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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:

Iain Macdonald
Director, TallWood Design Institute
Oregon State University

Prepared by:

Energy Studies in Buildings Laboratory
Department of Architecture
University of Oregon
Eugene, Oregon | Portland, Oregon

Research Team:

Kevin Van Den Wymelenberg (PI)
Dale Northcutt
Mark Fretz
Jason Stenson
Ethan Zagorec-Marks

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 National 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

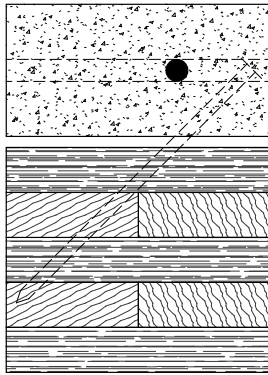
material that crews were already familiar using, such as cement board.

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

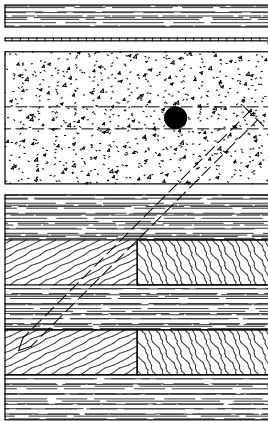


2-1/4" concrete slab @ 145 pcf density (as-tested density in lab report)

#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

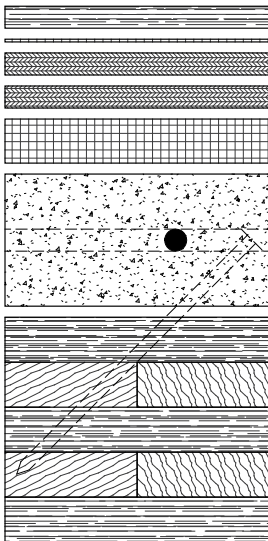


BOD: 6-1/2" wide x 1/2" thick random length Admonter Pine engineered floating floor, sanded, naturally oiled, T&G planks locked together

1/8" acoustic underlayment

* F02 - DEVELOPED BUT NOT TESTED AFTER VALUE ENGINEERING

F03

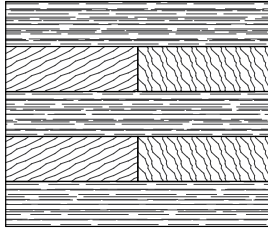


48"x 96"x 5/8" OSB nailed T&G sub-floor, stagger seams, adhered with ChemLink BuildSe-cure, bonds in 4 hours, apply GreenGlue to gaps (see CD drawings for orientation)

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

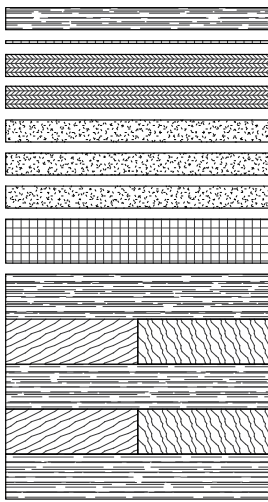
PROPOSED FLOOR ASSEMBLIES FOR TESTING - DRY ASSEMBLY

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

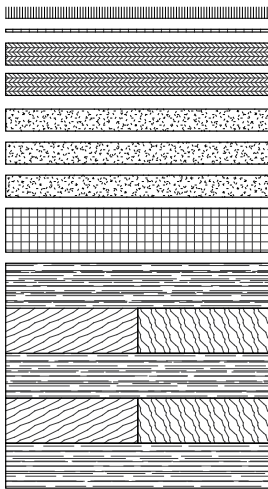
1/8" acoustic underlayment

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

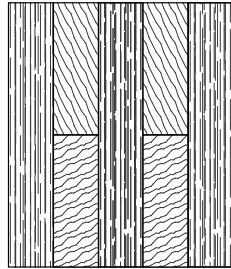


1/2" pile nylon carpet, 3343 oz/cb.yd. pile density, 97.5oz/sq.yd face weight

3/8" 8lb carpet pad

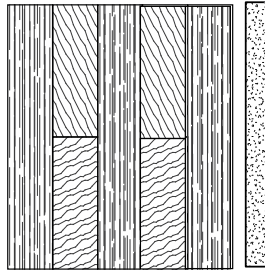
PROPOSED WALL ASSEMBLIES FOR TESTING

W07



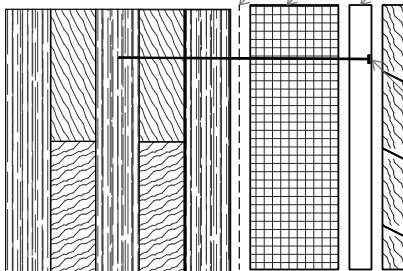
Specified mass timber. Half lap panel joint with single bead of construction adhesive. Joint fastened with 8mm x 140mm or 160mm ASSY VG CSK fastener depending on material (see CD drawings), 12" o.c. spacing

W08



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

W09



Soprasedal 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.

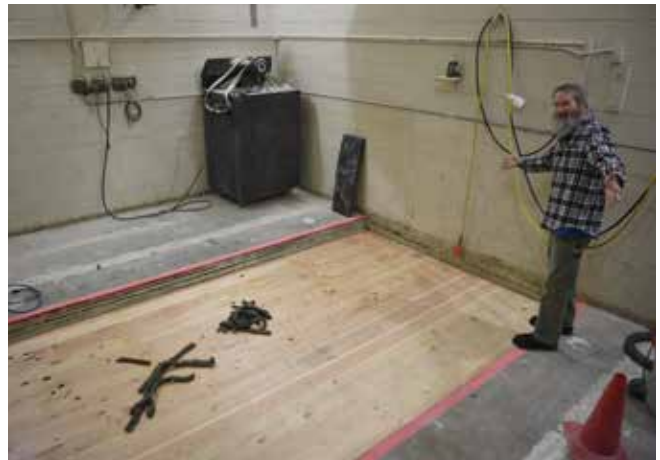
Credit for all images on this page:
Evan Schmidt, OSU TallWood Design Institute



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



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



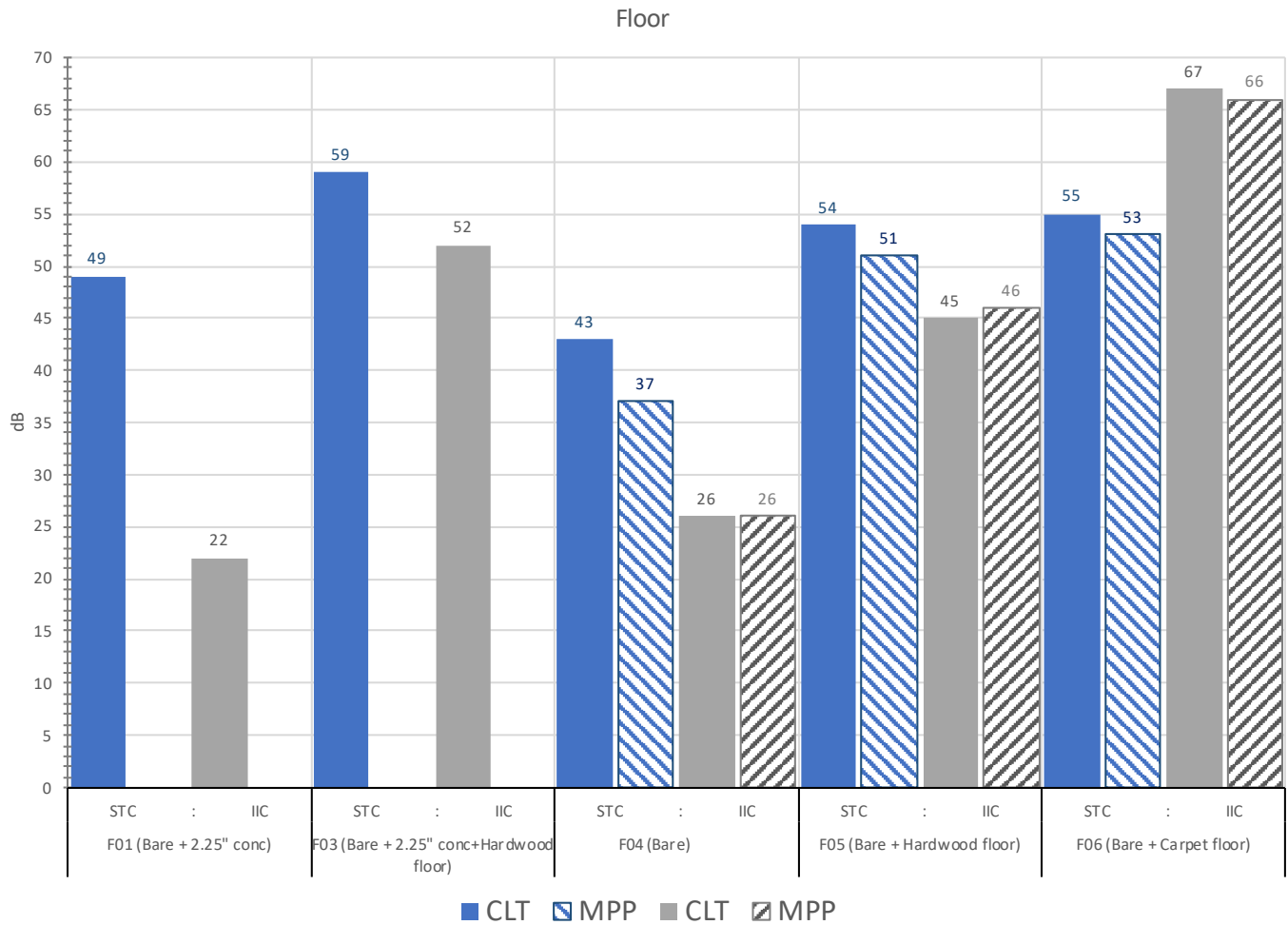
Images this page: the process of MPP installation into the chamber.
Images following page: MPP dry and structural composite assembly build up.

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



MPP WALL TESTING PROCESS

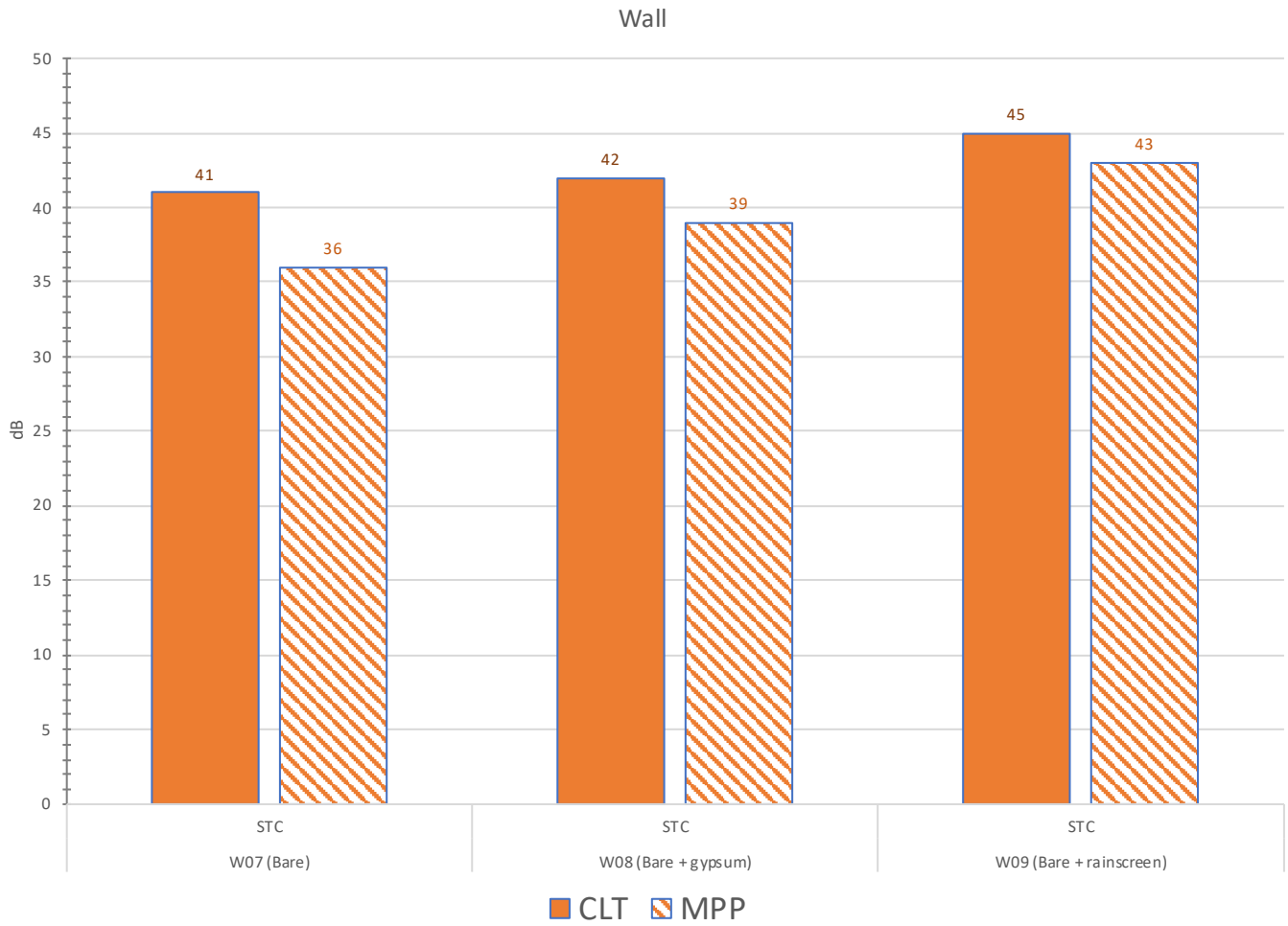


Images this page: the process of receiving the MPP at testing lab, installing and sealing in test opening and assembly build up.

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:

Oregon State University TallWood Design Institute

Iain McDonald
Judith Sheine
Evan Schmidt

Freres Lumber (for donation of MPP and shipping)

Tyler Freres
Patrick Farrell
Austin Basl

DR Johnson (for partial donation of CLT and shipping)

Valerie Johnson
Todd Black
Quinn Guerrero

Industry Advisors

Tobin Cooley, Listen Acoustics
Jake Ross, Creative Acoustics NW
Dean Lewis, DCI-Engineers
Erica Fischer, Oregon State University, School of Civil
and Construction Engineering
Alex Zelaya, Hacker
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

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 - 6.804 W08- MPP Wall Assembly- STC
 - 6.805 W09- CLT Wall Assembly- STC
 - 6.806 W09- MPP Wall Assembly- STC



6.1 PREVAILING CODES AND INDUSTRY STANDARDS

IBC

International Building Code

| <i>DESCRIPTION</i> | <i>IIC STC</i> |
|-----------------------|------------------|
| MULTI-FAMILY DWELLING | 50* 50* |

* 45 if field tested

ICC

International Code Council

| <i>DESCRIPTION</i> | <i>IIC STC</i> |
|--------------------|------------------|
| 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

| <i>DESCRIPTION</i> | <i>IIC STC</i> |
|---|------------------|
| 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 determine 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 through this survey please save your resulting PDF and send it back to the address below.

mfretz@uoregon.edu

your information

name :

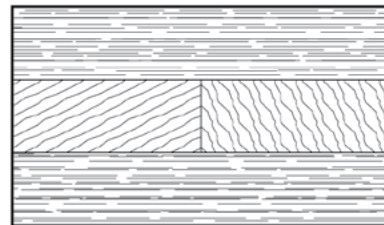
email :

phone :

organization :

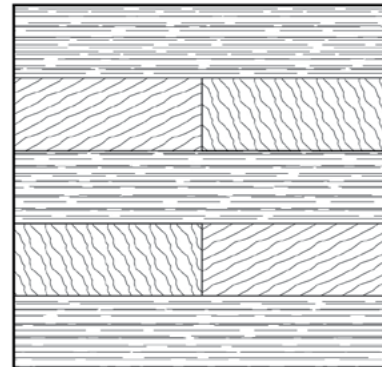
thank you!

3-layer CLT



| 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 | | |
| available 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 | | |

5-layer CLT



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

available in the U.S.
(y / n)

Y N

would you reccomend this assembly?
(y / n)

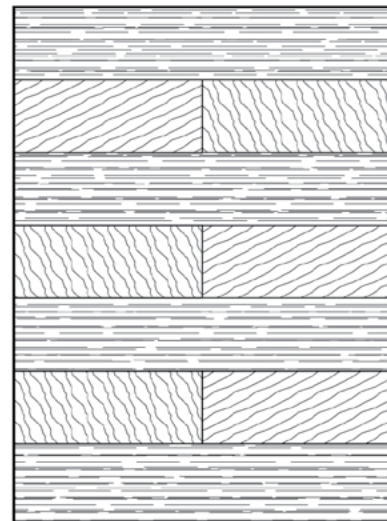
Y N

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

sources

CLT Handbook FPIInnovations PDF

7-layer CLT



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)

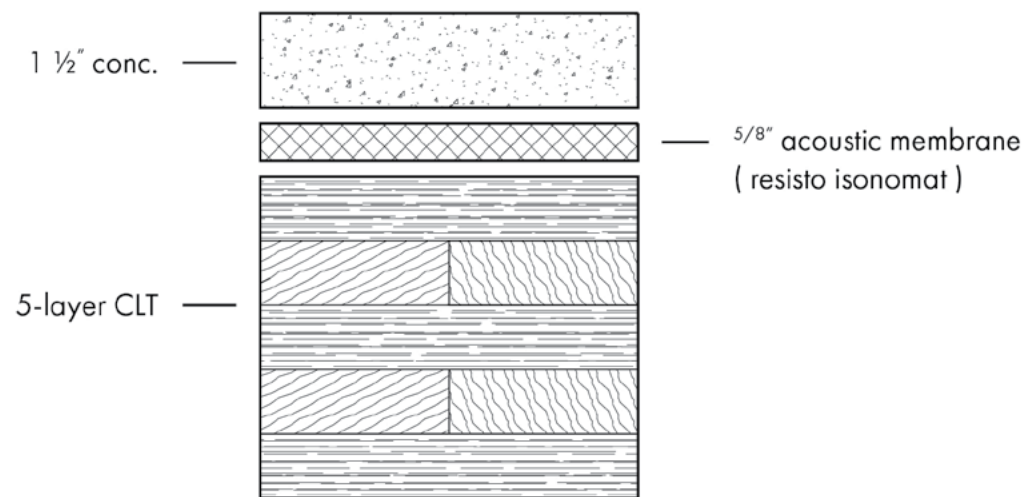
impact isolation class (IIC code minimum 52) 25

available in the U.S. (y / n) Y N

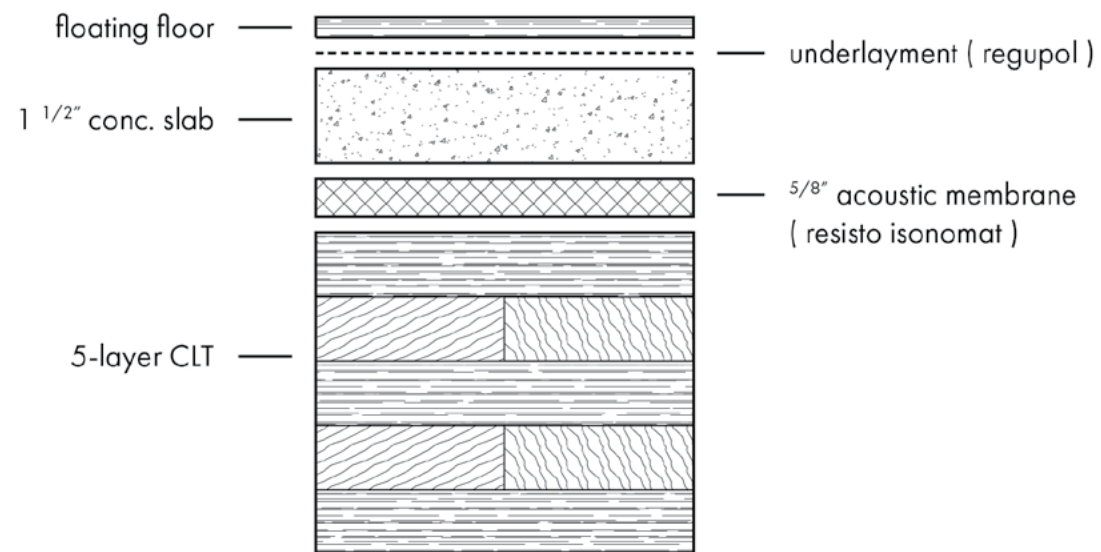
would you reccomend this assembly? (y / n) Y N

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

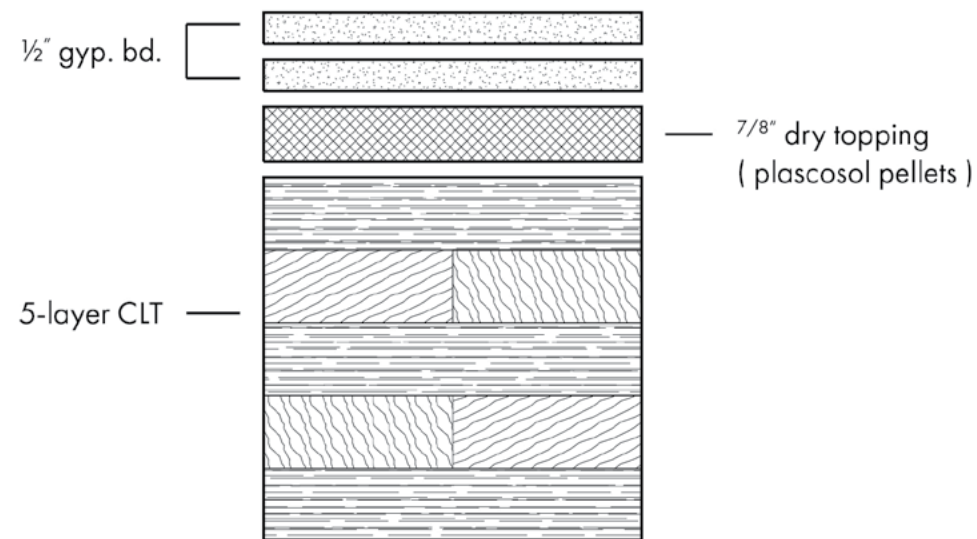
sources WoodWorks CLT Solutions



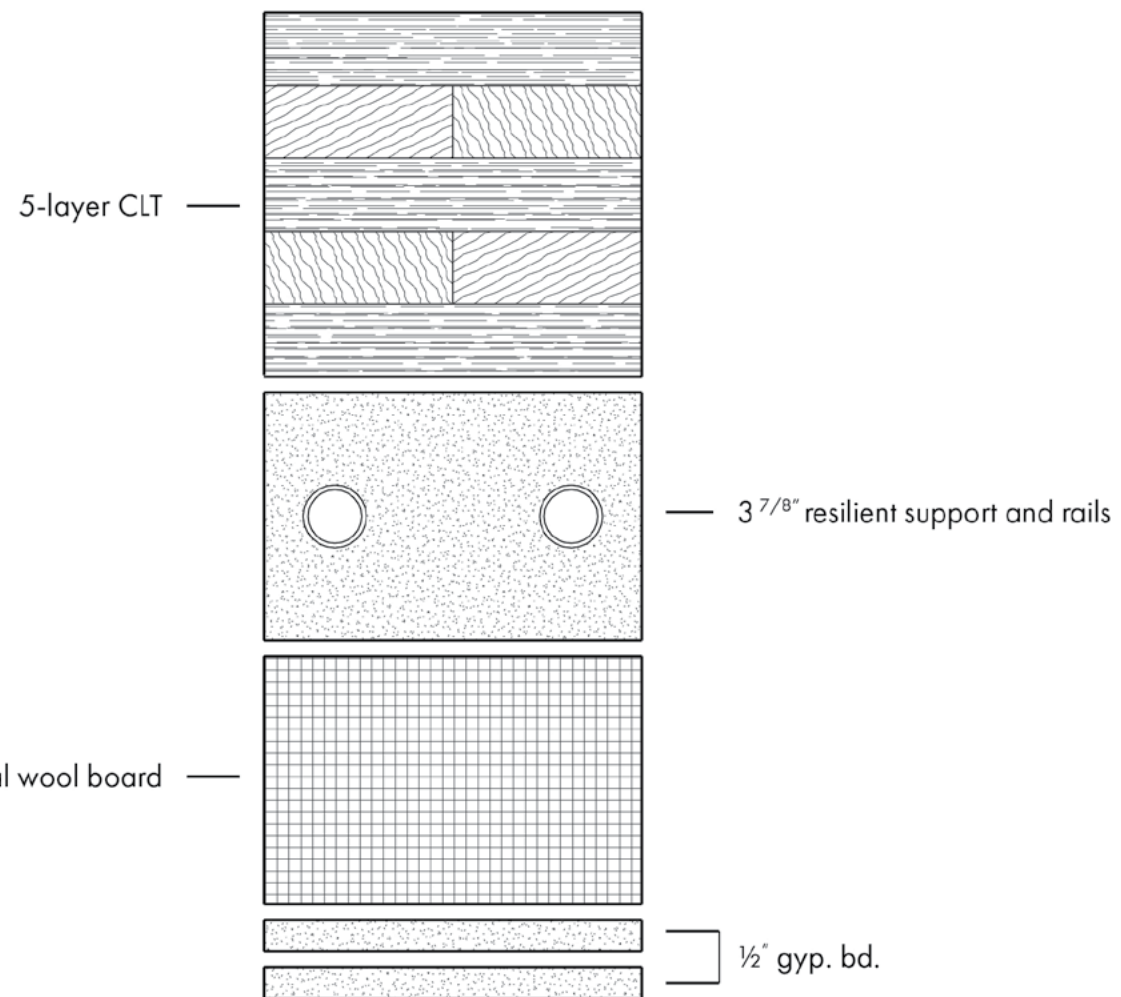
| base assembly | floor assembly | wall assembly | suggest an assembly |
|--|---|---------------|---------------------|
| assembly description (top layer - base layer) | 1 1/2" conc., 5/8" acoustic membrane (Resisto Isonomat), 5- layer CLT | | |
| cost (material, labor, installed , time) | \$ | \$\$ | \$\$\$ |
| 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 | | |
| available 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 | | |
| available 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 | | |

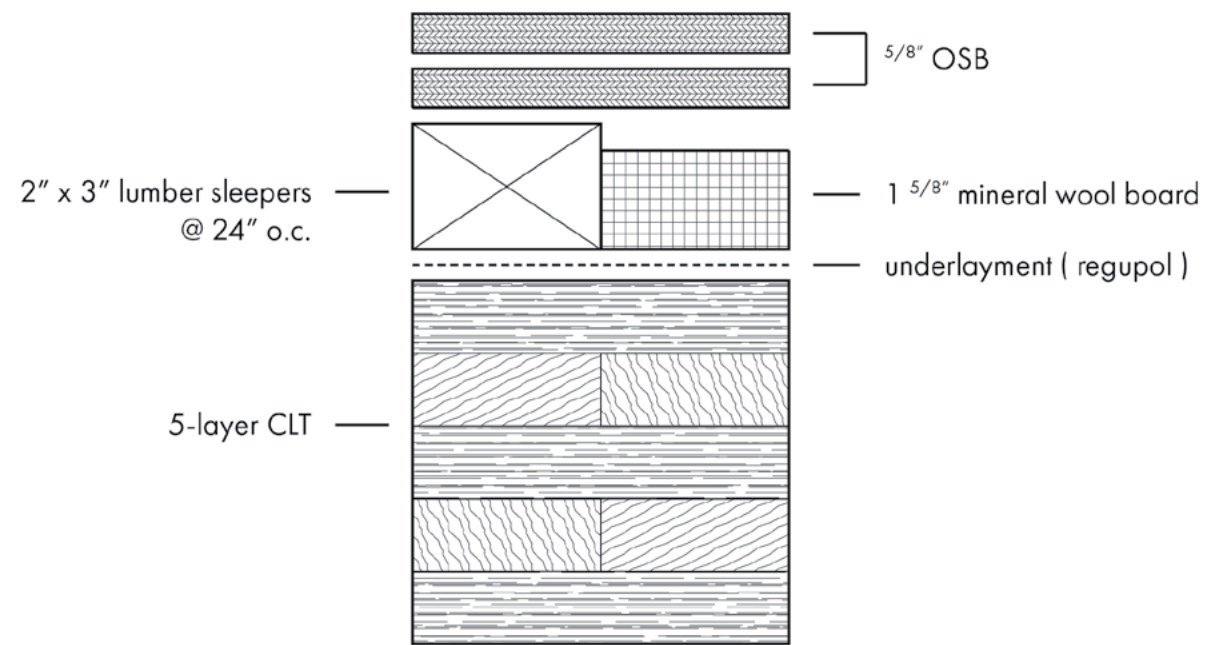


| base assembly | floor assembly | wall assembly | suggest an assembly |
|--|--|---------------|---------------------|
| assembly description (top layer - base layer) | (x2) 1/2" gyp. bd., 7/8" dry topping (PLACOSOL pellets), 5-layer CLT | | |
| cost (material, labor, installed , time) | \$ | \$\$ | \$\$\$ |
| 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 | | |
| available 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 | | |



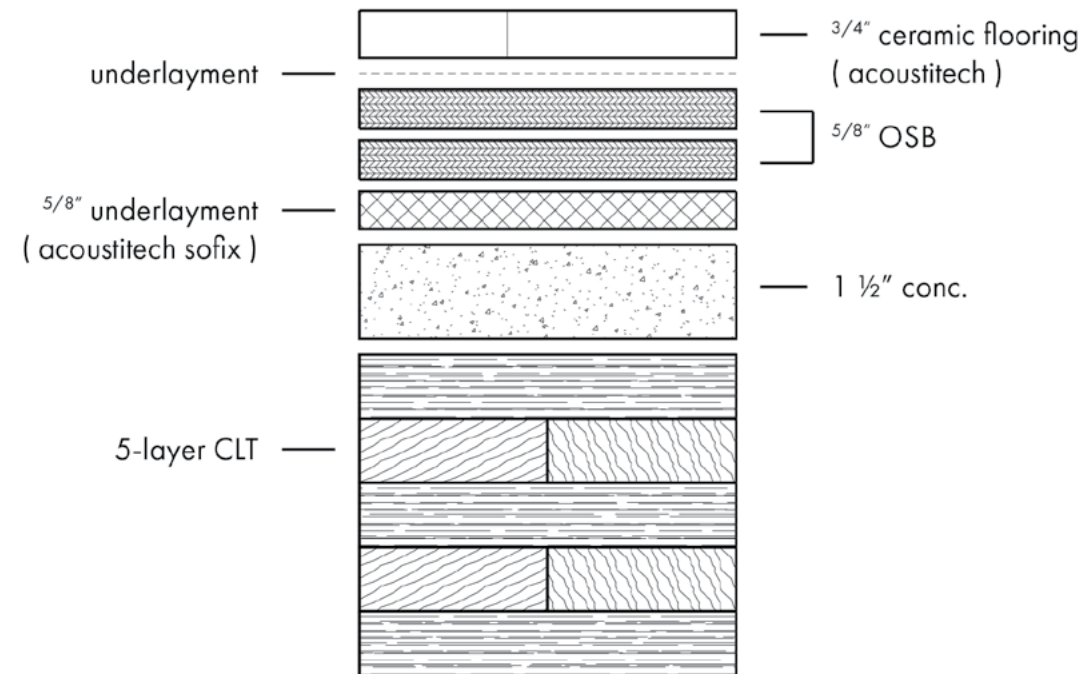
| base assembly | floor assembly | wall assembly | suggest an assembly |
|--|----------------|--|---------------------|
| assembly description (top layer - base layer) | | 5-layer CLT, resilient supports and rails, 7/8" mineral wool, (x2) 1/2" gyp. bd. | |
| cost (material, labor, installed , time) | | \$ | \$\$ \$\$\$ |
| 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 | |
| available 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



