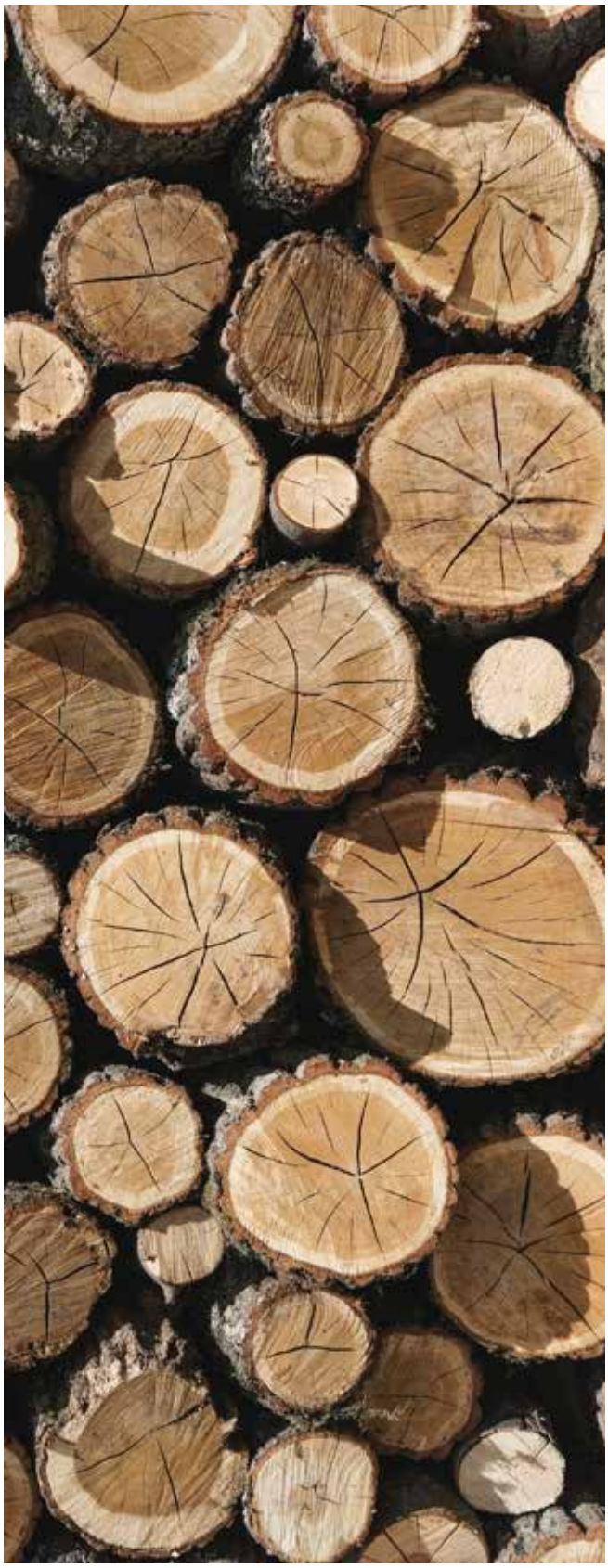

photo credit: rawpixel on unsplash.com

Acoustic Lab Testing (ASTM E492-2016, ASTM E90-2016) of Multi-Family Residential CLT and MPP Wall and Floor Assemblies

UNIVERSITY OF OREGON
Energy Studies in Buildings Laboratory

Acoustic Lab Testing (ASTM E492-2016, ASTM E90-2016) of Multi-Family Residential CLT and MPP Wall and Floor Assemblies

Prepared for:

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March, 2019

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1.0 INTRODUCTION

The use of mass timber panels is becoming a popular choice for construction due to concerns about climate change, resource sustainability, the need for construction efficiencies and the human biophilic affinity for wood. Developed about three decades ago in Austria, panelized mass timber products have been used in Europe for some time but are now gaining market traction across North America and represent an opportunity for designers, developers, engineers and contractors.

With this new design opportunity in North America comes jurisdictional code performance requirements that need to be demonstrated to building authorities in the United States. Among these are requirements for fire, seismic and acoustic testing. Acoustics standards in the United States are prescribed by various organizations, such as the International Code Council (ICC), Housing and Urban Development (HUD), American Nation Standards Institute (ANSI), American Society for Testing and Materials (ASTM) and Facility Guidelines Institute (FGI) and are codified by jurisdiction based on building typology.

In addition to code requirements, the economics of occupant satisfaction and well-being play a role in project development. Economic studies have shown that consumers value spaces with higher acoustic quality and display a willingness to pay for the relief from unwanted noise.[1] Furthermore, noise intrusion in places where people spend a majority of their time has been shown in a body of literature to effect cognitive function, disrupt sleep patterns, promote irritability, and provoke heart conditions.[2] Therefore, in order for a housing project to perform, it must not only meet code requirements but also market expectations for high quality, acoustically separated living spaces.

The acoustic performance of mass timber panels is measured by two metrics: STC (sound transmission class) and IIC (impact insulation class). STC, for example, is how well a wall assembly acoustically separates two spatial volumes. IIC is a measurement of how well a floor dampens the sound transmission of an impact between two adjacent spatial volumes, be that a dropped object or footstep. For multifamily housing, the International Code Council (ICC) prescribes a wall and floor assembly performance standard to meet or exceed a STC rating of 50 in a lab test (ASTM E 90)or 45 in field tests (ASTM E 336) and IIC rating of 50 in a lab test (ASTM E 492) or 45 in field tests (ASTM E 1007).[3]

Using industry standards such as ICC, HUD, ANSI, FGI as a starting point for designing a series of floor and wall assemblies we hope to find high performing cost-effective acoustic solutions for mass timber assemblies that can be readily adopted by design teams and jurisdictional authorities . In addition, this study aims to provide more third-party verified data on CLT + MPP acoustic performance and disseminate it into the public sphere.

1. Fahrländer, Stefan Sebastian; Gerfin, Michael; Lehner, Manuel (2015) : The influence of noise on net revenue and values of investment properties: Evidence from Switzerland, Discussion Papers, Universität Bern, Department of Economics, No. 15-02
2. Jarosińska, D., Héroux, M., Wilkhu, P., Creswick, J., Verbeek, J., Wothge, J., & Paunović, E. (2018). Development of the WHO Environmental Noise Guidelines for the European Region: An Introduction. *International Journal of Environmental Research and Public Health*, 15(4), .
3. International Code Council. (2010). *ICC G2-2010 Guideline for Acoustics.*

2.0 PROPOSED WALL AND FLOOR ASSEMBLIES

The following section illustrates the resulting CLT and MPP wall and floor assemblies that are proposed for acoustic testing based on market feedback. The wall and floor assemblies are optimized with careful consideration to the economics, aesthetics (desire for occupants to see mass timber in assembly construction), wellness (IAQ of material emissions), and acoustic viability that can be afforded by mass timber construction.

One grouping of floor assemblies is a structural composite and features a 2-1/4" concrete slab mechanically bonded to a 5-lam (6-7/8") CLT or 6" MPP base. The base assembly (F01) was developed by Oregon State University and SOM for use in regions of high seismic activity.[1] Due to the requirement for concrete to be bonded to wood, the dense concrete topping is not acoustically decoupled from the wood panel as is customarily the case. Therefore, lab testing data is needed to understand this structural composite's acoustic behavior.

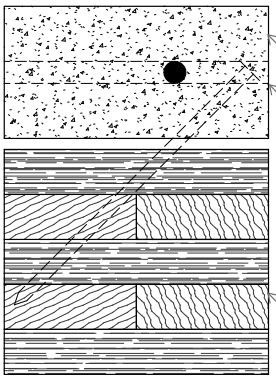
The second grouping of floor assemblies uses a construction sequence that does not require wet trades. To do this, three layers of cement board are bonded together for a 1-1/2" topping in place of a poured concrete topping. This floor assembly was developed from feedback that design teams wanted to increase construction speed by eliminating the need for concrete to be poured, formed, and cured. The use of a dry mineral aggregate, such as sand or gravel, was investigated as an option since this is used in Europe; however, an additional consideration from contractors is that they preferred a material that crews were already familiar using, such as cement board.

Currently, many mass timber buildings constructed or under construction are employing framed exterior walls. However, the potential for cost savings from using mass timber panels in shaft walls or as pre-manufactured off-site assemblies exists; therefore, influenced the final selections for testing. The wall assemblies utilize a prototypical exterior rainscreen assembly while maintaining the aesthetics of a natural CLT finish. Furthermore, the outboard insulation levels are sized to meet energy code requirements of most U.S. climate zones.

1. Skidmore, Owings, and Merrill. Timber Tower Research Project. Oregon State University. December 2017.

PROPOSED FLOOR ASSEMBLIES FOR TESTING - STRUCTURAL COMPOSITE

F01

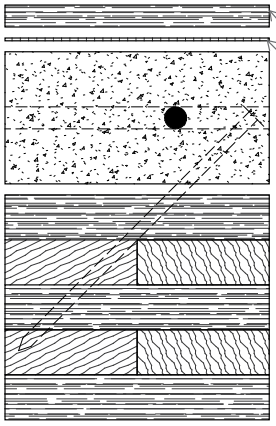


2-1/4" concrete slab @ 145 pcf density (as-tested density in lab report)

#3 rebar @ 6" o.c. in direction of span, 12" o.c. (maximum) perpendicular to span direction, pre-drill screw hole 1" to assure screw geometry, 8mm x 220mm ASSY VG CYL type shear fastener, position @ 12" o.c. field spacing, angle screw 45 degrees to surface of CLT, screw penetrates 5-1/4" into CLT leaving 1-1/2" of screw exposed (measured on vertical) to receive slab

5-Lam CLT or 6" MPP provided by TallWood, half lap panel to panel joint with ASSY VG CSK type shear fastener screw 8mm x 140mm or 160mm depending on material (see CD drawings), 12" o.c. spacing, single bead of construction adhesive, SealOnce Nano Guard wood sealer applied to all top surfaces and end-grain before pouring concrete slab

F02

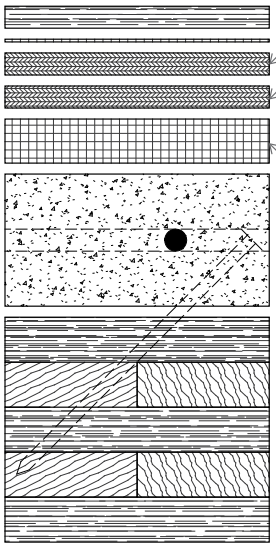


BOD: 6-1/2" wide x 1/2" thick random length Admonter Pine engineered floating floor, sanded, naturally oiled, T&G planks locked together

1/8" acoustic underlayment

* F02 - DEVELOPED BUT NOT TESTED AFTER VALUE ENGINEERING

F03

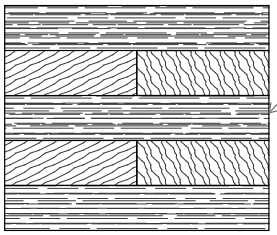


48"x 96"x 5/8" OSB nailed T&G sub-floor, stagger seams, adhered with ChemLink BuildSe-cure, bonds in 4 hours, apply GreenGlue to gaps (see CD drawings for orientation)

1" of acoustic underlayment, installed in opposite direction to hardwood flooring

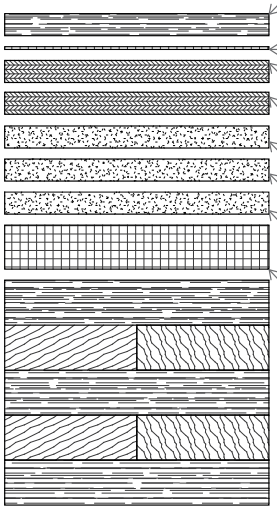
PROPOSED FLOOR ASSEMBLIES FOR TESTING - DRY ASSEMBLY

F04



5 lam CLT or 6" MPP, half lap panel to panel joint with ASSY VG CSK screw 8mm x 140mm or 160mm depending on material (see CD drawings), 12" o.c. spacing, single bead of construction adhesive

F05



BOD: 6-1/2" wide x 1/2" thick random length Admonter Pine engineered floating floor, sanded, naturally oiled, T&G planks locked together

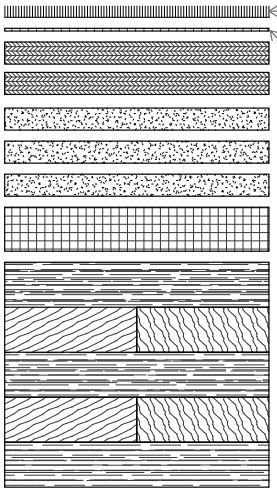
1/8" acoustic underlayment

48"x 96"x 5/8" OSB glued T&G sub-floor, stagger seams, adhered with ChemLink BuildSecure, bonds in 4 hours, OSB stack adhered to Durock stack with ChemLink BuildSecure, bonds in 4 hours

BOD: 1/2" Durock cement board, stagger board joints per CD drawings, adhere panels with ChemLink BuildSecure, bonds in 4 hours, apply GreenGlue to gaps

1" of acoustic underlayment, installed in parallel direction to hardwood flooring

F06



1/2" pile nylon carpet, 3343 oz/cb.yd. pile density, 97.5oz/sq.yd face weight

3/8" 8lb carpet pad

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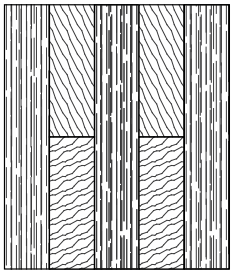
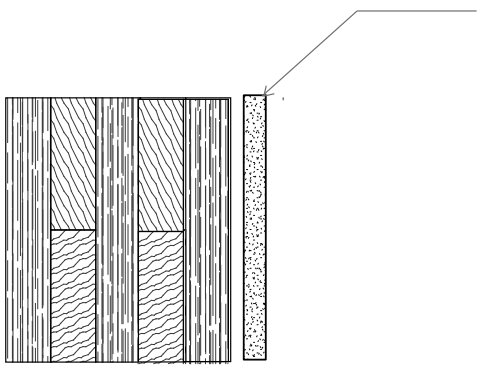
PROPOSED WALL ASSEMBLIES FOR TESTING

W07



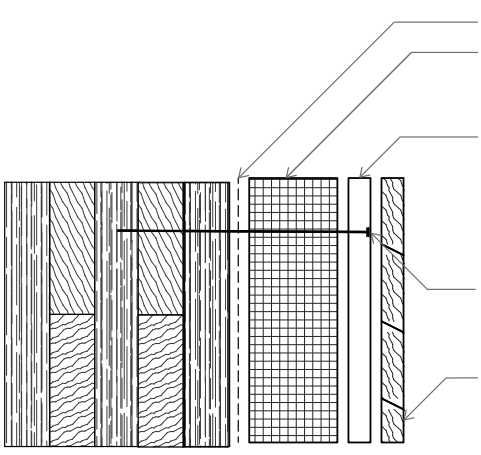
Specified mass timber. Half lap panel joint with single bead of construction adhesive. Joint fastened with 8mm x 140mm or 160mm ASSY VG CSK fastener depending on material (see CD drawings), 12” o.c. spacing

W08



5/8” gyp. bd. with 1-1/4" Type W fastener, field screw 16” spacing all directions, tape all joints

W09



Sopraseal stick 1100t and primer

4” mineral wool insulation

1” x 4” wood battens @ 24“ o.c.

Heco-Topix-Therm fasteners, 8mm x 200mm 12” o.c.

1” x 6” T&G cedar siding,1-1/4" drywall fastener centered at batten

3.0 CLT + MPP FLOOR TESTS

The following section shows the process of testing CLT and MPP floor assemblies for sound transmission at **Riverbank Acoustical Laboratories (Alion Science + Technology)** in Geneva, Illinois. CLT and MPP samples were shipped to the lab wrapped and covered during transport.

Above: calibrated impact sound generator used for IIC testing. Image Credit: Evan Schmidt, OSU TallWood Design Institute

CLT FLOOR TESTING PROCESS

Images depict the process of moving CLT panels into testing chamber and securing joint. Note the size of door opening and the need for a joint in the mass timber base floor.

Credit for all images on this page: Evan Schmidt, OSU TallWood Design Institute

CLT FLOOR TESTING PROCESS

Images depict the process of sealing perimeter of floor CLT using sand and acoustic putty.

Credit for all images on this page: Evan Schmidt, OSU TallWood Design Institute

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CLT FLOOR TESTING PROCESS

Images depict the process of assembling the layers of the dry floor construction.

Credit for all images on this page: Dale Northcutt, ESBL

CLT FLOOR TESTING PROCESS

Images depict the process of assembling the structural composite floor and IIC base testing.

Credit for all images on this page: Dale Northcutt, ESBL

MPP FLOOR TESTING PROCESS

Images this page: the process of MPP installation into the chamber.
Images following page: MPP dry and structural composite assembly build up.

Credit for all images on this page: Dale Northcutt, ESBL

MPP FLOOR TESTING PROCESS

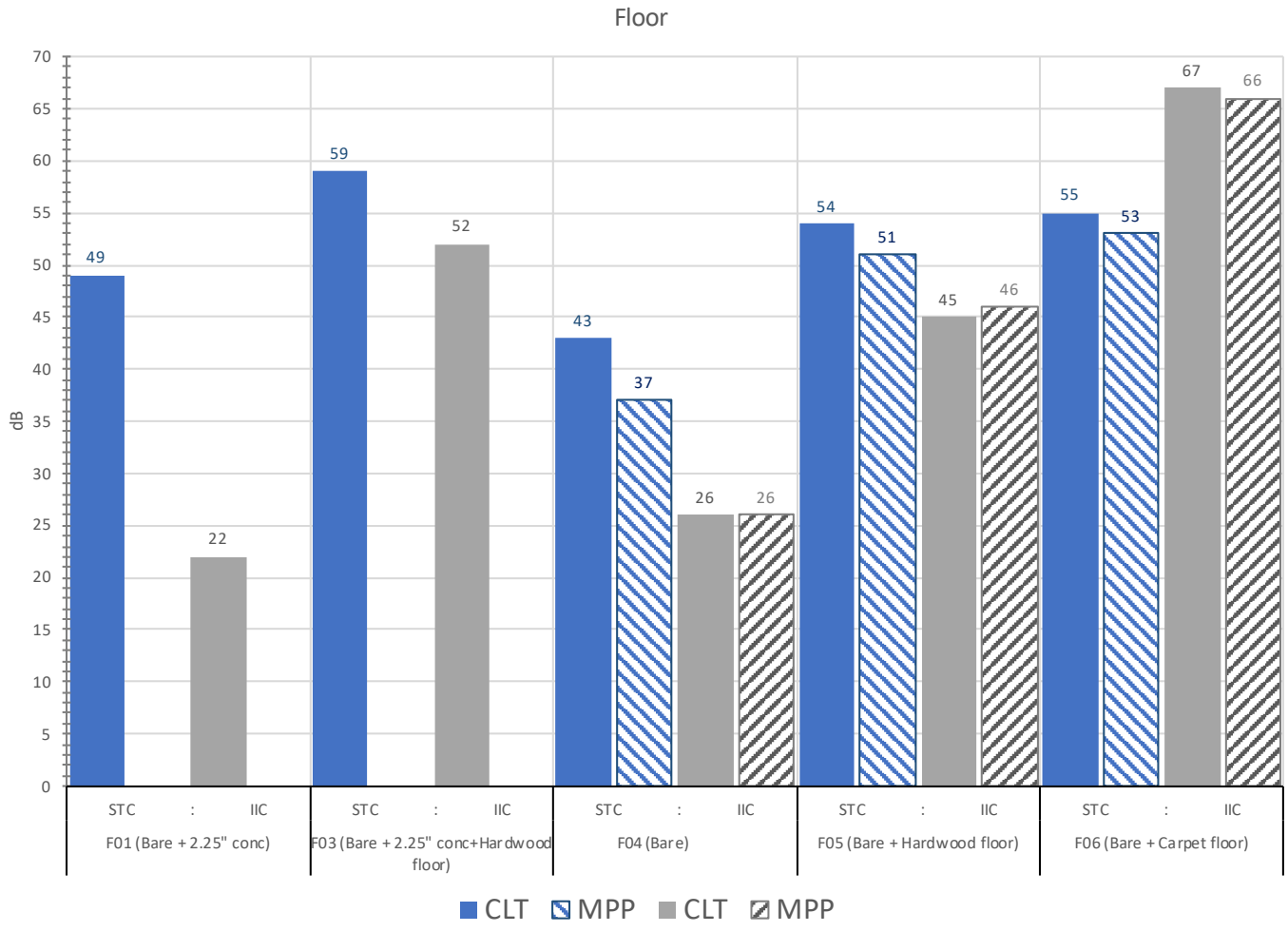








CLT + MPP FLOOR TESTING RESULTS



4.0 CLT + MPP WALL TESTS

The following section shows the process of testing CLT and MPP wall assemblies at **USG Testing Services, Corporate Innovation Center** in Libertyville, Illinois.

Below: fitting CLT panel into wall test opening. Image Credit: Dale Northcutt, ESBL

CLT WALL TESTING PROCESS

Images this page: the process of receiving the CLT at testing lab, sealing in test opening and assembly build up.

Credit for all images on this page: Dale Northcutt, ESBL

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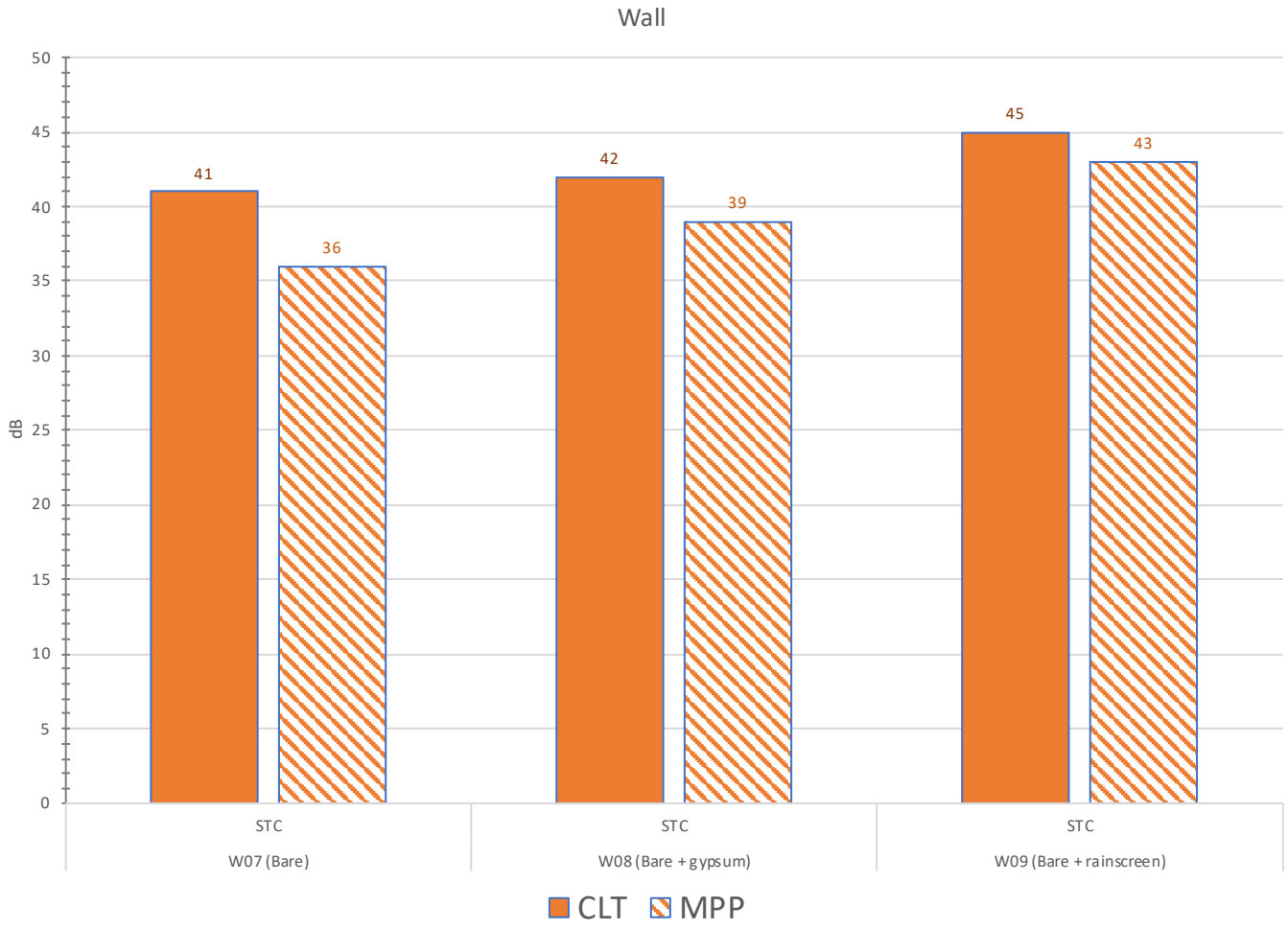
MPP WALL TESTING PROCESS

Images this page: the process of receiving the MPP at testing lab, installing and sealing in test opening and assembly build up.

Credit for all images on this page: Dale Northcutt, ESBL

CLT + MPP FLOOR TESTING RESULTS



5.0 DISCUSSION

Through the process of developing and acoustic testing mass timber wall and floor assemblies, there were some lessons learned that will be documented in this section. There was tremendous enthusiasm from industry to have more tested and verified assemblies at their disposal so that design teams can be flexible when bidding projects, such as having alternate assemblies with comparable performance available that can be substituted based on market conditions. The general summary of feedback that we received included a desire for generic materials, less wood fiber in the base construction, speed of assembly and visibility of the mass timber substrate.

During testing, both laboratory facilities were very helpful, educational, and accommodating to our research team. Being on-site during tests was an advantage to quickly understand and resolve issues that develop. A few of the lessons learned during testing include:

1. Original construction drawings needed updating for as-built due to some clarification. For instance, 145 pcf concrete was specified; however, available concrete used for testing was 151 pcf.
2. Some of the CLT had holes in an exterior layer where knots may have fallen out leaving 1-1/2” deep holes in the face.
3. MPP half lap slightly off in depth to cause a ~1/8” change in elevation rather than being flush, one side of the lap 3” and the other side of the lap 3-1/8”.
4. The MPP 1” plywood units sometimes have an air gap at the butt joint and those gaps can line up on every other layer, effectively reducing the sound path to half of the sectional dimension.
5. In future, it might be nice to specify sealing the half-lap joint at the perimeter face edge to prevent edge short circuit but it probably would not change these results very much but would represent larger panels better removing this edge effect.
6. MPP wall panels were a tight fit because the panels were slightly wider (50-1/4” rather than 50”).

ACKNOWLEDGMENTS

The research team from the Energy Studies in Buildings Laboratory would like to acknowledge and thank the following individuals and organizations for contributing to the successful completion of this project:

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Jake Ross, Creative Acoustics NW

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Denis Blount, Arup

Matt Mahon, Arup

Zach Brehm, Swinerton James Woods, Glumac

Peter Allen, ABD Engineering

Evan Stravers, Scott Edwards Architecture

Juliette Grummon-Beale, FFA

Randy McGee, ZGF Architects

Eric McDonnell, KPFF

Riverbank Acoustical Laboratories

USG Testing Services, Corporate Innovation Center

6.0 APPENDICIES

6.1 PREVAILING CODES AND INDUSTRY STANDARDS

IBC
International Building Code

DESCRIPTION	*IIC | STC*
MULTI-FAMILY DWELLING	50* | 50*

* 45 if field tested

ICC
International Code Council

DESCRIPTION	*IIC | STC*
GRADE A	60 | 60
GRADE B	55 | 55

HUD
Housing and Urban Development

MINIMUM	58 | 52
AVERAGE	62 | 56
LUXURY	65 | 60

ANSI/ ASA
American National Standards Institute

ENCLOSED AREA, THERAPY ROOM, HEAL CARE ROOM, HIGH ACOUSTICAL PRIVACY ROOM	na | 50
COMMON USE AND PUBLIC USE RESTROOMS	na | 53
CORRIDOR, STAIRCASE, OFFICE, OR CONFERENCE ROOM	na | 45
MUSIC ROOM, MUSIC PERFORMANCE SPACE, AUDITORIUM, MECHANICAL EQUIPMENT ROOM, CAFETERIA, GYMNASIUM, INDOOR POOL	na | 60

GSA
General Services Administration

OFFICE PARTITIONS	na | 45
HIGH ISOLATION OFFICE	na | 53
STANDARD OFFICE	na | 40
TELECONFERENCE ROOMS	na | 53

FGI
Facility Guidelines Institute

DESCRIPTION	*IIC | STC*
PATIENT ROOM NEXT TO PATIENT ROOM (WALL-SAME FLOOR)	na | 45
PATIENT ROOM NEXT TO PATIENT ROOM (FLOOR-TO-FLOOR)	na | 50
PATIENT ROOM NEXT TO CORRIDOR	na | 35
PATIENT ROOM NEXT TO PUBLIC SPACE	na | 50
NICU NEXT TO PUBLIC SPACE	na | 50
RESTROOM NEXT TO PUBLIC SPACE	na | 45
PUBLIC SPACE NEXT TO MRI ROOM	na | 50

6.2 ACOUSTIC SURVEY ISSUED TO INDUSTRY LEADERS

The following section shows wall and floor assemblies with known acoustical performance identified from published sources, such as *Think Wood's CLT Handbook* or acoustic product manufacturers. The goal of this survey was to document known assembly performance data and identify desirable CLT and MPP assemblies based on construction technique, performance, aesthetics and cost. Some of the assemblies are developed by us to gauge new directions that industry might consider and flag immediate needs due to a paucity of published data in order to reduce market barriers by providing the needed testing. The results from these tests will be disseminated to the building industry to facilitate mass timber construction projects by reducing market barriers.

These identified assemblies were compiled into a document which was sent out to twenty-three different developers, engineers, acousticians, architects, and contractors as a market climate field survey. Of the twenty-three surveys sent out, twenty were returned. By crowd-sourcing our efforts we were able to optimize two wall assemblies and two floor assemblies to provide value to the building industry.

CLT ACOUSTIC WALL AND FLOOR ASSEMBLY SURVEY

UNIVERSITY OF OREGON ENERGY STUDIES IN BUILDING LAB + TALL WOOD DESIGN INSTITUTE

Thank you for taking some time to provide feedback for a cross laminated timber acoustic study.

We need your input and comments on a series of floor and wall assemblies in order to deterimine which assemblies to initially test. Each assembly will include a diagram, some relevant information and a few fields for you to complete in a fillable PDF.

This survey is aimed at helping the ESBL better anticipate the needs and desires of the industry for CLT assemblies for acoustic performance. Your knowledge of CLT assemblies including aesthetics, cost, and constructability will inform the lab testing of 2 - 3 CLT based wall and floor assemblies.

After going throught this survey please save your resulting PDF and send it back to the address below.

mfretz@uoregon.edu

your information

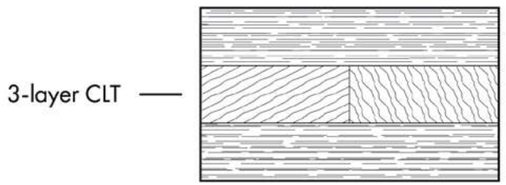
name :

email :

phone :

organization :

thank you!

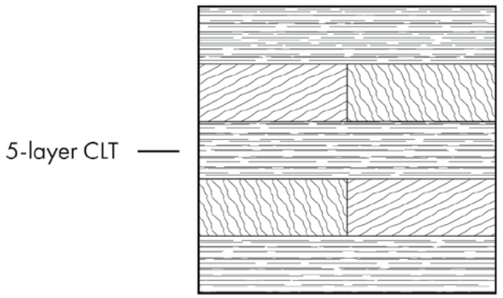


base assembly floor assembly wall assembly suggest an assembly

assembly description (top layer - base layer)	3-layer CLT
cost (material, labor, installed , time)	**$ $$ $$$**
constructability (1 - 3) easy - complex	**1 2 3**
aesthetic (! - !!!)	**! !! !!!**
thickness (inches)	4.5
sound transmission class rating (STC code minimum 52)	32
impact isolation class (IIC code minimum 52)	23.1
availible in the U.S. (y / n)	**Y N**
would you reccomend this assembly? (y / n)	**Y N**

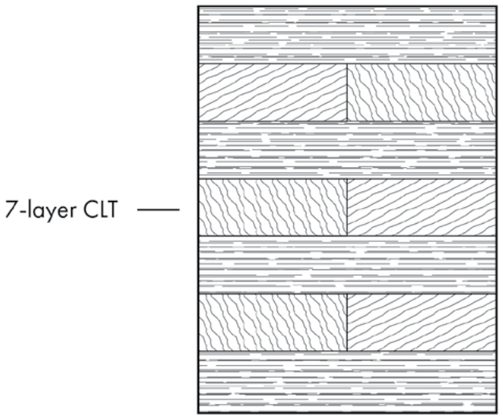
comments
(please feel free to share
comments, thoughts, questions,
reccomendations, etc.)

sources AcoustiTECH Acoustical Guide PDF, WoodWorks CLT Solutions



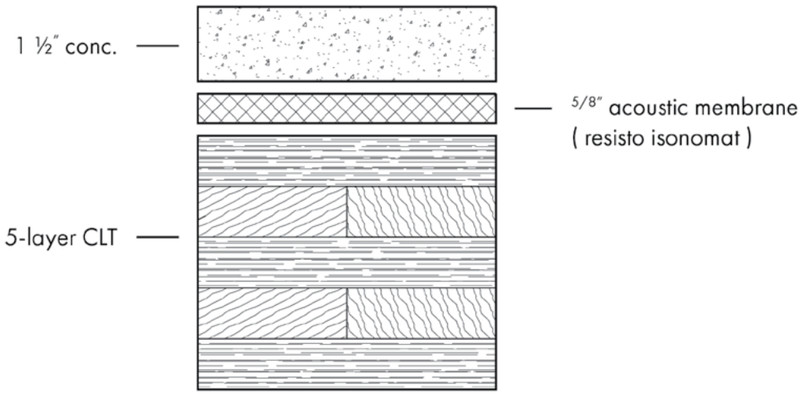
base assembly floor assembly wall assembly suggest an assembly

assembly description (top layer - base layer)	5-layer CLT
cost (material, labor, installed , time)	**$ $$ $$$**
constructability (1 - 3) easy - complex	**1 2 3**
aesthetic (! - !!!)	**! !! !!!**
thickness (inches)	5.8
sound transmission class rating (STC code minimum 52)	39
impact isolation class (IIC code minimum 52)	24
availible in the U.S. (y / n)	**Y N**
would you reccomend this assembly? (y / n)	**Y N**
comments (please feel free to share comments, thoughts, questions, reccomendations, etc.)	
sources	CLT Handbook FPInnovations PDF



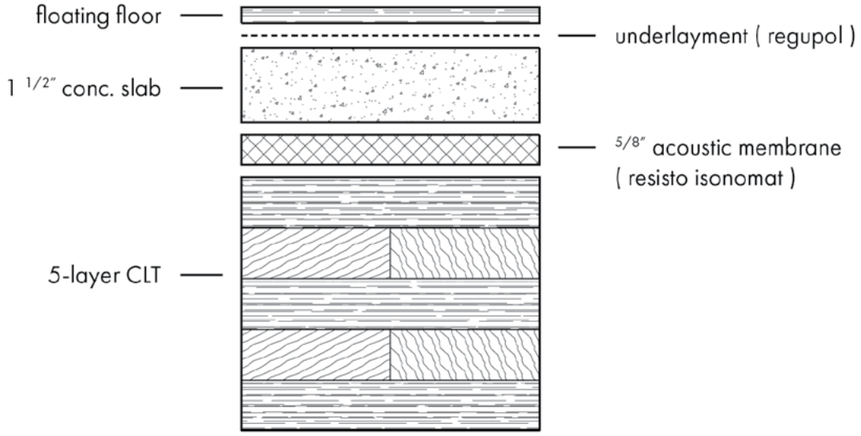
base assembly floor assembly wall assembly suggest an assembly

assembly description (top layer - base layer)	7-layer CLT
cost (material, labor, installed , time)	**$ $$ $$$**
constructability (1 - 3) easy - complex	**1 2 3**
aesthetic (! - !!!)	**! !! !!!**
thickness (inches)	8.3
sound transmission class rating (STC code minimum 52)	(untested)
impact isolation class (IIC code minimum 52)	25
availible in the U.S. (y / n)	**Y N**
would you reccomend this assembly? (y / n)	**Y N**
comments (please feel free to share comments, thoughts, questions, reccomendations, etc.)	
sources	WoodWorks CLT Soulutions



base assembly **floor assembly** wall assembly suggest an assembly

assembly description (top layer - base layer)	1 1/2" conc., 5/8" acoustic membrane (Resisto Isonomat), 5- layer CLT
cost (material, labor, installed , time)	**$ $$ $$$**
constructability (1 - 3) easy - complex	**1 2 3**
aesthetic (! - !!!)	**! !! !!!**
thickness (inches)	7.3
sound transmission class rating (STC code minimum 52)	(untested)
impact isolation class (IIC code minimum 52)	44
availible in the U.S. (y / n)	**Y N**
would you reccomend this assembly? (y / n)	**Y N**
comments (please feel free to share comments, thoughts, questions, reccomendations, etc.)	
sources	AcoustiTECH Acoustical Guide PDF



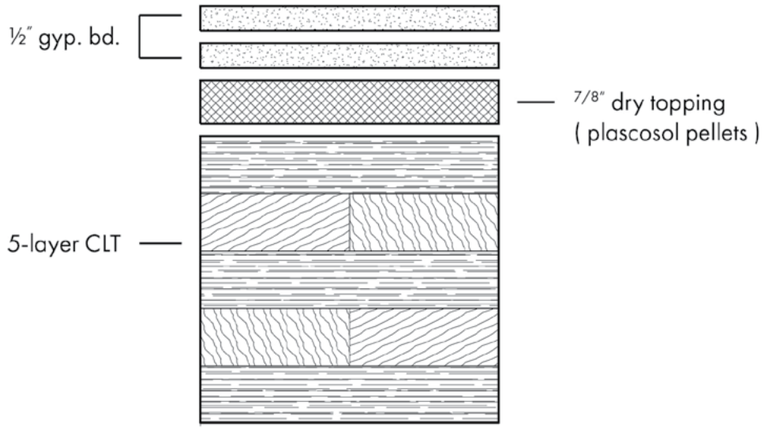
base assembly **floor assembly** wall assembly suggest an assembly

assembly description (top layer - base layer)	floating floor, 1 1/2" conc., 5/8" acoustic membrane (Resisto Isonomat), 5-layer CLT
cost (material, labor, installed , time)	**$ $$ $$$**
constructability (1 - 3) easy - complex	**1 2 3**
aesthetic (! - !!!)	**! !! !!!**
thickness (inches)	7.3
sound transmission class rating (STC code minimum 52)	(untested)
impact isolation class (IIC code minimum 52)	49
availible in the U.S. (y / n)	**Y N**

would you reccomend this assembly?
(y / n) **Y N**

comments
(please feel free to share
comments, thoughts, questions,
reccomendations, etc.)

sources AcoustiTECH Acoustical Guide PDF

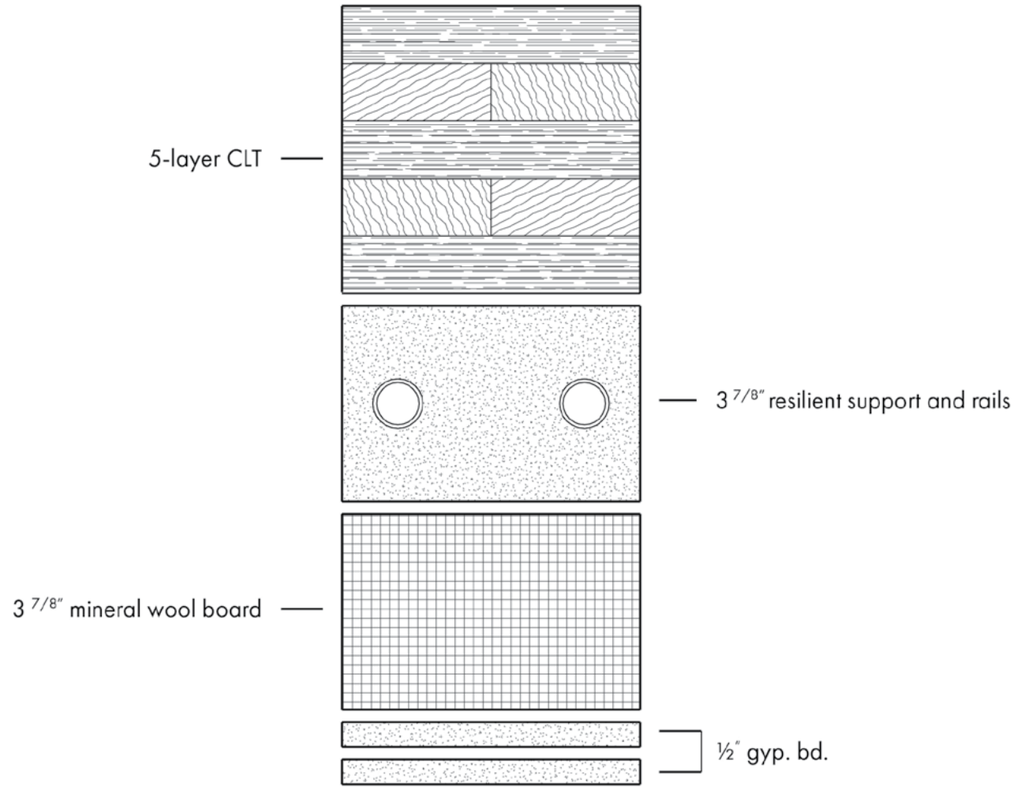


base assembly **floor assembly** wall assembly suggest an assembly

assembly description (top layer - base layer)	(x2) 1/2" gyp. bd., 7/8" dry topping (PLACOSOL pellets), 5-layer CLT		
cost (material, labor, installed , time)	**$**	**$$**	**$$$**
constructability (1 - 3) easy - complex	**1**	**2**	**3**
aesthetic (! - !!!)	**!**	**!!**	**!!!**
thickness (inches)	7.7		
sound transmission class rating (STC code minimum 52)	45		
impact isolation class (IIC code minimum 52)	35		
availible in the U.S. (y / n)	**Y**	**N**	
would you reccomend this assembly? (y / n)	**Y**	**N**	

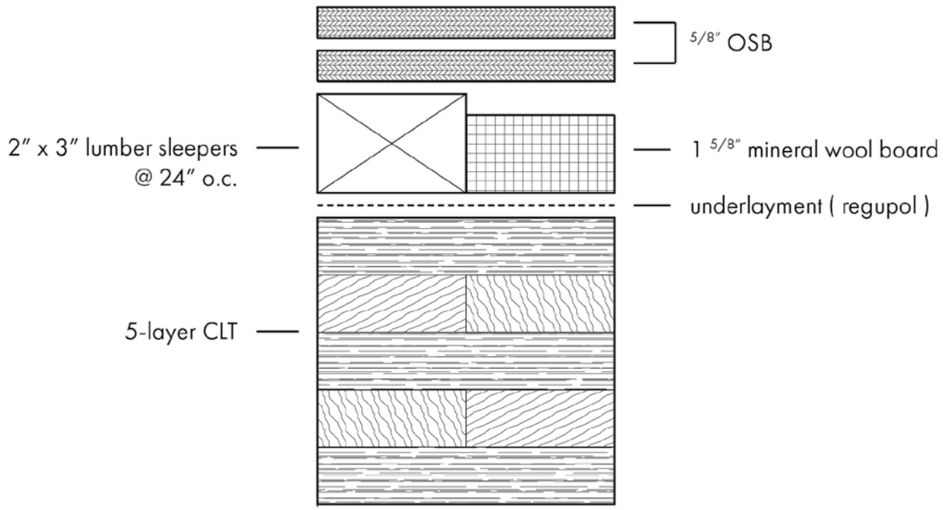
comments
(please feel free to share
comments, thoughts, questions,
reccomendations, etc.)

sources AcoustiTECH Acoustical Guide PDF



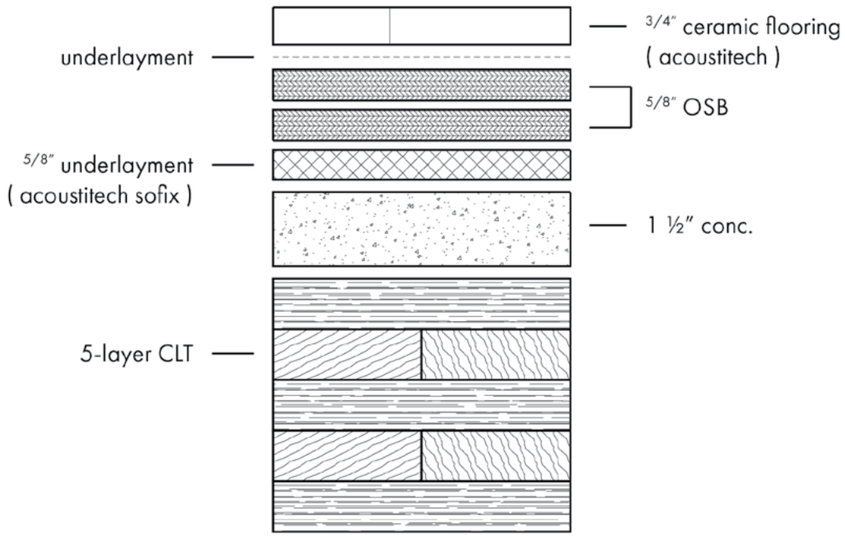
base assembly **floor assembly** wall assembly suggest an assembly

assembly description (top layer - base layer)	5-layer CLT, resilient supports and rails, 7/8" mineral wool, (x2) 1/2" gyp. bd.
cost (material, labor, installed , time)	**$ $$ $$$**
constructability (1 - 3) easy - complex	**1 2 3**
aesthetic (! - !!!)	**! !! !!!**
thickness (inches)	14.8
sound transmission class rating (STC code minimum 52)	64
impact isolation class (IIC code minimum 52)	59
availible in the U.S. (y / n)	**Y N**
would you reccomend this assembly? (y / n)	**Y N**
comments (please feel free to share comments, thoughts, questions, reccomendations, etc.)	
sources	AcoustiTECH Acoustical Guide PDF



