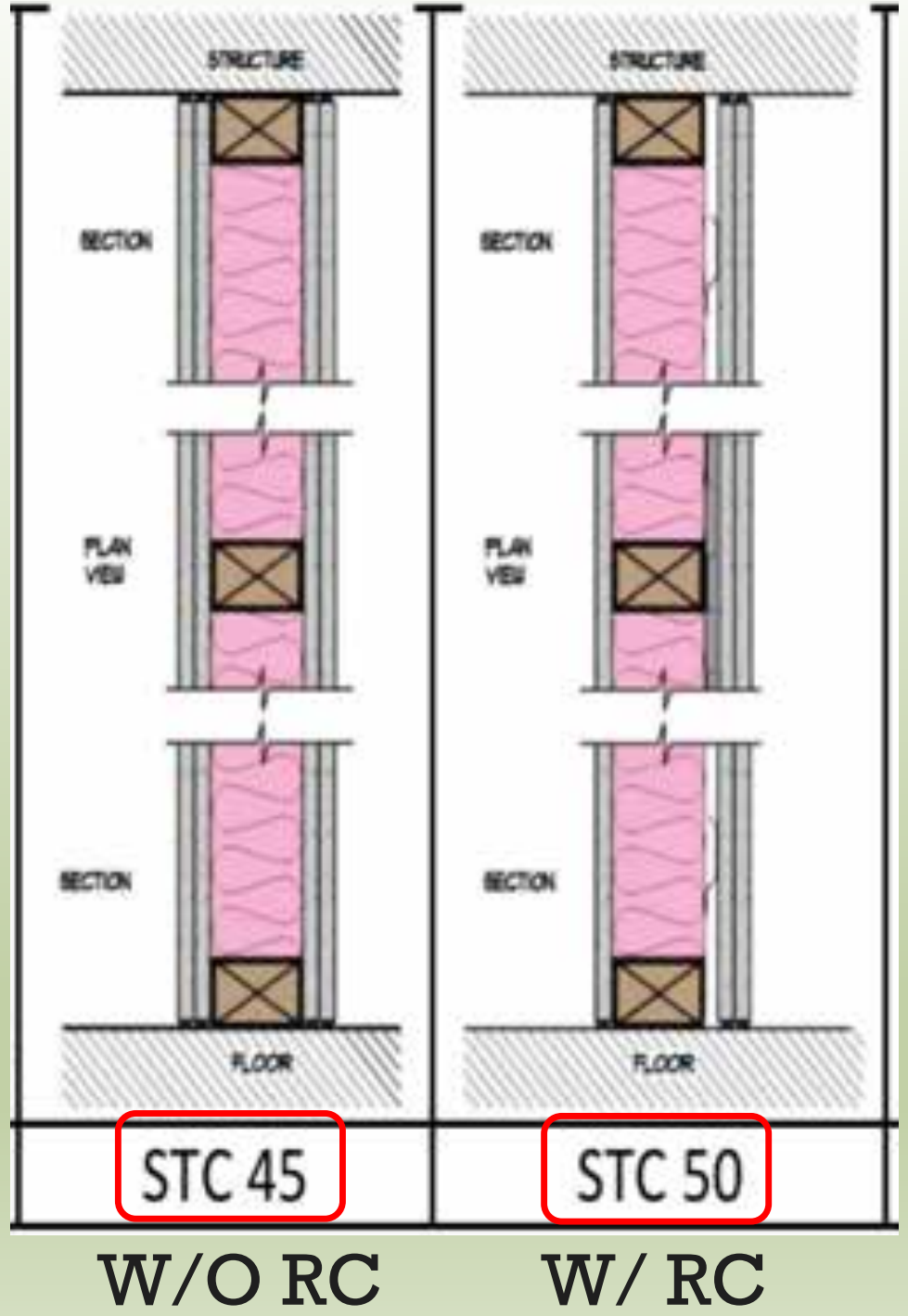
**Good Detailing +**
**Good Installation =**
**Good Performance**

# Acoustical Detailing

**Decoupled:**
Disconnect structure/finish from carrying all the way through the assembly

## Resilient Channels

# Acoustical Detailing



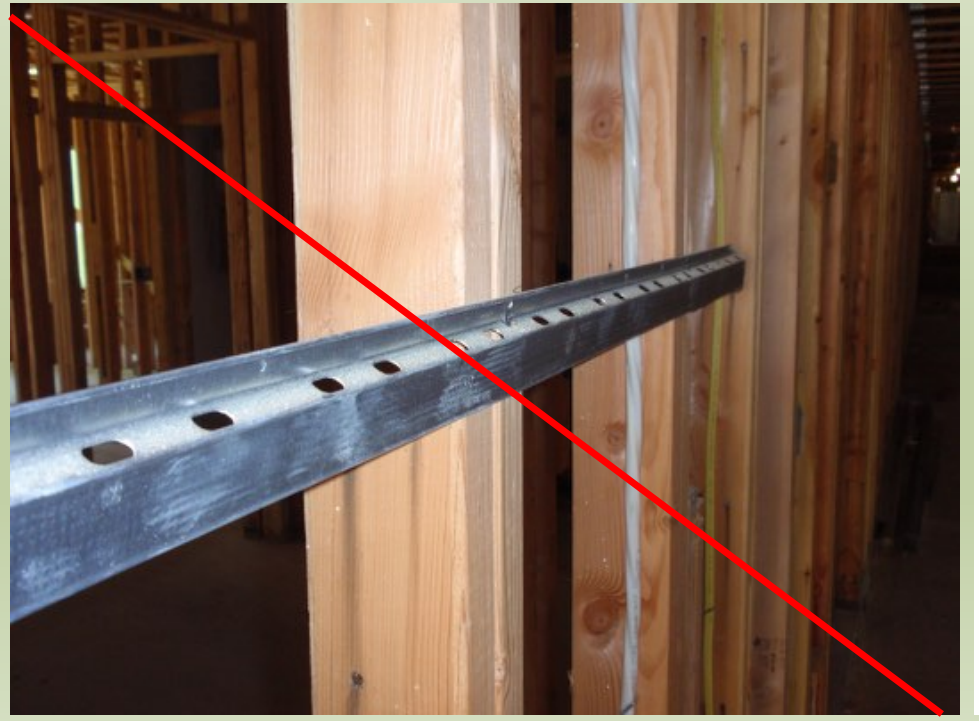

**Decouple:**

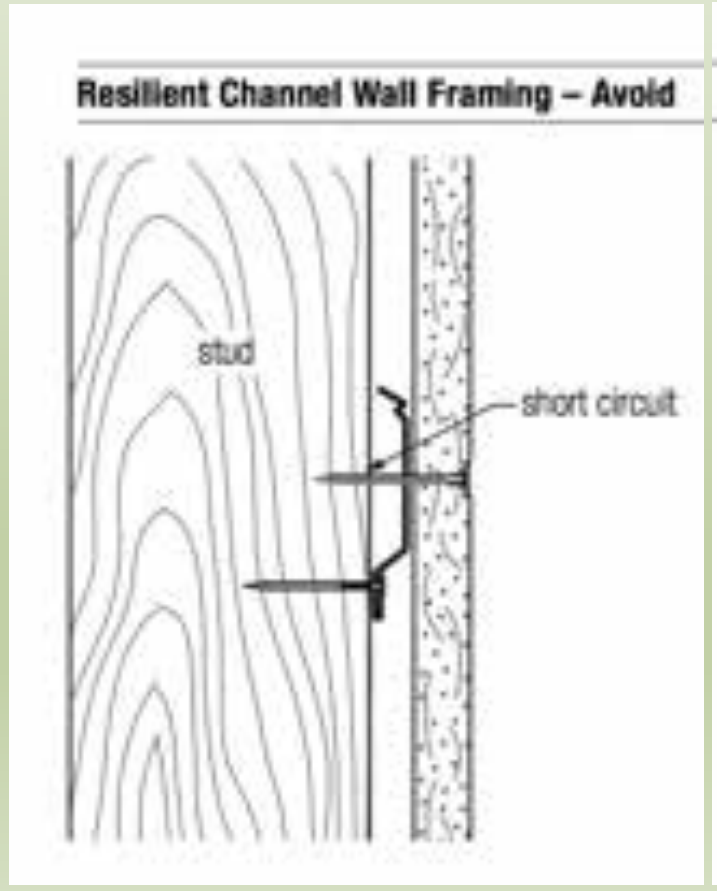
Resilient channels

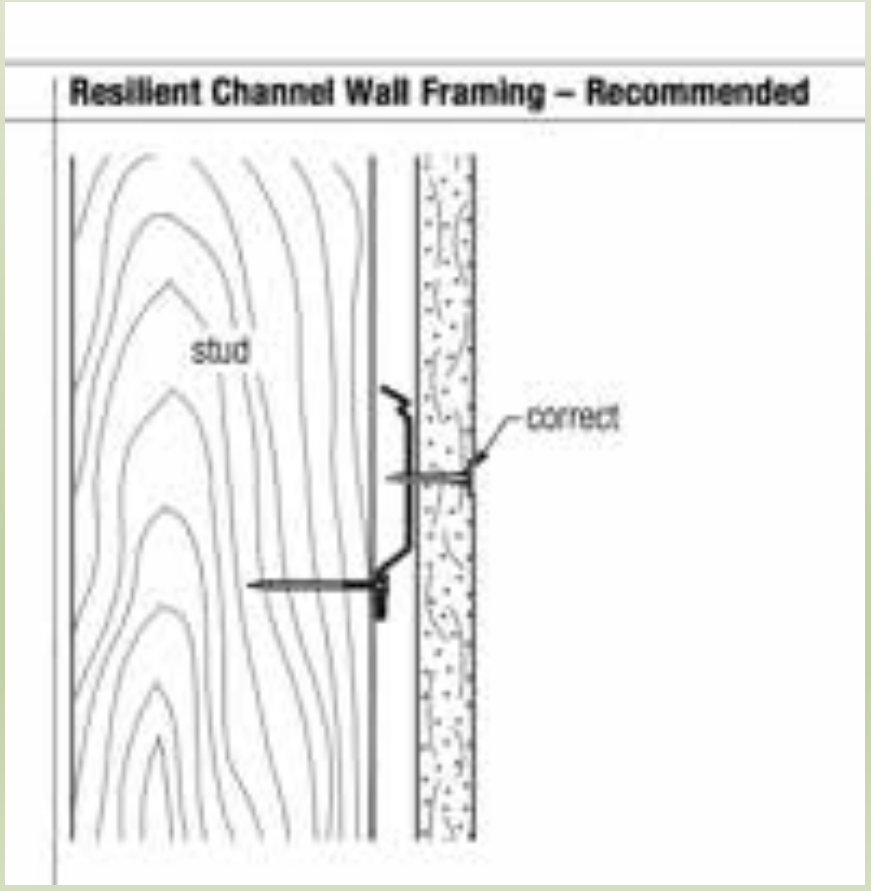
# Acoustical Detailing

Good Detailing + Good Installation = Good Performance

Open leg should be up on walls





# Acoustical Detailing

My interior, acoustically rated wall also needs to be a shearwall

Can I add wood structural panels to an acoustically tested wall?

