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

AIA Approved Continuing Education

Course Description

Mass timber construction is often perceived as acoustically inferior to conventional construction types, particularly in multi-family buildings subject to code-mandated sound transmission requirements. These perceptions often lead to design approaches that increase assembly mass—most commonly by adding concrete toppings, which can diminish the embodied carbon benefits of mass timber systems. This course evaluates the validity of these assumptions through a review of measured baseline acoustical performance data for mass timber assemblies and comparisons with conventional construction types. The presentation introduces the principles of sound transmission and isolation to provide a framework for understanding acoustical behavior in building assemblies, followed by an examination of design and construction strategies for improving airborne and structure-borne sound isolation in mass timber floors and walls. The presentation will also cover acoustic flanking and how it relates to mass timber construction. Participants will gain insight into informed decision-making strategies that balance performance, constructability, and sustainability.

Learning Objectives

1. Compare the baseline airborne and structure-borne sound isolation performance of mass timber assemblies.

2. Compare the measured acoustical performance of mass timber assemblies with conventional construction systems and evaluate common assumptions regarding code compliance and occupant comfort.

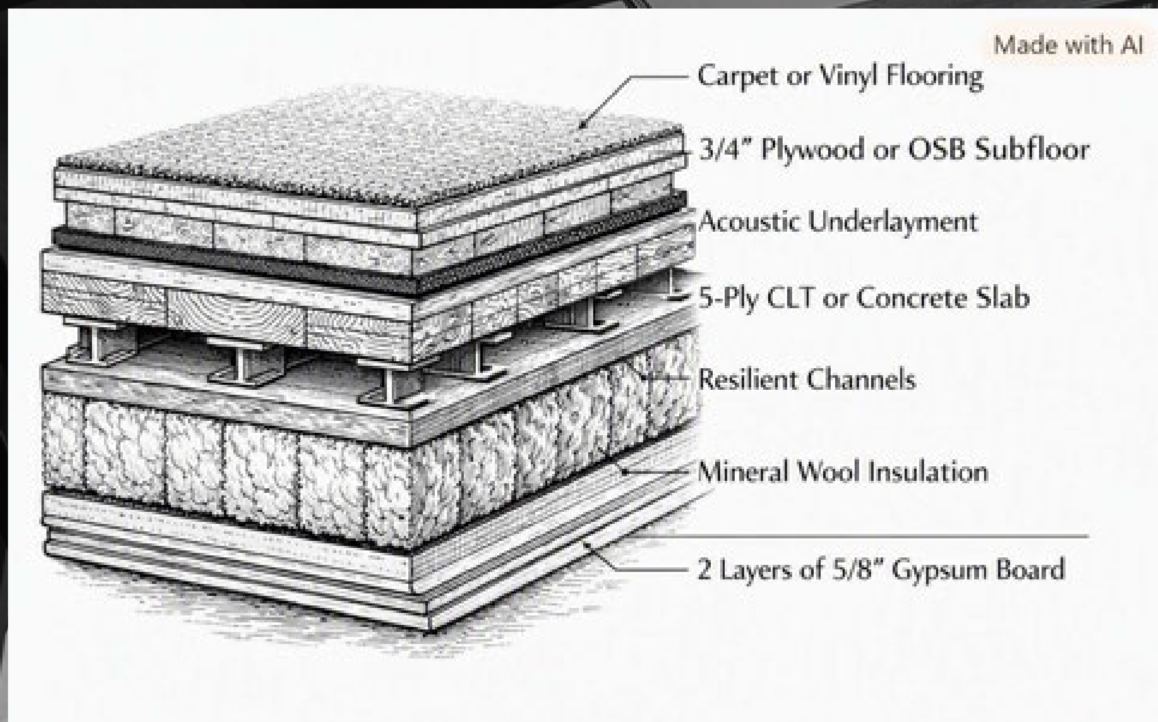
3. Evaluate the performance, constructability, and sustainability tradeoffs associated with common acoustical design decisions.

4. Differentiate between design approaches that rely on increased assembly mass and those that improve acoustical performance through targeted detailing, and evaluate their implications for occupant welfare, sustainability, and project outcomes.

Mass Timber Acoustic Design

Variables and Solutions

What's the best floor/ceiling assembly for acoustical performance between two units in an apartment building?

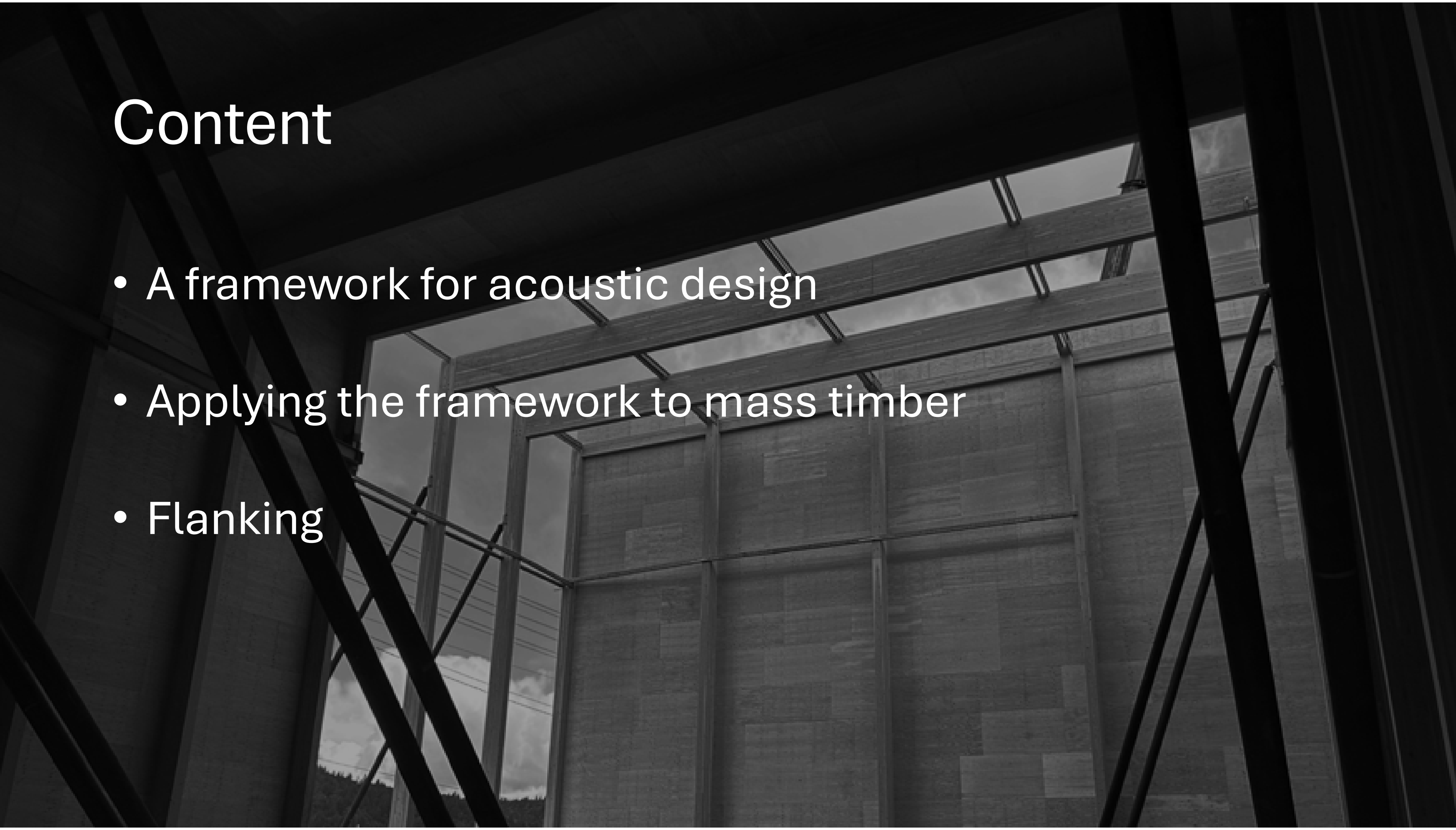


AI-generated Image

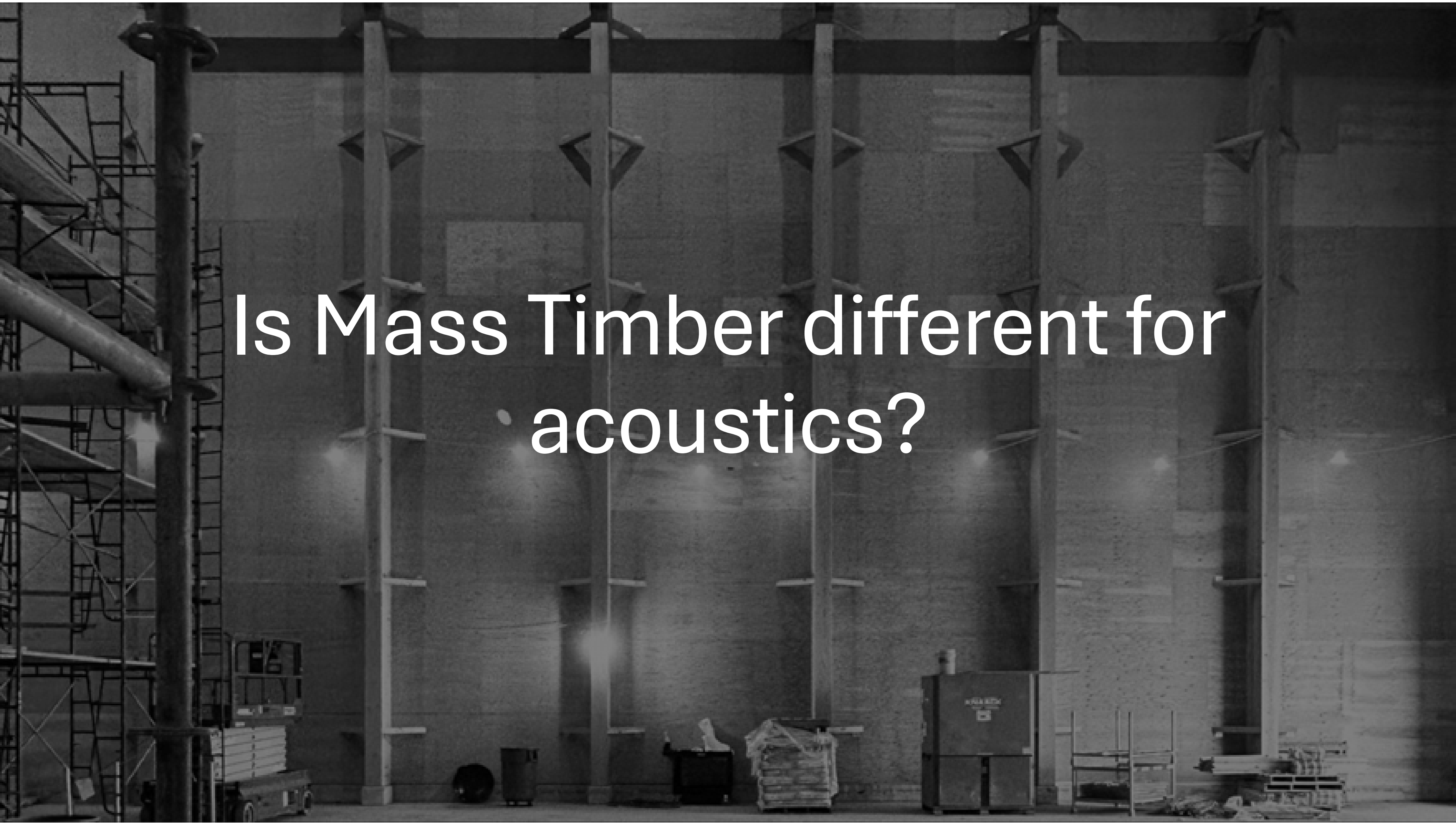
What’s the “best” acoustical assembly?

- How many stories is it?
- Where is it located?
- Is it a seismic zone?
- What’s your budget?
- What are the fire rating requirements?
- What are your sustainability goals?
- Are any building materials more expensive than usual?

Content



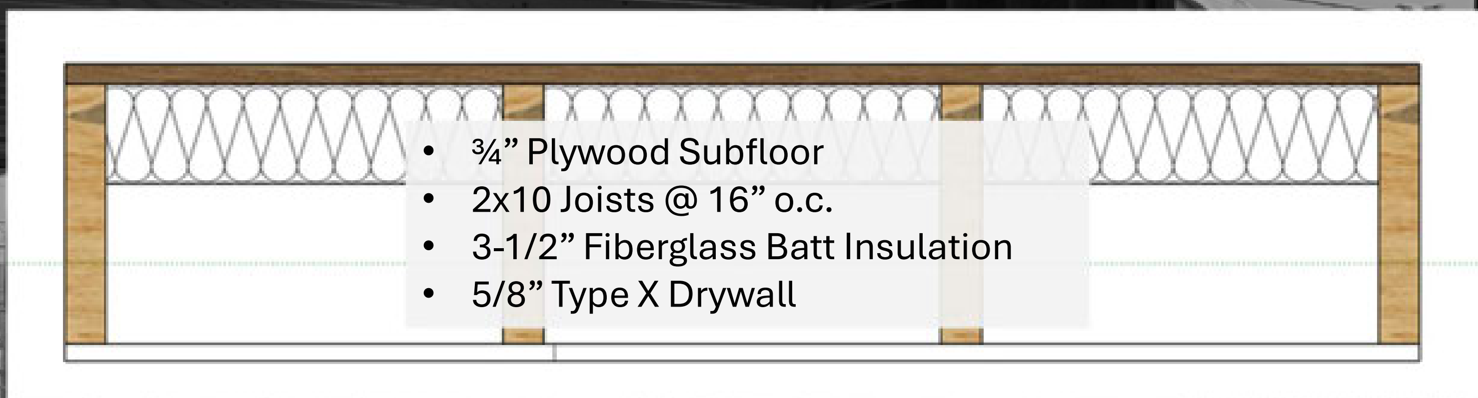
- A framework for acoustic design
- Applying the framework to mass timber
- Flanking



Is Mass Timber different for acoustics?