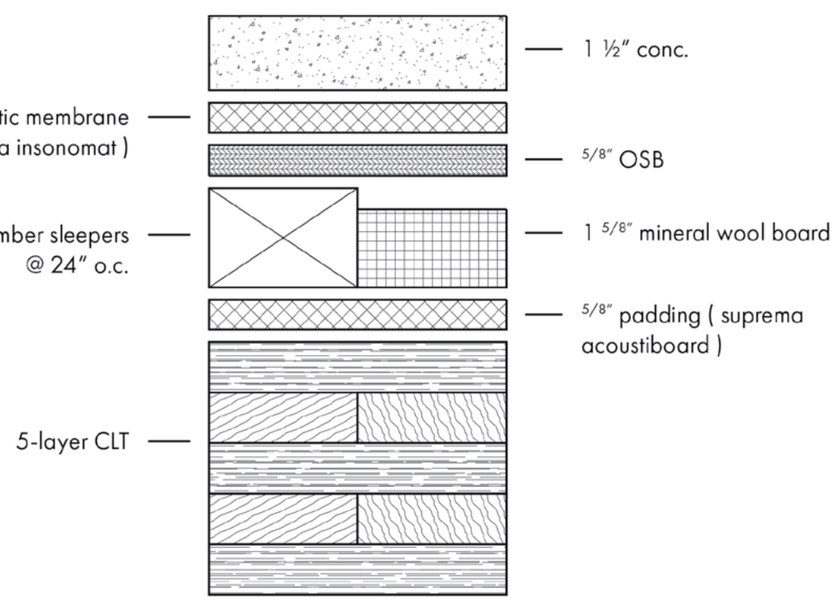
base assembly **floor assembly** wall assembly suggest an assembly

assembly description (top layer - base layer)	(x2) 5/8" OSB, 1 5/8" mineral wool board, lumber sleepers (2" x 3" @ 24" o.c.), underlayment (REGUPOL), 5-layer CLT
cost (material, labor, installed , time)	**$ $$ $$$**
constructability (1 - 3) easy - complex	**1 2 3**
aesthetic (! - !!!)	**! !! !!!**
thickness (inches)	11.1
sound transmission class rating (STC code minimum 52)	53
impact isolation class (IIC code minimum 52)	45
availible in the U.S. (y / n)	**Y N**
would you reccomend this assembly? (y / n)	**Y N**
comments (please feel free to share comments, thoughts, questions, reccomendations, etc.)	
sources	CLT Handbook FPInnovations PDF



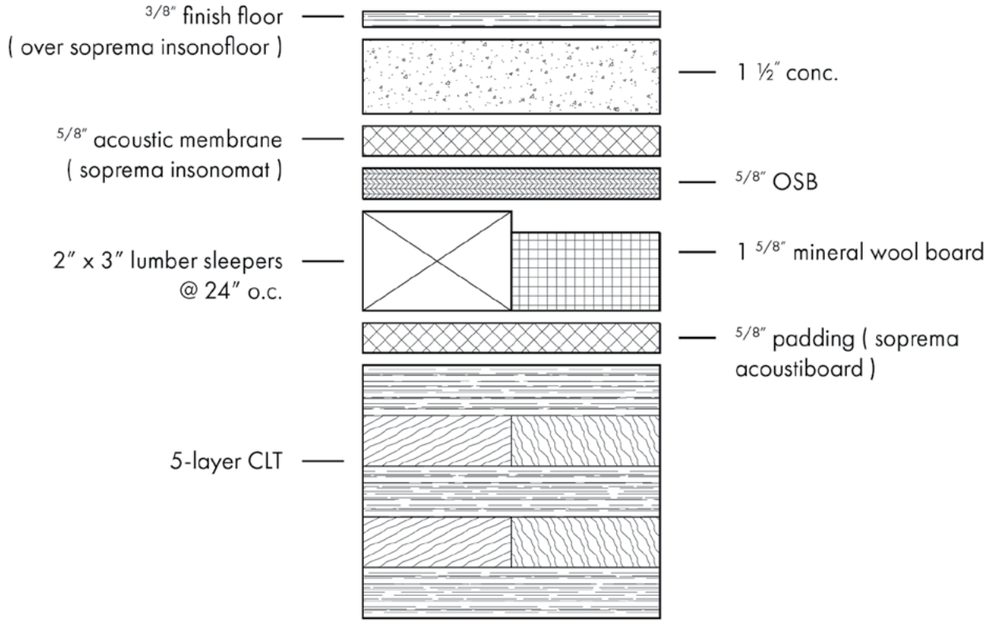
base assembly **floor assembly** wall assembly suggest an assembly

assembly description (top layer - base layer)	3/4" ceramic flooring (acoustiTECH), (x2) 5/8" OSB, 5/8" underlayment (AcoustiTECH SOFIX), 1 1/2" conc., 5-layer CLT
cost (material, labor, installed , time)	**$ $$ $$$**
constructability (1 - 3) easy - complex	**1 2 3**
aesthetic (! - !!!)	**! !! !!!**
thickness (inches)	9.5
sound transmission class rating (STC code minimum 52)	(untested)
impact isolation class (IIC code minimum 52)	60.1
availible in the U.S. (y / n)	**Y N**
would you reccomend this assembly? (y / n)	**Y N**
comments (please feel free to share comments, thoughts, questions, reccomendations, etc.)	
sources	AcoustiTECH Acoustical Guide PDF



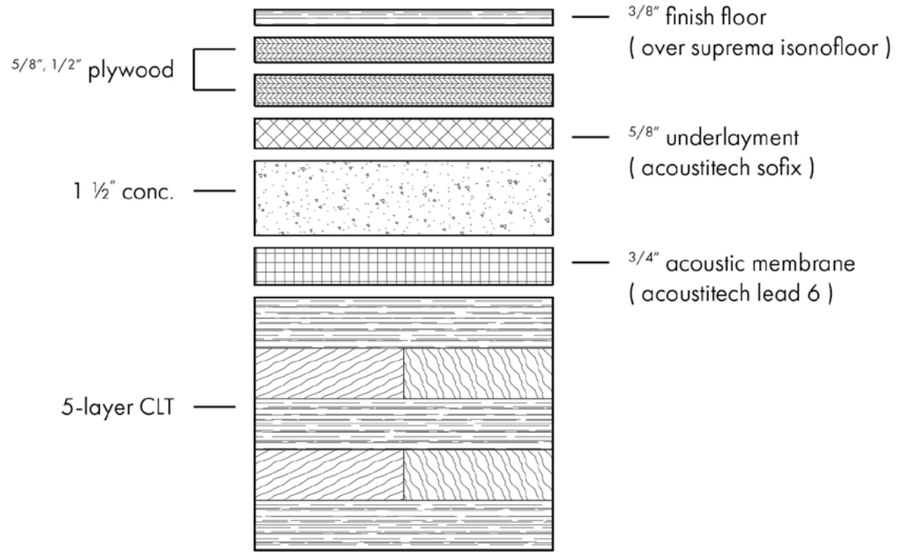
base assembly **floor assembly** wall assembly suggest an assembly

assembly description (top layer - base layer)	1 1/2" conc., 5/8" acoustic membrane (Soprema Insonomat), 5/8" OSB, lumber sleepers (2" x 3" @ 24" o.c.) 1 5/8" mineral wool board, 5/8" padding (Soprema Acoustiboard), 5-layer CLT
cost (material, labor, installed , time)	**$ $$ $$$**
constructability (1 - 3) easy - complex	**1 2 3**
aesthetic (! - !!!)	**! !! !!!**
thickness (inches)	11.2
sound transmission class rating (STC code minimum 52)	(untested)
impact isolation class (IIC code minimum 52)	56
availible in the U.S. (y / n)	**Y N**
would you reccomend this assembly? (y / n)	**Y N**
comments (please feel free to share comments, thoughts, questions, reccomendations, etc.)	
sources	AcoustiTECH Acoustical Guide PDF

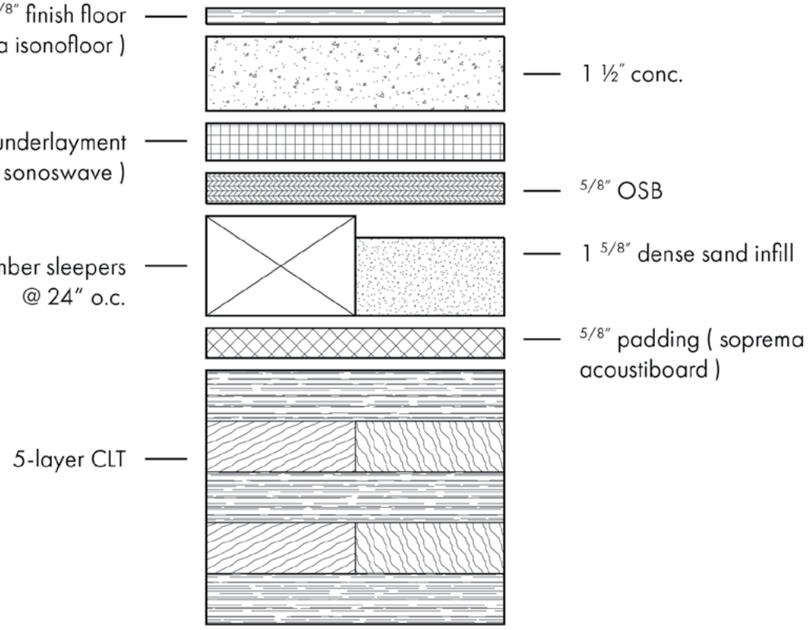


base assembly **floor assembly** wall assembly suggest an assembly

assembly description (top layer - base layer)	3/8" finish floor, acoustic membrane (Soprema Insonofloor), 1 1/2" conc., 5/8" acoustic membrane (Soprema Insonomat), 5/8" OSB, lumber sleepers (2" x 3" @ 24" o.c.) 1 5/8" mineral wool board, 5/8" padding (Soprema Acoustiboard), 5-layer CLT
cost (material, labor, installed , time)	**$ $$ $$$**
constructability (1 - 3) easy - complex	**1 2 3**
aesthetic (! - !!!)	**! !! !!!**
thickness (inches)	11.4
sound transmission class rating (STC code minimum 52)	(untested)
impact isolation class (IIC code minimum 52)	61
availible in the U.S. (y / n)	**Y N**
would you reccomend this assembly? (y / n)	**Y N**
comments (please feel free to share comments, thoughts, questions, reccomendations, etc.)	
sources	AcoustiTECH Acoustical Guide PDF

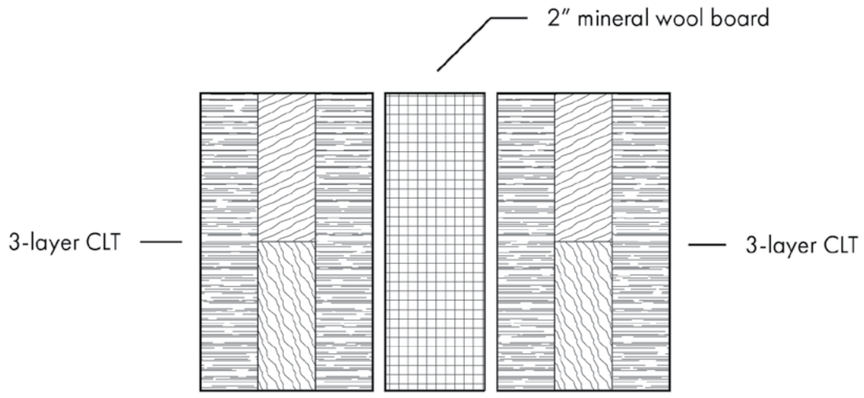


assembly description (top layer - base layer)	3/8" finish floor, acoustic membrane (Soprema Insonofloor), 1/2" plywood, 5/8" plywood, 5/8" underlayment (AcoustiTECH SOFIX), 1 1/2" conc., 3/4" acoustic membrane (AcoustiTECH LEAD 6), 5-layer CLT
cost (material, labor, installed , time)	**$ $$ $$$**
constructability (1 - 3) easy - complex	**1 2 3**
aesthetic (! - !!!)	**! !! !!!**
thickness (inches)	9.4
sound transmission class rating (STC code minimum 52)	(untested)
impact isolation class (IIC code minimum 52)	58
availible in the U.S. (y / n)	**Y N**
would you reccomend this assembly? (y / n)	**Y N**
comments (please feel free to share comments, thoughts, questions, reccomendations, etc.)	
sources	AcoustiTECH Acoustical Guide PDF

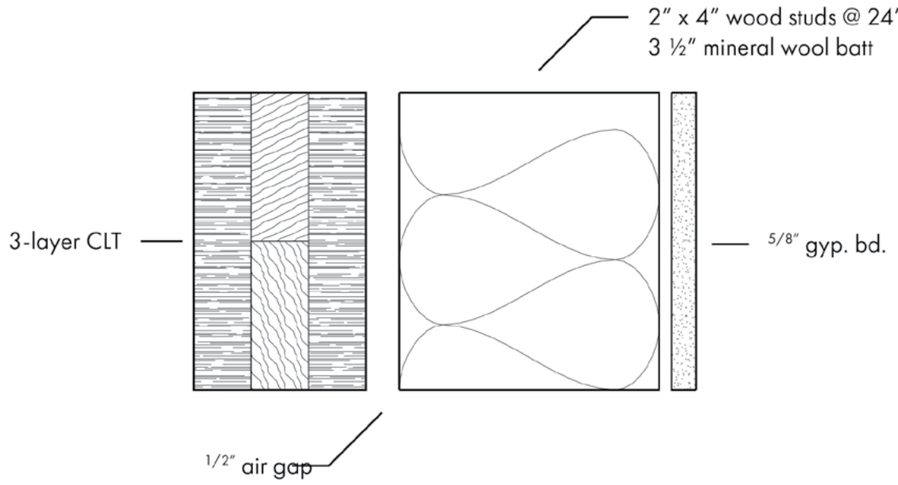


base assembly **floor assembly** wall assembly suggest an assembly

assembly description (top layer - base layer)	3/8" finish floor, acoustic membrane (Soprema Insonofloor), 1 1/2" conc., 3/4" underlayment (Regupol Sonuswave), 5/8" OSB, lumber sleepers (2" x 3" @ 24" o.c.) w/ sand infill, 5/8" padding (Soprema Acoustiboard), 5-layer CLT
cost (material, labor, installed , time)	**$ $$ $$$**
constructability (1 - 3) easy - complex	**1 2 3**
aesthetic (! - !!!)	**! !! !!!**
thickness (inches)	11.4
sound transmission class rating (STC code minimum 52)	(untested)
impact isolation class (IIC code minimum 52)	64
availible in the U.S. (y / n)	**Y N**
would you reccomend this assembly? (y / n)	**Y N**
comments (please feel free to share comments, thoughts, questions, reccomendations, etc.)	
sources	AcoustiTECH Acoustical Guide PDF

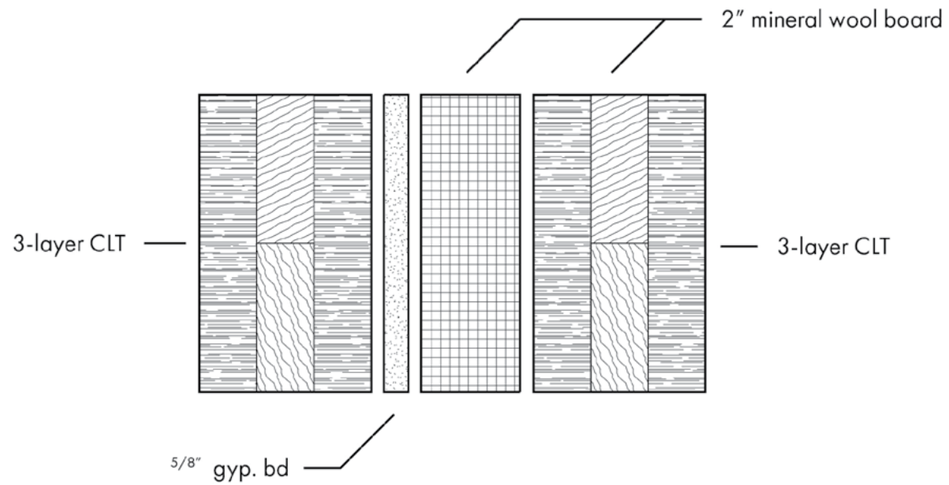


assembly description (top layer - base layer)	3-layer CLT, 2" mineral wool board, 3-layer CLT
cost (material, labor, installed , time)	**$ $$ $$$**
constructability (1 - 3) easy - complex	**1 2 3**
aesthetic (! - !!!)	**! !! !!!**
thickness (inches)	10.3
sound transmission class rating (STC code minimum 52)	50
impact isolation class (IIC code minimum 52)	(n/a)
availible in the U.S. (y / n)	**Y N**
would you reccomend this assembly? (y / n)	**Y N**
comments (please feel free to share comments, thoughts, questions, reccomendations, etc.)	
sources	CLT Handbook FPInnovations PDF, WoodWorks: The Case for Cross Laminated Timber



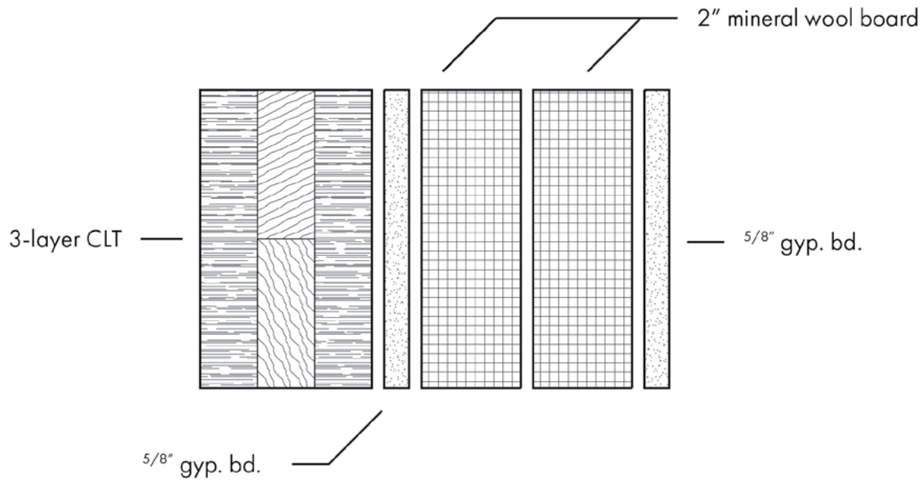
base assembly floor assembly **wall assembly** suggest an assembly

assembly description (top layer - base layer)	3-layer CLT, 1/2" air gap, 2" x 3" wood studs @ 24" o.c., 3 1/2" mineral wool batt, 5/8" gyp. bd.
cost (material, labor, installed , time)	**$ $$ $$$**
constructability (1 - 3) easy - complex	**1 2 3**
aesthetic (! - !!!)	**! !! !!!**
thickness (inches)	9.8
sound transmission class rating (STC code minimum 52)	47
impact isolation class (IIC code minimum 52)	(n/a)
availible in the U.S. (y / n)	**Y N**
would you reccomend this assembly? (y / n)	**Y N**
comments (please feel free to share comments, thoughts, questions, reccomendations, etc.)	
sources	CLT Handbook FPInnovations PDF



base assembly | floor assembly | **wall assembly** | suggest an assembly

assembly description (top layer - base layer)	3-layer CLT, 5/8″ gyp. bd., mineral wool board, 3-layer CLT
cost (material, labor, installed , time)	**$ $$ $$$**
constructability (1 - 3) easy - complex	**1 2 3**
aesthetic (! - !!!)	**! !! !!!**
thickness (inches)	12.1
sound transmission class rating (STC code minimum 52)	60
impact isolation class (IIC code minimum 52)	(n/a)
availible in the U.S. (y / n)	**Y N**
would you reccomend this assembly? (y / n)	**Y N**
comments (please feel free to share comments, thoughts, questions, reccomendations, etc.)	
sources	CLT Handbook FPInnovations PDF

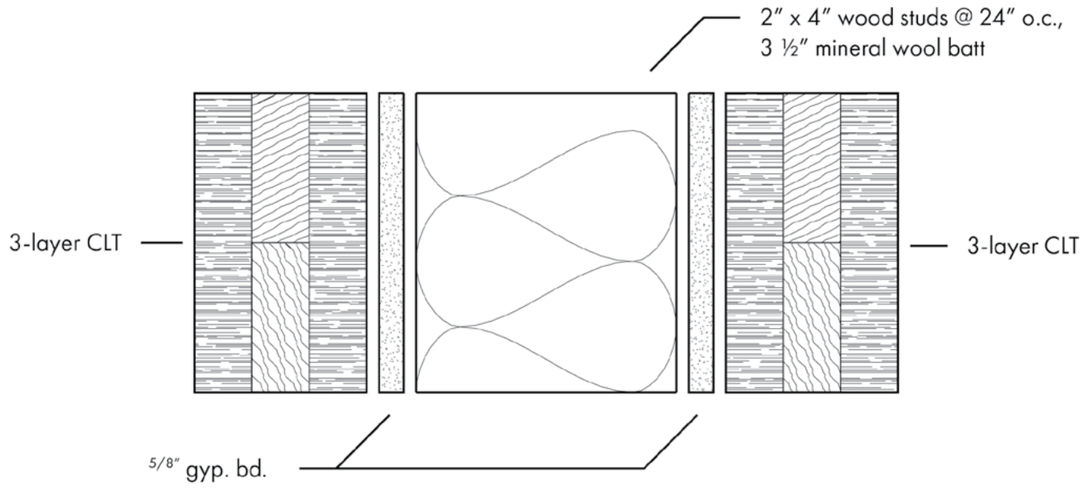


base assembly floor assembly **wall assembly** suggest an assembly

assembly description (top layer - base layer)	3-layer CLT, 5/8″ gyp. bd., (x2) mineral wool board, 5/8″ gyp. bd.
cost (material, labor, installed , time)	**$ $$ $$$**
constructability (1 - 3) easy - complex	**1 2 3**
aesthetic (! - !!!)	**! !! !!!**
thickness (inches)	8.9
sound transmission class rating (STC code minimum 52)	49
impact isolation class (IIC code minimum 52)	(n/a)
availible in the U.S. (y / n)	**Y N**
would you reccomend this assembly? (y / n)	**Y N**

comments
(please feel free to share
comments, thoughts, questions,
reccomendations, etc.)

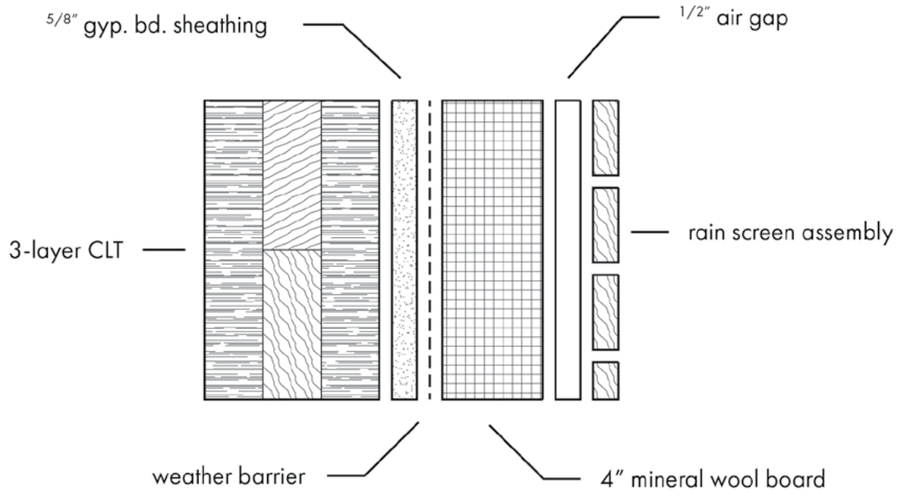
sources



assembly description (top layer - base layer)	3-layer CLT, 5/8" gyp. bd., 2 x 4" typ. stud wall @ 24" o.c., 3 1/2" mineral wool batt between studs, 5/8" gyp. bd., 3-layer CLT
cost (material, labor, installed , time)	**$ $$ $$$**
constructability (1 - 3) easy - complex	**1 2 3**
aesthetic (! - !!!)	**! !! !!!**
thickness (inches)	11.8
sound transmission class rating (STC code minimum 52)	(untested)
impact isolation class (IIC code minimum 52)	(n/a)
availible in the U.S. (y / n)	**Y N**
would you reccomend this assembly? (y / n)	**Y N**

comments
(please feel free to share
comments, thoughts, questions,
reccomendations, etc.)

sources

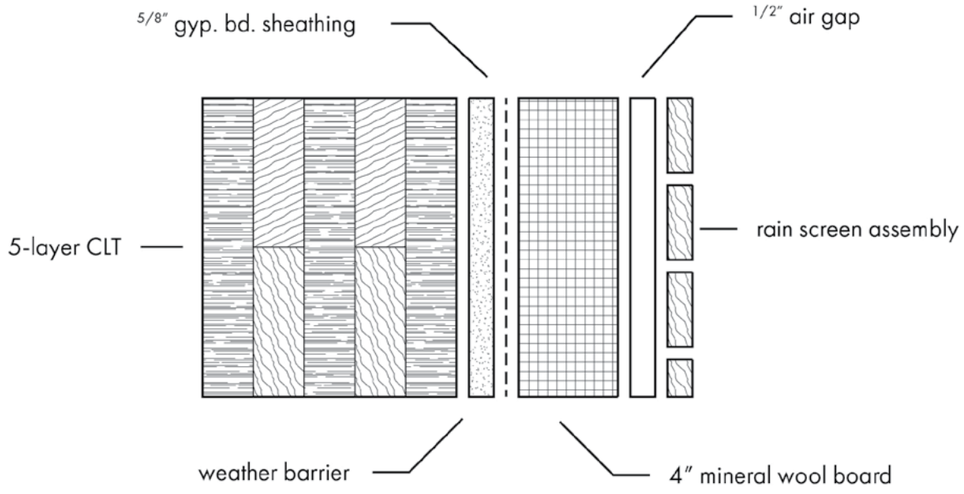


base assembly floor assembly **wall assembly** suggest an assembly

assembly description (top layer - base layer)	3-layer CLT, 5/8" gyp. bd. sheathing, weather barrier, 4" mineral wool board, air gap, exterior rain screen assembly
cost (material, labor, installed , time)	**$ $$ $$$**
constructability (1 - 3) easy - complex	**1 2 3**
aesthetic (! - !!!)	**! !! !!!**
thickness (inches)	13.3
sound transmission class rating (STC code minimum 52)	(untested)
impact isolation class (IIC code minimum 52)	(n/a)
availible in the U.S. (y / n)	**Y N**
would you reccomend this assembly? (y / n)	**Y N**

comments
(please feel free to share
comments, thoughts, questions,
reccomendations, etc.)

sources



base assembly | floor assembly | **wall assembly** | suggest an assembly

assembly description (top layer - base layer)	5-layer CLT, 5/8" gyp. bd., weather barrier, 4" mineral wool board, air gap, rain screen assembly
cost (material, labor, installed , time)	**$** **$$** **$$$**
constructability (1 - 3) easy - complex	**1** **2** **3**
aesthetic (! - !!!)	**!** **!!** **!!!**
thickness (inches)	14.7
sound transmission class rating (STC code minimum 52)	(untested)
impact isolation class (IIC code minimum 52)	(n/a)
availible in the U.S. (y / n)	**Y** **N**
would you reccomend this assembly? (y / n)	**Y** **N**
comments (please feel free to share comments, thoughts, questions, reccomendations, etc.)	
sources	

base assembly floor assembly wall assembly **suggest an assembly**

assembly description (top layer - base layer)			
cost (material, labor, installed , time)	**$**	**$$**	**$$$**
constructability (1 - 3) easy - complex	**1**	**2**	**3**
aesthetic (! - !!!)	**!**	**!!**	**!!!**
thickness (inches)			
sound transmission class rating (STC code minimum 52)			
impact isolation class (IIC code minimum 52)			
availible in the U.S. (y / n)	**Y**	**N**	

comments
(please feel free to share
comments, thoughts, questions,
reccomendations, etc.)

thank you!

6.3 INDUSTRY FEEDBACK

The following section is a compilation of emails, phone calls, and survey responses and meeting feedback from industry professionals who have designed, specified, engineered or constructed with mass timber. We reached out 23 individuals and their response data informed our assembly decisions and guided the final selection of assemblies to lab test. Assemblies were selected based on cost, availability of materials, use of non-proprietary materials (when available), construction ease and speed, anticipated performance and paucity of existing test data.

Dean Lewis, Engineer
DCI-Engineers
(email response)

Below is a list of considerations for the industry in relation to acoustics with mass timber products:
1. What are the most thin assemblies which expose the CLT soffit which can achieve a STC & IIC rating of 50. Typically we are looking at 131mm 5PLY CLT panel 9 (note thickness is optimized with thin weak axis layers) with acoustic mat (typically from Maxxon) and 1-1/2" to 2" layer of gypcrete. Below are some sub-topics on this assembly
a. Besides Maxxon are there any other products which can fulfill this need?
b. What is the range in performance with 1-1/2" of gypcrete vs 2" of gypcrete?
i. Does normal weight or lightweight concrete perform better?
c. If we substitute an MPP plywood panel will need to confirm it performs similarly.
2. What are the risks of flanking between the CLT walls and floors.
a. Are there similar risks with CLT floors and light frame walls (wood and CFS).
b. Are there product suggestions which can help range performance, we know that Rothoblaas offers a lot of solutions.
3. How much can custom shapes of NLT or DLT enhance acoustics? This could really push mass timber to beat out steel and concrete in any office or school project.
a. Also, if the NLT or DLT has its cavities stuffed with acoustical insulation, how much better performance do we achieve.

Alex Zelaya, Architect
Hacker
(survey response)

(Work on several office CLT projects.)
Floor:
1 1/2" Concrete seems too thin and would likely crack - needs to be covered by flooring.

Would be interesting to have mineral wool instead of concrete.

James Woods, Engineer
Glumac
(email response)

(Has done a lot of work with raised access floors and CLT)

I am definitely interested in being involved, but our expertise is MEP and Lighting design so we don't have much to say about the acoustics of the assemblies themselves (that's a bit more architectural/acoustic consultant specific). Some topics I would expect to have some thoughts on are:

- Designing for open/no ceilings/exposed services
- Coordination of MEP penetrations
- Energy efficiency/reduced carbon footprint potential of timber + MEP+Lighting system concepts
- Moisture control through envelope for timber buildings
- Is humidity control needed in timber buildings???
- Pressurization of the building?

Etc!

Evan Stravers, Architect
SEA
(survey response)

(Worked at Path on Carbon 12)

Floor:

[5-ply with acoustic mat, concrete topping] also seems like a prototypical CLT floor assembly for future use. Would highly suggest this as a test, since additional flooring assemblies and adhesives to top this with also likely receive testing, and the results could be extrapolated.

[5-ply with acoustic mat, concrete topping, underlayment, floating floor] is the closest to the main Carbon 12 floor assembly, and probably represents what architecture firms would ideally pursue from a look perspective moving forward, with exposed undersides and floating floor to match. Seems like this could be tested without the underlayment and flooring, and retested with those installed?

[like above with additional topping] Like the Carbon12 floor slab with 2x the layering. Could represent a "cadillac" solution.

Wall:

[3-ply with rainscreen] Seems like a prototypical exterior CLT wall assembly for many applications. Would suggest.

Juliette Grummon-Beale, Architect
FFA
(email response)

(Two CLT projects on the boards)

We have completed one project using CLT- a single story library in Boise, ID. We had a two story office project go on hold that was CLT. We are currently in the CD phase on a two-story police/public safety building that will have CLT floors and walls that essentially functions as an office. Would any of these qualify?

For each of these projects, exposed CLT has been critical for aesthetics and showcasing a local Pacific NW resource. I believe the designers have thought CLT does double duty as a finish and structural system, but I am still unsure about how cost effective it is for a single or even two story project.

Yes, acoustics have been tricky. We are even considering Structurecraft's DLT product for an upcoming higher-ed project where we'd like exposed wood but just can't get the acoustic separation required. The vibration design criteria has also been limiting since you can structurally span longer distances, but for acoustics and comfort you need to reduce the structural bay size.

Most of our CLT projects have also gone the route of radiant heating, so the ceiling may be clean and have little mechanical. This does double duty since a topping slab is recommended for CLT floors. The exposed concrete along with the exposed wood has to be weighed with acoustics, so we've dropped in ACT clouds in areas like conference rooms.

Jake Ross, Engineer/ Acoustician
Creative Acoustics NW
(phone conversation)

For CLT tests, would like to see:

Bare structure (base case), solid ceiling with resilient channel ,resilient mat, kinetics noise control - for floor products, the thicker the resilient piece is, the more it can deflect, therefore better IIC.

Bare structure

2 ceilings: Solid, resilient

2 floors : 1 thicker, 1 thinner

As we improve IIC, STC will increase. The inverse is not usually true.

Randy McGee, Architect
ZGF
(email response)

I am building a 3 story 1000 Sf CLT addition to my NW Portland residence. All CLT is 3 ply and exposed on the interior with an exterior rainscreen over semi-rigid insulation.

All CLT fasteners are concealed. Very simple (except for the cantilever).

The brewery we are working on in NW Portland will be receiving the CLT panels from DR Johnson in about two weeks for installation. Those panels vary from 3 ply to 7 ply. Again, all CLT is exposed on the interior with concealed fasteners. Exterior is Corten rainscreen over semi rigid insulation.

Erica Fischer, PhD, PE, Engineering Professor, OSU
(Structural concrete/ CLT hybrid diaphragms)
(email response)

We chose 2.5 inches because that is what was used in the seismic/dynamic tests performed by Andre Barbosa and Chris Higgins. We are using their same assembly, which was developed by SOM and OSU because it has been tested quite a bit, but not in fire. These fire tests will "complete the story" per se. The 2.5 inches is at the lower end of what you would want to use structurally for a composite floor. It is hard to rationalize a 1.5 inch concrete on CLT as structural. Below 2"-2.25", the concrete is considered really a topping and not structural.

We are putting reinforcement in the concrete, so it is going to be part of the structural system. You bring up a great point about the acoustical barrier. You are right in that it typically goes on top of the CLT. However, if we are drilling self-tapping screws through the acoustical barrier, we are weakening its effectiveness. We are not using an acoustical barrier in our tests. We are assuming (and we are aware of the magnitude of this assumption) that the acoustical barrier could go on top of the concrete. This way the screws are not going through the barrier and the concrete and CLT can be composite.

In the PNW we use normal weight concrete which has a density of about 145 pcf, 150 pcf is assumed when including reinforcement. Other locations of the country have light weight aggregate that allow for lower density concrete. It is very difficult to get that aggregate in the PNW.

Denis Blount, Engineer
Arup
(AIA Woodworks presentation on acoustics)
(survey response)

Denis worked as consultant on Framework project

- Stuff in CLT handbook wasn't always tested in a lab and they are finding numbers are off

- Not a lot of data on built projects

- Test data needs to be done in ISO or ASTM certified lab

- Chunk of the testing out there has been done by manufacturers so questionable reliability

- IBC requirement for multifamily is way too low

- ICC recent report talks about houses built to the lowest common denominator of IBC has whole groups of people that are unhappy

- Mass timber opportunity to re-establish baseline for multifamily prototypical assembly to improve people's wellbeing

- Hans Erik Blomgren at Katerra looked at doing away with wet trades using offsite fabrication. Found out that eliminating wet trades doesn't save as much as first thought

- Concrete massive topping was defacto solution

- Now there is a lot more data available on floor assemblies using sheet goods

- Great to get test data on MPP but since this is a proprietary product, its use might be limited

- Nothing magic about resilient underlayment

- Regupol is the "kleenex" of underlayments and not much difference in performance between these.

- Stay away from woven fiber underlayments

- There is flat rubber, dimpled and variations (e.g. GenieMat)

Randy Waldeck, Engineer/ Acoustician
CSDA Design Group
(AIA Woodworks presentation on acoustics)
(email response)

In general, I can tell you that STC 50 and IIC 50 is the magic number for Building Code and other acoustical standards. So, at a minimum, we should focus on those assemblies that have achieved or are expected to achieve 50.

Zach Brehm, Contractor
Swinerton
(Construction project manager on CLT projects)
(email response)

Zach interested in finding generic assemblies that can have substitutions during bidding and feel comfortable that it will meet code.

- Don't use concrete unless structural. Interested in structural composite testing

- Gypcrete achieves goal for less

- Less fiber = more economical and desirable. 3 lam best or 5 lam if needed. Stay away from 7 lam

- Plywood more expensive than osb

- "sand is difficult to handle"

- Haven't seen adoption of CLT walls in Western US due to seismic rigidity

- wood studs less than half the cost of clt

- Need to test structural concrete floor assembly

Eric McDonnell, Engineer
KPFF
(Worked on several CLT projects includeing Framework and Albina Yard)
(conversation)

Eric gave feedback at Mass Timber meetup on acoustics regarding wall assembly - Need to use 5-lam vs proposed 3-lam in wall assembly due to 1 hour fire rating requirement.

6.4 ACOUSTIC TESTING LAB SELECTION MATRIX

The selection of an acoustic testing facility for wall and floor assemblies involves a multi-factorial analysis of criteria. In addition to typical considerations of cost, lead time, shipping distance, procurement of materials (lab versus client), some additional criteria to consider that are specific to mass timber involve the ability to handle, maneuver and install large, heavy panels. Testing bed size is a significant factor in structuring the test since panels can be manufactured in various widths and transportation requirements and facility clear opening dimensions will determine whether a single panel will suffice or multiple panels need to be joined.

Based on our international (Canada + USA) search of testing facilities and analysis of multiple criteria (see matrix), the decision was made to use the following ASTM-certified facilities:

FLOOR PANEL TESTS

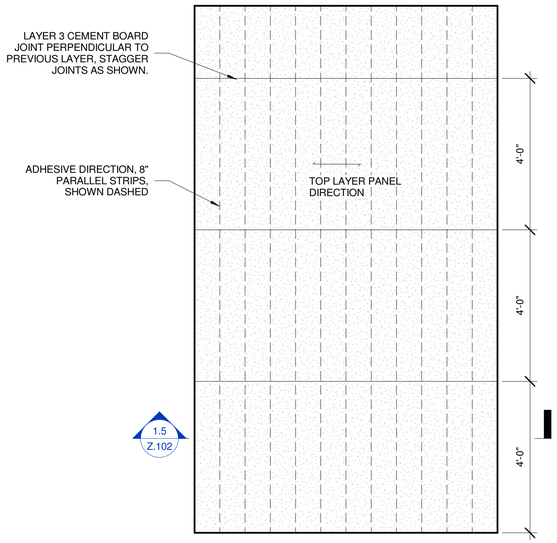
Riverbank Acoustical Laboratories
1512 S Batavia Ave
Geneva, IL 60134-3302
Tel: 630-232-0104

WALL PANEL TESTS

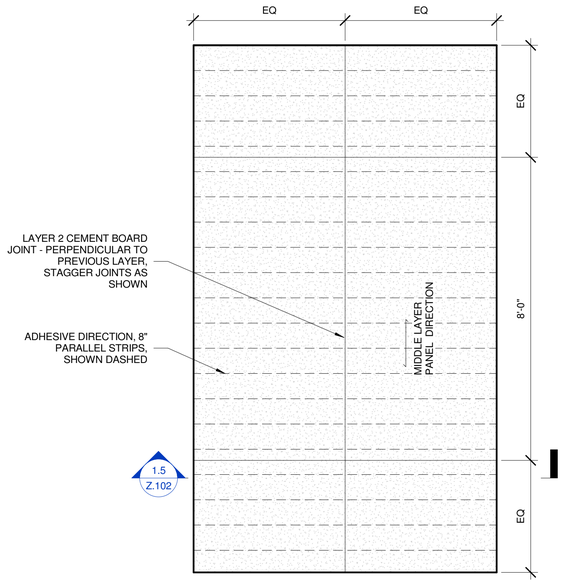
USG Testing Services, Corporate Innovation Center
700 N. Highway 45
Libertyville, IL 60048
Phone : 847-970-5106

Type	Lab Name	City	State	Phone	Address	Zip	Website	Estimated lead time	Testing bed sizes (note: many facilities can accommodate other sizes)	Access Limitations for Mass Timber (note: panels maybe up to 12 feet wide)	Structural Limitations of Test Chamber (max sample weight)
Walls ASTM E90 & Floors ASTM E90 & ASTM E492	Intertek Testing Services NA Inc.	York	PA	800-967-5352	130 Derry Ct.	17402	http://www.intertek.com/building/acoustical//	2-3 weeks	Floor 12' x 10' Wall 8' x 8'		
	Intertek Testing Services NA Inc.	Lake Forest	CA	949-460-9600	25800 Commercentre Drive	92630	http://www.intertek.com/building/acoustical//	2-3 weeks	Floor 12' x 10' Wall 8' x 8'		
	NGC Testing Services	Buffalo	NY	716-873-9750	1650 Military Road	14217	http://www.ngctestingservices.com/acoustical.html	2 weeks after materials and signed agreement	16' x 12'		crane is 12 ton capacity
	Orfield Laboratories, Inc.	Minneapolis	MN	612-721-2455	2709 East 25th Street	55406	https://www.orfieldlabs.com/acoustics.html		14' x 12.5'		
	Riverbank Acoustical Laboratories (Alion Science & Technology)	Geneva	IL	630-232-0104	1512 S. Batavia Ave	60134	https://www.alionscience.com/riverbank-acoustical-laboratories/	4-6weeks	Floor 14' x 8' Wall 14' x 9'	Panels must be 48 inches wide or less. We may be able to accommodate slightly wider if we bring them in on an angle.	Maximum weight capacity for each panel is 5000lbs. No weight restriction for the entire assembly. Maximum sample thickness for floors is 22inches
	National Research Council Canada	Ottawa, Ontario	Canada	613-991-0436	1200 Montreal Road	K1A 0R6	https://www.nrc-cnrc.gc.ca/eng/solutions/facilities/indoor_environment.html	8 weeks	Floor: 16'-3" by 13'-3" Wall 12' x 8' x 14.75" deep		
Walls ASTM E90	USG Corporate Innovation Center - Construction Systems Laboratory	Libertyville	IL	847-970-5200	700 NORTH HIGHWAY 45	60048	https://www.usg.com/content/usgcom/en/about-usg/innovative-sciences/testing-facilities/usg-testing-services.html	4 weeks	8' x 9' typical; 16'x9' maximum with 8' x 8' minimum.	NA	NA
	ETS- Lindgren Acoustic Research Laboratory	Cedar Park	TX	512-531-6400	1301 Arrow Point Drive	78613	http://www.ets-lindgren.com/services/certification-test	2 weeks	8' x 8'	3.1mx3.1m door	5 ton crane, but 1 ton frame, so 4,000 pound samples
	Owens Corning Acoustic & Insulation Product Testing Laboratories	Granville	OH	740-321-6865	2790 Columbus Rd, Route 16	43023	https://www2.owenscorning.com/quietzone/ourservices.asp	4 weeks	8' x 12'	door is 4' x 10'	13,000 pounds
	Western Electro-Acoustic Lab., a div. of Veneklasen Assoc., Inc.	Santa Clarita	CA	661-775-3741	25132 Rye Canyon Loop	91355	http://www.weal.com/pages/lab.html		16' x 14' x up to 14 inches deep. Typical test size is 8x8.	The access door to the chamber is 5 feet wide by 7 feet tall. The panels would be assembled in the chamber.	The framing is made from 2 x 8 wood studs. We can accommodate specimen up to 3000 Lbs.