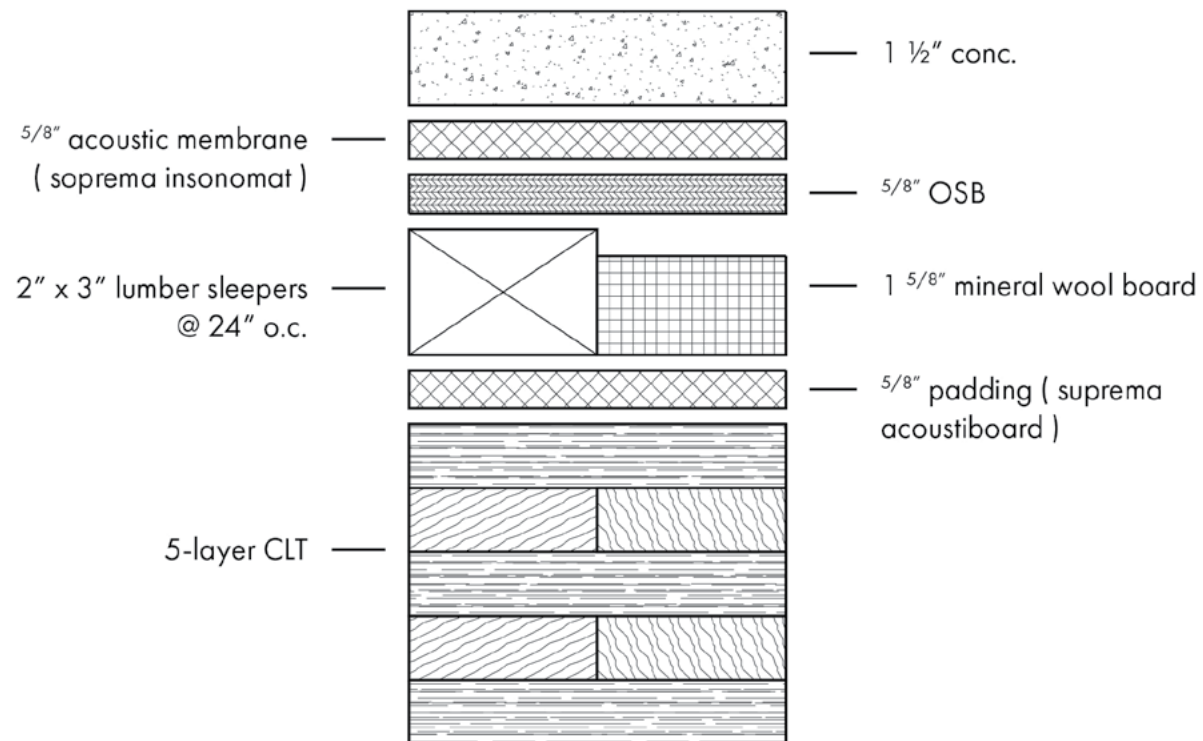
| base assembly | floor assembly | wall assembly | suggest an assembly |
|--|--|---------------|---------------------|
| assembly description (top layer - base layer) | (x2) 5/8" OSB, 1 5/8" mineral wool board, lumber sleepers (2" x 3" @ 24" o.c.), underlayment (REGUPOL), 5-layer CLT | | |
| cost (material, 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 | | |
| available 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 FPIInnovations PDF



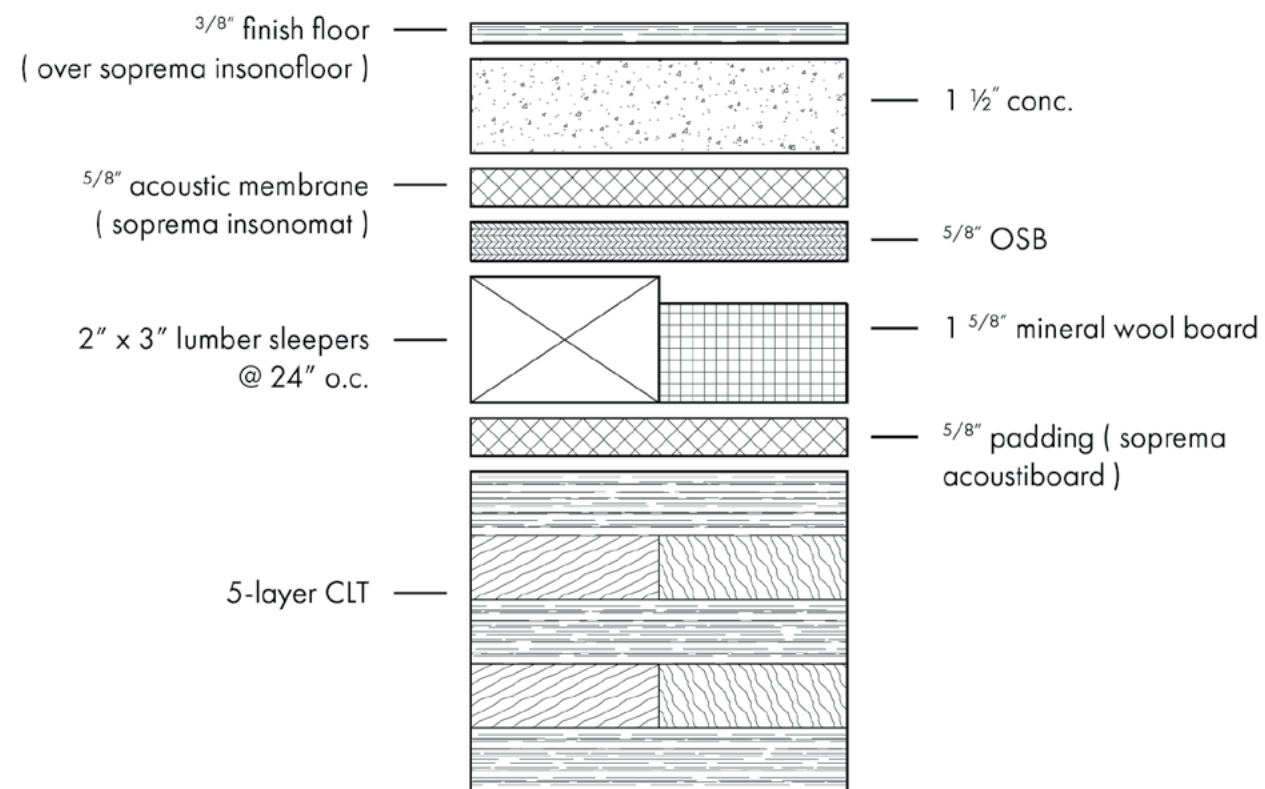
| base assembly | floor assembly | wall assembly | suggest an assembly |
|--|---|---------------|---------------------|
| assembly description (top layer - base layer) | 3/4" ceramic flooring (acoustiTECH), (x2) 5/8" OSB, 5/8" underlayment (AcoustiTECH SOFIX), 1 1/2" conc., 5-layer CLT | | |
| cost (material, 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 | | |
| available 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

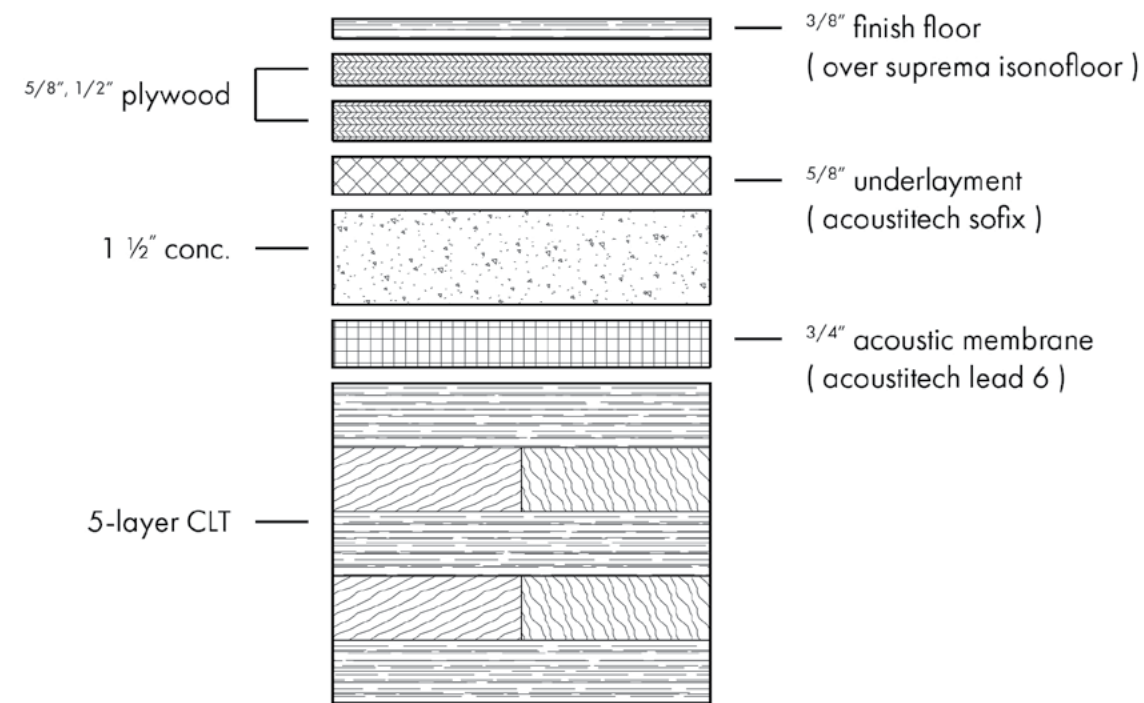


| base assembly | floor assembly | wall assembly | suggest an assembly |
|--|--|---------------|---------------------|
| assembly description (top layer - base layer) | 1 1/2" conc., 5/8" acoustic membrane (Soprema Insonomat), 5/8" OSB, lumber sleepers (2" x 3" @ 24" o.c.) 1 5/8" mineral wool board, 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 | | |
| available 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

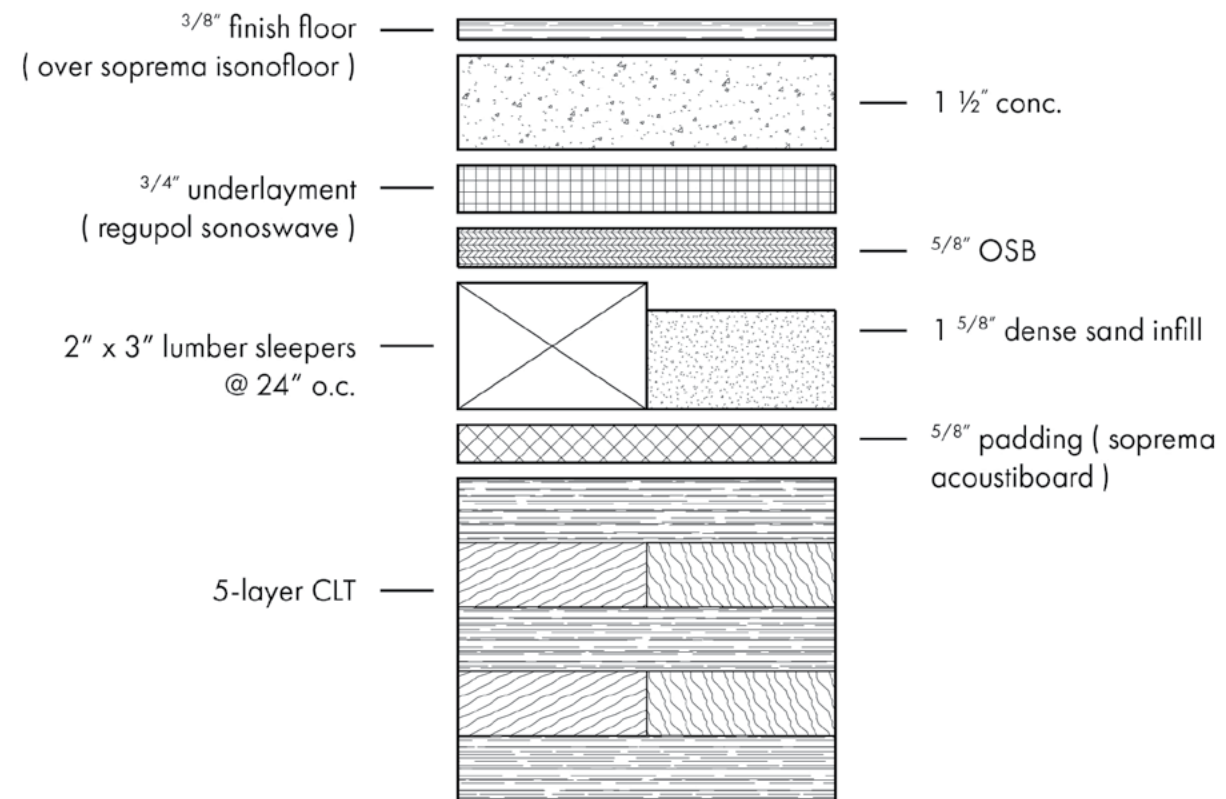


| base assembly | floor assembly | wall assembly | suggest an assembly |
|--|--|---------------|---------------------|
| assembly description (top layer - base layer) | 3/8" finish floor, acoustic membrane (Soprema Insonofloor), 1 1/2" conc., 5/8" acoustic membrane (Soprema Insonomat), 5/8" OSB, lumber 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 | | |
| available 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), 1/2" 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 | | |
| available 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.) | | | |

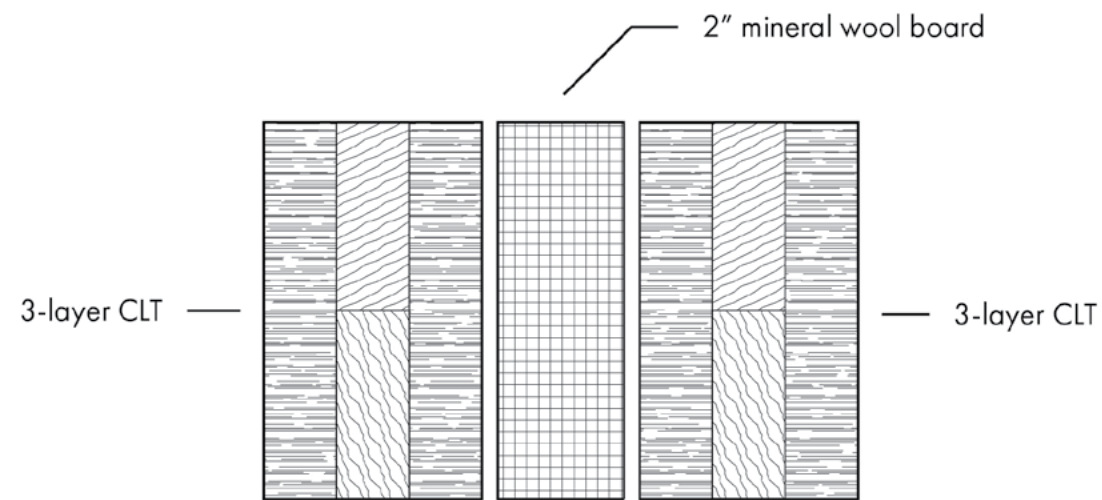
sources AcoustiTECH Acoustical Guide PDF



| 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 Sonoswave), 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 | | |
| available 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.) | | | |

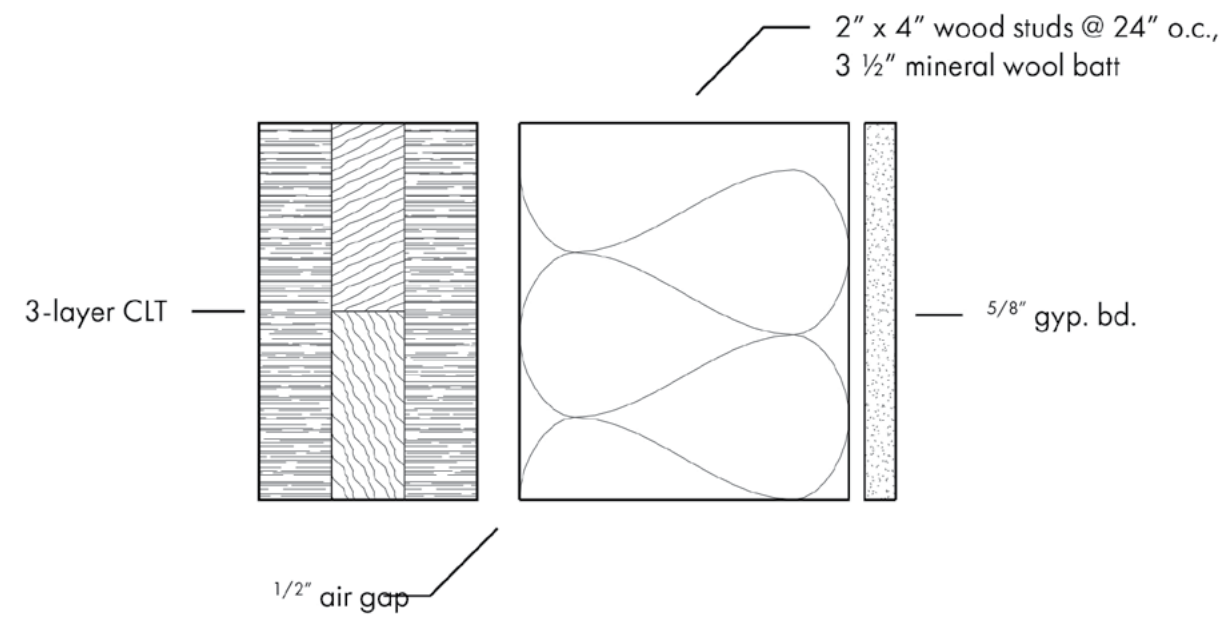
sources

AcoustiTECH Acoustical Guide PDF



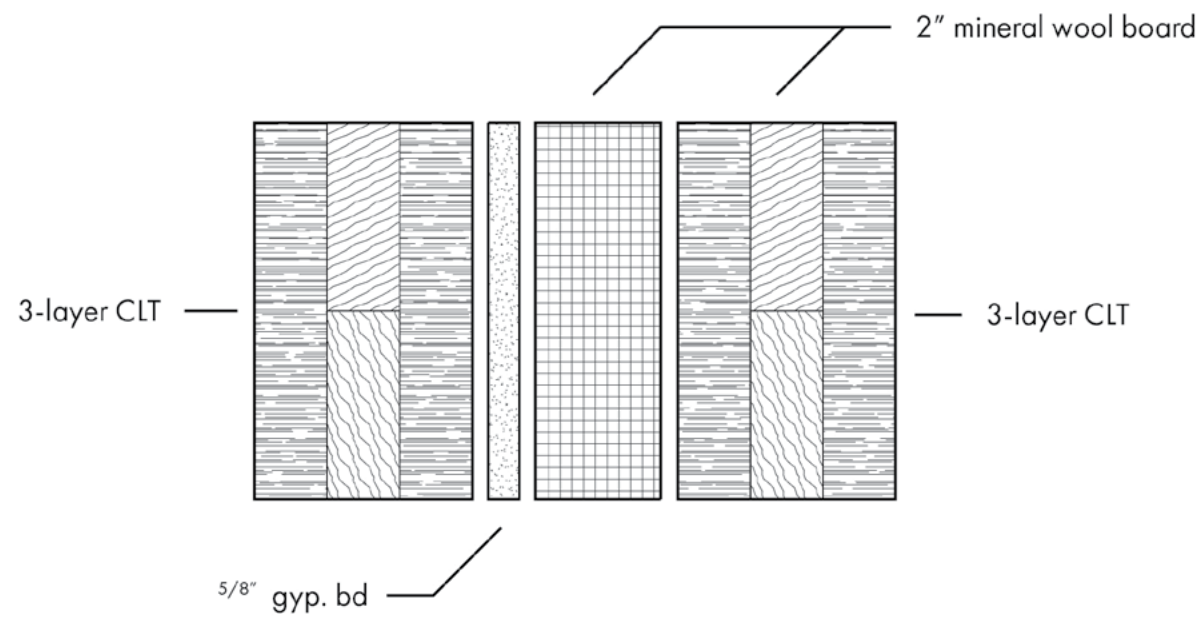
| base assembly | floor assembly | wall assembly | suggest an assembly |
|--|----------------|---|---------------------|
| assembly description (top layer - base layer) | | 3-layer CLT, 2" mineral wool board, 3-layer CLT | |
| cost (material, labor, installed , time) | | \$ | \$\$ \$\$\$ |
| constructability (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) | |
| available 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 FPIinnovations PDF, WoodWorks: The Case for Cross Laminated Timber



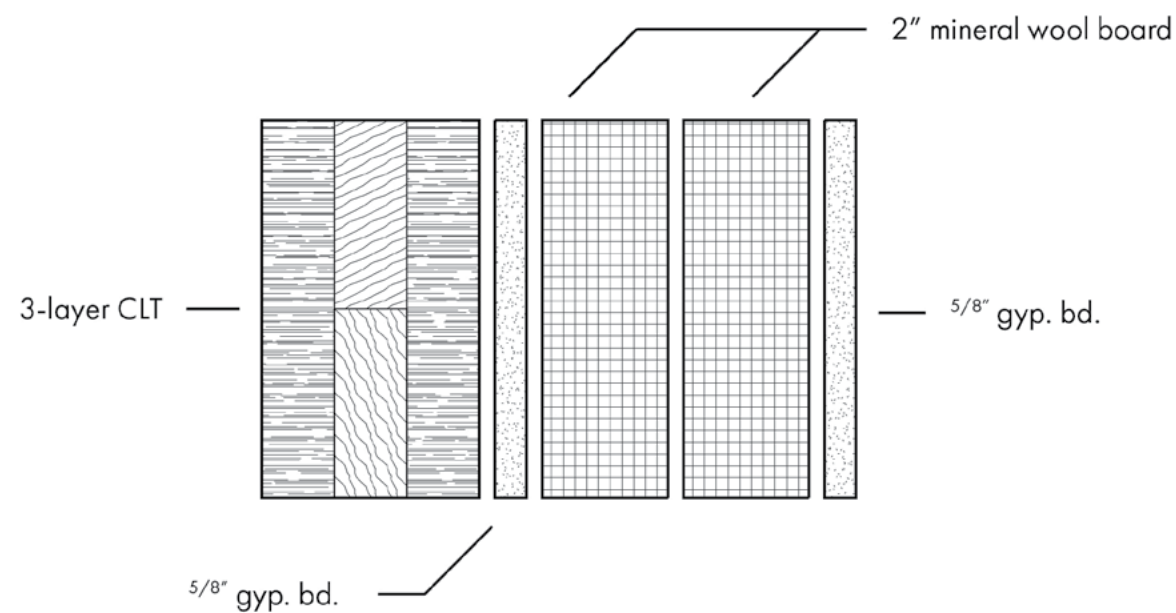
| base assembly | floor assembly | wall assembly | suggest an assembly |
|--|----------------|---|---------------------|
| assembly description (top layer - base layer) | | 3-layer CLT, 1/2" air gap, 2" x 3" wood studs @ 24" o.c., 3 1/2" mineral wool batt, 5/8" gyp. bd. | |
| cost (material, labor, installed , 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) | |
| available 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 FPIInnovations PDF



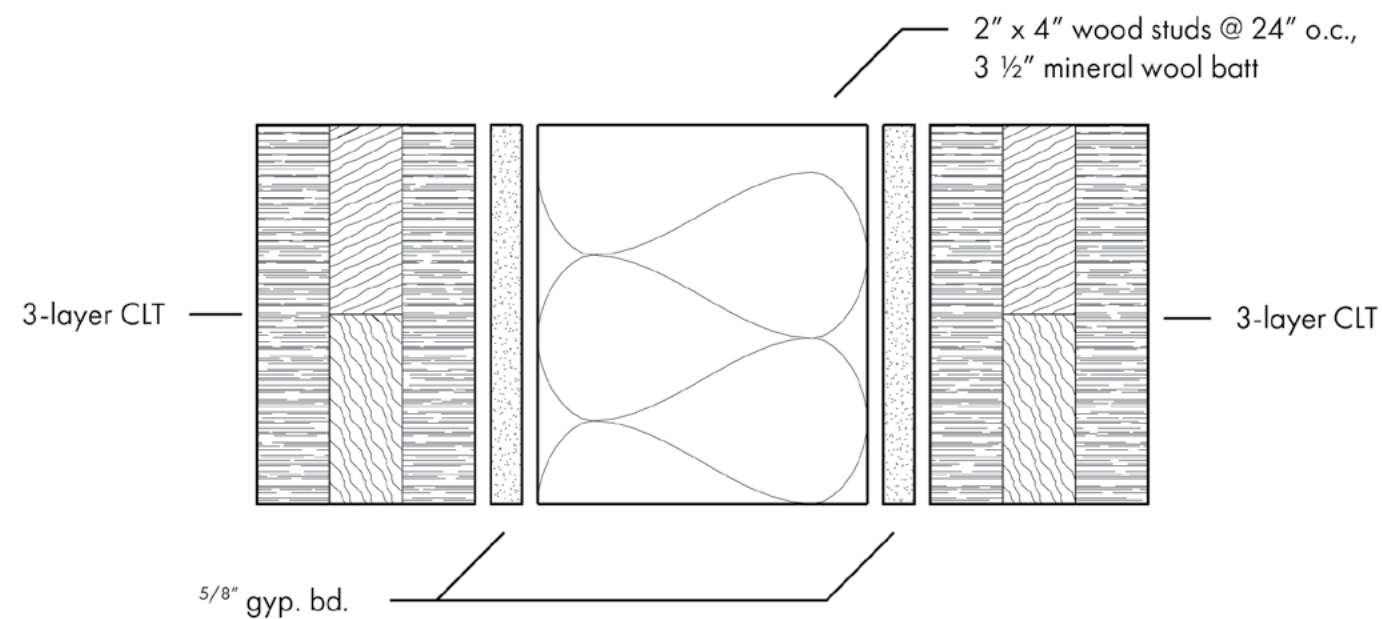
| base assembly | floor assembly | wall assembly | suggest an assembly |
|--|----------------|---|---------------------|
| assembly description (top layer - base layer) | | 3-layer CLT, 5/8" gyp. bd., mineral wool board, 3-layer CLT | |
| cost (material, labor, installed , time) | | \$ | \$\$ \$\$\$ |
| 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) | |
| available 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 FPIinnovations PDF



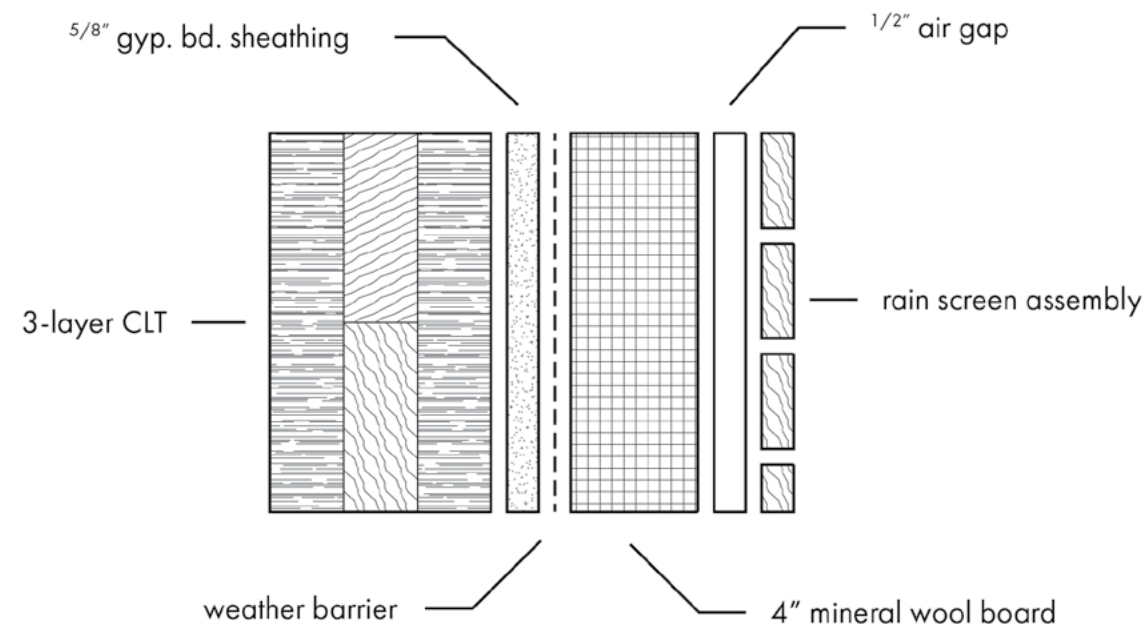
| base assembly | floor assembly | wall assembly | suggest an assembly |
|--|----------------|--|---------------------|
| assembly description (top layer - base layer) | | 3-layer CLT, 5/8" gyp. bd., (x2) mineral wool board, 5/8" gyp. bd. | |
| cost (material, labor, installed , time) | | \$ | \$\$ \$\$\$ |
| 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) | |
| available 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



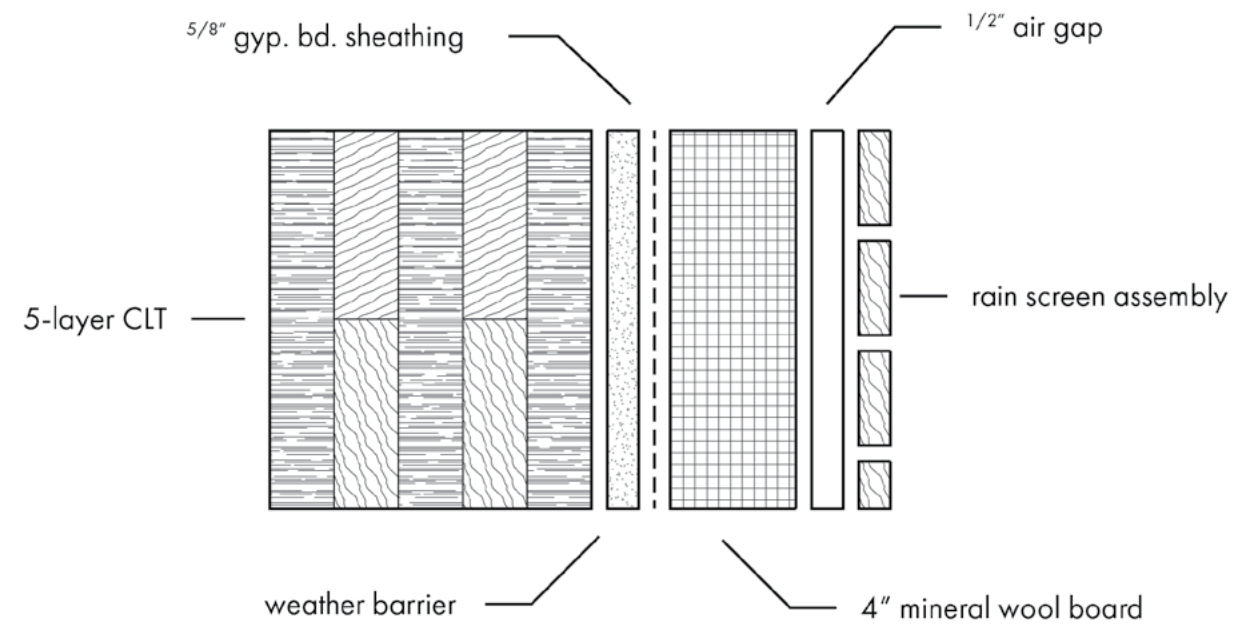
| base assembly | floor assembly | wall assembly | suggest an assembly |
|--|----------------|--|---------------------|
| assembly description (top layer - base layer) | | 3-layer CLT, 5/8" gyp. bd., 2 x 4" typ. stud wall @ 24" o.c., 3 1/2" mineral wool batt between studs, 5/8" gyp. bd., 3-layer CLT | |
| 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) | |
| available 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) | |
| available 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) | |
| available 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)

available 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.

INDUSTRY FEEDBACK

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.

INDUSTRY FEEDBACK

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.