Concrete slab
• 6” Concrete Slab
STC 53 | IIC 27
TLF-97-107a & IIF-97-048
NRC IRC-IR-766

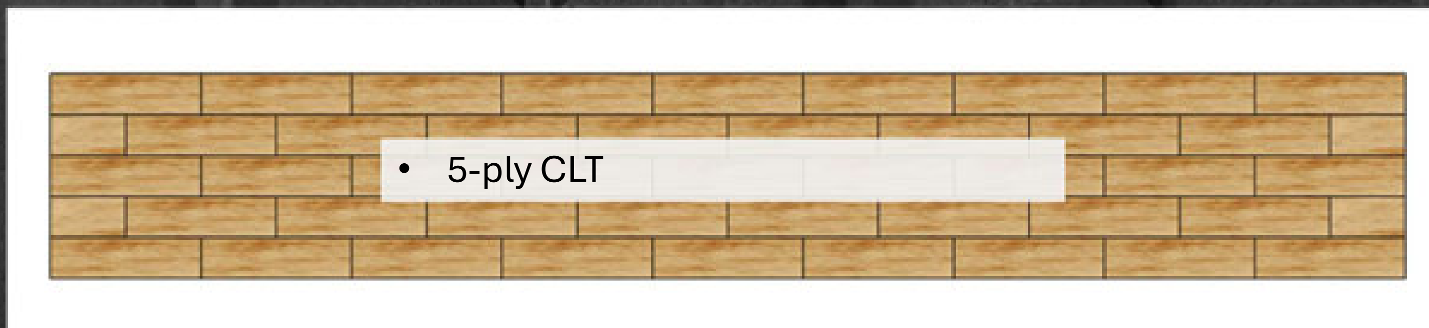
2x10 Joists



STC 34 | IIC 30

TLF-95-073a & IIF-95-024
NRC IRC-IR-766

5-ply CLT

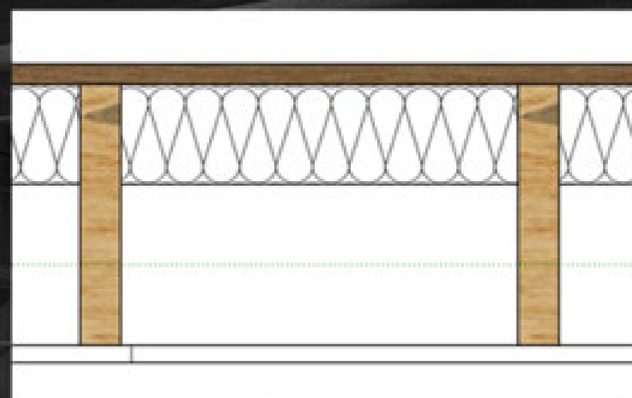


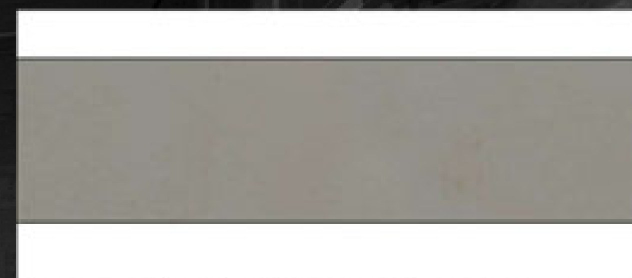
STC 41 | IIC 25

TLF-12-039 & IIF-12-026

NRC CR A1-100035-02.1

Comparison

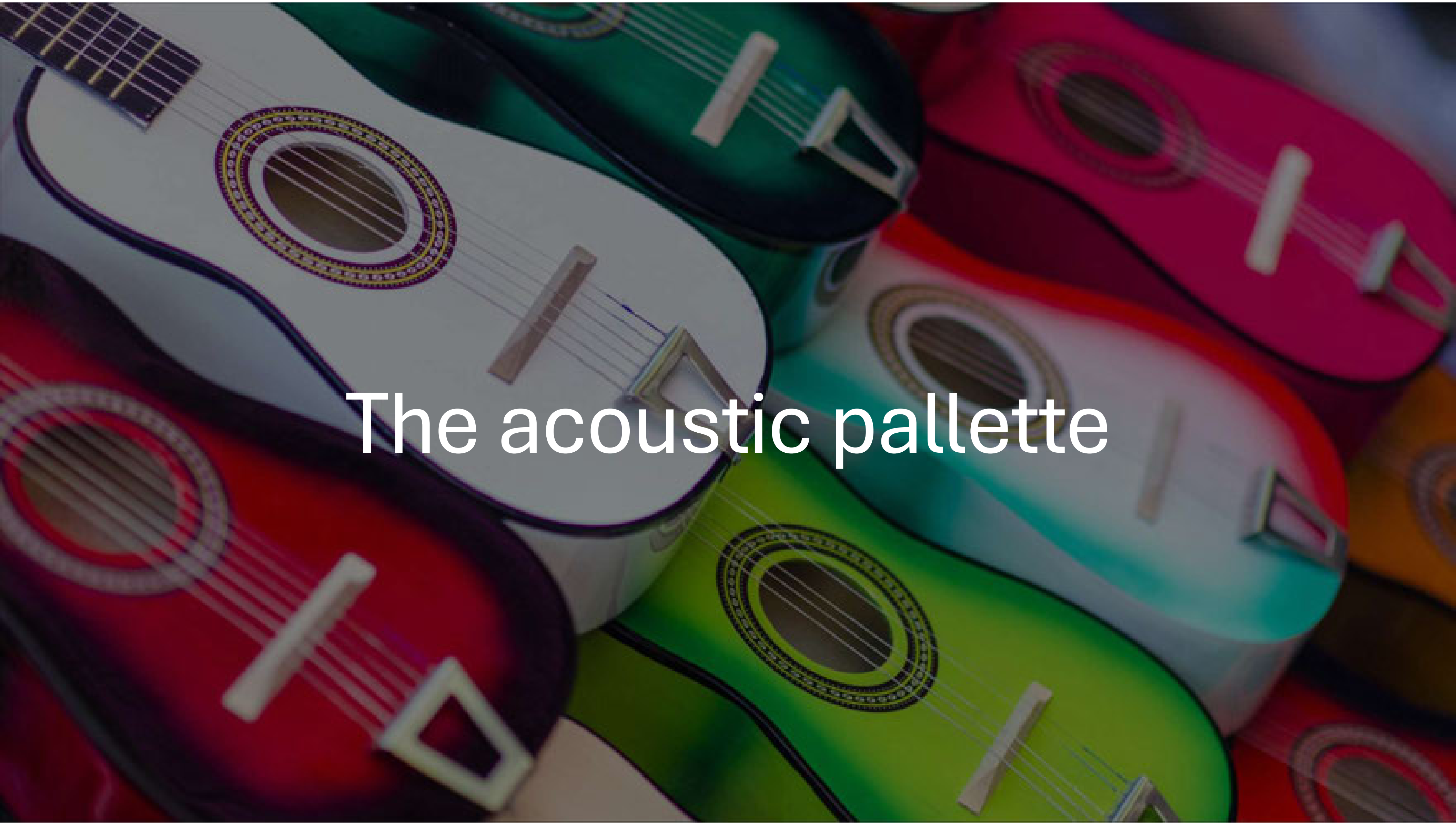




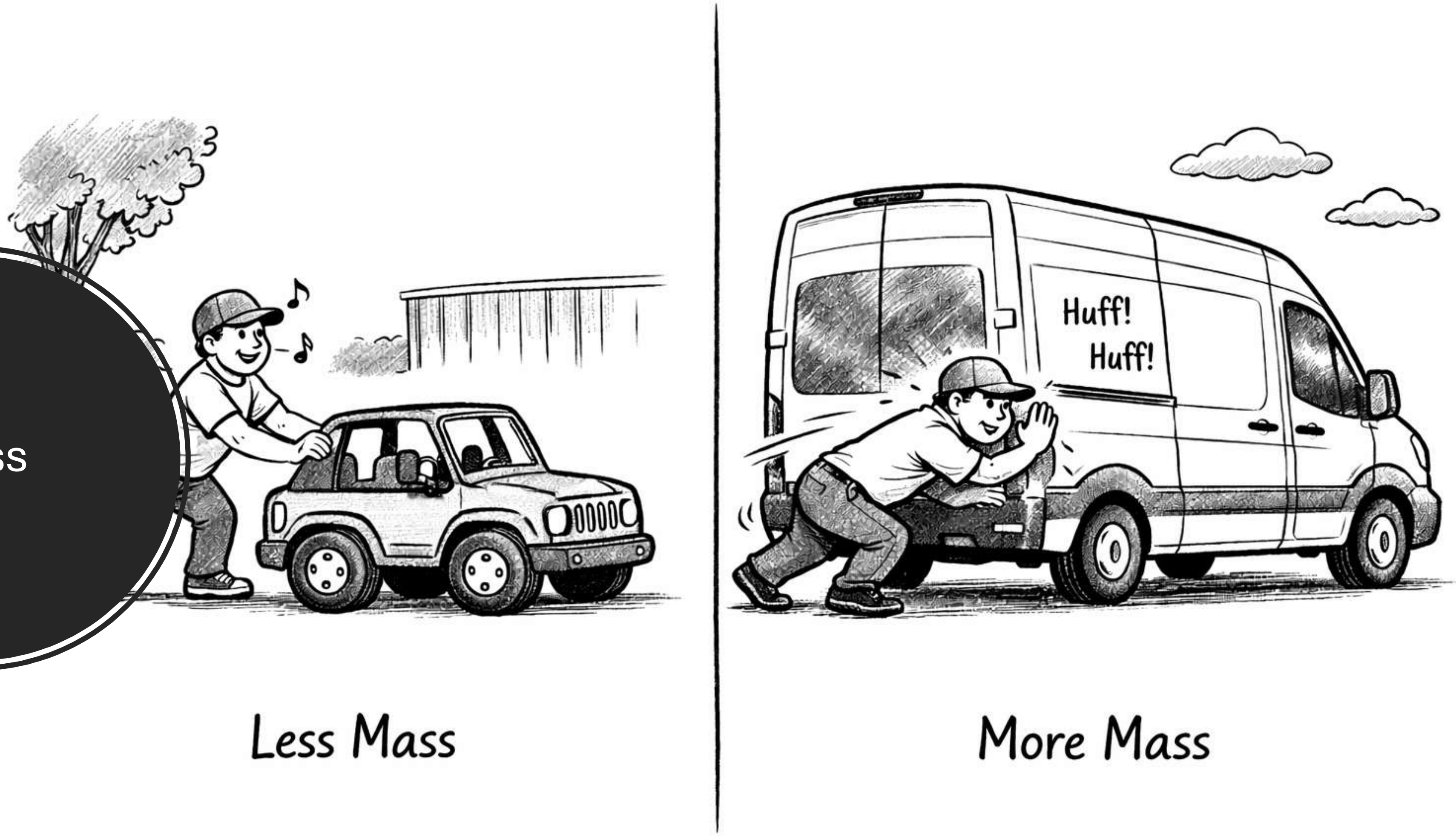
STC 41
IIC 25
TLF-12-039 & IIF-12-026
NRC CR A1-100035-02.1

STC 34
IIC 30
TLF-95-073a & IIF-95-024
NRC IRC-IR-766

STC 53
IIC 27
TLF-97-107a & IIF-97-048
NRC IRC-IR-766


The acoustic pallette

Mass



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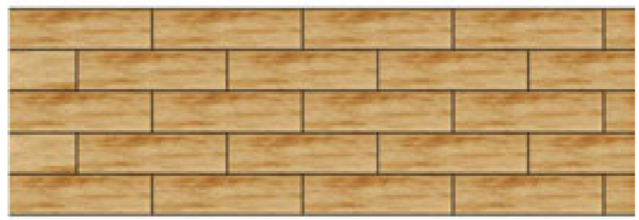
Mass



STC 41
IIC 25
TLF-12-039 & IIF-12-026
NRC CR A1-100035.02

STC 53
IIC 27
TLF-97-107a & IIF-97-048
NRC IRC-IR-766

Isolation

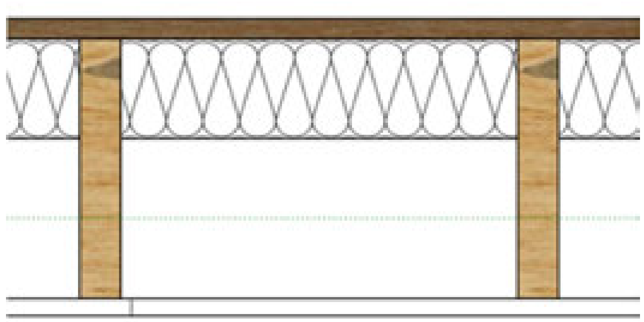
“Isolation”

AI-generated Image

Isolation

STC 34
IIC 30

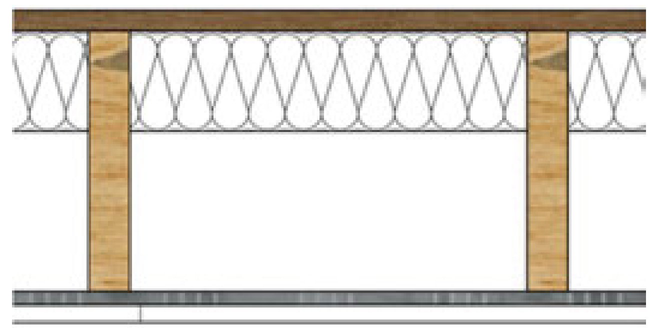
TLF-95-073a & IIF-95-024
NRC IRC-IR-766



- ¾” Plywood Subfloor
- 2x10 Joists @ 16” o.c.
- 3-1/2” Fiberglass Batt Insulation
- 5/8” Type X Drywall

STC 50
IIC 42

TLF-95-075a & IIF-95-025
NRC IRC-IR-766



- ¾” Plywood Subfloor
- 2x10 Joists @ 16” o.c.
- 3-1/2” Fiberglass Batt Insulation
- RC-Deluxe @ 16” o.c.
- 5/8” Type X Drywall

Stiffness

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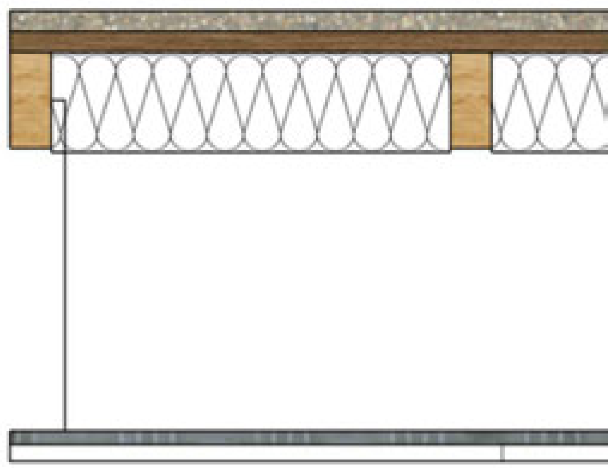
Stiffness

STC 64
IIC 47 | LIIC 52

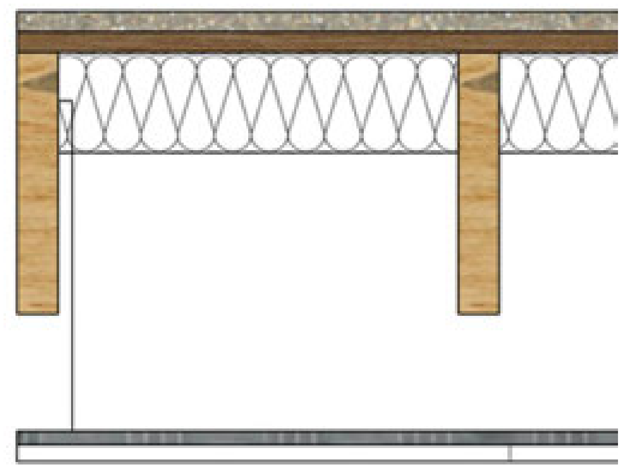
Maxxon 0031-149.1



- ¾" Gypsum Concrete
- OSB Subfloor
- 2x4 Joists @ 16" o.c.
- 3-1/2" Fiberglass Batt Insulation
- Wire hangers
- 5/8" Type X Drywall