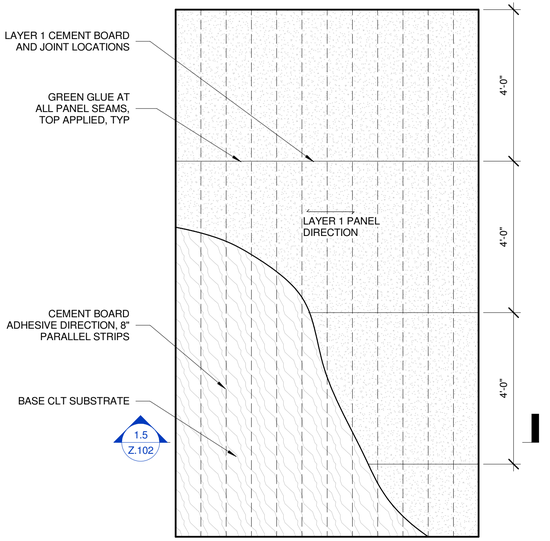
Notes:
All but National Research Council Canada was a US-certified (ASTM) testing lab for acoustical testing.
Johns Manville Technical Center declined our invitation due to safety concerns in handeling panels without mechanical assistance.
** This does not represent an exhaustive search and represents accreditation and facility configuration as of Fall 2018



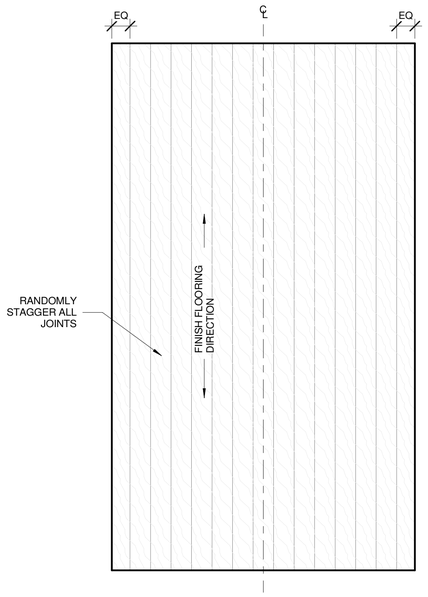
1.13 CEMENT BOARD LAYOUT - LAYER 3
1/2" = 1'-0"



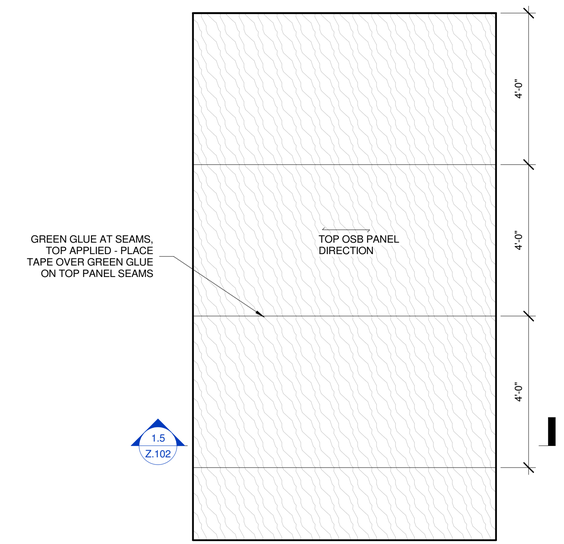
1.12 CEMENT BOARD LAYOUT - LAYER 2
1/2" = 1'-0"



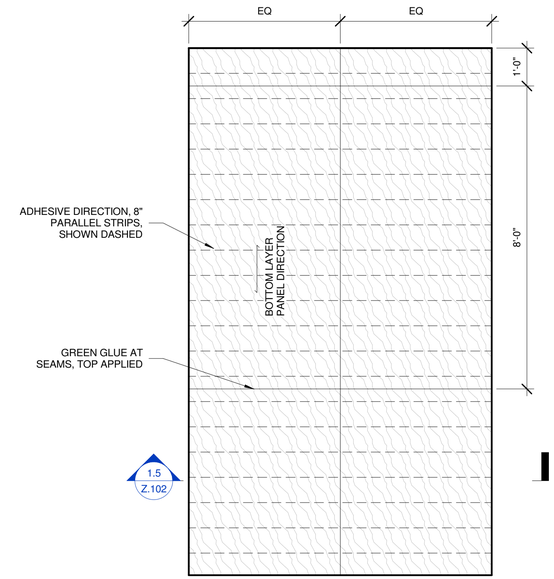
1.11 CEMENT BOARD LAYOUT - LAYER 1
1/2" = 1'-0"



1.2 FLOATING FLOOR LAYOUT PLAN
1/2" = 1'-0"



1.15 OSB LAYOUT - LAYER 2
1/2" = 1'-0"



1.14 OSB LAYOUT - LAYER 1
1/2" = 1'-0"

3/25/2019 8:43:44 AM

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Acoustic Lab Testing of Typical Multi-Family Residential CLT Wall and Floor Assemblies

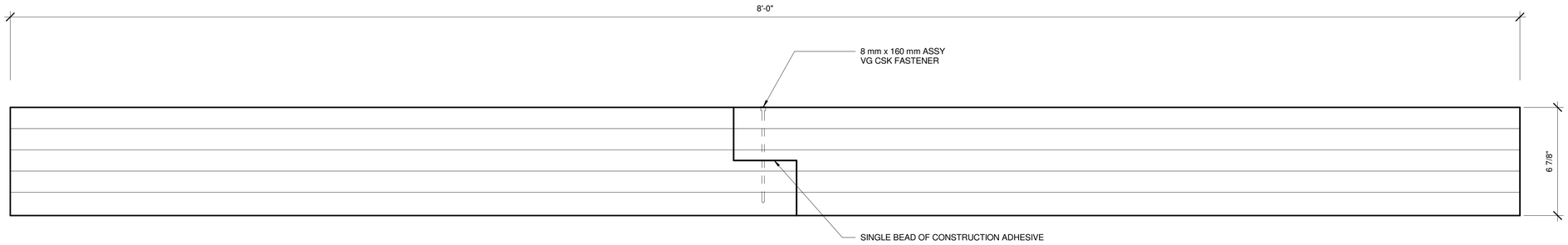
FLOATING FLOOR, CEMENT BOARD PLANS

Z.101

SCALE | 1/2" = 1'-0"

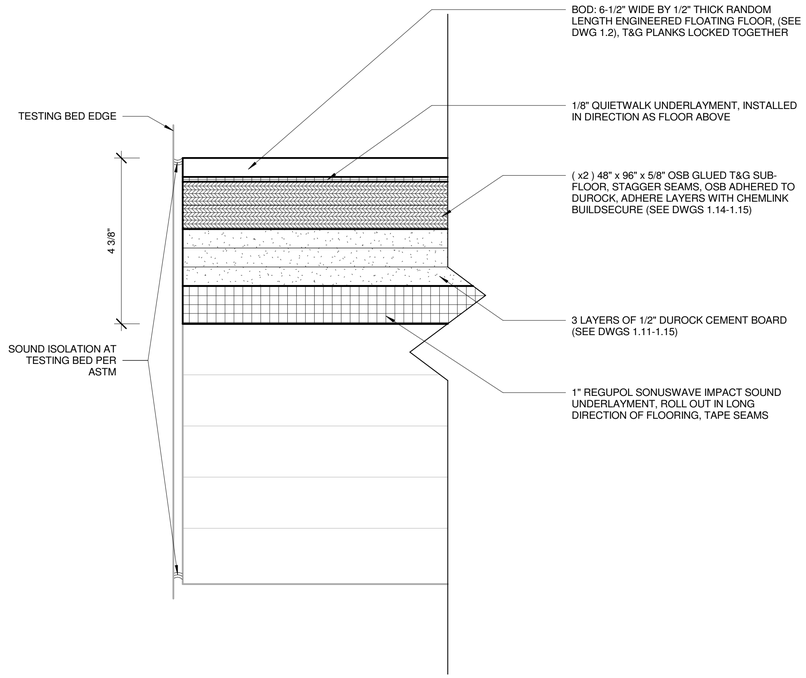
ISSUE DATE | 03.25.2019

AS-BUILT DRAWINGS



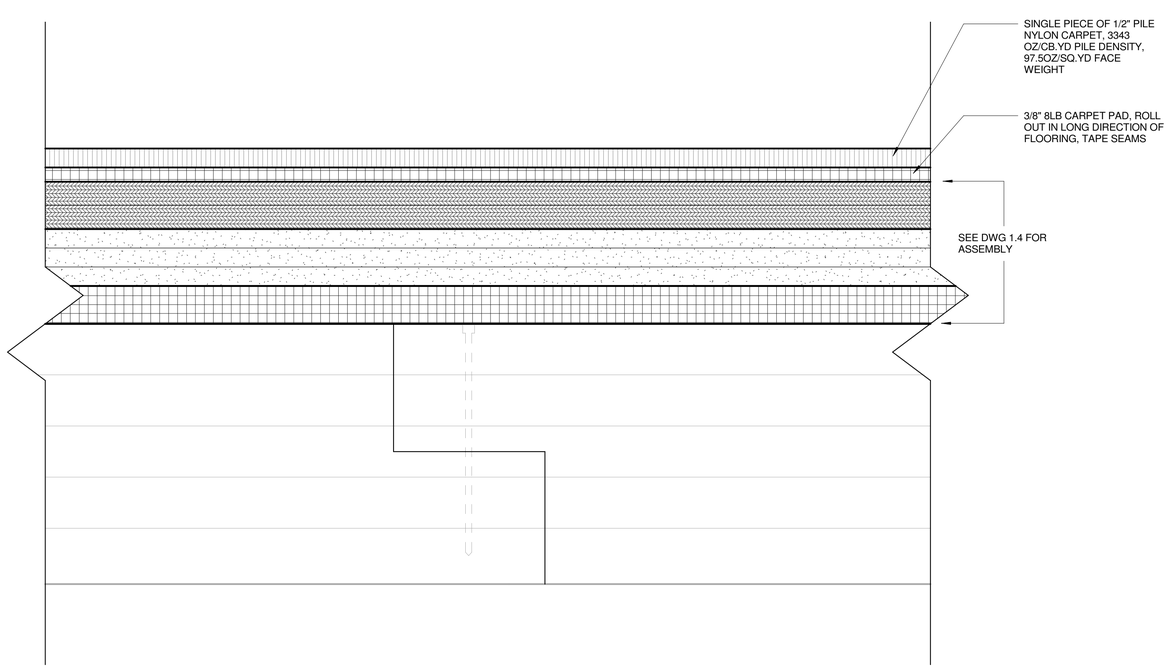
1.3 F04 - 5-LAM BASE CASE CLT SECTION

3" = 1'-0"



1.4 F05 - CEMENT BOARD SECTION

6" = 1'-0"



1.5 F06 - ALTERNATE CARPET ASSEMBLY SECTION

6" = 1'-0"

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Acoustic Lab Testing of Typical Multi-Family Residential CLT Wall and Floor Assemblies

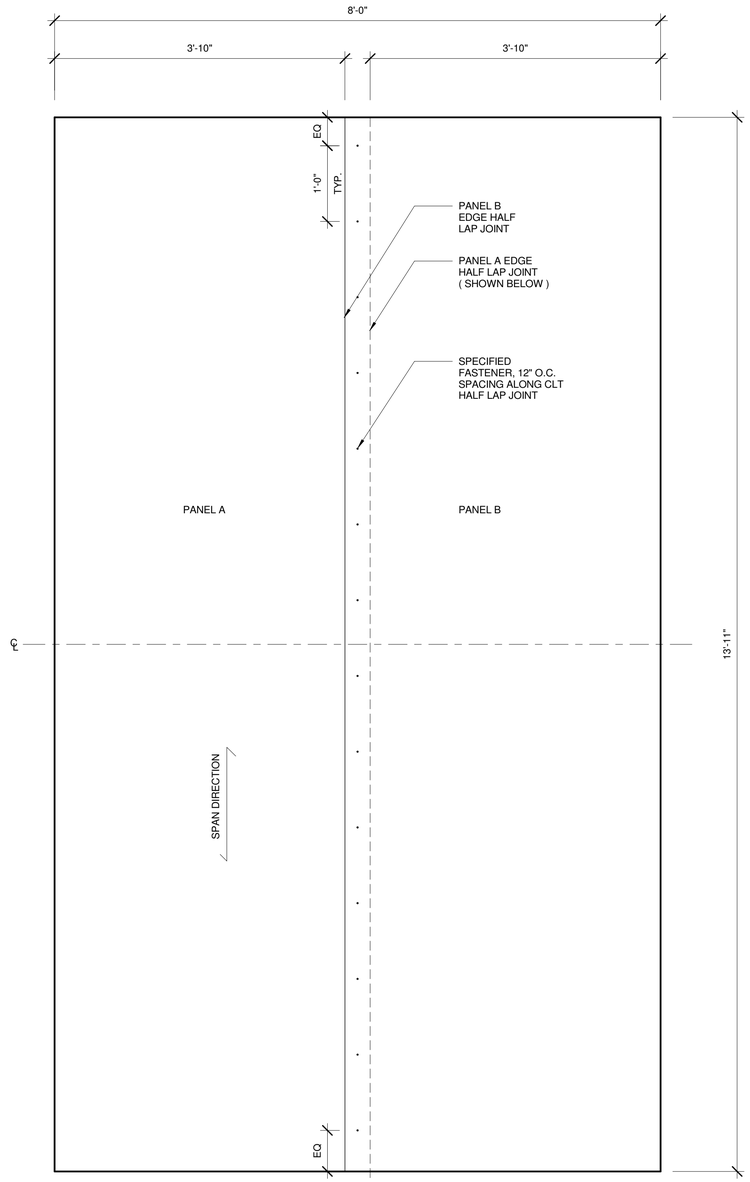
CEMENT BOARD FLOOR SECTIONS

Z.102

SCALE |As indicated

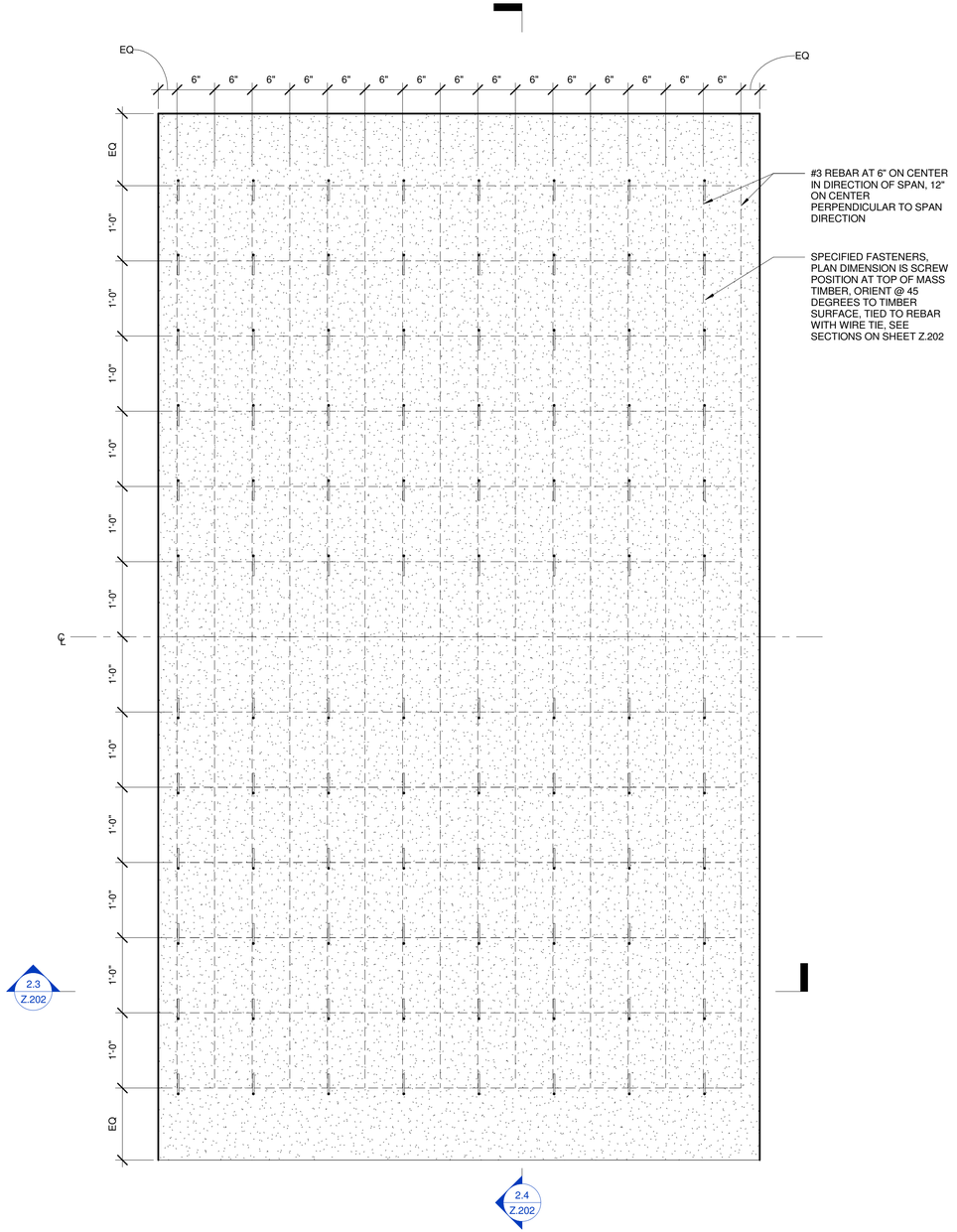
ISSUE DATE | 03.25.2019

AS-BUILT DRAWINGS



2.1 5-LAM BASE CASE CLT PLAN

1" = 1'-0"



2.2 COMPOSITE SLAB W/ STRUCTURAL REBAR REINFORCEMENT PLAN

1" = 1'-0"

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Acoustic Lab Testing of Typical Multi-Family Residential CLT Wall and Floor Assemblies

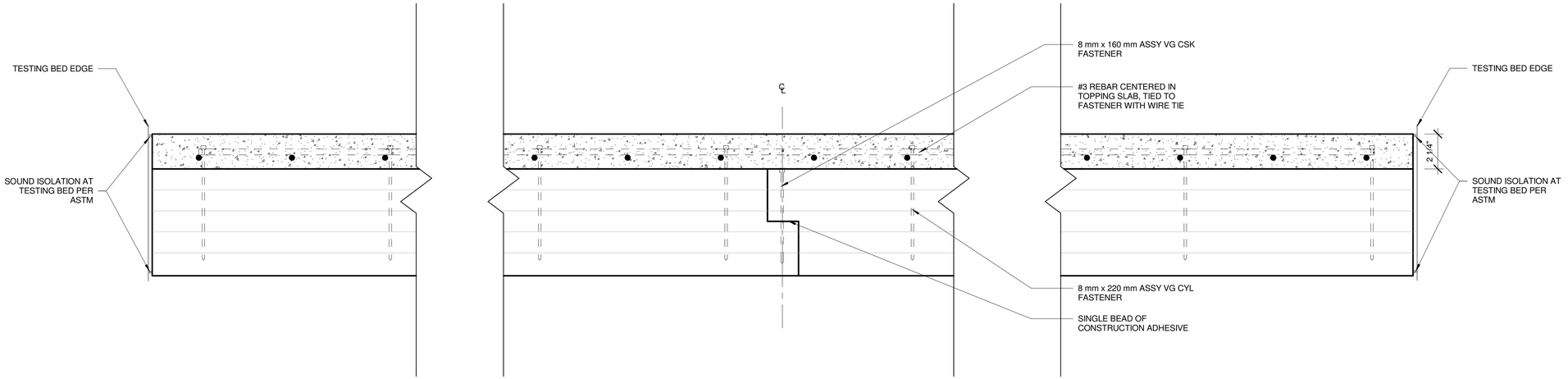
CLT BASE, COMPOSITE ASSEMBLY PLANS

Z.201

SCALE | 1" = 1'-0"

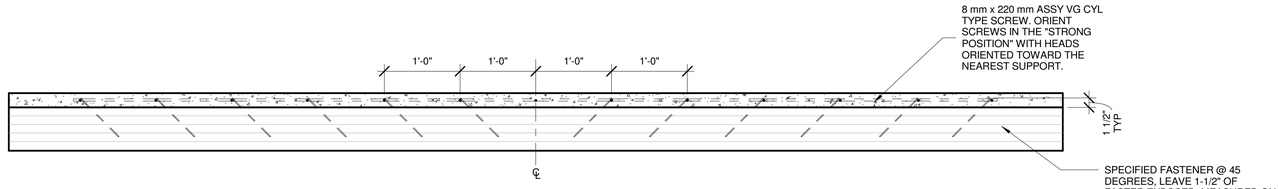
ISSUE DATE | 03.25.2019

AS-BUILT DRAWINGS



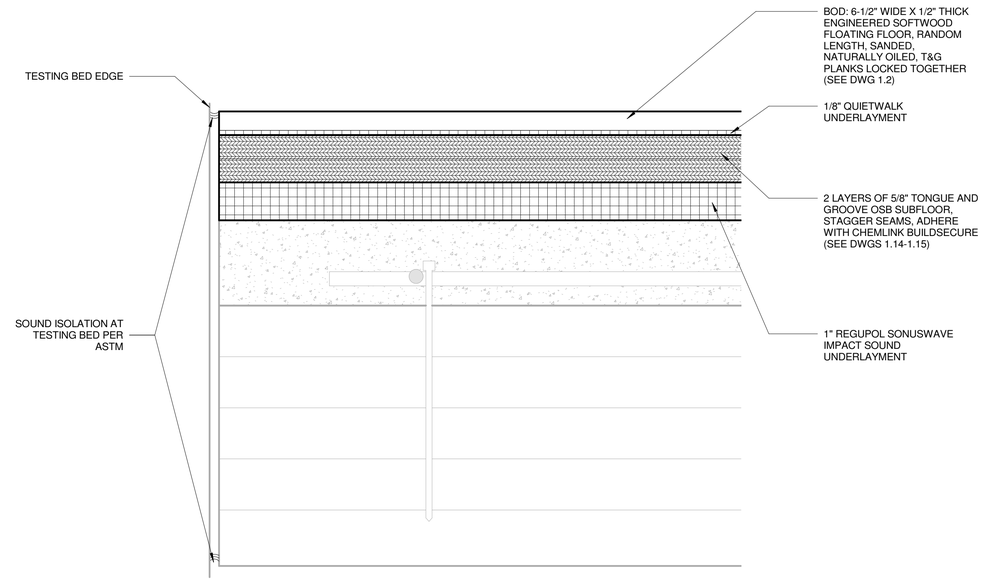
2.3 F01 - COMPOSITE SLAB, LATITUDINAL SECTION

3" = 1'-0"



2.4 F01 - COMPOSITE SLAB, LONGITUDINAL SECTION

1" = 1'-0"



2.5 F03 - ALTERNATE ENGINEERED FLOORING SECTION

6" = 1'-0"

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Acoustic Lab Testing of Typical Multi-Family Residential CLT Wall and Floor Assemblies

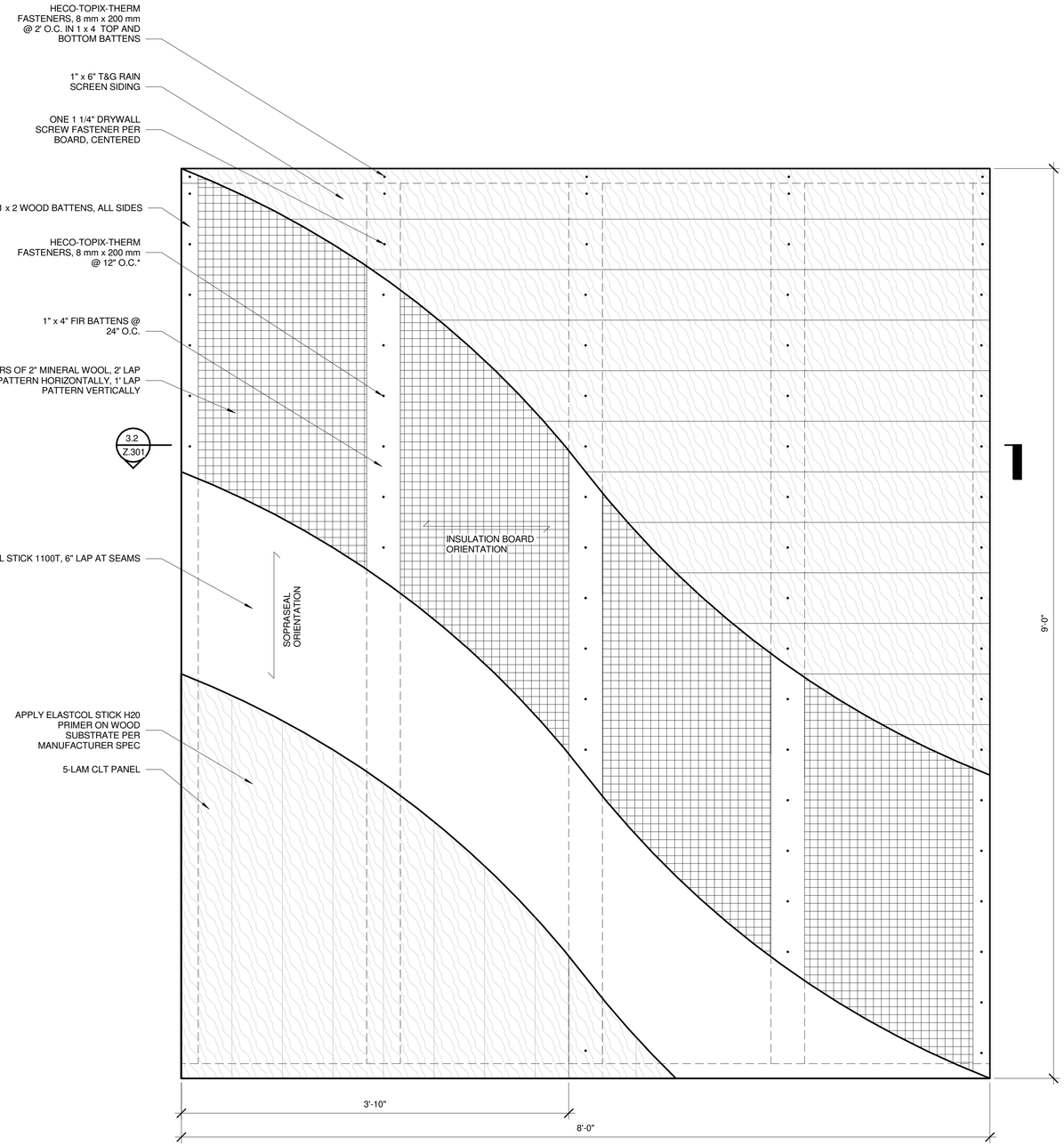
COMPOSITE SLAB FLOOR SECTIONS

Z.202

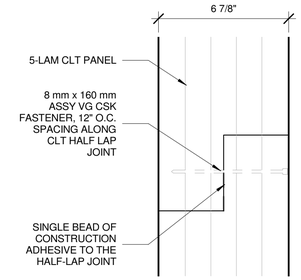
SCALE |As indicated

ISSUE DATE | 03.25.2019

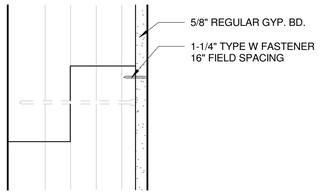
AS-BUILT DRAWINGS



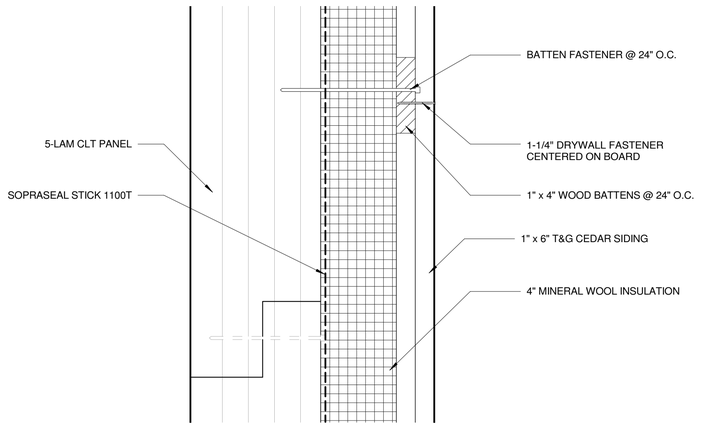
3.1 RAINSCREEN ASSEMBLY PEEL AWAY DIAGRAM
1 1/2" = 1'-0"



W01 W07 - CLT - BASE CASE
3" = 1'-0"



W02 W08 - CLT - SHAFT CASE - PLIN VIEW
3" = 1'-0"



W03 W09 - RAINSCREEN w/o GYP. BD. - PLAN VIEW
3" = 1'-0"

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Acoustic Lab Testing of Typical Multi-Family Residential CLT Wall and Floor Assemblies

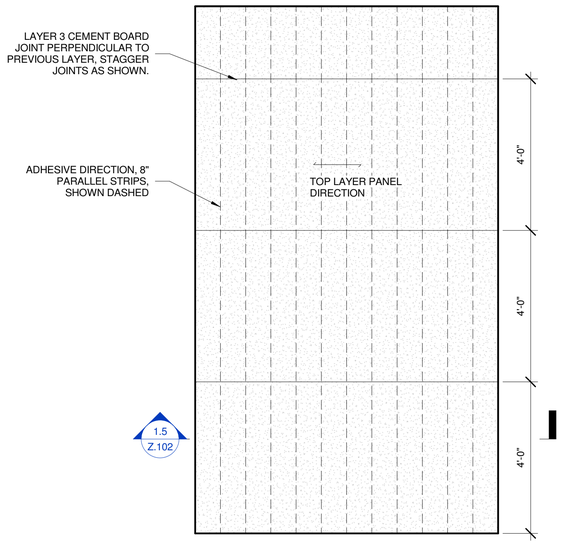
WALL ASSEMBLY, SECTION

Z.301

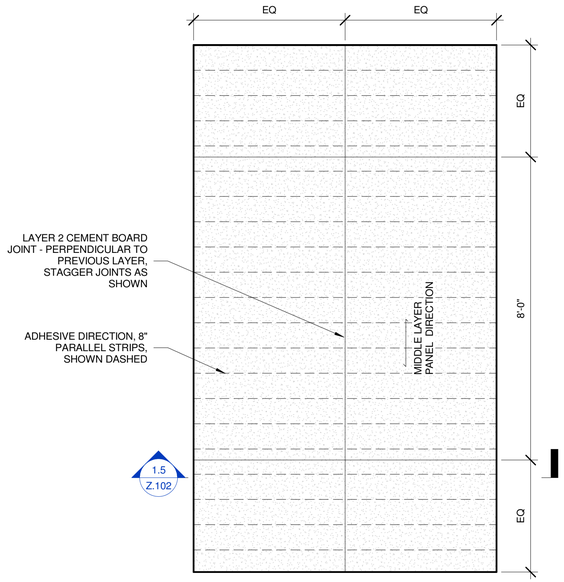
SCALE |As indicated

ISSUE DATE | 03.25.2019

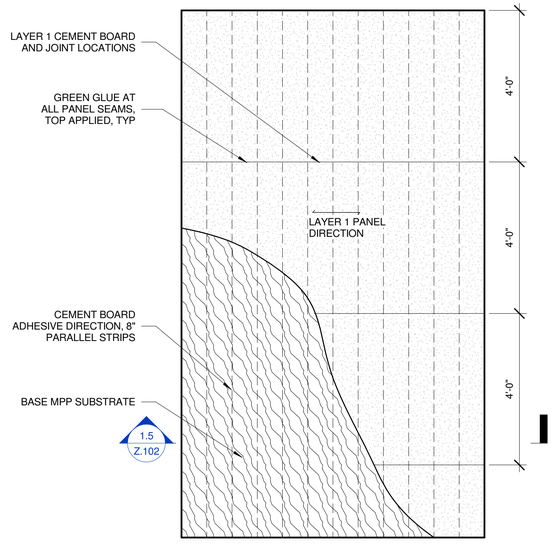
AS-BUILT DRAWINGS



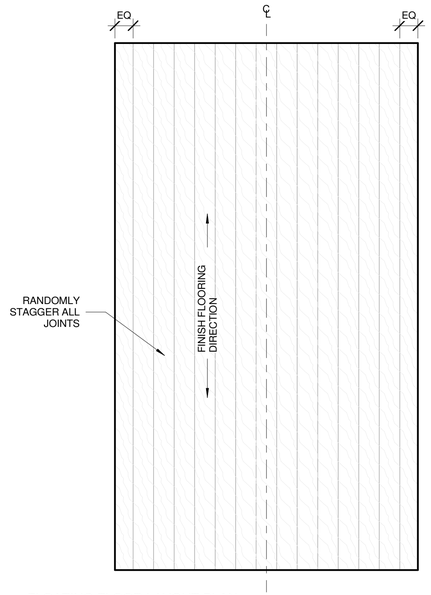
1.13 CEMENT BOARD LAYOUT - LAYER 3
1/2" = 1'-0"



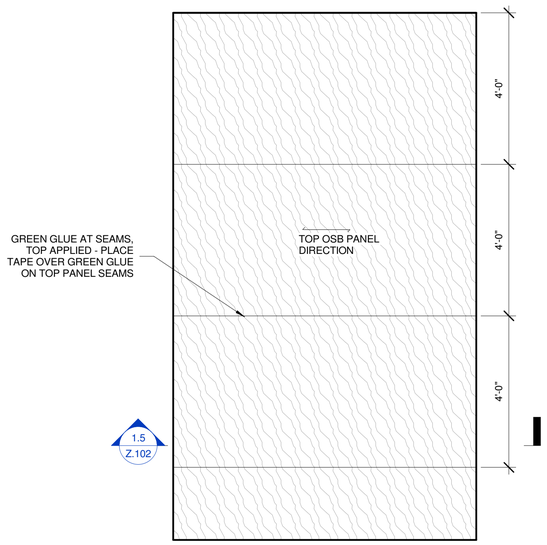
1.12 CEMENT BOARD LAYOUT - LAYER 2
1/2" = 1'-0"



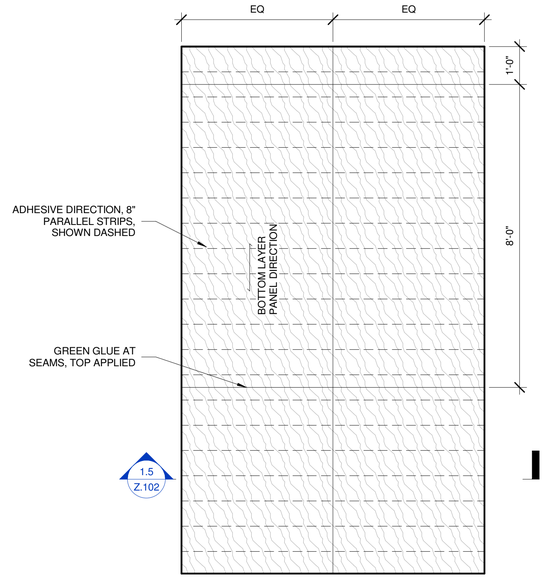
1.11 CEMENT BOARD LAYOUT - LAYER 1
1/2" = 1'-0"



1.2 FLOATING FLOOR LAYOUT PLAN
1/2" = 1'-0"



1.15 OSB LAYOUT - LAYER 2
1/2" = 1'-0"



1.14 OSB LAYOUT - LAYER 1
1/2" = 1'-0"

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Acoustic Lab Testing of Typical Multi-Family Residential MPP Wall and Floor Assemblies

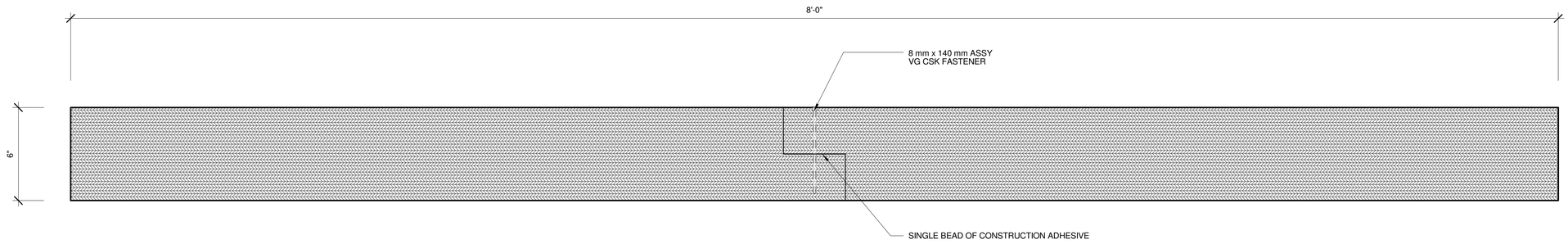
FLOATING FLOOR, CEMENT BOARD PLANS

Z.101

SCALE | 1/2" = 1'-0"

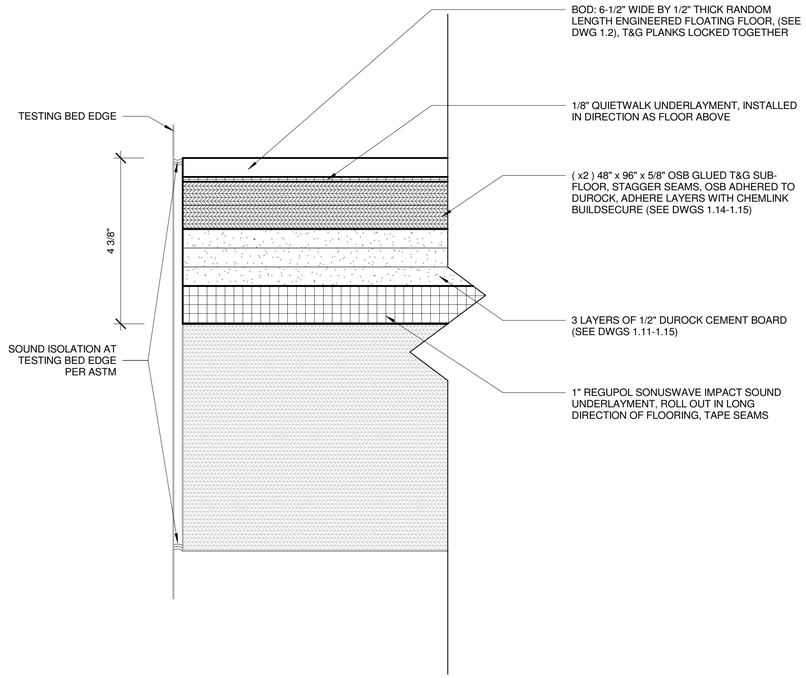
ISSUE DATE | 03.25.2018

AS-BUILT DRAWINGS



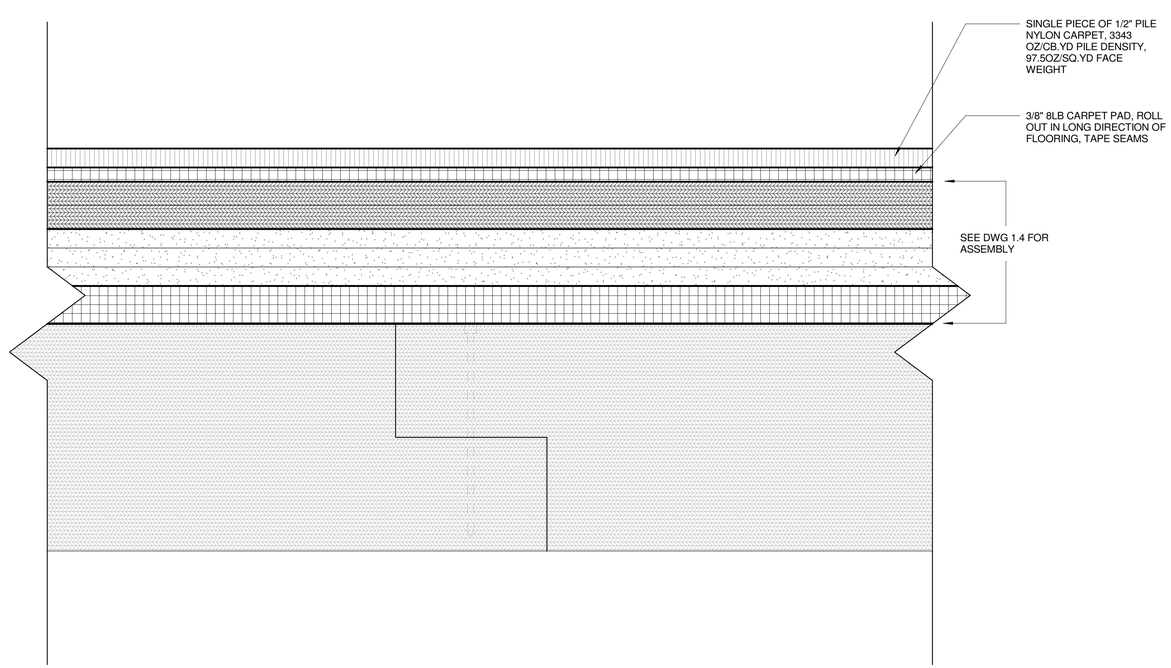
1.3 F04 - 6" MPP BASE CASE SECTION

3" = 1'-0"



1.4 F05 - CEMENT BOARD SECTION

6" = 1'-0"



1.5 F06 - ALTERNATE CARPET ASSEMBLY SECTION

6" = 1'-0"

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Acoustic Lab Testing of Typical Multi-Family Residential MPP Wall and Floor Assemblies

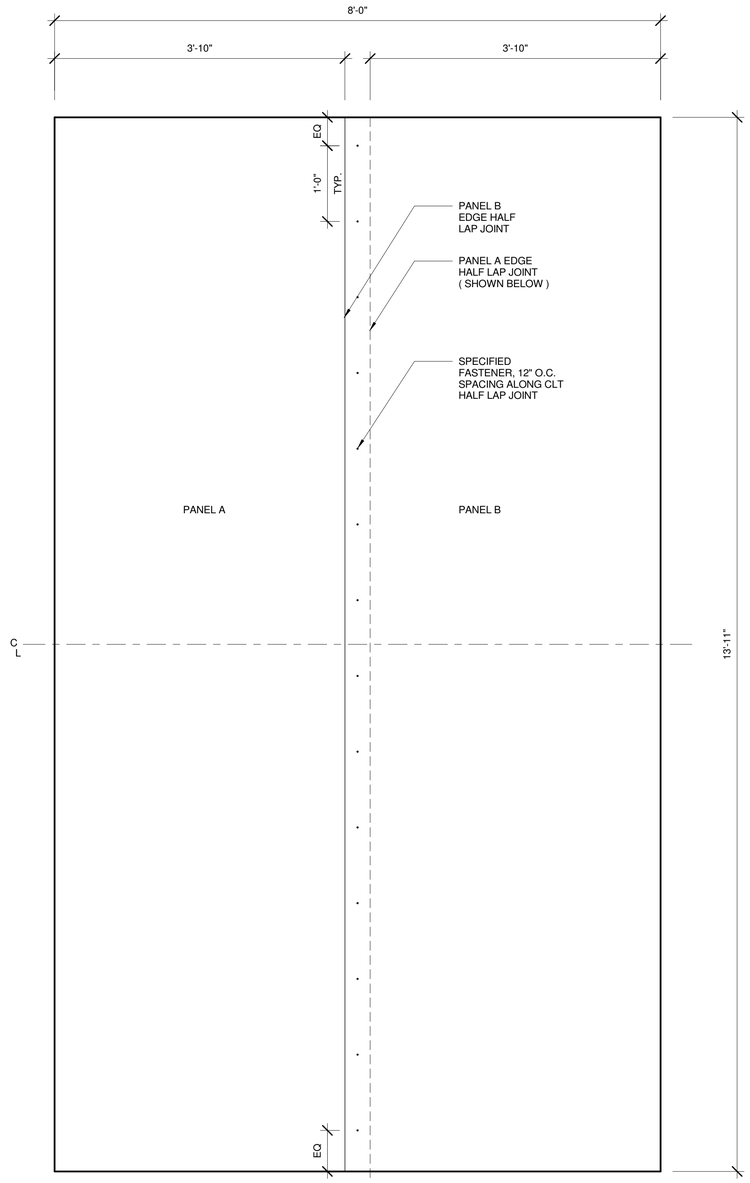
CEMENT BOARD FLOOR SECTIONS

Z.102

SCALE |As indicated

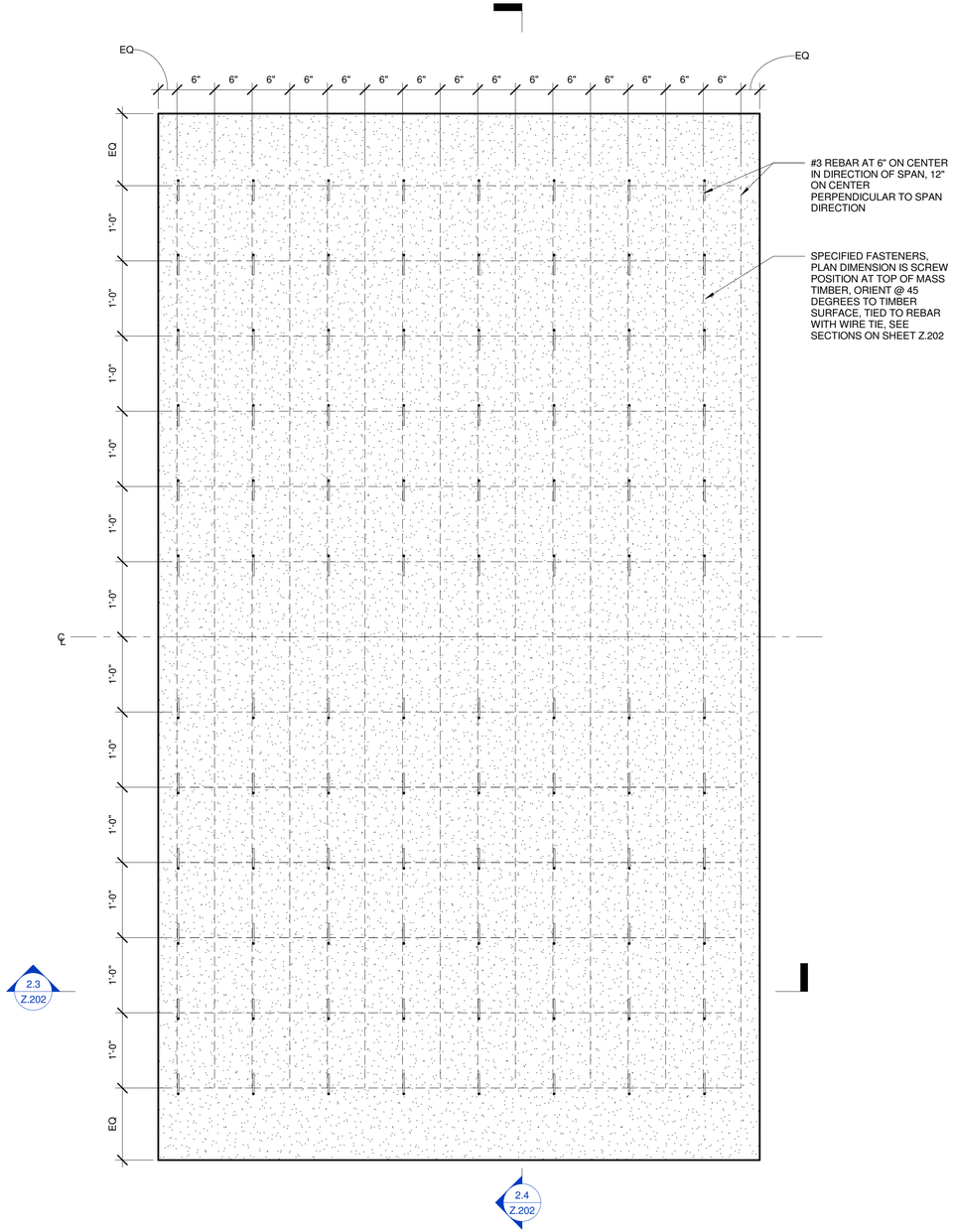
ISSUE DATE | 03.25.2018

AS-BUILT DRAWINGS



2.1 6" MPP BASE CASE PLAN

1" = 1'-0"