INDUSTRY FEEDBACK

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 Kattera 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

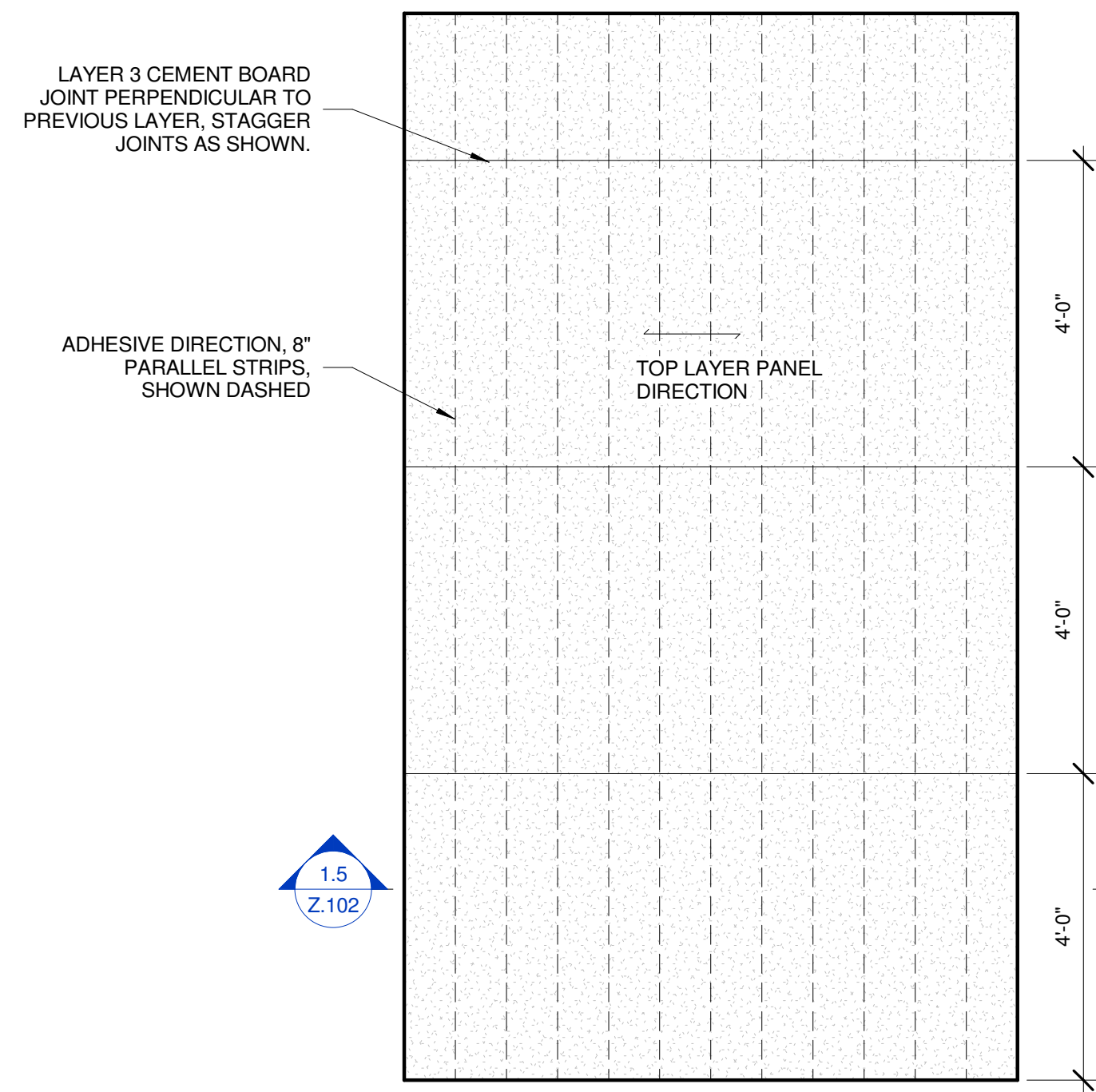
USG Testing Services, Corporate Innovation
Center
700 N. Highway 45
Libertyville, IL 60048
Phone : 847-970-5106

| 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. |

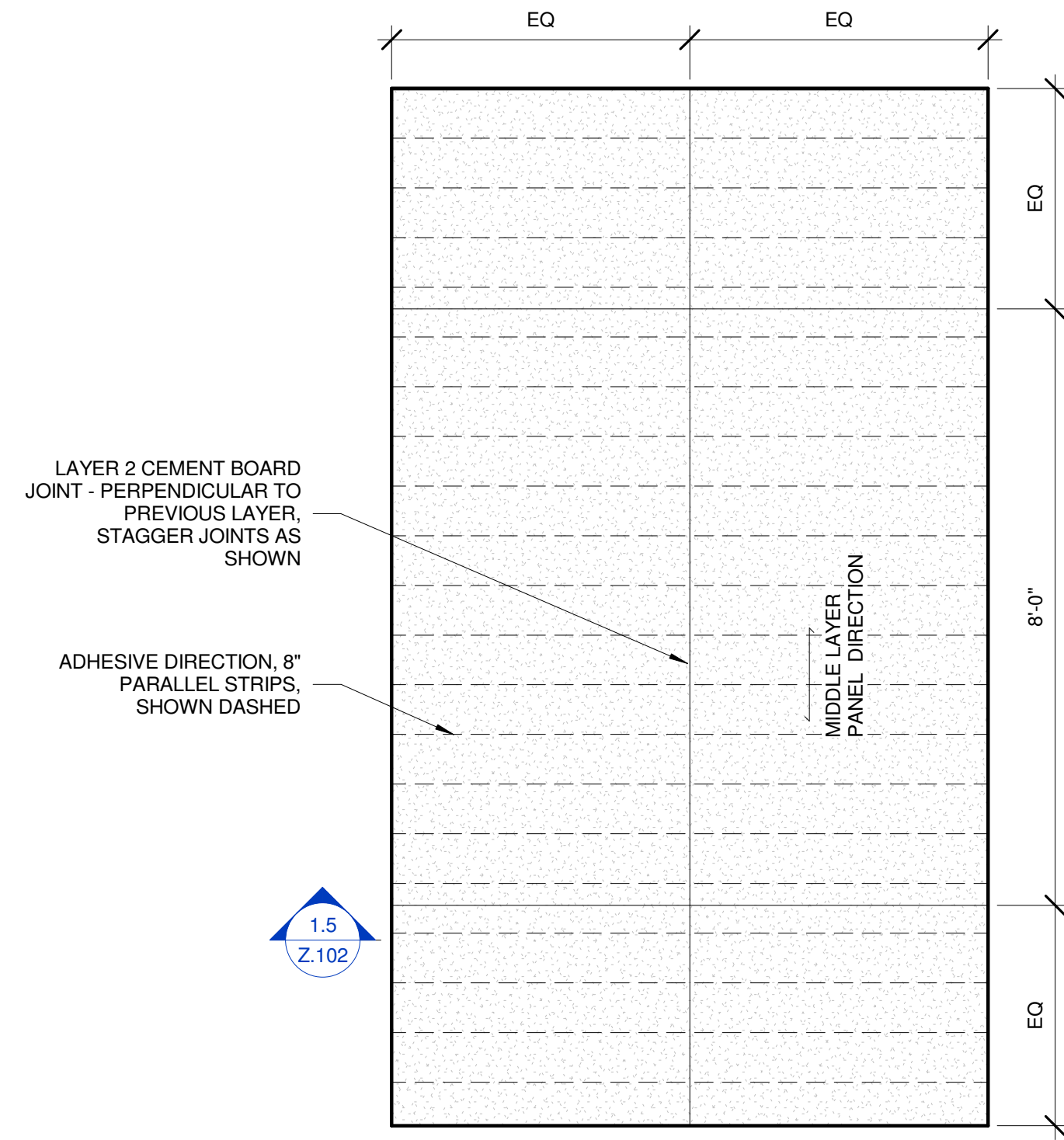
Notes:

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 handling panels without mechanical assistance.
 ** This does not represent an exhaustive search and represents accreditation and facility configuration as of Fall 2018

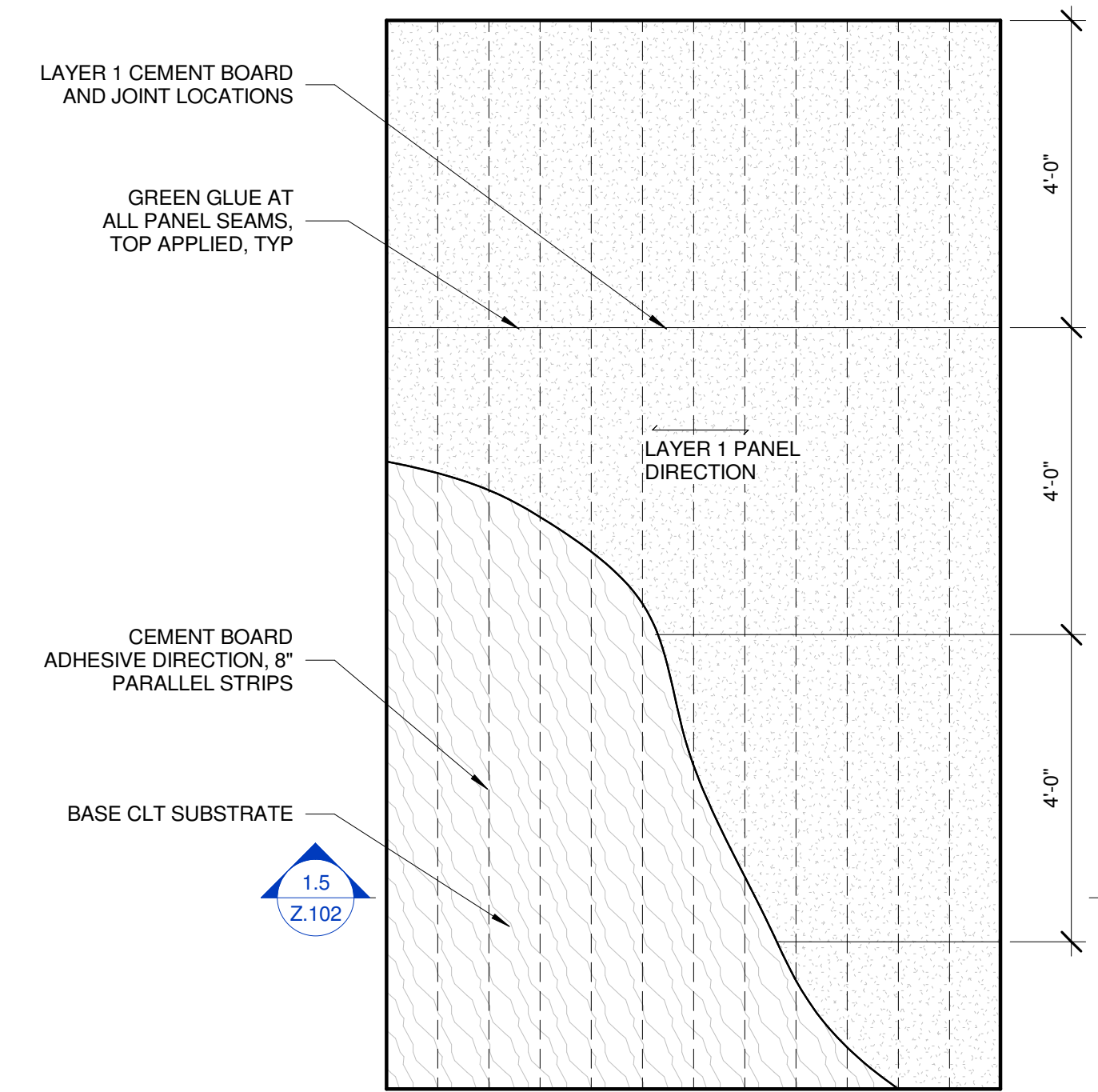
6.5 AS-BUILT CONSTRUCTION DRAWINGS FOR CLT ASSEMBLIES



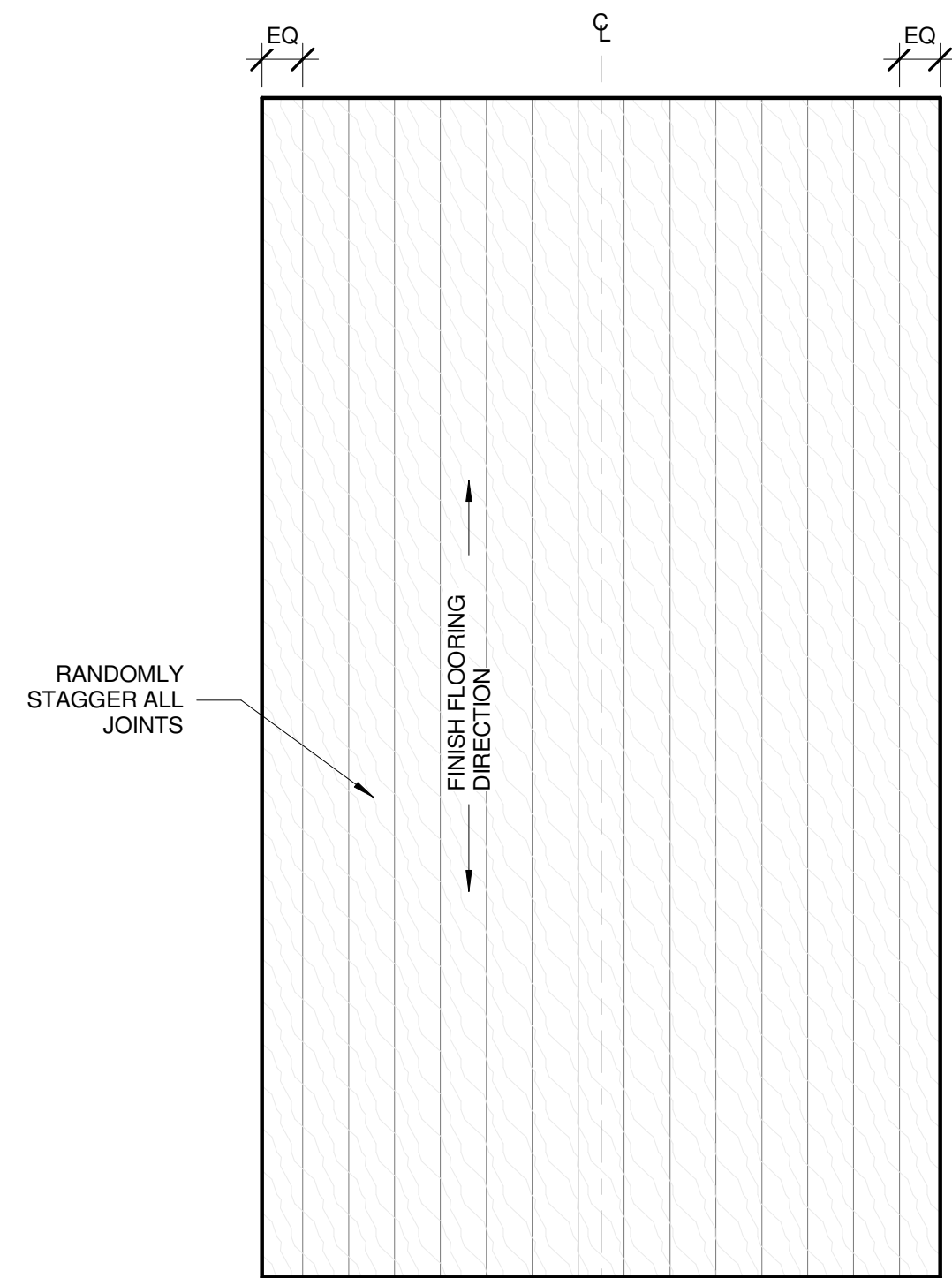
1.13 CEMENT BOARD LAYOUT - LAYER 3
1/2" = 1'-0"



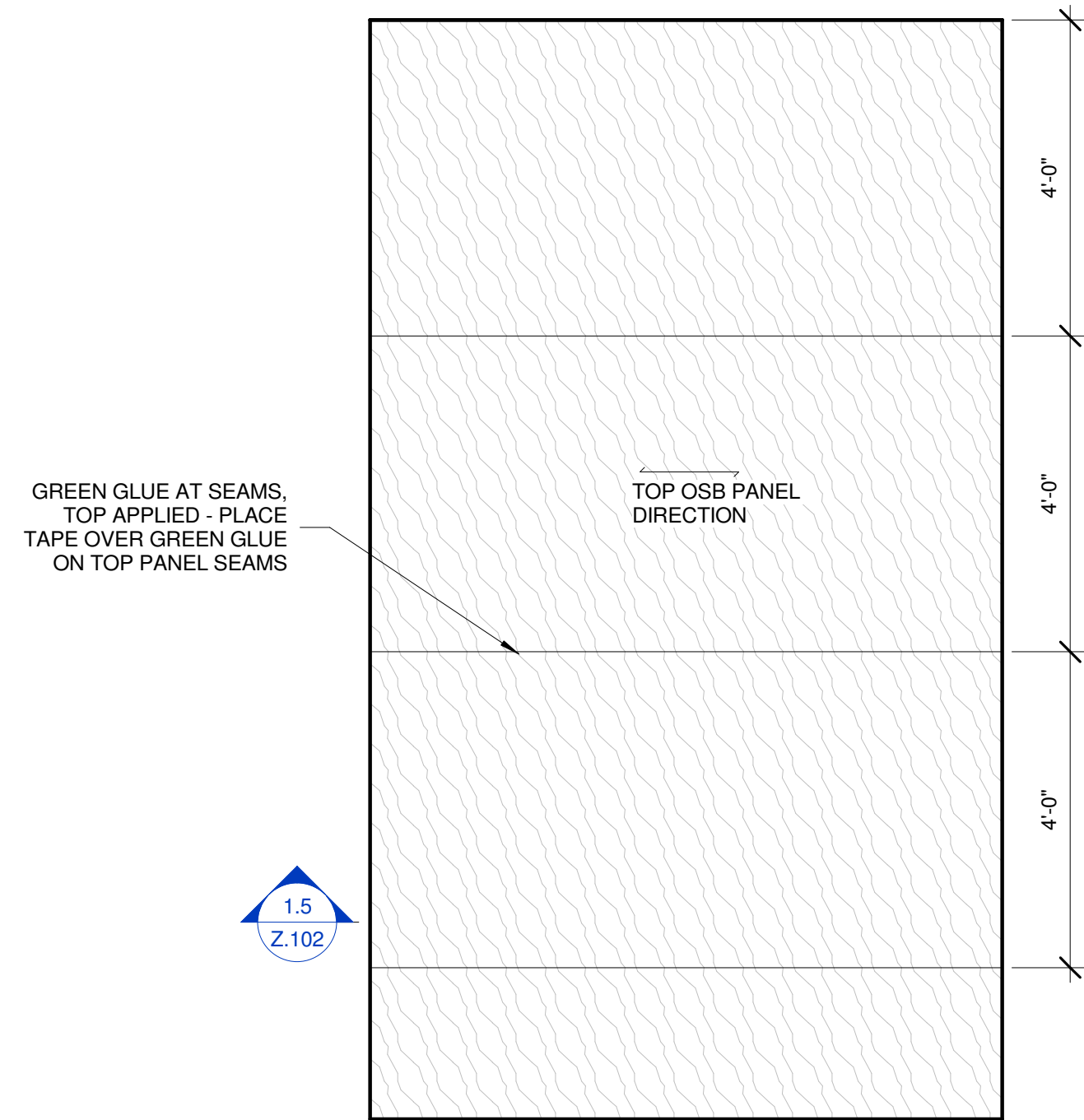
1.12 CEMENT BOARD LAYOUT - LAYER 2
1/2" = 1'-0"



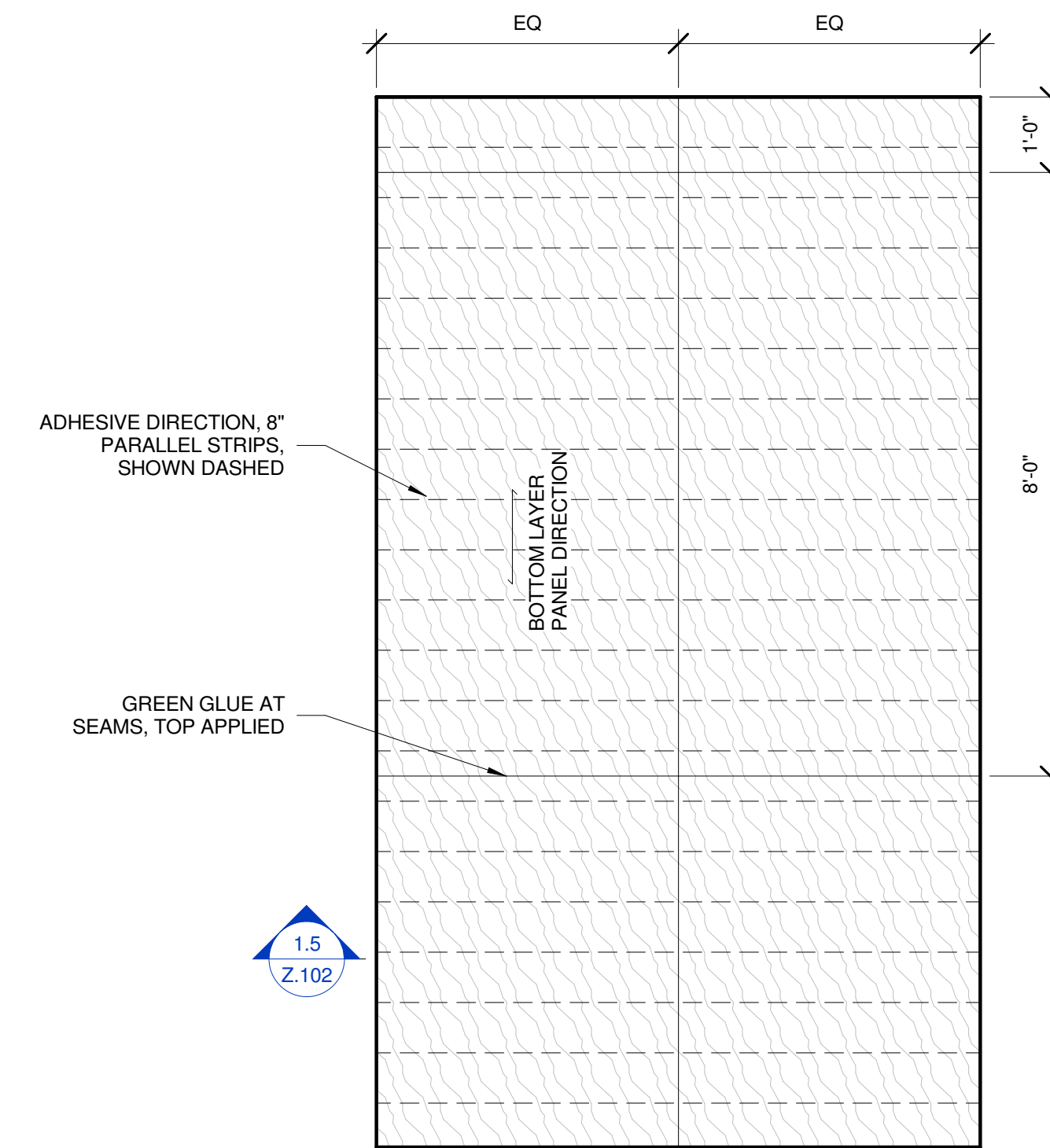
1.11 CEMENT BOARD LAYOUT - LAYER 1
1/2" = 1'-0"



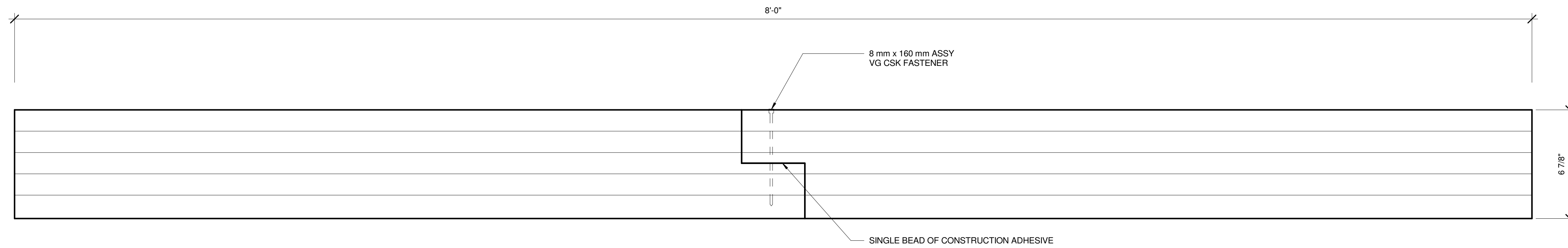
1.2 FLOATING FLOOR LAYOUT PLAN
1/2" = 1'-0"



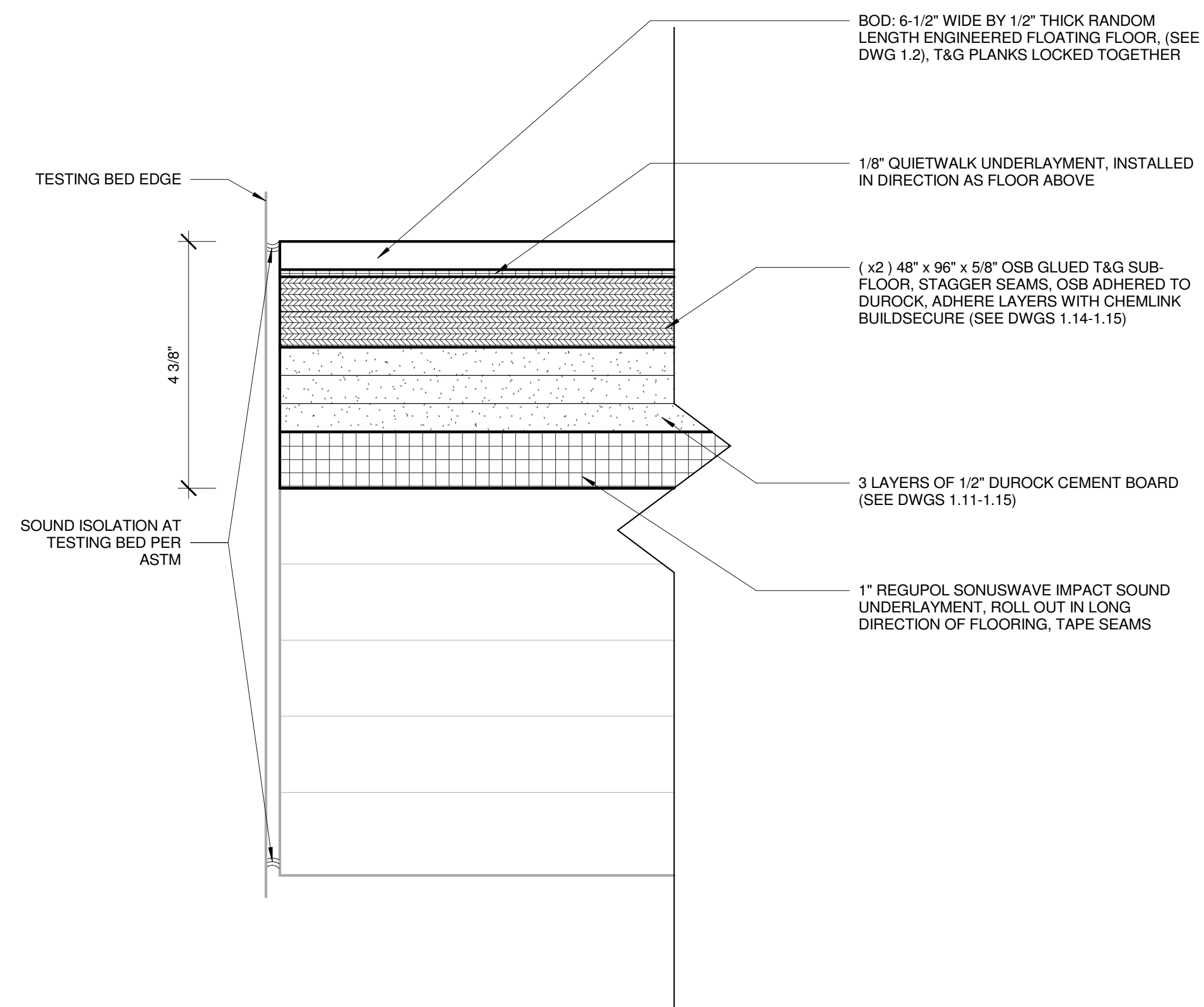
1.15 OSB LAYOUT - LAYER 2
1/2" = 1'-0"



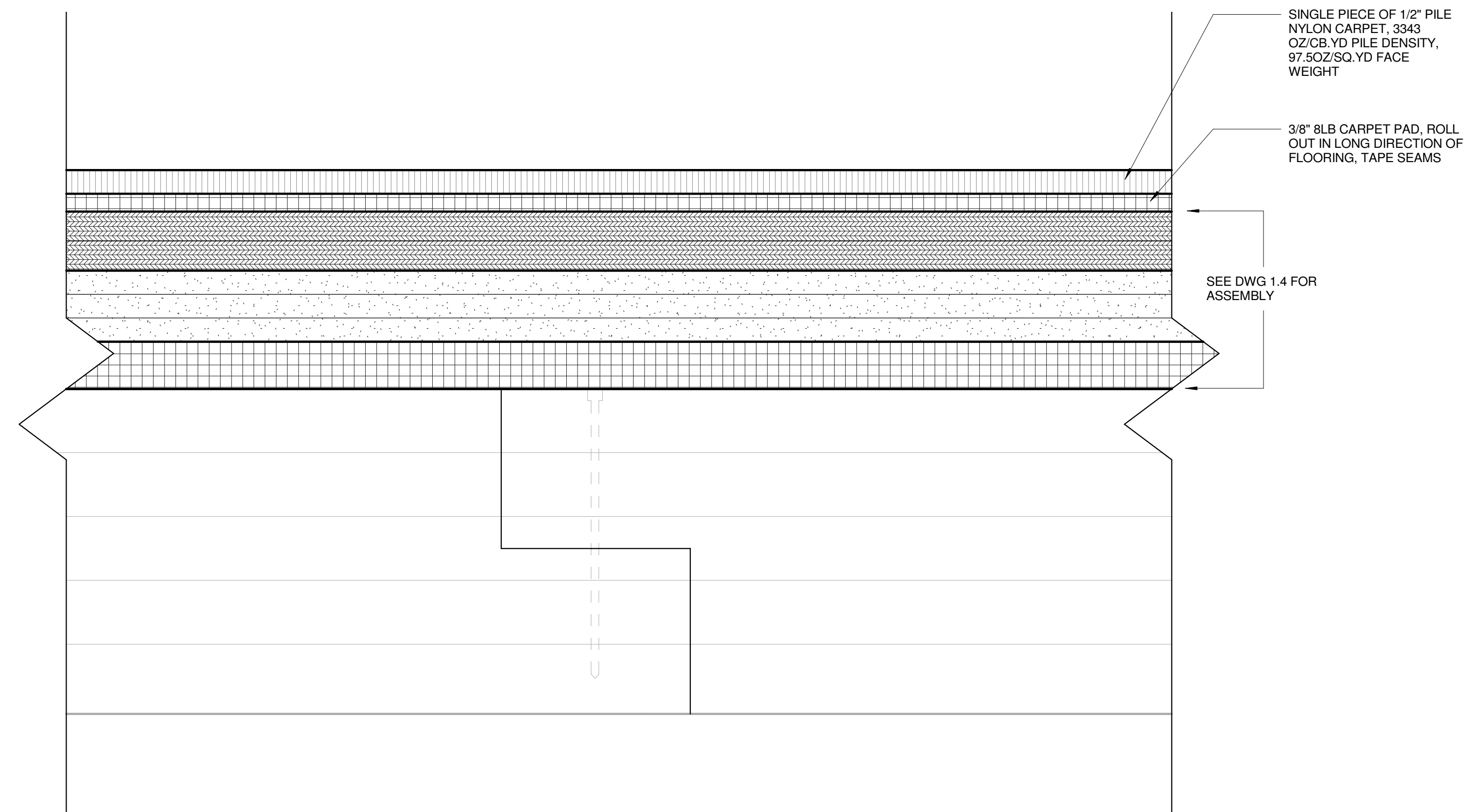
1.14 OSB LAYOUT - LAYER 1
1/2" = 1'-0"



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"