STC 67
IIC 49 | LIIC 64

Maxxon 0031-146.1



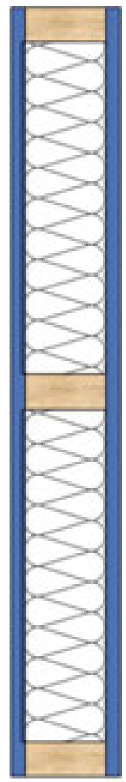
- ¾" Gypsum Concrete
- OSB Subfloor
- 2x10 Joists @ 16" o.c.
- 3-1/2" Fiberglass Batt Insulation
- Wire Hangers
- 5/8" Type X Drywall

Damping

AI-generated Image

“~~Dampening.~~” *DAMPING!*

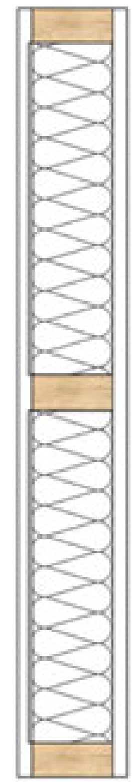
Damping



STC 45

PABCO
NOAL 20-0412

- 5/8” Damped Drywall
- 2x4 Wood Studs @ 16” o.c.
- 3-1/2” Fiberglass Batt Insulation
- 5/8” Damped Drywall



STC 35

PABCO
NOAL 23-10092

- 5/8” Type X Drywall
- 2x4 Wood Studs @ 16” o.c.
- 3-1/2” Fiberglass Batt Insulation
- 5/8” Type X Drywall

Insulation

AI-generated Image

Insulation

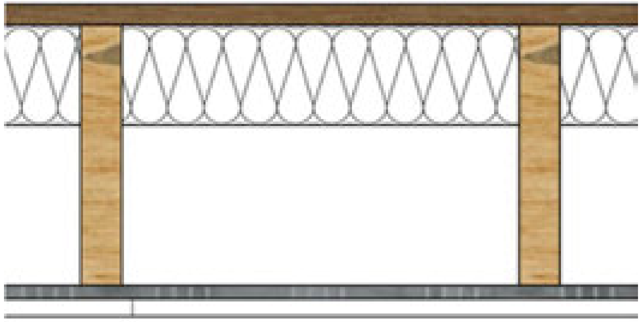
STC 43
IIC 37

TLF-95-063a & IIF-95-019
NRC IRC-IR-766

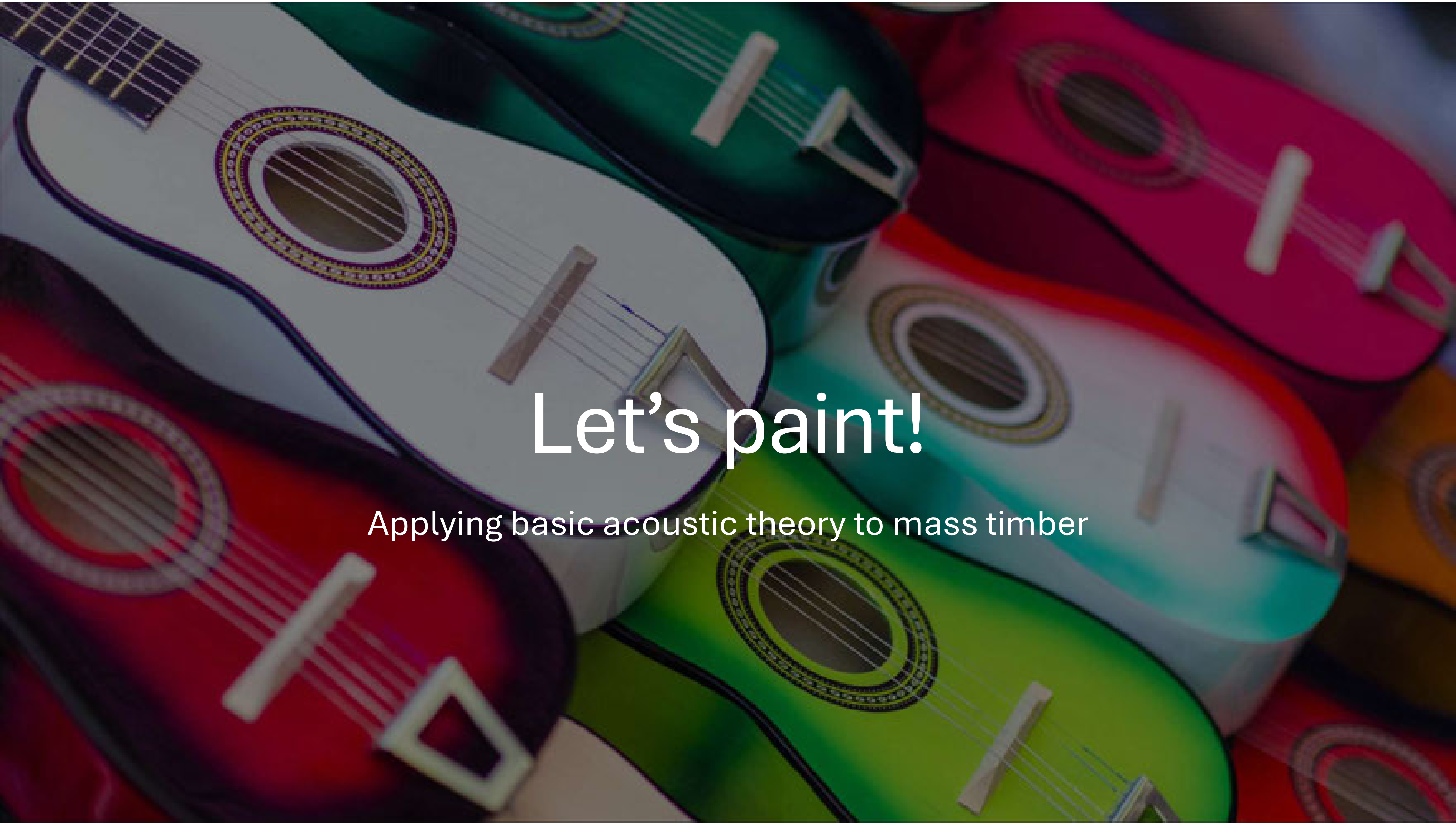
- ¾” Plywood Subfloor
- 2x10 Joists @ 16” o.c.
- RC-Deluxe @ 16” o.c.
- 5/8” Type X Drywall

STC 51
IIC 45

TLF-95-085a & IIF-95-030
NRC IRC-IR-766



- ¾” Plywood Subfloor
- 2x10 Joists @ 16” o.c.
- 3-1/2” Fiberglass Batt Insulation
- RC-Deluxe @ 16” o.c.
- 5/8” Type X Drywall



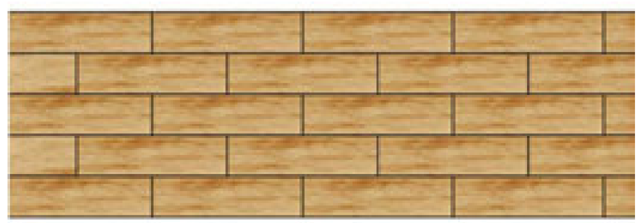
Let’s paint!

Applying basic acoustic theory to mass timber

Mass

STC 43
IIC 26

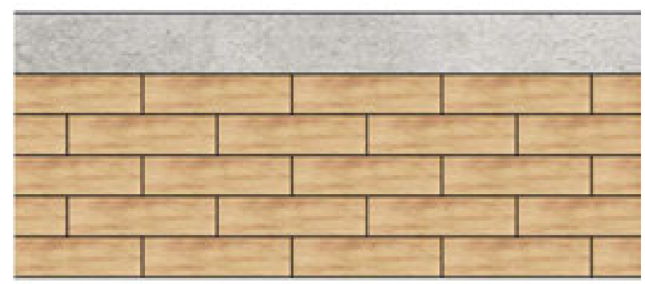
UO ESBL Research Report



- 5-ply CLT

STC 49
IIC 22

UO ESBL Research Report



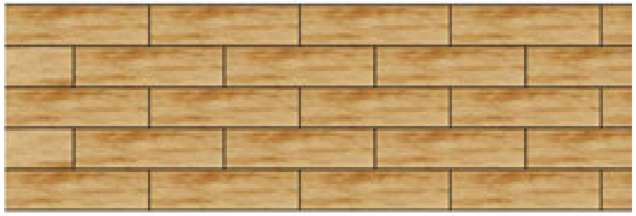
- 2-1/4” Concrete Slab
- 5-ply CLT

Mass

- Pros
  - Increased mass for acoustical performance
  - Increased strength for longer spans or decreased timber quantity
- Cons
  - Increased structural load -> possible cost increases
  - Increased embodied carbon
  - Increased construction time for concrete forming and curing

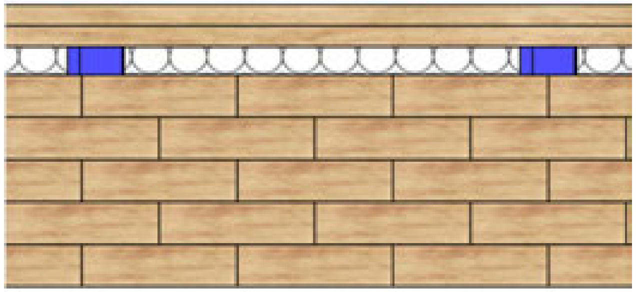
Isolation (Floor Side)

STC 42
IIC 28
PAC R5915.01



- 5-ply CLT

STC 61
IIC 57
PAC R5915.02



- 2x ¾” Plywood
- 1”x2”x2” Foam Isolators @ 24”x24” o.c.
- 5-ply CLT

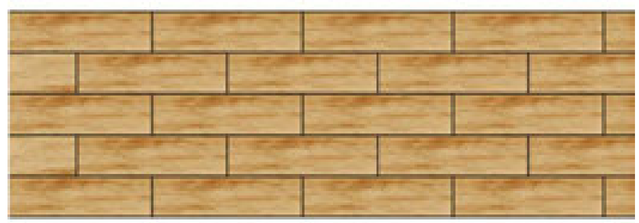
Isolation
(Floor Side)

- Pros
  - Relatively small increase in assembly thickness
  - Leaves the wood ceiling exposed
  - Many options with quality acoustical test data
  - Stops impact noise at the source (more later when we discuss flanking)
- Cons
  - Doesn't necessarily address the ceiling flanking path (more later when we discuss flanking)

Isolation
(Ceiling Side)

STC 41
IIC 25

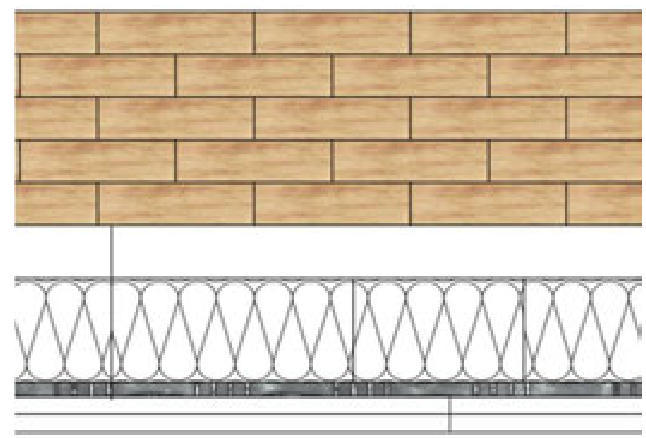
TLF-12-039 & IIF-12-026
NRC CR A1-100035.02



- 5-ply CLT

STC 68
IIC 54

TLF-13-016 & IIF-13-014
NRC CR A1-100035.02



- 5-ply CLT
- 8” Airspace w/8-ga Wires @48” o.c.
- 5-1/2” Fiberglass Batt Insulation
- 1-1/2” CRC @ ~ 48” o.c.
- 25ga Hat Channel @24” o.c.
- 2x ½” Type X Gypsum Board

Isolation
(Ceiling Side)

- Pros
  - Relatively lightweight compared to concrete toppings
  - Achieves good acoustical performance
  - Provides a place to hide MEP items
  - Uses standard and relatively inexpensive construction materials
- Cons
  - Covers up all that pretty wood!
  - Decreases ceiling heights/increases assembly thickness
  - Concealed airspace complicates fire ratings

Stiffness

Difficult to isolate in testing

Stiffness

- Pros
  - Creative design can increase stiffness without adding material
  - Other knock-on effects
    - Better floor vibration response
    - Increased isolation efficiency
- Cons
  - Difficult to design and predict for acoustical performance
  - Must be done early in the design phase

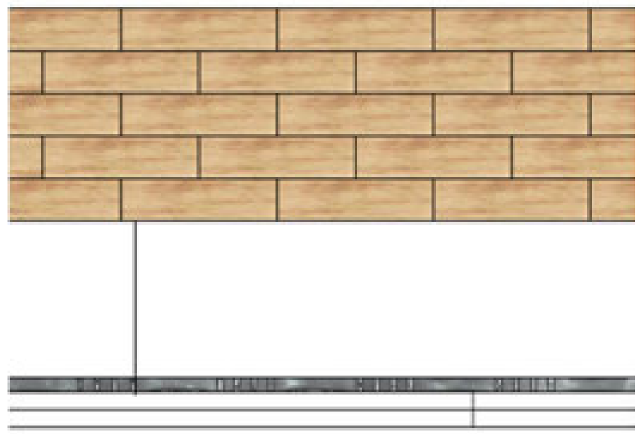
Damping

R&D opportunity

Damping

- Pros
  - Can help address flanking transmission if used correctly
- Cons
  - Typical damping-specific materials are too thin and too lightweight to be effective on large mass timber panels
  - Very little test data to substantiate performance and inform design

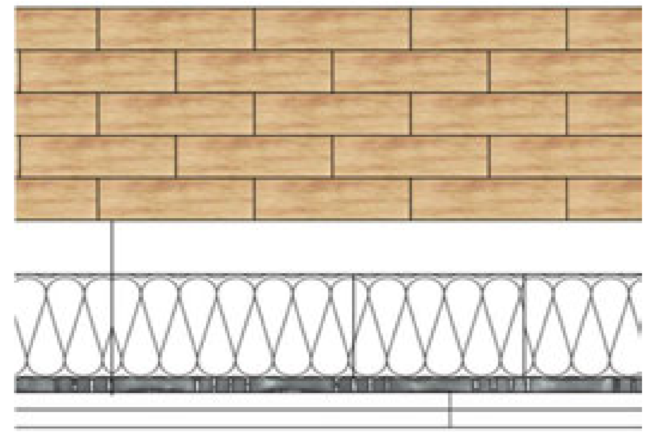
Insulation



STC ?