2.2 COMPOSITE SLAB W/ STRUCTURAL REBAR REINFORCEMENT PLAN

1" = 1'-0"

3/25/2019 8:40:50 AM

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Acoustic Lab Testing of Typical Multi-Family Residential MPP Wall and Floor Assemblies

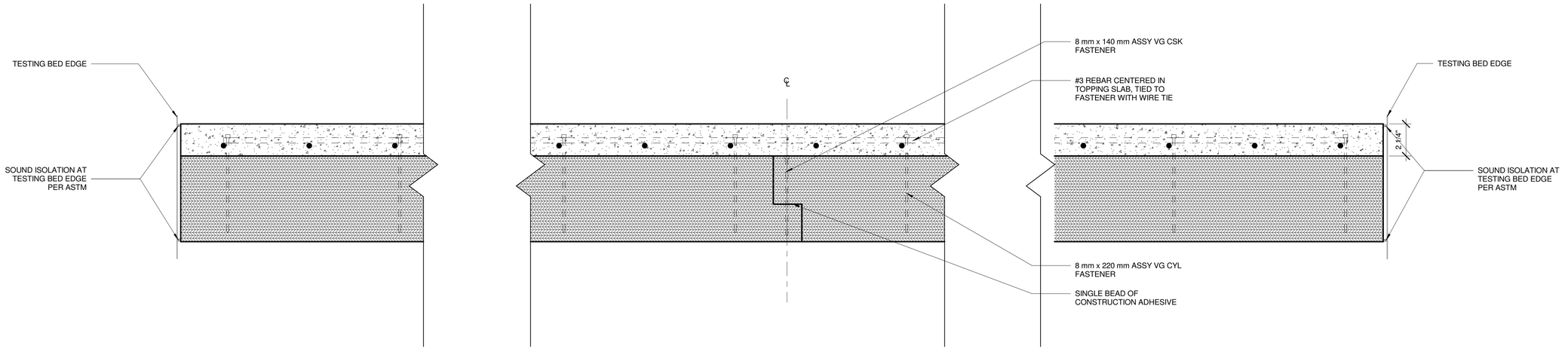
MPP BASE, COMPOSITE ASSEMBLY PLANS

Z.201

SCALE | 1" = 1'-0"

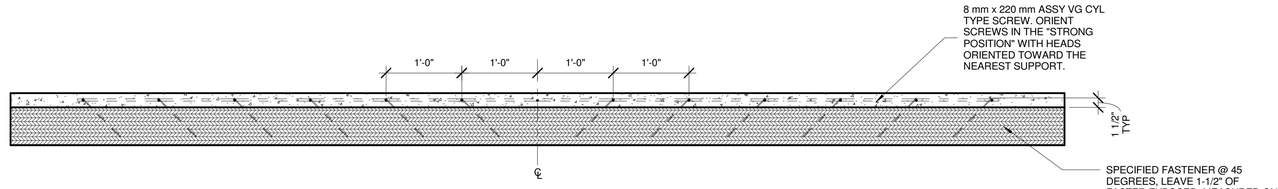
ISSUE DATE | 03.25.2018

AS-BUILT DRAWINGS



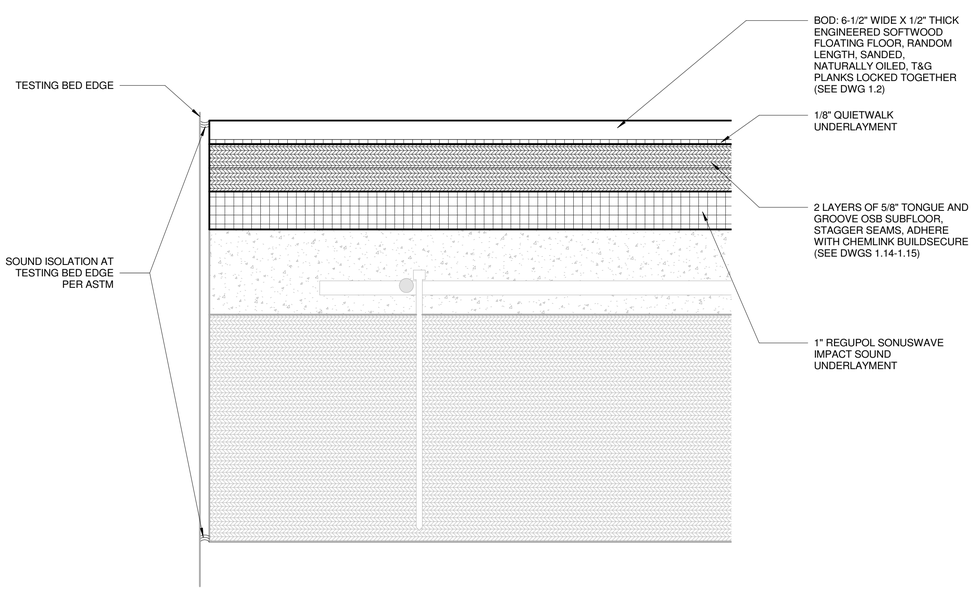
2.3 F01 - COMPOSITE SLAB, LATITUDINAL SECTION

3" = 1'-0"



2.4 F01 - COMPOSITE SLAB, LONGITUDINAL SECTION

1" = 1'-0"



2.5 F03 - ALTERNATE ENGINEERED FLOORING SECTION

6" = 1'-0"

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Primary Contact: Dale Northcutt
p: 541/ 346-0896

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Acoustic Lab Testing of Typical Multi-Family Residential MPP Wall and Floor Assemblies

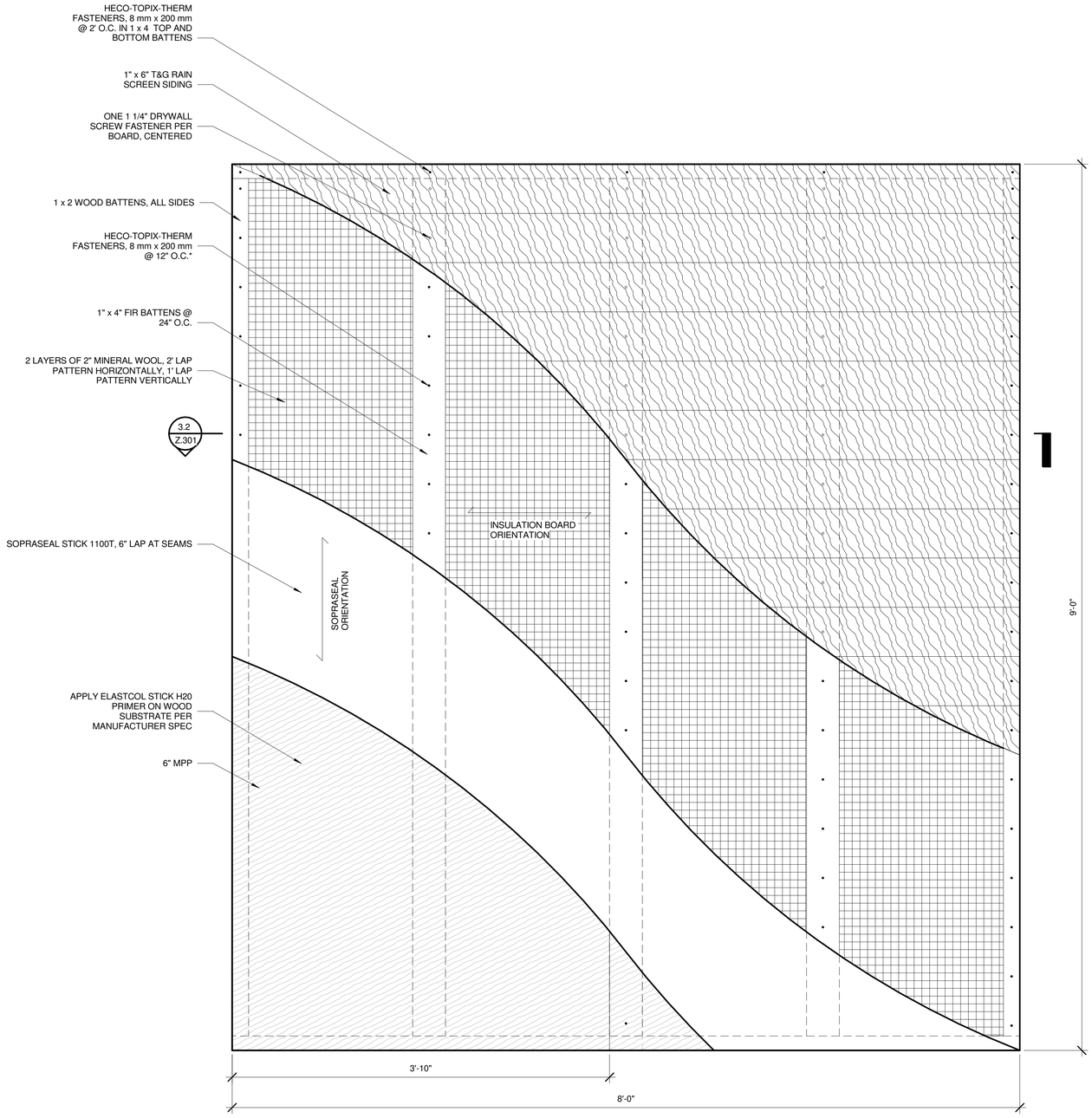
COMPOSITE SLAB FLOOR SECTIONS

Z.202

SCALE |As indicated

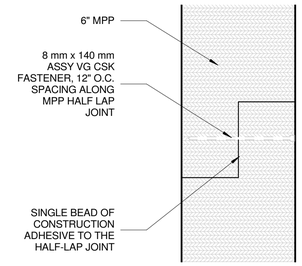
ISSUE DATE | 03.25.2018

AS-BUILT DRAWINGS



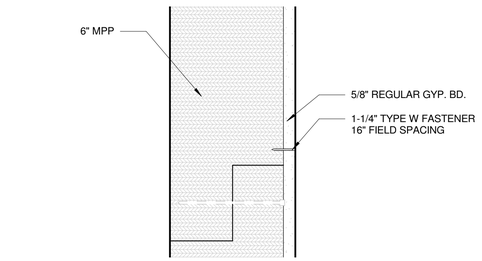
3.1 RAINSCREEN ASSEMBLY PEEL AWAY DIAGRAM

1 1/2" = 1'-0"



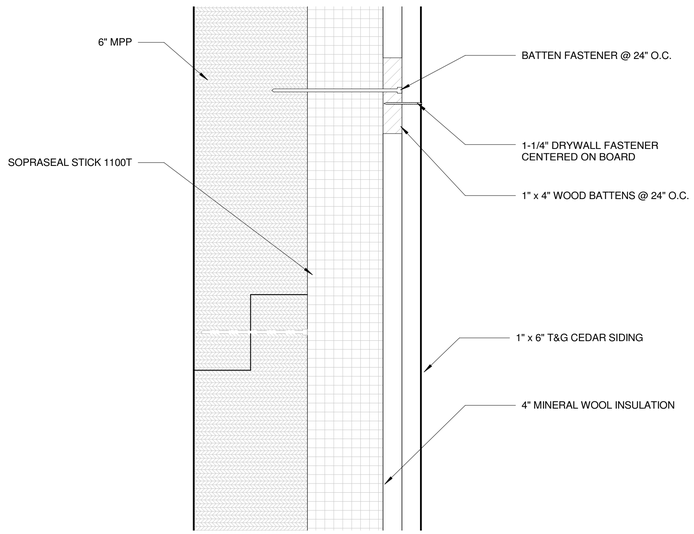
3.2 W07 - MPP BASE CASE - PLAN VIEW

3" = 1'-0"



3.3 W08 - MPP SHAFT CASE - PLAN VIEW

3" = 1'-0"



3.4 W09 - RAINSCREEN w/o GYP. BD. - PLAN VIEW

3" = 1'-0"

3/25/2019 8:40:50 AM

Energy Studies in Buildings Laboratory

UNIVERSITY OF OREGON

ENERGY STUDIES IN BUILDINGS LAB

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Acoustic Lab Testing of Typical Multi-Family Residential MPP Wall and Floor Assemblies

WALL ASSEMBLY, SECTION

Z.301

SCALE |As indicated

ISSUE DATE | 03.25.2018

AS-BUILT DRAWINGS

6.7 RIVERBANK LABORATORY FLOOR REPORTS

F01 - CLT STRUCTURAL COMPOSITE FLOOR ASSEMBLY - RIVERBANK LABORATORY REPORT - STC

Unofficial Test Results & Preliminary Data Sheet

Riverbank Acoustical Laboratories (RAL)™

Laboratory Measurement of Airborne Sound Transmission Loss per ASTM E-90

Test Number: TL19-070 Test Date: 3/22/2019

Sponsor: University of Oregon

Designation: F01 - 2 1/4" Concrete Slab, 5 lam CLT (No Ceiling)

Dimensions: 2.44 m x 4.27 m x 0.23 m Test Conducted By: Marc Sciaky

Area: 10.41 m² Test Interface: 1.3.3

Weight: 4.06 kg Area Weight: 0.39 kg/m²

Specimen Details:

Source Room: Room 3 Volume: 131.5 m³ Surface Area: 174.8 m²

Receive Room: Room 4 Volume: 81.8 m³ Surface Area: 130.7 m²

Freq (Hz)	TL (dB)	Precision (dB)	Deficiencies (dB)
31.5	44	3.72	
40	40	1.42	
50	40	1.12	
63	28	1.16	
80	37	0.68	
100	37	0.34	
125	40	0.63	
160	38	0.78	
200	37	0.34	2
250	37	0.26	5
315	39	0.32	6
400	41	0.29	7
500	44	0.20	5
630	47	0.17	3
800	49	0.18	2
1000	51	0.13	1
1250	54	0.15	
1600	56	0.12	
2000	57	0.12	
2500	61	0.13	
3150	64	0.11	
4000	66	0.07	
5000	67	0.06	
6300	71	0.10	
8000	70	0.12	
10000	61	0.14	
12500	49	0.14	

Sound Transmission Coefficient (STC): 49

Total Deficiencies: 31

OITC: 43

Calculation Date: 3/22/2019

Calculated By: Marc Sciaky

This single report page and accompanying graph contain the instantaneous raw data as provided to the client after testing of the specimen. This data, although accurate, is incomplete without the full specimen description, mounting details and signature pages. The full report referenced by the RAL test number above should be consulted for further information regarding these results.

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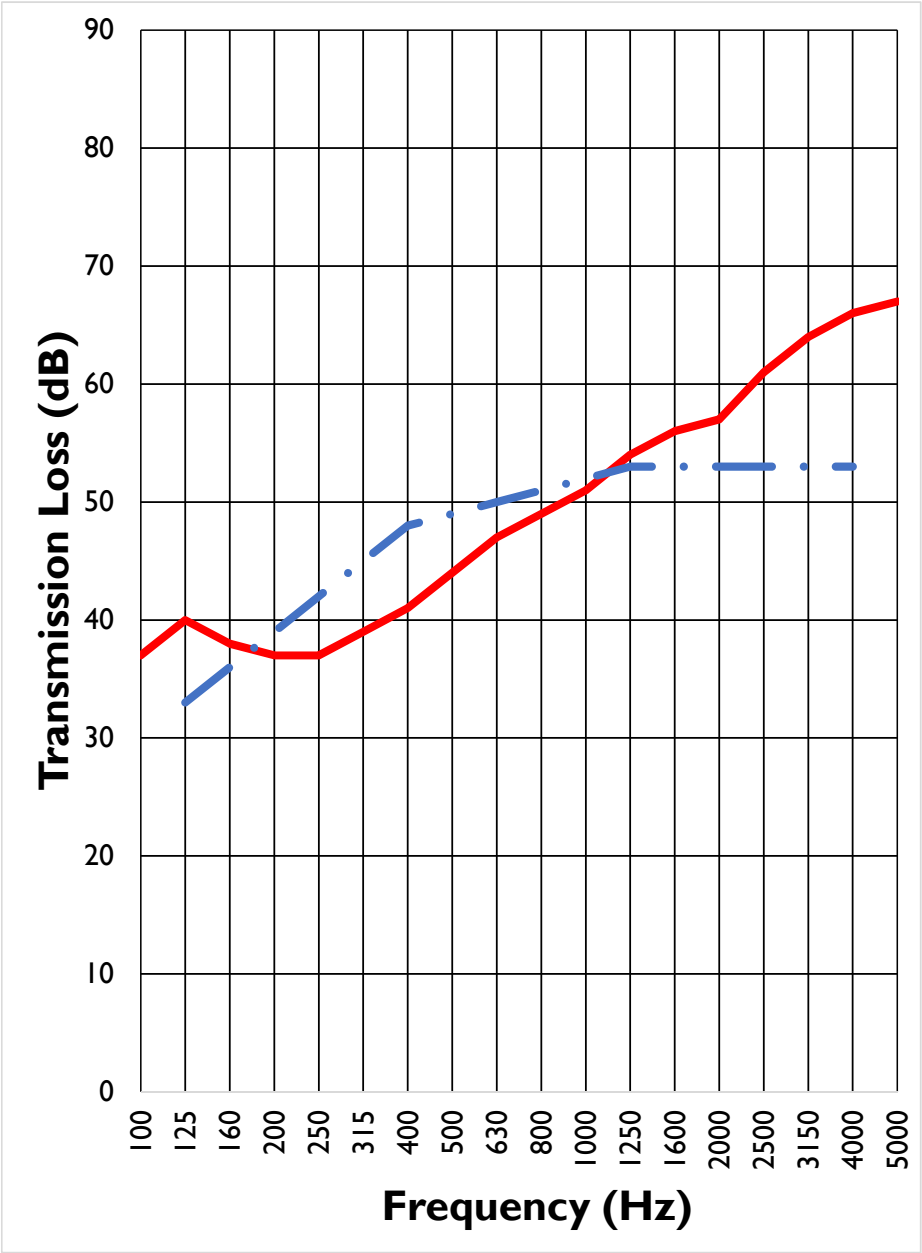
SOUND TRANSMISSION RESULTS

F01 - 2 1/4" Concrete Slab, 5 lam CLT (No Ceiling)

TL19-070



STC = 49

TOTAL DEFICIENCIES = 31

F01 - CLT STRUCTURAL COMPOSITE FLOOR ASSEMBLY - RIVERBANK LABORATORY REPORT - IIC

Unofficial Test Results & Preliminary Data Sheet

Riverbank Acoustical Laboratories (RAL)™ / An Alion Science Technical Center (RALVer 15.2)
Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions ASTM E 90-09/NVLAP 08/P06

Test Number: IN19-015 Test Date: 3/22/2019
Sponsor: University of Oregon
Designation: F01 - 2 1/4" Concrete Slab, 5 lam CLT (No Ceiling)

Dimensions: 2.44 m x 4.27 m x 0.23 m Test Conducted By: Marc Sciaky
Area: 10.41 m² Test Interface: 1.3.3
Weight: 4.06 kg Area Weight: 0.39 kg/m²
Specimen Details:

Source Room: Room 3 Volume: 131.5 m³ Surface Area: 174.8 m²
Receive Room: Room 4 Volume: 81.8 m³ Surface Area: 130.7 m²

Freq (Hz)	nISPL (dB)	ΔLn (dB)	Deficiencies (dB)
31.5	57	8.41	
40	54	3.62	
50	56	1.08	
63	64	3.94	
80	63	4.39	
100	63	2.42	
125	61	1.35	
160	63	1.27	
200	67	1.35	
250	70	0.60	
315	74	1.95	
400	76	1.68	
500	76	1.72	
630	77	2.03	
800	78	1.68	
1000	79	1.91	
1250	80	1.38	
1600	81	1.33	2
2000	81	0.83	5
2500	80	0.80	7
3150	78	1.08	8
4000	77	1.34	
5000	75	1.81	
6300	68	2.49	
8000	59	3.72	
10000	47	3.71	
12500	37	4.07	

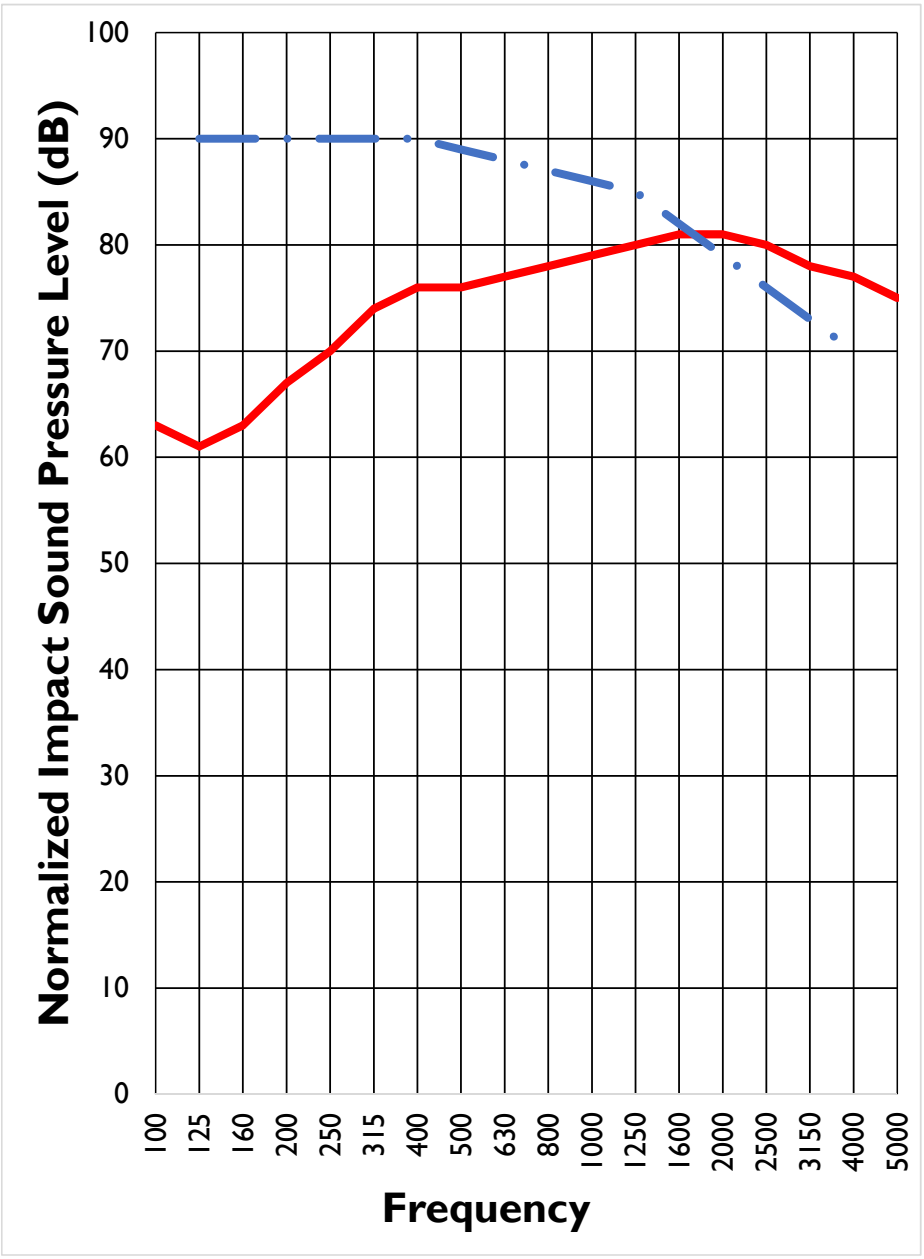
Impact Insulation Class (IIC): 22
Total Deficiencies: 22

Calculation Date: 3/22/2019
Calculated By: Marc Sciaky

This single report page and accompanying graph contain the instantaneous raw data as provided to the client after testing of the specimen. This data, although accurate, is incomplete without the full specimen description, mounting details and signature pages. The full report referenced by the RAL test number above should be consulted for further information regarding these results.

SOUND TRANSMISSION RESULTS

IN19-015



IIC = 22

TOTAL DEFICIENCIES = 22

F01 - MPP STRUCTURAL COMPOSITE FLOOR ASSEMBLY - RIVERBANK LABORATORY REPORT - STC

F01 - MPP STRUCTURAL COMPOSITE FLOOR ASSEMBLY - RIVERBANK LABORATORY REPORT - IIC

F03 - CLT STRUCTURAL COMPOSITE FLOOR ASSEMBLY - RIVERBANK LABORATORY REPORT - STC

Unofficial Test Results & Preliminary Data Sheet

Riverbank Acoustical Laboratories (RAL)™
Laboratory Measurement of Airborne Sound Transmission Loss per ASTM E-90

Test Number: TL19-071 Test Date: 2019-03-22
Sponsor: University of Oregon
Designation: F03 - Admonter Pine engineered Floor,1/8" underlayment, 2layers OSB, 1" underlayment, 5 lam CLT (No Ceiling)
Dimensions: 2.44 m x 4.27 m x 0.31 m Test Conducted By: Marc Sciaky
Area: 10.41 m² Test Interface: 1.3.3
Weight: 2858.88 kg Area Weight: 274.76 kg/m²
Specimen Details:

Source Room: Room 3 Volume: 130.7 m³ Surface Area: 174.8 m²
Receive Room: Room 4 Volume: 81.8 m³ Surface Area: 130.7 m²

Freq (Hz)	TL (dB)	Precision (dB)	Deficiencies (dB)
31.5	38	2.18	
40	39	1.12	
50	36	1.51	
63	32	0.87	
80	34	0.70	
100	35	0.61	
125	41	0.75	2
160	42	0.48	4
200	45	0.38	4
250	45	0.22	7
315	48	0.20	7
400	54	0.33	4
500	59	0.15	
630	65	0.25	
800	68	0.18	
1000	71	0.15	
1250	75	0.14	
1600	78	0.10	
2000	81	0.15	
2500	84	0.11	
3150	89	0.35	
4000	90	0.06	
5000	86	0.07	
6300	79	0.12	
8000	70	0.21	
10000	60	0.18	
12500	47	0.30	

Sound Transmission Coefficient (STC): 59
Total Deficiencies: 28

OITC: 47

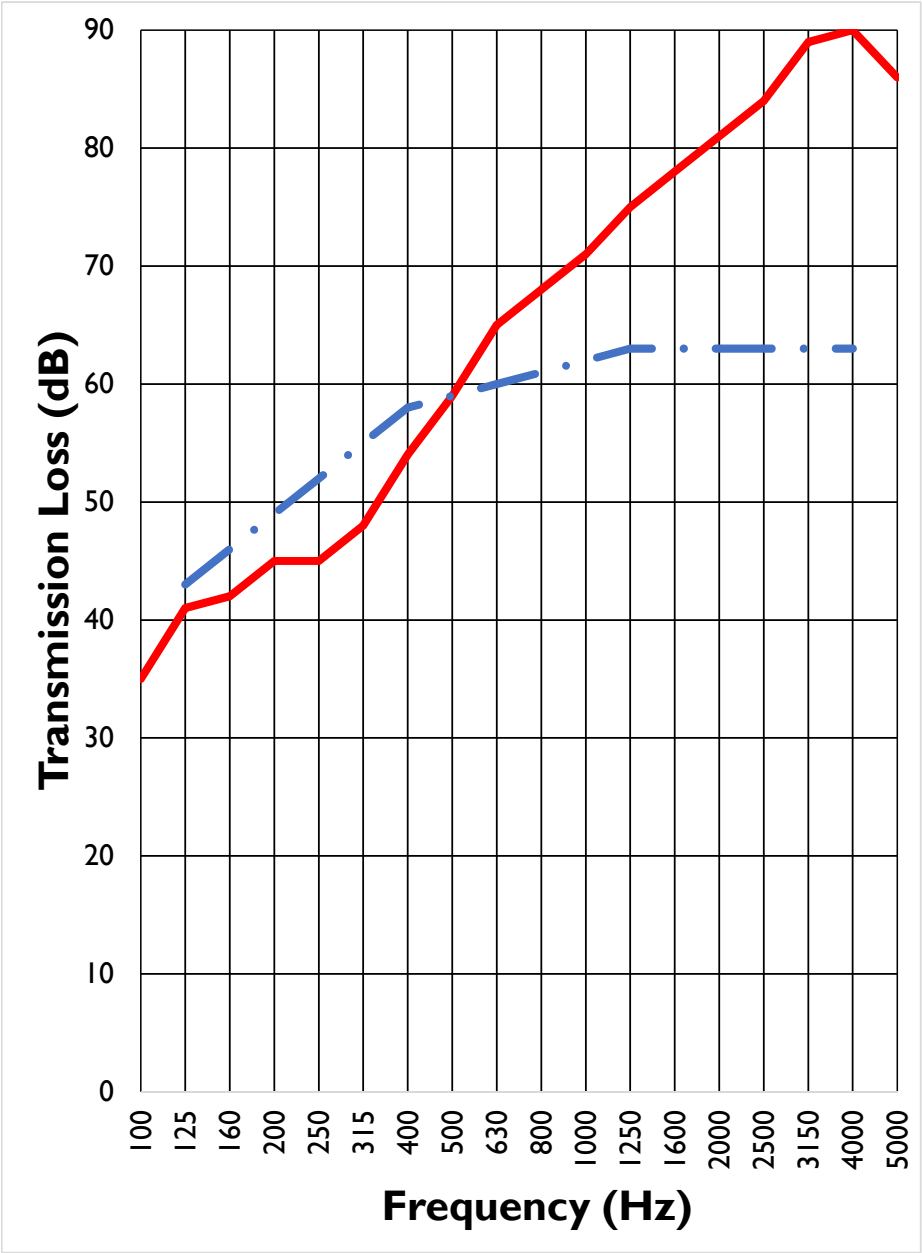
Calculation Date: 2019-03-22
Calculated By: Marc Sciaky

This single report page and accompanying graph contain the instantaneous raw data as provided to the client after testing of the specimen. This data, although accurate, is incomplete without the full specimen description, mounting details and signature pages. The full report referenced by the RAL test number above should be consulted for further information regarding these results.

SOUND TRANSMISSION RESULTS

F03 - Admonter Pine engineered Floor,1/8" underlayment, 2layers OSB, 1" underlayment, 5 lam CLT (No Ceiling)

TL19-071



STC = 59

TOTAL DEFICIENCIES = 28

F03 - CLT STRUCTURAL COMPOSITE FLOOR ASSEMBLY - RIVERBANK LABORATORY REPORT - IIC

Unofficial Test Results & Preliminary Data Sheet

Riverbank Acoustical Laboratories (RAL)™ / An Alion Science Technical Center (RALVer 15.2)

Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions ASTM E 90-09/NVLAP 08/P06

Test Number: IN19-016 Test Date: 2019-03-22

Sponsor: University of Oregon

Designation: F03 - Admonter Pine engineered Floor,1/8" underlayment, 2layers OSB, 1" underlayment, 5 lam CLT (No Ceiling)

Dimensions: 2.44 m x 4.27 m x 0.31 m Test Conducted By: Marc Sciaky

Area: 10.41 m² Test Interface: 1.3.3

Weight: 2858.88 kg Area Weight: 274.76 kg/m²

Specimen Details:

Source Room: Room 3 Volume: 130.7 m³ Surface Area: 174.8 m²

Receive Room: Room 4 Volume: 81.8 m³ Surface Area: 130.7 m²

Freq (Hz)	nISPL (dB)	ΔLn (dB)	Deficiencies (dB)
31.5	59	7.65	
40	51	3.00	
50	56	3.03	
63	61	4.04	
80	65	4.24	
100	68	1.82	8
125	61	1.80	1
160	63	1.39	3
200	62	1.67	2
250	59	2.23	
315	59	2.27	
400	55	2.86	
500	48	3.58	
630	41	1.47	
800	40	1.63	
1000	36	1.93	
1250	29	1.80	
1600	22	1.73	
2000	17	2.39	
2500	12	3.07	
3150	7	2.31	
4000	4	0.85	
5000	7	0.64	
6300	6	0.80	
8000	8	1.02	
10000	12	1.63	
12500	9	1.68	

Impact Insulation Class (IIC): 52

Total Deficiencies: 14

Calculation Date: 2019-03-22

Calculated By: Marc Sciaky

This single report page and accompanying graph contain the instantaneous raw data as provided to the client after testing of the specimen. This data, although accurate, is incomplete without the full specimen description, mounting details and signature pages. The full report referenced by the RAL test number above should be consulted for further information regarding these results.

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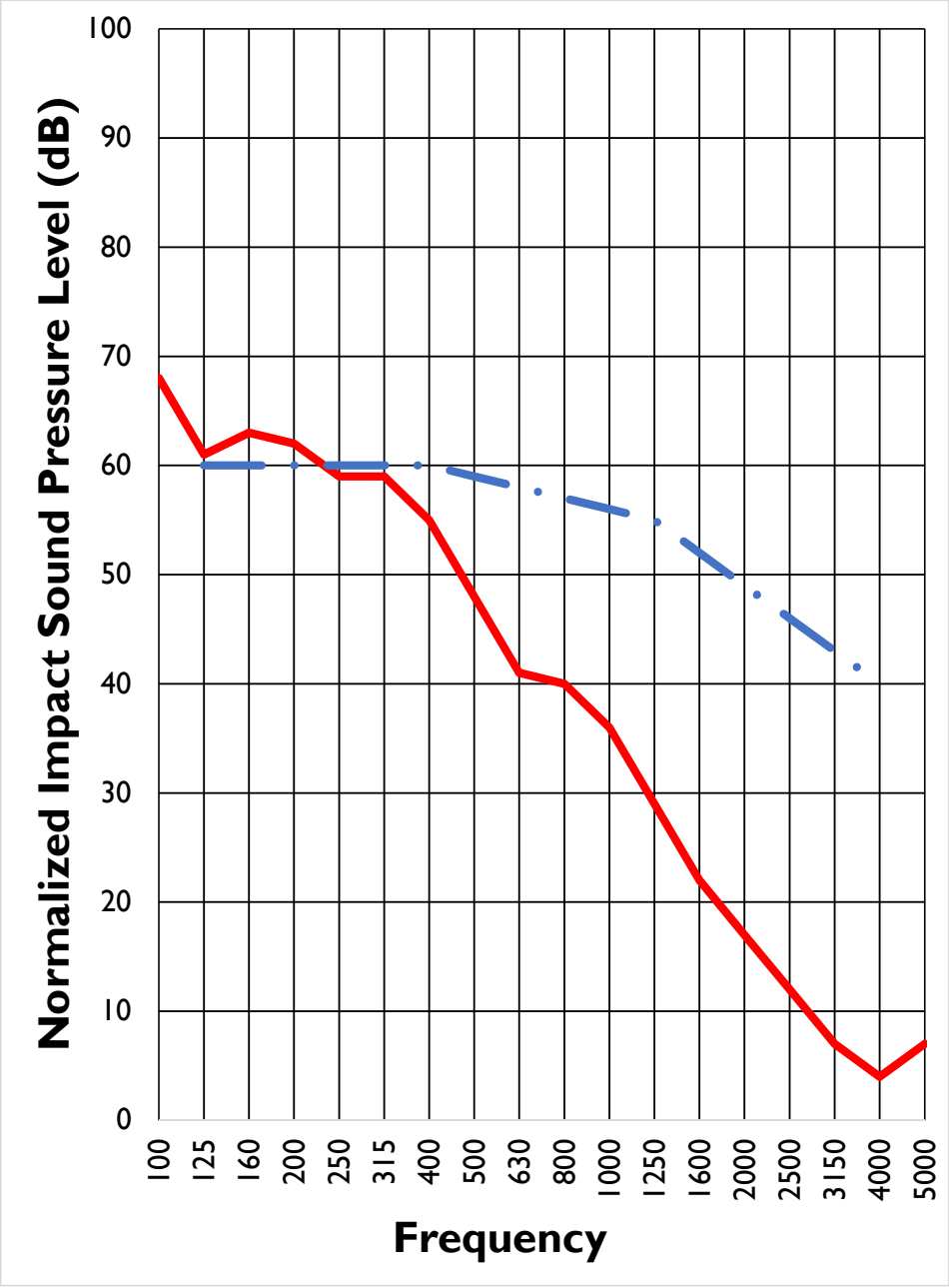
SOUND TRANSMISSION RESULTS

IN19-016



IIC = 52

TOTAL DEFICIENCIES = 14

F03 - MPP STRUCTURAL COMPOSITE FLOOR ASSEMBLY - RIVERBANK LABORATORY REPORT - STC

F03 - MPP STRUCTURAL COMPOSITE FLOOR ASSEMBLY - RIVERBANK LABORATORY REPORT - IIC

F04 - CLT BASE CASE MASS TIMBER PANEL - RIVERBANK LABORATORY REPORT - STC

RIVERBANK ACOUSTICAL LABORATORIES

1512 S BATAVIA AVENUE
GENEVA, IL 60134
630-232-0104

An ALION Technical Center

Test Report

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SPONSOR: **University of Oregon**
Eugene, OR

Sound Transmission Loss
RAL™-TL19-033

CONDUCTED: 2019-02-18

ON: Floor F04 - cross-laminated timber panels

TEST METHODOLOGY

Riverbank Acoustical Laboratories™ is accredited by the U.S. Department of Commerce, National Institute of Standards and Technology (NIST) under the National Voluntary Laboratory Accreditation Program (NVLAP) as an ISO 17025:2005 Laboratory (NVLAP Lab Code: 100227-0) and for this test procedure. The test reported in this document conformed explicitly with ASTM E90-09 (2016): "Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements." The single number rating of the specimen was calculated according to ASTM E413-16: "Classification for Rating Sound Insulation." A description of the measurement procedure and room specifications is available upon request. The transmission loss values are for a single direction of measurement. The results presented in this report apply to the sample as received from the test sponsor.

INFORMATION PROVIDED BY SPONSOR

The test specimen was designated by the sponsor as Floor F04 - cross-laminated timber panels. The following nominal product information was provided by the sponsor prior to testing. The accuracy of such sponsor-provided information can affect the validity of the test results.

Product Under Test

Materials:	Cross-laminated timber panels, 5 layers
Manufacturer:	Tallwood Design Institute
Construction Designation:	F04

SPECIMEN CONSTRUCTION & TEST CONDITIONS

The building contractor and RAL staff compiled the following construction specification, in order of installation:

Test Specimen

Dimensions:	2 @ 4241.8 mm (167 in.) x 1270 mm (50 in.)
Thickness:	174.62 mm (6.875 in.)
Joint:	Shiplap joint, 101.6 mm (4 in.) wide x 85.72 mm (3.375 in.) tall
Installation:	Panel ends brushed with Seal Once Nano-guard wood sealer prior to laying in test opening 6.35 mm (0.25 in.) diameter bead of Chemlink Build Secure adhesive along center of joint Panels screwed together through joint

F04 - CLT BASE CASE MASS TIMBER PANEL - RIVERBANK LABORATORY REPORT - STC

Test Specimen (continued)

Fasteners:	ASSY VG CSK screws, 8 mm (0.315 in.) x 160 mm (6.299 in.)
Fastener Spacing:	304.8 mm (12 in.) on center, 15 fasteners total
Weights:	Panels @ 977.04 kg (2154 lbs)
	Adhesive @ 0.23 kg (0.5 lbs)
	Fasteners @ 0.57 kg (1.25 lbs)

Overall Specimen Measurements

Dimensions:	2.44 m (96.0 in) wide by 4.27 m (168.0 in) high
Thickness:	0.17 m (6.875 in)
Weight:	977.83 kg (2155.75 lbs)
Transmission Area:	10.405 m² (112 ft²)
Mass per Unit Area:	93.98 kg/m² (19.25 lbs/ft²)

Test Aperture

Size:	4.27 m (14.0 ft) x 2.44 m (8.0 ft)
Filler Wall:	None
Sealed:	Source Side: Dense mastic seal around perimeter
	Received Side: ½" or 3/8" Backer Rod (by gap size), acoustical caulk applied full perimeter, then gap above filled to level with sand around full perimeter.

Test Environment

Source Room

Volume:	132.08 m³
Temperature:	21.7 °C ± 0.0 °C
Relative Humidity:	50.5 % ± 1.0 %

Receive Room

Volume:	81.81 m³
Temperature:	22.8 °C ± 0.0 °C
Relative Humidity:	52.0 % ± 0.0 %

Requirements

Temperature:	22° C +/- 2° C, not more than 3° C change over all tests.
Relative Humidity:	≥ 30%, not more than +/- 3% change over all tests.

NVLAP TESTING
NVLAP LAB CODE 100227-0

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F04 - CLT BASE CASE MASS TIMBER PANEL - RIVERBANK LABORATORY REPORT - STC

Figure 1 – Specimen mounted in test opening, as viewed from source room

Figure 2 – Underside of specimen, as viewed from receive room

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University of Oregon
2019-02-18

Figure 3 – Individual cross-laminated timber panel

Figure 4 – Panel laid in test opening

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Figure 5 – Adhesive at shiplap joint

Figure 6 – Fasteners at joint

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RAL™-TL19-033

TEST RESULTS

Sound transmission loss values are tabulated at the eighteen standard frequencies. A graphic presentation of the data and additional information appear on the following pages. The precision of the transmission loss test data is within the limits set by the ASTM Standard E90-09 (2016).

FREQ.	TL	ΔTL	DEF.	FREQ.	TL	ΔTL	DEF.
100	32	0.66	0	800	43	0.21	2
125	32	0.91	0	1000	46	0.21	0
160	32	0.44	0	1250	48	0.15	0
200	31	0.42	2	1600	50	0.12	0
250	32	0.44	4	2000	52	0.14	0
315	33	0.21	6	2500	53	0.12	0
400	34	0.33	8	3150	51	0.13	0
500	38	0.19	5	4000	49	0.08	0
630	40	0.20	4	5000	50	0.15	0

STC=43

ABBREVIATION INDEX

FREQ. = FREQUENCY, HERTZ
TL = TRANSMISSION LOSS, dB
ΔTL = 95% CONFIDENCE INTERVAL FOR TL MEAUREMENTS, dB
DEF. = DEFICIENCIES, dB BELOW STC CONTOUR (SUM OF DEF = 31)
STC = SOUND TRANSMISSION CLASS

Tested by _____
Marc Sciaky
Senior Experimentalist

Report by _____
Malcolm Kelly
Acoustician

Approved by _____
Eric P. Wolfram
Laboratory Manager

Digitally signed by Eric P Wolfram
DN: cn=Eric P Wolfram, o=Alion Science & Technology, ou=Riverbank Acoustical Laboratories, email=ewolfram@alionscience.com, c=US
Date: 2019.03.25 17:07:02 -05'00'

NVLAP TESTING
NVLAP LAB CODE 100227-0

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F04 - CLT BASE CASE MASS TIMBER PANEL - RIVERBANK LABORATORY REPORT - STC

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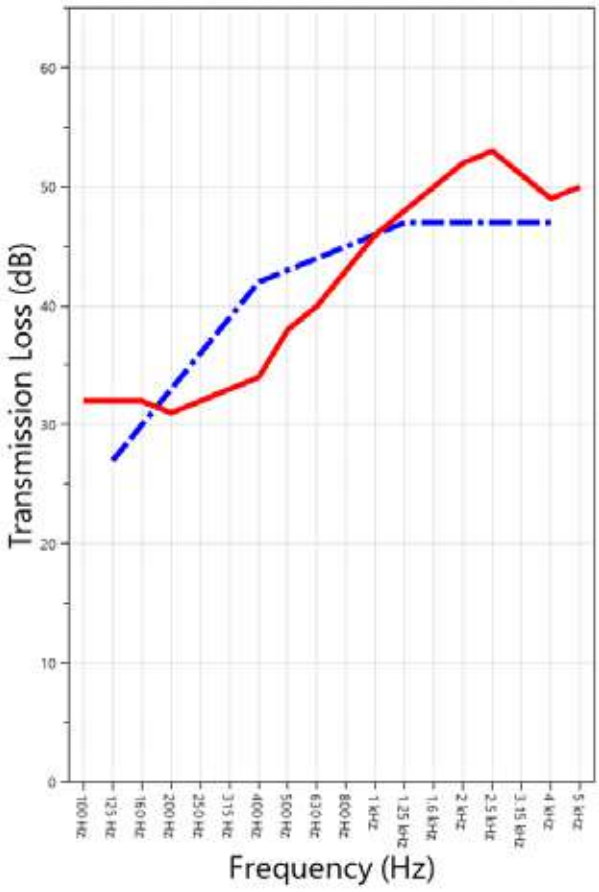
SOUND TRANSMISSION REPORT

Floor F04 - cross-laminated timber panels



STC=43

TRANSMISSION LOSS
SOUND TRANSMISSION CLASS CONTOUR

NVLAP TESTING
NVLAP LAB CODE 100227-0

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2019-02-18

RAL™-TL19-033

APPENDIX A: Extended Frequency Range Data
Specimen: Floor F04 - cross-laminated timber panels (See Full Report)

The following non-accredited data were obtained in accordance with ASTM E90-09 (2016), but extend beyond the defined frequency range of 100Hz to 5,000Hz. These unofficial results are representative of the RAL test environment only and intended for research & comparison purposes. Sampling precision observed during this procedure is reported below.