ENERGY STUDIES IN BUILDINGS LAB

103 Pacific Hall
University of Oregon
Eugene, Oregon
541 346 5647

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

105A White Stag Building
University of Oregon
Portland, Oregon, 97209

Contact: Jason Stenson
p: 503/ 412-3656

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

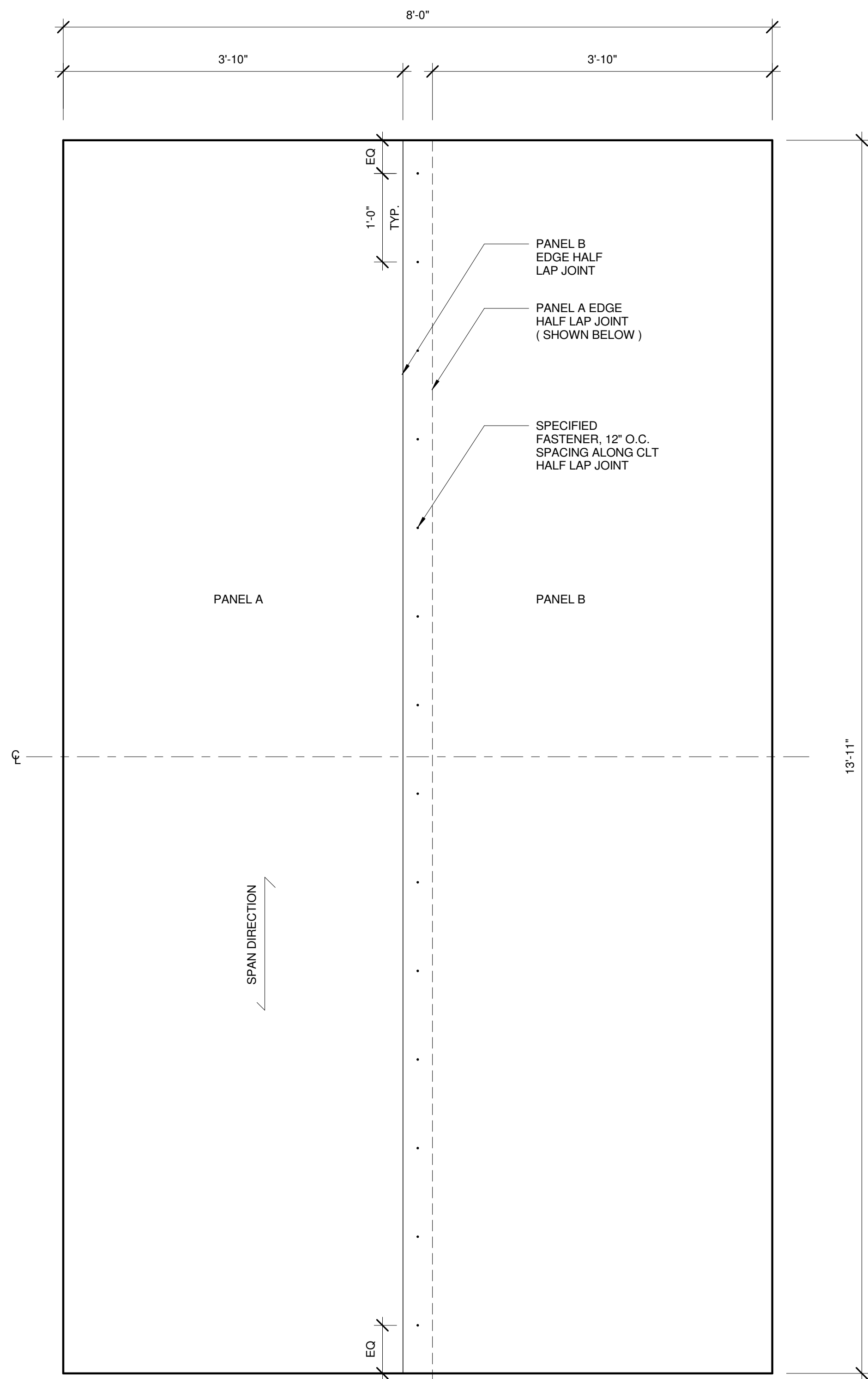
CEMENT
BOARD FLOOR
SECTIONS

Z.102

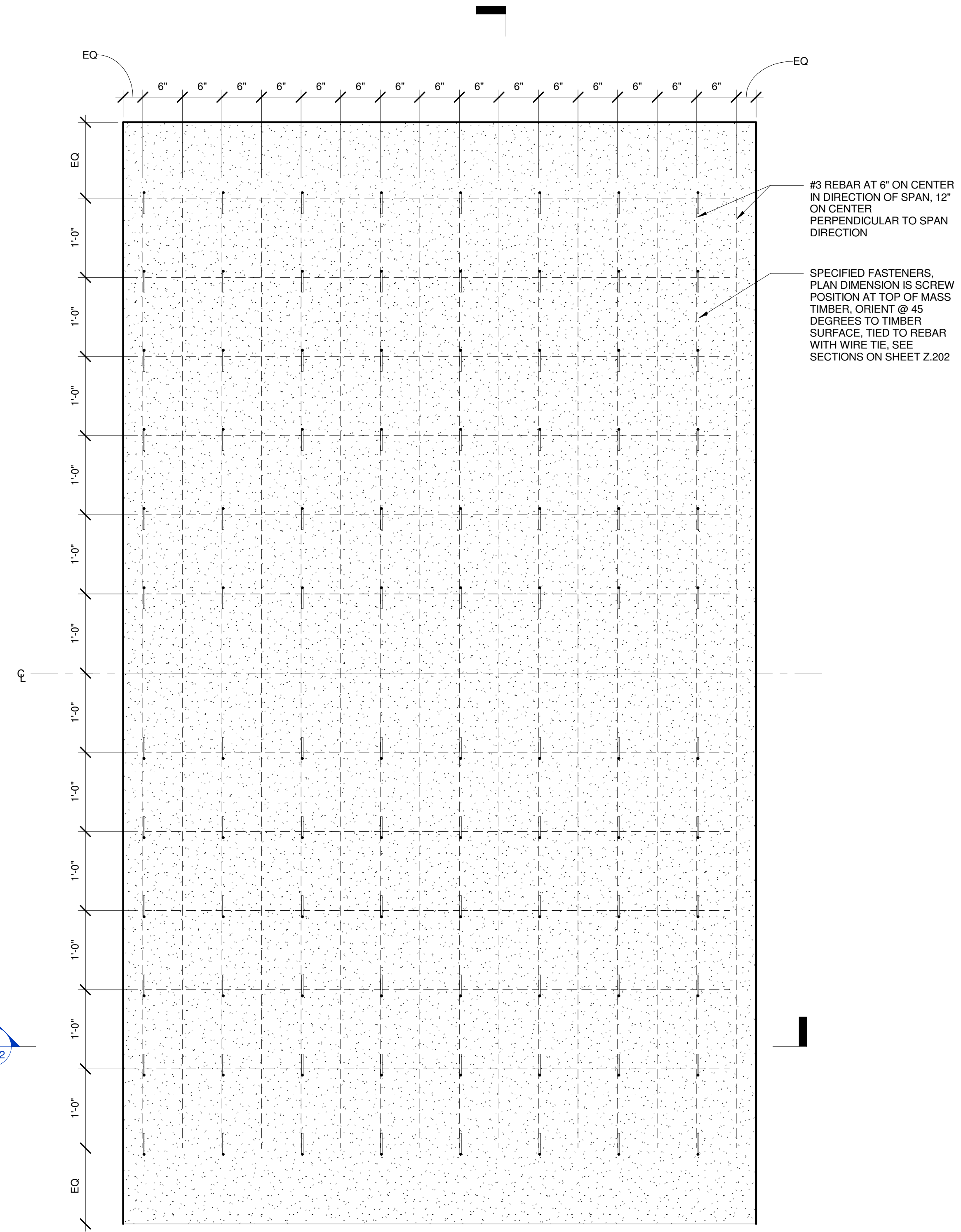
SCALE | As indicated

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"

3/25/2019 8:43:45 AM



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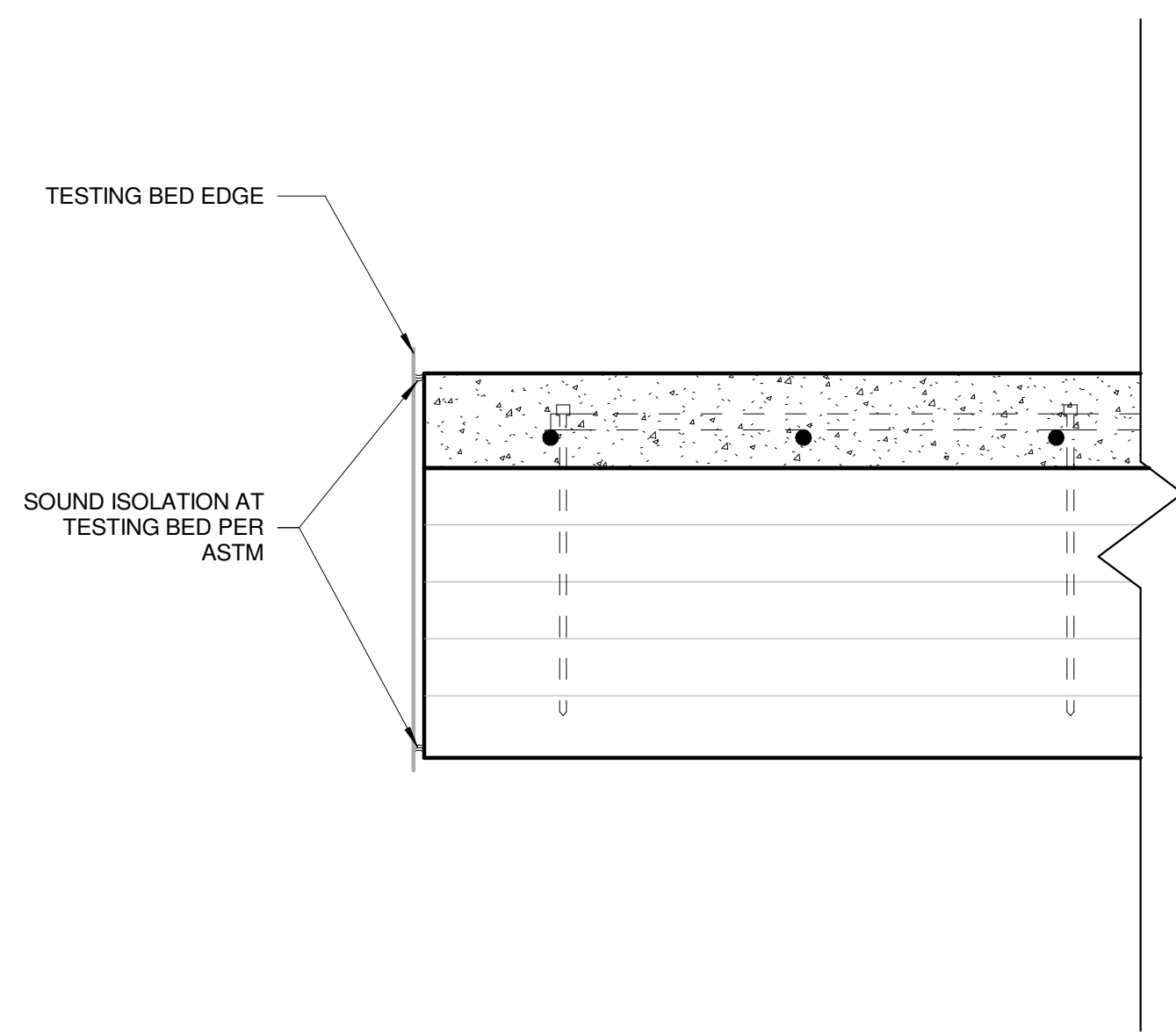
CLT BASE,
COMPOSITE
ASSEMBLY
PLANS

Z.201

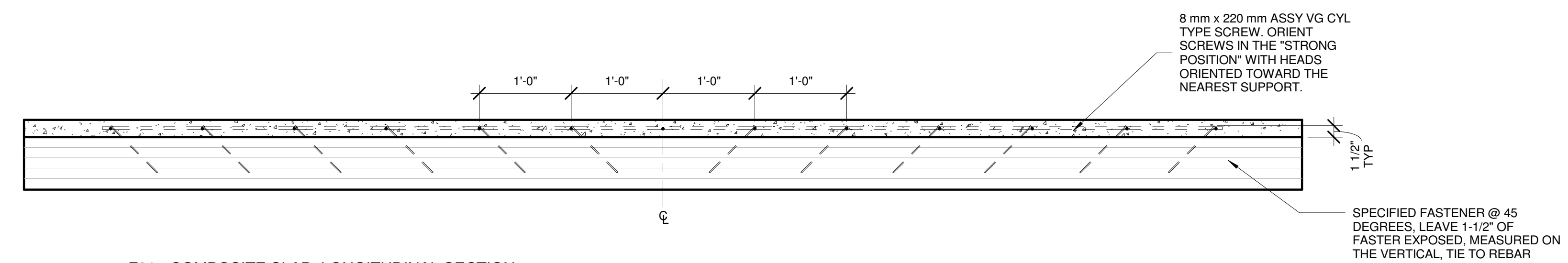
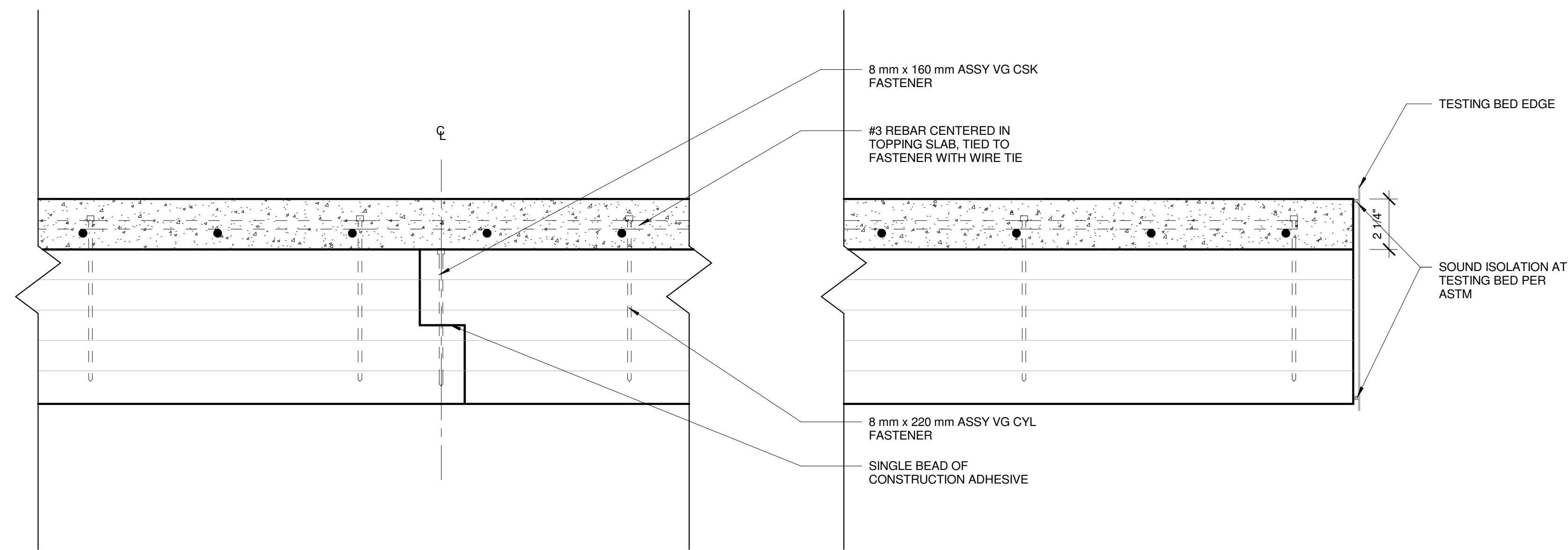
SCALE | 1" = 1'-0"

ISSUE DATE | 03.25.2019

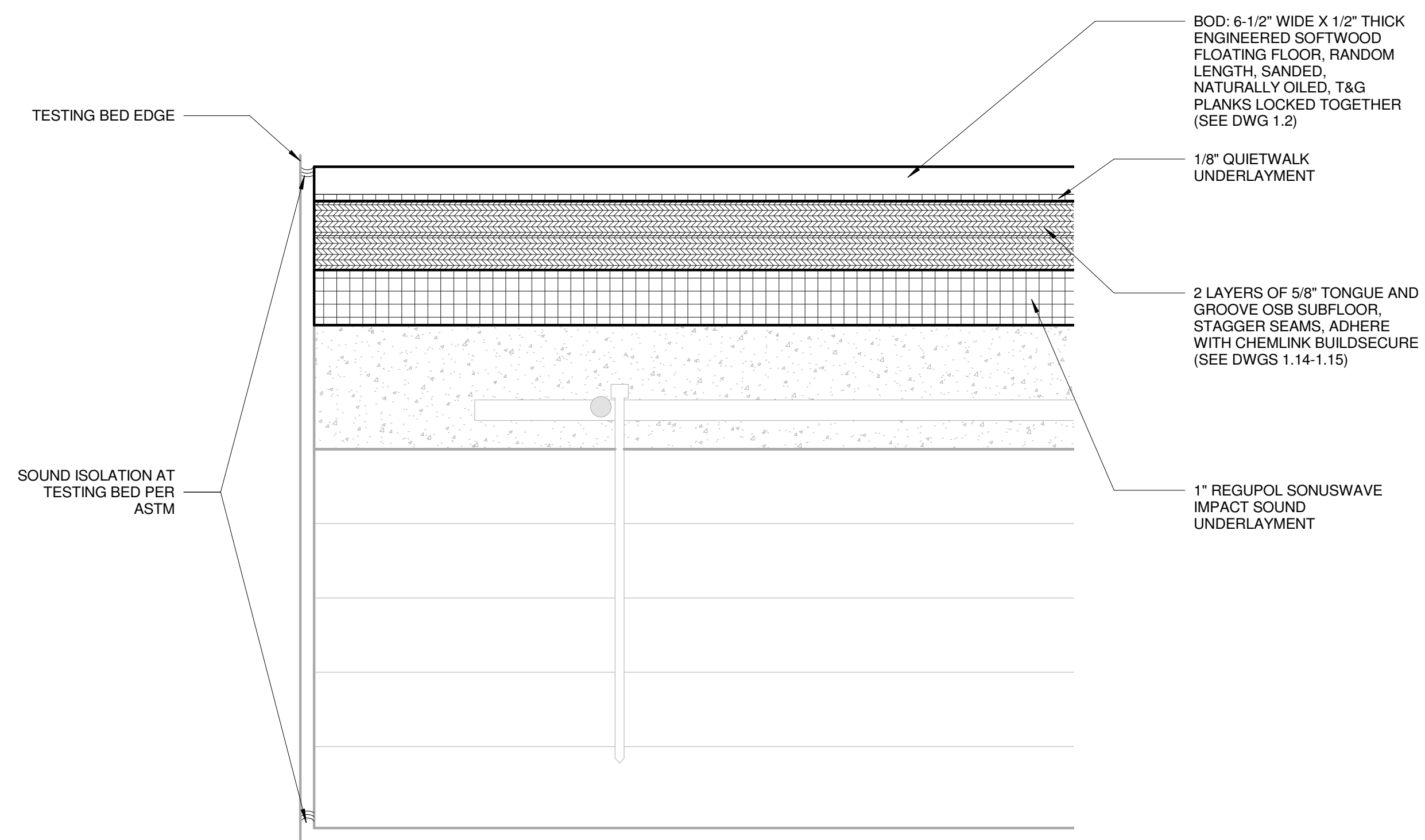
AS-BUILT
DRAWINGS



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"

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

Section 6.5 | 57

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University of Oregon
Eugene, Oregon
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**Acoustic Lab
Testing of Typical
Multi-Family
Residential CLT
Wall and Floor
Assemblies**

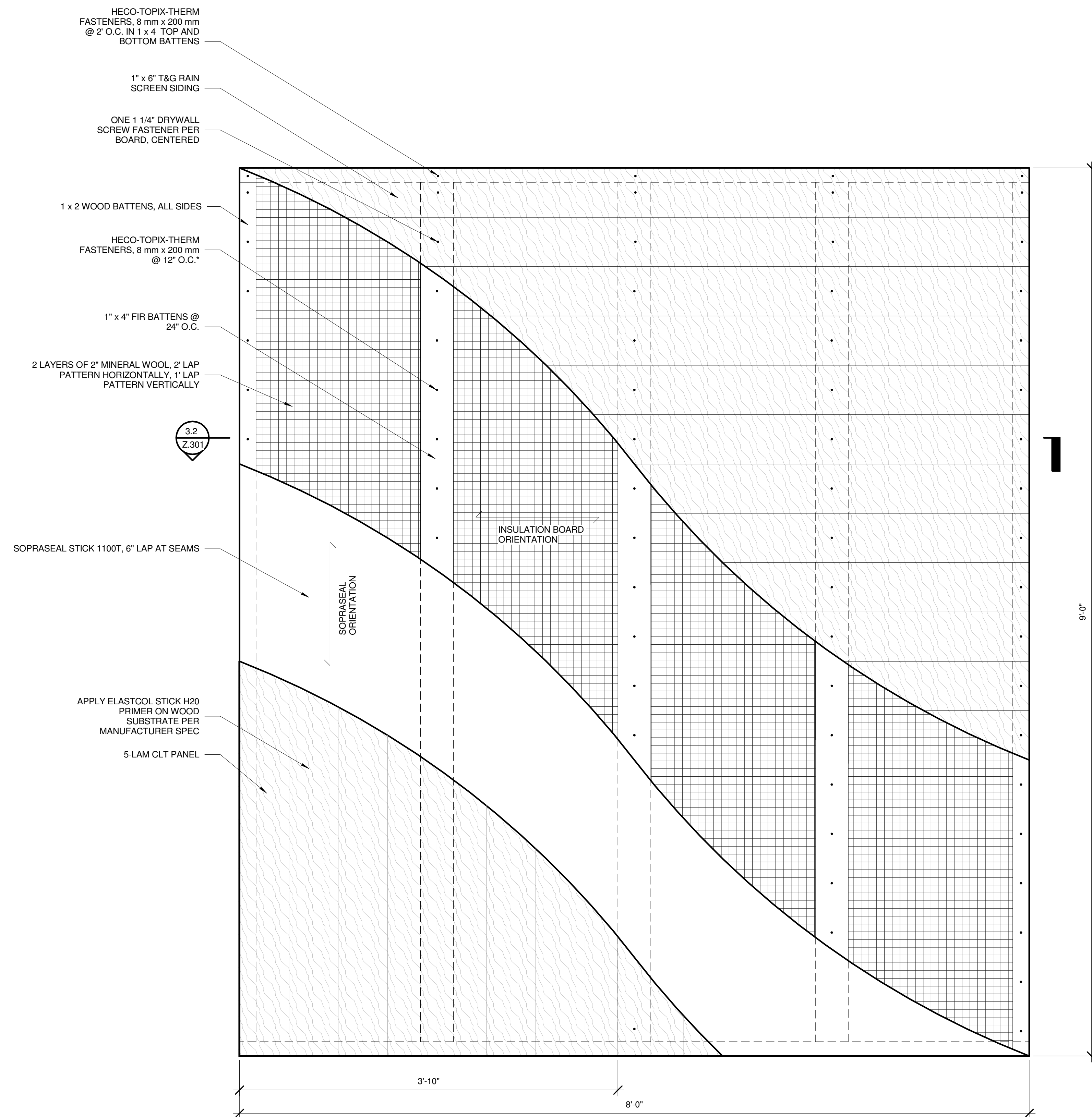
**WALL
ASSEMBLY,
SECTION**

Z.301

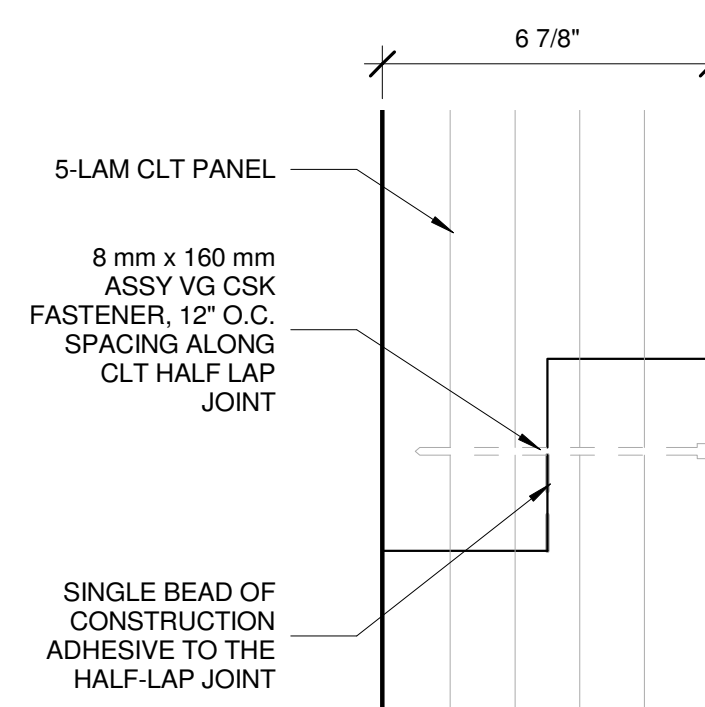
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ISSUE DATE | 03.25.2019

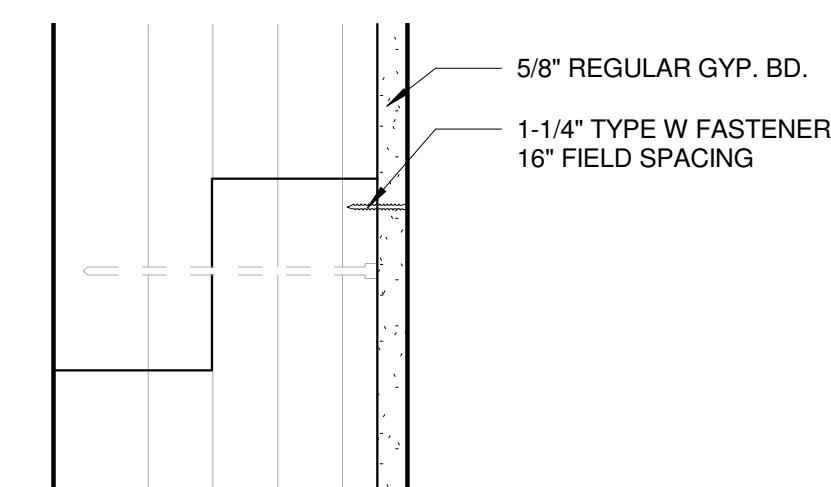
**AS-BUILT
DRAWINGS**



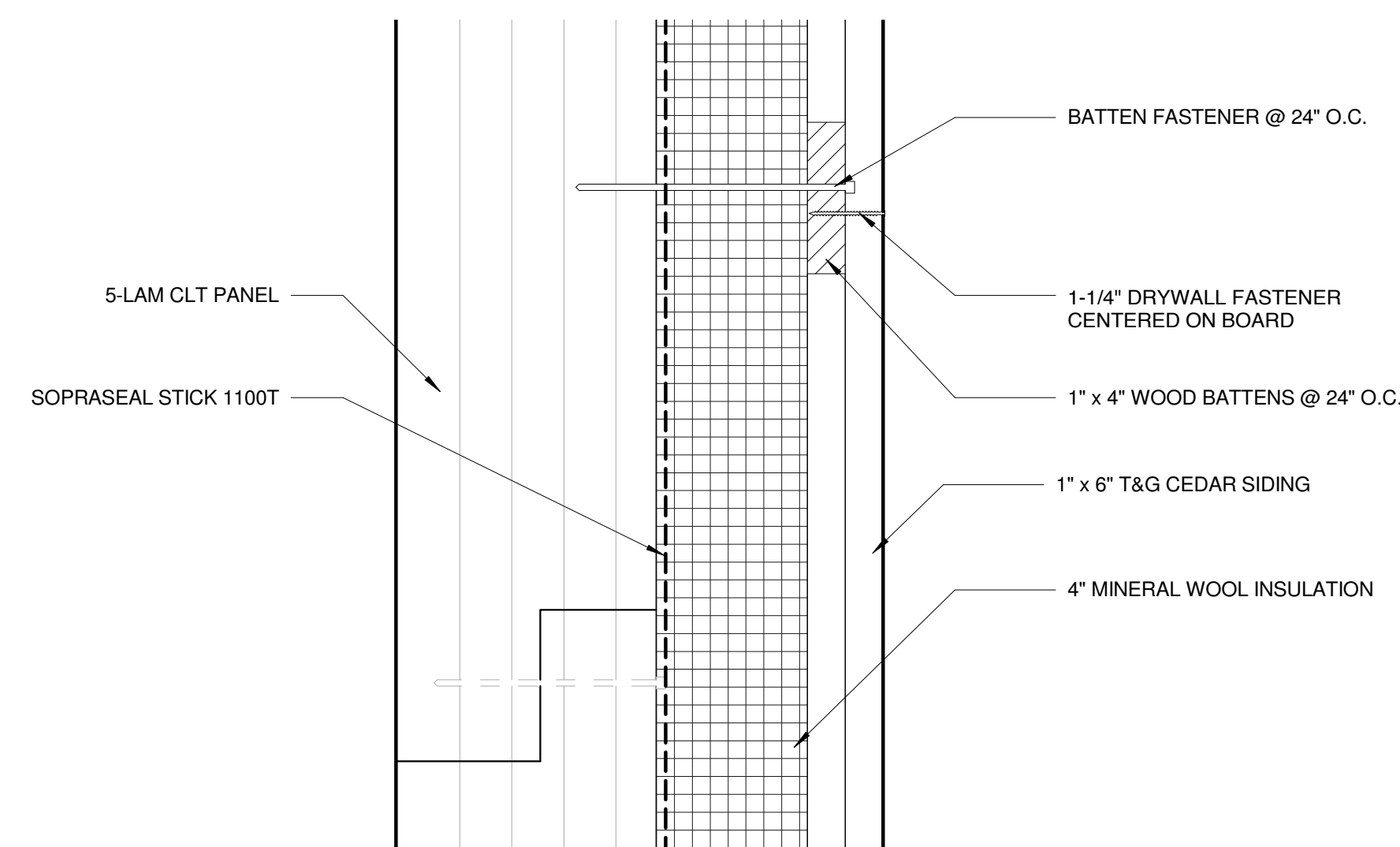
3.1 RAINSCREEN ASSEMBLY PEEL AWAY DIAGRAM
1 1/2" = 1'-0"



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

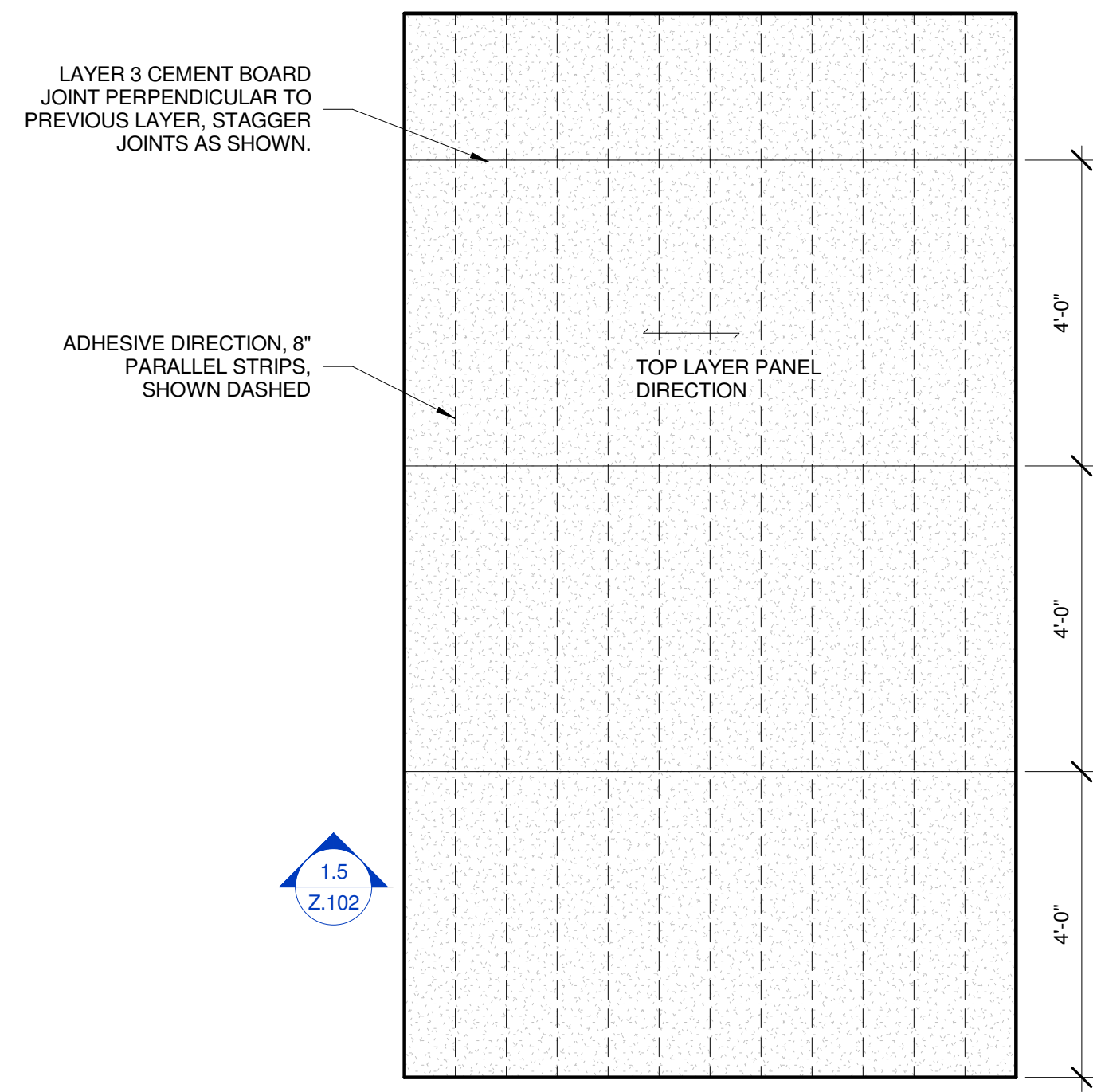


W02 W08 - CLT - SHAFT CASE - PLAN VIEW
3" = 1'-0"