Yes, but placement is very important!

# Can wood structural panels be added to an acoustically-tested wall assembly?

In many multi-family structures, interior demising walls that separate dwelling units from other units or from public spaces are required to have a minimum level of acoustical performance (IBC Section 1207). In some cases, these interior walls are also used as shear walls, utilizing plywood or OSB on one or both sides of the wall. Appropriate STC performance for walls are typically justified through the use of a tested assembly; however, most tested assemblies do not include wood structural panels (WSPs). This post contains information to help justify its inclusion in these cases.

In the WoodWorks technical paper, *Acoustical Considerations for Mixed-Use Wood-Frame Buildings*, author Steve Thorburn discusses the impact that WSPs can have on acoustical performance of walls. Adding shear wall sheathing to a wall assembly can actually increase its acoustical performance in certain circumstances because it adds mass to the assembly. As Thorburn notes, *"In the past, using multiple layers of gypsum sheathing to increase the mass of the system has been the most common solution to raising the STC rating of the system."* He goes on, *"In the case of shear wall sheathing, mass can be traded out for mass."* However, designers should be careful where they place WSPs within the wall assembly.

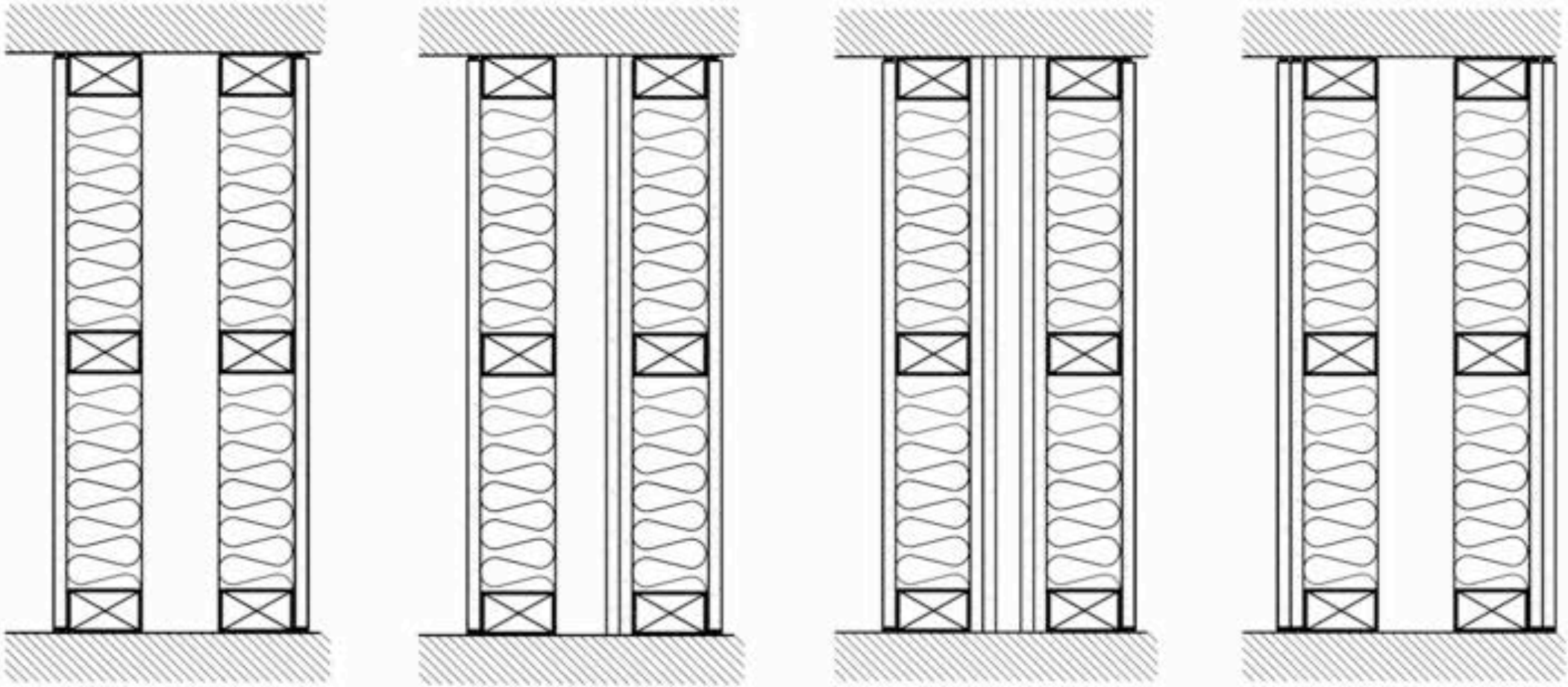
With respect to placement, two conditions that could negatively affect the STC performance of a wall are 1) if the WSPs impede the performance of resilient channels, and 2) if the WSPs alter the depth of the air cavity.

Resilient channels are a common component of many high performing acoustically tested wall assemblies. If the assembly includes resilient channels on one side of the wall, between the gypsum board and wall, between the gypsum board and wood structural panels create numerous contact points between the resilient channels and sheathing, counteracting the isolation purpose of the channels.

http://www.woodworks.org/ask-an-expert/

*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

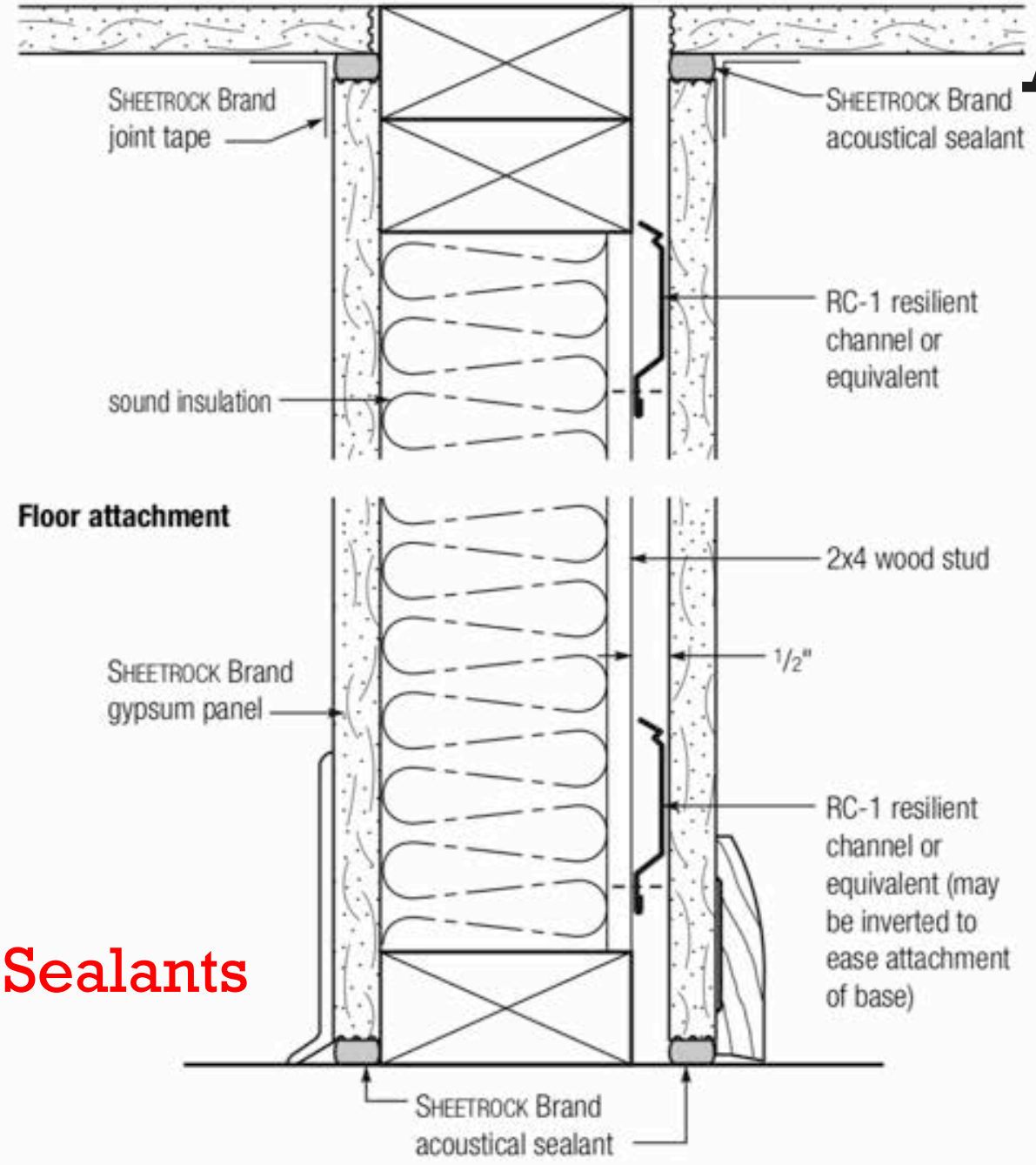
Single-Sided Double-Sheathed Shear Walls with Wood Structural Panel Sheathing