1/3 Octave Band Center Frequency (Hz)	**Sound Transmission Loss** (dB)	**ΔTL (Eq. A2.5)** (dB)
31.5	47	5.60
40	38	0.77
50	36	1.09
63	27	1.05
80	30	0.46
100	32	0.66
125	32	0.91
160	32	0.44
200	31	0.42
250	32	0.44
315	33	0.21
400	34	0.33
500	38	0.19
630	40	0.20
800	43	0.21
1000	46	0.21
1250	48	0.15
1600	50	0.12
2000	52	0.14
2500	53	0.12
3150	51	0.13
4000	49	0.08
5000	50	0.15
6300	52	0.13
8000	54	0.16
10000	56	0.20
12500	53	0.42

NVLAP TESTING
NVLAP LAB CODE 100227-0

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2019-02-18

RAL™-TL19-033

APPENDIX B: Instruments of Traceability
Specimen: Floor F04 - cross-laminated timber panels (See Full Report)

Description	Model	Serial Number	Date of Certification	Calibration Due
System 2	Type 3160-A-042	3160-106974	2018-08-09	2019-08-09
Bruel & Kjaer Mic And Preamp D	Type 4943-B-001	2311440	2018-09-28	2019-09-28
Bruel & Kjaer Pistonphone	Type 4228	2781248	2018-08-06	2019-08-06
EXTECH Hygro 330	SD700	A083330	2018-09-07	2019-09-07
EXTECH Hygro 322	SD700	A083322	2018-09-07	2019-09-07

APPENDIX C: Revisions to Original Test Report
Specimen: Floor F04 - cross-laminated timber panels (See Full Report)

Date	Revision
2019-03-13	Original report issued

END

F04 - CLT BASE CASE MASS TIMBER PANEL - RIVERBANK LABORATORY REPORT - IIC

RIVERBANK ACOUSTICAL LABORATORIES

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630-232-0104

An ALION Technical Center

Test Report

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SPONSOR: **University of Oregon**
Eugene, OR

Impact Sound Transmission
RAL™-IN19-012

CONDUCTED: 2019-02-18

ON: Floor F04 - cross-laminated timber panels

TEST METHODOLOGY

Riverbank Acoustical Laboratories™ is accredited by the U.S. Department of Commerce, National Institute of Standards and Technology (NIST) under the National Voluntary Laboratory Accreditation Program (NVLAP) as an ISO 17025:2005 Laboratory (NVLAP Lab Code: 100227-0) and for this test procedure. The test reported in this document conformed explicitly with ASTM E492-09: "Standard Test Method for Laboratory Measurement of Impact Sound Transmission Through Floor-Ceiling Assemblies Using the Tapping Machine." The single number rating of the specimen was calculated according to ASTM E989-18: "Standard Classification for Determination of Single-Number Metrics for Impact Noise." A description of the measurement procedure and room specifications is available upon request. The results presented in this report apply to the individual test specimen as described and assembled.

INFORMATION PROVIDED BY SPONSOR

The test specimen was designated by the sponsor as Floor F04 - cross-laminated timber panels. The following nominal product information was provided by the sponsor prior to testing. The accuracy of such sponsor-provided information can affect the validity of the test results.

Product Under Test

Materials:	Cross-laminated timber panels, 5 layers
Manufacturer:	Tallwood Design Institute
Construction Designation:	F04

SPECIMEN CONSTRUCTION & TEST CONDITIONS

The building contractor and RAL staff compiled the following construction specification, in order of installation:

Test Specimen

Dimensions:	2 @ 4241.8 mm (167 in.) x 1270 mm (50 in.)
Thickness:	174.62 mm (6.875 in.)
Joint:	Shiplap joint, 101.6 mm (4 in.) wide x 85.72 mm (3.375 in.) tall
Installation:	Panel ends brushed with Seal Once Nano-guard wood sealer prior to laying in test opening 6.35 mm (0.25 in.) diameter bead of Chemlink Build Secure adhesive along center of joint Panels screwed together through joint

F04 - CLT BASE CASE MASS TIMBER PANEL - RIVERBANK LABORATORY REPORT - IIC

Test Specimen (continued)

Fasteners:	ASSY VG CSK screws, 8 mm (0.315 in.) x 160 mm (6.299 in.)
Fastener Spacing:	304.8 mm (12 in.) on center, 15 fasteners total
Weights:	Panels @ 977.04 kg (2154 lbs)
	Adhesive @ 0.23 kg (0.5 lbs)
	Fasteners @ 0.57 kg (1.25 lbs)

Overall Specimen Measurements

Dimensions:	2.44 m (96.0 in) wide by 4.27 m (168.0 in) high
Thickness:	0.17 m (6.875 in)
Weight:	977.83 kg (2155.75 lbs)
Transmission Area:	10.405 m² (112 ft²)
Mass per Unit Area:	93.98 kg/m² (19.25 lbs/ft²)

Test Aperture

Size:	4.27 m (14.0 ft.) by 2.44 m (8 ft.)
Filler Wall:	None
Sealed:	Source Side: Dense mastic seal around perimeter
	Received Side: ½" or 3/8" Backer Rod (by gap size), acoustical caulk applied full perimeter, then gap above filled to level with sand around full perimeter.

Test Environment

Source Room

Volume:	132.08 m³
Temperature:	21.7 °C ± 0.0 °C
Relative Humidity:	52.0 % ± 2.0 %

Receive Room

Volume:	81.81 m³
Temperature:	22.8 °C ± 0.0 °C
Relative Humidity:	53.0 % ± 2.0 %

Requirements

Temperature:	22° C +/- 5° C, not more than 3° C change over all tests.
Relative Humidity:	≥ 30% RH; not more than +/- 3% change over all tests.

NVLAP TESTING
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Figure 1 – Specimen mounted in test opening, as viewed from source room

Figure 2 – Underside of specimen, as viewed from receive room

Figure 3 – Individual cross-laminated timber panel

Figure 4 – Panel laid in test opening

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Figure 5 – Adhesive at shiplap joint

Figure 6 – Fasteners at joint

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University of Oregon **RAL™-IN19-012**

2019-02-18

TEST RESULTS

The averaged sound pressure levels, normalized to a receive room reference absorption of 10 m^2, are tabulated at the sixteen standard frequencies. A graphic presentation of the data and additional information appear on the following pages. The 95% confidence interval for the sound pressure level in the receive room is below the limits specified in Section A1.4 of ASTM E492-09.

FREQ.	Ln	ΔLn	DEV	FREQ.	Ln	ΔLn	DEV
100	69	1.07	0	800	84	1.89	2
125	68	1.48	0	1000	85	2.27	4
160	70	1.70	0	1250	83	2.55	5
200	76	2.82	0	1600	82	2.86	7
250	78	0.67	0	2000	79	3.78	7
315	79	0.87	0	2500	74	6.20	5
400	84	2.88	0	3150	67	6.91	1
500	83	1.32	0				
630	84	2.35	1				

IIC=26

ABBREVIATION INDEX

FREQ. = FREQUENCY, HERTZ, (cps)
Ln = NORMALIZED SOUND PRESSURE LEVEL, dB
ΔLn = 95% UNCERTAINTY LIMIT FOR Ln, dB
DEV. = DEVIATION FROM SHIFTED IIC CONTOUR, dB (SUM OF DEV = 32)
IIC = IMPACT INSULATION CLASS
* = INDICATES A CORRECTION HAS BEEN APPLIED TO DATA DUE TO BACKGROUND NOISE LEVELS

Tested by _____
Marc Sciaky
Senior Experimentalist

Report by _____
Malcolm Kelly
Test Engineer, Acoustician

Approved by _____
Eric P. Wolfram
Laboratory Manager

Digitally signed by Eric P Wolfram
DN: cn=Eric P Wolfram, o=Alion Science & Technology, ou=Riverbank Acoustical Laboratories, email=ewolfram@alionscience.com, c=US
Date: 2019.03.25 17:04:50 -05'00'

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F04 - CLT BASE CASE MASS TIMBER PANEL - RIVERBANK LABORATORY REPORT - IIC

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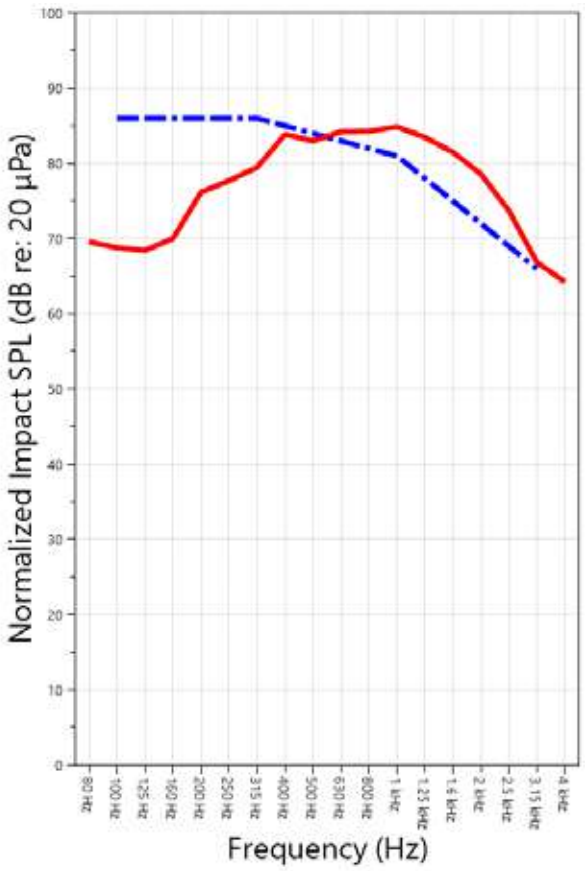
RAL™-IN19-012
Page 7 of 9

IMPACT SOUND TRANSMISSION REPORT

Floor F04 - cross-laminated timber panels



IIC=26

IMPACT SOUND PRESSURE LEVEL
IMPACT INSULATION CLASS CONTOUR

NVLAP® TESTING
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University of Oregon **RAL™-IN19-012**
2019-02-18

APPENDIX A: Extended Frequency Range Data

Specimen: Floor F04 - cross-laminated timber panels (See Full Report)

The following non-accredited data were obtained in accordance with ASTM E989-06 (2012), but extend beyond the defined frequency range of 100 Hz to 3,150 Hz. These unofficial results are representative of the RAL test environment only and intended for research & comparison purposes.

1/3 Octave Band Center Frequency (Hz)	L_n (dB)	ΔL_n (dB)	Repeatability (dB)
31.5	53	6.18	4.45
40	65	1.75	3.47
50	67	1.58	2.55
63	69	3.33	5.07
80	70	4.71	2.23
100	69	1.07	3.47
125	68	1.48	2.85
160	70	1.70	2.46
200	76	2.82	1.93
250	78	0.67	0.73
315	79	0.87	0.79
400	84	2.88	2.17
500	83	1.32	1.93
630	84	2.35	0.21
800	84	1.89	1.41
1000	85	2.27	2.05
1250	83	2.55	1.49
1600	82	2.86	2.22
2000	79	3.78	2.51
2500	74	6.20	1.26
3150	67	6.91	1.51
4000	64	4.47	1.85
5000	58	3.11	1.82
6300	53	2.63	1.90
8000	48	2.08	0.88
10000	44	2.23	4.02
12500	35	2.26	5.26

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APPENDIX B: Glossary for Variability Metrics

Specimen: Floor F04 - cross-laminated timber panels (See Full Report)

ΔL_n, the 95% confidence interval for the reported normalized sound pressure level, is calculated from the standard deviation of the set of sound pressure levels measured during this individual test. This metric is calculated in an effort to quantify the variability in measured levels due to the combined influences of variation in the receive room sound field and differences in the specimen's response to different tapping machine locations.

Repeatability, expressed as a 95% confidence interval, is calculated from the standard deviation in normalized sound pressure level as obtained from a total of six consecutive tests conducted according to this test method by RAL from 2019-02-07 to 2019-02-12. The tests were performed on a 152.4 mm (6 in.) thick concrete slab specimen which was left installed and unaltered between tests. This metric provides an estimate of the variation in results that might be observed if the test were repeated with no change to the installed specimen. Note that repeatability will differ with construction type.

APPENDIX C: Instruments of Traceability

Specimen: Floor F04 - cross-laminated timber panels (See Full Report)

Description	Model	Serial Number	Date of Certification	Calibration Due
System 2	Type 3160-A-042	3160-106974	2018-08-09	2019-08-09
Bruel & Kjaer Mic And Preamp D	Type 4943-B-001	2311440	2018-09-28	2019-09-28
Wood Case Tapping Machine	Type 3204	226940	2018-08-23	2019-08-23
Bruel & Kjaer Pistonphone	Type 4228	2781248	2018-08-06	2019-08-06
EXTECH Hygro 330	SD700	A083330	2018-09-07	2019-09-07
EXTECH Hygro 322	SD700	A083322	2018-09-07	2019-09-07

APPENDIX D: Revisions to Original Test Report

Specimen: Floor F04 - cross-laminated timber panels (See Full Report)

Date	Revision
2019-03-13	Original report issued

END

F04 - MPP BASE CASE MASS TIMBER PANEL - RIVERBANK LABORATORY REPORT - STC

Unofficial Test Results & Preliminary Data Sheet

Riverbank Acoustical Laboratories (RAL)™
Laboratory Measurement of Airborne Sound Transmission Loss per ASTM E-90

Test Number: TL19-075 Test Date: 2019-03-27
Sponsor: Oregon State University
Designation: F04 - 6"MPP (No Ceiling)

Dimensions: 2.44 m x 4.27 m x 0.16 m Test Conducted By: Marc Sciaky
Area: 10.41 m² Test Interface: 1.3.3
Weight: 931.11 kg Area Weight: 89.49 kg/m²
Specimen Details:

Source Room: Room 3 Volume: 132.3 m³ Surface Area: 174.8 m²
Receive Room: Room 4 Volume: 81.8 m³ Surface Area: 130.7 m²

Freq (Hz)	TL (dB)	Precision (dB)	Deficiencies (dB)
31.5	41	4.09	
40	40	1.12	
50	37	1.33	
63	22	0.72	
80	31	0.79	
100	29	0.60	
125	32	0.78	
160	31	0.36	
200	29	0.30	
250	31	0.27	
315	32	0.23	1
400	32	0.28	4
500	34	0.21	3
630	35	0.20	3
800	36	0.12	3
1000	37	0.18	3
1250	38	0.12	3
1600	40	0.14	1
2000	41	0.16	
2500	41	0.08	
3150	40	0.12	1
4000	42	0.08	
5000	43	0.14	
6300	44	0.41	
8000	46	0.71	
10000	47	0.86	
12500	47	2.31	

Sound Transmission Coefficient (STC): 37
Total Deficiencies: 22

OITC: 34

Calculation Date: 2019-03-27
Calculated By: Marc Sciaky

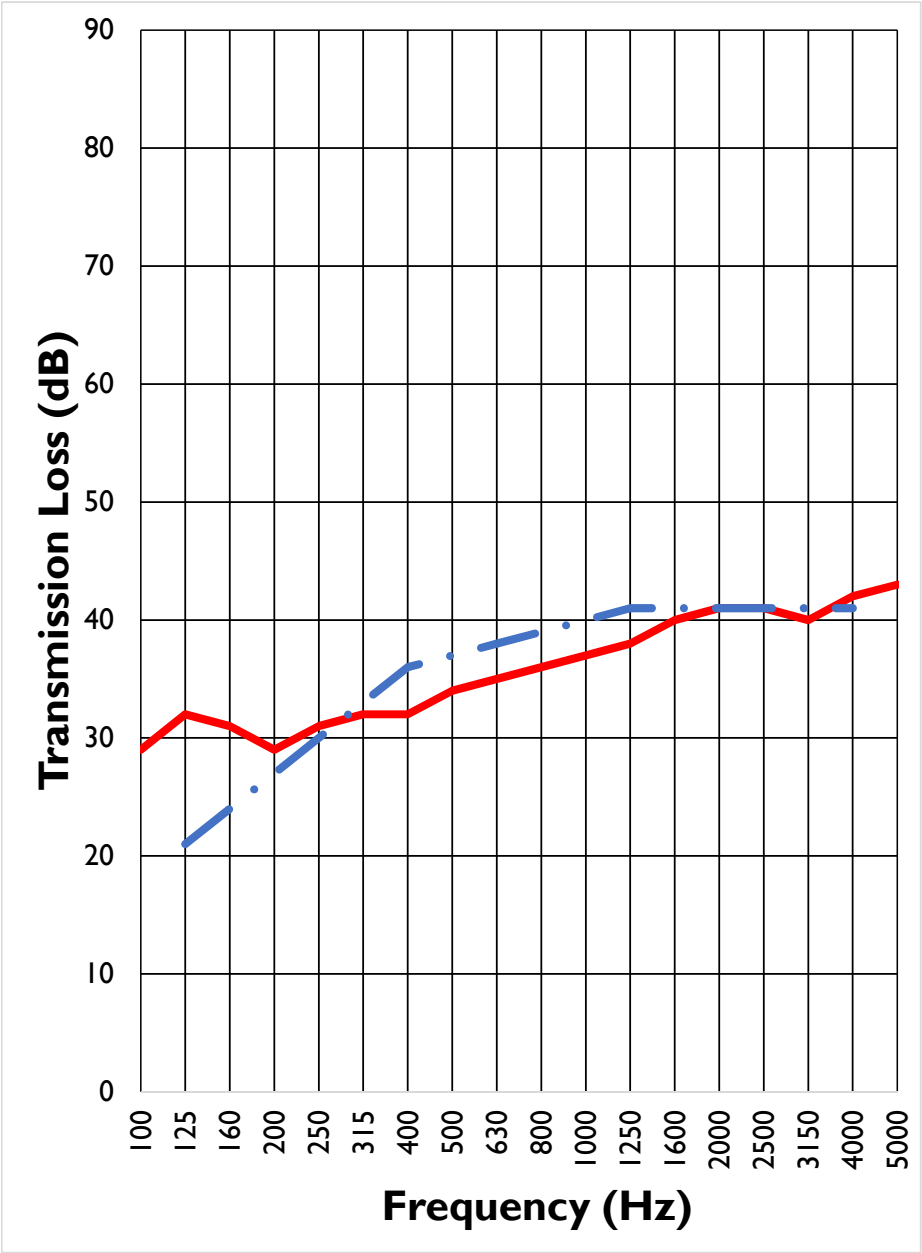
This single report page and accompanying graph contain the instantaneous raw data as provided to the client after testing of the specimen. This data, although accurate, is incomplete without the full specimen description, mounting details and signature pages. The full report referenced by the RAL test number above should be consulted for further information regarding these results.

F04 - MPP BASE CASE MASS TIMBER PANEL - RIVERBANK LABORATORY REPORT - STC

SOUND TRANSMISSION RESULTS

F04 - 6"MPP (No Ceiling)

TL19-075



STC = 37

TOTAL DEFICIENCIES = 22

F04 - MPP BASE CASE MASS TIMBER PANEL - RIVERBANK LABORATORY REPORT - IIC

Unofficial Test Results & Preliminary Data Sheet

Riverbank Acoustical Laboratories (RAL)™ / An Alion Science Technical Center (RALVer 15.2)

Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions ASTM E 90-09/NVLAP 08/P06

Test Number: IN19-020 Test Date: 2019-03-27

Sponsor: Oregon State University

Designation: F04 - 6"MPP (No Ceiling)

Dimensions: 2.44 m x 4.27 m x 0.16 m Test Conducted By: Marc Sciaky

Area: 10.41 m² Test Interface: 1.3.3

Weight: 931.11 kg Area Weight: 89.49 kg/m²

Specimen Details:

Source Room: Room 3 Volume: 132.3 m³ Surface Area: 174.8 m²

Receive Room: Room 4 Volume: 81.8 m³ Surface Area: 130.7 m²

Freq (Hz)	nISPL (dB)	ΔLn (dB)	Deficiencies (dB)
31.5	52	4.67	
40	66	1.42	
50	68	1.70	
63	72	3.47	
80	72	4.22	
100	71	1.40	
125	70	2.16	
160	72	1.76	
200	79	3.92	
250	79	1.17	
315	82	1.18	
400	84	1.15	
500	85	0.99	1
630	87	0.88	4
800	88	1.23	6
1000	87	1.39	6
1250	84	2.13	6
1600	80	2.72	5
2000	72	3.50	
2500	68	1.95	
3150	65	2.01	
4000	63	2.13	
5000	57	2.60	
6300	53	3.49	
8000	48	4.52	
10000	41	4.94	
12500	35	4.99	

Impact Insulation Class (IIC): 26

Total Deficiencies: 28

Calculation Date: 2019-03-27

Calculated By: Marc Sciaky

This single report page and accompanying graph contain the instantaneous raw data as provided to the client after testing of the specimen. This data, although accurate, is incomplete without the full specimen description, mounting details and signature pages. The full report referenced by the RAL test number above should be consulted for further information regarding these results.

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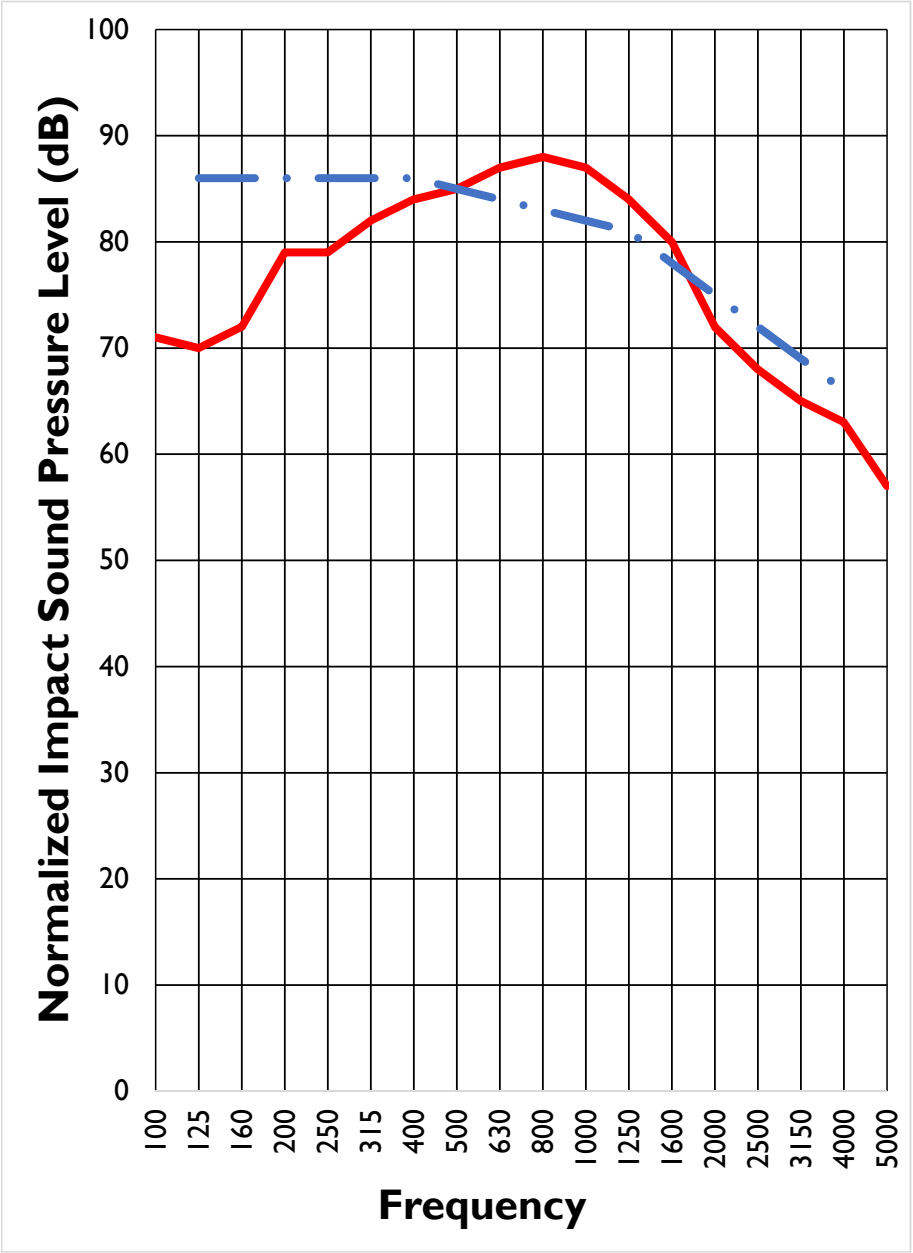
F04 - MPP BASE CASE MASS TIMBER PANEL - RIVERBANK LABORATORY REPORT - IIC

SOUND TRANSMISSION RESULTS

IN19-020



IIC = 26

TOTAL DEFICIENCIES = 28

F05 - CLT DRY COMPOSITE FLOOR ASSEMBLY - RIVERBANK LABORATORY REPORT - STC

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SPONSOR: **University of Oregon**
Eugene, OR

Sound Transmission Loss
RAL™-TL19-034

CONDUCTED: 2019-02-20

ON: Floor F05 - Composite floor with cross-laminated timber base, engineered wood surface

TEST METHODOLOGY

Riverbank Acoustical Laboratories™ is accredited by the U.S. Department of Commerce, National Institute of Standards and Technology (NIST) under the National Voluntary Laboratory Accreditation Program (NVLAP) as an ISO 17025:2005 Laboratory (NVLAP Lab Code: 100227-0) and for this test procedure. The test reported in this document conformed explicitly with ASTM E90-09 (2016): "Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements." The single number rating of the specimen was calculated according to ASTM E413-16: "Classification for Rating Sound Insulation." A description of the measurement procedure and room specifications is available upon request. The transmission loss values are for a single direction of measurement. The results presented in this report apply to the sample as received from the test sponsor.

INFORMATION PROVIDED BY SPONSOR

The test specimen was designated by the sponsor as Floor F05 - Composite floor with cross-laminated timber base, engineered wood surface. The following nominal product information was provided by the sponsor prior to testing. The accuracy of such sponsor-provided information can affect the validity of the test results.

Product Under Test

Materials:	Cross-laminated timber panels, 5 layers
Manufacturer:	Tallwood Design Institute
Construction Designation:	F05

SPECIMEN CONSTRUCTION & TEST CONDITIONS

The building contractor and RAL staff compiled the following construction specification, in order of installation:

Base Slab

Dimensions:	2 @ 4241.8 mm (167 in.) x 1270 mm (50 in.)
Thickness:	174.62 mm (6.875 in.)
Joint:	Shiplap joint, 101.6 mm (4 in.) wide x 85.72 mm (3.375 in.) tall
Installation:	Panel ends brushed with Seal Once Nano-guard wood sealer prior to laying in test opening 6.35 mm (0.25 in.) diameter bead of Chemlink Build Secure adhesive along center of joint Panels screwed together through joint

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2019-02-20

Base Slab (continued)

Fasteners:	ASSY VG CSK screws, 8 mm (0.315 in.) x 160 mm (6.299 in.)
Fastener Spacing:	304.8 mm (12 in.) on center, 15 fasteners total
Weights:	Panels @ 977.04 kg (2154 lbs) Adhesive @ 0.23 kg (0.5 lbs) Fasteners @ 0.57 kg (1.25 lbs)

Composite Flooring

Layer 1

Trade Name:	Regupol Sonus Wave underlayment
Material:	Bonded crumb rubber
Dimensions:	2 @ 1219.2 mm (48 in.) x 4267.2 mm (168 in.)
Thickness:	Maximum @ 28 mm (1.102 in.)
Overall Weight:	90.04 kg (198.5 lbs)
Mass per Unit Area:	8.65 kg/m^2 (1.77 lbs/ft^2)
Installation:	Loose laid parallel to length of base slab Joint sealed with duct tape

Layer 2

Trade Name:	USG Durock
Material:	Cement board
Dimensions:	3 @ 1219.2 mm (48 in.) x 2438.4 mm (96 in.) 1 @ 596.9 mm (23.5 in.) x 2438.4 mm (96 in.)
Thickness:	12.7 mm (0.5 in.)
Overall Weight:	118.16 kg (260.5 lbs)
Mass per Unit Area:	11.36 kg/m^2 (2.33 lbs/ft^2)
Installation:	Loose laid perpendicular to length of base slab, joint staggered 12 in. along length from previous layer (see drawing attached). Joints treated with thin bead of CertainTeed Green Glue 6.35 mm (0.25 in.) diameter bead of Chemlink Build Secure adhesive applied in lines spaced 203.2 mm (8 in.) on center along board width

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Composite Flooring (continued)

Layer 3

Trade Name:	USG Durock
Material:	Cement board
Dimensions:	4 @ 1219.2 mm (48 in.) x 914.4 mm (36 in.) 2 @ 1219.2 mm (48 in.) x 2438.4 mm (96 in.)
Thickness:	12.7 mm (0.5 in.)
Overall Weight:	115.78 kg (255.25 lbs)
Mass per Unit Area:	11.13 kg/m^2 (2.28 lbs/ft^2)
Installation:	Laid over Layer 2 on adhesive parallel to length of base slab, joint staggered 12 in. along length from previous layer (see drawing attached). Joints treated with thin bead of CertainTeed Green Glue 6.35 mm (0.25 in.) diameter bead of Chemlink Build Secure adhesive applied in lines spaced 203.2 mm (8 in.) on center along board width

Layer 4

Trade Name:	USG Durock
Material:	Cement board
Dimensions:	3 @ 1219.2 mm (48 in.) x 2438.4 mm (96 in.) 1 @ 609.6 mm (24 in.) x 2438.4 mm (96 in.)
Thickness:	12.7 mm (0.5 in.)
Overall Weight:	121.11 kg (267 lbs)
Mass per Unit Area:	11.64 kg/m^2 (2.38 lbs/ft^2)
Installation:	Laid over Layer 3 on adhesive perpendicular to length of base slab, joint staggered 12 in. along length from previous layer (see drawing attached). Joints treated with thin bead of CertainTeed Green Glue 6.35 mm (0.25 in.) diameter bead of Chemlink Build Secure adhesive applied in lines spaced 203.2 mm (8 in.) on center along board width

Layer 5

Material:	Tongue & groove oriented strand board subfloor
Manufacturer:	Georgia Pacific
Dimensions:	2 @ 1219.2 mm (48 in.) x 304.8 mm (12 in.) 2 @ 1219.2 mm (48 in.) x 2438.4 mm (96 in.) 2 @ 1219.2 mm (48 in.) x 1524 mm (60 in.)
Thickness:	15.88 mm (0.625 in.)
Overall Weight:	96.62 kg (213 lbs)
Mass per Unit Area:	9.29 kg/m^2 (1.90 lbs/ft^2)

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Layer 5 Installation:	Laid over Layer 4 on adhesive parallel to length of base slab, joint staggered 12 in. along length from previous layer (see drawing attached). Joints treated with thin bead of CertainTeed Green Glue 6.35 mm (0.25 in.) diameter bead of Chemlink Build Secure adhesive applied in lines spaced 203.2 mm (8 in.) on center along board width
Layer 6	
Material:	Tongue & groove oriented strand board subfloor
Manufacturer:	Georgia Pacific
Dimensions:	3 @ 1219.2 mm (48 in.) x 2438.4 mm (96 in.) 1 @ 609.6 mm (24 in.) x 2438.4 mm (96 in.)
Thickness:	15.88 mm (0.625 in.)
Overall Weight:	98.09 kg (216.25 lbs)
Mass per Unit Area:	9.43 kg/m^2 (1.93 lbs/ft^2)
Installation:	Laid over Layer 5 on adhesive perpendicular to length of base slab, joint staggered 12 in. along length from previous layer (see drawing attached). Joints sealed with Green Glue and covered with duct tape

Note: The joint treatment and adhesives used in Layers 2-6 weighed 7.48 kg (16.5 lbs) total.

Layer 7	
Trade Name:	MP Global Quietwalk underlayment
Material:	Recycled cotton
Dimensions:	2 @ 914.4 mm (36 in.) x 4267.2 mm (168 in.) 1 @ 609.6 mm (24 in.) x 4267.2 mm (168 in.)
Thickness:	2.88 mm (0.113 in.)
Overall Weight:	6.24 kg (13.75 lbs)
Mass per Unit Area:	0.51 kg/m^2 (0.10 lbs/ft^2)
Installation:	Loose laid over Layer 6 parallel to length of base slab, joint staggered 12 in. along length from previous layer (see drawing attached). Joints sealed with duct tape
Layer 8	
Trade Name:	Mohawk 32506-79 engineered plank flooring
Material:	Engineered wood
Plank Dimensions:	190.5 mm (7.5 in.) x 1828.8 mm (72 in.) (actual installed length varied to facilitate a staggered appearance; see figures 1 & 9)
Plank Thickness:	14.22 mm (0.56 in.)
Overall Weight:	134.94 kg (297.5 lbs)
Mass per Unit Area:	12.97 kg/m^2 (2.66 lbs/ft^2)
Installation:	Loose laid over Layer 7 parallel to length of base slab Click-lock design at joints

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Test Report

University of Oregon
2019-02-20

RAL™-TL19-034

Overall Specimen Measurements

Dimensions:	2.44 m (96.0 in) wide by 4.27 m (168.0 in) high
Thickness:	0.29 m (11.312 in)
Weight:	1766.29 kg (3894 lbs)
Transmission Area:	10.405 m² (112 ft²)
Mass per Unit Area:	169.75 kg/m² (34.77 lbs/ft²)

Test Aperture

Size:	4.27 m (14.0 ft) x 2.44 m (8.0 ft)
Filler Wall:	None
Sealed:	Source Side: Dense mastic seal around perimeter Received Side: ½" or 3/8" Backer Rod (by gap size), acoustical caulk applied full perimeter, then gap above filled to level with sand around full perimeter.

Test Environment

Source Room

Volume:	130.89 m³
Temperature:	22.8 °C ± 0.0 °C
Relative Humidity:	53.5 % ± 1.0 %

Receive Room

Volume:	81.81 m³
Temperature:	23.3 °C ± 0.0 °C
Relative Humidity:	51.0 % ± 0.0 %

Requirements

Temperature:	22° C +/- 2° C, not more than 3° C change over all tests.
Relative Humidity:	≥ 30%, not more than +/- 3% change over all tests.

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Figure 1 – Specimen mounted in test opening, as viewed from source room

Figure 2 – Underside of installed test specimen

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Figure 3 – Installation of cross-laminated timber base slab

Figure 4 – Sample of composite flooring layer 1

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Figure 5– Composite flooring layer 1 installed over base slab

Figure 6 – Typical sealant and adhesive application on cement board layers

Figure 7 – Oriented strand board layers partially installed

Figure 8 – Recycled cotton underlayment partially installed

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Figure 9 – Engineered wood flooring partially installed

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TEST RESULTS

Sound transmission loss values are tabulated at the eighteen standard frequencies. A graphic presentation of the data and additional information appear on the following pages. The precision of the transmission loss test data is within the limits set by the ASTM Standard E90-09 (2016).

FREQ.	TL	ΔTL	DEF.	FREQ.	TL	ΔTL	DEF.
100	30	0.77	0	800	67	0.17	0
125	38	0.79	0	1000	71	0.25	0
160	36	0.52	5	1250	75	0.28	0
200	37	0.47	7	1600	78	0.23	0
250	39	0.38	8	2000	81	0.24	0
315	45	0.28	5	2500	85	0.17	0
400	51	0.23	2	3150	89	0.62	0
500	58	0.21	0	4000	89	0.31	0
630	63	0.18	0	5000	79	0.50	0

STC=54

ABBREVIATION INDEX

FREQ. = FREQUENCY, HERTZ
TL = TRANSMISSION LOSS, dB
ΔTL = 95% CONFIDENCE INTERVAL FOR TL MEAUREMENTS, dB
DEF. = DEFICIENCIES, dB BELOW STC CONTOUR (SUM OF DEF = 27)
STC = SOUND TRANSMISSION CLASS

Tested by _____
Marc Sciaky
Senior Experimentalist

Report by _____
Malcolm Kelly
Acoustician

Approved by _____
Eric P. Wolfram
Laboratory Manager

Digitally signed by Eric P Wolfram
DN: cn=Eric P Wolfram, o=Alion Science & Technology, ou=Riverbank Acoustical Laboratories, email=ewolfram@alionscience.com, c=US
Date: 2019.03.25 17:07:35 -05'00'

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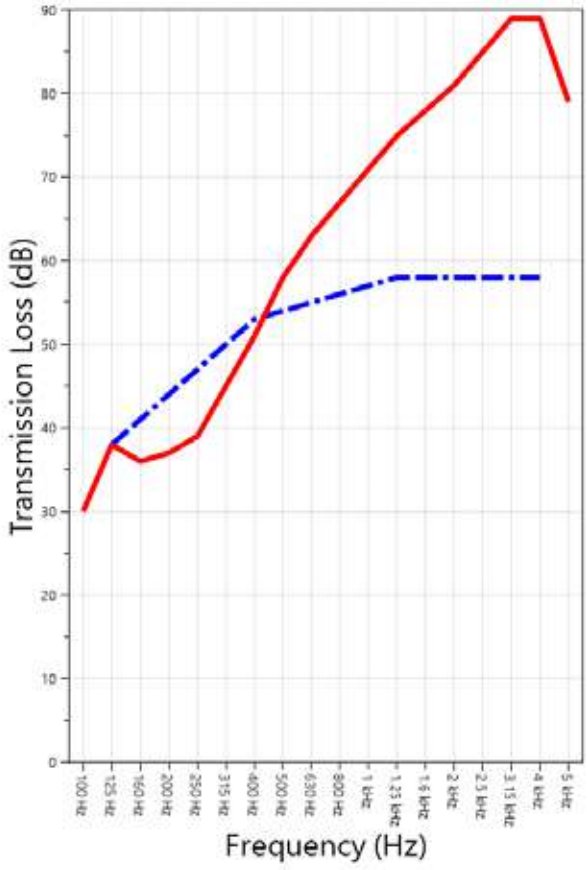
SOUND TRANSMISSION REPORT

Floor F05 - Composite floor with cross-laminated timber base, engineered wood surface



STC=54

TRANSMISSION LOSS
SOUND TRANSMISSION CLASS CONTOUR

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APPENDIX A: Extended Frequency Range Data

Specimen: Floor F05 - Composite floor with cross-laminated timber base, engineered wood surface (See Full Report)

The following non-accredited data were obtained in accordance with ASTM E90-09 (2016), but extend beyond the defined frequency range of 100Hz to 5,000Hz. These unofficial results are representative of the RAL test environment only and intended for research & comparison purposes. Sampling precision observed during this procedure is reported below.

1/3 Octave Band Center Frequency (Hz)	**Sound Transmission Loss** (dB)	**ΔTL (Eq. A2.5)** (dB)
31.5	49	3.65
40	41	1.00
50	35	1.03
63	30	0.96
80	33	0.87
100	30	0.77
125	38	0.79
160	36	0.52
200	37	0.47
250	39	0.38
315	45	0.28
400	51	0.23
500	58	0.21
630	63	0.18
800	67	0.17
1000	71	0.25
1250	75	0.28
1600	78	0.23
2000	81	0.24
2500	85	0.17
3150	89	0.62
4000	89	0.31
5000	79	0.50
6300	77	0.30
8000	73	0.18
10000	65	0.20
12500	53	0.18

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APPENDIX B: Instruments of Traceability

Specimen: Floor F05 - Composite floor with cross-laminated timber base, engineered wood surface (See Full Report)

Description	Model	Serial Number	Date of Certification	Calibration Due
System 2	Type 3160-A-042	3160-106974	2018-08-09	2019-08-09
Bruel & Kjaer Mic And Preamp D	Type 4943-B-001	2311440	2018-09-28	2019-09-28
Bruel & Kjaer Pistonphone	Type 4228	2781248	2018-08-06	2019-08-06
EXTECH Hygro 330	SD700	A083330	2018-09-07	2019-09-07
EXTECH Hygro 322	SD700	A083322	2018-09-07	2019-09-07

APPENDIX C: Revisions to Original Test Report

Specimen: Floor F05 - Composite floor with cross-laminated timber base, engineered wood surface (See Full Report)

Date	Revision
2019-03-13	Original report issued

END

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Test Report

SPONSOR: **University of Oregon**
Eugene, OR

Impact Sound Transmission
RAL™-IN19-013

CONDUCTED: 2019-02-20

ON: Floor F05 – Composite floor with cross-laminated timber base, engineered wood surface

TEST METHODOLOGY

Riverbank Acoustical Laboratories™ is accredited by the U.S. Department of Commerce, National Institute of Standards and Technology (NIST) under the National Voluntary Laboratory Accreditation Program (NVLAP) as an ISO 17025:2005 Laboratory (NVLAP Lab Code: 100227-0) and for this test procedure. The test reported in this document conformed explicitly with ASTM E492-09: "Standard Test Method for Laboratory Measurement of Impact Sound Transmission Through Floor-Ceiling Assemblies Using the Tapping Machine." The single number rating of the specimen was calculated according to ASTM E989-18: "Standard Classification for Determination of Single-Number Metrics for Impact Noise." A description of the measurement procedure and room specifications is available upon request. The results presented in this report apply to the individual test specimen as described and assembled.

INFORMATION PROVIDED BY SPONSOR

The test specimen was designated by the sponsor as Floor F05 - Composite floor with cross-laminated timber base, engineered wood surface. The following nominal product information was provided by the sponsor prior to testing. The accuracy of such sponsor-provided information can affect the validity of the test results.

Product Under Test

Materials:	Cross-laminated timber panels, 5 layers
Manufacturer:	Tallwood Design Institute
Construction Designation:	F05

SPECIMEN CONSTRUCTION & TEST CONDITIONS

The building contractor and RAL staff compiled the following construction specification, in order of installation:

Base Slab

Dimensions:	2 @ 4241.8 mm (167 in.) x 1270 mm (50 in.)
Thickness:	174.62 mm (6.875 in.)
Joint:	Shiplap joint, 101.6 mm (4 in.) wide x 85.72 mm (3.375 in.) tall
Installation:	Panel ends brushed with Seal Once Nano-guard wood sealer prior to laying in test opening 6.35 mm (0.25 in.) diameter bead of Chemlink Build Secure adhesive along center of joint Panels screwed together through joint

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Base Slab (continued)

Fasteners:	ASSY VG CSK screws, 8 mm (0.315 in.) x 160 mm (6.299 in.)
Fastener Spacing:	304.8 mm (12 in.) on center, 15 fasteners total
Weights:	Panels @ 977.04 kg (2154 lbs)
	Adhesive @ 0.23 kg (0.5 lbs)
	Fasteners @ 0.57 kg (1.25 lbs)

Composite Flooring

Layer 1

Trade Name:	Regupol Sonus Wave underlayment
Material:	Bonded crumb rubber
Dimensions:	2 @ 1219.2 mm (48 in.) x 4267.2 mm (168 in.)
Thickness:	Maximum @ 28 mm (1.102 in.)
Overall Weight:	90.04 kg (198.5 lbs)
Mass per Unit Area:	8.65 kg/m^2 (1.77 lbs/ft^2)
Installation:	Loose laid parallel to length of base slab
	Joint sealed with duct tape

Layer 2

Trade Name:	USG Durock
Material:	Cement board
Dimensions:	3 @ 1219.2 mm (48 in.) x 2438.4 mm (96 in.)
	1 @ 596.9 mm (23.5 in.) x 2438.4 mm (96 in.)
Thickness:	12.7 mm (0.5 in.)
Overall Weight:	118.16 kg (260.5 lbs)
Mass per Unit Area:	11.36 kg/m^2 (2.33 lbs/ft^2)
Installation:	Loose laid perpendicular to length of base slab, joint staggered 12 in. along length from previous layer (see drawing attached)
	Joints treated with thin bead of CertainTeed Green Glue
	6.35 mm (0.25 in.) diameter bead of Chemlink Build Secure adhesive applied in lines spaced 203.2 mm (8 in.) on center along board width

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Composite Flooring (continued)

Layer 3

Trade Name:	USG Durock
Material:	Cement board
Dimensions:	4 @ 1219.2 mm (48 in.) x 914.4 mm (36 in.) 2 @ 1219.2 mm (48 in.) x 2438.4 mm (96 in.)
Thickness:	12.7 mm (0.5 in.)
Overall Weight:	115.78 kg (255.25 lbs)
Mass per Unit Area:	11.13 kg/m^2 (2.28 lbs/ft^2)
Installation:	Laid over Layer 2 on adhesive parallel to length of base slab, joint staggered 12 in. along length from previous layer (see drawing attached) Joints treated with thin bead of CertainTeed Green Glue 6.35 mm (0.25 in.) diameter bead of Chemlink Build Secure adhesive applied in lines spaced 203.2 mm (8 in.) on center along board width

Layer 4

Trade Name:	USG Durock
Material:	Cement board
Dimensions:	3 @ 1219.2 mm (48 in.) x 2438.4 mm (96 in.) 1 @ 609.6 mm (24 in.) x 2438.4 mm (96 in.)
Thickness:	12.7 mm (0.5 in.)
Overall Weight:	121.11 kg (267 lbs)
Mass per Unit Area:	11.64 kg/m^2 (2.38 lbs/ft^2)
Installation:	Laid over Layer 3 on adhesive perpendicular to length of base slab, joint staggered 12 in. along length from previous layer (see drawing attached) Joints treated with thin bead of CertainTeed Green Glue 6.35 mm (0.25 in.) diameter bead of Chemlink Build Secure adhesive applied in lines spaced 203.2 mm (8 in.) on center along board width

Layer 5

Material:	Tongue & groove oriented strand board subfloor
Manufacturer:	Georgia Pacific
Dimensions:	2 @ 1219.2 mm (48 in.) x 304.8 mm (12 in.) 2 @ 1219.2 mm (48 in.) x 2438.4 mm (96 in.) 2 @ 1219.2 mm (48 in.) x 1524 mm (60 in.)
Thickness:	15.88 mm (0.625 in.)
Overall Weight:	96.62 kg (213 lbs)
Mass per Unit Area:	9.29 kg/m^2 (1.90 lbs/ft^2)

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Layer 5 Installation:	Laid over Layer 4 on adhesive parallel to length of base slab, joint staggered 12 in. along length from previous layer (see drawing attached). Joints treated with thin bead of CertainTeed Green Glue 6.35 mm (0.25 in.) diameter bead of Chemlink Build Secure adhesive applied in lines spaced 203.2 mm (8 in.) on center along board width
Layer 6	
Material:	Tongue & groove oriented strand board subfloor
Manufacturer:	Georgia Pacific
Dimensions:	3 @ 1219.2 mm (48 in.) x 2438.4 mm (96 in.) 1 @ 609.6 mm (24 in.) x 2438.4 mm (96 in.)
Thickness:	15.88 mm (0.625 in.)
Overall Weight:	98.09 kg (216.25 lbs)
Mass per Unit Area:	9.43 kg/m^2 (1.93 lbs/ft^2)
Installation:	Laid over Layer 5 on adhesive perpendicular to length of base slab, joint staggered 12 in. along length from previous layer (see drawing attached) Joints sealed with Green Glue and covered with duct tape

Note: The joint treatment and adhesives used in Layers 2-6 weighed 7.48 kg (16.5 lbs) total.