IIC ?

Not yet tested



STC 68

IIC 54

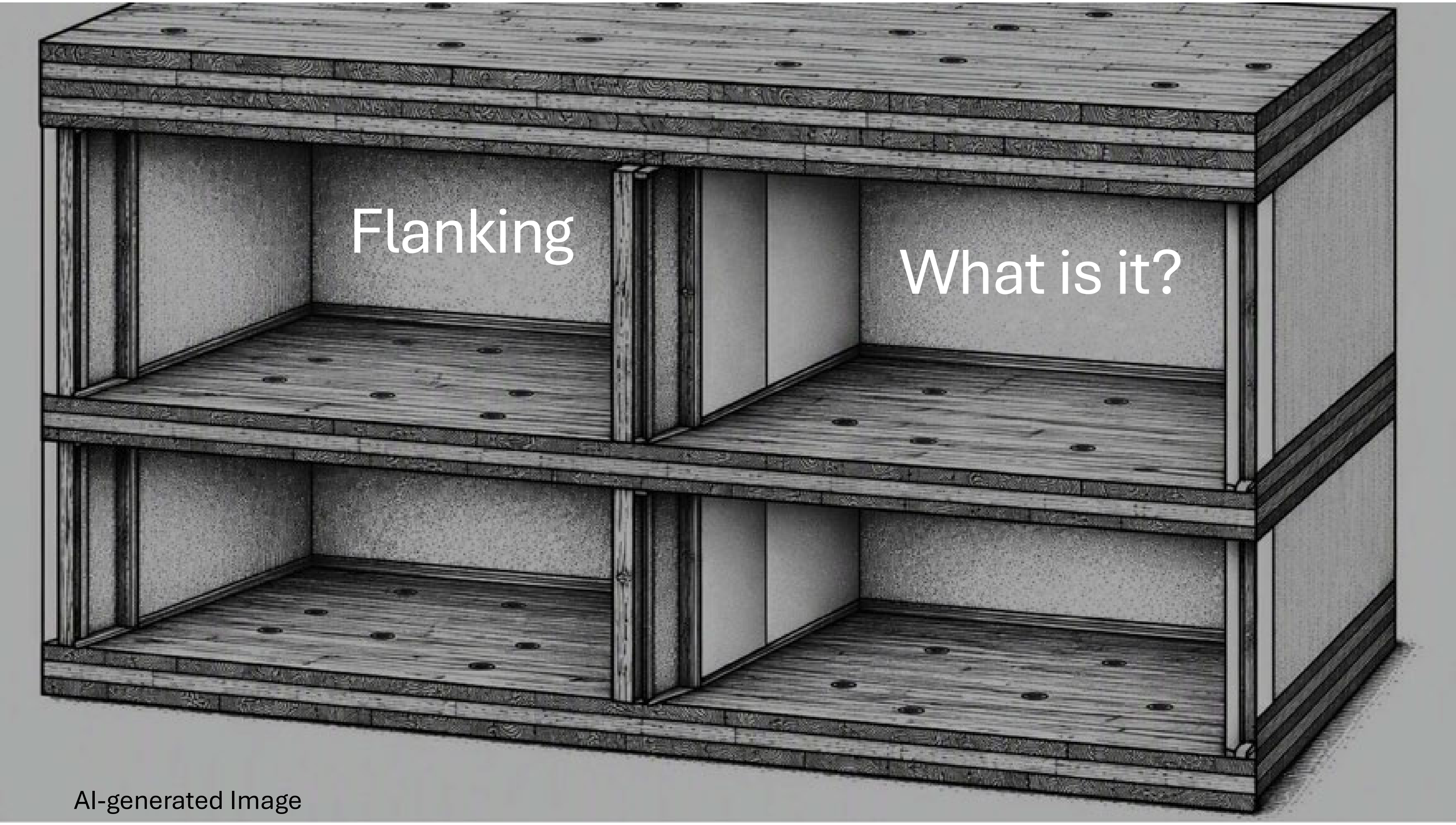
TLF-13-016 & IIF-13-014

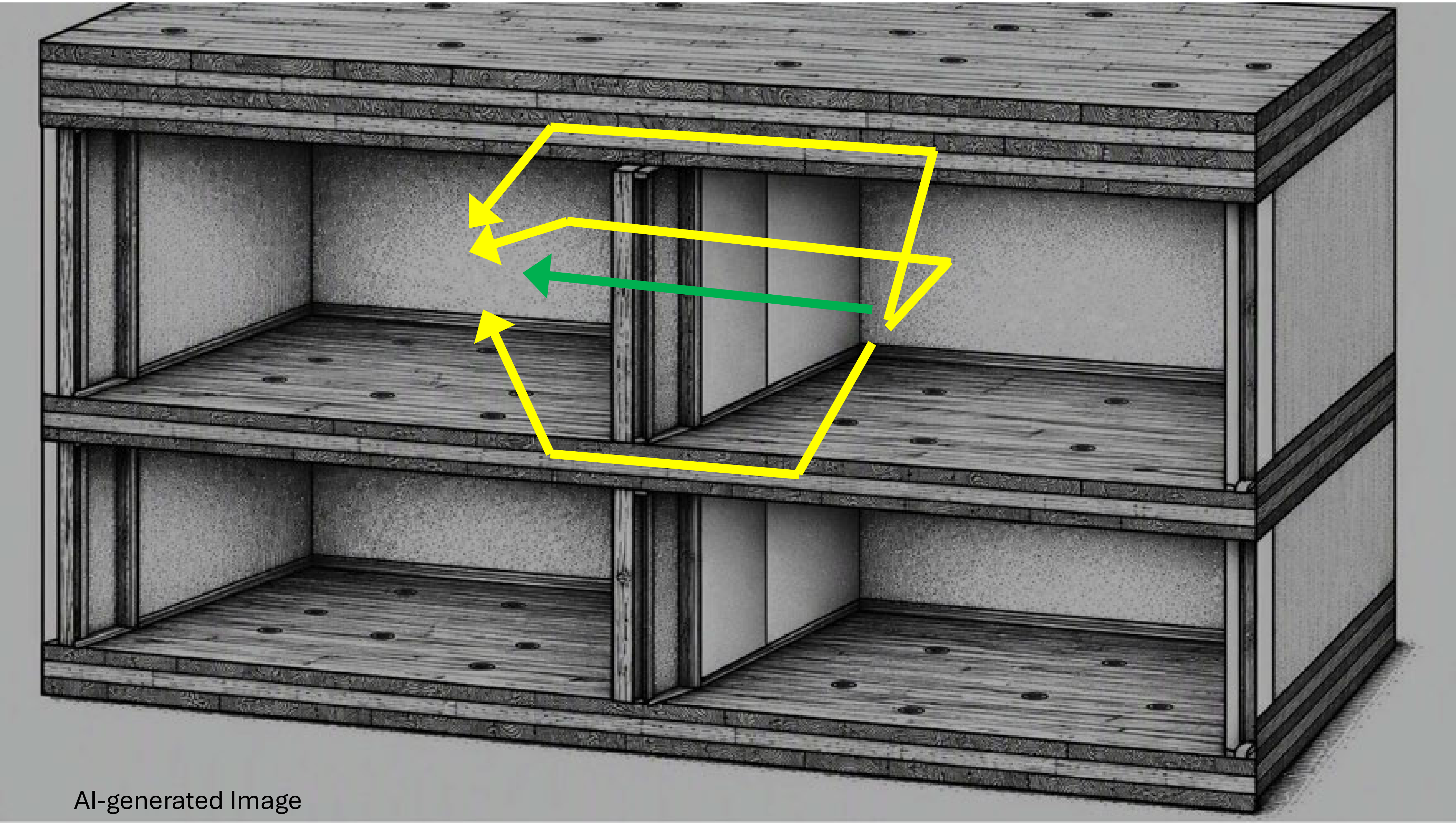
NRC CR A1-100035.02

Insulation

- Pros
  - Inexpensive and common building material with potential big acoustical gains
  - Wide variety of options from typical fiberglass batt to newer wood-wool and other more sustainable options
- Cons
  - Only works in combination with isolated assemblies like floors or ceilings

Mass-Timber-Specific Challenges


Flanking
What is it?
AI-generated Image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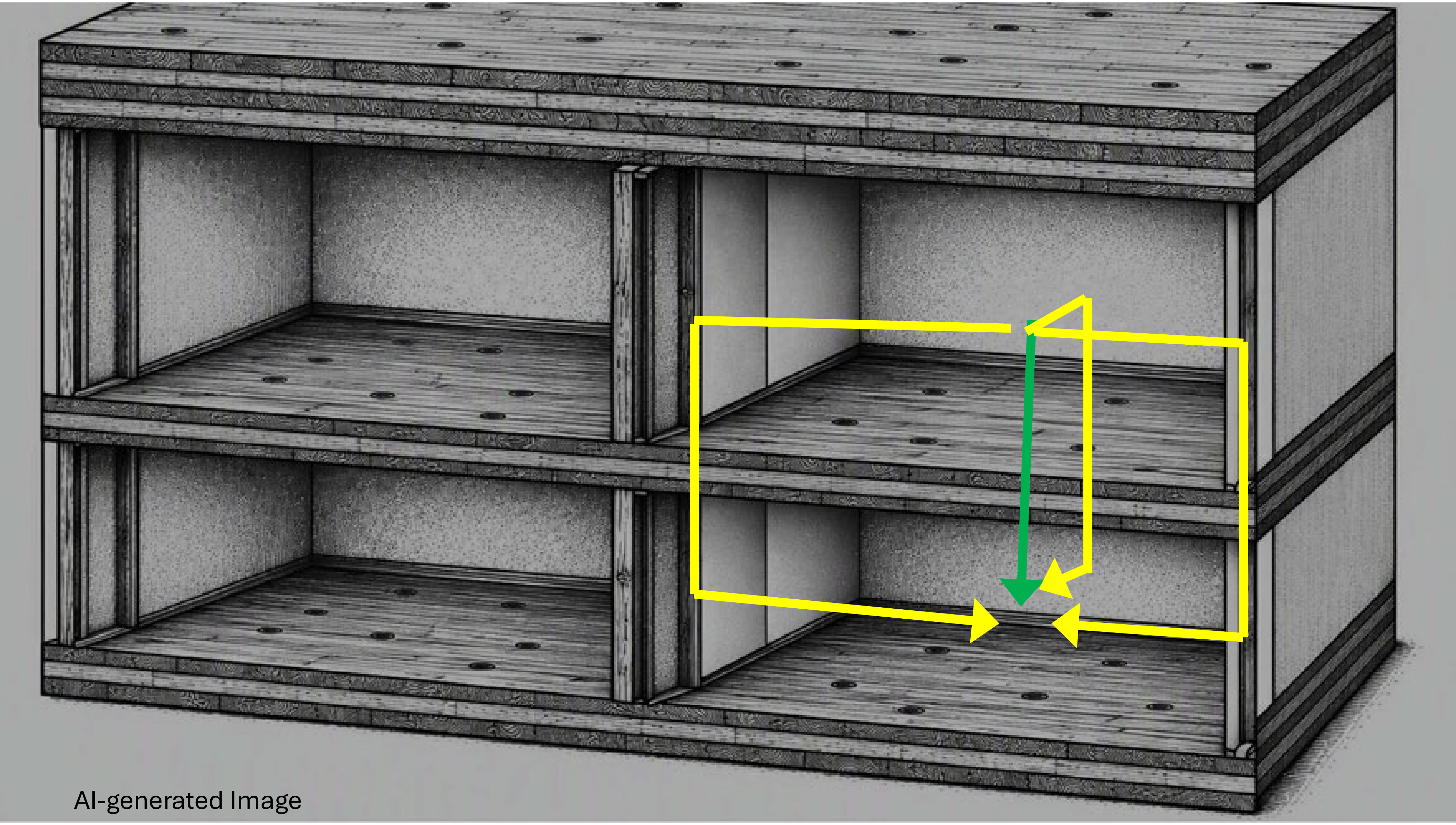
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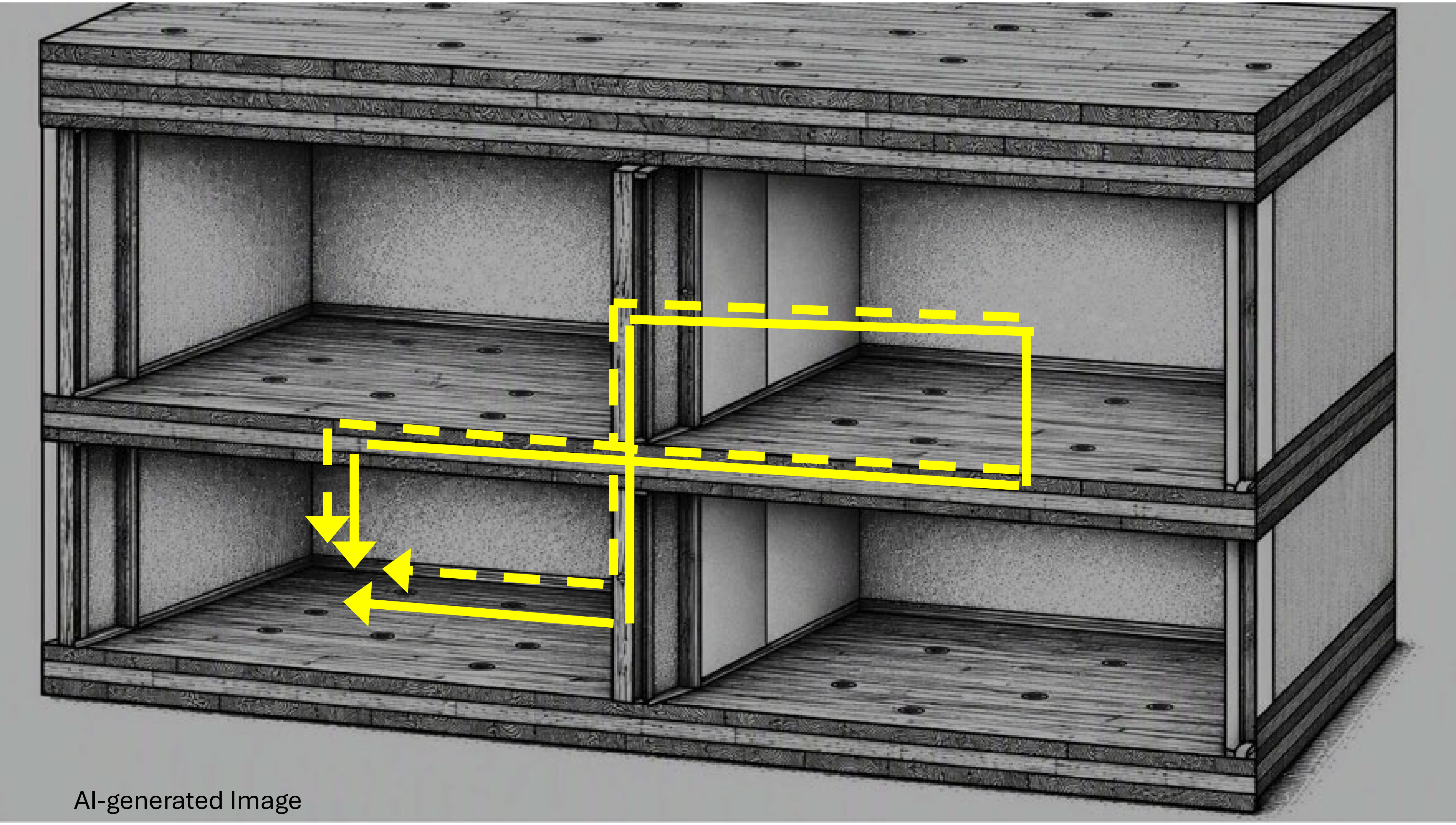
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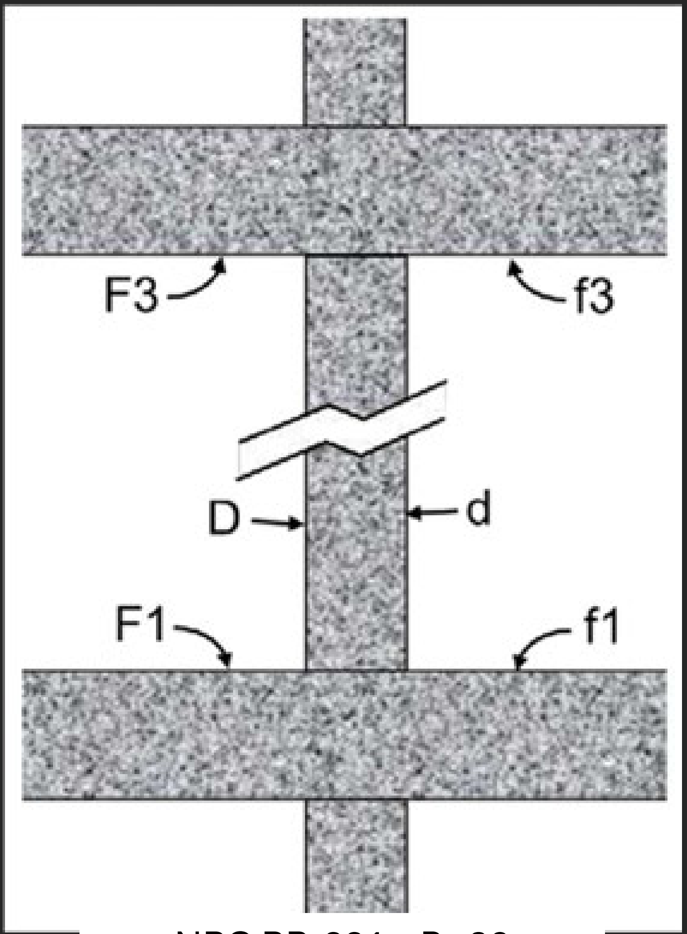
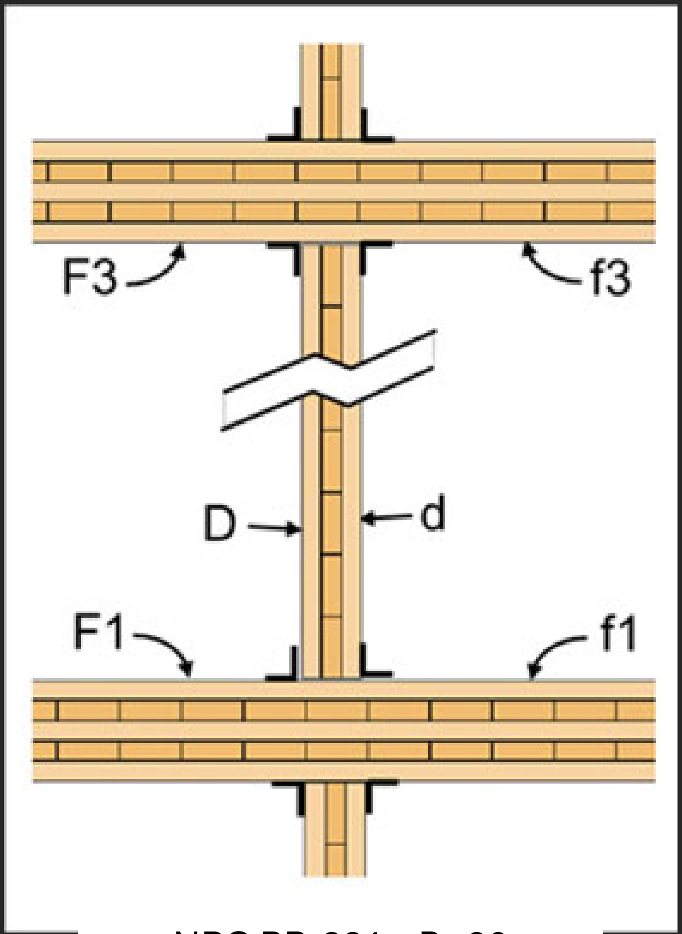
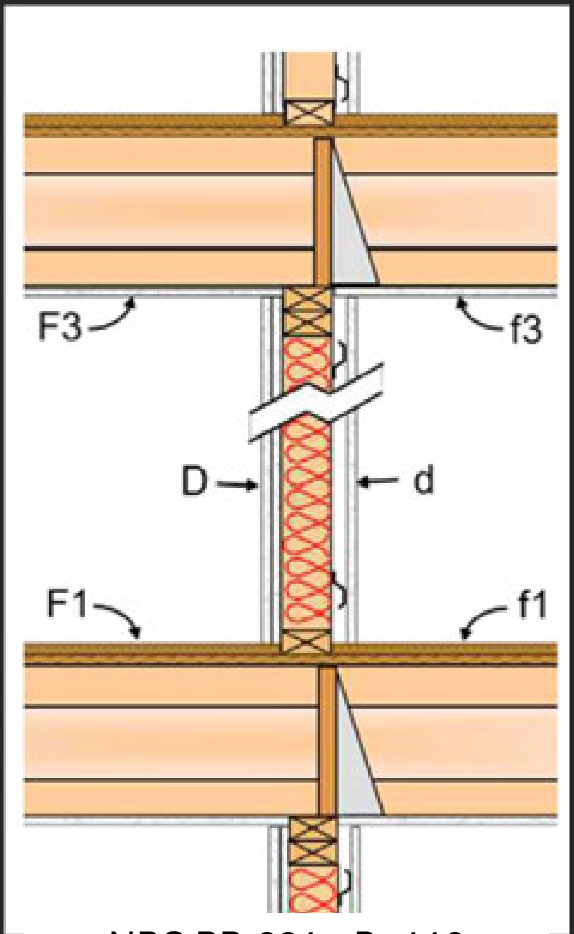
Flanking – Is mass timber different?