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

# Acoustical Design

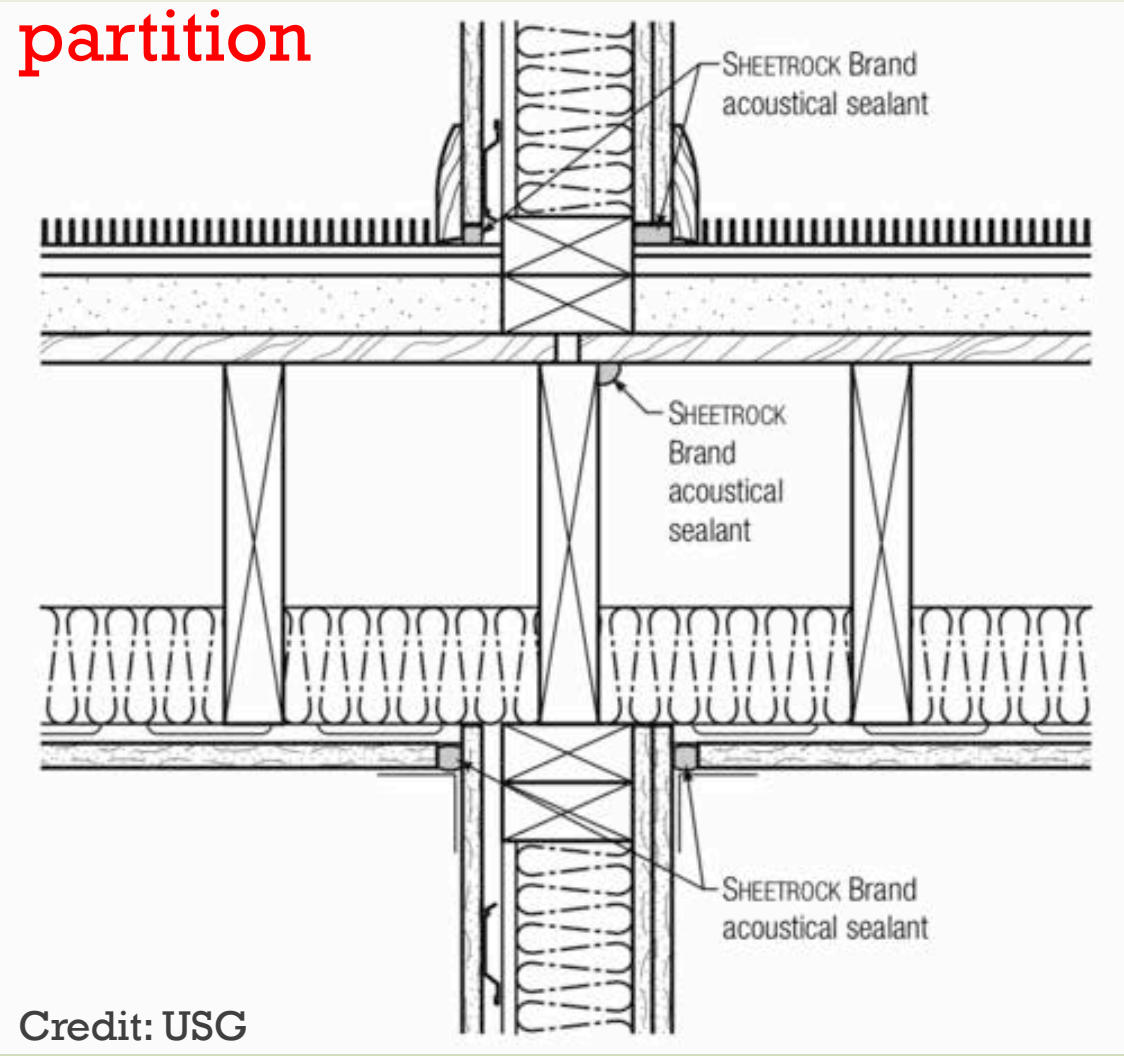
- Staggered stud wall condition:
- Blocking bridges finish on one side of wall to studs on opposite side, defeats purpose.
- Solution: use flat blocking in wall (wide face against WSP)