Layer 7	
Trade Name:	MP Global Quietwalk underlayment
Material:	Recycled cotton
Dimensions:	2 @ 914.4 mm (36 in.) x 4267.2 mm (168 in.) 1 @ 609.6 mm (24 in.) x 4267.2 mm (168 in.)
Thickness:	2.88 mm (0.113 in.)
Overall Weight:	6.24 kg (13.75 lbs)
Mass per Unit Area:	0.51 kg/m^2 (0.10 lbs/ft^2)
Installation:	Loose laid over Layer 6 parallel to length of base slab, joint staggered 12 in. along length from previous layer (see drawing attached). Joints sealed with duct tape.
Layer 8	
Trade Name:	Mohawk 32506-79 engineered plank flooring
Material:	Engineered wood
Plank Dimensions:	190.5 mm (7.5 in.) x 1828.8 mm (72 in.) (actual installed length varied to facilitate a staggered appearance; see figures 1 & 9)
Plank Thickness:	14.22 mm (0.56 in.)
Overall Weight:	134.94 kg (297.5 lbs)
Mass per Unit Area:	12.97 kg/m^2 (2.66 lbs/ft^2)
Installation:	Loose laid over Layer 7 parallel to length of base slab Click-lock design at joints

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Overall Specimen Measurements

Dimensions:	2.44 m (96.0 in) wide by 4.27 m (168.0 in) high
Thickness:	0.29 m (11.312 in)
Weight:	1766.29 kg (3894 lbs)
Transmission Area:	10.405 m² (112 ft²)
Mass per Unit Area:	169.75 kg/m² (34.77 lbs/ft²)

Test Aperture

Size:	4.27 m (14.0 ft.) by 2.44 m (8 ft.)
Filler Wall:	None
Sealed:	Source Side: Dense mastic seal around perimeter Received Side: ½" or 3/8" Backer Rod (by gap size), acoustical caulk applied full perimeter, then gap above filled to level with sand around full perimeter.

Test Environment

Source Room

Volume:	130.89 m³
Temperature:	22.8 °C ± 0.0 °C
Relative Humidity:	52.5 % ± 3.0 %

Receive Room

Volume:	81.81 m³
Temperature:	23.3 °C ± 0.0 °C
Relative Humidity:	51.5 % ± 1.0 %

Requirements

Temperature:	22° C +/- 5° C, not more than 3° C change over all tests.
Relative Humidity:	≥ 30% RH; not more than +/- 3% change over all tests.

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Figure 1 – Specimen mounted in test opening, as viewed from source room

Figure 2 – Underside of installed test specimen

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Figure 3 – Installation of cross-laminated timber base slab

Figure 4 – Sample of composite flooring layer 1

Figure 5– Composite flooring layer 1 installed over base slab

Figure 6 – Typical sealant and adhesive application on cement board layers

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Figure 7 – Oriented strand board layers partially installed

Figure 8 – Recycled cotton underlayment partially installed

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Figure 9 – Engineered wood flooring partially installed

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TEST RESULTS

The averaged sound pressure levels, normalized to a receive room reference absorption of 10 m^2, are tabulated at the sixteen standard frequencies. A graphic presentation of the data and additional information appear on the following pages. The 95% confidence interval for the sound pressure level in the receive room is below the limits specified in Section A1.4 of ASTM E492-09.

FREQ.	Ln	ΔLn	DEV	FREQ.	Ln	ΔLn	DEV
100	75	4.05	8	800	38	1.36	0
125	68	3.52	1	1000	33	0.92	0
160	66	2.22	0	1250	28	1.13	0
200	66	2.59	0	1600	24	1.22	0
250	69	2.96	2	2000	18	1.34	0
315	66	2.73	0	2500	13	2.72	0
400	59	4.27	0	3150	8	0.74	0
500	52	3.90	0				
630	42	1.45	0				

IIC=45

ABBREVIATION INDEX

FREQ. = FREQUENCY, HERTZ, (cps)
Ln = NORMALIZED SOUND PRESSURE LEVEL, dB
ΔLn = 95% UNCERTAINTY LIMIT FOR Ln, dB
DEV. = DEVIATION FROM SHIFTED IIC CONTOUR, dB (SUM OF DEV = 11)
IIC = IMPACT INSULATION CLASS
* = INDICATES A CORRECTION HAS BEEN APPLIED TO DATA DUE TO BACKGROUND NOISE LEVELS

Tested by _____
Marc Sciaky
Senior Experimentalist

Report by _____
Malcolm Kelly
Test Engineer, Acoustician

Approved by _____
Eric P. Wolfram
Laboratory Manager

Digitally signed by Eric P Wolfram
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Date: 2019.03.25 17:06:04 -05'00'

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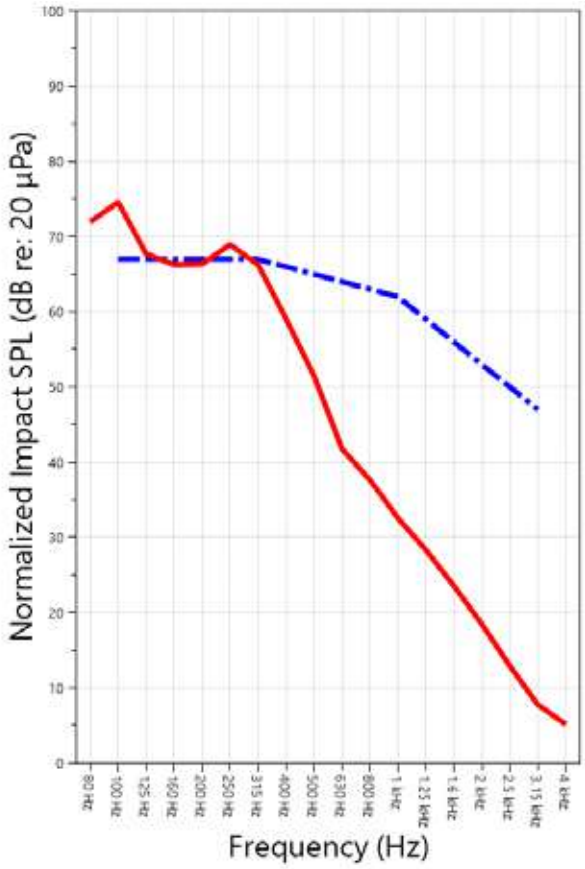
IMPACT SOUND TRANSMISSION REPORT

Floor F05 - Composite floor with cross-laminated timber base, engineered wood surface



IIC=45

IMPACT SOUND PRESSURE LEVEL
IMPACT INSULATION CLASS CONTOUR

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APPENDIX A: Extended Frequency Range Data

Specimen: Floor F05 - Composite floor with cross-laminated timber base, engineered wood surface (See Full Report)

The following non-accredited data were obtained in accordance with ASTM E989-06 (2012), but extend beyond the defined frequency range of 100 Hz to 3,150 Hz. These unofficial results are representative of the RAL test environment only and intended for research & comparison purposes.

1/3 Octave Band Center Frequency (Hz)	L_n (dB)	ΔL_n (dB)	Repeatability (dB)
31.5	58	5.22	4.45
40	58	2.16	3.47
50	65	4.64	2.55
63	65	2.77	5.07
80	72	6.22	2.23
100	75	4.05	3.47
125	68	3.52	2.85
160	66	2.22	2.46
200	66	2.59	1.93
250	69	2.96	0.73
315	66	2.73	0.79
400	59	4.27	2.17
500	52	3.90	1.93
630	42	1.45	0.21
800	38	1.36	1.41
1000	33	0.92	2.05
1250	28	1.13	1.49
1600	24	1.22	2.22
2000	18	1.34	2.51
2500	13	2.72	1.26
3150	8	0.74	1.51
4000	5	0.49	1.85
5000	6	0.66	1.82
6300	6	0.81	1.90
8000	8	1.02	0.88
10000	11	1.63	4.02
12500	10	1.68	5.26

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NVLAP LAB CODE 100227-0

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2019-02-20

APPENDIX B: Glossary for Variability Metrics

Specimen: Floor F05 - Composite floor with cross-laminated timber base, engineered wood surface (See Full Report)

ΔL_n, the 95% confidence interval for the reported normalized sound pressure level, is calculated from the standard deviation of the set of sound pressure levels measured during this individual test. This metric is calculated in an effort to quantify the variability in measured levels due to the combined influences of variation in the receive room sound field and differences in the specimen's response to different tapping machine locations.

Repeatability, expressed as a 95% confidence interval, is calculated from the standard deviation in normalized sound pressure level as obtained from a total of six consecutive tests conducted according to this test method by RAL from 2019-02-07 to 2019-02-12. The tests were performed on a 152.4 mm (6 in.) thick concrete slab specimen which was left installed and unaltered between tests. This metric provides an estimate of the variation in results that might be observed if the test were repeated with no change to the installed specimen. Note that repeatability will likely differ between different construction types.

APPENDIX C: Instruments of Traceability

Specimen: Floor F05 - Composite floor with cross-laminated timber base, engineered wood surface (See Full Report)

Description	Model	Serial Number	Date of Certification	Calibration Due
System 2	Type 3160-A-042	3160-106974	2018-08-09	2019-08-09
Bruel & Kjaer Mic And Preamp D	Type 4943-B-001	2311440	2018-09-28	2019-09-28
Wood Case Tapping Machine	Type 3204	226940	2018-08-23	2019-08-23
Bruel & Kjaer Pistonphone	Type 4228	2781248	2018-08-06	2019-08-06
EXTECH Hygro 330	SD700	A083330	2018-09-07	2019-09-07
EXTECH Hygro 322	SD700	A083322	2018-09-07	2019-09-07

APPENDIX D: Revisions to Original Test Report

Specimen: Floor F05 - Composite floor with cross-laminated timber base, engineered wood surface (See Full Report)

Date	Revision
2019-03-14	Original report issued

END

F05 - MPP DRY COMPOSITE FLOOR ASSEMBLY - RIVERBANK LABORATORY REPORT - STC

Unofficial Test Results & Preliminary Data Sheet

Riverbank Acoustical Laboratories (RAL)™
Laboratory Measurement of Airborne Sound Transmission Loss per ASTM E-90

Test Number: TL19-073 Test Date: 2019-03-27
Sponsor: Oregon State University
Designation: F05 Dry - Admonter Pine engineered Floor,1/8" underlayment, 2layers OSB, 3 layers 1/2" Durock cement board, 1" underlayment, 6" MPP (No Ceiling)
Dimensions: 2.44 m x 4.27 m x 0.27 m Test Conducted By: Marc Sciaky
Area: 10.41 m² Test Interface: 1.3.3
Weight: 1666.84 kg Area Weight: 160.19 kg/m²
Specimen Details:

Source Room: Room 3 Volume: 131.1 m³ Surface Area: 174.8 m²
Receive Room: Room 4 Volume: 81.8 m³ Surface Area: 130.7 m²

Freq (Hz)	TL (dB)	Precision (dB)	Deficiencies (dB)
31.5	38	6.71	
40	30	1.66	
50	30	1.44	
63	27	1.22	
80	34	1.04	
100	27	0.74	
125	34	0.96	1
160	34	0.43	4
200	35	0.35	6
250	37	0.40	7
315	42	0.29	5
400	46	0.28	4
500	50	0.22	1
630	53	0.20	
800	54	0.15	
1000	57	0.15	
1250	59	0.16	
1600	63	0.49	
2000	66	0.28	
2500	68	0.21	
3150	66	0.38	
4000	67	0.48	
5000	62	0.29	
6300	60	0.32	
8000	57	0.38	
10000	47	0.50	
12500	41	0.47	

Sound Transmission Coefficient (STC): 51
Total Deficiencies: 28

OITC: 40

Calculation Date: 2019-03-27
Calculated By: Marc Sciaky

This single report page and accompanying graph contain the instantaneous raw data as provided to the client after testing of the specimen. This data, although accurate, is incomplete without the full specimen description, mounting details and signature pages. The full report referenced by the RAL test number above should be consulted for further information regarding these results.

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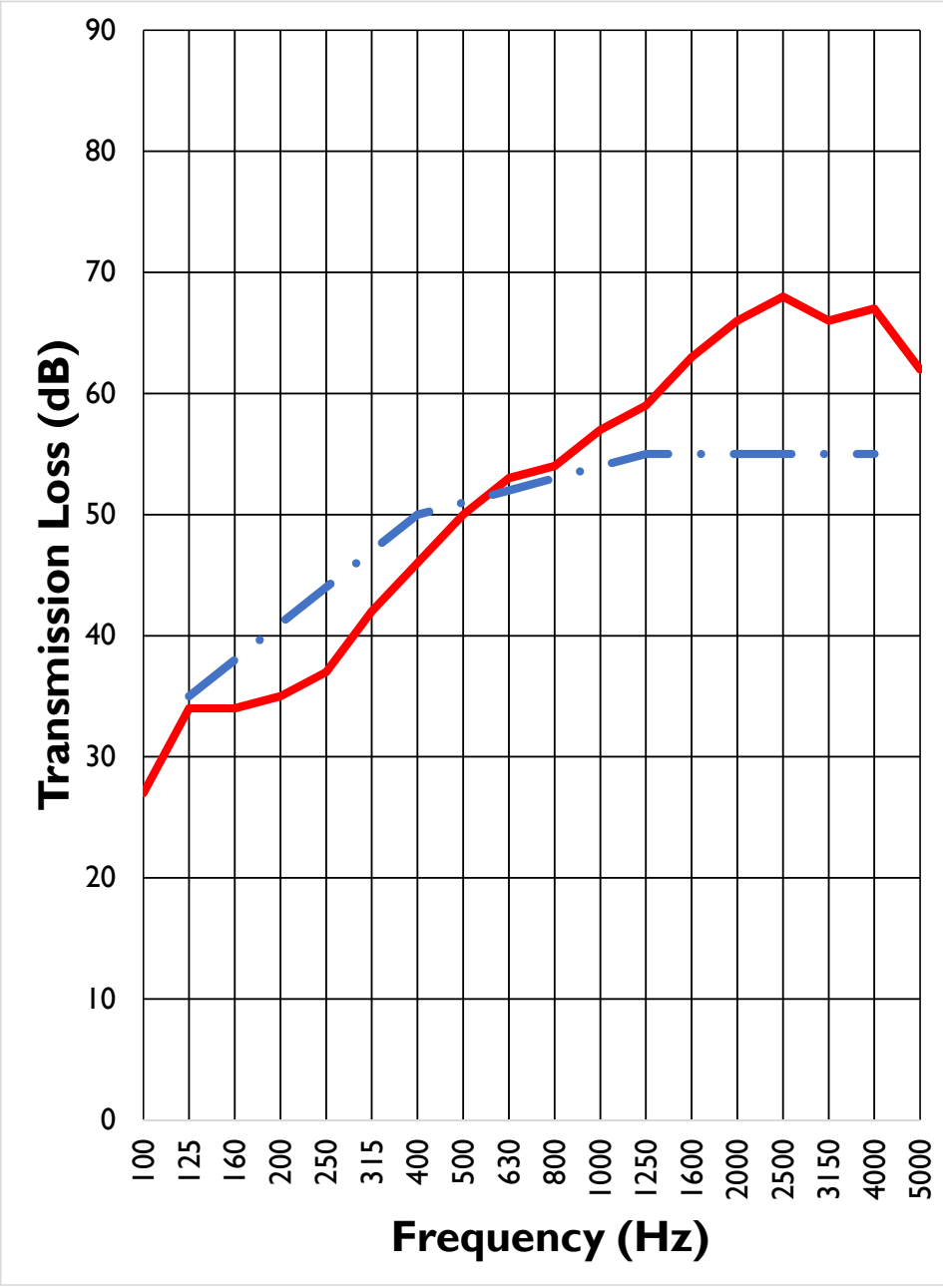
SOUND TRANSMISSION RESULTS

F05 Dry - Admonter Pine engineered Floor,1/8" underlayment, 2layers OSB, 3 layers 1/2" Durock cement board, 1" underlayment, 6" MPP (No Ceiling)

TL19-073



STC = 51

TOTAL DEFICIENCIES = 28

F05 - MPP DRY COMPOSITE FLOOR ASSEMBLY - RIVERBANK LABORATORY REPORT - IIC

Unofficial Test Results & Preliminary Data Sheet

Riverbank Acoustical Laboratories (RAL)™ / An Alion Science Technical Center (RALVer 15.2)

Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions ASTM E 90-09/NVLAP 08/P06

Test Number: IN19-018 Test Date: 2019-03-26

Sponsor: Oregon State University

Designation: F05 Dry - Admonter Pine engineered Floor,1/8" underlayment, 2layers OSB, 3 layers 1/2" Durock cement board, 1" underlayment, 6" MPP (No Ceiling)

Dimensions: 2.44 m x 4.27 m x 0.27 m Test Conducted By: Marc Sciaky

Area: 10.41 m² Test Interface: 1.3.3

Weight: 1666.84 kg Area Weight: 160.19 kg/m²

Specimen Details:

Source Room: Room 3 Volume: 131.1 m³ Surface Area: 174.8 m²

Receive Room: Room 4 Volume: 81.8 m³ Surface Area: 130.7 m²

Freq (Hz)	nISPL (dB)	ΔLn (dB)	Deficiencies (dB)
31.5	62	6.56	
40	57	2.48	
50	62	3.82	
63	65	4.61	
80	71	5.34	
100	74	3.75	8
125	68	2.06	2
160	65	1.33	
200	67	3.06	1
250	68	2.13	2
315	65	2.36	
400	58	4.12	
500	51	1.84	
630	46	0.76	
800	42	1.13	
1000	36	1.54	
1250	31	1.31	
1600	24	0.88	
2000	19	1.34	
2500	13	2.04	
3150	8	1.40	
4000	6	0.53	
5000	8	0.65	
6300	7	0.84	
8000	8	1.03	
10000	11	1.62	
12500	10	1.68	

Impact Insulation Class (IIC): 46

Total Deficiencies: 13

Calculation Date: 2019-03-26

Calculated By: Marc Sciaky

This single report page and accompanying graph contain the instantaneous raw data as provided to the client after testing of the specimen. This data, although accurate, is incomplete without the full specimen description, mounting details and signature pages. The full report referenced by the RAL test number above should be consulted for further information regarding these results.

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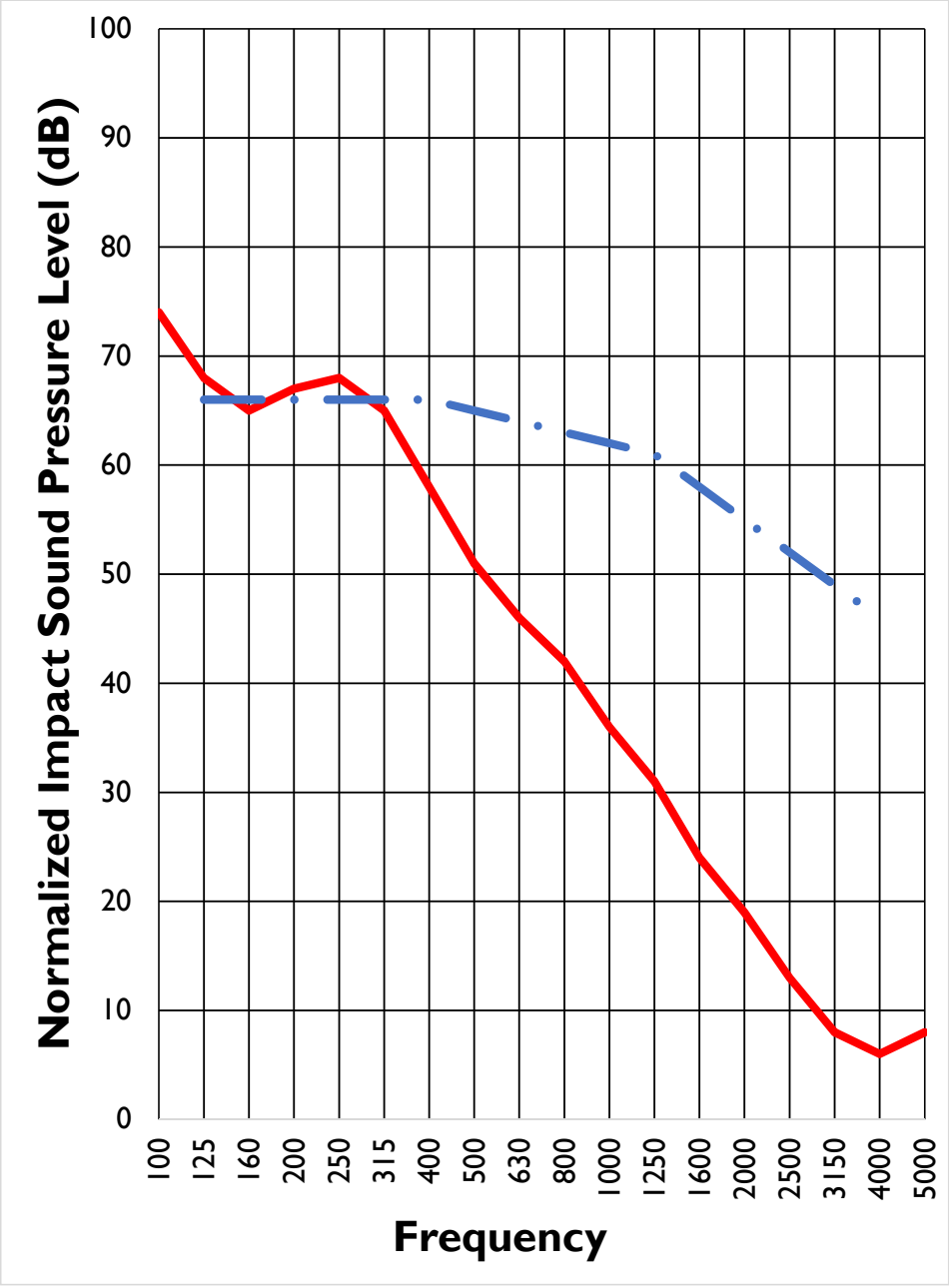
SOUND TRANSMISSION RESULTS

IN19-018



IIC = 46

TOTAL DEFICIENCIES = 13

F06 - CLT DRY COMPOSITE FLOOR ASSEMBLY - RIVERBANK LABORATORY REPORT - STC

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SPONSOR: **University of Oregon**
Eugene, OR

Sound Transmission Loss
RAL™-TL19-035

CONDUCTED: 2019-02-20

ON: Floor F06 - Composite floor with cross-laminated timber base, carpeted surface

TEST METHODOLOGY

Riverbank Acoustical Laboratories™ is accredited by the U.S. Department of Commerce, National Institute of Standards and Technology (NIST) under the National Voluntary Laboratory Accreditation Program (NVLAP) as an ISO 17025:2005 Laboratory (NVLAP Lab Code: 100227-0) and for this test procedure. The test reported in this document conformed explicitly with ASTM E90-09 (2016): "Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements." The single number rating of the specimen was calculated according to ASTM E413-16: "Classification for Rating Sound Insulation." A description of the measurement procedure and room specifications is available upon request. The transmission loss values are for a single direction of measurement. The results presented in this report apply to the sample as received from the test sponsor.

INFORMATION PROVIDED BY SPONSOR

The test specimen was designated by the sponsor as Floor F06 - Composite floor with cross-laminated timber base, carpeted surface. The following nominal product information was provided by the sponsor prior to testing. The accuracy of such sponsor-provided information can affect the validity of the test results.

Product Under Test

Materials:	Cross-laminated timber panels, 5 layers
Manufacturer:	Tallwood Design Institute
Construction Designation:	F06

SPECIMEN CONSTRUCTION & TEST CONDITIONS

The building contractor and RAL staff compiled the following construction specification, in order of installation:

Base Slab

Dimensions:	2 @ 4241.8 mm (167 in.) x 1270 mm (50 in.)
Thickness:	174.62 mm (6.875 in.)
Joint:	Shiplap joint, 101.6 mm (4 in.) wide x 85.72 mm (3.375 in.) tall
Installation:	Panel ends brushed with Seal Once Nano-guard wood sealer prior to laying in test opening 6.35 mm (0.25 in.) diameter bead of Chemlink Build Secure adhesive along center of joint Panels screwed together through joint

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2019-02-20

RAL™-TL19-035

Base Slab (continued)

Fasteners:	ASSY VG CSK screws, 8 mm (0.315 in.) x 160 mm (6.299 in.)
Fastener Spacing:	304.8 mm (12 in.) on center, 15 fasteners total
Weights:	Panels @ 977.04 kg (2154 lbs) Adhesive @ 0.23 kg (0.5 lbs) Fasteners @ 0.57 kg (1.25 lbs)

Composite Flooring

Layer 1

Trade Name:	Regupol Sonus Wave underlayment
Material:	Bonded crumb rubber
Dimensions:	2 @ 1219.2 mm (48 in.) x 4267.2 mm (168 in.)
Thickness:	Maximum @ 28 mm (1.102 in.)
Overall Weight:	90.04 kg (198.5 lbs)
Mass per Unit Area:	8.65 kg/m^2 (1.77 lbs/ft^2)
Installation:	Loose laid parallel to length of base slab Joint sealed with duct tape

Layer 2

Trade Name:	USG Durock
Material:	Cement board
Dimensions:	3 @ 1219.2 mm (48 in.) x 2438.4 mm (96 in.) 1 @ 596.9 mm (23.5 in.) x 2438.4 mm (96 in.)
Thickness:	12.7 mm (0.5 in.)
Overall Weight:	118.16 kg (260.5 lbs)
Mass per Unit Area:	11.36 kg/m^2 (2.33 lbs/ft^2)
Installation:	Loose laid perpendicular to length of base slab, joint staggered 12 in. along length from previous layer (see drawing attached). Joints treated with thin bead of CertainTeed Green Glue 6.35 mm (0.25 in.) diameter bead of Chemlink Build Secure adhesive applied in lines spaced 203.2 mm (8 in.) on center along board width

F06 - CLT DRY COMPOSITE FLOOR ASSEMBLY - RIVERBANK LABORATORY REPORT - STC

Composite Flooring (continued)

Layer 3	
Trade Name:	USG Durock
Material:	Cement board
Dimensions:	4 @ 1219.2 mm (48 in.) x 914.4 mm (36 in.) 2 @ 1219.2 mm (48 in.) x 2438.4 mm (96 in.)
Thickness:	12.7 mm (0.5 in.)
Overall Weight:	115.78 kg (255.25 lbs)
Mass per Unit Area:	11.13 kg/m^2 (2.28 lbs/ft^2)
Installation:	Laid over Layer 2 on adhesive parallel to length of base slab, joint staggered 12 in. along length from previous layer (see drawing attached). Joints treated with thin bead of CertainTeed Green Glue 6.35 mm (0.25 in.) diameter bead of Chemlink Build Secure adhesive applied in lines spaced 203.2 mm (8 in.) on center along board width
Layer 4	
Trade Name:	USG Durock
Material:	Cement board
Dimensions:	3 @ 1219.2 mm (48 in.) x 2438.4 mm (96 in.) 1 @ 609.6 mm (24 in.) x 2438.4 mm (96 in.)
Thickness:	12.7 mm (0.5 in.)
Overall Weight:	121.11 kg (267 lbs)
Mass per Unit Area:	11.64 kg/m^2 (2.38 lbs/ft^2)
Installation:	Laid over Layer 3 on adhesive perpendicular to length of base slab, joint staggered 12 in. along length from previous layer (see drawing attached). Joints treated with thin bead of CertainTeed Green Glue 6.35 mm (0.25 in.) diameter bead of Chemlink Build Secure adhesive applied in lines spaced 203.2 mm (8 in.) on center along board width
Layer 5	
Material:	Tongue & groove oriented strand board subfloor
Manufacturer:	Georgia Pacific
Dimensions:	2 @ 1219.2 mm (48 in.) x 304.8 mm (12 in.) 2 @ 1219.2 mm (48 in.) x 2438.4 mm (96 in.) 2 @ 1219.2 mm (48 in.) x 1524 mm (60 in.)
Thickness:	15.88 mm (0.625 in.)
Overall Weight:	96.62 kg (213 lbs)
Mass per Unit Area:	9.29 kg/m^2 (1.90 lbs/ft^2)

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Layer 5 Installation:	Laid over Layer 4 on adhesive parallel to length of base slab, joint staggered 12 in. along length from previous layer (see drawing attached). Joints treated with thin bead of CertainTeed Green Glue 6.35 mm (0.25 in.) diameter bead of Chemlink Build Secure adhesive applied in lines spaced 203.2 mm (8 in.) on center along board width

Layer 6

Material:	Tongue & groove oriented strand board subfloor
Manufacturer:	Georgia Pacific
Dimensions:	3 @ 1219.2 mm (48 in.) x 2438.4 mm (96 in.) 1 @ 609.6 mm (24 in.) x 2438.4 mm (96 in.)
Thickness:	15.88 mm (0.625 in.)
Overall Weight:	98.09 kg (216.25 lbs)
Mass per Unit Area:	9.43 kg/m^2 (1.93 lbs/ft^2)
Installation:	Laid over Layer 5 on adhesive perpendicular to length of base slab, joint staggered 12 in. along length from previous layer (see drawing attached). Joints sealed with Green Glue and covered with duct tape

Note: The joint treatment and adhesives used in Layers 2-6 weighed 7.48 kg (16.5 lbs) total.

Layer 7

Material:	Carpet pad
Manufacturer:	Future Foams
Dimensions:	1 @ 1828.8 mm (72 in.) x 4267.2 mm (168 in.) 1 @ 609.6 mm (24 in.) x 4267.2 mm (168 in.)
Thickness:	9.52 mm (0.375 in.)
Overall Weight:	12.25 kg (27 lbs)
Mass per Unit Area:	1.18 kg/m^2 (0.24 lbs/ft^2)
Installation:	Loose laid over Layer 6 parallel to length of base slab, joint staggered 12 in. along length from previous layer (see drawing attached). Joint sealed with duct tape

Layer 8

Material:	Nylon carpet
Manufacturer:	Looptex Mills
Dimensions:	1 @ 2438.4 mm (96 in.) x 4267.2 mm (168 in.)
Pile Height:	12.7 mm (0.5 in.)
Overall Weight:	31.52 kg (69.5 lbs)
Mass per Unit Area:	3.03 kg/m^2 (0.62 lbs/ft^2)
Installation:	Loose laid over Layer 7

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Overall Specimen Measurements

Dimensions:	2.44 m (96.0 in) wide by 4.27 m (168.0 in) high
Thickness:	0.3 m (11.625 in)
Weight:	1668.88 kg (3679.25 lbs)
Transmission Area:	10.405 m² (112 ft²)
Mass per Unit Area:	160.39 kg/m² (32.85 lbs/ft²)

Test Aperture

Size:	4.27 m (14.0 ft) x 2.44 m (8.0 ft)
Filler Wall:	None
Sealed:	Source Side: Dense mastic seal around perimeter Received Side: ½" or 3/8" Backer Rod (by gap size), acoustical caulk applied full perimeter, then gap above filled to level with sand around full perimeter.

Test Environment

Source Room

Volume:	130.89 m³
Temperature:	22.8 °C ± 0.0 °C
Relative Humidity:	50.0 % ± 0.0 %

Receive Room

Volume:	81.81 m³
Temperature:	23.1 °C ± 0.6 °C
Relative Humidity:	51.0 % ± 0.0 %

Requirements

Temperature:	22° C +/- 2° C, not more than 3° C change over all tests.
Relative Humidity:	≥ 30%, not more than +/- 3% change over all tests.

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Figure 1 – Specimen mounted in test opening, as viewed from source room (tapping machine removed for test)

Figure 2 – Underside of installed test specimen, as viewed from receive room

Figure 3 – Installation of cross-laminated timber base slab

Figure 4 – Detail of bonded crumb rubber underlayment

Figure 5 – Composite flooring layer 1 installed

Figure 6 – Typical joint treatment and adhesive application pattern in cement board layers

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Figure 7 – Oriented strand board layers partially installed

Figure 8 – Carpet pad installed

F06 - CLT DRY COMPOSITE FLOOR ASSEMBLY - RIVERBANK LABORATORY REPORT - STC

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TEST RESULTS

Sound transmission loss values are tabulated at the eighteen standard frequencies. A graphic presentation of the data and additional information appear on the following pages. The precision of the transmission loss test data is within the limits set by the ASTM Standard E90-09 (2016).

FREQ.	TL	ΔTL	DEF.	FREQ.	TL	ΔTL	DEF.
100	30	0.54	0	800	65	0.25	0
125	37	0.70	2	1000	69	0.23	0
160	36	0.46	6	1250	73	0.36	0
200	40	0.30	5	1600	76	0.38	0
250	42	0.40	6	2000	79	0.37	0
315	46	0.35	5	2500	82	0.33	0
400	49	0.28	5	3150	86	0.56	0
500	54	0.23	1	4000	84	0.39	0
630	60	0.18	0	5000	71	0.92	0

STC=55

ABBREVIATION INDEX

FREQ. = FREQUENCY, HERTZ
TL = TRANSMISSION LOSS, dB
ΔTL = 95% CONFIDENCE INTERVAL FOR TL MEAUREMENTS, dB
DEF. = DEFICIENCIES, dB BELOW STC CONTOUR (SUM OF DEF = 30)
STC = SOUND TRANSMISSION CLASS

Tested by _____
Marc Sciaky
Senior Experimentalist

Report by _____
Malcolm Kelly
Acoustician

Approved by _____
Eric P. Wolfram
Laboratory Manager

Digitally signed by Eric P Wolfram
DN: cn=Eric P Wolfram, o=Alion Science & Technology, ou=Riverbank Acoustical Laboratories, email=ewolfram@alionscience.com, c=US
Date: 2019.03.25 17:07:55 -05'00'

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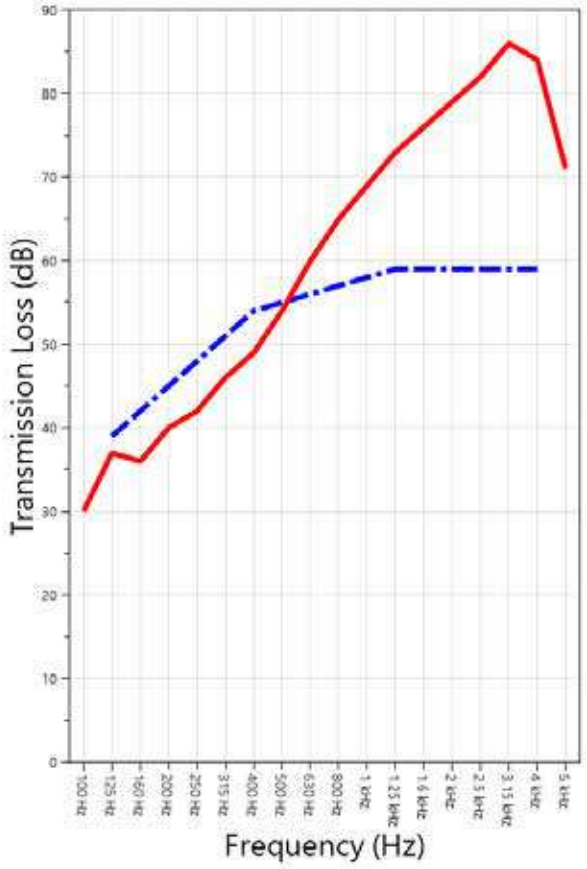
SOUND TRANSMISSION REPORT

Floor F06 - Composite floor with cross-laminated timber base, carpeted surface



STC=55

TRANSMISSION LOSS
SOUND TRANSMISSION CLASS CONTOUR

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APPENDIX A: Extended Frequency Range Data

Specimen: Floor F06 - Composite floor with cross-laminated timber base, carpeted surface (See Full Report)

The following non-accredited data were obtained in accordance with ASTM E90-09 (2016), but extend beyond the defined frequency range of 100Hz to 5,000Hz. These unofficial results are representative of the RAL test environment only and intended for research & comparison purposes. Sampling precision observed during this procedure is reported below.

1/3 Octave Band Center Frequency (Hz)	**Sound Transmission Loss** (dB)	**ΔTL (Eq. A2.5)** (dB)
31.5	51	5.10
40	36	1.25
50	34	1.41
63	29	0.89
80	32	0.76
100	30	0.54
125	37	0.70
160	36	0.46
200	40	0.30
250	42	0.40
315	46	0.35
400	49	0.28
500	54	0.23
630	60	0.18
800	65	0.25
1000	69	0.23
1250	73	0.36
1600	76	0.38
2000	79	0.37
2500	82	0.33
3150	86	0.56
4000	84	0.39
5000	71	0.92
6300	71	0.36
8000	68	0.17
10000	61	0.18
12500	51	0.13

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APPENDIX B: Instruments of Traceability

Specimen: Floor F06 - Composite floor with cross-laminated timber base, carpeted surface (See Full Report)

Description	Model	Serial Number	Date of Certification	Calibration Due
System 2	Type 3160-A-042	3160-106974	2018-08-09	2019-08-09
Bruel & Kjaer Mic And Preamp D	Type 4943-B-001	2311440	2018-09-28	2019-09-28
Bruel & Kjaer Pistonphone	Type 4228	2781248	2018-08-06	2019-08-06
EXTECH Hygro 330	SD700	A083330	2018-09-07	2019-09-07
EXTECH Hygro 322	SD700	A083322	2018-09-07	2019-09-07

APPENDIX C: Revisions to Original Test Report

Specimen: Floor F06 - Composite floor with cross-laminated timber base, carpeted surface (See Full Report)

Date	Revision
2019-03-13	Original report issued

END

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Test Report

SPONSOR: **University of Oregon**
Eugene, OR

Impact Sound Transmission
RAL™-IN19-014

CONDUCTED: 2019-02-20

ON: Floor F06 – Composite floor with cross-laminated timber base, carpeted surface

TEST METHODOLOGY

Riverbank Acoustical Laboratories™ is accredited by the U.S. Department of Commerce, National Institute of Standards and Technology (NIST) under the National Voluntary Laboratory Accreditation Program (NVLAP) as an ISO 17025:2005 Laboratory (NVLAP Lab Code: 100227-0) and for this test procedure. The test reported in this document conformed explicitly with ASTM E492-09: "Standard Test Method for Laboratory Measurement of Impact Sound Transmission Through Floor-Ceiling Assemblies Using the Tapping Machine." The single number rating of the specimen was calculated according to ASTM E989-18: "Standard Classification for Determination of Single-Number Metrics for Impact Noise." A description of the measurement procedure and room specifications is available upon request. The results presented in this report apply to the individual test specimen as described and assembled.

INFORMATION PROVIDED BY SPONSOR

The test specimen was designated by the sponsor as Floor F06 - Composite floor with cross-laminated timber base, carpeted surface. The following nominal product information was provided by the sponsor prior to testing. The accuracy of such sponsor-provided information can affect the validity of the test results.

Product Under Test

Materials:	Cross-laminated timber panels, 5 layers
Manufacturer:	Tallwood Design Institute
Construction Designation:	F06

SPECIMEN CONSTRUCTION & TEST CONDITIONS

The building contractor and RAL staff compiled the following construction specification, in order of installation:

Base Slab

Dimensions:	2 @ 4241.8 mm (167 in.) x 1270 mm (50 in.)
Thickness:	174.62 mm (6.875 in.)
Joint:	Shiplap joint, 101.6 mm (4 in.) wide x 85.72 mm (3.375 in.) tall
Installation:	Panel ends brushed with Seal Once Nano-guard wood sealer prior to laying in test opening 6.35 mm (0.25 in.) diameter bead of Chemlink Build Secure adhesive along center of joint Panels screwed together through joint

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Base Slab (continued)

Fasteners:	ASSY VG CSK screws, 8 mm (0.315 in.) x 160 mm (6.299 in.)
Fastener Spacing:	304.8 mm (12 in.) on center, 15 fasteners total
Weights:	Panels @ 977.04 kg (2154 lbs) Adhesive @ 0.23 kg (0.5 lbs) Fasteners @ 0.57 kg (1.25 lbs)

Composite Flooring

Layer 1

Trade Name:	Regupol Sonus Wave underlayment
Material:	Bonded crumb rubber
Dimensions:	2 @ 1219.2 mm (48 in.) x 4267.2 mm (168 in.)
Thickness:	Maximum @ 28 mm (1.102 in.)
Overall Weight:	90.04 kg (198.5 lbs)
Mass per Unit Area:	8.65 kg/m^2 (1.77 lbs/ft^2)
Installation:	Loose laid parallel to length of base slab Joint sealed with duct tape

Layer 2

Trade Name:	USG Durock
Material:	Cement board
Dimensions:	3 @ 1219.2 mm (48 in.) x 2438.4 mm (96 in.) 1 @ 596.9 mm (23.5 in.) x 2438.4 mm (96 in.)
Thickness:	12.7 mm (0.5 in.)
Overall Weight:	118.16 kg (260.5 lbs)
Mass per Unit Area:	11.36 kg/m^2 (2.33 lbs/ft^2)
Installation:	Loose laid perpendicular to length of base slab, joint staggered 12 in. along length from previous layer (see drawing attached). Joints treated with thin bead of CertainTeed Green Glue 6.35 mm (0.25 in.) diameter bead of Chemlink Build Secure adhesive applied in lines spaced 203.2 mm (8 in.) on center along board width

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Composite Flooring (continued)

Layer 3	
Trade Name:	USG Durock
Material:	Cement board
Dimensions:	4 @ 1219.2 mm (48 in.) x 914.4 mm (36 in.) 2 @ 1219.2 mm (48 in.) x 2438.4 mm (96 in.)
Thickness:	12.7 mm (0.5 in.)
Overall Weight:	115.78 kg (255.25 lbs)
Mass per Unit Area:	11.13 kg/m^2 (2.28 lbs/ft^2)
Installation:	Laid over Layer 2 on adhesive parallel to length of base slab, joint staggered 12 in. along length from previous layer (see drawing attached). Joints treated with thin bead of CertainTeed Green Glue 6.35 mm (0.25 in.) diameter bead of Chemlink Build Secure adhesive applied in lines spaced 203.2 mm (8 in.) on center along board width
Layer 4	
Trade Name:	USG Durock
Material:	Cement board
Dimensions:	3 @ 1219.2 mm (48 in.) x 2438.4 mm (96 in.) 1 @ 609.6 mm (24 in.) x 2438.4 mm (96 in.)
Thickness:	12.7 mm (0.5 in.)
Overall Weight:	121.11 kg (267 lbs)
Mass per Unit Area:	11.64 kg/m^2 (2.38 lbs/ft^2)
Installation:	Laid over Layer 3 on adhesive perpendicular to length of base slab, joint staggered 12 in. along length from previous layer (see drawing attached). Joints treated with thin bead of CertainTeed Green Glue 6.35 mm (0.25 in.) diameter bead of Chemlink Build Secure adhesive applied in lines spaced 203.2 mm (8 in.) on center along board width
Layer 5	
Material:	Tongue & groove oriented strand board subfloor
Manufacturer:	Georgia Pacific
Dimensions:	2 @ 1219.2 mm (48 in.) x 304.8 mm (12 in.) 2 @ 1219.2 mm (48 in.) x 2438.4 mm (96 in.) 2 @ 1219.2 mm (48 in.) x 1524 mm (60 in.)
Thickness:	15.88 mm (0.625 in.)
Overall Weight:	96.62 kg (213 lbs)
Mass per Unit Area:	9.29 kg/m^2 (1.90 lbs/ft^2)

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Layer 5 Installation: Laid over Layer 4 on adhesive parallel to length of base slab, joint staggered 12 in. along length from previous layer (see drawing attached).
Joints treated with thin bead of CertainTeed Green Glue
6.35 mm (0.25 in.) diameter bead of Chemlink Build Secure adhesive applied in lines spaced 203.2 mm (8 in.) on center along board width

Composite Flooring (continued)

Layer 6

Material:	Tongue & groove oriented strand board subfloor
Manufacturer:	Georgia Pacific
Dimensions:	3 @ 1219.2 mm (48 in.) x 2438.4 mm (96 in.) 1 @ 609.6 mm (24 in.) x 2438.4 mm (96 in.)
Thickness:	15.88 mm (0.625 in.)
Overall Weight:	98.09 kg (216.25 lbs)
Mass per Unit Area:	9.43 kg/m^2 (1.93 lbs/ft^2)
Installation:	Laid over Layer 5 on adhesive perpendicular to length of base slab, joint staggered 12 in. along length from previous layer (see drawing attached). Joints sealed with Green Glue and covered with duct tape

Note: The joint treatment and adhesives used in Layers 2-6 weighed 7.48 kg (16.5 lbs) total.