NRC RR-331 – Pg 28

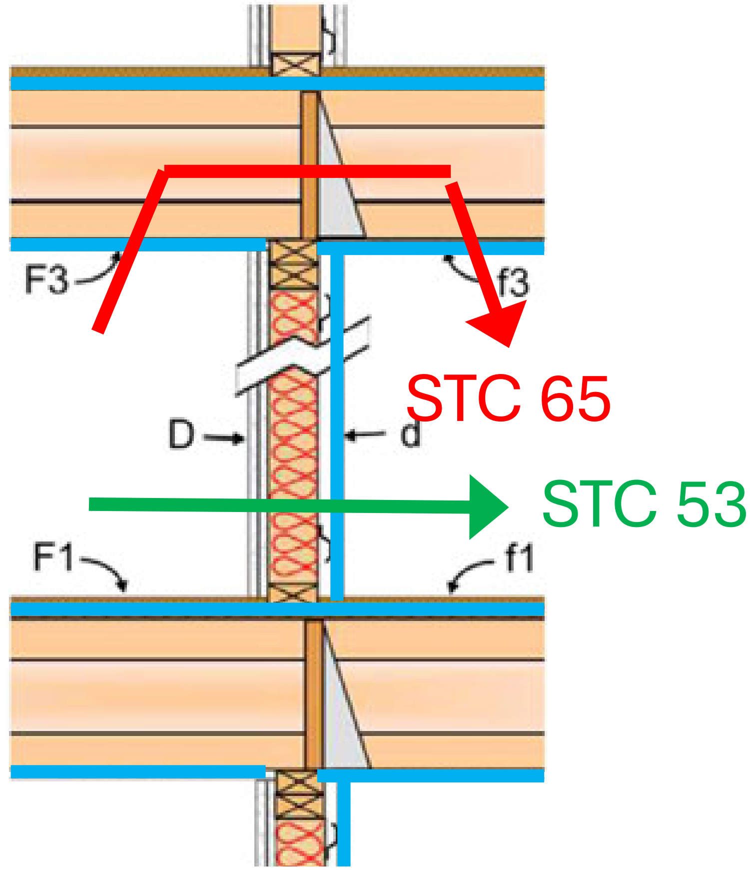


NRC RR-331 – Pg 80



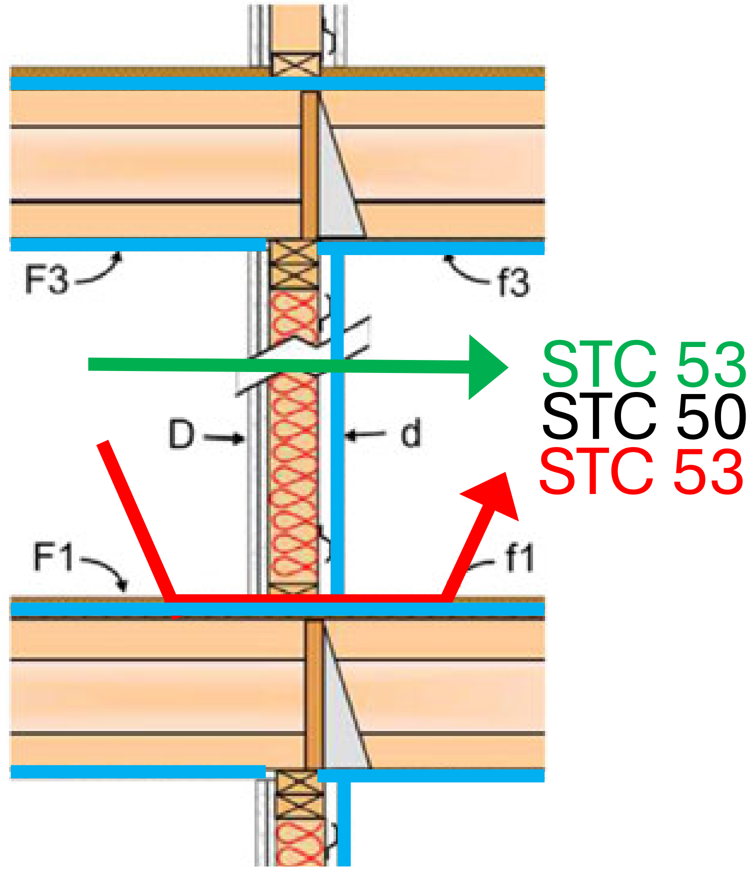
NRC RR-331 – Pg 116

Stick Framed



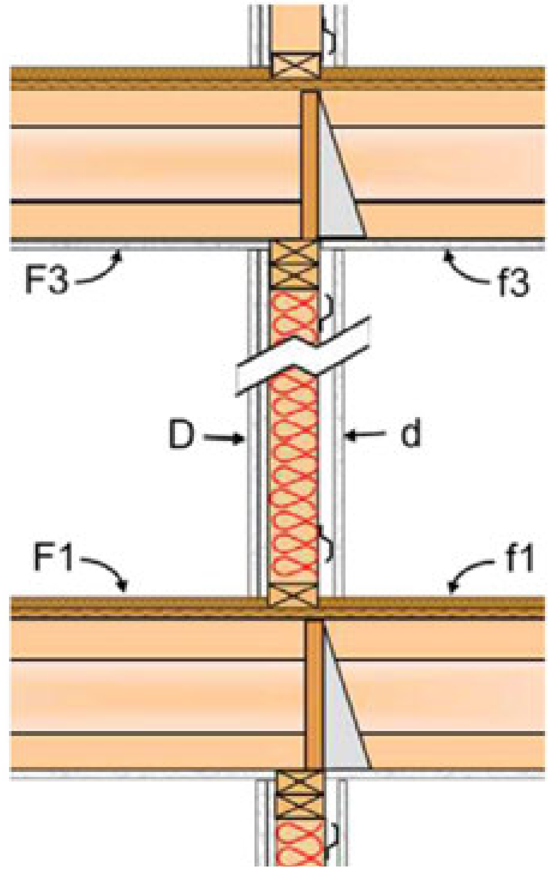
NRC RR-331 – Pg 116

Stick Framed



NRC RR-331 – Pg 116

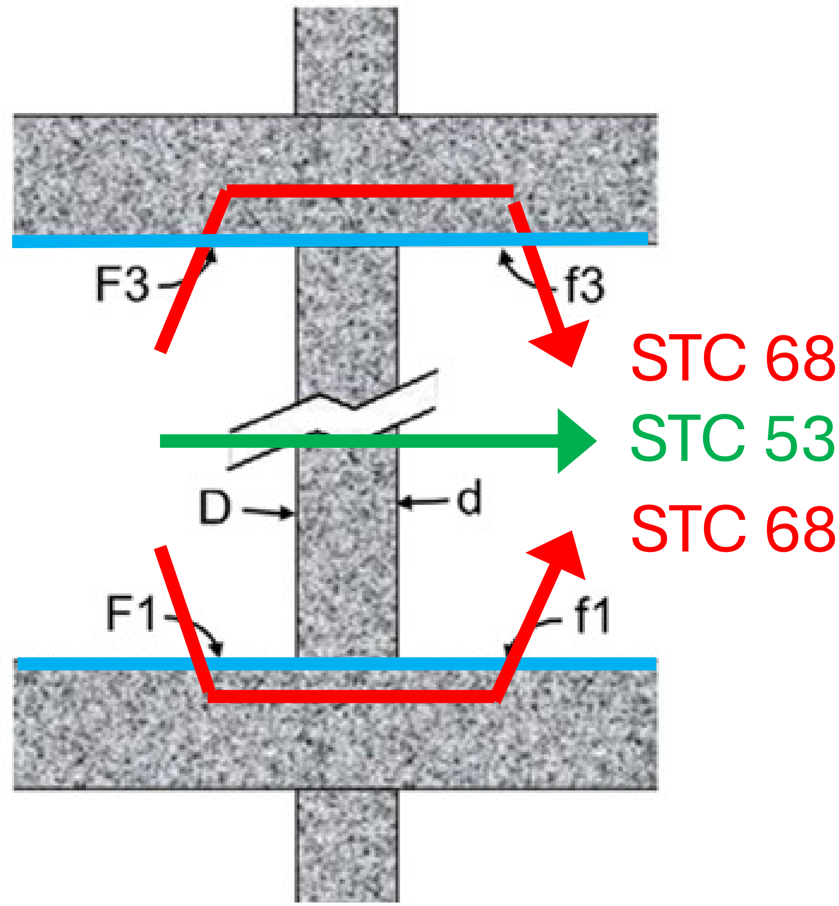
Stick Framed



NRC RR-331 – Pg 116

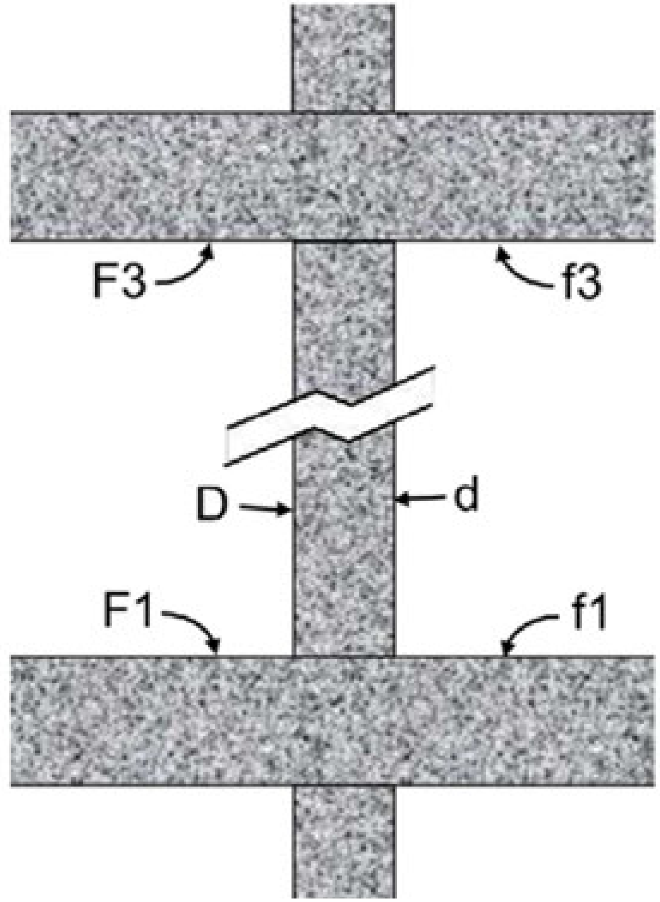
All Paths:
ASTC 48

Concrete



NRC RR-331 – Pg 28

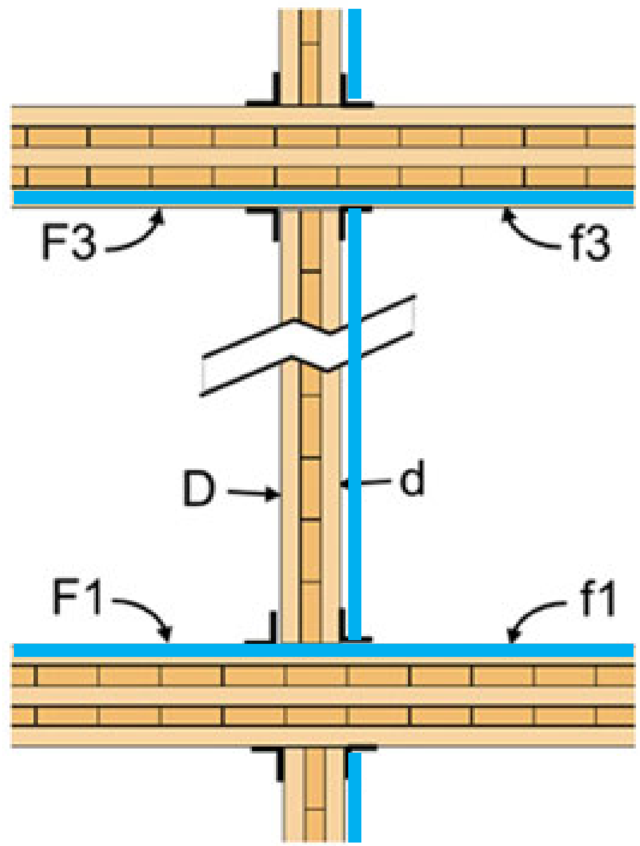
Concrete



NRC RR-331 – Pg 28

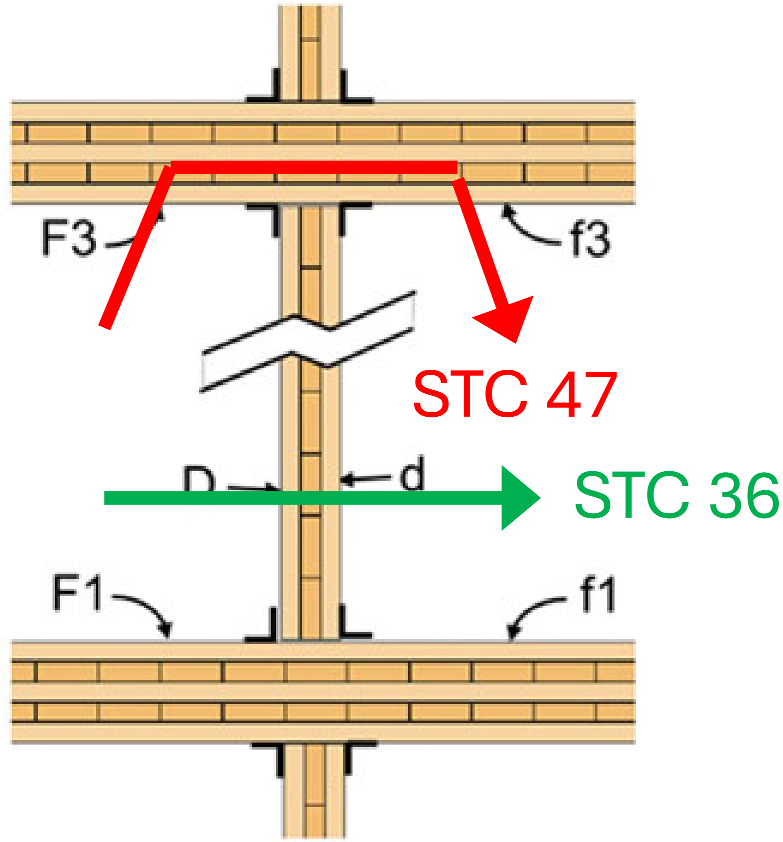
All Paths:
ASTC 53

Mass Timber



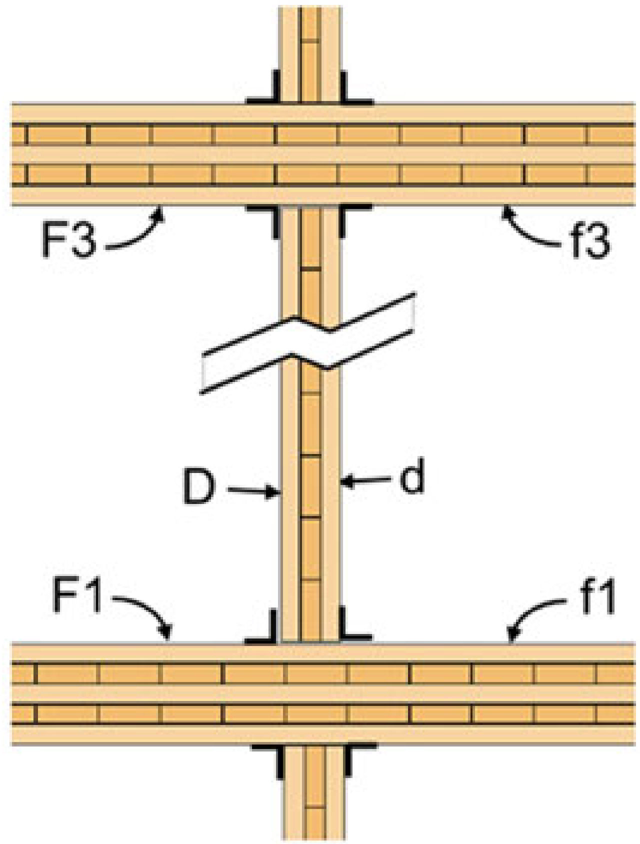
NRC RR-331 – Pg 80

Mass Timber



NRC RR-331 – Pg 80

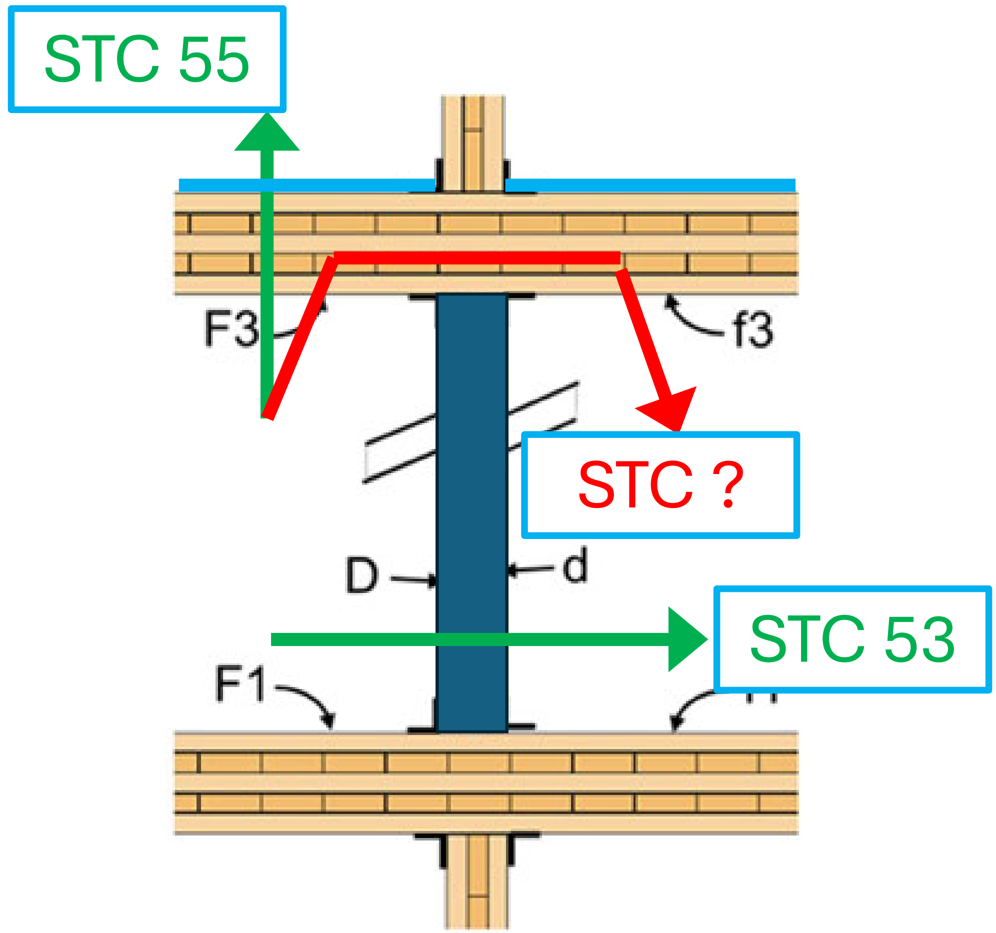
Mass Timber



NRC RR-331 – Pg 80

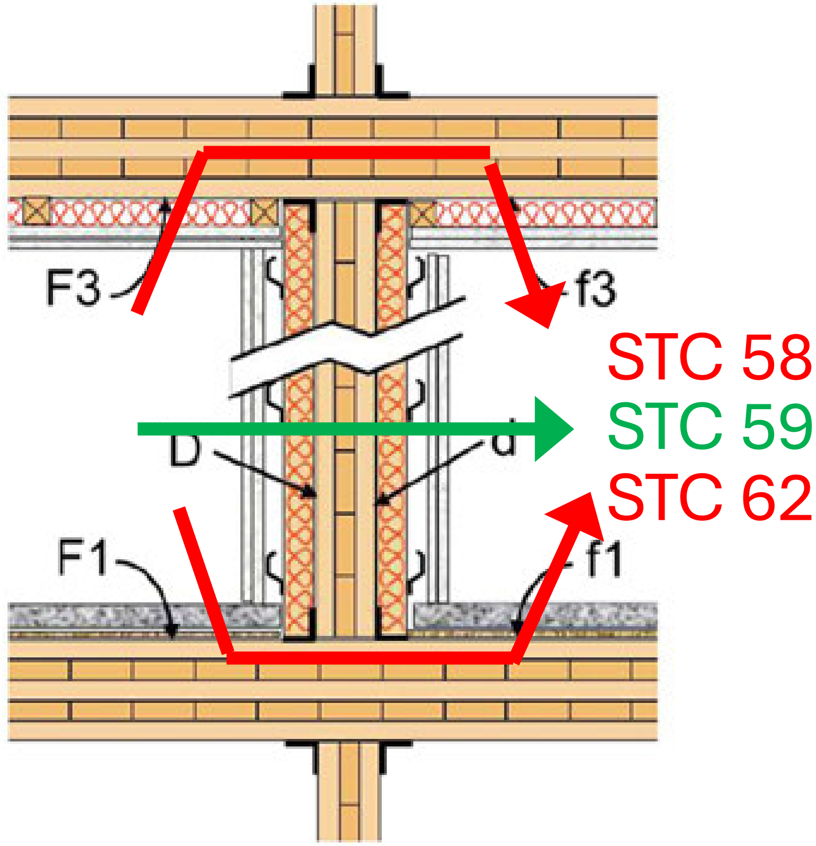
All Paths:
ASTC 32

Mass Timber



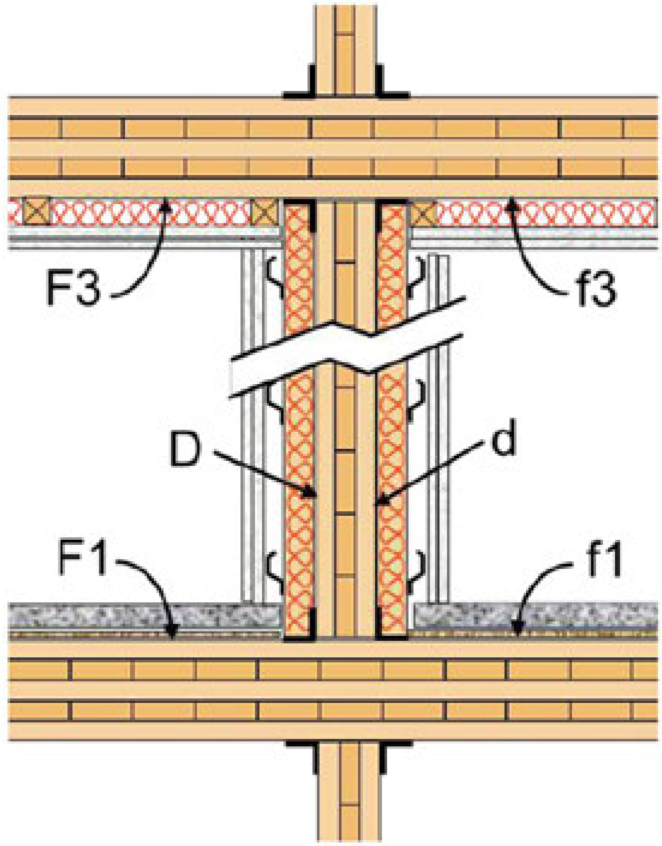
NRC RR-331 – Pg 80

Mass Timber



NRC RR-331 – Pg 84

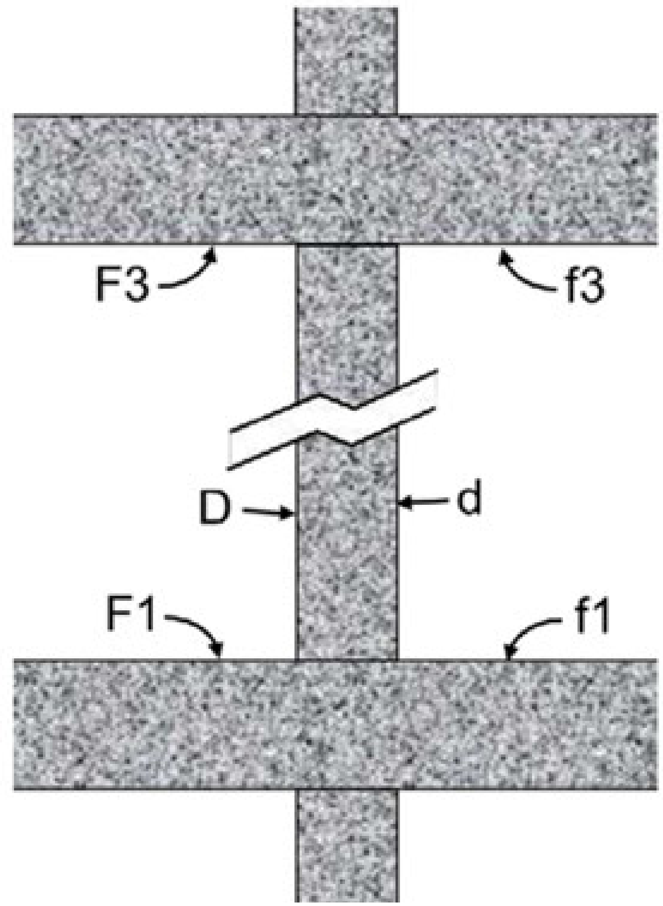
Mass Timber



NRC RR-331 – Pg 84

All Paths:
ASTC 52

Concrete

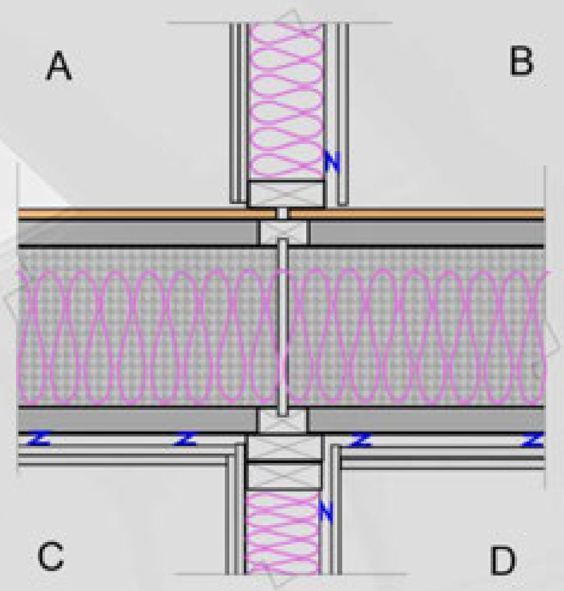


NRC RR-331 – Pg 28

All Paths:
ASTC 53

Flanking – Stick Framed

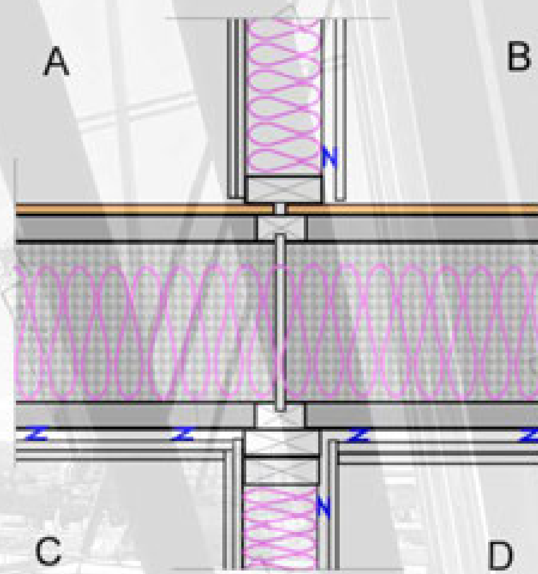
Case 6X: Load Bearing Single Stud Wall
Continuous Wood-I Joists
Subfloor Discontinuous but Supported



Apparent airborne sound insulation	Room Pairs	6X	Reference to 6X	Change due to saw cut
		(Apparent-STC)		
Horizontal	A-B	40	40	0
Horizontal	C-D	51	51	0
Vertical	B-D	56	55	+1
Vertical	A-C	55	55	0
Diagonal	A-D	64	64	0
Diagonal	B-C	59	57	+2