# Acoustical Detailing



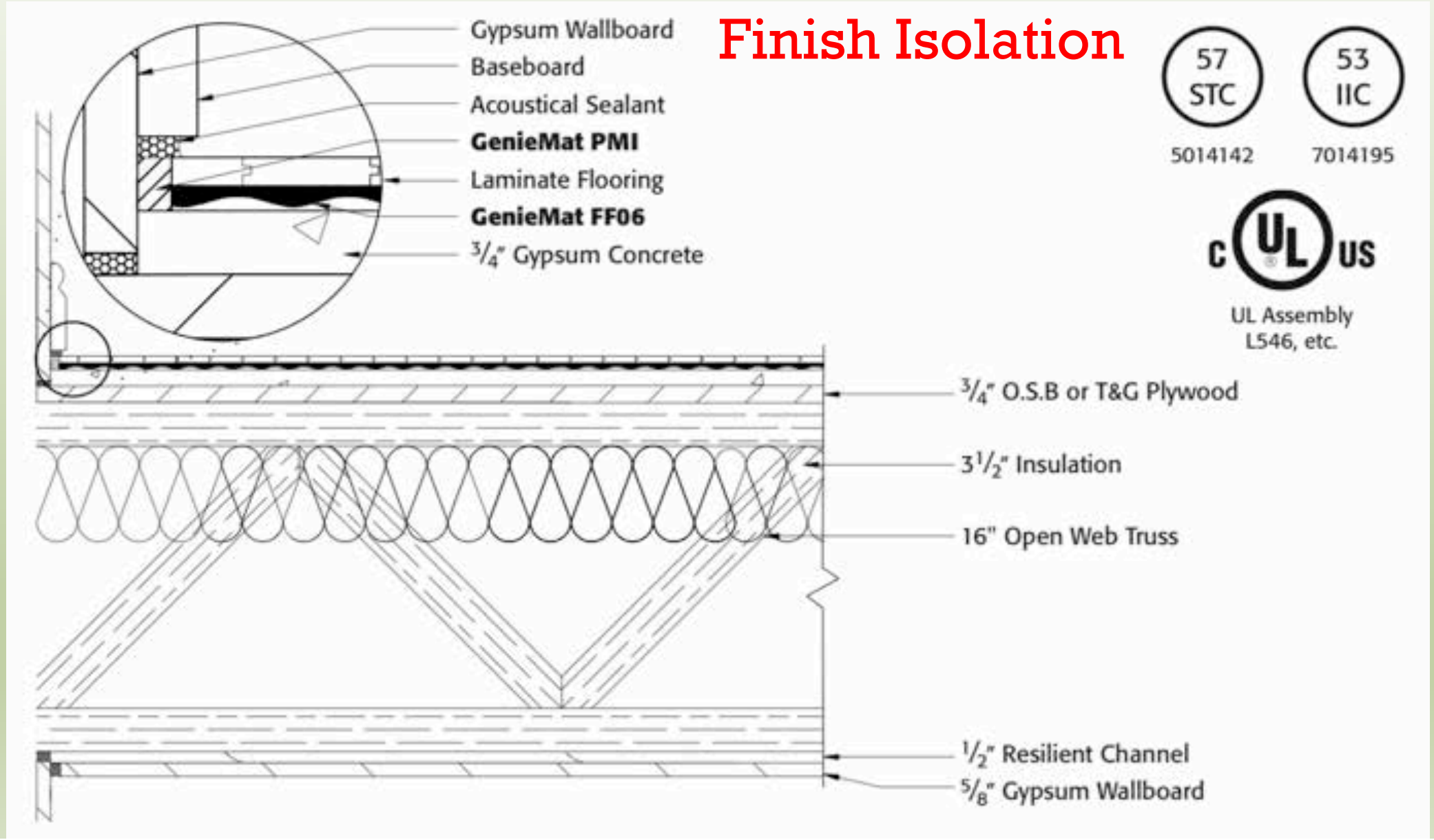

Sealants

Discontinuous topping at unit partition




Credit: USG

# Acoustical Detailing

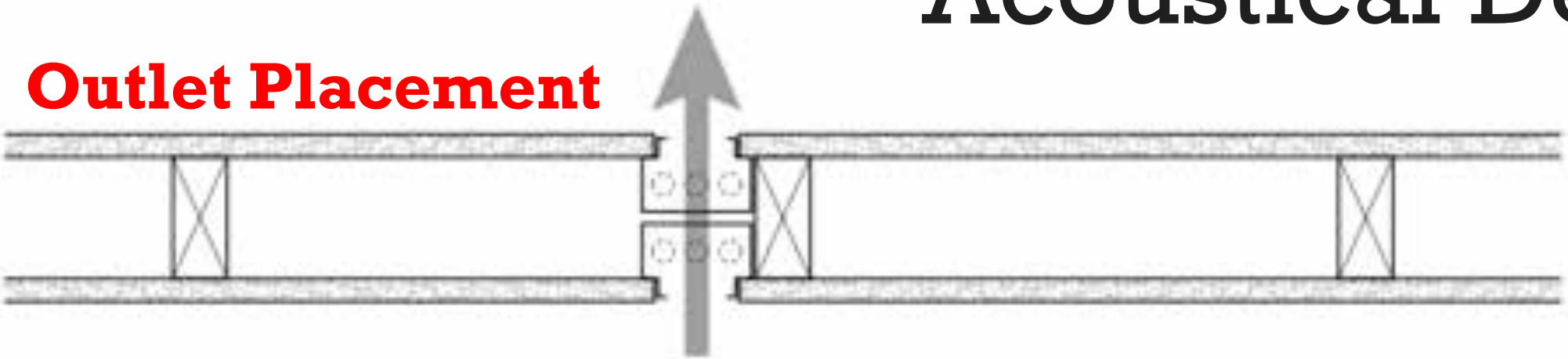



Credit: Pliteq

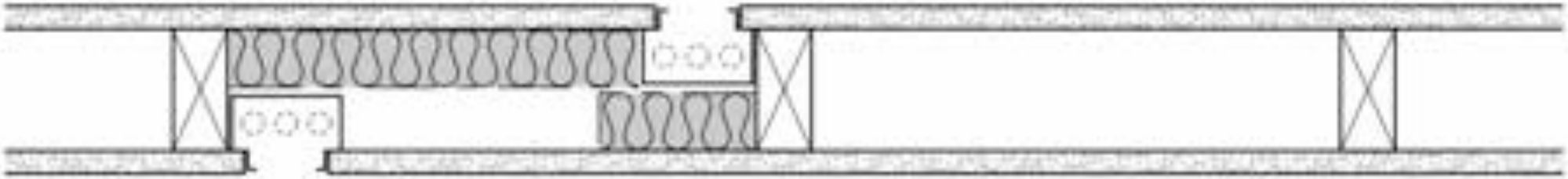
# Acoustical Detailing

## Outlet Placement

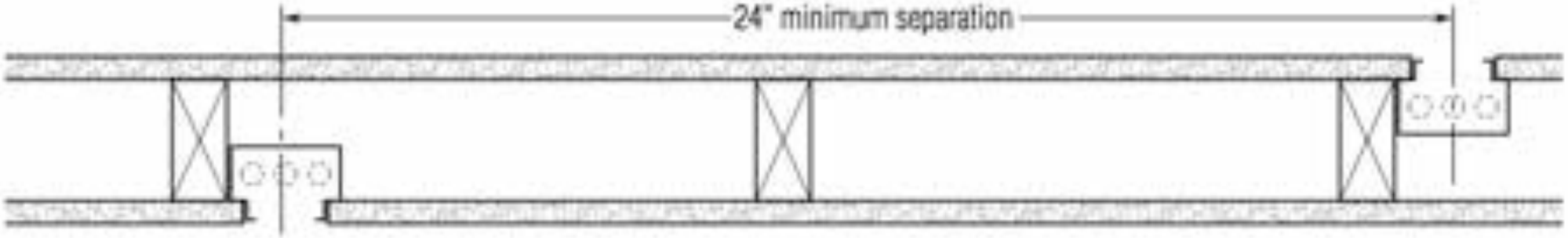
Electrical Boxes – Avoid



Electrical Boxes – Better

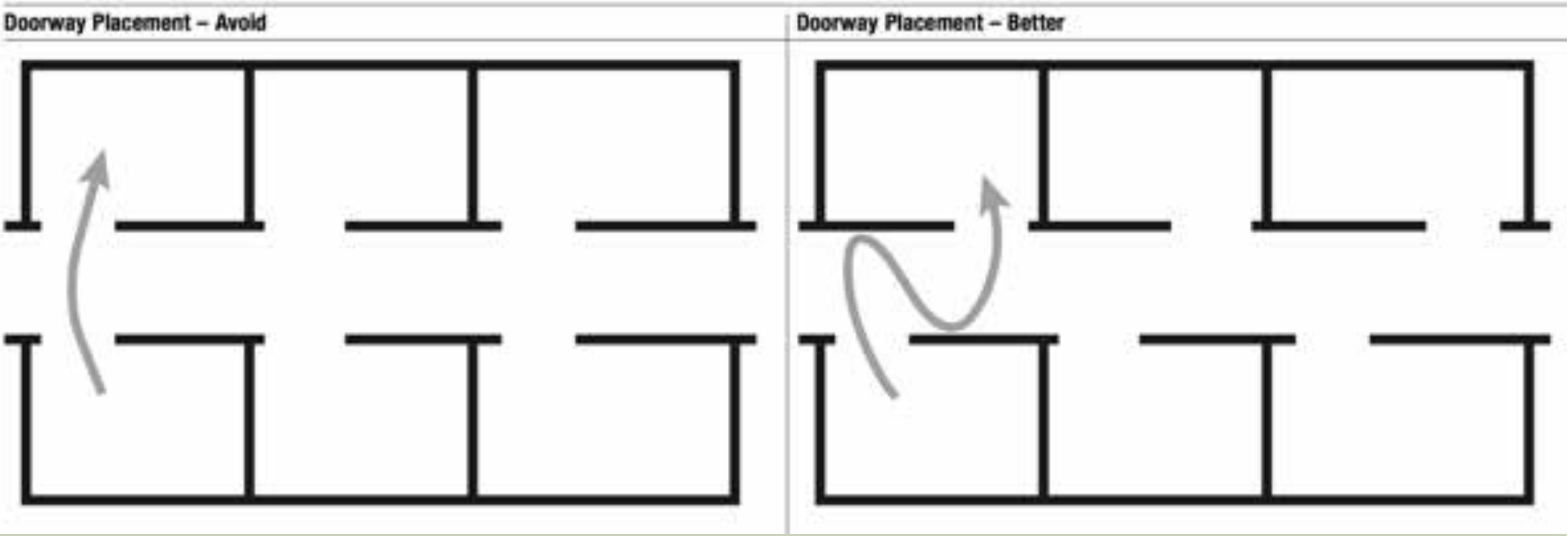


Electrical Boxes – Recommended



# Acoustical Detailing

## Door Placement



# Acoustical Design Resource

**Code provisions, tested assemblies, detailing options and more for acoustical design of wood structures**

**Free resource at woodworks.org**

WoodWorks
WOOD PRODUCTS COUNCIL

Acoustical Considerations for Mixed-Use Wood-Frame Buildings

Acoustics are just one aspect of building performance and must be considered in combination with requirements such as fire protection, structural systems and energy efficiency. To determine an optimal design solution, it is critically important to understand how the design and detailing for each individual system affects the others. Specifically, in addition to meeting the appropriate acoustical rating(s), the assemblies chosen must achieve the required fire ratings and accommodate the structural and energy needs of the project. Understanding the effects of each performance area enables the design team to more easily navigate the decisions and trade-offs required when evaluating different assembly options.

**Multi-Family Housing Acoustical Expectations**

As with any issue of building performance, the acoustics of a mixed-use wood-frame structure can be designed to meet or exceed minimal requirements, depending on the expectations of the developer, buyers and tenants.

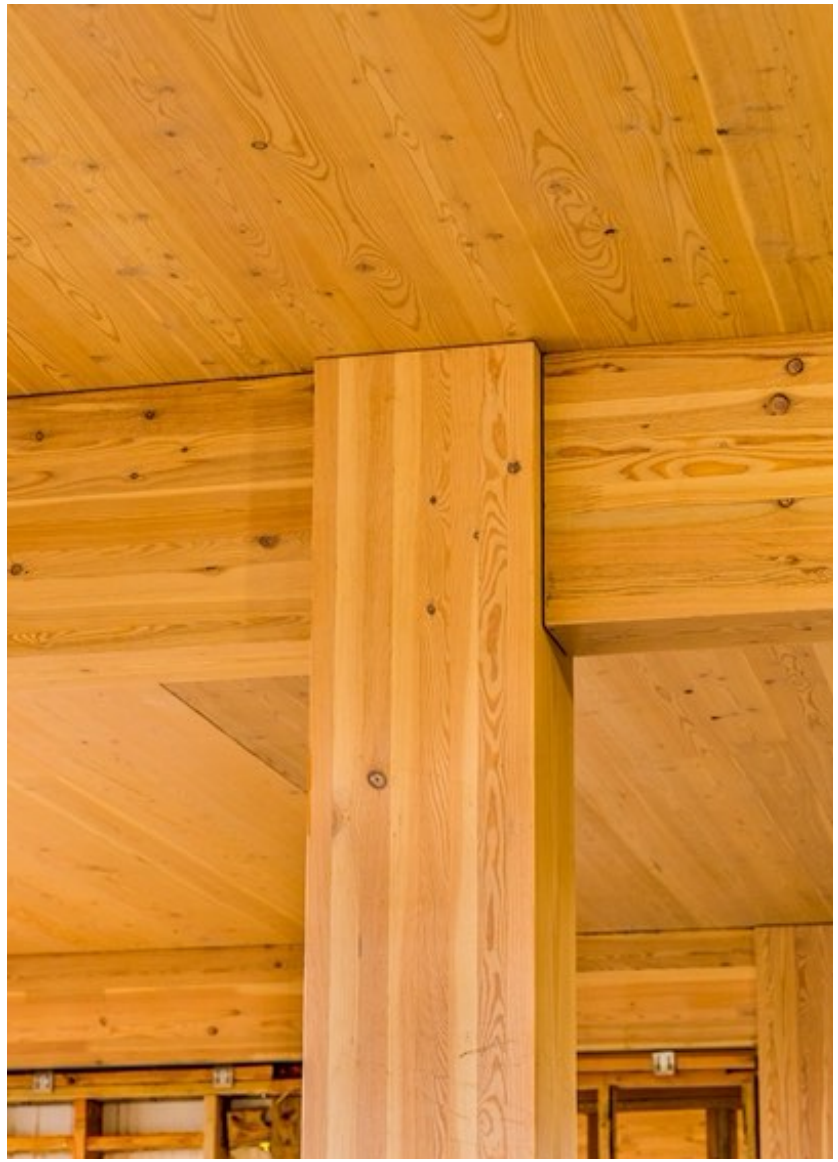
In residential buildings, the *International Building Code* (IBC) provides a minimum design requirement for unit-to-unit acoustical protection between floors. It requires a Sound Transmission Class (STC) rating or Impact Insulation Class (IIC) rating of 50, unless the "Authority Having Jurisdiction" has its own more stringent requirement, which is rarely the case. The *International Residential Code* (IRC) requires a minimum design separation of STC 45 for townhouses.