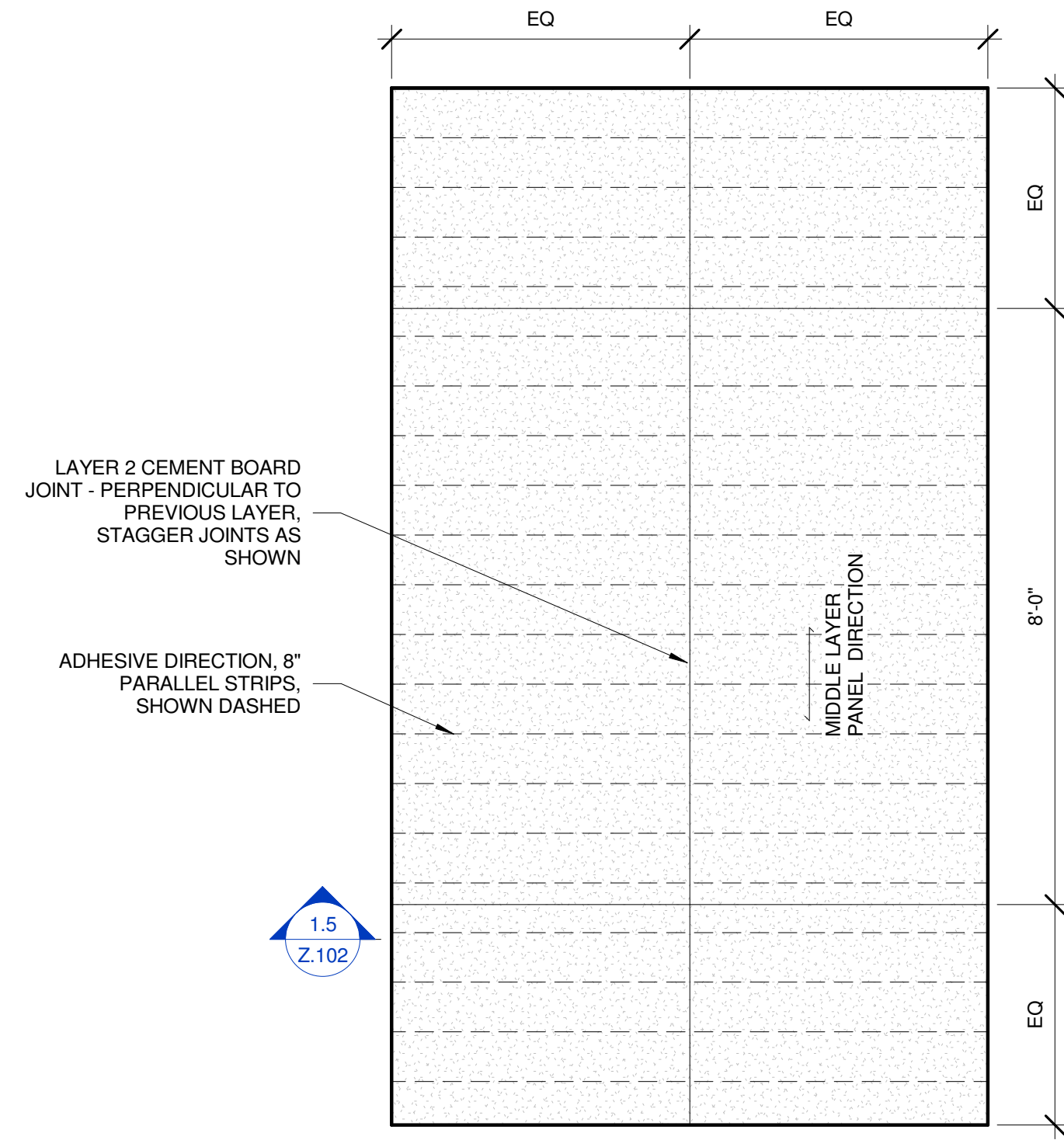


W03 W09 - RAINSCREEN w/o GYP. BD. - PLAN VIEW
3" = 1'-0"

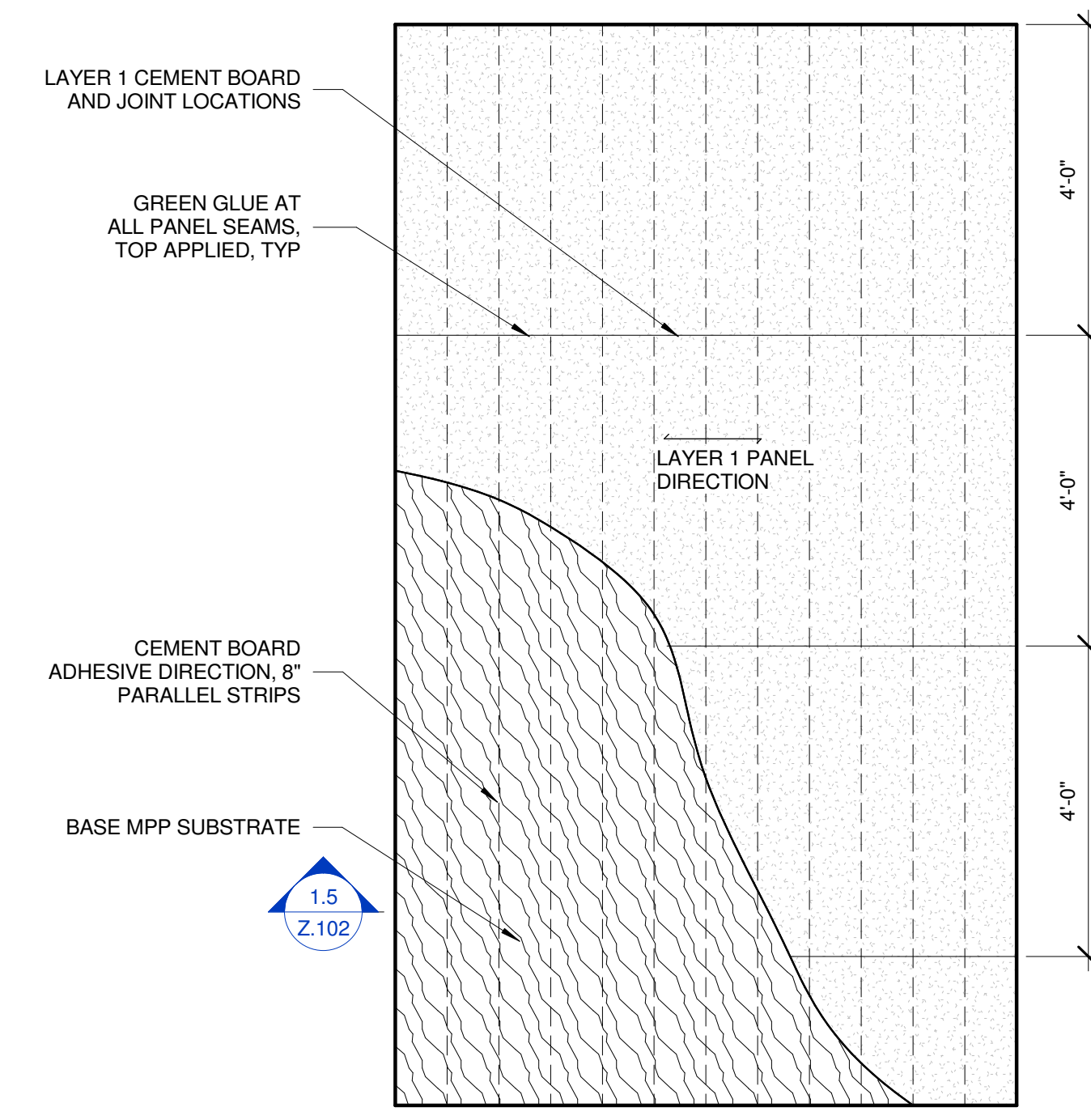
6.6 AS-BUILT CONSTRUCTION DRAWINGS FOR MPP ASSEMBLIES



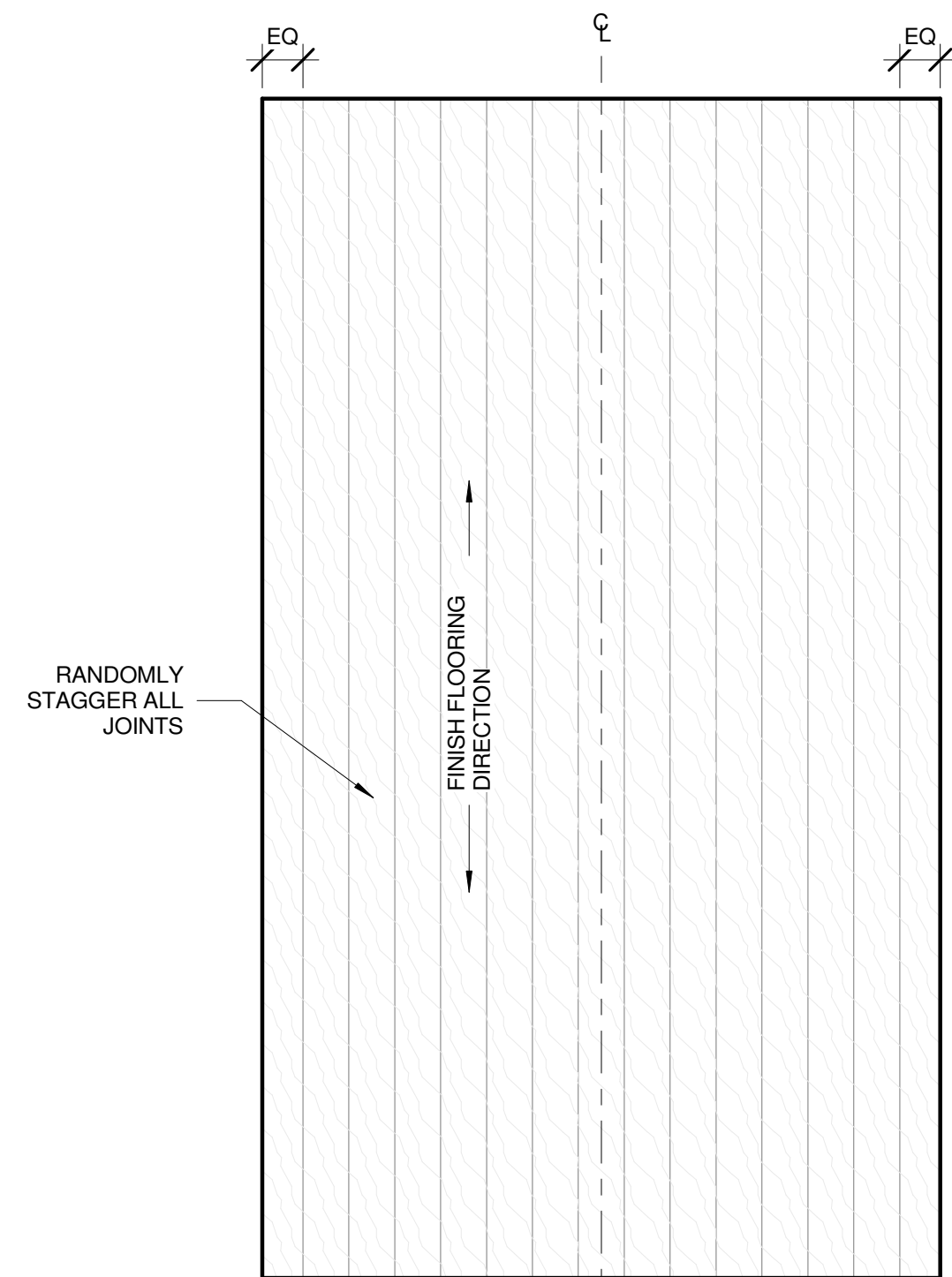
1.13 CEMENT BOARD LAYOUT - LAYER 3
1/2" = 1'-0"



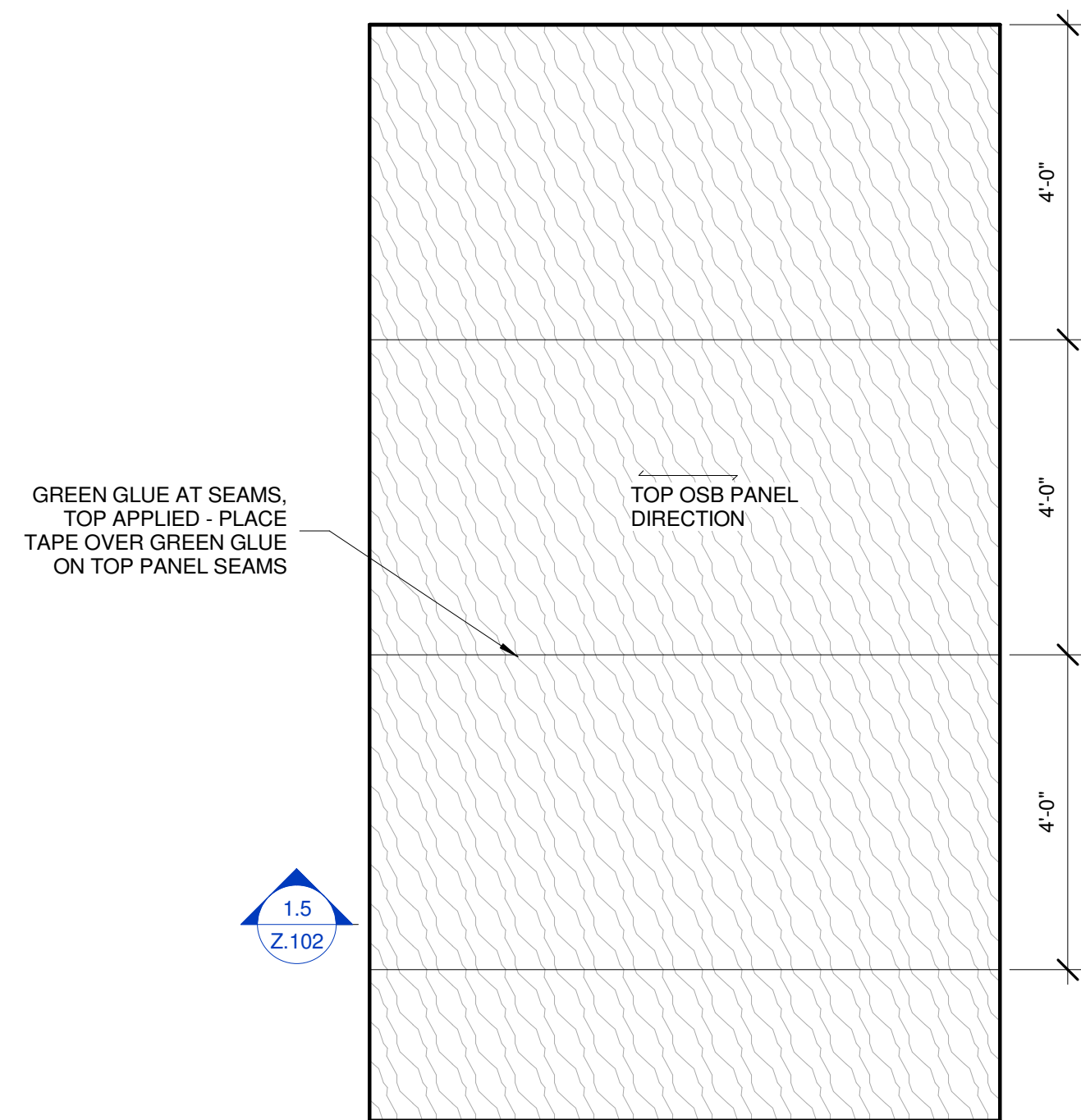
1.12 CEMENT BOARD LAYOUT - LAYER 2
1/2" = 1'-0"



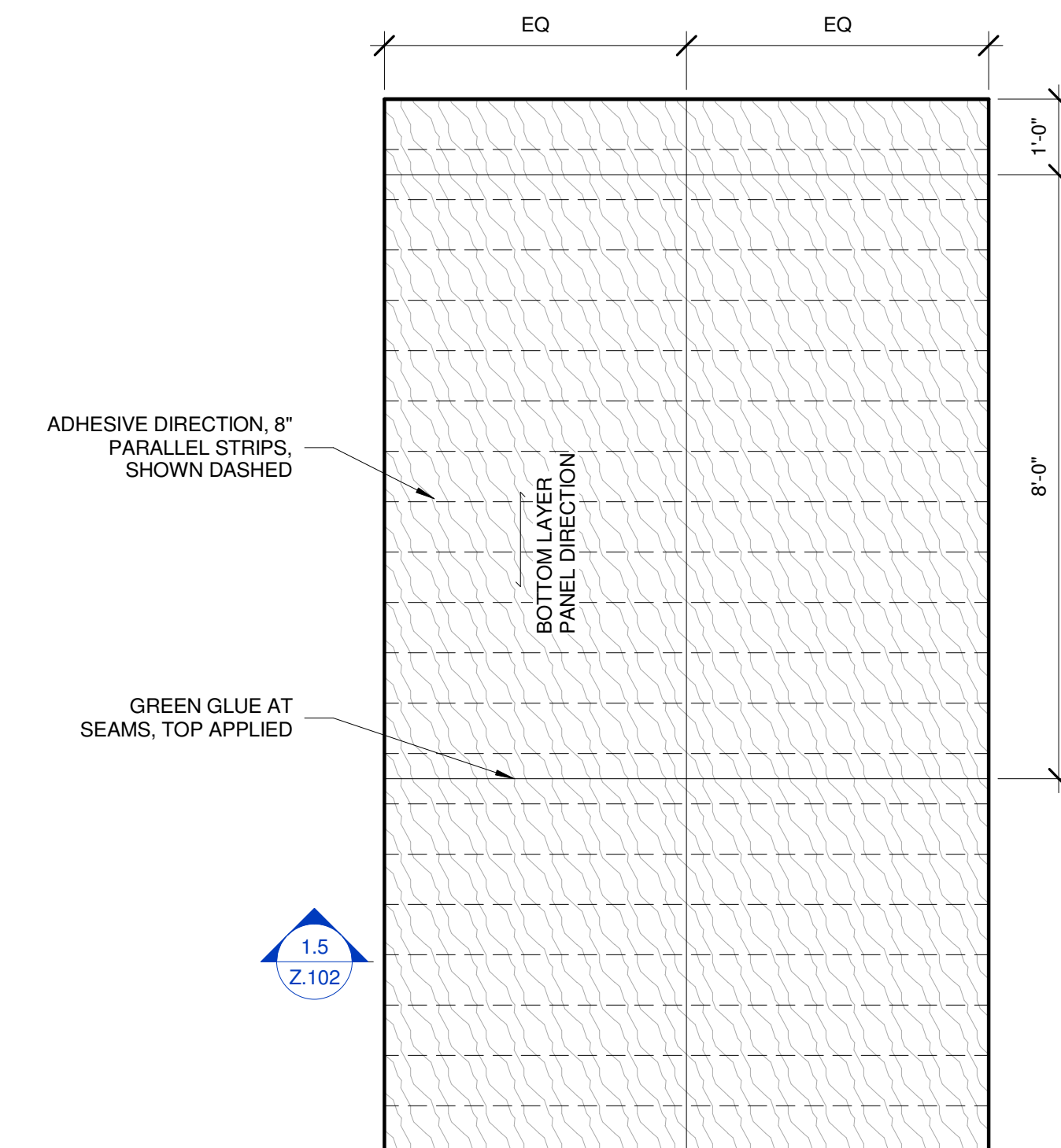
1.11 CEMENT BOARD LAYOUT - LAYER 1
1/2" = 1'-0"



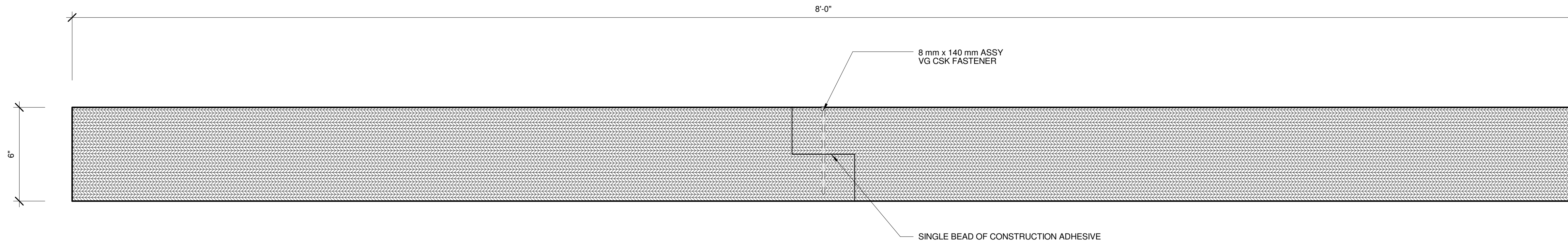
1.2 FLOATING FLOOR LAYOUT PLAN
1/2" = 1'-0"



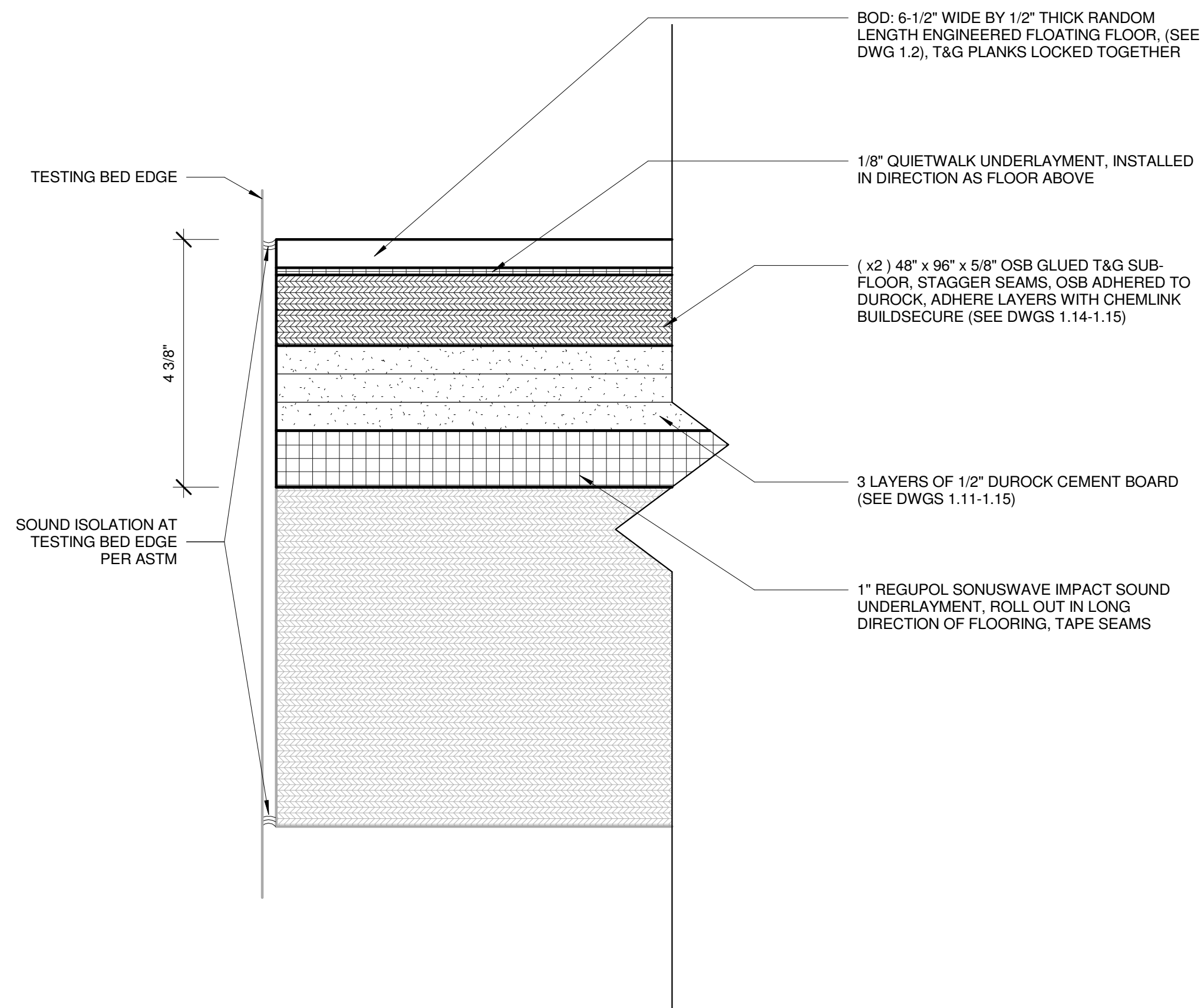
1.15 OSB LAYOUT - LAYER 2
1/2" = 1'-0"



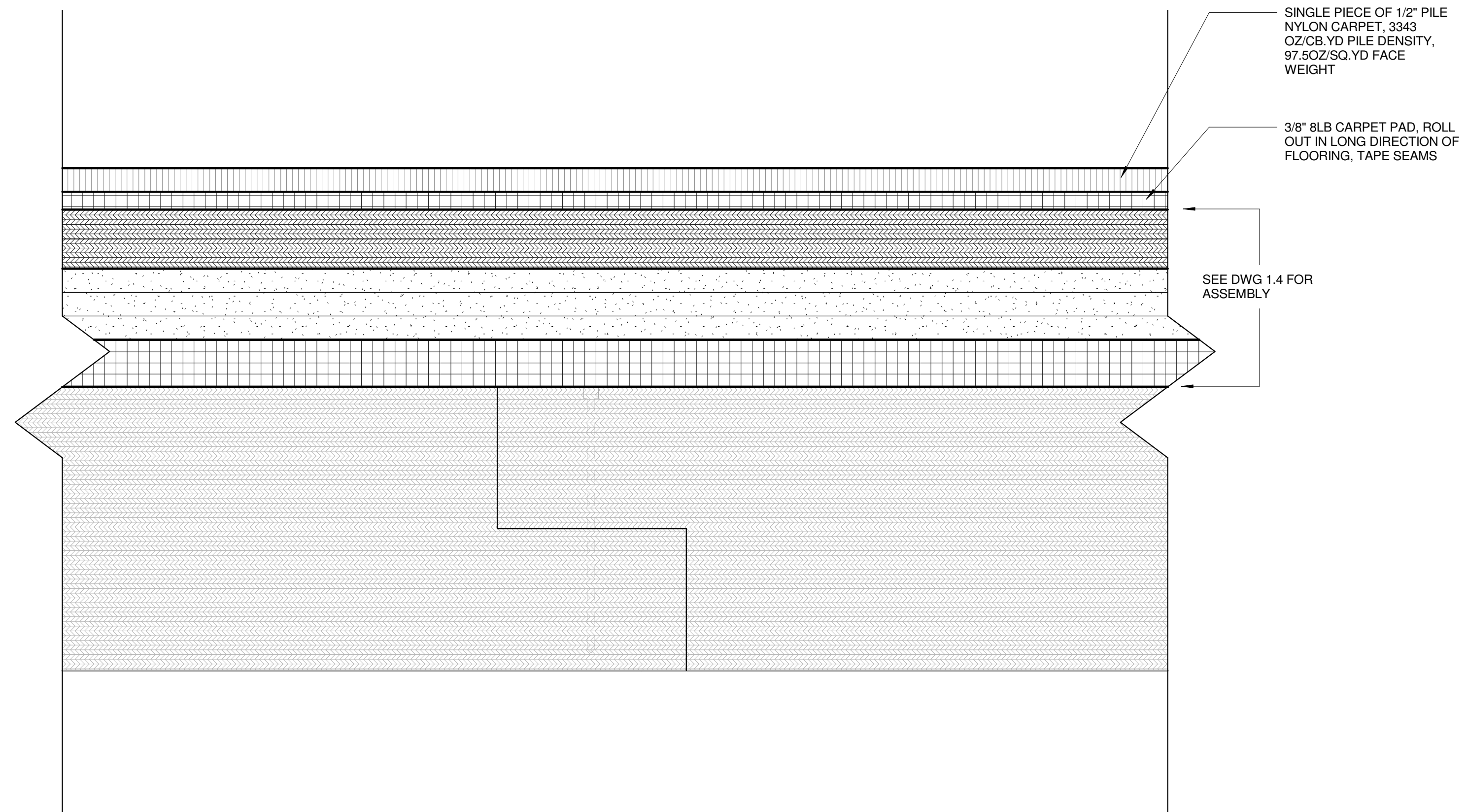
1.14 OSB LAYOUT - LAYER 1
1/2" = 1'-0"



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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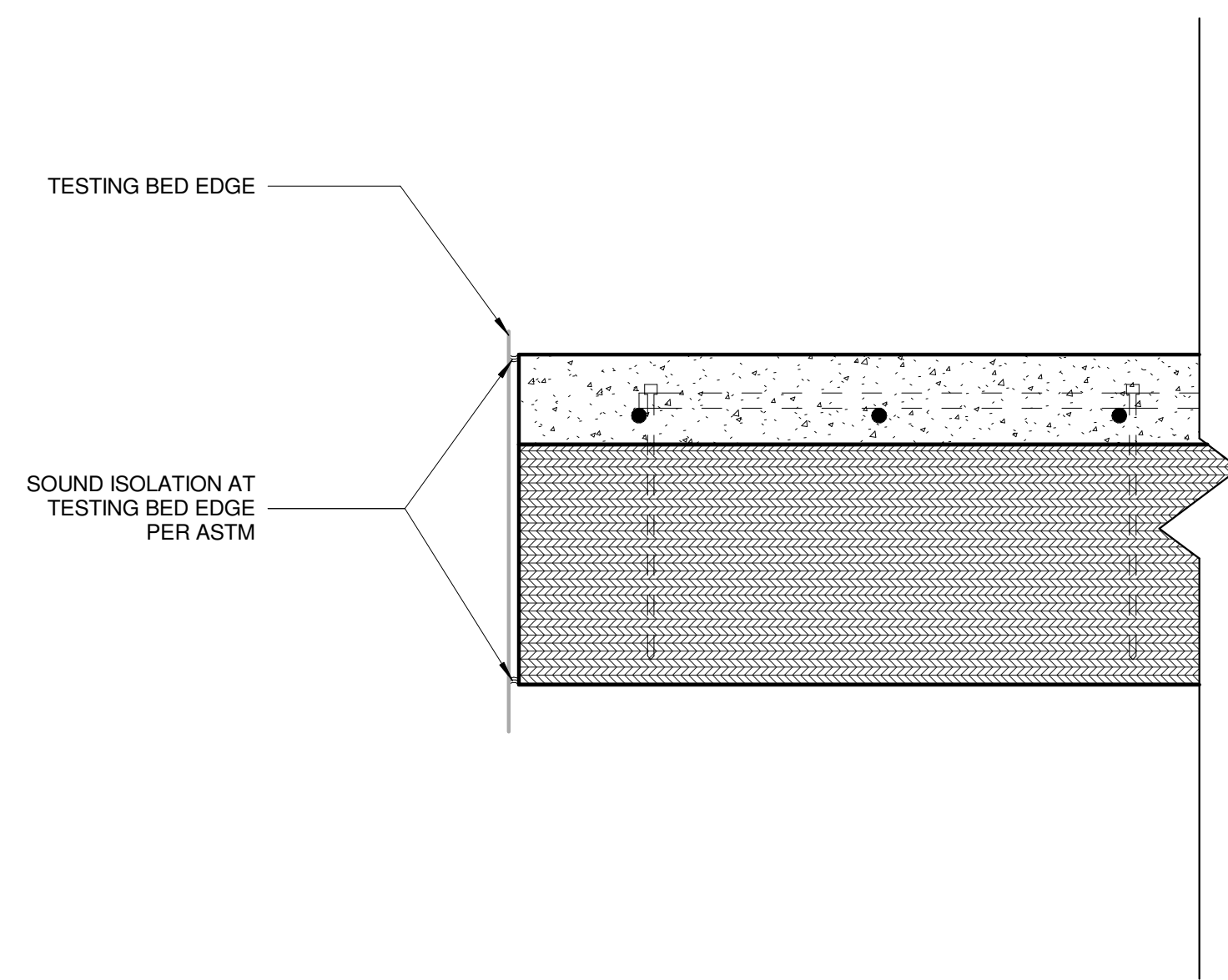
CEMENT
BOARD FLOOR
SECTIONS