Layer 7

Material:	Carpet pad
Manufacturer:	Future Foams
Dimensions:	1 @ 1524 mm (60 in.) x 4267.2 mm (168 in.) 1 @ 609.6 mm (24 in.) x 4267.2 mm (168 in.)
Thickness:	9.52 mm (0.375 in.)
Overall Weight:	12.25 kg (27 lbs)
Mass per Unit Area:	1.18 kg/m^2 (0.24 lbs/ft^2)
Installation:	Loose laid over Layer 6 parallel to length of base slab, joint staggered 12 in. along length from previous layer (see drawing attached). Joint sealed with duct tape

Layer 8

Material:	Nylon carpet
Manufacturer:	Looptex Mills
Dimensions:	1 @ 2438.4 mm (96 in.) x 4267.2 mm (168 in.)
Pile Height:	12.7 mm (0.5 in.)
Overall Weight:	31.52 kg (69.5 lbs)
Mass per Unit Area:	3.03 kg/m^2 (0.62 lbs/ft^2)
Installation:	Loose laid over Layer 7

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University of Oregon **RAL™-IN19-014**

2019-02-20

Overall Specimen Measurements

Dimensions:	2.44 m (96.0 in) wide by 4.27 m (168.0 in) high
Thickness:	0.3 m (11.625 in)
Weight:	1668.88 kg (3679.25 lbs)
Transmission Area:	10.405 m² (112 ft²)
Mass per Unit Area:	160.39 kg/m² (32.85 lbs/ft²)

Test Aperture

Size:	4.27 m (14.0 ft.) by 2.44 m (8 ft.)
Filler Wall:	None
Sealed:	Source Side: Dense mastic seal around perimeter Received Side: ½" or 3/8" Backer Rod (by gap size), acoustical caulk applied full perimeter, then gap above filled to level with sand around full perimeter.

Test Environment

Source Room

Volume:	130.89 m³
Temperature:	22.8 °C ± 0.0 °C
Relative Humidity:	50.5 % ± 1.0 %

Receive Room

Volume:	81.81 m³
Temperature:	23.1 °C ± 0.6 °C
Relative Humidity:	51.5 % ± 1.0 %

Requirements

Temperature:	22º C +/- 5° C, not more than 3° C change over all tests.
Relative Humidity:	≥ 30% RH; not more than +/- 3% change over all tests.

NVLAP TESTING
NVLAP LAB CODE 100227-0

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Figure 1 – Specimen mounted in test opening, as viewed from source room

Figure 2 – Underside of installed test specimen, as viewed from receive room

Figure 3 – Installation of cross-laminated timber base slab

Figure 4 – Detail of bonded crumb rubber underlayment

Figure 5 – Composite flooring layer 1 installed

Figure 6 – Typical joint treatment and adhesive application pattern in cement board layers

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Figure 7 – Oriented strand board layers partially installed

Figure 8 – Carpet pad installed

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University of Oregon **RAL™-IN19-014**

2019-02-20

TEST RESULTS

The averaged sound pressure levels, normalized to a receive room reference absorption of 10 m^2, are tabulated at the sixteen standard frequencies. A graphic presentation of the data and additional information appear on the following pages. The 95% confidence interval for the sound pressure level in the receive room is below the limits specified in Section A1.4 of ASTM E492-09.

FREQ.	L_n	ΔL_n	DEV	FREQ.	L_n	ΔL_n	DEV
100	53	5.13	8	800	6	0.35	0
125	40	3.91	0	1000	5	0.22	0
160	35	1.99	0	1250	2	0.37	0
200	31	1.91	0	1600	3	0.61	0
250	30	2.46	0	2000	2	0.31	0
315	33	6.14	0	2500	2	0.29	0
400	29	6.04	0	3150	5	0.77	0
500	23	1.93	0				
630	8	0.66	0				

IIC=67

ABBREVIATION INDEX

FREQ. = FREQUENCY, HERTZ, (cps)
L_n = NORMALIZED SOUND PRESSURE LEVEL, dB
ΔL_n = 95% UNCERTAINTY LIMIT FOR L_n, dB
DEV. = DEVIATION FROM SHIFTED IIC CONTOUR, dB (SUM OF DEV = 8)
IIC = IMPACT INSULATION CLASS
* = INDICATES A CORRECTION HAS BEEN APPLIED TO DATA DUE TO BACKGROUND NOISE LEVELS

Tested by _____
Marc Sciaky
Senior Experimentalist

Report by _____
Malcolm Kelly
Test Engineer, Acoustician

Approved by _____
Eric P. Wolfram
Laboratory Manager

Digitally signed by Eric P Wolfram
DN: cn=Eric P Wolfram, o=Alion Science & Technology, ou=Riverbank Acoustical Laboratories, email=ewolfram@alionscience.com, c=US
Date: 2019.03.25 17:06:40 -05'00'

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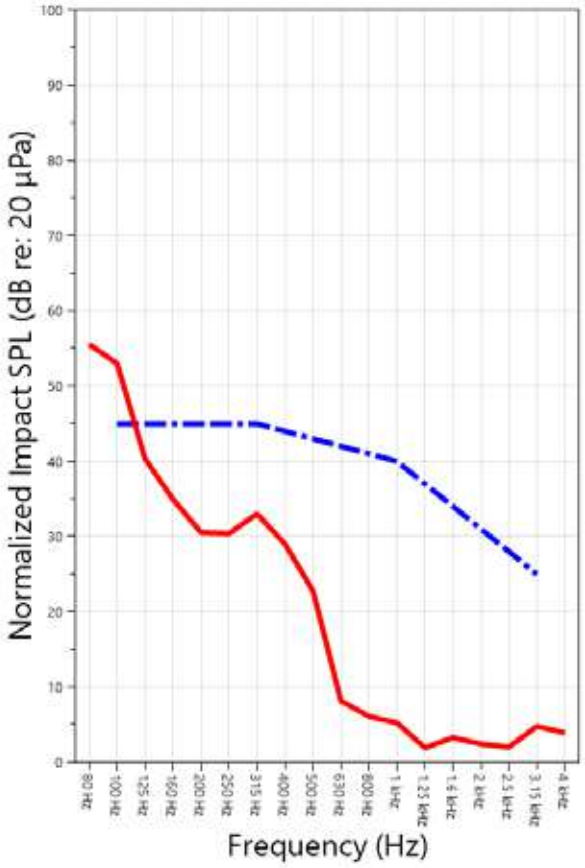
2019-02-20

RAL™-IN19-014

IMPACT SOUND TRANSMISSION REPORT

Floor F06 - Composite floor with cross-laminated timber base, carpeted surface



IIC=67

IMPACT SOUND PRESSURE LEVEL
IMPACT INSULATION CLASS CONTOUR

NVLAP® TESTING
NVLAP LAB CODE 100227-0

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Test Report

University of Oregon **RAL™-IN19-014**

2019-02-20

APPENDIX A: Extended Frequency Range Data

Specimen: Floor F06 - Composite floor with cross-laminated timber base, carpeted surface (See Full Report)

The following non-accredited data were obtained in accordance with ASTM E989-06 (2012), but extend beyond the defined frequency range of 100 Hz to 3,150 Hz. These unofficial results are representative of the RAL test environment only and intended for research & comparison purposes.

1/3 Octave Band Center Frequency (Hz)	L_n (dB)	ΔL_n (dB)	Repeatability (dB)
31.5	35	5.29	4.45
40	52	2.51	3.47
50	58	1.77	2.55
63	55	2.76	5.07
80	56	5.61	2.23
100	53	5.13	3.47
125	40	3.91	2.85
160	35	1.99	2.46
200	31	1.91	1.93
250	30	2.46	0.73
315	33	6.14	0.79
400	29	6.04	2.17
500	23	1.93	1.93
630	8	0.66	0.21
800	6	0.35	1.41
1000	5	0.22	2.05
1250	2	0.37	1.49
1600	3	0.61	2.22
2000	2	0.31	2.51
2500	2	0.29	1.26
3150	5	0.77	1.51
4000	4	0.49	1.85
5000	6	0.64	1.82
6300	6	0.82	1.90
8000	8	1.03	0.88
10000	10	1.62	4.02
12500	11	1.68	5.26

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APPENDIX B: Glossary for Variability Metrics

Specimen: Floor F06 - Composite floor with cross-laminated timber base, carpeted surface (See Full Report)

ΔL_n, the 95% confidence interval for the reported normalized sound pressure level, is calculated from the standard deviation of the set of sound pressure levels measured during this individual test. This metric is calculated in an effort to quantify the variability in measured levels due to the combined influences of variation in the receive room sound field and differences in the specimen's response to different tapping machine locations.

Repeatability, expressed as a 95% confidence interval, is calculated from the standard deviation in normalized sound pressure level as obtained from a total of six consecutive tests conducted according to this test method by RAL from 2019-02-07 to 2019-02-12. The tests were performed on a 152.4 mm (6 in.) thick concrete slab specimen which was left installed and unaltered between tests. This metric provides an estimate of the variation in results that might be observed if the test were repeated with no change to the installed specimen. Note that repeatability will likely differ between different construction types.

APPENDIX C: Instruments of Traceability

Specimen: Floor F06 - Composite floor with cross-laminated timber base, carpeted surface (See Full Report)

Description	Model	Serial Number	Date of Certification	Calibration Due
System 2	Type 3160-A-042	3160-106974	2018-08-09	2019-08-09
Bruel & Kjaer Mic And Preamp D	Type 4943-B-001	2311440	2018-09-28	2019-09-28
Wood Case Tapping Machine	Type 3204	226940	2018-08-23	2019-08-23
Bruel & Kjaer Pistonphone	Type 4228	2781248	2018-08-06	2019-08-06
EXTECH Hygro 330	SD700	A083330	2018-09-07	2019-09-07
EXTECH Hygro 322	SD700	A083322	2018-09-07	2019-09-07

APPENDIX D: Revisions to Original Test Report

Specimen: Floor F06 - Composite floor with cross-laminated timber base, carpeted surface (See Full Report)

Date	Revision
2019-03-14	Original report issued

END

F06 - MPP DRY COMPOSITE FLOOR ASSEMBLY - RIVERBANK LABORATORY REPORT - STC

Unofficial Test Results & Preliminary Data Sheet

Riverbank Acoustical Laboratories (RAL)™
Laboratory Measurement of Airborne Sound Transmission Loss per ASTM E-90

Test Number: TL19-074 Test Date: 2019-03-27
Sponsor: Oregon State University
Designation: F06 Dry - 1/2" pile nylon carpet, 3/8" 8lb carpet pad, 2layers OSB, 3 layers 1/2" Durock cement board, 1" underlayment, 6" MPP (No Ceiling)
Dimensions: 2.44 m x 4.27 m x 0.28 m Test Conducted By: Marc Sciaky
Area: 10.41 m² Test Interface: I.3.3
Weight: 1655.39 kg Area Weight: 159.09 kg/m²
Specimen Details:

Source Room: Room 3 Volume: 131.1 m³ Surface Area: 174.8 m²
Receive Room: Room 4 Volume: 81.8 m³ Surface Area: 130.7 m²

Freq (Hz)	TL (dB)	Precision (dB)	Deficiencies (dB)
31.5	43	3.36	
40	35	1.37	
50	35	1.21	
63	30	0.92	
80	33	0.57	
100	30	0.53	
125	34	0.63	3
160	36	0.57	4
200	38	0.25	5
250	41	0.32	5
315	45	0.18	4
400	47	0.21	5
500	52	0.20	1
630	59	0.21	
800	65	0.26	
1000	69	0.14	
1250	74	0.19	
1600	77	0.15	
2000	80	0.28	
2500	83	0.34	
3150	88	0.15	
4000	89	0.16	
5000	85	0.26	
6300	80	0.39	
8000	72	0.12	
10000	63	0.15	
12500	50	0.18	

Sound Transmission Coefficient (STC): 53
Total Deficiencies: 27

OITC: 42

Calculation Date: 2019-03-27
Calculated By: Marc Sciaky

This single report page and accompanying graph contain the instantaneous raw data as provided to the client after testing of the specimen. This data, although accurate, is incomplete without the full specimen description, mounting details and signature pages. The full report referenced by the RAL test number above should be consulted for further information regarding these results.

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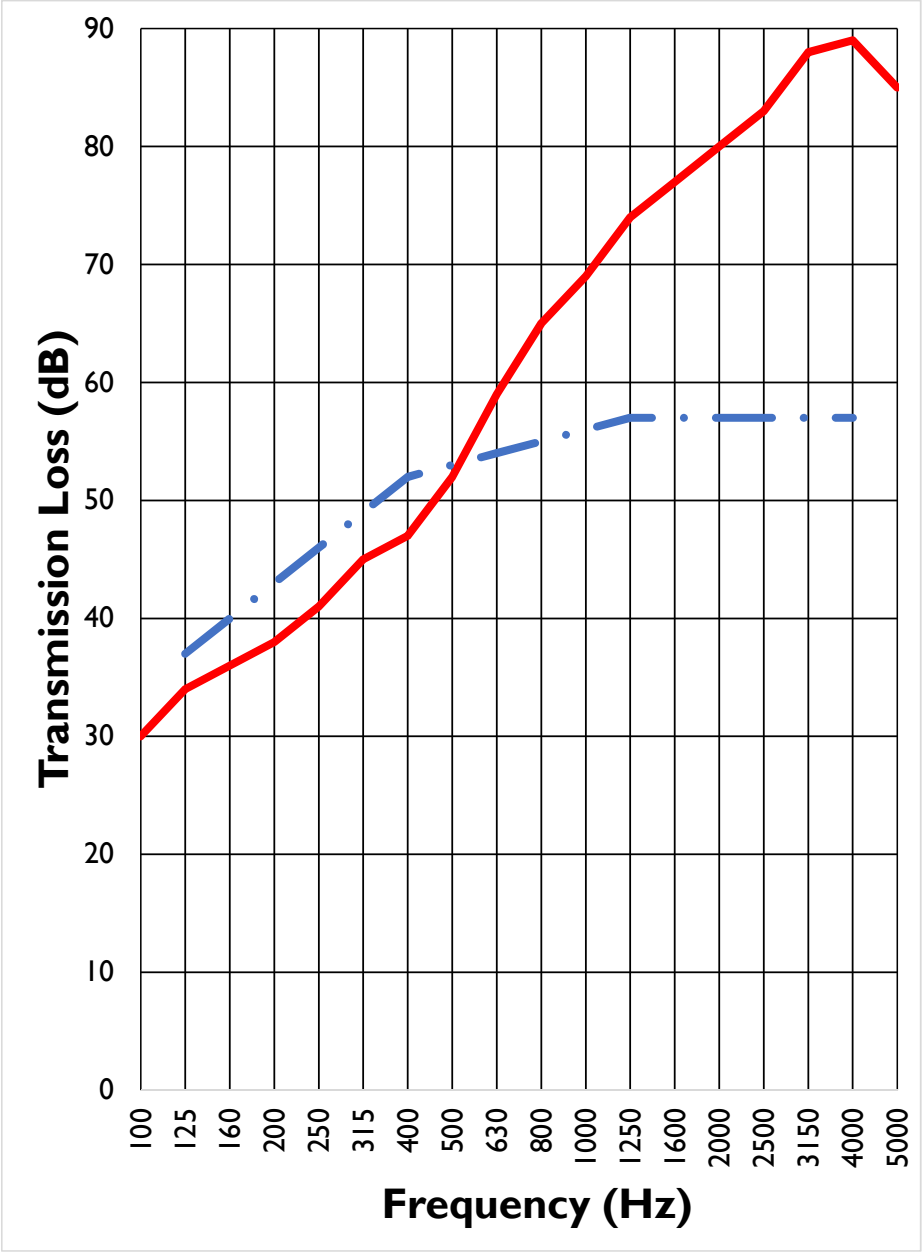
F06 - MPP DRY COMPOSITE FLOOR ASSEMBLY - RIVERBANK LABORATORY REPORT - STC

SOUND TRANSMISSION RESULTS

F06 Dry - 1/2" pile nylon carpet, 3/8" 8lb carpet pad, 2layers OSB, 3 layers 1/2" Durock cement board, 1" underlayment, 6" MPP (No Ceiling)

TL19-074



STC = 53

TOTAL DEFICIENCIES = 27

F06 - MPP DRY COMPOSITE FLOOR ASSEMBLY - RIVERBANK LABORATORY REPORT - IIC

Unofficial Test Results & Preliminary Data Sheet
Riverbank Acoustical Laboratories (RAL)™ / An Alion Science Technical Center (RALVer 15.2)
Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions ASTM E 90-09/NVLAP 08/P06

Test Number: IN19-019 Test Date: 2019-03-27
Sponsor: Oregon State University
Designation: F06 Dry - 1/2" pile nylon carpet, 3/8" 8lb carpet pad, 2layers OSB, 3 layers 1/2" Durock cement board, 1" underlayment, 6" MPP (No Ceiling)
Dimensions: 2.44 m x 4.27 m x 0.28 m Test Conducted By: Marc Sciaky
Area: 10.41 m² Test Interface: 1.3.3
Weight: 1655.39 kg Area Weight: 159.09 kg/m²
Specimen Details:

Source Room: Room 3 Volume: 131.1 m³ Surface Area: 174.8 m²
Receive Room: Room 4 Volume: 81.8 m³ Surface Area: 130.7 m²

Freq (Hz)	nISPL (dB)	ΔLn (dB)	Deficiencies (dB)
31.5	44	5.05	
40	52	2.84	
50	58	2.44	
63	57	2.88	
80	55	3.96	
100	54	5.10	8
125	41	3.29	
160	34	1.67	
200	30	1.19	
250	31	2.55	
315	39	1.82	
400	35	2.20	
500	23	1.76	
630	10	0.76	
800	8	0.29	
1000	5	0.47	
1250	1	0.25	
1600	3	0.16	
2000	6	0.42	
2500	4	0.42	
3150	3	0.50	
4000	3	0.45	
5000	7	0.64	
6300	6	0.80	
8000	8	1.02	
10000	12	1.64	
12500	9	1.68	

Impact Insulation Class (IIC): 66
Total Deficiencies: 8

Calculation Date: 2019-03-27
Calculated By: Marc Sciaky

This single report page and accompanying graph contain the instantaneous raw data as provided to the client after testing of the specimen. This data, although accurate, is incomplete without the full specimen description, mounting details and signature pages. The full report referenced by the RAL test number above should be consulted for further information regarding these results.

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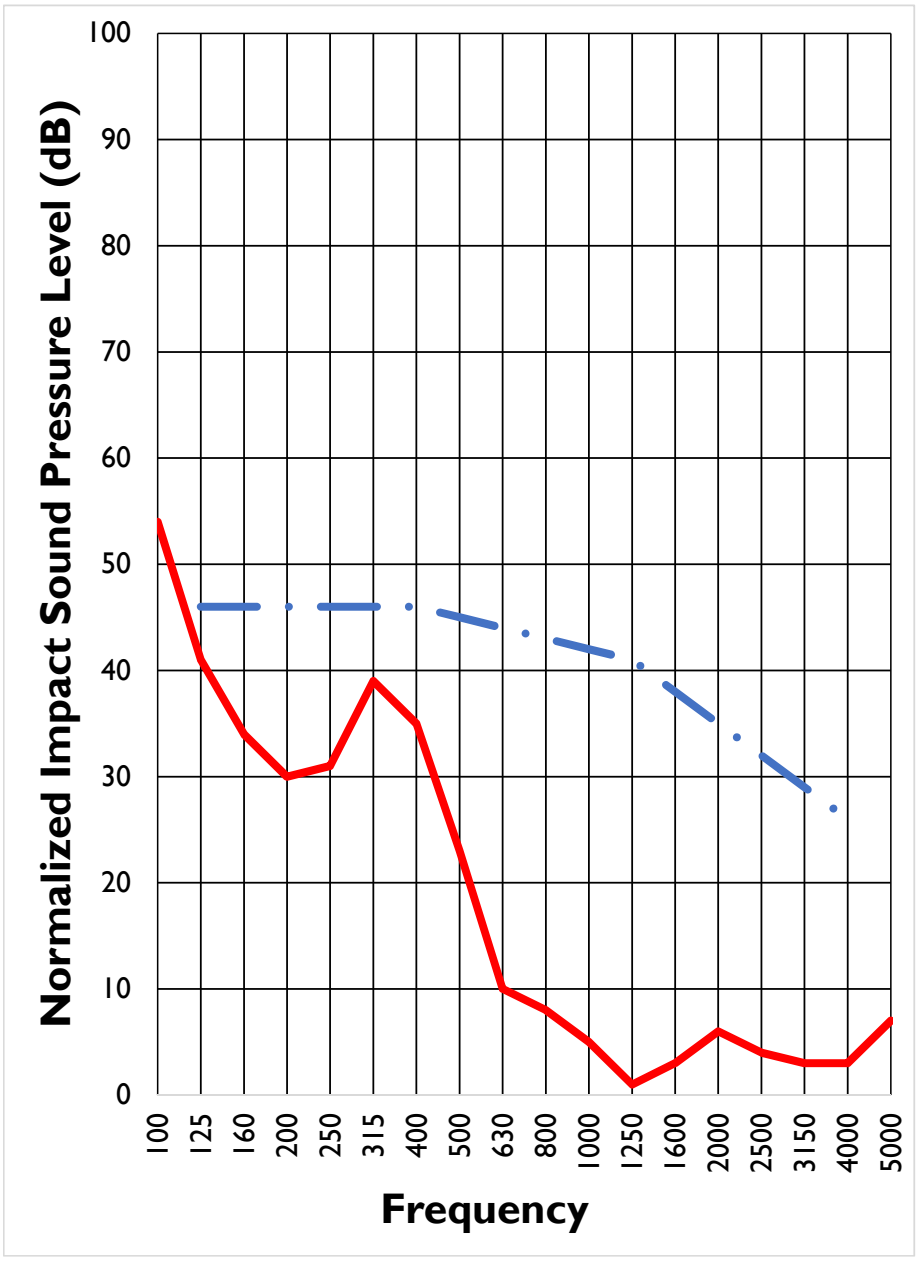
F06 - MPP DRY COMPOSITE FLOOR ASSEMBLY - RIVERBANK LABORATORY REPORT - IIC



IIC = 66

TOTAL DEFICIENCIES = 8

6.8 USG LABORATORY WALL REPORTS

Corporate Innovation Center
Construction Systems Lab
700 North Highway 45
Libertyville, IL 60048

USG Testing Services
TEST REPORT

ASTM E90-09
"Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements"

Prepared for:
University of Oregon
Energy Studies in Building Laboratory
103 Pacific Hall
Eugene, OR 97403
Attn: Dale Northcutt

Project No: UOREG - 012519
Report No: Wall STC -190245
Date Submitted: 3/29/19
Date Tested: 2/26/2019

Introduction
This documented contains ASTM E90-09 test results of CLT panels.

Prepared By:

David Moyer
Senior Researcher

Authorized By:

Joe Chambers
Director, Innovation Services Lab

Summary of Results

Test Number	Specimen	STC
Wall STC -190245	CLT panels	41

1. TITLE

ASTM E90-09 "Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements" testing of CLT Panels.

2. OBJECTIVE

To determine the Sound Transmission Class (STC) and the frequency specific Airborne Sound Transmission Loss of a manufactured panel system.

3. TESTED FOR

University of Oregon - Energy Studies in Building Laboratory
103 Pacific Hall
Eugene, OR 97403

4. TESTING ORGANIZATION

USG Testing Services

USG CORPORATION
Corporate Innovation Center
700 N US Highway 45
Libertyville, IL 60048-1268

5. TESTING PERSONNEL

Laboratory Manager: Joe Chambers
Tests Reviewed By: David Moyer

6. REFERENCE STANDARDS

ASTM E90-09 Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements

ASTM E413-16 Classification for Rating Sound Insulation

7. CALIBRATED TEST EQUIPMENT

Microphone: Bruel & Kjaer Type 4942 C 1 SN: 2741263
Bruel & Kjaer Type 4942 C 1 SN: 2807422

8. TEST SPECIMEN

5-LAM CLT PANEL. The specimen consisted of two CLT panels connected with a half lap joint. Each panel was nominally 1.27 m (50 in.) wide by 2.743 m (108 in.) high and 178 mm (7 in.) thick. Each panel had a nominal 51 mm (2 in.) wide by 102 mm (4 in.) deep half lap joint along one of the long sides of the panel. A single bead of construction adhesive was applied to the joint prior to installation and the panels were fastened together using 8 mm x 160 mm ASSY VG CSK fasteners spaced at 305 mm (12 in.) centers. The total weight of CLT panels was 671 kg (1479 lbs). The exposed joint was left unsealed. The full perimeter both sides of the specimen was sealed with dense mastic.

The total weight of the specimen as measured was 1479.4 bs., an average of 20.5 lbs/ft^2. The transmission area used in the calculations was 72.0 ft^2.

Additional details and photos regarding the test specimen and environmental conditions are provided in the appendix.

9. TEST SPECIMEN CONSTRUCTION

The test panels were provided by University of Oregon. All other materials and assembly were provided by USG personnel. Detailed drawings have been provided by the client and are considered proprietary. They have purposely been withheld from this report and are retained on file. They can be made available to other entities upon the written request of the client.

10. TEST SPECIMEN CONDITIONING

The test specimens were conditioned in the laboratory prior to testing. Average environmental conditions of the lab are 65 degrees F and 50 % RH.

11. TEST SETUP

The specimen was installed in a reduced opening of the full 9 ft. high by 16 ft. wide wood lined opening of an isolated partition between two large reverberant chambers. The periphery (both sides) was sealed with a dense mastic. The source room volume was 4542 ft^3 and the receive room volume was 7236 ft^3.

12. TEST PROCEDURE

The measurements reported below were made with all facilities and procedures in explicit conformity with the ASTM Designations E90-09 and E413-16, as well as other pertinent standards. The USG Acoustical Testing Facility has been accredited by the U.S. Department of Commerce, National Institute of Standards and Technology (NIST) under the National Voluntary Laboratory Accreditation Program (NVLAP) for this test procedure (NVLAP Lab Code: 200132-0). A full description of the measurement procedure is available separately. The transmission loss values are measured for a single direction of measurement.

13. TEST RESULTS

Summary of Test Results		
Test Number	**Specimen**	**STC**
Wall STC -190245	CLT panels	41

14. CONCLUSION

Based on the data obtained from this test, an STC of 41 can be obtained from a panel system assembled per Section 8 of this report.

15. TEST DATA

Test data has been attached to this report in the form of an appendix.

W07 - CLT WALL BASE CASE MASS TIMBER PANEL - USG LABORATORY REPORT

USG Testing Services
Corporate Innovation Center
700 North Highway 45 • Libertyville, IL 60048-1296 • (847) 970-5200
DATA REPORT

Airborne Sound Transmission Loss
ASTM E 90

Test Date:	2/26/2019
Test Number:	Wall STC - 190245
Client:	University of Oregon - Dale Northcutt
Project:	UOREG-012519
Test Operator:	Austin Phillips
Sample ID:	Sample A
Sample Description:	Two (4' x 9') CLT panels

Sample Physical Details:

Thickness:	7.00	in	Length:	96.00	in
Weight:	1479.4	lb	Height:	108.00	in
Specimen Area:	72.0	sq. ft	Filler Area:	72.00	sq. ft
Area Weight	20.5	PSF			

Detailed Description:

5-LAM CLT PANEL. The specimen consisted of two CLT panels connected with a half lap joint.Each panel was nominally 1.27 m (50 in.) wide by 2.743 m (108 in.) high and 178 mm (7 in.) thick. Each panel had a nominal 51 mm (2 in.) wide by 102 mm (4 in.) deep half lap joint along one of the long sides of the panel. A single bead of construction adhesive was applied to the joint prior to installation and the panels were fastened together using 8 mm x 160 mm ASSY VG CSK fasteners spaced at 305 mm (12 in.) centers.The total weight of CLT panels was 671 kg (1479 lbs). The exposed joint was left unsealed. The full perimeter both sides of the specimen was sealed with dense mastic.

Room Conditions	**Source Room**		**Receive Room**	
Temperature:	64.9 °F	18.3 °C	71.6 °F	22.0 °C
Relative Humidity:	53.7 %		55.0 %	
Volume:	4542 ft^3	128.6 m^3	7236 ft^3	204.9 m^3
Microphone:	B&K Type 4942 C 1 SN: 2741263		B&K Type 4942 C 1 SN: 2807422	

Data Page 1 of 3 Filename: Wall STC-190245 (Sample A Bare CLT Panels (Joint Untreated).xls

USG Testing Services
Corporate Innovation Center
700 North Highway 45 • Libertyville, IL 60048-1296 • (847) 970-5200
DATA REPORT

Airborne Sound Transmission Loss
ASTM E 90

Test Results

	FREQ (Hz)	Abs (m^2)	SOR (dB)	-REC (db)	TLc (dB)	FILLER ADJ	TLs (dB)	DEF. (dB)	UNC w/95% C.L.
35	80	8.9	97	67	32	*	30		1.07
39	100	7.1	101	72	32	*	30		1.54
50	125	5.2	103	70	37		34	-	1.47
54	160	6.3	102	68	37		34	-	0.65
56	200	5.9	100	67	37		34	-	0.87
57	250	6.1	100	67	36		33	1	0.78
62	315	8.3	97	61	38		35	2	0.37
65	400	8.6	98	63	37		34	6	0.46
67	500	8.4	96	59	39		36	5	0.27
71	630	7.7	98	60	40		37	5	0.17
76	800	7.1	97	58	41		38	5	0.28
80	1000	6.7	96	55	44		41	3	0.16
81	1250	6.9	97	53	47		44	1	0.17
82	1600	7.6	92	46	48		45	-	0.25
81	2000	8.4	89	42	49		46	-	0.26
82	2500	9.9	88	39	50		47	-	0.26
81	3150	11.7	87	37	51		48	-	0.25
83	4000	14.0	89	39	51		48	-	0.25
80	5000	17.2	88	37	50		47		0.33
73	6300	22.3	89	34	52		49		0.51
65	8000	30.3	89	33	52		49		0.51

Sound Transmission Class (STC):	**41**	Total Deficiencies:	28
		Max:	6

NOTES: • Indicates that receive room levels were adjusted for background noise
* Indicates a correction for the filler wall has been applied. *** Indicates measured perfomance is limited by filler.
Shaded lines indicate frequencies not governed by this test method.

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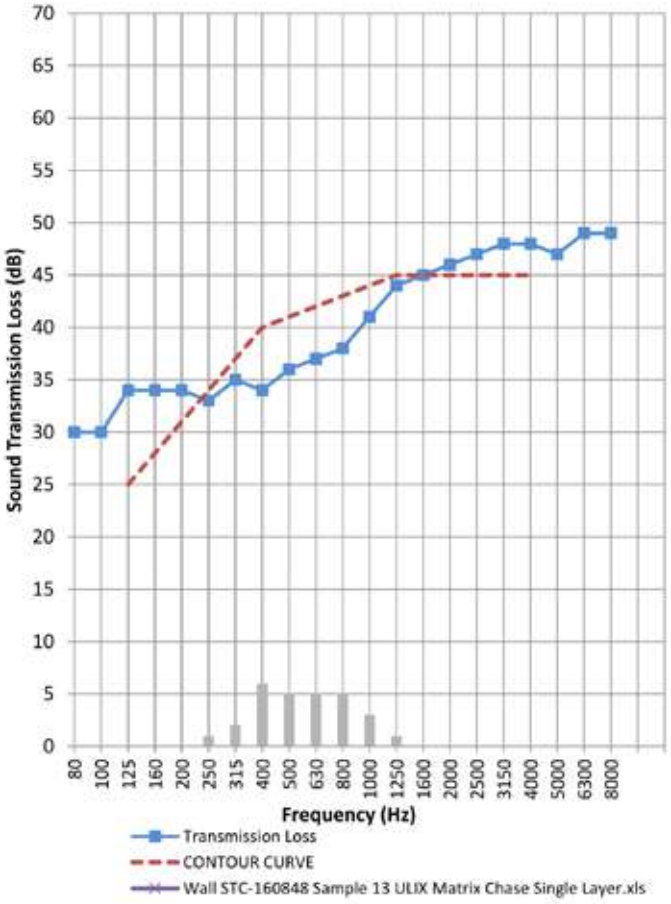
Data Page 2 of 3 Filename: Wall STC-190245 (Sample A Bare CLT Panels (Joint Untreated).xls

W07 - CLT WALL BASE CASE MASS TIMBER PANEL - USG LABORATORY REPORT

USG Testing Services
Corporate Innovation Center
700 North Highway 45 • Libertyville, IL 60048-1296 • (847) 970-5200
DATA REPORT

Airborne Sound Transmission Loss
ASTM E 90



Data Page 3 of 3

Filename: Wall STC-190245 (Sample A Bare CLT Panels (Joint Untreated).xls

Figure 1: Specimen prior to test

Corporate Innovation Center
Construction Systems Lab
700 North Highway 45
Libertyville, IL 60048

USG Testing Services
TEST REPORT

ASTM E90-09
"Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements"

Prepared for:
University of Oregon
Energy Studies in Building Laboratory
103 Pacific Hall
Eugene, OR 97403
Attn: Dale Northcutt

Project No: UOREG - 012519
Report No: Wall STC -190247
Date Submitted: 3/29/19
Date Tested: 2/27/2019

Introduction
This documented contains ASTM E90-09 test results of MPP panels.

Prepared By:

David Moyer
Senior Researcher

Authorized By:

Joe Chambers
Director, Innovation Services Lab

Summary of Results

Test Number	Specimen	STC
Wall STC -190247	MPP panels	36

1. TITLE

ASTM E90-09 "Standard Test Method for for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements" testing of MPP panels. .

2. OBJECTIVE

To determine the Sound Transmission Class (STC) and the frequency specific Airborne Sound Transmission Loss of a manufactured panel system.

3. TESTED FOR

University of Oregon - Energy Studies in Building Laboratory
103 Pacific Hall
Eugene, OR 97403

4. TESTING ORGANIZATION

USG Testing Services

USG CORPORATION
Corporate Innovation Center
700 N US Highway 45
Libertyville, IL 60048-1268

5. TESTING PERSONNEL

Laboratory Manager: Joe Chambers
Tests Reviewed By: David Moyer

6. REFERENCE STANDARDS

ASTM E90-09 Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements

ASTM E413-16 Classification for Rating Sound Insulation

7. CALIBRATED TEST EQUIPMENT

Microphone: Bruel & Kjaer Type 4942 C 1 SN: 2741263
Bruel & Kjaer Type 4942 C 1 SN: 2807422

8. TEST SPECIMEN

MPP PANEL. The specimen consisted of two MPP panels connected with a half lap joint. Each panel was nominally 1.27 m (50 in.) wide by 2.743 m (108 in.) high and 152 mm (6 in.) thick. Each panel had a nominal 51 mm (2 in.) wide by 102 mm (4 in.) deep half lap joint along one of the long sides of the panel. A single bead of construction adhesive was applied to the joint prior to installation and the panels were fastened together using 8 mm x 160 mm ASSY VG CSK fasteners spaced at 305 mm (12 in.) centers. The total weight of MPP panels, as measured, was 604 kg (1331 lbs). The exposed joint was left unsealed. The full perimeter both sides of the specimen was sealed with dense mastic.

The total weight of the specimen as measured was 1331 bs., an average of 18.5 lbs/ft^2. The transmission area used in the calculations was 72.0 ft^2.

Additional details and photos regarding the test specimen and environmental conditions are provided in the appendix.

9. TEST SPECIMEN CONSTRUCTION

The test panels were provided by University of Oregon. All other materials and assembly were provided by USG personnel. Detailed drawings have been provided by the client and are considered proprietary. They have purposely been withheld from this report and are retained on file. They can be made available to other entities upon the written request of the client.

10. TEST SPECIMEN CONDITIONING

The test specimens were conditioned in the laboratory prior to testing. Average environmental conditions of the lab are 65 degrees F and 50 % RH.

11. TEST SETUP

The specimen was installed in a reduced opening of the full 9 ft. high by 16 ft. wide wood lined opening of an isolated partition between two large reverberant chambers. The periphery (both sides) was sealed with a dense mastic. The source room volume was 4542 ft^3 and the receive room volume was 7236 ft^3.

12. TEST PROCEDURE

The measurements reported below were made with all facilities and procedures in explicit conformity with the ASTM Designations E90-09 and E413-16, as well as other pertinent standards. The USG Acoustical Testing Facility has been accredited by the U.S. Department of Commerce, National Institute of Standards and Technology (NIST) under the National Voluntary Laboratory Accreditation Program (NVLAP) for this test procedure (NVLAP Lab Code: 200132-0). A full description of the measurement procedure is available separately. The transmission loss values are measured for a single direction of measurement.

13. TEST RESULTS

Summary of Test Results		
Test Number	**Specimen**	**STC**
Wall STC -190247	MPP panels	36

14. CONCLUSION

Based on the data obtained from this test, an STC of 36 can be obtained from a panel system assembled per Section 8 of this report.

15. TEST DATA

Test data has been attached to this report in the form of an appendix.

W07 - MPP WALL BASE CASE MASS TIMBER PANEL - USG LABORATORY REPORT

USG Testing Services
Corporate Innovation Center
700 North Highway 45 • Libertyville, IL 60048-1296 • (847) 970-5200
DATA REPORT

Airborne Sound Transmission Loss
ASTM E 90

Test Date:	2/27/2019
Test Number:	Wall STC - 190247
Client:	University of Oregon - Dale Northcutt
Project:	UOREG-012519
Test Operator:	Austin Phillips
Sample ID:	Sample D
Sample Description:	Two (4' x 9') MPP panels

Sample Physical Details:

Thickness:	6.00	in	Length:	96.00	in
Weight:	1331.2	lb	Height:	108.00	in
Specimen Area:	72.0	sq. ft	Filler Area:	72.00	sq. ft
Area Weight	18.5	PSF			

Detailed Description:

MPP PANEL. The specimen consisted of two MPP panels connected with a half lap joint.Each panel was nominally 1.27 m (50 in.) wide by 2.743 m (108 in.) high and 152 mm (6 in.) thick. Each panel had a nominal 51 mm (2 in.) wide by 102 mm (4 in.) deep half lap joint along one of the long sides of the panel. A single bead of construction adhesive was applied to the joint prior to installation and the panels were fastened together using 8 mm x 160 mm ASSY VG CSK fasteners spaced at 305 mm (12 in.) centers. The total weight of MPP panels, as measured, was 604 kg (1331 lbs). The exposed joint was left unsealed. The full perimeter both sides of the specimen was sealed with dense mastic.

Room Conditions	**Source Room**		**Receive Room**	
Temperature:	66.0 °F	18.9 °C	71.6 °F	22.0 °C
Relative Humidity:	41.9 %		55.0 %	
Volume:	4542 ft^3	128.6 m^3	7236 ft^3	204.9 m^3
Microphone:	B&K Type 4942 C 1 SN: 2741263		B&K Type 4942 C 1 SN: 2807422	

Data Page 1 of 3 Filename: Wall STC-190247 (Sample D Bare MPP Panels (Joint Untreated)).xls

USG Testing Services
Corporate Innovation Center
700 North Highway 45 • Libertyville, IL 60048-1296 • (847) 970-5200
DATA REPORT

Airborne Sound Transmission Loss
ASTM E 90

Test Results

	FREQ (Hz)	Abs (m^2)	SOR (dB)	-REC (db)	TLc (dB)	FILLER ADJ	TLs (dB)	DEF. (dB)	UNC w/95% C.L.
35	80	10.4	98	70	29	*	26		0.97
39	100	6.9	102	73	32	*	29		1.57
50	125	5.4	103	72	35		**32**	-	1.22
54	160	6.3	101	70	34		**31**	-	0.72
56	200	6.0	100	68	36		**33**	-	0.82
57	250	5.7	100	70	34		**31**	-	0.86
62	315	8.5	97	64	35		**32**	-	0.43
65	400	8.7	98	64	36		**33**	2	0.40
67	500	8.3	97	63	36		**33**	3	0.31
71	630	7.6	98	64	37		**34**	3	0.27
76	800	7.2	97	62	38		**35**	3	0.20
80	1000	6.8	96	61	38		**35**	4	0.09
81	1250	7.1	97	61	39		**36**	4	0.16
82	1600	7.9	92	54	40		**37**	3	0.26
81	2000	9.0	89	50	41		**38**	2	0.25
82	2500	10.7	88	47	42		**39**	1	0.31
81	3150	13.1	87	46	41		**38**	2	0.30
83	4000	16.1	90	47	42		**39**	1	0.18
80	5000	20.3	89	44	43		40		0.33
73	6300	26.6	89	41	45		42		0.46
65	8000	36.5	89	39	46		43		0.45

Sound Transmission Class (STC):	**36**	Total Deficiencies:	28
		Max:	4

NOTES: • Indicates that receive room levels were adjusted for background noise
* Indicates a correction for the filler wall has been applied. *** Indicates measured perfomance is limited by filler.
Shaded lines indicate frequencies not governed by this test method.

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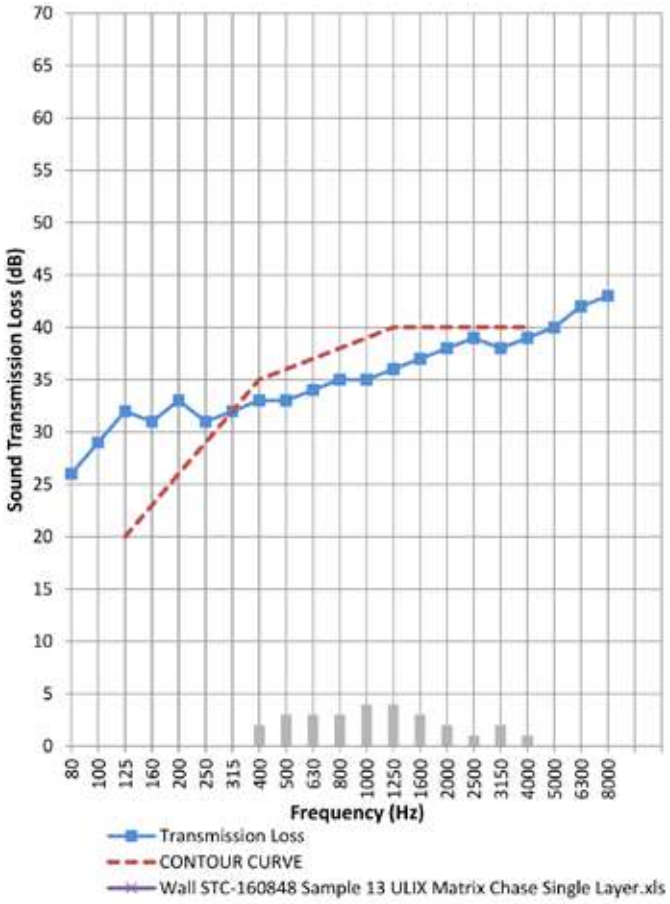
Data Page 2 of 3

Filename: Wall STC-190247 (Sample D Bare MPP Panels (Joint Untreated)).xls

W07 - MPP WALL BASE CASE MASS TIMBER PANEL - USG LABORATORY REPORT

USG Testing Services
Corporate Innovation Center
700 North Highway 45 • Libertyville, IL 60048-1296 • (847) 970-5200
DATA REPORT

Airborne Sound Transmission Loss
ASTM E 90



Data Page 3 of 3

Filename: Wall STC-190247 (Sample D Bare MPP Panels (Joint Untreated)).xls

Figure 1: Specimen prior to test

Corporate Innovation Center
Construction Systems Lab
700 North Highway 45
Libertyville, IL 60048

USG Testing Services
TEST REPORT

ASTM E90-09
"Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements"

Prepared for:
University of Oregon
Energy Studies in Building Laboratory
103 Pacific Hall
Eugene, OR 97403
Attn: Dale Northcutt

Project No: UOREG - 012519
Report No: Wall STC -190245
Date Submitted: 3/29/19
Date Tested: 2/26/2019

Introduction
This documented contains ASTM E90-09 test results of CLT panels with 5/8 in. USG Firecode X (UL Type ULIX) .