For wood-frame mixed-use buildings, Section 1207 of the 2012 IBC includes the following:

# Acoustics Design Topics - Agenda

1. Principles of Acoustics Design
2. Code Requirements and Owner Expectations
3. Tested Assemblies & Calculated Performance
4. Light-Frame Floor & Walls
5. **Mass Timber Floors & Walls**

# Mass Timber: Structure Often is Finish



Photos: Baumberger Studio/PATH Architecture/Marcus Kauffman | Architect: PATH Architecture

# But by Itself, Not Adequate for Acoustics

# Mass Timber Acoustics

TABLE 1:

**Examples of Acoustically-Tested Mass Timber Panels**

| Mass Timber Panel | Thickness | STC Rating | IIC Rating |
|---|---|---|---|
| 3-ply CLT wall[4] | 3.07" | 33 | N/A |
| 5-ply CLT wall[4] | 6.875" | 38 | N/A |
| 5-ply CLT floor[5] | 5.1875" | 39 | 22 |
| 5-ply CLT floor[4] | 6.875" | 41 | 25 |
| 7-ply CLT floor[4] | 9.65" | 44 | 30 |
| 2x4 NLT wall[6] | 3-1/2" bare NLT<br>4-1/4" with 3/4" plywood | 24 bare NLT<br>29 with 3/4" plywood | N/A |
| 2x6 NLT wall[6] | 5-1/2" bare NLT<br>6-1/4" with 3/4" plywood | 22 bare NLT<br>31 with 3/4" plywood | N/A |
| 2x6 NLT floor + 1/2" plywood[2] | 6" with 1/2" plywood | 34 | 33 |

*Source: Inventory of Acoustically-Tested Mass Timber Assemblies, WoodWorks[7]*

# Mass Timber Acoustics

**One of the main reasons is "mass"**

**Recall the three ways to increase acoustical performance:**

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


Image credit: Christian Columbres

# Mass Timber Acoustics

| Concrete Slab: | | CLT Slab: |
|---|---|---|
| 6” Thick | | 6-7/8” Thick |
| 80 PSF | ⟷ | 18 PSF |
| STC 53 | ⟷ | STC 41 |

# Mass Timber Acoustics

There are three main ways to improve an assembly's acoustical performance:

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

# Mass Timber Acoustics

There are three main ways to improve an assembly's acoustical performance:

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

**Acoustical Mat:**

- Typically roll out or board products
- Thicknesses vary: Usually ¼" to 1"+

Image credit: Maxxon

# Mass Timber Acoustics

Acoustical floor underlayments

# Mass Timber Acoustics

**Common mass timber floor assembly:**

- Finish floor (if applicable)
- Underlayment (if finish floor)
- 1.5” to 4” thick concrete/gypcrete topping
- Acoustical mat
- WSP (if applicable)
- Mass timber floor panels

Image credit: AcoustiTECH

# Mass Timber Acoustics


To Help Designers Navigate Options for Mass Timber Acoustically Tested Assemblies, WoodWorks Created 2 New Resources

# Solutions Paper

# Mass Timber Acoustics

WoodWorks™
WOOD PRODUCTS COUNCIL

## Acoustics and Mass Timber: Room-to-Room Noise Control

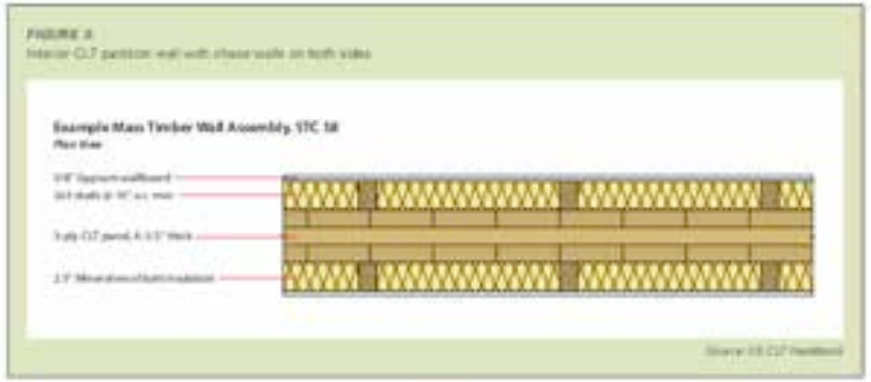
*Richard McLain, PE, SE • Senior Technical Director • WoodWorks*

T3 Minneapolis
Architect: MGA | Michael Green Architecture, DLR Group
Structural Engineer: Magnusson Klemencic Associates
Design Assist + Build: StructureCraft

The growing availability and code acceptance of mass timber—i.e., large solid wood panel products such as cross-laminated timber (CLT) and nail-laminated timber (NLT)—for floor, wall and roof construction has given designers a low-carbon alternative to steel, concrete, and masonry for many applications. However, the use of mass timber in multi-family and commercial buildings presents unique acoustic challenges.

While laboratory measurements of the impact and airborne sound isolation of traditional building assemblies such as light wood-frame, steel and concrete are widely available, fewer resources exist that quantify the acoustic performance of mass timber assemblies. Additionally, one of the most desired aspects of mass timber construction is the ability to leave a building's structure exposed as finish, which creates the need for asymmetric assemblies. With careful design and detailing, mass timber buildings can meet the acoustic performance expectations of most building types.

http://www.woodworks.org/wp-content/uploads/wood_solution_paper-MASS-TIMBER-ACOUSTICS.pdf



Example Mass Timber Wall Assembly, STC 58

### Mass Timber Assembly Options: Walls

Mass timber panels can also be used for interior and exterior walls—both bearing and non-bearing. For interior walls, the need to conceal services such as electrical and plumbing is an added consideration. Common approaches include building a chase wall in front of the mass timber wall or installing gypsum wallboard on resilient channels that are attached to the mass timber wall. As with bare mass timber floor panels, bare mass timber walls don't typically provide adequate noise control, and chase walls also function as acoustical improvements. For example, a 3-ply CLT wall panel with a thickness of 3.07" has an STC rating of 33.* In contrast, Figure 3 shows an interior CLT partition wall with chase walls on both sides. This assembly achieves an STC rating of 58, exceeding the IBC's acoustical requirements for multi-family construction. Other examples are included in the inventory of tested assemblies noted above.

### Acoustical Differences between Mass Timber Panel Options

The majority of acoustically-tested mass timber assemblies include CLT. However, tests have also been done on other mass timber panel options such as NLT and dowel-laminated timber (DLT), as well as traditional heavy timber options such as tongue and groove decking. Most tests have concluded that CLT acoustical performance is slightly better than that of other mass timber options, largely because the cross-orientation of laminations in a CLT panel limits sound flanking.

For those interested in comparing similar assemblies and mass timber panel types and thicknesses, the inventory noted above contains tested assemblies using CLT, NLT, glued-laminated timber panels (GLT), and tongue and groove decking.

### Improving Performance by Minimizing Flanking

Even when the assemblies in a building are carefully designed and installed for high acoustical performance, consideration of flanking paths—in areas such as assembly intersections, beam-to-column/wall connections, and MEP penetrations—is necessary for a building to meet overall acoustical performance objectives.

One way to minimize flanking paths at these connections and interfaces is to use resilient connection isolation and sealant strips. These products are capable of resisting structural loads in compression between structural members and connections while providing isolation and breaking hard, direct connections between members. In the context of the three methods for improving acoustical performance noted above, these strips act as decouplers. With airtight connections, interfaces and penetrations, there is a much greater chance that the acoustic performance of a mass timber building will meet expectations.

# Inventory of Tested Assemblies


**Acoustically-Tested Mass Timber Assemblies**

Following is a list of mass timber assemblies that have been acoustically tested as of January 23, 2019. Sources are noted at the end of this document. For free technical assistance on any questions related to the acoustical design of mass timber assemblies, or free technical assistance related to any aspect of the design, engineering or construction of a commercial or multi-family wood building in the U.S., email help@woodworks.org or contact the WoodWorks Regional Director nearest you: http://www.woodworks.org/project-assistance

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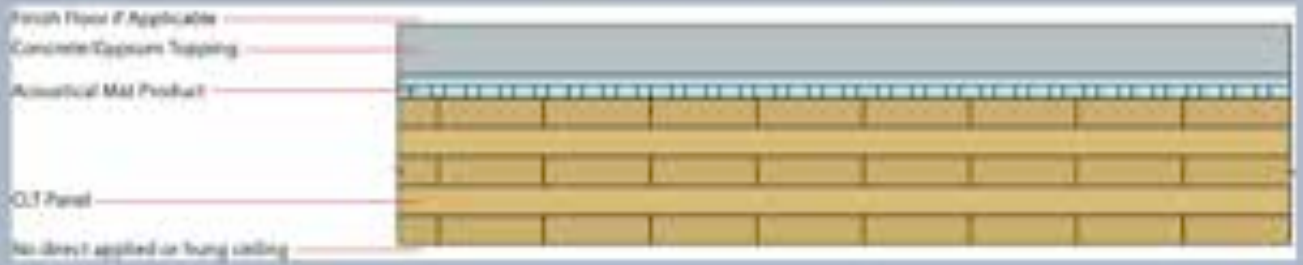
http://bit.ly/mass-timber-assemblies