Z.102

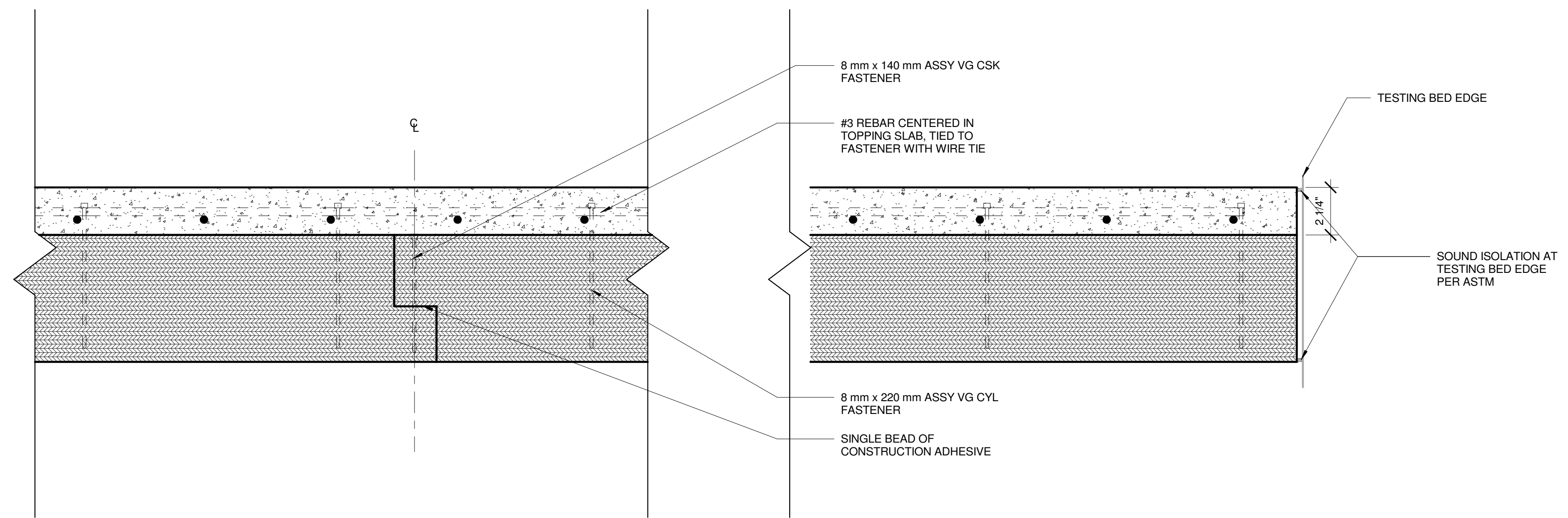
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ISSUE DATE | 03.25.2018

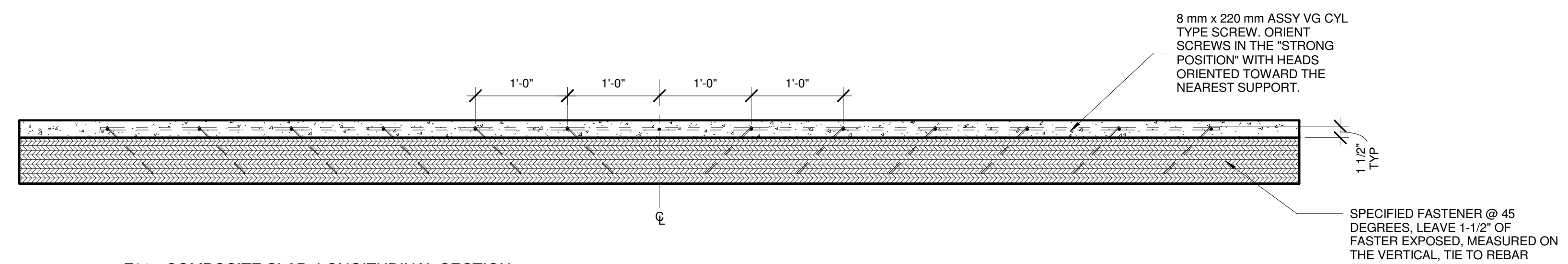
AS-BUILT
DRAWINGS



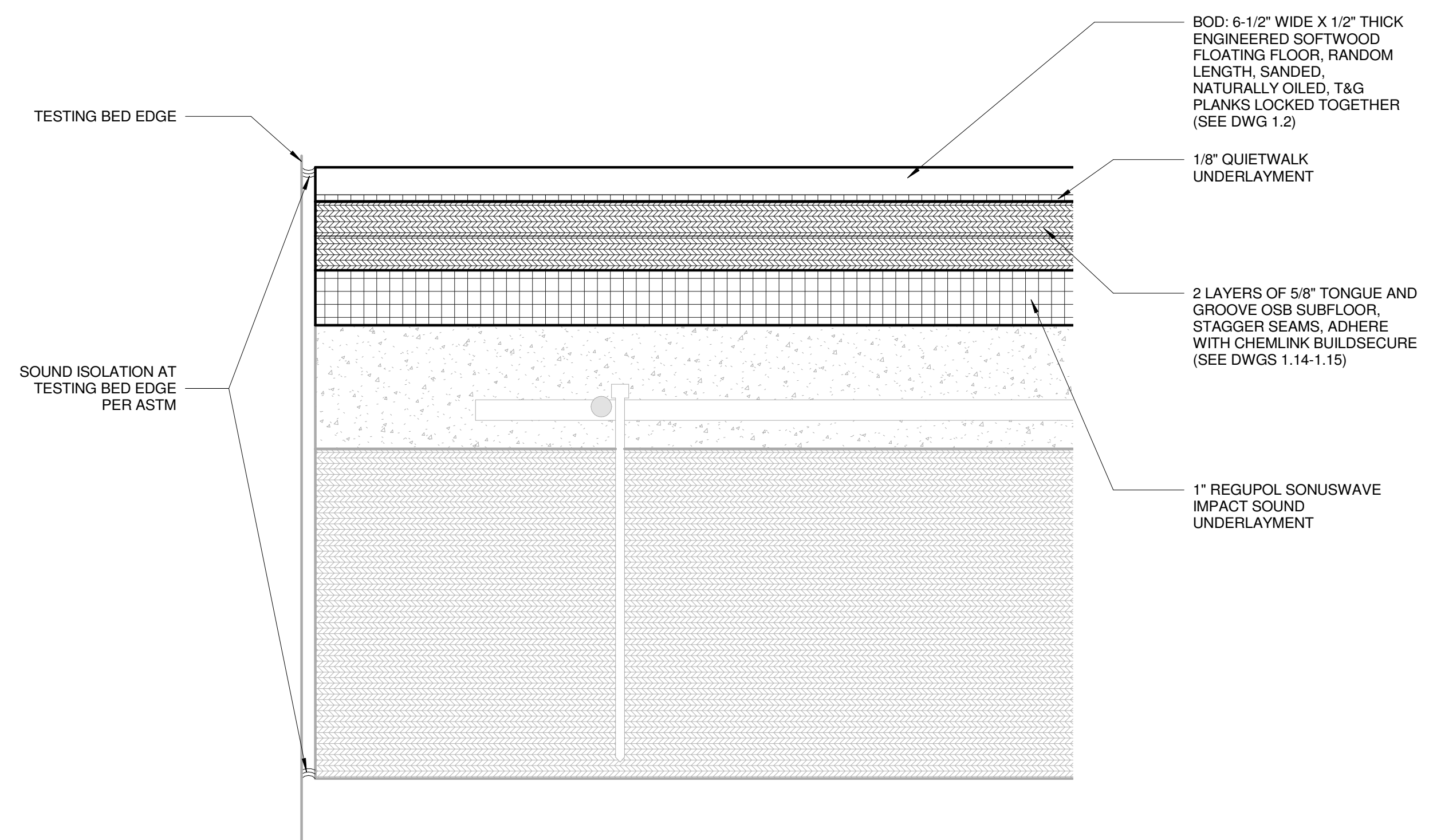
2.3 F01 - COMPOSITE SLAB, LATITUDINAL SECTION
3" = 1'-0"



2.4 F01 - COMPOSITE SLAB, LONGITUDINAL SECTION
1" = 1'-0"



2.5 F03 - ALTERNATE ENGINEERED FLOORING SECTION
6" = 1'-0"





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

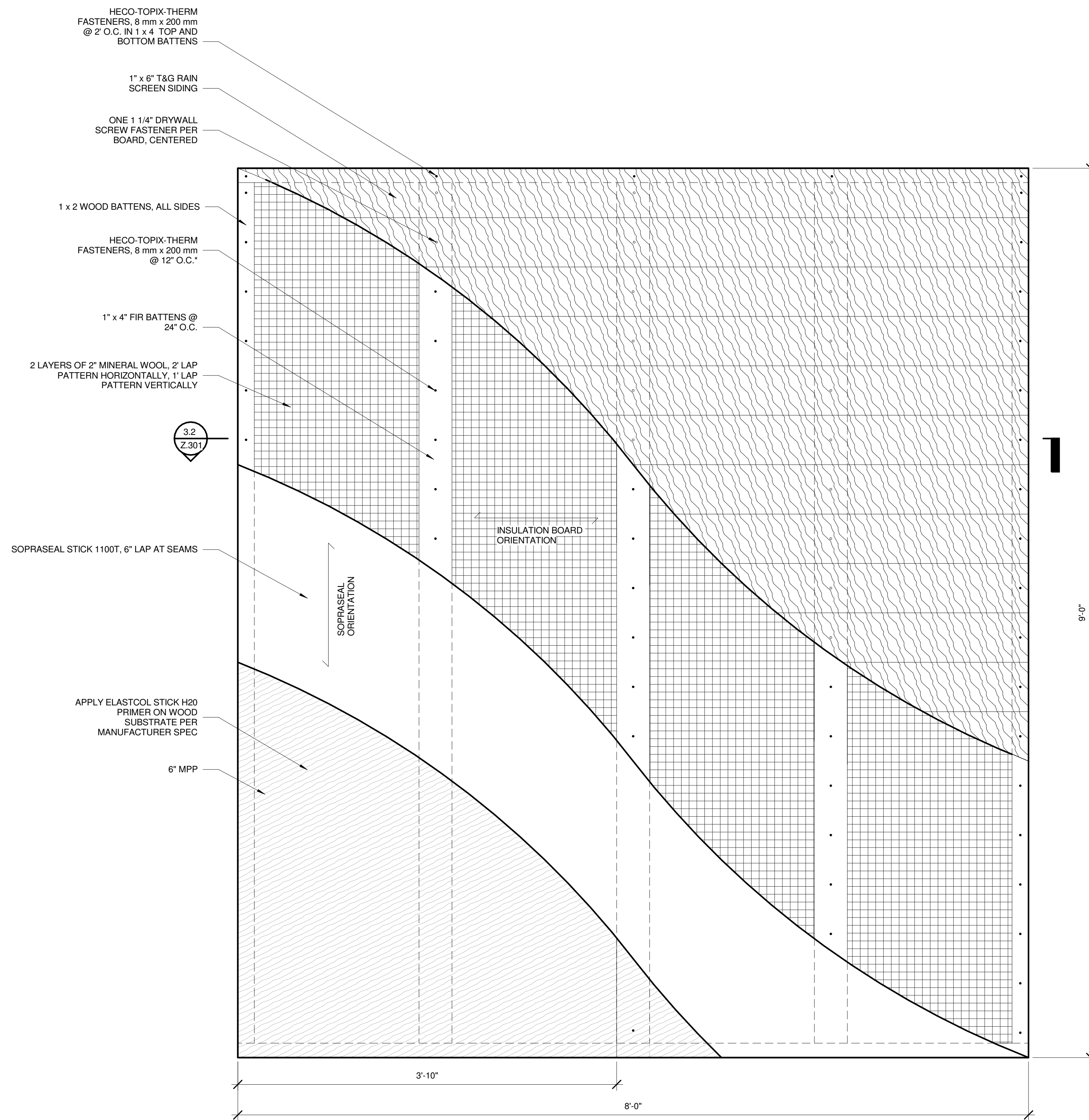
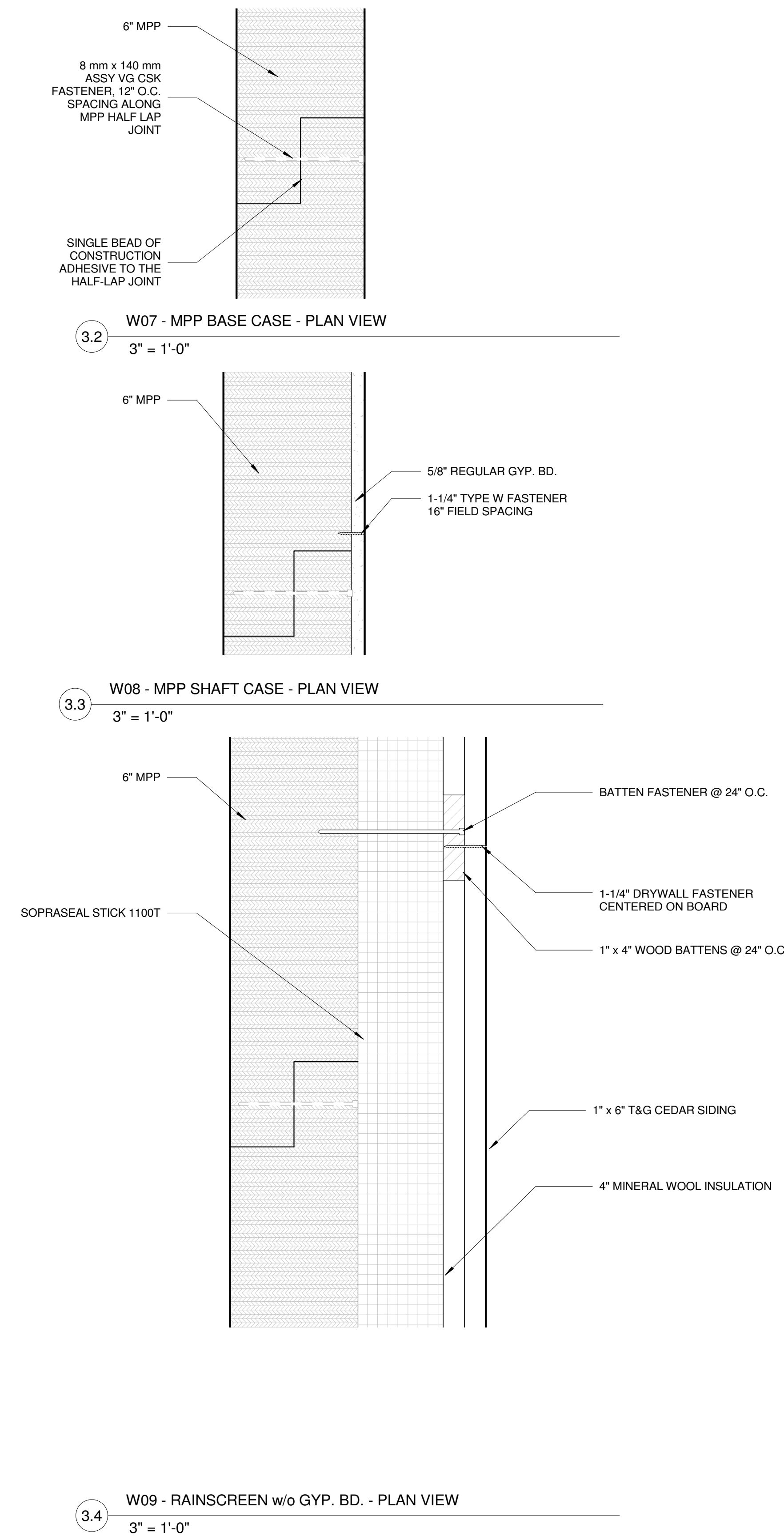
**WALL
ASSEMBLY,
SECTION**

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

Page 1 of 2

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.



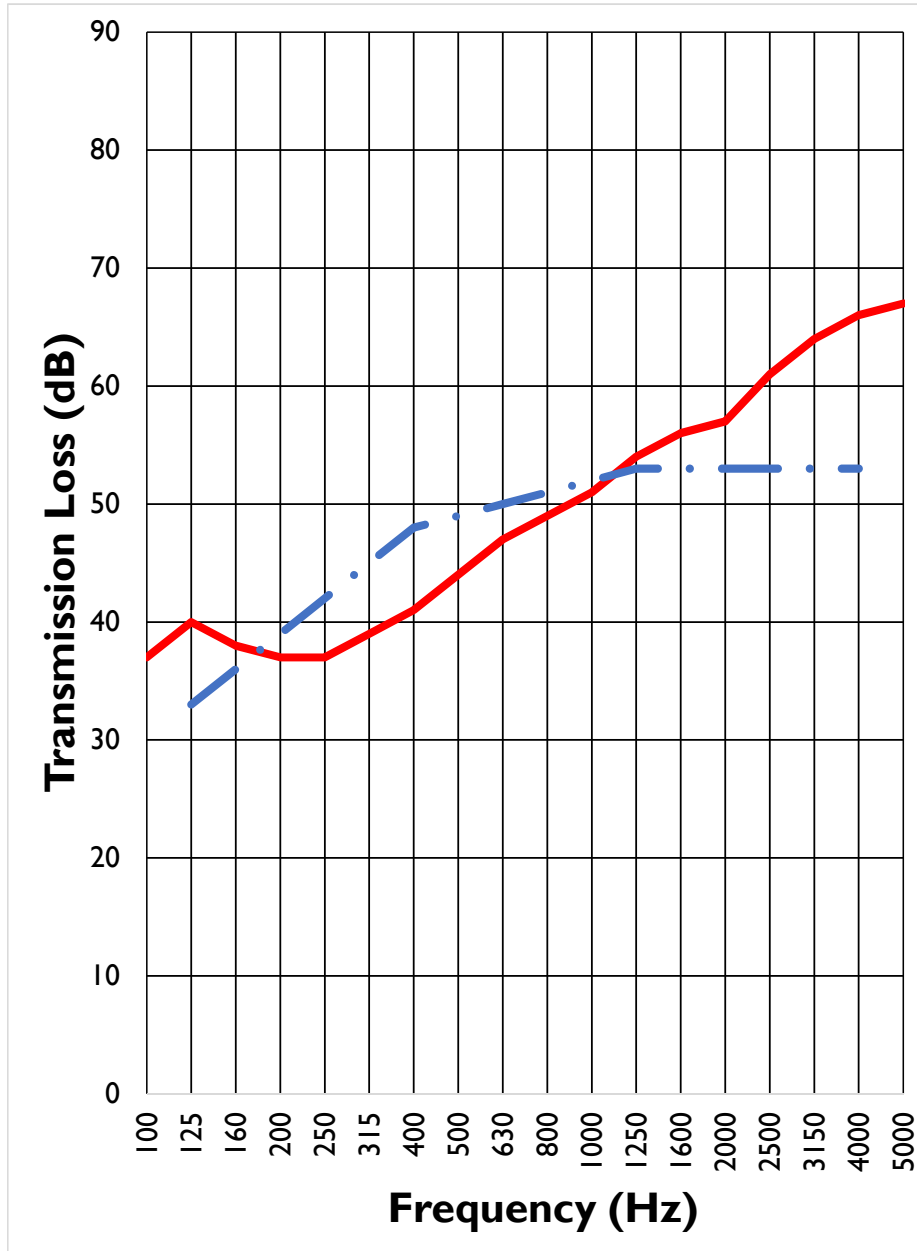
UNIVERSITY OF
OREGON

Energy Studies in
Buildings Laboratory

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

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

TL19-070

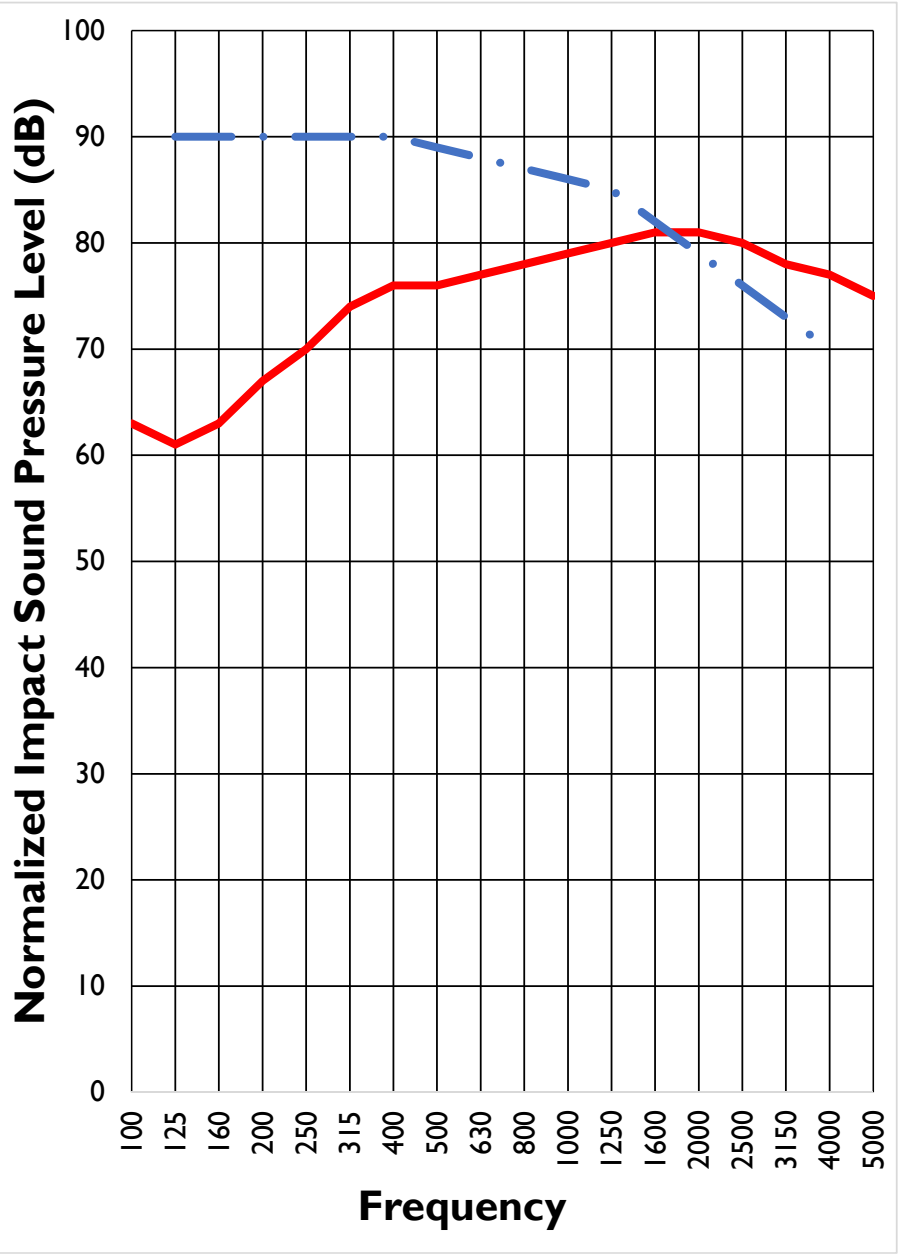


STC = 49
TOTAL DEFICIENCIES = 31

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

SOUND TRANSMISSION RESULTS

INI9-015



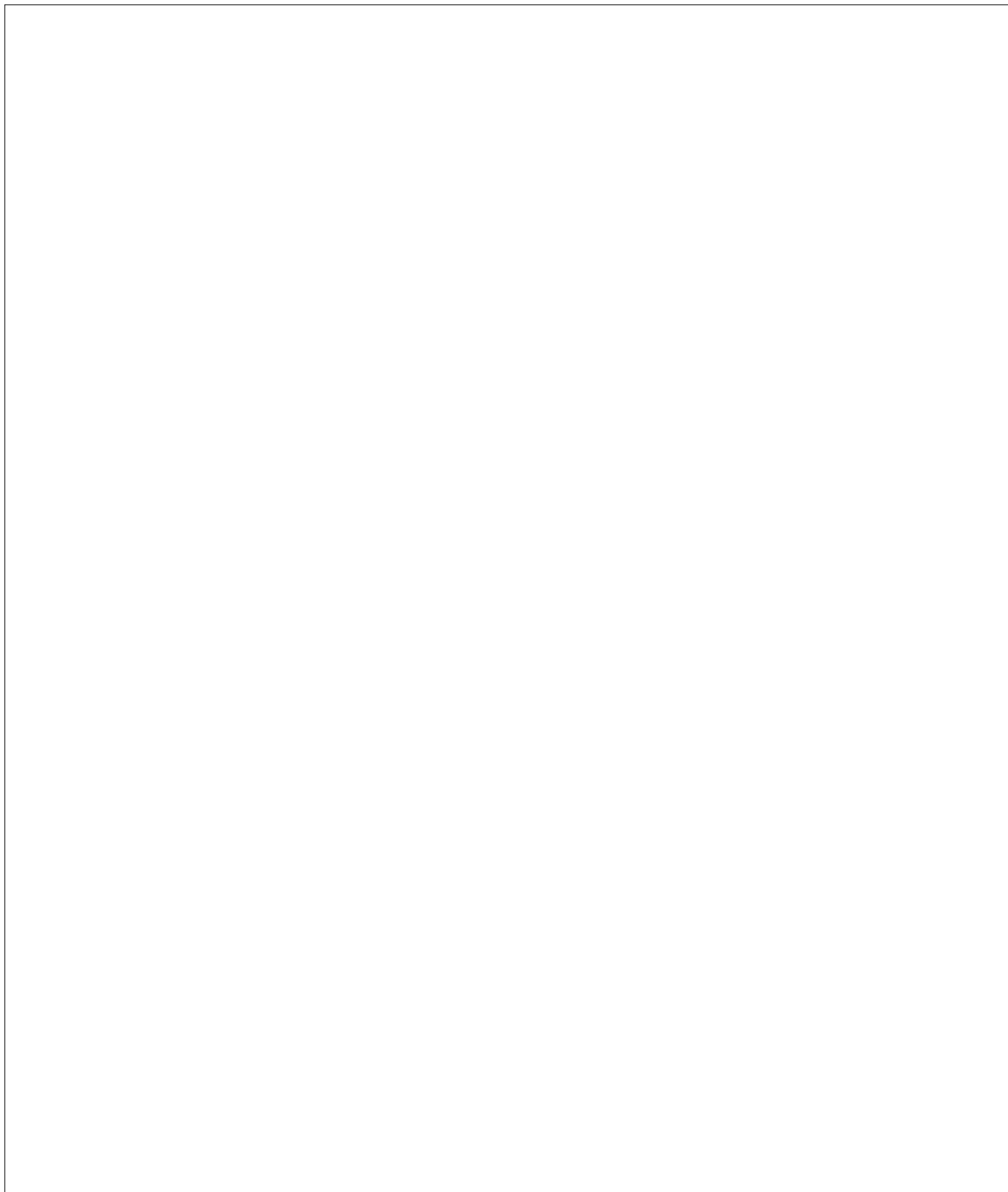
IIC = 22

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

Page 1 of 2

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

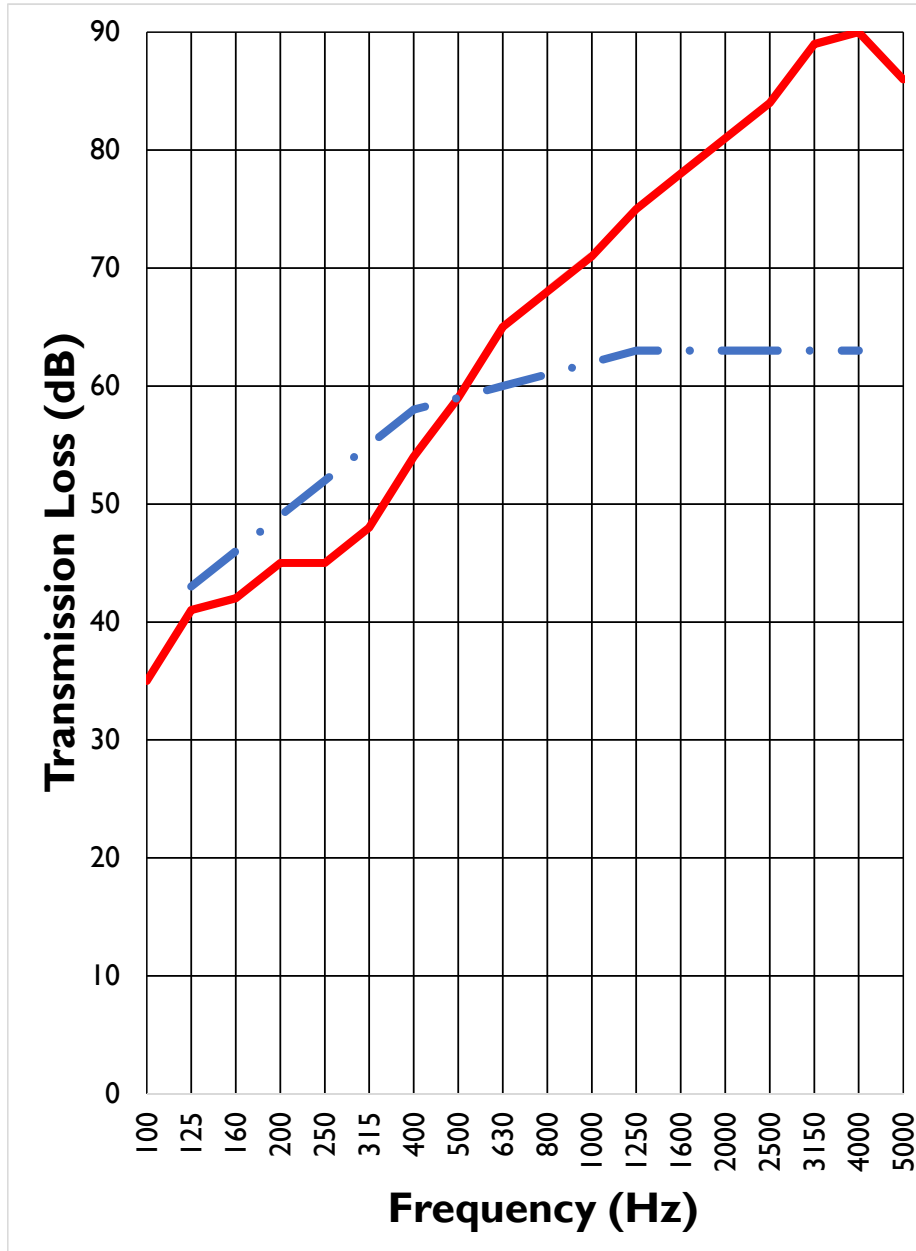
This single report page and accompanying graph contain the instantaneous raw data as provided to the client after testing of the specimen. This data, although accurate, is incomplete without the full specimen description, mounting details and signature pages. The full report referenced by the RAL test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

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

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

Page 1 of 2

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

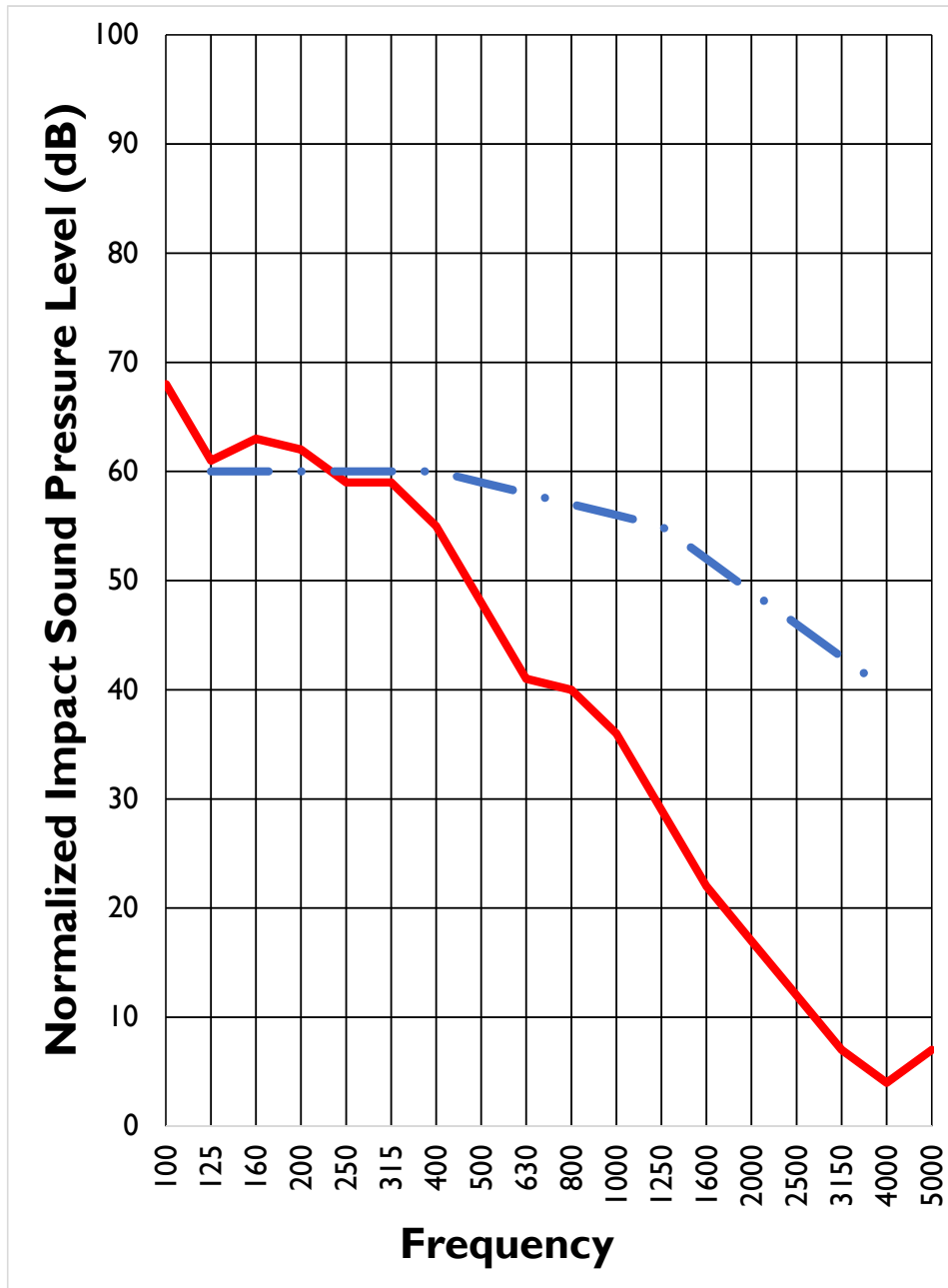
This single report page and accompanying graph contain the instantaneous raw data as provided to the client after testing of the specimen. This data, although accurate, is incomplete without the full specimen description, mounting details and signature pages. The full report referenced by the RAL test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

Page 2 of 2

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

SOUND TRANSMISSION RESULTS

INI9-016



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

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630-232-0104

An ALION Technical Center

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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

Page 1 of 9

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



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Buildings Laboratory

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

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Page 2 of 9

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.