Flanking – Stick Framed

**Case 6X: Load Bearing Single Stud Wall
Continuous Wood-I Joists
Subfloor Discontinuous but Supported**



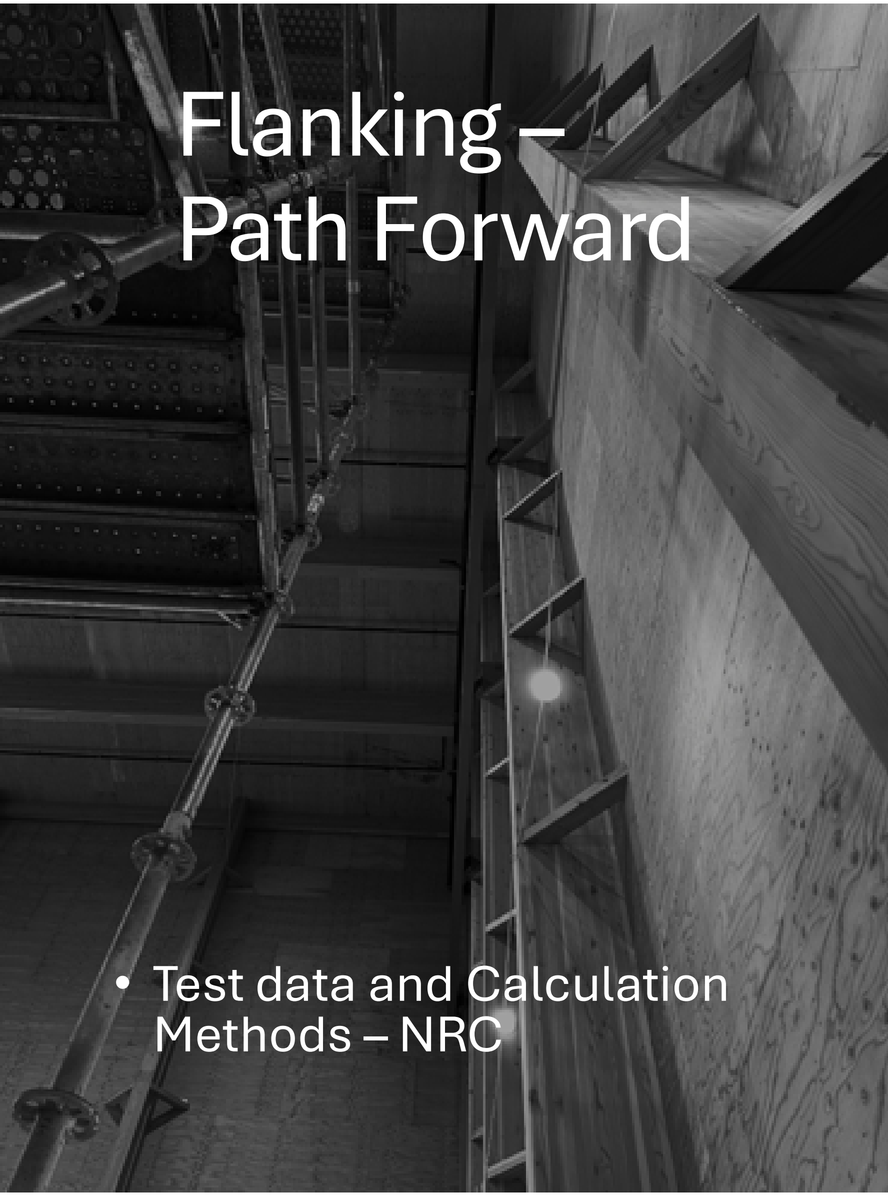
Apparent impact sound insulation

	Room Pairs	6X	Reference to 6X	Change due to saw cut
		(Apparent-IIC)		
Horizontal	A-B	42	41	+1
Horizontal	B-A	42	41	+1
Vertical	B-D	51	51	0
Vertical	A-C	51	50	+1
Diagonal	A-D	61	62	-1
Diagonal	B-C	58	55	+3

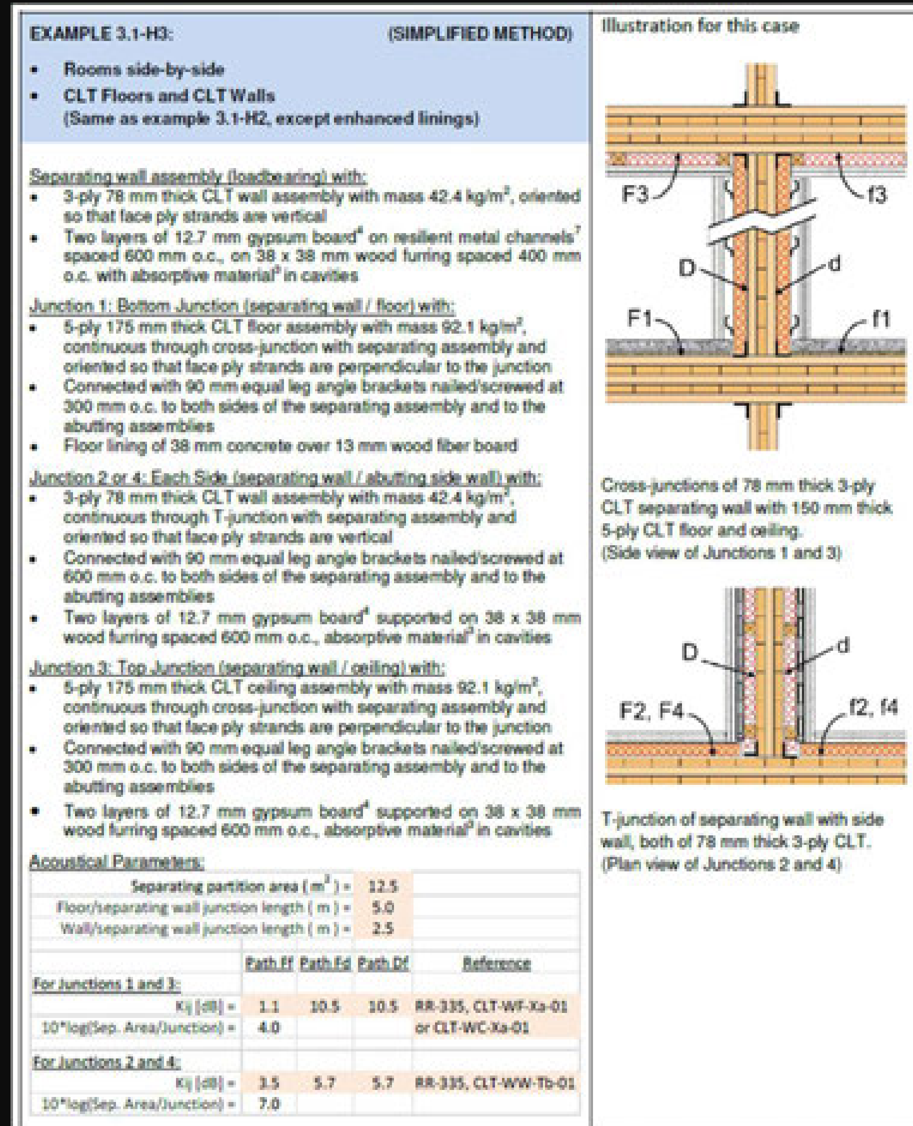
Flanking – Path Forward

- Test data and Calculation Methods – NRC
  - RR-331 – Guide to calculating airborne sound transmission in buildings
  - RR-333 – Apparent sound insulation in precast concrete buildings
  - RR-334 – Apparent sound insulation in concrete block buildings
  - RR-335 – Apparent sound insulation in mass timber buildings
  - RR-336 – Apparent sound insulation in wood framed buildings
  - RR-337 – Apparent sound insulation in cold formed steel framed buildings

Flanking – Path Forward



- Test data and Calculation Methods – NRC



EXAMPLE 3.1-H3: **(SIMPLIFIED METHOD)**

- **Rooms side-by-side**
- **CLT Floors and CLT Walls**
  (Same as example 3.1-H2, except enhanced linings)

Separating wall assembly (loadbearing) with:
- 3-ply 78 mm thick CLT wall assembly with mass 42.4 kg/m[2], oriented so that face ply strands are vertical
- Two layers of 12.7 mm gypsum board[4] on resilient metal channels[7] spaced 600 mm o.c., on 38 x 38 mm wood furring spaced 400 mm o.c. with absorptive material[3] in cavities