## Table 1: CLT Floor Assemblies with Concrete/Gypsum Topping, Ceiling Side Exposed

WoodWorks



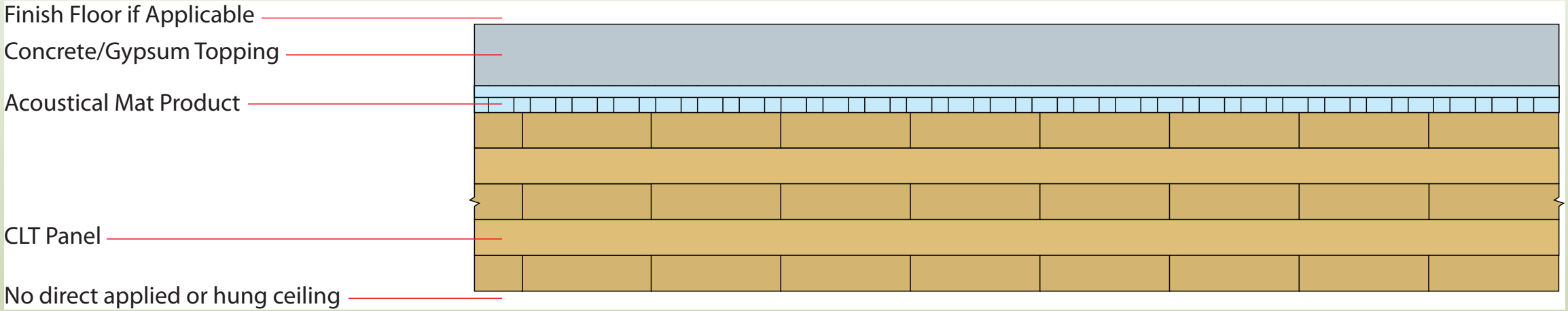

| CLT Panel | Concrete/Gypsum Topping | Acoustical Mat Product Between CLT and Topping | Finish Floor | STC[1] | IIC[1] | Source |
|---|---|---|---|---|---|---|
| CLT 5-ply (6.875") | 1-1/2" Gyp-Crete® | Maxxon Acousti-Mat® 3/4 | None | 47[1] ASTC | 47[1] AIIC | 1 |
| | | | LVT | - | 49[1] AIIC | |
| | | | Carpet + Pad | - | 75[1] AIIC | |
| | | | LVT on Acousti-Top® | - | 52[1] AIIC | |
| | | | Eng Wood on Acousti-Top® | - | 51[1] AIIC | |
| | | Maxxon Acousti-Mat® N Premium | None | 49[1] ASTC | 45[1] AIIC | |
| | | | LVT | - | 47[1] AIIC | |
| | | | LVT on Acousti-Top® | - | 49[1] AIIC | |
| | 1-1/2" Levelrock® Brand 2500 | USG SAM N25 Ultra | None | 45[3] | 39[3] | 15 |
| | | | LVT | 48[3] | 47[3] | 16 |
| | | | LVT Plus | 48[3] | 49[3] | 58 |
| | | | Eng Wood | 47[3] | 47[3] | 59 |
| | | | Carpet + Pad | 45[3] | 67[3] | 60 |
| | | | Ceramic Tile | 50[3] | 46[3] | 61 |
| | | Soprema® Insonomat | None | 45[3] | 42[3] | 15 |
| | | | LVT | 48[3] | 44[3] | 16 |
| | | | LVT Plus | 48[3] | 47[3] | 58 |
| | | | Eng Wood | 47[3] | 45[3] | 59 |
| | | | Eng Wood | 47[3] | 49[3] | 59 |