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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



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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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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 |

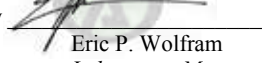
STC=43

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 Sciak
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.co
m, c=US
Date: 2019.03.25 17:07:02 -0500'



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

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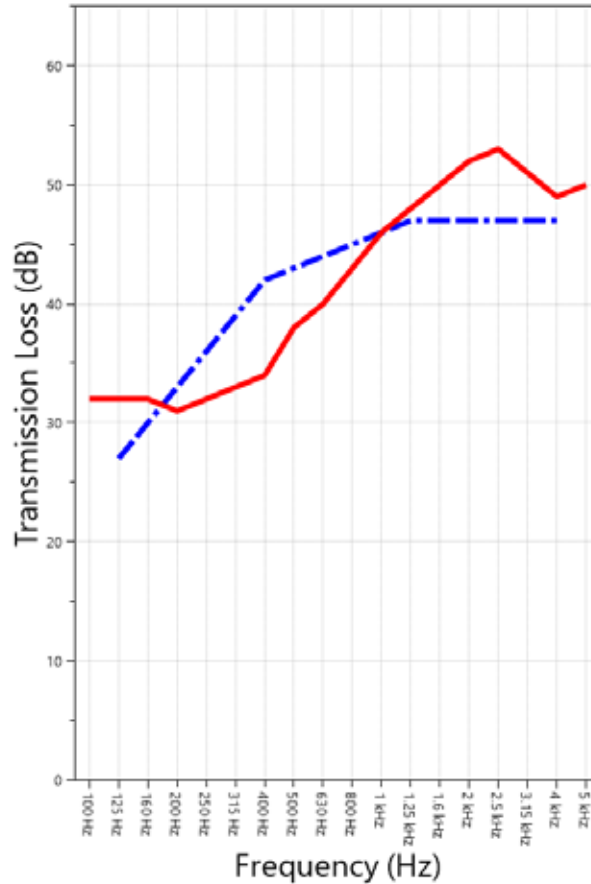
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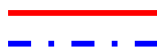
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SOUND TRANSMISSION REPORT
Floor F04 - cross-laminated timber panels



STC=43



TRANSMISSION LOSS
SOUND TRANSMISSION CLASS CONTOUR



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

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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) | Δ TL (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 |



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

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RAL™-TL19-033
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APPENDIX B: Instruments of Traceability

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

| <u>Description</u> | <u>Model</u> | <u>Serial Number</u> | <u>Date of Certification</u> | <u>Calibration Due</u> |
|--------------------------------|-----------------|----------------------|------------------------------|------------------------|
| 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)

| <u>Date</u> | <u>Revision</u> |
|-------------|------------------------|
| 2019-03-13 | Original report issued |

END



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

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Test Report

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

Impact Sound Transmission
RAL™-IN19-012

CONDUCTED: 2019-02-18

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ON: Floor F04 - cross-laminated timber panels

TEST METHODOLOGY

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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



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2019-02-18

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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.



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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



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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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TEST RESULTS

The averaged sound pressure levels, normalized to a receive room reference absorption of 10 m², 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 | 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)

L_n = NORMALIZED SOUND PRESSURE LEVEL, dB

ΔL_n = 95% UNCERTAINTY LIMIT FOR L_n, dB

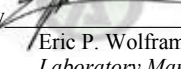
DEV. = DEVIATION FROM SHIFTED IIC CONTOUR, dB (SUM OF DEV = 32)


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
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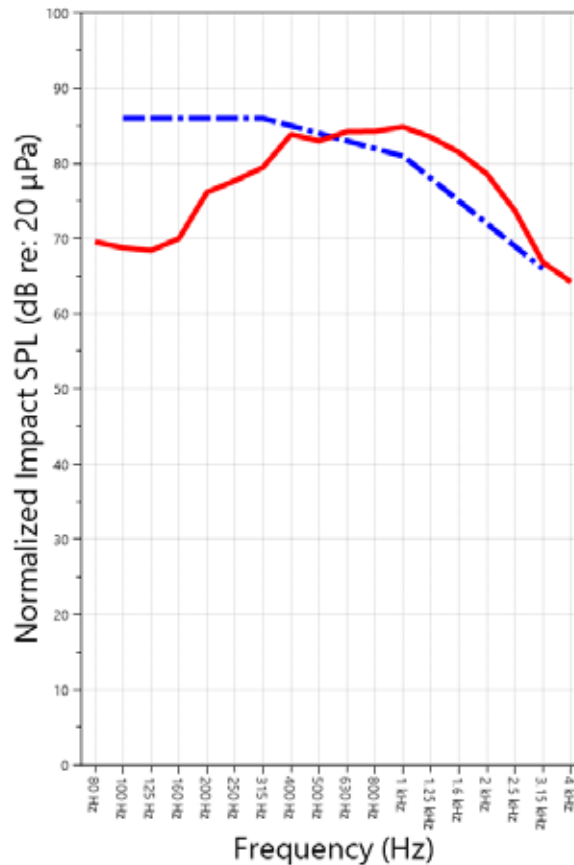
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IMPACT SOUND TRANSMISSION REPORT

Floor F04 - cross-laminated timber panels



IIC=26

— IMPACT SOUND PRESSURE LEVEL
- . - . - IMPACT INSULATION CLASS CONTOUR



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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)

| <u>Description</u> | <u>Model</u> | <u>Serial Number</u> | <u>Date of Certification</u> | <u>Calibration Due</u> |
|--------------------------------|-----------------|----------------------|------------------------------|------------------------|
| 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)

| <u>Date</u> | <u>Revision</u> |
|-------------|------------------------|
| 2019-03-13 | Original report issued |

END



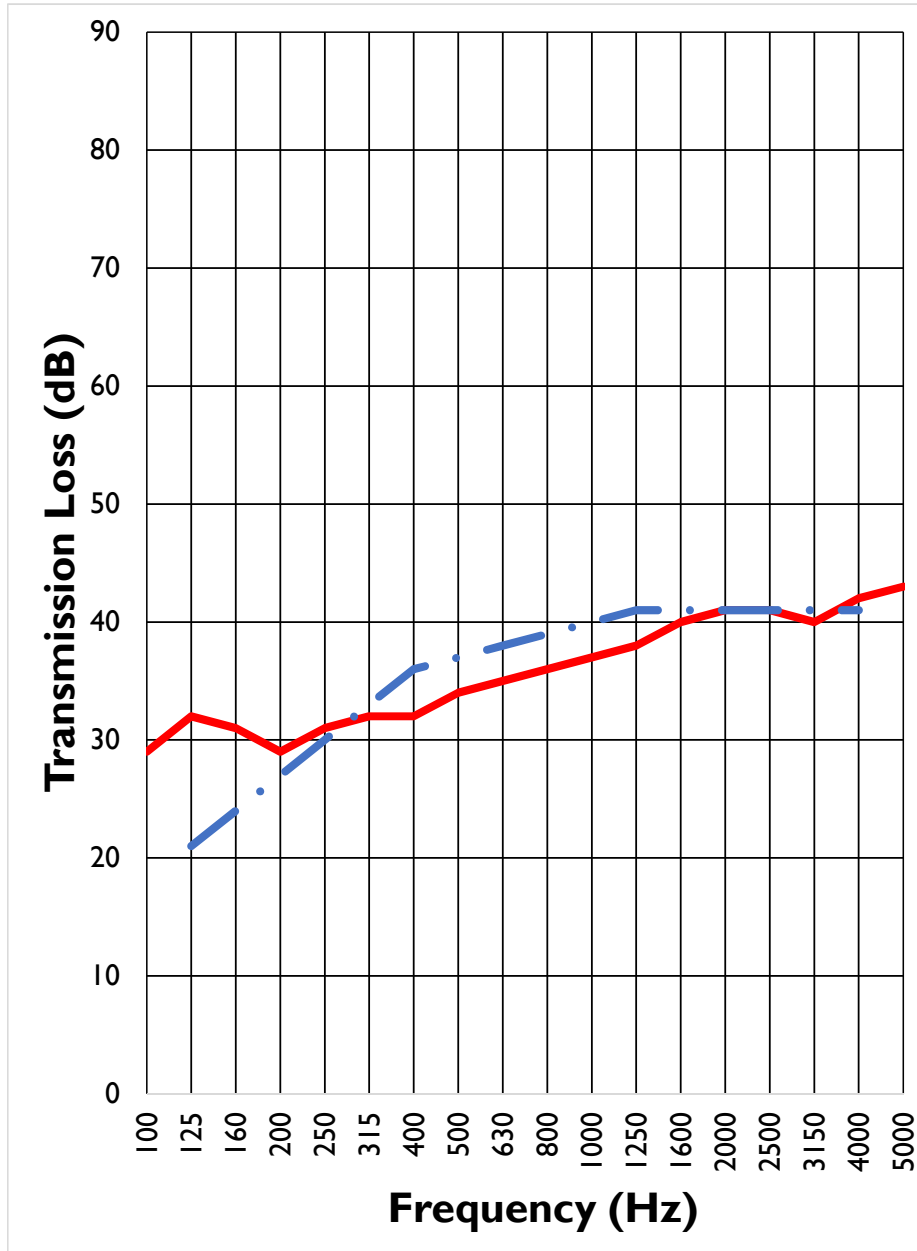
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**F04 - MPP BASE CASE MASS TIMBER PANEL - RIVERBANK LABORATORY
REPORT - STC**

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

Page 1 of 2

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

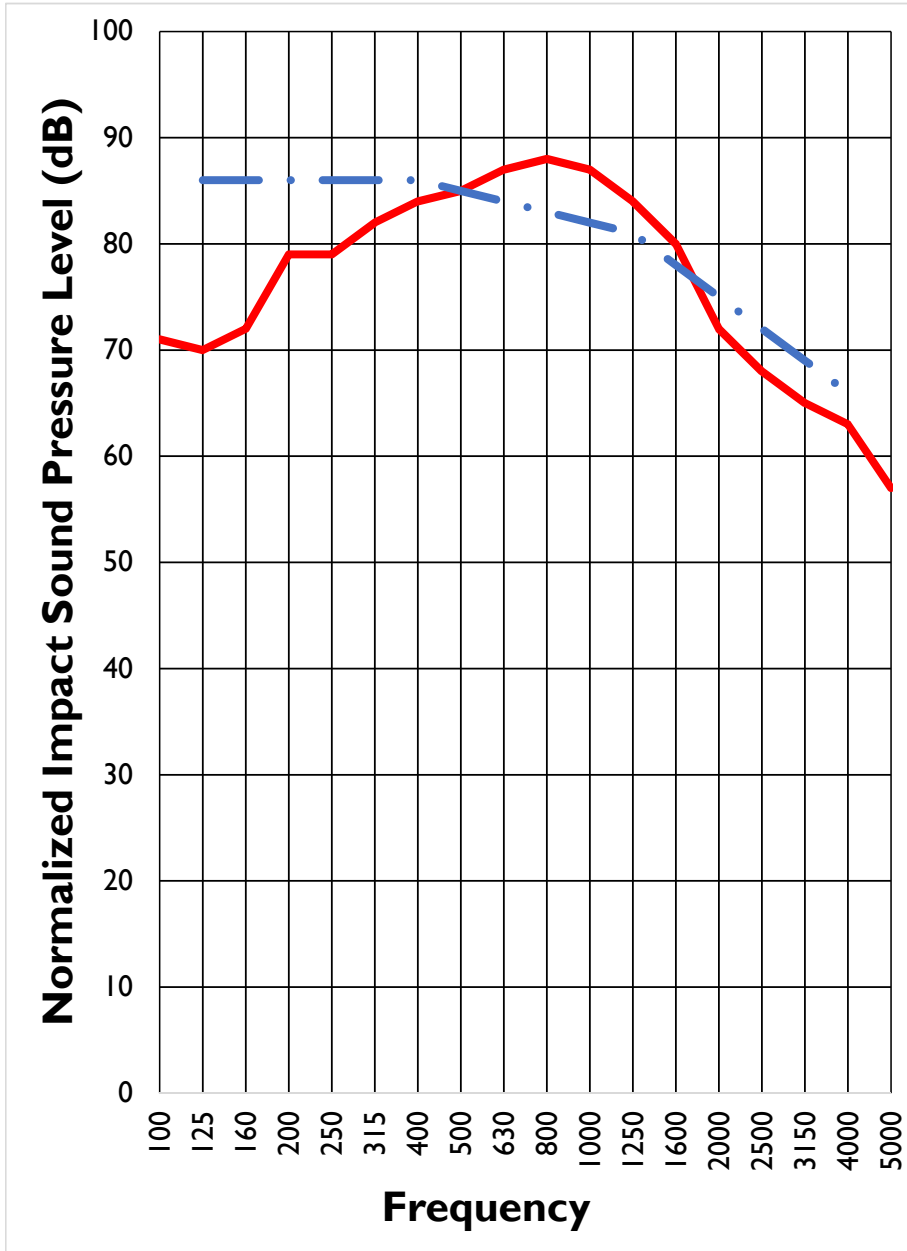
Calculation Date: 2019-03-27
 Calculated By: Marc Sciaky

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
INI19-020



IIC = 26
TOTAL DEFICIENCIES = 28

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

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Eugene, OR

Sound Transmission Loss
RAL™-TL19-034

CONDUCTED: 2019-02-20

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

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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/m² (1.77 lbs/ft²)
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/m² (2.33 lbs/ft²)
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/m² (2.28 lbs/ft²)
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/m² (2.38 lbs/ft²)
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/m² (1.90 lbs/ft²)



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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/m² (1.93 lbs/ft²)
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/m² (0.10 lbs/ft²)
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/m² (2.66 lbs/ft²)
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) 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



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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

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 Sciak
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.co
m, c=US
Date: 2019.03.25 17:07:35 -05'00'



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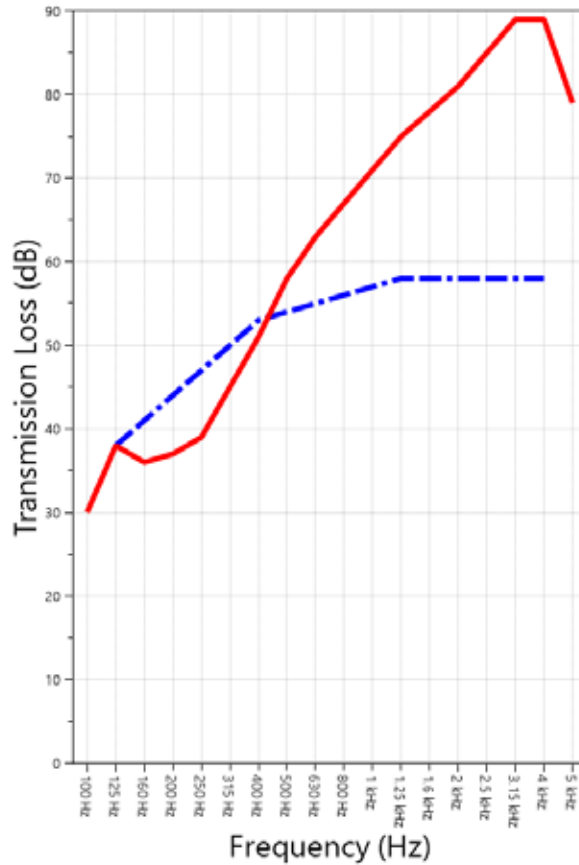
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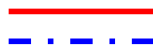
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SOUND TRANSMISSION REPORT

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



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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)

| <u>Description</u> | <u>Model</u> | <u>Serial Number</u> | <u>Date of Certification</u> | <u>Calibration Due</u> |
|--------------------------------|-----------------|----------------------|------------------------------|------------------------|
| 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)

| <u>Date</u> | <u>Revision</u> |
|-------------|------------------------|
| 2019-03-13 | Original report issued |

END



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Impact Sound Transmission
RAL™-IN19-013

CONDUCTED: 2019-02-20

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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/m² (1.77 lbs/ft²)
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/m² (2.33 lbs/ft²)
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/m² (2.28 lbs/ft²)
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/m² (2.38 lbs/ft²)
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/m² (1.90 lbs/ft²)



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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/m² (1.93 lbs/ft²)
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/m² (0.10 lbs/ft²)
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/m² (2.66 lbs/ft²)
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



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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



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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 m², 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 | 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)
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 = 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
DN: cn=Eric P Wolfram, o=Alion
Science & Technology, ou=Riverbank
Acoustical Laboratories,
email=ewolfram@alionscience.com,
c=US
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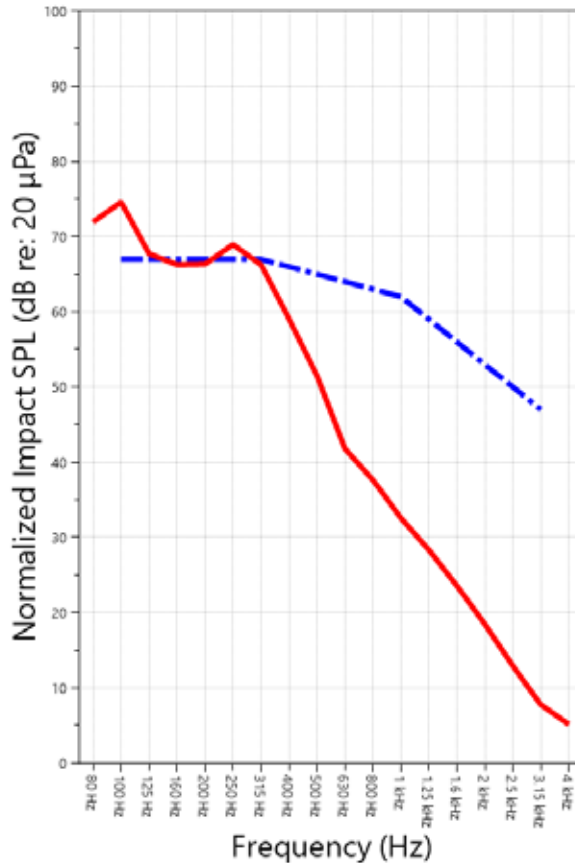
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IMPACT SOUND TRANSMISSION REPORT

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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APPENDIX B: Glossary for Variability Metrics

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

AL_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)

| <u>Description</u> | <u>Model</u> | <u>Serial Number</u> | <u>Date of Certification</u> | <u>Calibration Due</u> |
|--------------------------------|-----------------|----------------------|------------------------------|------------------------|
| 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)

| <u>Date</u> | <u>Revision</u> |
|-------------|------------------------|
| 2019-03-14 | Original report issued |

END



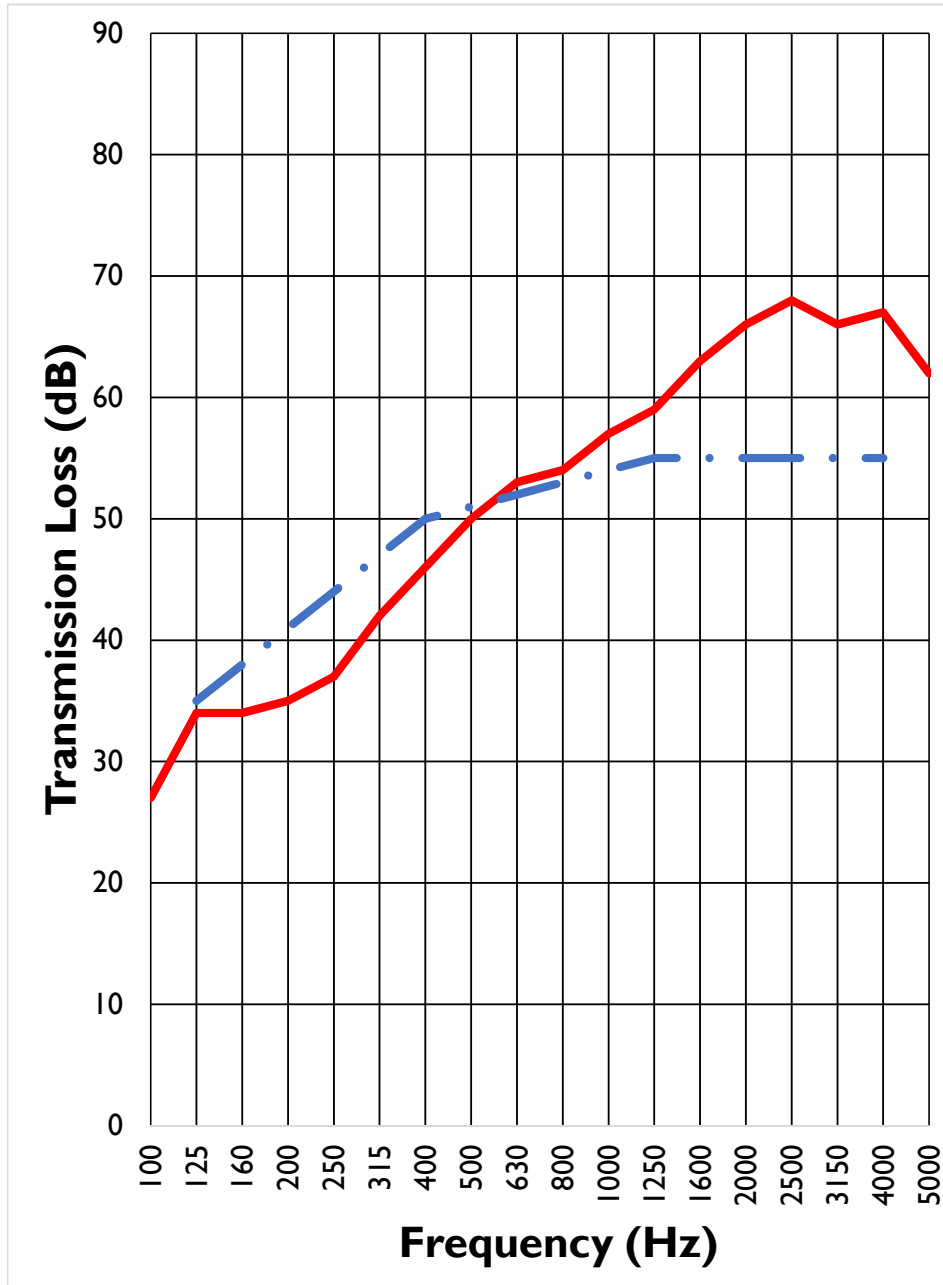
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**F05 - MPP DRY COMPOSITE FLOOR ASSEMBLY - RIVERBANK LABORATORY
REPORT - STC**

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



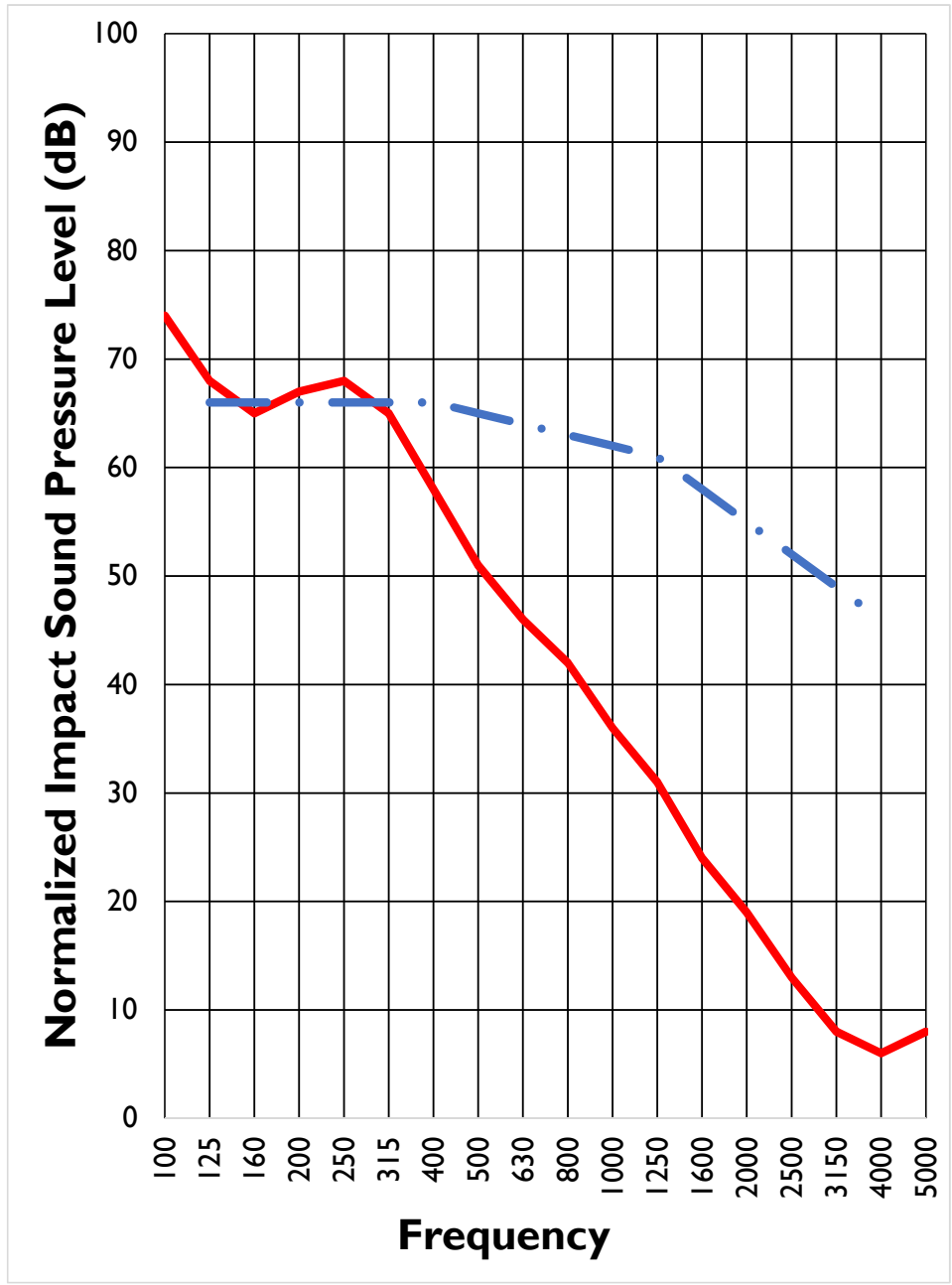
STC = 51

TOTAL DEFICIENCIES = 28

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

SOUND TRANSMISSION RESULTS

INI19-018



IIC = 46

TOTAL DEFICIENCIES = 13



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

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Eugene, OR

Sound Transmission Loss
RAL™-TL19-035

CONDUCTED: 2019-02-20

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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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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/m² (1.77 lbs/ft²)
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/m² (2.33 lbs/ft²)
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/m² (2.28 lbs/ft²)
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/m² (2.38 lbs/ft²)
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/m² (1.90 lbs/ft²)



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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/m² (1.93 lbs/ft²)
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/m² (0.24 lbs/ft²)
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/m² (0.62 lbs/ft²)
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



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Figure 3 – Installation of cross-laminated timber base slab



Figure 4 – Detail of bonded crumb rubber underlayment



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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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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 MEASUREMENTS, dB
DEF. = DEFICIENCIES, dB BELOW STC CONTOUR (SUM OF DEF = 30)
STC = SOUND TRANSMISSION CLASS