Junction 1: Bottom Junction (separating wall / floor) with:
- 5-ply 175 mm thick CLT floor assembly with mass 92.1 kg/m[2], continuous through cross-junction with separating assembly and oriented so that face ply strands are perpendicular to the junction
- Connected with 90 mm equal leg angle brackets nailed/screwed at 300 mm o.c. to both sides of the separating assembly and to the abutting assemblies
- Floor lining of 38 mm concrete over 13 mm wood fiber board

Junction 2 or 4: Each Side (separating wall / abutting side wall) with:
- 3-ply 78 mm thick CLT wall assembly with mass 42.4 kg/m[2], continuous through T-junction with separating assembly and oriented so that face ply strands are vertical
- Connected with 90 mm equal leg angle brackets nailed/screwed at 600 mm o.c. to both sides of the separating assembly and to the abutting assemblies
- Two layers of 12.7 mm gypsum board[4] supported on 38 x 38 mm wood furring spaced 600 mm o.c., absorptive material[3] in cavities

Junction 3: Top Junction (separating wall / ceiling) with:
- 5-ply 175 mm thick CLT ceiling assembly with mass 92.1 kg/m[2], continuous through cross-junction with separating assembly and oriented so that face ply strands are perpendicular to the junction
- Connected with 90 mm equal leg angle brackets nailed/screwed at 300 mm o.c. to both sides of the separating assembly and to the abutting assemblies
- Two layers of 12.7 mm gypsum board[4] supported on 38 x 38 mm wood furring spaced 600 mm o.c., absorptive material[3] in cavities