**More than 430 Tested Assemblies**

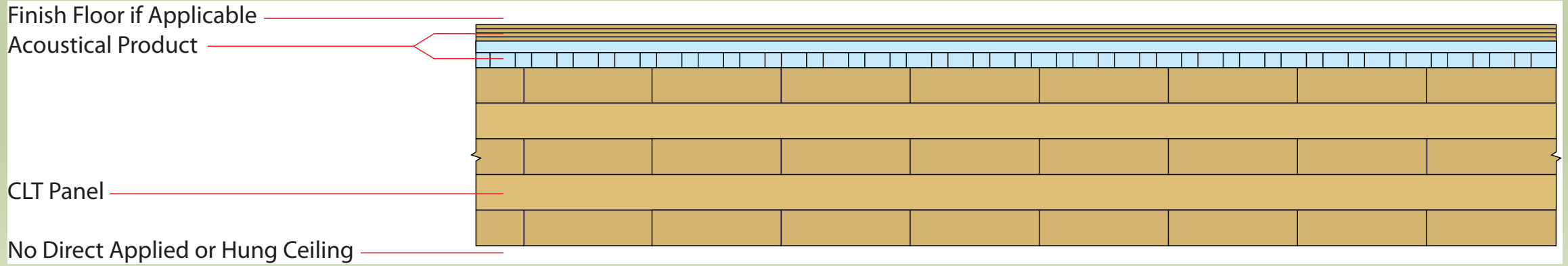
http://bit.ly/mass-timber-assemblies

# Mass Timber Acoustics Inventory

## Table 1: CLT Floor Assemblies with Concrete/Gypsum Topping, Ceiling Side Exposed

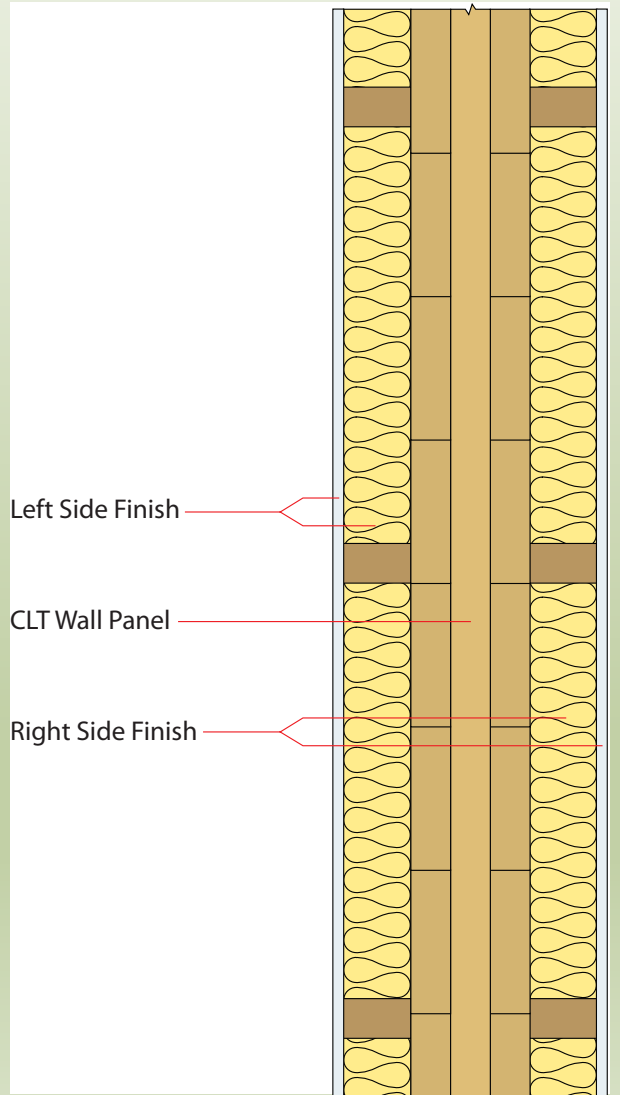



## Table 2: CLT Floor Assemblies without Concrete/Gypsum Topping, Ceiling Side Exposed

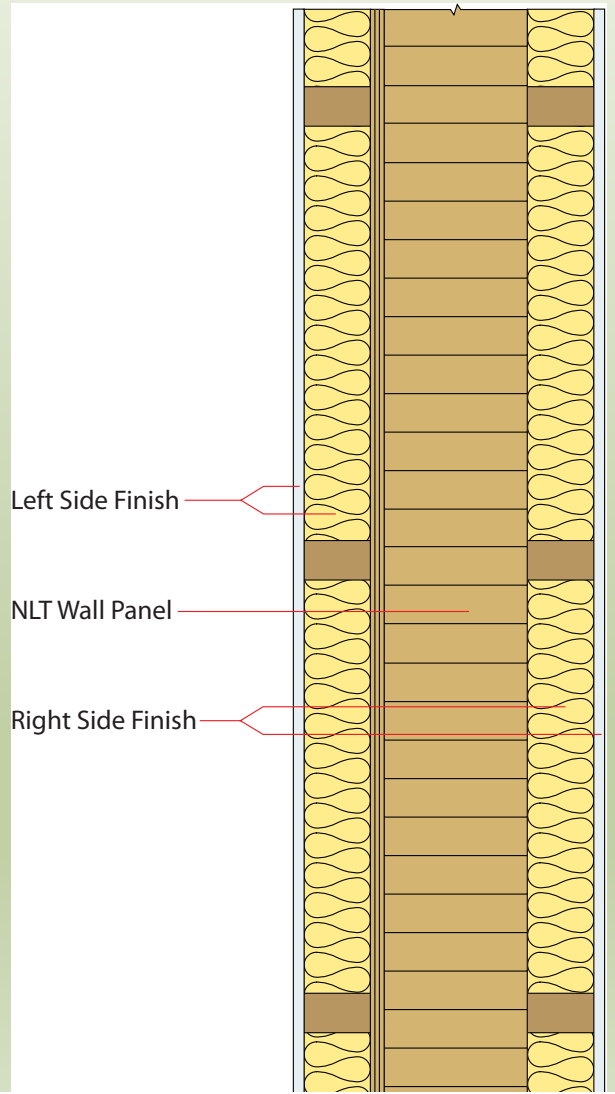


# Mass Timber Acoustics Inventory

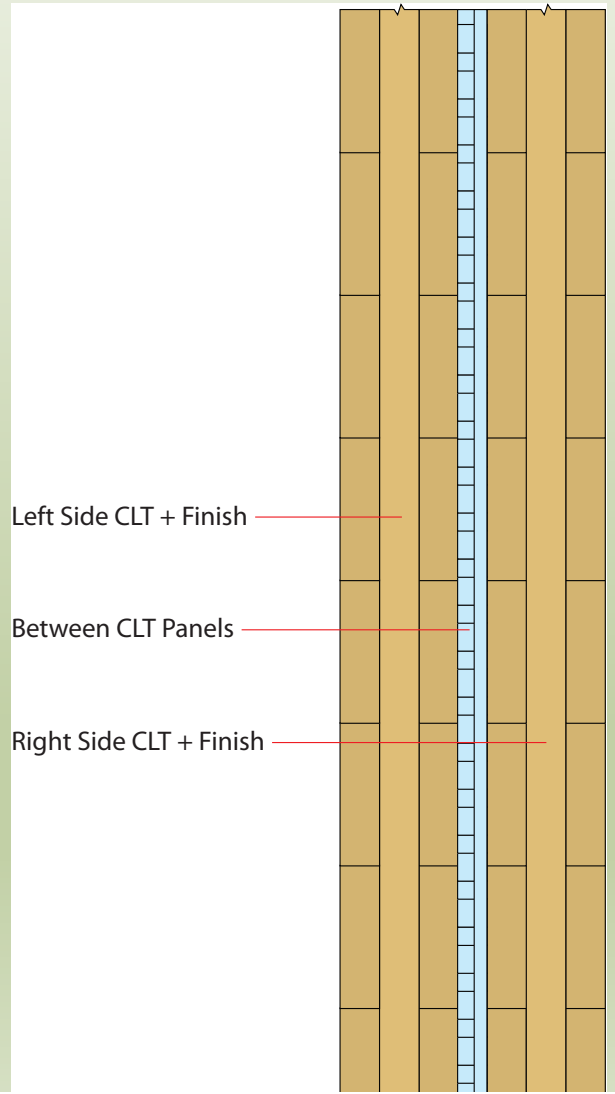
## Table 6: Single CLT Wall




## Table 7: Single NLT Wall




## Table 8: Double CLT Wall



# MT Acoustics Inventory

| r | STC[1] | IIC[1] | Source |
|---|---|---|---|
| | 47[2] ASTC | 47[2] AIIC | |
| | - | 49[2] AIIC | |
| | - | 75[2] AIIC | |
| op® | - | 52[2] AIIC | |
| usti- | - | 51[2] AIIC | 1 |

**Read the Footnotes**

**Table 1 Notes:**

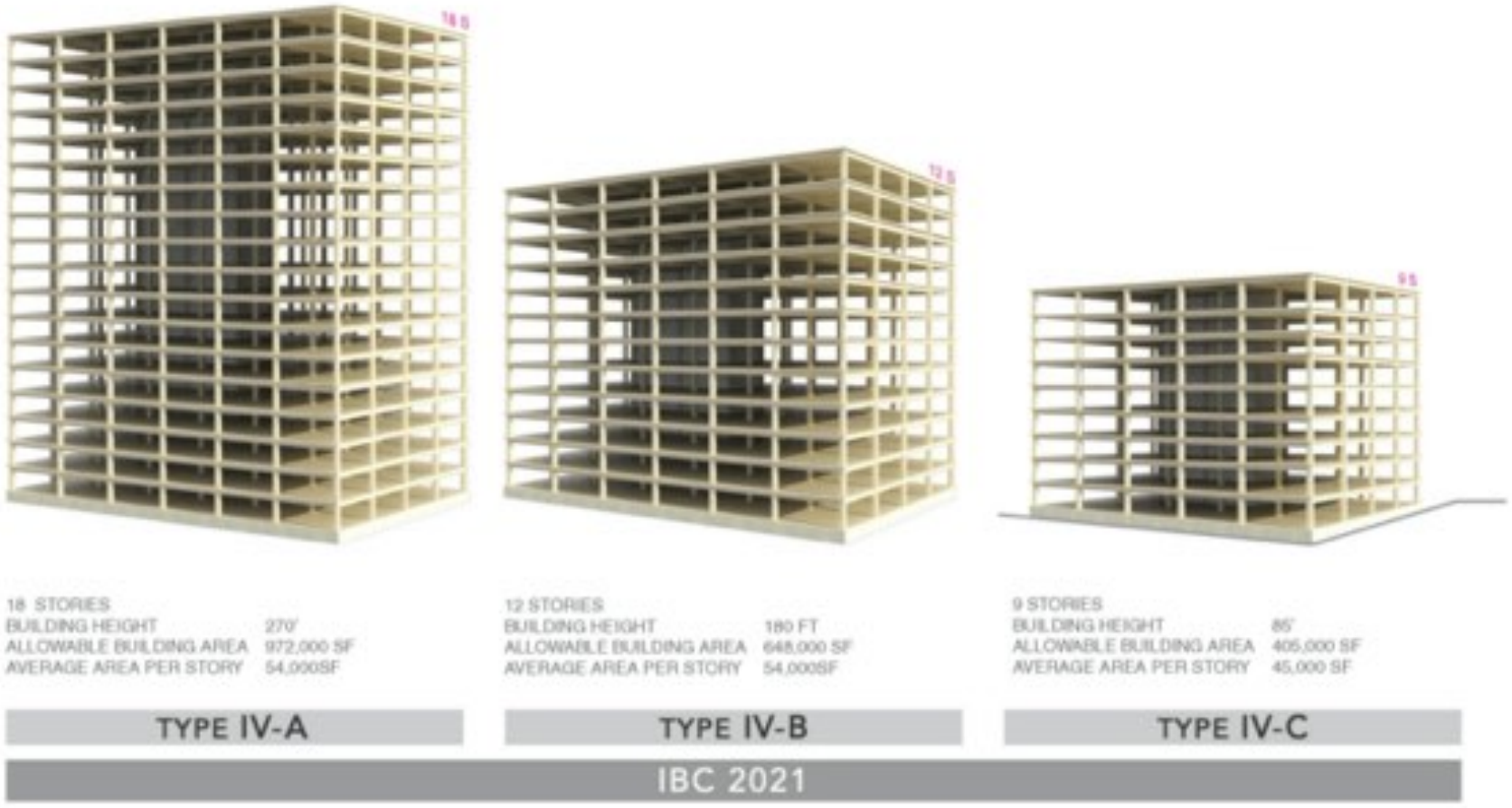
1. All STC tests performed in accordance with ASTM E 90 unless otherwise noted below. All IIC tests performed in accordance with ASTM E 492 unless otherwise noted below. See end of document for sources and referenced test reports.
2. ASTC field tests performed in accordance with ASTM E 336. AIIC field tests performed in accordance with ASTM E 1007.
3. IIC tests not performed in accordance with a singular test standard. Test measurement method used a combination of ASTM E492 and ASTM 1007 per acoustical mat product manufacturer.
4. FSTC field test performed in accordance with ASTM E 336. AIIC field test not performed in accordance with ASTM E 1007 (inadequate number of measurements).
5. STC and IIC noted is a prediction based on the ISO 15712-1 prediction method as noted in the referenced test report.
6. STC and IIC noted is based on floor zone testing procedures that are modifications of ASTM E90 and E492 test and do not fully conform with these test standards per acoustical mat product manufacturer and as noted in the referenced test report.
7. Actual thickness of CLT in this test was 6.3” (160 mm)
8. Assemblies included in the 1st edition of the CLT Handbook are included herein due to their legacy use. However, the testing standards used for these assemblies are European and direct correlation to IBC-referenced ASTM standards is not currently available.
9. STC and IIC noted is a based on the ISO 12354 model as noted in the referenced manufacturer’s literature

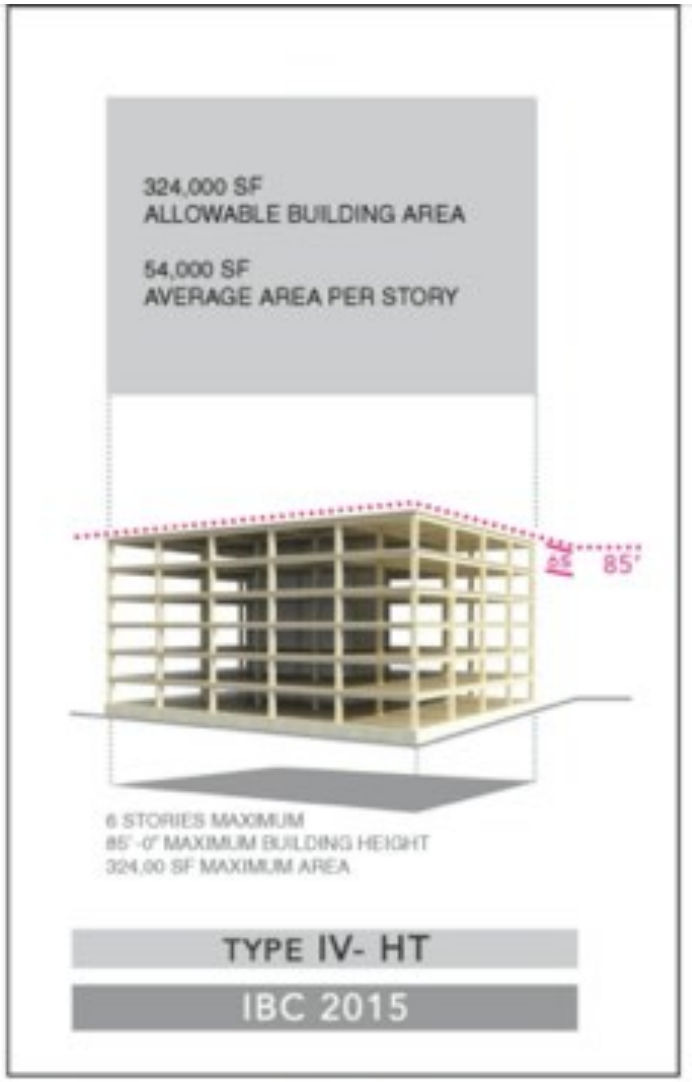
# MT Acoustics Inventory

Image credit: Structure Fusion

Inventory contains tests conducted on CLT, NLT, MPP, GLT, T&G Decking

# New Tall Timber Opportunities




BUSINESS OCCUPANCY [GROUP B]

*BUILDING FLOOR-TO-FLOOR HEIGHTS ARE SHOWN AT 12'-0" FOR ALL EXAMPLES FOR CLARITY IN COMPARISON BETWEEN 2015 TO 2021 IBC CODES.