Tested by


Marc Sciaiky
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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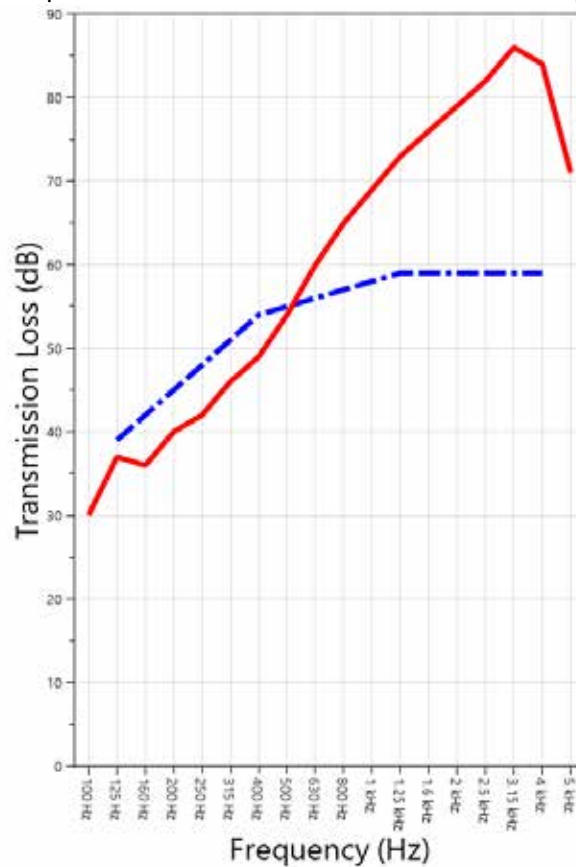
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SOUND TRANSMISSION REPORT

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



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— 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) | Δ TL (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)

| <u>Description</u> | <u>Model</u> | <u>Serial Number</u> | <u>Date of Certification</u> | <u>Calibration Due</u> |
|--------------------------------|-----------------|----------------------|------------------------------|------------------------|
| 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)

| <u>Date</u> | <u>Revision</u> |
|-------------|------------------------|
| 2019-03-13 | Original report issued |

END



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Impact Sound Transmission
RAL™-IN19-014

CONDUCTED: 2019-02-20

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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/m² (1.77 lbs/ft²)
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/m² (2.33 lbs/ft²)
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/m² (2.28 lbs/ft²)
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/m² (2.38 lbs/ft²)
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/m² (1.90 lbs/ft²)



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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/m² (1.93 lbs/ft²)
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/m² (0.24 lbs/ft²)
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/m² (0.62 lbs/ft²)
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.) 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: 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, as viewed from receive room



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Figure 3 – Installation of cross-laminated timber base slab



Figure 4 – Detail of bonded crumb rubber underlayment



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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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TEST RESULTS

The averaged sound pressure levels, normalized to a receive room reference absorption of 10 m², 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,
c=email=ewolfram@alionscience.com,
c=US
Date: 2019.03.25 17:06:40 -0500



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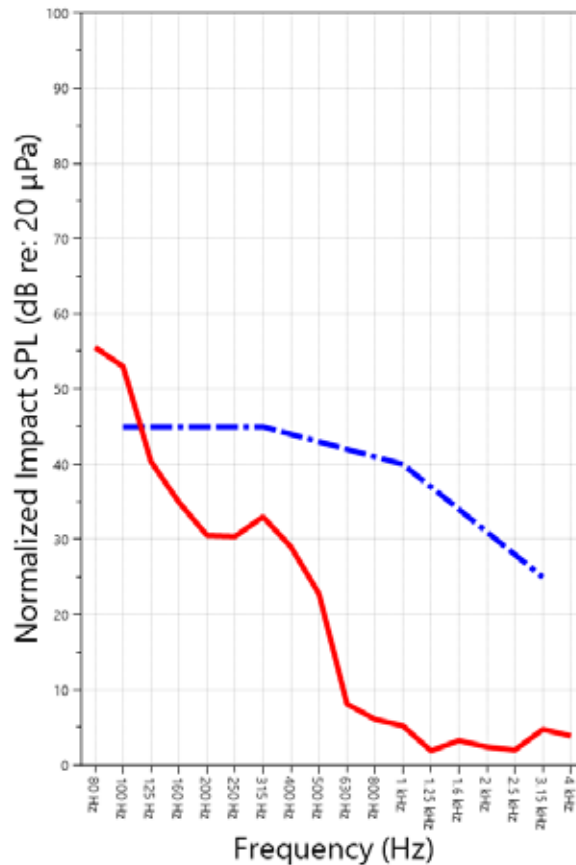
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IMPACT SOUND TRANSMISSION REPORT

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



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— IMPACT SOUND PRESSURE LEVEL
- - - IMPACT INSULATION 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 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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F06 - CLT DRY COMPOSITE FLOOR ASSEMBLY - RIVERBANK LABORATORY REPORT - IIC

RIVERBANK ACOUSTICAL LABORATORIES

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

An ALION Technical Center

RIVERBANK.ALIONSCIENCE.COM

FOUNDED 1918 BY
WALLACE CLEMENT SABINE

Test Report

University of Oregon

2019-02-20

RAL™-IN19-014

Page 13 of 13

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)

| <u>Description</u> | <u>Model</u> | <u>Serial Number</u> | <u>Date of Certification</u> | <u>Calibration Due</u> |
|--------------------------------|-----------------|----------------------|------------------------------|------------------------|
| 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)

| <u>Date</u> | <u>Revision</u> |
|-------------|------------------------|
| 2019-03-14 | Original report issued |

END



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

Unofficial Test Results & Preliminary Data Sheet

Page 1 of 2

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: 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) | 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

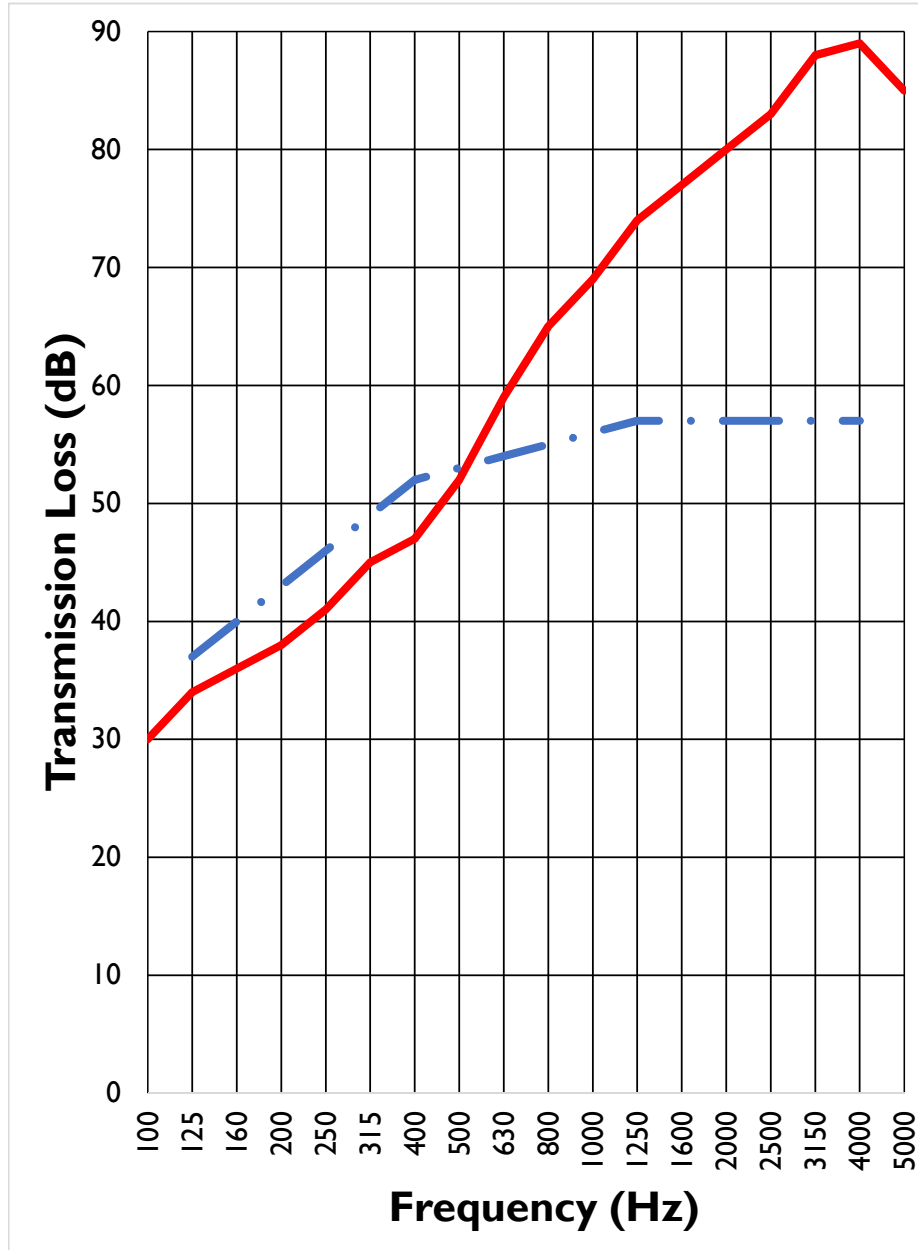
This single report page and accompanying graph contain the instantaneous raw data as provided to the client after testing of the specimen. This data, although accurate, is incomplete without the full specimen description, mounting details and signature pages. The full report referenced by the RAL test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

**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

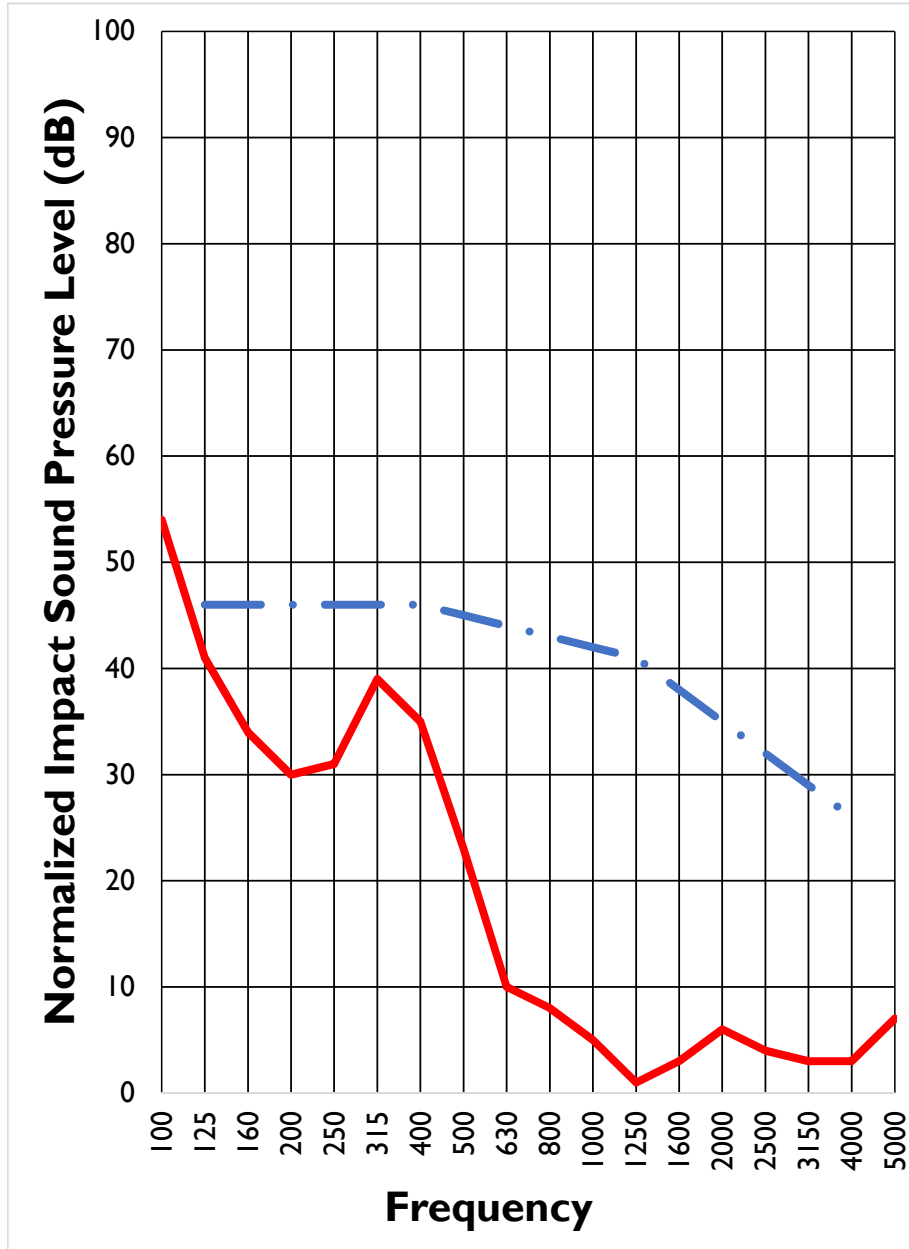


STC = 53

TOTAL DEFICIENCIES = 27

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

SOUND TRANSMISSION RESULTS
INI9-019



IIC = 66

TOTAL DEFICIENCIES = 8

6.8 USG LABORATORY WALL REPORTS

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



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 |

This report contains eight (8) pages, including the cover sheet. Any additions to, alterations of, or unauthorized use of excerpts from this report are expressly forbidden.

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Page 1 of 8

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

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

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Page 2 of 8



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Energy Studies in
Buildings Laboratory

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

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/ft². The transmission area used in the calculations was 72.0 ft².

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 ft³ and the receive room volume was 7236 ft³.

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Page 3 of 8

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

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.

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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

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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 Results

| | FREQ (Hz) | Abs (m ²) | SOR (dB) | -REC (dB) | Tl _c (dB) | FILLER ADJ | Tl _s (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 performance 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-190245 (Sample A Bare CLT Panels (Joint Untreated).xls)

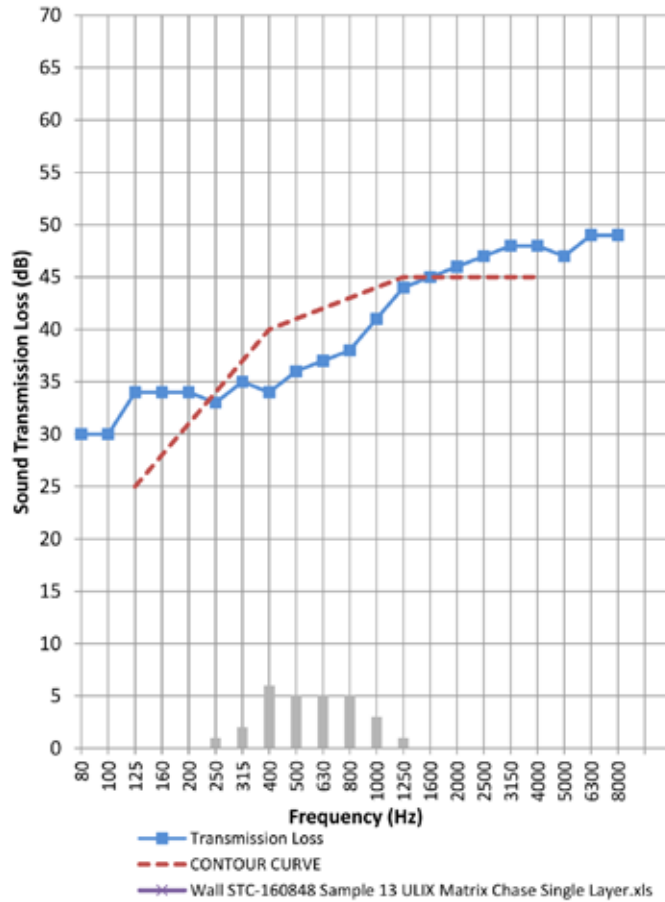
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W07 - CLT WALL BASE CASE MASS TIMBER PANEL - USG LABORATORY REPORT

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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

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



Figure 1: Specimen prior to test

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Page 8 of 8

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



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 document contains ASTM E90-09 test results of MPP panels.

Prepared By:

Handwritten signature of David Moyer.

David Moyer
Senior Researcher

Authorized By:

Handwritten signature of Joe Chambers.

Joe Chambers
Director, Innovation Services Lab

Summary of Results

| Test Number | Specimen | STC |
|------------------|------------|-----|
| Wall STC -190247 | MPP panels | 36 |

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Page 1 of 8



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Energy Studies in
Buildings Laboratory

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

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.

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

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Page 2 of 8

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

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/ft². The transmission area used in the calculations was 72.0 ft².

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 ft³ and the receive room volume was 7236 ft³.

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Buildings Laboratory

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

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.

This report contains eight (8) pages, including the cover sheet. Any additions to, alterations of, or unauthorized use of excerpts from this report are expressly forbidden.

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Page 4 of 8

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

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

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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 Results

| | FREQ (Hz) | Abs (m ²) | SOR (dB) | -REC (db) | T _{Lc} (dB) | FILLER ADJ | T _{Ls} (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 performance is limited by filler.
 Shaded lines indicate frequencies not governed by this test method.



NVLAP LAB CODE 200132-0 Filename: Wall STC-190247 (Sample D Bare MPP Panels (Joint Untreated)).xls

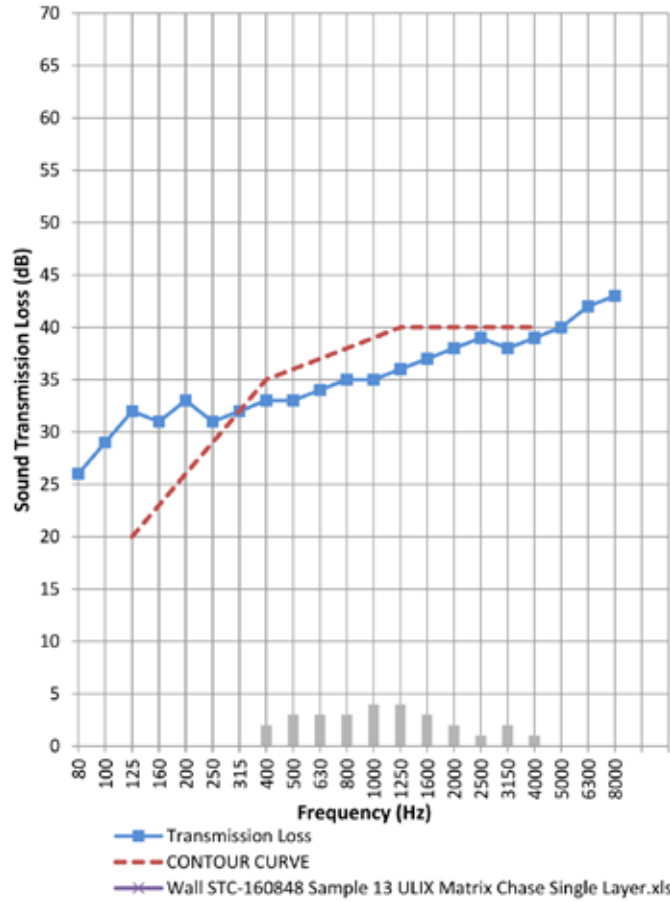
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W07 - MPP WALL BASE CASE MASS TIMBER PANEL - USG LABORATORY REPORT

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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

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



Figure 1: Specimen prior to test

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W08 - CLT WALL ASSEMBLY - USG LABORATORY REPORT



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 |

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UNIVERSITY OF
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Energy Studies in
Buildings Laboratory

W08 - CLT WALL ASSEMBLY - USG LABORATORY REPORT

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 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

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Page 2 of 8

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/ft². The transmission area used in the calculations was 72.0 ft².

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 ft³ and the receive room volume was 7236 ft³.

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W08 - CLT WALL ASSEMBLY - USG LABORATORY REPORT

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.

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W08 - CLT WALL ASSEMBLY - 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 - 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)

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W08 - CLT WALL ASSEMBLY - USG LABORATORY REPORT

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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 performance is limited by filler.
 Shaded lines indicate frequencies not governed by this test method.



ACCREDITED BY THE U.S. DEPARTMENT OF COMMERCE, NATIONAL INSTITUTE OF STANDARDS & TECHNOLOGY – NATIONAL VOLUNTARY LABORATORY ACCREDITATION PROGRAM FOR SELECTED TEST METHODS IN ACOUSTICS. THIS REPORT SHALL NOT BE USED TO CLAIM PRODUCT ENDORSEMENT BY NVLAP OR ANY AGENCY OF THE U.S. GOVERNMENT.

NVLAP LAB CODE 200132-0
 Data Page 2 of 3

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

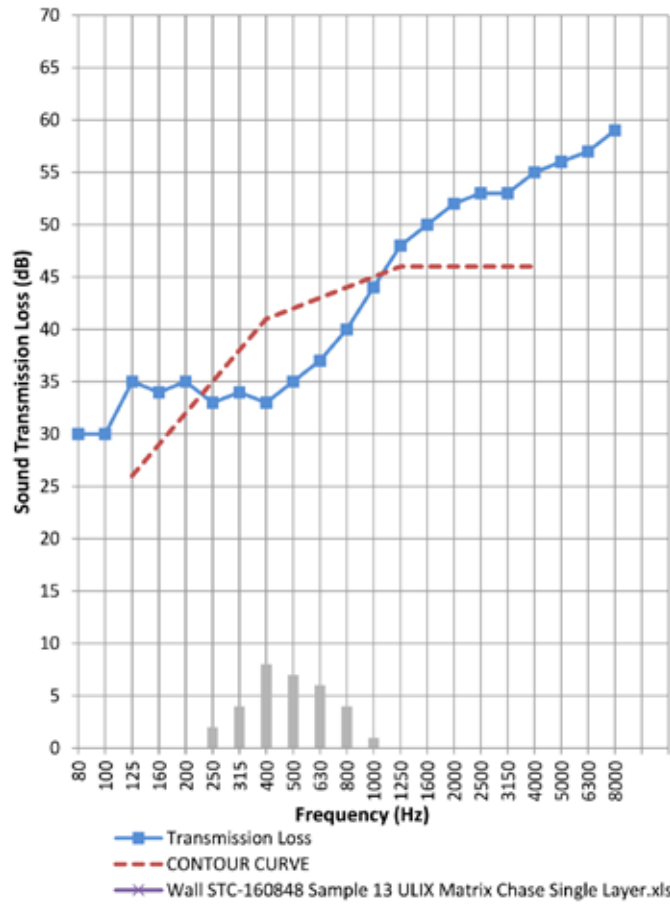
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W08 - CLT WALL ASSEMBLY - USG LABORATORY REPORT

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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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W08 - CLT WALL ASSEMBLY - USG LABORATORY REPORT



Figure 1: Specimen prior to addition of gypsum wall board

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W08 - MPP WALL ASSEMBLY - USG LABORATORY REPORT



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 |

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UNIVERSITY OF
OREGON

Energy Studies in
Buildings Laboratory

W08 - MPP WALL ASSEMBLY - USG LABORATORY REPORT

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

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W08 - MPP WALL ASSEMBLY - USG LABORATORY REPORT

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/ft². The transmission area used in the calculations was 72.0 ft².

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 ft³ and the receive room volume was 7236 ft³.

This report contains eight (8) pages, including the cover sheet. Any additions to, alterations of, or unauthorized use of excerpts from this report are expressly forbidden.

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Page 3 of 8

W08 - MPP WALL ASSEMBLY - USG LABORATORY REPORT

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.

This report contains eight (8) pages, including the cover sheet. Any additions to, alterations of, or unauthorized use of excerpts from this report are expressly forbidden.

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W08 - MPP WALL ASSEMBLY - 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 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 performance 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-190248 (Sample E MPP Panels with Type ULIX Source Side.xls)

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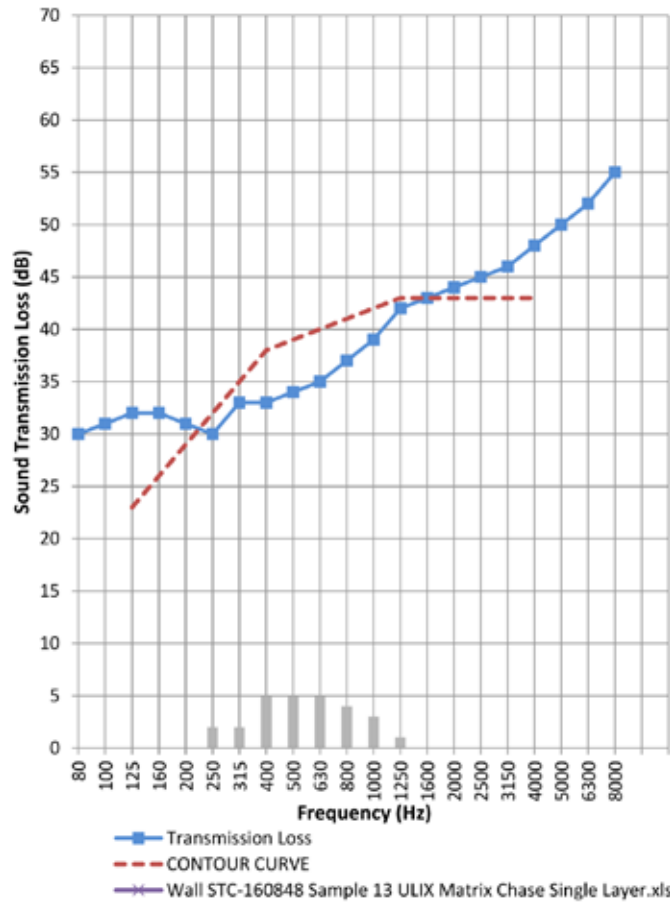
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W08 - MPP WALL ASSEMBLY - USG LABORATORY REPORT

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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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W08 - MPP WALL ASSEMBLY - USG LABORATORY REPORT



Figure 1: Specimen prior to addition of gypsum wall board

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W09 - CLT WALL ASSEMBLY - USG LABORATORY REPORT



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 |

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Page 1 of 12



UNIVERSITY OF
OREGON

Energy Studies in
Buildings Laboratory

W09 - CLT WALL ASSEMBLY - USG LABORATORY REPORT

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

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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 mm (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/ft². The transmission area used in the calculations was 72.0 ft².

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.

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Page 3 of 12



W09 - CLT WALL ASSEMBLY - USG LABORATORY REPORT

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 ft³ and the receive room volume was 7236 ft³.

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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W09 - CLT WALL ASSEMBLY - USG LABORATORY REPORT

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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 mm (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)

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W09 - CLT WALL ASSEMBLY - USG LABORATORY REPORT

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Corporate Innovation Center
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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 performance 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-190246 (Sample C CLT Panels wMembrane, Insulation, Siding.xls)

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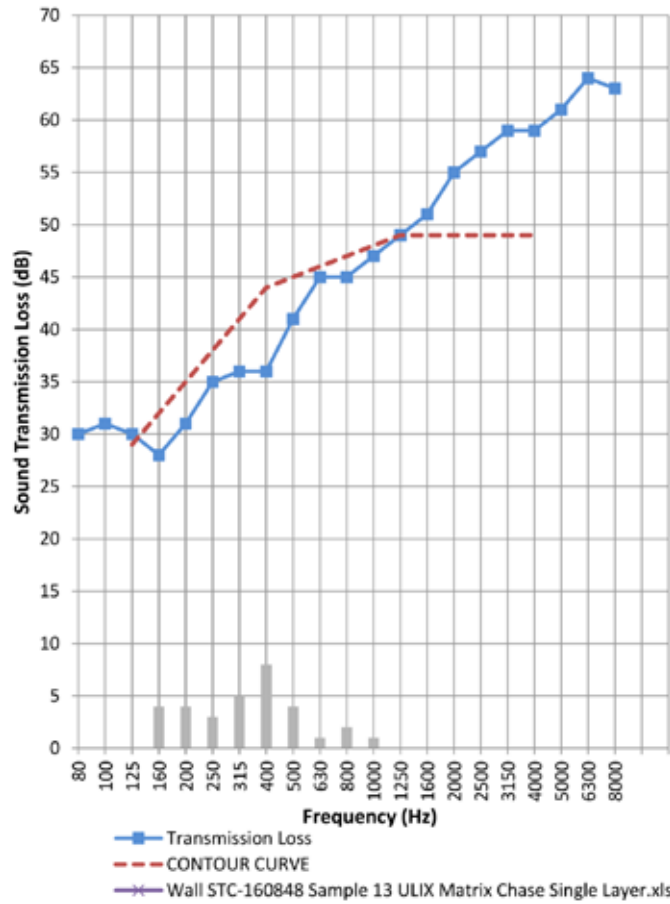
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W09 - CLT WALL ASSEMBLY - USG LABORATORY REPORT

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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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W09 - CLT WALL ASSEMBLY - USG LABORATORY REPORT



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

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Figure 2: Specimen with primer

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Figure 3: Specimen with membrane

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Figure 4: Specimen with membrane and insulation

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W09 - CLT WALL ASSEMBLY - USG LABORATORY REPORT



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

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W09 - MPP WALL ASSEMBLY - USG LABORATORY REPORT



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 document 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 |

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Page 1 of 11



UNIVERSITY OF
OREGON

Energy Studies in
Buildings Laboratory

W09 - MPP WALL ASSEMBLY - USG LABORATORY REPORT

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

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Page 2 of 11

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 mm (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/ft². The transmission area used in the calculations was 72.0 ft².

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.

This report contains eleven (11) pages, including the cover sheet. Any additions to, alterations of, or unauthorized use of excerpts from this report are expressly forbidden.

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W09 - MPP WALL ASSEMBLY - USG LABORATORY REPORT

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 ft³ and the receive room volume was 7236 ft³.

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.

This report contains eleven (11) pages, including the cover sheet. Any additions to, alterations of, or unauthorized use of excerpts from this report are expressly forbidden.

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W09 - MPP WALL ASSEMBLY - 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: | 2/28/2019 |
| 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 mm (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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Energy Studies in
Buildings Laboratory

W09 - MPP WALL ASSEMBLY - 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 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 performance is limited by filler.
 Shaded lines indicate frequencies not governed by this test method.



ACCREDITED BY THE U.S. DEPARTMENT OF COMMERCE, NATIONAL INSTITUTE OF STANDARDS & TECHNOLOGY – NATIONAL VOLUNTARY LABORATORY ACCREDITATION PROGRAM FOR SELECTED TEST METHODS IN ACOUSTICS. THIS REPORT SHALL NOT BE USED TO CLAIM PRODUCT ENDORSEMENT BY NVLAP OR ANY AGENCY OF THE U.S. GOVERNMENT.

NVLAP LAB CODE 200132-0

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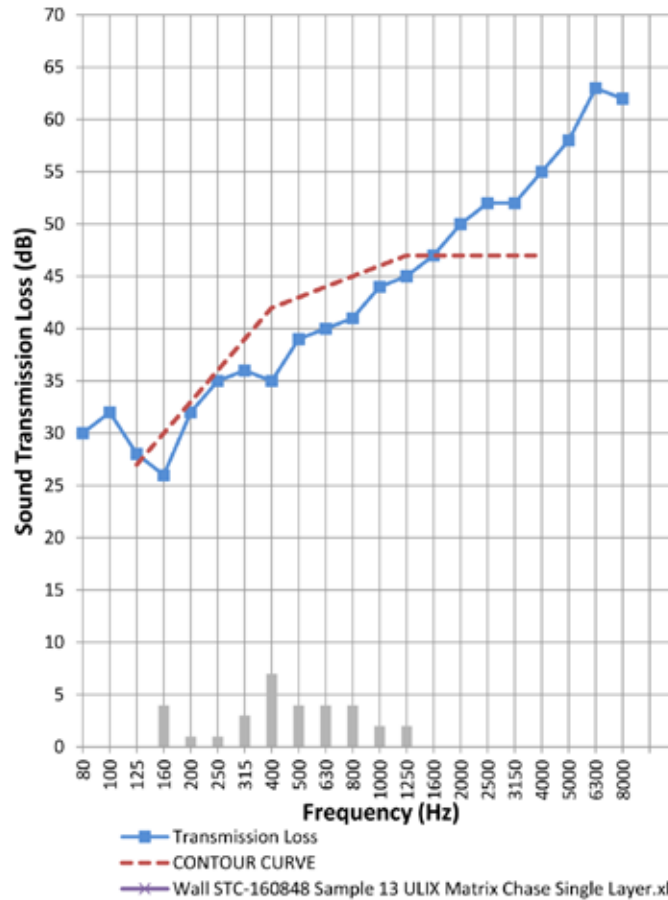
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Airborne Sound Transmission Loss
ASTM E 90



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Figure 1: Specimen prior to addition of gypsum wall board

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Figure 2: Specimen with membrane

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Figure 3: Specimen with membrane and insulation

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

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