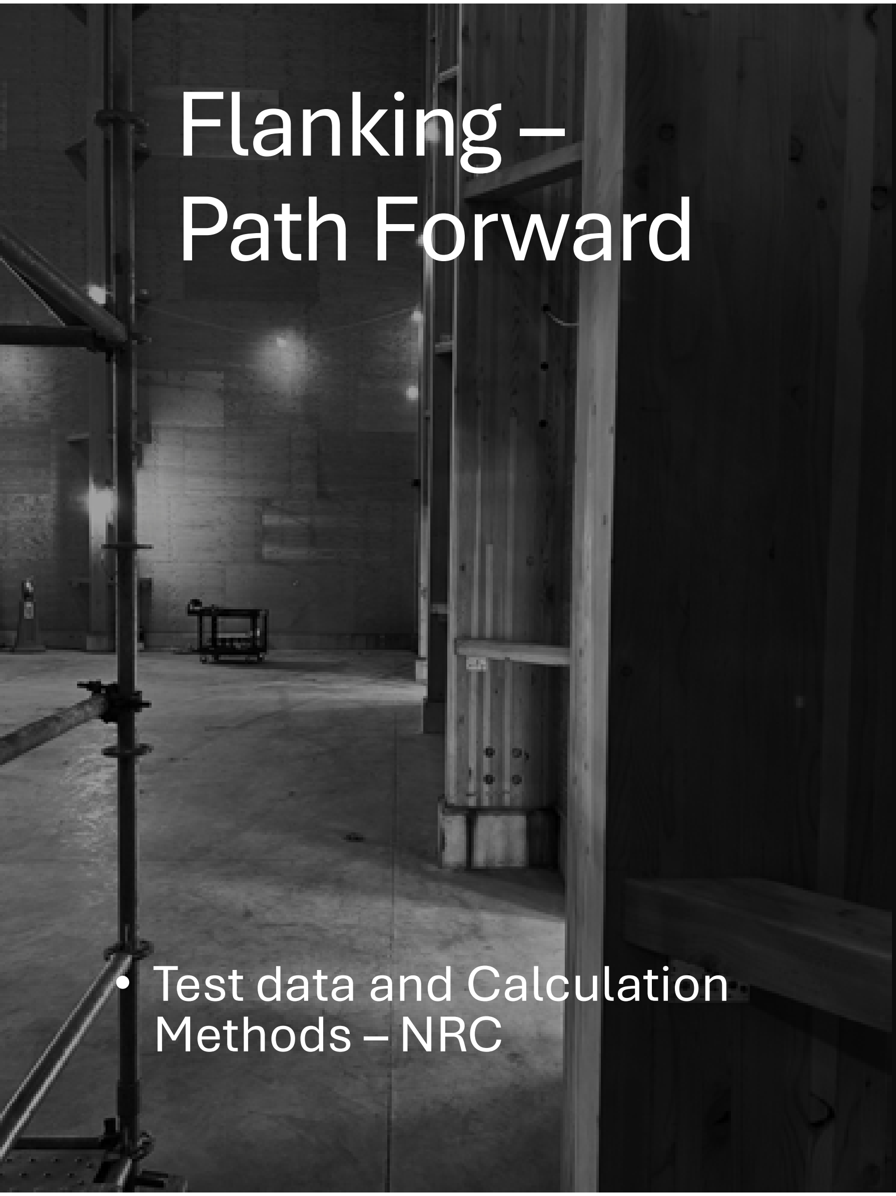
Acoustical Parameters:

Separating partition area (m^2) =			12.5	
Floor/separating wall junction length (m) =			5.0	
Wall/separating wall junction length (m) =			2.5	
	Path Ff	Path Fd	Path Df	Reference
For Junctions 1 and 3:				
Kij [dB] =	1.1	10.5	10.5	RR-335, CLT-WF-Xa-01
10*log(Sep. Area/Junction) =	4.0			or CLT-WC-Xa-01
For Junctions 2 and 4:				
Kij [dB] =	3.5	5.7	5.7	RR-335, CLT-WW-Tb-01
10*log(Sep. Area/Junction) =	7.0			

Illustration for this case

Cross-junctions of 78 mm thick 3-ply CLT separating wall with 150 mm thick 5-ply CLT floor and ceiling.
(Side view of Junctions 1 and 3)

T-junction of separating wall with side wall, both of 78 mm thick 3-ply CLT.
(Plan view of Junctions 2 and 4)



Flanking – Path Forward

- Test data and Calculation Methods – NRC

	ISO Symbol	Reference	STC or ΔSTC	STC or ASTC
Separating Partition (78 mm 3-ply CLT)				
Laboratory STC for Dd	R_s,w	RR-335, Base CLT03	36	
ΔSTC change by Lining on D	ΔR_D,w	RR-335, ΔTL-CLT-W04	15	
ΔSTC change by Lining on d	ΔR_d,w	RR-335, ΔTL-CLT-W04	15	
If airborne flanking or bare CLT		RR-335, STC(Bare CLT03) - STC(Base CLT03)	N/A	
Direct STC in-situ	R_Dd,w	RR-335, Eq. 4.1.2	36 + MAX(15,15) + MIN(15,15)/2 =	**59**
Junction 1 (Cross-Junction, 78 mm 3-ply CLT Separating Wall / 175 mm 5-ply CLT Floor)				
Flanking Element F1:				
Laboratory STC for F1	R_F1,w	RR-335, Base CLT05-Mean	42	
ΔSTC change by Lining on F1	ΔR_F1,w	RR-335, ΔTL-CLT-F03	10	
Flanking Element f1:				
Laboratory STC for f1	R_f1,w	RR-335, Base CLT05-Mean	42	
ΔSTC change by Lining on f1	ΔR_f1,w	RR-335, ΔTL-CLT-F03	10	
Flanking STC for path Ff_1	R_Ff,w	RR-335, Eq. 4.1.3	42/2 + 42/2 + MAX(10,10) + MIN(10,10)/2 + 1.1 + 4 =	**62**
Flanking STC for path Fd_1	R_Fd,w	RR-335, Eq. 4.1.3	42/2 + 36/2 + MAX(10,15) + MIN(10,15)/2 + 10.5 + 4 =	**74**
Flanking STC for path Df_1	R_Df,w	RR-335, Eq. 4.1.3	36/2 + 42/2 +MAX(15,10) + MIN(15,10)/2 + 10.5 + 4 =	**74**
Junction 1: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-6.2 + 10^- 7.4 + 10^- 7.4) =	61
Junction 2 (T-Junction, 78 mm 3-ply CLT Separating Wall / 78 mm 3-ply CLT Flanking Wall)				
Flanking Element F2:				
Laboratory STC for F2	R_F2,w	RR-335, Base CLT03	36	
ΔSTC change by Lining on F2	ΔR_F2,w	RR-335, ΔTL-CLT03-W03	9	
Flanking Element f2:				
Laboratory STC for f2	R_f2,w	RR-335, Base CLT03	36	
ΔSTC change by Lining on f2	ΔR_f2,w	RR-335, ΔTL-CLT03-W03	9	
Flanking STC for path Ff_2	R_Ff,w	RR-335, Eq. 4.1.3	36/2 + 36/2 + MAX(9,9) + MIN(9,9)/2 + 3.5 + 7 =	**60**
Flanking STC for path Fd_2	R_Fd,w	RR-335, Eq. 4.1.3	36/2 + 36/2 + MAX(9,15) + MIN(9,15)/2 + 5.7 + 7 =	**68**
Flanking STC for path Df_2	R_Df,w	RR-335, Eq. 4.1.3	36/2 + 36/2 +MAX(15,9) + MIN(15,9)/2 + 5.7 + 7 =	**68**
Junction 2: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-6 + 10^- 6.8 + 10^- 6.8) =	59
Junction 3 (Cross-Junction, 78 mm 3-ply CLT Separating Wall / 175 mm 5-ply CLT Ceiling)				
Flanking Element F3:				
Laboratory STC for F3	R_F3,w	RR-335, Base CLT05-Mean	42	
ΔSTC change by Lining on F3	ΔR_F3,w	RR-335, ΔTL-CLT-C01	7	
Flanking Element f3:				
Laboratory STC for f3	R_f3,w	RR-335, Base CLT05-Mean	42	
ΔSTC change by Lining on f3	ΔR_f3,w	RR-335, ΔTL-CLT-C01	7	
Flanking STC for path Ff_3	R_Ff,w	RR-335, Eq. 4.1.3	42/2 + 42/2 + MAX(7,7) + MIN(7,7)/2 + 1.1 + 4 =	**58**
Flanking STC for path Fd_3	R_Fd,w	RR-335, Eq. 4.1.3	42/2 + 36/2 + MAX(7,15) + MIN(7,15)/2 + 10.5 + 4 =	**72**
Flanking STC for path Df_3	R_Df,w	RR-335, Eq. 4.1.3	36/2 + 42/2 +MAX(15,7) + MIN(15,7)/2 + 10.5 + 4 =	**72**
Junction 3: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-5.8 + 10^- 7.2 + 10^- 7.2) =	58
Junction 4 (T-Junction, 78 mm 3-ply CLT Separating Wall / 78 mm 3-ply CLT Flanking Wall)				
Flanking Element F4:				
Laboratory STC for F4	R_F4,w	RR-335, Base CLT03	36	
ΔSTC change by Lining on F4	ΔR_F4,w	RR-335, ΔTL-CLT03-W03	9	
Flanking Element f4:				
Laboratory STC for f4	R_f4,w	RR-335, Base CLT03	36	
ΔSTC change by Lining on f4	ΔR_f4,w	RR-335, ΔTL-CLT03-W03	9	
Flanking STC for path Ff_4	R_Ff,w	RR-335, Eq. 4.1.3	36/2 + 36/2 + MAX(9,9) + MIN(9,9)/2 + 3.5 + 7 =	**60**
Flanking STC for path Fd_4	R_Fd,w	RR-335, Eq. 4.1.3	36/2 + 36/2 + MAX(9,15) + MIN(9,15)/2 + 5.7 + 7 =	**68**
Flanking STC for path Df_4	R_Df,w	RR-335, Eq. 4.1.3	36/2 + 36/2 +MAX(15,9) + MIN(15,9)/2 + 5.7 + 7 =	**68**
Junction 4: Flanking STC for all paths		Subset of Eq. 4.1.1	- 10*LOG10(10^-6 + 10^- 6.8 + 10^- 6.8) =	59
Total Flanking STC (for all 4 junctions)		Subset of Eq. 4.1.1	Combining all 12 Flanking STC values:	53
ASTC due to Direct plus Flanking Paths		Eq. 4.1.1	**Combining Direct STC and 12 Flanking STC values:**	**52**

Mass Timber – Ongoing/Upcoming Research

- Timber Sounds field testing in existing buildings
- HGC’s flanking testing
- NRC’s flanking testing
- University of Oregon – Oregon Acoustic Research Laboratory (OARL)

Partnering in Mass Timber Field Acoustics Research:

Know of Mass Timber projects we can test? Know of Funding Partners? Let us know!

Timber Sounds Project

liniar studio
collaborative acoustic design | portland, or usa
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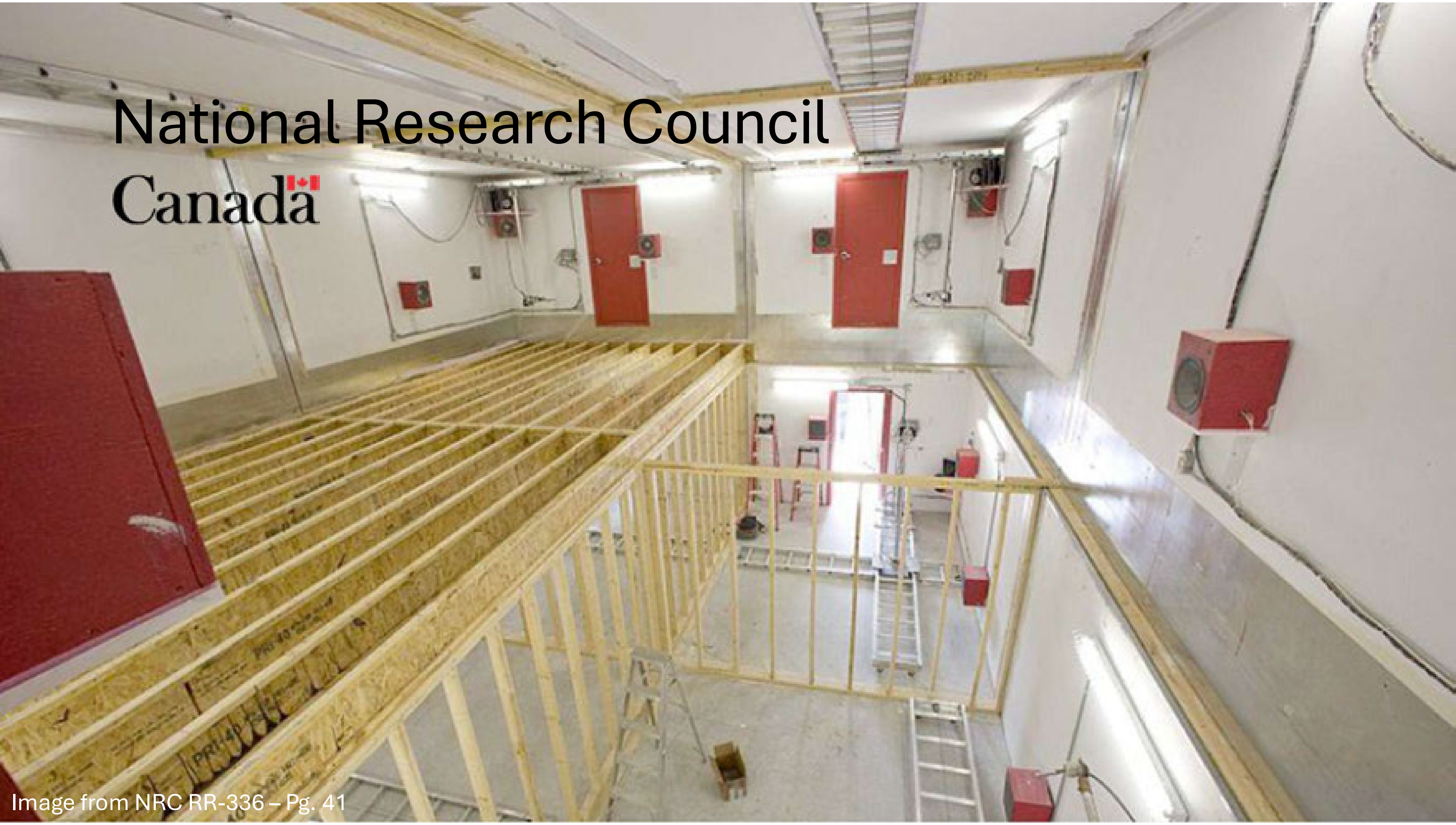
TimberSoundsProject.org

Image: https://acoustical-consultants.com/built-environment/mass-timber-clt/mass-timber-clt-acoustics-study-research/



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QUESTIONS?

This concludes The American Institute of Architects Continuing Education Systems Course

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