Credit: Susan Jones, atelierjones

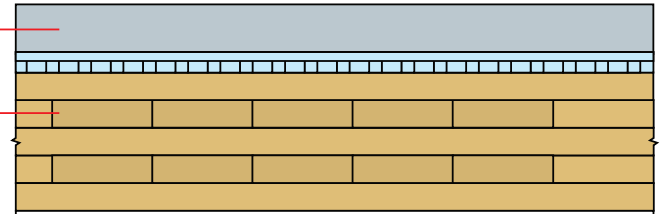
# 1” Bare Gypsum (no finish floor)

# Tall Timber Assemblies

**Without Dropped Ceiling**

Minimum 1" noncombustible material

Mass timber floor panel



**STC 50**

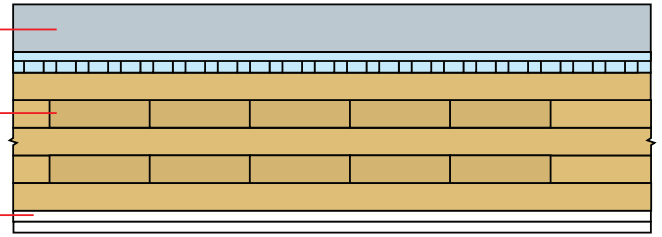
**IIC 40**

**Without Dropped Ceiling**

Minimum 1" noncombustible material

Mass timber floor panel

Two layers 5/8" Type X gypsum*



**STC 52**

**IIC 46**

**Applicable to most locations; limited exposed mass timber permitted in IV-B*

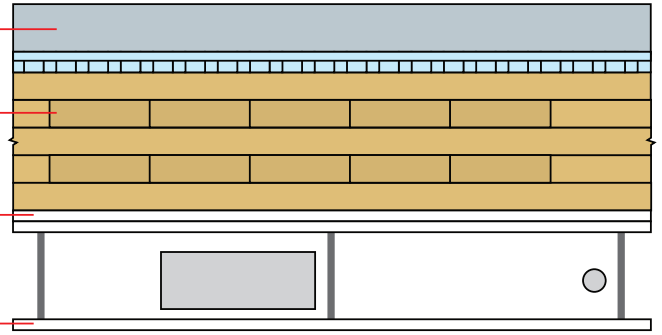
**With Dropped Ceiling**

Minimum 1" noncombustible material

Mass timber floor panel

Two layers 5/8" Type X gypsum

Dropped ceiling



**STC 63**

**IIC 60**

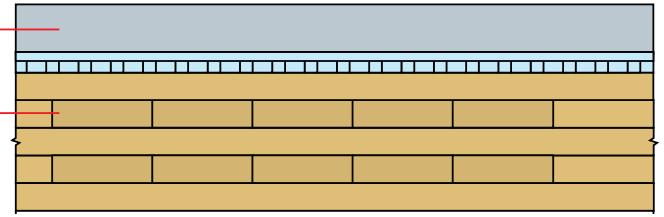
# LVT on 1” Gypsum

# Tall Timber Assemblies

**Without Dropped Ceiling**

Minimum 1" noncombustible material

Mass timber floor panel



**STC 51**

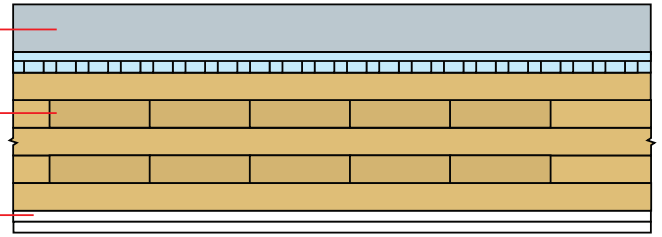
**IIC 43**

**Without Dropped Ceiling**

Minimum 1" noncombustible material

Mass timber floor panel

Two layers 5/8" Type X gypsum*



**STC 52**

**IIC 48**

**Applicable to most locations; limited exposed mass timber permitted in IV-B*

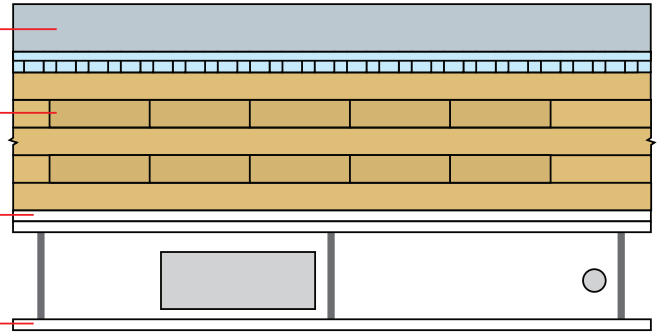
**With Dropped Ceiling**

Minimum 1" noncombustible material

Mass timber floor panel

Two layers 5/8" Type X gypsum

Dropped ceiling



**STC 63**

**IIC 63**

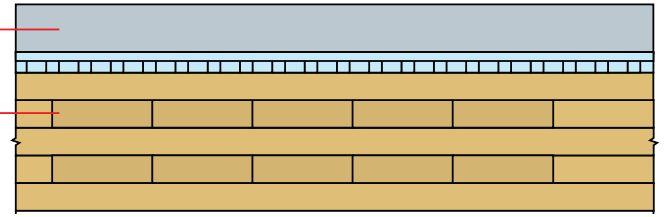
# 2” Bare Concrete (no finish floor)

# Tall Timber Assemblies

**Without Dropped Ceiling**

Minimum 1" noncombustible material

Mass timber floor panel



**STC 52**

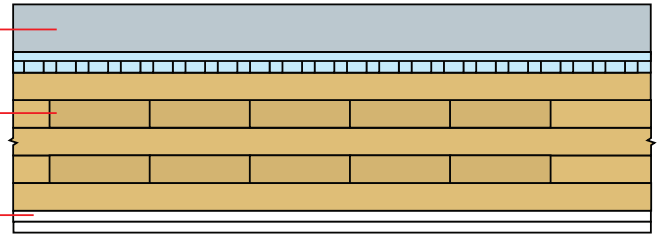
**IIC 46**

**Without Dropped Ceiling**

Minimum 1" noncombustible material

Mass timber floor panel

Two layers 5/8" Type X gypsum*



**STC 59**

**IIC 52**

**Applicable to most locations; limited exposed mass timber permitted in IV-B*

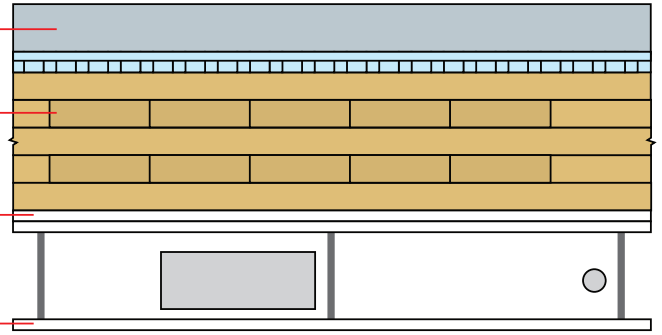
**With Dropped Ceiling**

Minimum 1" noncombustible material

Mass timber floor panel

Two layers 5/8" Type X gypsum

Dropped ceiling



**NA**

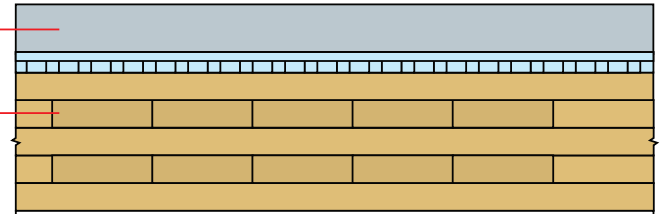
# LVT on 2” Concrete

# Tall Timber Assemblies

**Without Dropped Ceiling**

Minimum 1" noncombustible material

Mass timber floor panel



**STC 53**

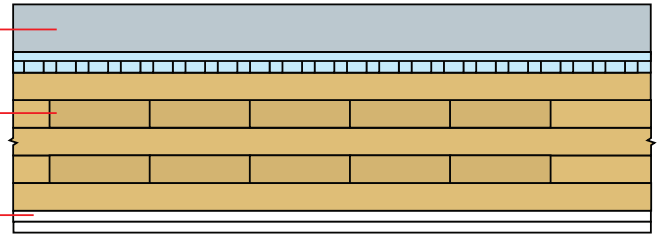
**IIC 52**

**Without Dropped Ceiling**

Minimum 1" noncombustible material

Mass timber floor panel

Two layers 5/8" Type X gypsum*



**STC 58**

**IIC 55**

**Applicable to most locations; limited exposed mass timber permitted in IV-B*

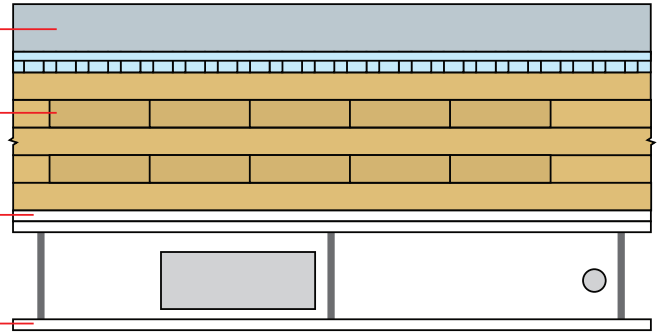
**With Dropped Ceiling**

Minimum 1" noncombustible material

Mass timber floor panel

Two layers 5/8" Type X gypsum

Dropped ceiling



**NA**

# Mass Timber Acoustics

**A Solved Challenge?**

Still exploring further tests:

- New product assemblies
- More dry systems (no poured toppings)
- Tall wood code-compliant floor assemblies
- Others – what challenges do you face when designing mass timber for acoustics? Let us know.
- Are these resources helpful? Let us know.


Credit: Susan Jones, atelierjones

# QUESTIONS?

This concludes The American Institute of Architects Continuing Education Systems Course

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Image credit: LEVER Architcture

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