Prepared By:

David Moyer
Senior Researcher

Authorized By:

Joe Chambers
Director, Innovation Services Lab

Summary of Results

Test Number	Specimen	STC
Wall STC -190244	CLT panels with 5/8 in. USG Firecode X (UL Type ULIX)	42

1. TITLE

ASTM E90-09 “Standard Test Method for for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements” testing of CLT panels with 5/8 in. USG Firecode X (UL Type ULIX).

2. OBJECTIVE

To determine the Sound Transmission Class (STC) and the frequency specific Airborne Sound Transmission Loss of a manufactured panel system.

3. TESTED FOR

University of Oregon - Energy Studies in Building Laboratory
103 Pacific Hall
Eugene, OR 97403

4. TESTING ORGANIZATION

USG Testing Services

USG CORPORATION
Corporate Innovation Center
700 N US Highway 45
Libertyville, IL 60048-1268

5. TESTING PERSONNEL

Laboratory Manager: Joe Chambers
Tests Reviewed By: David Moyer

6. REFERENCE STANDARDS

ASTM E90-09 Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements

ASTM E413-16 Classification for Rating Sound Insulation

7. CALIBRATED TEST EQUIPMENT

Microphone: Bruel & Kjaer Type 4942 C 1 SN: 2741263
Bruel & Kjaer Type 4942 C 1 SN: 2807422

8. TEST SPECIMEN

5-LAM CLT PANEL. The specimen consisted of two CLT panels connected with a half lap joint. Each panel was nominally 1.27 m (50 in.) wide by 2.743 m (108 in.) high and 178 mm (7 in.) thick. Each panel had a nominal 51 mm (2 in.) wide by 102 mm (4 in.) deep half lap joint along one of the long sides of the panel. A single bead of construction adhesive was applied to the joint prior to installation and the panels were fastened together using 8 mm x 160 mm ASSY VG CSK fasteners spaced at 305 mm (12 in.) centers. The total weight of CLT panels, as measured, was 671 kg (1479 lbs). On the source side of the wall, a single layer of 5/8"" USG Sheetrock® Brand EcoSmart Panels Firecode® X was attached vertically with 32 mm (1 1/4 in.) long Type W screws spaced 406 mm (16 in.) on center. Joints were sealed with acoustical caulk and metal tape. Screw heads were covered with metal tape. Total weight of the gypsum panels, as measured, was 62 kg (136 lbs). The full perimeter both sides of the specimen was sealed with dense mastic.

The total weight of the specimen as measured was 1615 bs., an average of 22.4 lbs/ft^2. The transmission area used in the calculations was 72.0 ft^2.

Additional details and photos regarding the test specimen and environmental conditions are provided in the appendix.

9. TEST SPECIMEN CONSTRUCTION

The test panels were provided by University of Oregon. All other materials and assembly were provided by USG personnel. Detailed drawings have been provided by the client and are considered proprietary. They have purposely been withheld from this report and are retained on file. They can be made available to other entities upon the written request of the client.

10. TEST SPECIMEN CONDITIONING

The test specimens were conditioned in the laboratory prior to testing. Average environmental conditions of the lab are 65 degrees F and 50 % RH.

11. TEST SETUP

The specimen was installed in a reduced opening of the full 9 ft. high by 16 ft. wide wood lined opening of an isolated partition between two large reverberant chambers. The periphery (both sides) was sealed with a dense mastic. The source room volume was 4542 ft^3 and the receive room volume was 7236 ft^3.

12. TEST PROCEDURE

The measurements reported below were made with all facilities and procedures in explicit conformity with the ASTM Designations E90-09 and E413-16, as well as other pertinent standards. The USG Acoustical Testing Facility has been accredited by the U.S. Department of Commerce, National Institute of Standards and Technology (NIST) under the National Voluntary Laboratory Accreditation Program (NVLAP) for this test procedure (NVLAP Lab Code: 200132-0). A full description of the measurement procedure is available separately. The transmission loss values are measured for a single direction of measurement.

13. TEST RESULTS

Summary of Test Results		
Test Number	**Specimen**	**STC**
Wall STC -190244	CLT panels with 5/8 in. USG Firecode X (UL Type ULIX)	42

14. CONCLUSION

Based on the data obtained from this test, an STC of 42 can be obtained from a panel system assembled per Section 8 of this report.

15. TEST DATA

Test data has been attached to this report in the form of an appendix.

USG Testing Services
Corporate Innovation Center
700 North Highway 45 • Libertyville, IL 60048-1296 • (847) 970-5200
DATA REPORT

Airborne Sound Transmission Loss
ASTM E 90

Test Date:	2/26/2019
Test Number:	Wall STC - 190244
Client:	USG - Dale Northcutt
Project:	UOREG-012519
Test Operator:	Austin Phillips
Sample ID:	Sample B
Sample Description:	Two (4' x 9') CLT panels, 5/8 in. USG Firecode X (UL Type ULIX)

Sample Physical Details:

Thickness:	7.63	in	Length:	96.00	in
Weight:	1615.0	lb	Height:	108.00	in
Specimen Area:	72.0	sq. ft	Filler Area:	72.00	sq. ft
Area Weight	22.4	PSF			

Detailed Description:

5-LAM CLT PANEL. The specimen consisted of two CLT panels connected with a half lap joint.Each panel was nominally 1.27 m (50 in.) wide by 2.743 m (108 in.) high and 178 mm (7 in.) thick. Each panel had a nominal 51 mm (2 in.) wide by 102 mm (4 in.) deep half lap joint along one of the long sides of the panel. A single bead of construction adhesive was applied to the joint prior to installation and the panels were fastened together using 8 mm x 160 mm ASSY VG CSK fasteners spaced at 305 mm (12 in.) centers.The total weight of CLT panels, as measured, was 671 kg (1479 lbs). On the source side of the wall, a single layer of 5/8" USG Sheetrock® Brand EcoSmart Panels Firecode® X was attached vertically with 32 mm (1 1/4 in.) long Type W screws spaced 406 mm (16 in.) on center. Joints were sealed with acoustical caulk and metal tape. Screw heads were covered with metal tape. Total weight of the gypsum panels, as measured, was 62 kg (136 lbs). The full perimeter both sides of the specimen was sealed with dense mastic.

Room Conditions	**Source Room**		**Receive Room**	
Temperature:	65.1 °F	18.4 °C	71.6 °F	22.0 °C
Relative Humidity:	55.1 %		55.0 %	
Volume:	4542 ft^3	128.6 m^3	7236 ft^3	204.9 m^3
Microphone:	B&K Type 4942 C 1 SN: 2741263		B&K Type 4942 C 1 SN: 2807422	

Data Page 1 of 3 Filename: Wall STC-190244 (Sample B CLT Panels with Type ULIX Source Side.xls

USG Testing Services
Corporate Innovation Center
700 North Highway 45 • Libertyville, IL 60048-1296 • (847) 970-5200
DATA REPORT

Airborne Sound Transmission Loss
ASTM E 90

Test Results

	FREQ (Hz)	Abs (m^2)	SOR (dB)	-REC (db)	TLc (dB)	FILLER ADJ	TLs (dB)	DEF. (dB)	UNC w/95% C.L.
35	80	8.8	97	67	32	***	30		1.30
39	100	7.3	101	71	33	*	30		1.56
50	125	5.3	103	69	38	*	35	-	1.13
54	160	6.3	101	68	37		34	-	0.90
56	200	5.8	100	66	38		35	-	0.78
57	250	6.0	99	67	36		33	2	0.53
62	315	8.4	97	62	37		34	4	0.30
65	400	8.7	97	63	36		33	8	0.44
67	500	8.5	96	60	38		35	7	0.35
71	630	7.7	97	60	40		37	6	0.24
76	800	7.2	96	56	43		40	4	0.28
80	1000	6.7	96	51	47		44	1	0.15
81	1250	6.8	96	49	51		48	-	0.15
82	1600	7.5	91	41	53		50	-	0.22
81	2000	8.5	88	36	55		52	-	0.22
82	2500	9.9	88	33	56		53	-	0.34
81	3150	11.8	87	31	56		53	-	0.30
83	4000	13.9	89	31	58		55	-	0.35
80	5000	17.1	88	28	59		56		0.47
73	6300	22.0	88	26	60		57		0.52
65	8000	29.9	89	24	61	*	59		0.50

Sound Transmission Class (STC):	**42**	Total Deficiencies:	32
		Max:	8

NOTES: • Indicates that receive room levels were adjusted for background noise

* Indicates a correction for the filler wall has been applied. *** Indicates measured perfomance is limited by filler.

Shaded lines indicate frequencies not governed by this test method.

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NVLAP LAB CODE 200132-0

Data Page 2 of 3

Filename: Wall STC-190244 (Sample B CLT Panels with Type ULIX Source Side.xls

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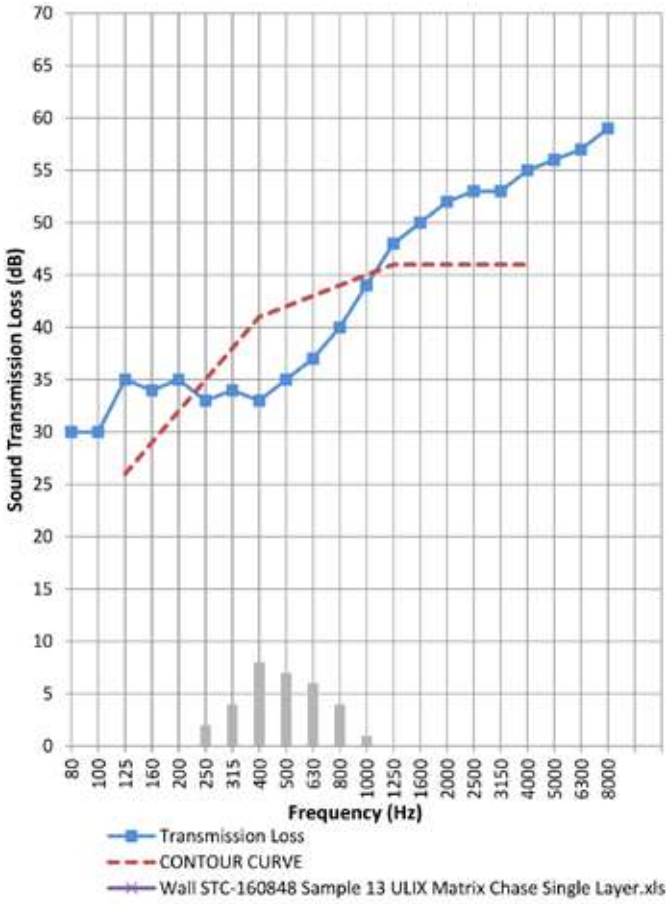
Corporate Innovation Center
700 North Highway 45 • Libertyville, IL 60048-1296 • (847) 970-5200
DATA REPORT

Airborne Sound Transmission Loss
ASTM E 90



Data Page 3 of 3

Filename: Wall STC-190244 (Sample B CLT Panels with Type ULIX Source Side.xls

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Page **7** of **8**

Figure 1: Specimen prior to addition of gypsum wall board

Corporate Innovation Center
Construction Systems Lab
700 North Highway 45
Libertyville, IL 60048

USG Testing Services
TEST REPORT

ASTM E90-09
"Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements"

Prepared for:
University of Oregon
Energy Studies in Building Laboratory
103 Pacific Hall
Eugene, OR 97403
Attn: Dale Northcutt

Project No: UOREG - 012519
Report No: Wall STC -190248
Date Submitted: 3/29/19
Date Tested: 2/28/2019

Introduction
This documented contains ASTM E90-09 test results of MPP panels with 5/8 in. USG Firecode X (UL Type ULIX). .

Prepared By:

David Moyer
Senior Researcher

Authorized By:

Joe Chambers
Director, Innovation Services Lab

Summary of Results

Test Number	Specimen	STC
Wall STC -190248	MPP panels with 5/8 in. USG Firecode X (UL Type ULIX)	39

1. TITLE

ASTM E90-09 (Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements" testing of MPP panels with 5/8 in. USG Firecode X (UL Type ULIX).

2. OBJECTIVE

To determine the Sound Transmission Class (STC) and the frequency specific Airborne Sound Transmission Loss of a manufactured panel system.

3. TESTED FOR

University of Oregon - Energy Studies in Building Laboratory
103 Pacific Hall
Eugene, OR 97403

4. TESTING ORGANIZATION

USG Testing Services

USG CORPORATION
Corporate Innovation Center
700 N US Highway 45
Libertyville, IL 60048-1268

5. TESTING PERSONNEL

Laboratory Manager: Joe Chambers
Tests Reviewed By: David Moyer

6. REFERENCE STANDARDS

ASTM E90-09 Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements

ASTM E413-16 Classification for Rating Sound Insulation.

7. CALIBRATED TEST EQUIPMENT

Microphone: Bruel & Kjaer Type 4942 C 1 SN: 2741263
Bruel & Kjaer Type 4942 C 1 SN: 2807422

8. TEST SPECIMEN

MPP PANEL. The specimen consisted of two MPP panels connected with a half lap joint. Each panel was nominally 1.27 m (50 in.) wide by 2.743 m (108 in.) high and 152 mm (6 in.) thick. Each panel had a nominal 51 mm (2 in.) wide by 102 mm (4 in.) deep half lap joint along one of the long sides of the panel. A single bead of construction adhesive was applied to the joint prior to installation and the panels were fastened together using 8 mm x 160 mm ASSY VG CSK fasteners spaced at 305 mm (12 in.) centers. The total weight of MPP panels, as measured, was 604 kg (1331 lbs). On the source side of the wall, a single layer of 5/8"" USG Sheetrock® Brand EcoSmart Panels Firecode® X was attached vertically with 32 mm (1 1/4 in.) long Type W screws spaced 406 mm (16 in.) on center. Joints were sealed with acoustical caulk and metal tape. Screw heads were covered with metal tape. Total weight of the gypsum panels, as measured, was 62 kg (136 lbs). The full perimeter both sides of the specimen was sealed with dense mastic.

The total weight of the specimen as measured was 1466 bs., an average of 20.4 lbs/ft^2. The transmission area used in the calculations was 72.0 ft^2.

Additional details and photos regarding the test specimen and environmental conditions are provided in the appendix.

9. TEST SPECIMEN CONSTRUCTION

The test panels were provided by University of Oregon. All other materials and assembly were provided by USG personnel. Detailed drawings have been provided by the client and are considered proprietary. They have purposely been withheld from this report and are retained on file. They can be made available to other entities upon the written request of the client.

10. TEST SPECIMEN CONDITIONING

The test specimens were conditioned in the laboratory prior to testing. Average environmental conditions of the lab are 65 degrees F and 50 % RH.

11. TEST SETUP

The specimen was installed in a reduced opening of the full 9 ft. high by 16 ft. wide wood lined opening of an isolated partition between two large reverberant chambers. The periphery (both sides) was sealed with a dense mastic. The source room volume was 4542 ft^3 and the receive room volume was 7236 ft^3.

12. TEST PROCEDURE

The measurements reported below were made with all facilities and procedures in explicit conformity with the ASTM Designations E90-09 and E413-16, as well as other pertinent standards. The USG Acoustical Testing Facility has been accredited by the U.S. Department of Commerce, National Institute of Standards and Technology (NIST) under the National Voluntary Laboratory Accreditation Program (NVLAP) for this test procedure (NVLAP Lab Code: 200132-0). A full description of the measurement procedure is available separately. The transmission loss values are measured for a single direction of measurement.

13. TEST RESULTS

Summary of Test Results		
Test Number	**Specimen**	**STC**
Wall STC -190248	MPP panels with 5/8 in. USG Firecode X (UL Type ULIX)	39

14. CONCLUSION

Based on the data obtained from this test, an STC of 39 can be obtained from a panel system assembled per Section 8 of this report.

15. TEST DATA

Test data has been attached to this report in the form of an appendix.

USG Testing Services
Corporate Innovation Center
700 North Highway 45 • Libertyville, IL 60048-1296 • (847) 970-5200
DATA REPORT

Airborne Sound Transmission Loss
ASTM E 90

Test Results

	FREQ (Hz)	Abs (m^2)	SOR (dB)	-REC (db)	TLc (dB)	FILLER ADJ	TLs (dB)	DEF. (dB)	UNC w/95% C.L.
35	80	8.8	98	68	31	*	30		1.03
39	100	6.8	101	71	33	*	31		1.44
50	125	5.3	103	72	35		**32**	-	1.07
54	160	6.4	101	69	35		**32**	-	0.99
56	200	5.9	100	69	35		**31**	-	0.85
57	250	6.0	100	70	33		**30**	2	0.69
62	315	8.4	97	63	36		**33**	2	0.29
65	400	8.7	98	64	36		**33**	5	0.49
67	500	8.4	96	62	37		**34**	5	0.31
71	630	7.7	98	62	38		**35**	5	0.24
76	800	7.1	97	59	40		**37**	4	0.30
80	1000	6.8	96	56	42		**39**	3	0.18
81	1250	7.1	97	55	45		**42**	1	0.18
82	1600	7.9	92	48	46		**43**	-	0.31
81	2000	8.9	89	43	47		**44**	-	0.25
82	2500	10.8	88	41	48		**45**	-	0.35
81	3150	13.2	87	39	49		**46**	-	0.32
83	4000	15.9	89	38	51		**48**	-	0.23
80	5000	20.3	89	34	53		50		0.40
73	6300	26.8	88	31	55		52		0.62
65	8000	36.7	89	27	58	*	55		0.60

Sound Transmission Class (STC): **39** Total Deficiencies: 27
Max: 5

NOTES: • Indicates that receive room levels were adjusted for background noise
* Indicates a correction for the filler wall has been applied. *** Indicates measured perfomance is limited by filler.
Shaded lines indicate frequencies not governed by this test method.

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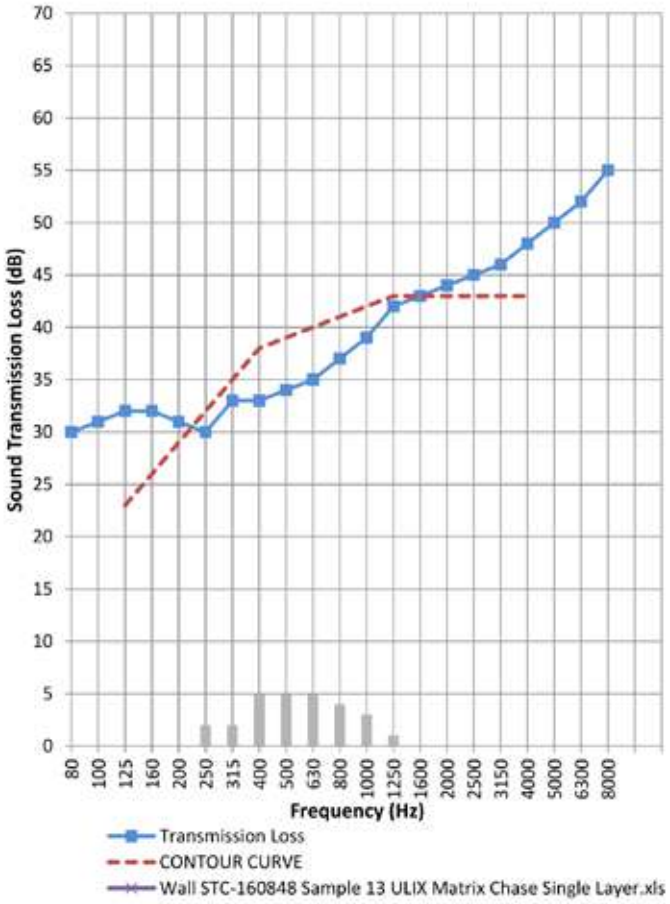
Data Page 2 of 3 Filename: Wall STC-190248 (Sample E MPP Panels with Type ULIX Source Side.xls

USG Testing Services
Corporate Innovation Center
700 North Highway 45 • Libertyville, IL 60048-1296 • (847) 970-5200
DATA REPORT

Airborne Sound Transmission Loss
ASTM E 90



Data Page 3 of 3

Filename: Wall STC-190248 (Sample E MPP Panels with Type ULIX Source Side.xls

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Page **7** of **8**

Figure 1: Specimen prior to addition of gypsum wall board

Corporate Innovation Center
Construction Systems Lab
700 North Highway 45
Libertyville, IL 60048

USG Testing Services
TEST REPORT

ASTM E90-09
"Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements"

Prepared for:
University of Oregon
Energy Studies in Building Laboratory
103 Pacific Hall
Eugene, OR 97403
Attn: Dale Northcutt

Project No: UOREG - 012519
Report No: Wall STC -190246
Date Submitted: 3/29/19
Date Tested: 2/26/2019

Introduction

This documented contains ASTM E90-09 test results of CLT panels with 4 in. Mineral Wool Insulation, Cedar Siding .

Prepared By:

David Moyer
Senior Researcher

Authorized By:

Joe Chambers
Director, Innovation Services Lab

Summary of Results

Test Number	Specimen	STC
Wall STC -190246	CLT panels with 4 in. Mineral Wool Insulation, Cedar Siding	45

1. TITLE

ASTM E90-09 “Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements” testing of CLT panels with 4 in. Mineral Wool Insulation, Cedar Siding.

2. OBJECTIVE

To determine the Sound Transmission Class (STC) and the frequency specific Airborne Sound Transmission Loss of a manufactured panel system.

3. TESTED FOR

University of Oregon - Energy Studies in Building Laboratory
103 Pacific Hall
Eugene, OR 97403

4. TESTING ORGANIZATION

USG Testing Services

USG CORPORATION
Corporate Innovation Center
700 N US Highway 45
Libertyville, IL 60048-1268

5. TESTING PERSONNEL

Laboratory Manager: Joe Chambers
Tests Reviewed By: David Moyer

6. REFERENCE STANDARDS

ASTM E90-09 Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements

ASTM E413-16 Classification for Rating Sound Insulation

7. CALIBRATED TEST EQUIPMENT

Microphone: Bruel & Kjaer Type 4942 C 1 SN: 2741263
Bruel & Kjaer Type 4942 C 1 SN: 2807422

8. TEST SPECIMEN

5-LAM CLT PANEL. The specimen consisted of two CLT panels connected with a half lap joint. Each panel was nominally 1.27 m (50 in.) wide by 2.74 m (108 in.) high and 178 mm (7 in.) thick. Each panel had a nominal 51 mm (2 in.) wide by 102 mm (4 in.) deep half lap joint along one of the long sides of the panel. A single bead of construction adhesive was applied to the joint prior to installation and the panels were fastened together using 8 mm x 160 mm ASSY VG CSK fasteners spaced at 305 mm (12 in.) centers.The total weight of CLT panels, as measured, was 671 kg (1479 lbs). The following items were applied to the source side of the wall: SOPRASEAL® Stick 1100T with ELASTOCOL STICK H2O. Two layers of 51 mm (2 in.) thick Roxul Comfortboard 80 mineral wool insulation (8 pcf) provided in 1.2 m (48 in.) wide by 2.4 m (96 in.) long pieces. Five 25 mm (1 in.) thick wood battens were fastened to the panel over the insulation. Four battens were 51 mm (2 in.) wide with two at 2.44 m (96 in.) long at the top and bottom and two 2.67 m (105 in.) long at the vertical edges. Three battens at 102 m (4 in.) wide and 2.67 m (105 in.) long were installed vertically at 610 mm (24 in.) on center. Twenty-two (22), 2.44 m (96 in.) long sections of 1x6 T&G Cedar siding was installed horizontally using 6 mm x 80 mm SWG ASSY 3.0 ECO STAINLESS STEE CSH Cladding fasteners. The total weight of items added to panels, as measured, was 340 kg (154 lbs). The full perimeter both sides of the specimen was sealed with dense mastic.

The total weight of the specimen as measured was 1819 lbs., an average of 25.3 lbs/ft^2. The transmission area used in the calculations was 72.0 ft^2.

Additional details and photos regarding the test specimen and environmental conditions are provided in the appendix.

9. TEST SPECIMEN CONSTRUCTION

The test panels were provided by University of Oregon. All other materials and assembly were provided by USG personnel. Detailed drawings have been provided by the client and are considered proprietary. They have purposely been withheld from this report and are retained on file. They can be made available to other entities upon the written request of the client.

10. TEST SPECIMEN CONDITIONING

The test specimens were conditioned in the laboratory prior to testing. Average environmental conditions of the lab are 65 degrees F and 50 % RH.

11. TEST SETUP

The specimen was installed in a reduced opening of the full 9 ft. high by 16 ft. wide wood lined opening of an isolated partition between two large reverberant chambers. The periphery (both sides) was sealed with a dense mastic. The source room volume was 4542 ft^3 and the receive room volume was 7236 ft^3.

12. TEST PROCEDURE

The measurements reported below were made with all facilities and procedures in explicit conformity with the ASTM Designations E90-09 and E413-16, as well as other pertinent standards. The USG Acoustical Testing Facility has been accredited by the U.S. Department of Commerce, National Institute of Standards and Technology (NIST) under the National Voluntary Laboratory Accreditation Program (NVLAP) for this test procedure (NVLAP Lab Code: 200132-0). A full description of the measurement procedure is available separately. The transmission loss values are measured for a single direction of measurement.

13. TEST RESULTS

Summary of Test Results		
Test Number	**Specimen**	**STC**
Wall STC -190246	CLT panels with 4 in. Mineral Wool Insulation, Cedar Siding	45

14. CONCLUSION

Based on the data obtained from this test, an STC of 45 can be obtained from a panel system assembled per Section 8 of this report.

15. TEST DATA

Test data has been attached to this report in the form of an appendix.

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Corporate Innovation Center
700 North Highway 45 • Libertyville, IL 60048-1296 • (847) 970-5200
DATA REPORT

Airborne Sound Transmission Loss
ASTM E 90

Test Date:	2/27/2019
Test Number:	Wall STC - 190246
Client:	University of Oregon - Dale Northcutt
Project:	UOREG-012519
Test Operator:	Austin Phillips
Sample ID:	Sample C
Sample Description:	Two (4' x 9') CLT panels, 4 in. Mineral Wool Insulation, Cedar Siding

Sample Physical Details:

Thickness:	13.04	in	Length:	96.00	in
Weight:	1819.5	lb	Height:	108.00	in
Specimen Area:	72.0	sq. ft	Filler Area:	72.00	sq. ft
Area Weight	25.3	PSF			

Detailed Description:

5-LAM CLT PANEL. The specimen consisted of two CLT panels connected with a half lap joint.Each panel was nominally 1.27 m (50 in.) wide by 2.74 m (108 in.) high and 178 mm (7 in.) thick. Each panel had a nominal 51 mm (2 in.) wide by 102 mm (4 in.) deep half lap joint along one of the long sides of the panel. A single bead of construction adhesive was applied to the joint prior to installation and the panels were fastened together using 8 mm x 160 mm ASSY VG CSK fasteners spaced at 305 mm (12 in.) centers.The total weight of CLT panels, as measured, was 671 kg (1479 lbs). The following items were applied to the source side of the wall: SOPRASEAL® Stick 1100T with ELASTOCOL STICK H2O. Two layers of 51 mm (2 in.) thick Roxul Comfortboard 80 mineral wool insulation (8 pcf) provided in 1.2 m (48 in.) wide by 2.4 m (96 in.) long pieces. Five 25 mm (1 in.) thick wood battens were fastened to the panel over the insulation. Four battens were 51 mm (2 in.) wide with two at 2.44 m (96 in.) long at the top and bottom and two 2.67 m (105 in.) long at the vertical edges. Three battens at 102 m (4 in.) wide and 2.67 m (105 in.) long were installed vertically at 610 mm (24 in.) on center. Twenty-two (22), 2.44 m (96 in.) long sections of 1x6 T&G Cedar siding was installed horizontally using 6 mm x 80 mm SWG ASSY 3.0 ECO STAINLESS STEE CSH Cladding fasteners.The total weight of items added to panels, as measured, was 340 kg (154 lbs). The full perimeter both sides of the specimen was sealed with dense mastic.

Room Conditions	**Source Room**		**Receive Room**	
Temperature:	65.8 °F	18.8 °C	71.6 °F	22.0 °C
Relative Humidity:	49.9 %		55.0 %	
Volume:	4542 ft^3	128.6 m^3	7236 ft^3	204.9 m^3
Microphone:	B&K Type 4942 C 1 SN: 2741263		B&K Type 4942 C 1 SN: 2807422	

Data Page 1 of 3 Filename: Wall STC-190246 (Sample C CLT Panels wMembrane, Insulation, Siding.xls

USG Testing Services
Corporate Innovation Center
700 North Highway 45 • Libertyville, IL 60048-1296 • (847) 970-5200
DATA REPORT

Airborne Sound Transmission Loss
ASTM E 90

Test Results

	FREQ (Hz)	Abs (m^2)	SOR (dB)	-REC (db)	TLc (dB)	FILLER ADJ	TLs (dB)	DEF. (dB)	UNC w/95% C.L.
35	80	9.6	97	67	31	*	30		0.91
39	100	6.9	101	71	33	*	31		1.52
50	125	4.9	101	73	33		**30**	-	1.35
54	160	6.1	98	70	31		**28**	4	1.16
56	200	5.8	97	67	34		**31**	4	0.74
57	250	6.0	98	64	38		**35**	3	0.81
62	315	8.6	96	59	39		**36**	5	0.43
65	400	8.7	97	60	39		**36**	8	0.45
67	500	8.5	96	54	44		**41**	4	0.12
71	630	7.7	97	52	48		**45**	1	0.18
76	800	7.1	96	51	48		**45**	2	0.30
80	1000	6.7	95	49	50		**47**	1	0.11
81	1250	6.9	96	48	52		**49**	-	0.18
82	1600	7.6	91	40	54		**51**	-	0.27
81	2000	8.5	88	32	58		**55**	-	0.20
82	2500	10.1	87	29	60		**57**	-	0.39
81	3150	12.1	87	25	62		**59**	-	0.43
83	4000	14.5	89	27	62		**59**	-	0.44
80	5000	18.1	88	23	64		61		0.48
73	6300	23.6	88	19	67	*	64		0.53
65	8000	32.1	89	21	64	***	63		0.53

Sound Transmission Class (STC): **45** Total Deficiencies: 32
Max: 8

NOTES: • Indicates that receive room levels were adjusted for background noise
* Indicates a correction for the filler wall has been applied. *** Indicates measured perfomance is limited by filler.
Shaded lines indicate frequencies not governed by this test method.

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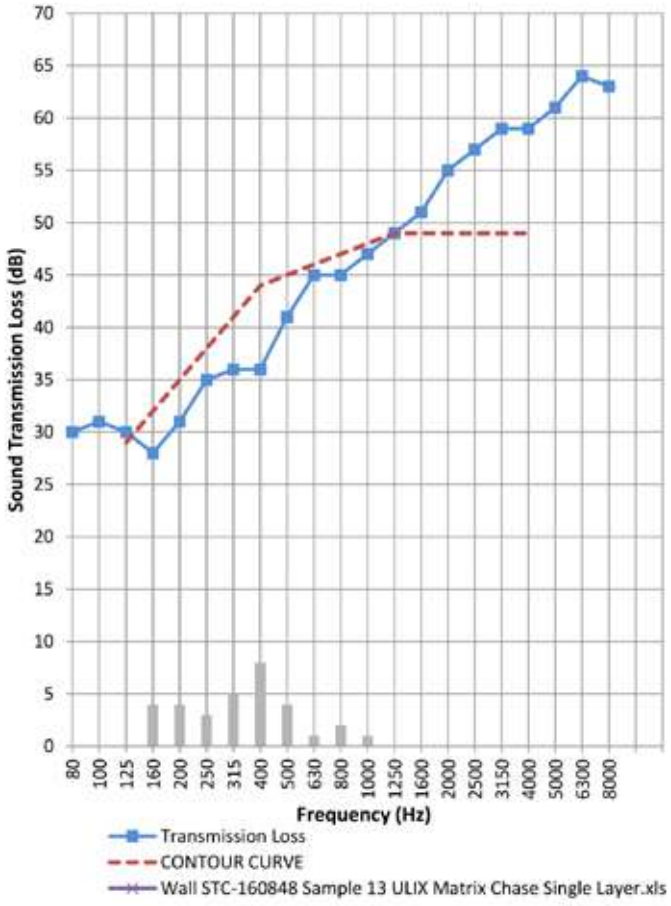
Data Page 2 of 3 Filename: Wall STC-190246 (Sample C CLT Panels wMembrane, Insulation, Siding.xls

USG Testing Services
Corporate Innovation Center
700 North Highway 45 • Libertyville, IL 60048-1296 • (847) 970-5200
DATA REPORT

Airborne Sound Transmission Loss
ASTM E 90



Data Page 3 of 3

Filename: Wall STC-190246 (Sample C CLT Panels wMembrane, Insulation, Siding.xls

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Page **7** of **12**

Figure 1: Specimen prior to addition of insulation and cedar siding

Figure 2: Specimen with primer

Figure 3: Specimen with membrane

Figure 4: Specimen with membrane and insulation

Figure 5: Specimen with membrane, insulation, and partial cedar siding

Corporate Innovation Center
Construction Systems Lab
700 North Highway 45
Libertyville, IL 60048

USG Testing Services
TEST REPORT

ASTM E90-09
"Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements"

Prepared for:
University of Oregon
Energy Studies in Building Laboratory
103 Pacific Hall
Eugene, OR 97403
Attn: Dale Northcutt

Project No: UOREG - 012519
Report No: Wall STC -190249
Date Submitted: 3/29/19
Date Tested: 2/28/2019

Introduction
This documented contains ASTM E90-09 test results of MPP panels with 4 in. Mineral Wool Insulation, Cedar Siding .

Prepared By:

David Moyer
Senior Researcher

Authorized By:

Joe Chambers
Director, Innovation Services Lab

Summary of Results

Test Number	Specimen	STC
Wall STC -190249	MPP panels with 4 in. Mineral Wool Insulation, Cedar Siding	43

1. TITLE

ASTM E90-09 “Standard Test Method for for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements” testing of MPP panels with 4 in. Mineral Wool Insulation, Cedar Siding. .

2. OBJECTIVE

To determine the Sound Transmission Class (STC) and the frequency specific Airborne Sound Transmission Loss of a manufactured panel system.

3. TESTED FOR

University of Oregon - Energy Studies in Building Laboratory
103 Pacific Hall
Eugene, OR 97403

4. TESTING ORGANIZATION

USG Testing Services

USG CORPORATION
Corporate Innovation Center
700 N US Highway 45
Libertyville, IL 60048-1268

5. TESTING PERSONNEL

Laboratory Manager: Joe Chambers
Tests Reviewed By: David Moyer

6. REFERENCE STANDARDS

ASTM E90-09 Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements

ASTM E413-16 Classification for Rating Sound Insulation

7. CALIBRATED TEST EQUIPMENT

Microphone: Bruel & Kjaer Type 4942 C 1 SN: 2741263
Bruel & Kjaer Type 4942 C 1 SN: 2807422

8. TEST SPECIMEN

MPP PANEL. The specimen consisted of two MPP panels connected with a half lap joint. Each panel was nominally 1.27 m (50 in.) wide by 2.743 m (108 in.) high and 152 mm (6 in.) thick. Each panel had a nominal 51 mm (2 in.) wide by 102 mm (4 in.) deep half lap joint along one of the long sides of the panel. A single bead of construction adhesive was applied to the joint prior to installation and the panels were fastened together using 8 mm x 160 mm ASSY VG CSK fasteners spaced at 305 mm (12 in.) centers. The total weight of MPP panels, as measured, was 604 kg (1331 lbs). The following items were applied to the source side of the wall: SOPRASEAL® Stick 1100T with ELASTOCOL STICK H2O. Two layers of 51 mm (2 in.) thick Roxul Comfortboard 80 mineral wool insulation (8 pcf) provided in 1.2 m (48 in.) wide by 2.4 m (96 in.) long pieces. Five 25 mm (1 in.) thick wood battens were fastened to the panel over the insulation. Four battens were 51 mm (2 in.) wide with two at 2.44 m (96 in.) long at the top and bottom and two 2.67 m (105 in.) long at the vertical edges. Three battens at 102 m (4 in.) wide and 2.67 m (105 in.) long were installed vertically at 610 mm (24 in.) on center. Twenty-two (22), 2.44 m (96 in.) long sections of 1x6 T&G Cedar siding was installed horizontally using 6 mm x 80 mm SWG ASSY 3.0 ECO STAINLESS STEE CSH Cladding fasteners. The total weight of items added to panels, as measured, was 343 kg (155 lbs). The full perimeter both sides of the specimen was sealed with dense mastic.

The total weight of the specimen as measured was 1674 bs., an average of 23.2 lbs/ft^2. The transmission area used in the calculations was 72.0 ft^2.

Additional details and photos regarding the test specimen and environmental conditions are provided in the appendix.

9. TEST SPECIMEN CONSTRUCTION

The test panels were provided by University of Oregon. All other materials and assembly were provided by USG personnel. Detailed drawings have been provided by the client and are considered proprietary. They have purposely been withheld from this report and are retained on file. They can be made available to other entities upon the written request of the client.

10. TEST SPECIMEN CONDITIONING

The test specimens were conditioned in the laboratory prior to testing. Average environmental conditions of the lab are 65 degrees F and 50 % RH.

11. TEST SETUP

The specimen was installed in a reduced opening of the full 9 ft. high by 16 ft. wide wood lined opening of an isolated partition between two large reverberant chambers. The periphery (both sides) was sealed with a dense mastic. The source room volume was 4542 ft^3 and the receive room volume was 7236 ft^3.

12. TEST PROCEDURE

The measurements reported below were made with all facilities and procedures in explicit conformity with the ASTM Designations E90-09 and E413-16, as well as other pertinent standards. The USG Acoustical Testing Facility has been accredited by the U.S. Department of Commerce, National Institute of Standards and Technology (NIST) under the National Voluntary Laboratory Accreditation Program (NVLAP) for this test procedure (NVLAP Lab Code: 200132-0). A full description of the measurement procedure is available separately. The transmission loss values are measured for a single direction of measurement.

13. TEST RESULTS

Summary of Test Results		
Test Number	**Specimen**	**STC**
Wall STC -190249	MPP panels with 4 in. Mineral Wool Insulation, Cedar Siding	43

14. CONCLUSION

Based on the data obtained from this test, an STC of 43 can be obtained from a panel system assembled per Section 8 of this report.

15. TEST DATA

Test data has been attached to this report in the form of an appendix.

USG Testing Services
Corporate Innovation Center
700 North Highway 45 • Libertyville, IL 60048-1296 • (847) 970-5200
DATA REPORT

Airborne Sound Transmission Loss
ASTM E 90

Test Date:	2/28/2019
Test Number:	Wall STC - 190249
Client:	University of Oregon - Dale Northcutt
Project:	UOREG-012519
Test Operator:	Austin Phillips
Sample ID:	Sample F
Sample Description:	Two (4' x 9') MPP panels, 4 in. Mineral Wool Insulation, Cedar Siding

Sample Physical Details:

Thickness:	12.00	in	Length:	96.00	in
Weight:	1673.7	lb	Height:	108.00	in
Specimen Area:	72.0	sq. ft	Filler Area:	72.00	sq. ft
Area Weight	23.2	PSF			

Detailed Description:

MPP PANEL. The specimen consisted of two MPP panels connected with a half lap joint.Each panel was nominally 1.27 m (50 in.) wide by 2.743 m (108 in.) high and 152 mm (6 in.) thick. Each panel had a nominal 51 mm (2 in.) wide by 102 mm (4 in.) deep half lap joint along one of the long sides of the panel. A single bead of construction adhesive was applied to the joint prior to installation and the panels were fastened together using 8 mm x 160 mm ASSY VG CSK fasteners spaced at 305 mm (12 in.) centers. The total weight of MPP panels, as measured, was 604 kg (1331 lbs). The following items were applied to the source side of the wall: SOPRASEAL® Stick 1100T with ELASTOCOL STICK H2O. Two layers of 51 mm (2 in.) thick Roxul Comfortboard 80 mineral wool insulation (8 pcf) provided in 1.2 m (48 in.) wide by 2.4 m (96 in.) long pieces. Five 25 mm (1 in.) thick wood battens were fastened to the panel over the insulation. Four battens were 51 mm (2 in.) wide with two at 2.44 m (96 in.) long at the top and bottom and two 2.67 m (105 in.) long at the vertical edges. Three battens at 102 m (4 in.) wide and 2.67 m (105 in.) long were installed vertically at 610 mm (24 in.) on center. Twenty-two (22), 2.44 m (96 in.) long sections of 1x6 T&G Cedar siding was installed horizontally using 6 mm x 80 mm SWG ASSY 3.0 ECO STAINLESS STEE CSH Cladding fasteners.The total weight of items added to panels, as measured, was 343 kg (155 lbs). The full perimeter both sides of the specimen was sealed with dense mastic.

Room Conditions	**Source Room**		**Receive Room**	
Temperature:	65.8 °F	18.8 °C	71.6 °F	22.0 °C
Relative Humidity:	43.0 %		55.0 %	
Volume:	4542 ft^3	128.6 m^3	7236 ft^3	204.9 m^3
Microphone:	B&K Type 4942 C 1 SN: 2741263		B&K Type 4942 C 1 SN: 2807422	

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Test Results

	FREQ (Hz)	Abs (m^2)	SOR (dB)	-REC (db)	TLc (dB)	FILLER ADJ	**TLs (dB)**	DEF. (dB)	UNC w/95% C.L.
35	80	9.6	98	67	32	***	30		1.18
39	100	7.0	101	70	34	*	32		1.24
50	125	5.3	102	74	31		**28**	-	1.09
54	160	6.4	98	73	29		**26**	4	1.01
56	200	5.9	98	67	35		**32**	1	0.76
57	250	6.0	99	65	38		**35**	1	0.65
62	315	8.4	97	60	39		**36**	3	0.35
65	400	8.8	97	61	38		**35**	7	0.35
67	500	8.3	96	56	42		**39**	4	0.22
71	630	7.8	98	58	43		**40**	4	0.21
76	800	7.2	97	56	44		**41**	4	0.29
80	1000	6.8	96	52	47		**44**	2	0.13
81	1250	7.2	97	52	48		**45**	2	0.12
82	1600	7.9	92	44	50		**47**	-	0.25
81	2000	8.9	89	38	53		**50**	-	0.18
82	2500	10.7	88	35	55		**52**	-	0.36
81	3150	13.2	87	32	55		**52**	-	0.35
83	4000	16.0	90	31	58		**55**	-	0.17
80	5000	20.1	89	26	61		58		0.31
73	6300	26.6	89	20	66	*	63		0.57
65	8000	36.5	89	21	64	***	62		0.58

Sound Transmission Class (STC):	**43**	Total Deficiencies:	32
		Max:	7

NOTES: • Indicates that receive room levels were adjusted for background noise

* Indicates a correction for the filler wall has been applied. *** Indicates measured perfomance is limited by filler.

Shaded lines indicate frequencies not governed by this test method.

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NVLAP LAB CODE 200132-0

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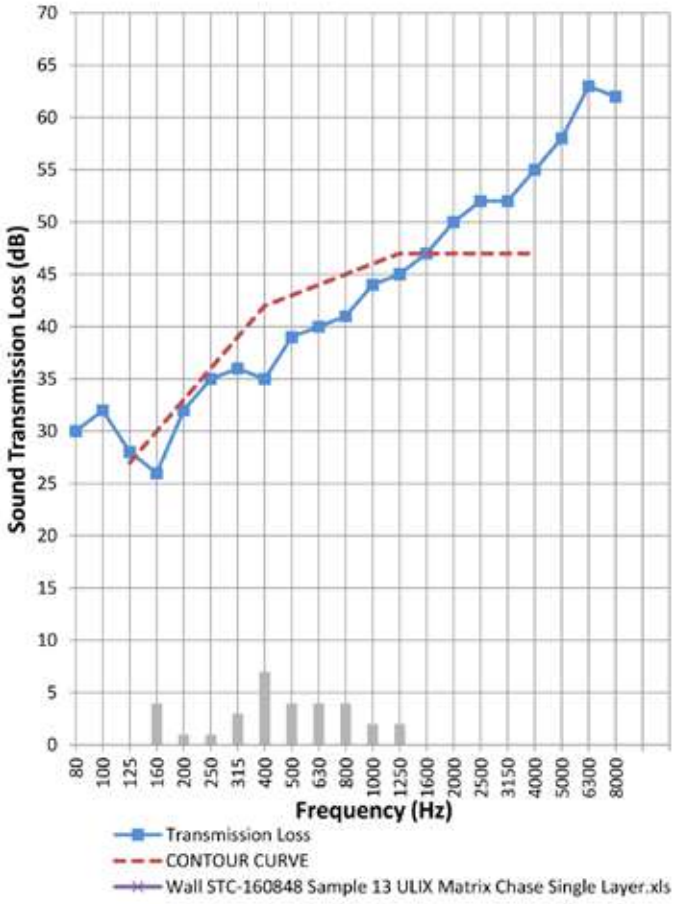

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Figure 1: Specimen prior to addition of gypsum wall board

Figure 2: Specimen with membrane

Figure 3: Specimen with membrane and insulation

Figure 4: Specimen with membrane, insulation, and partial cedar siding