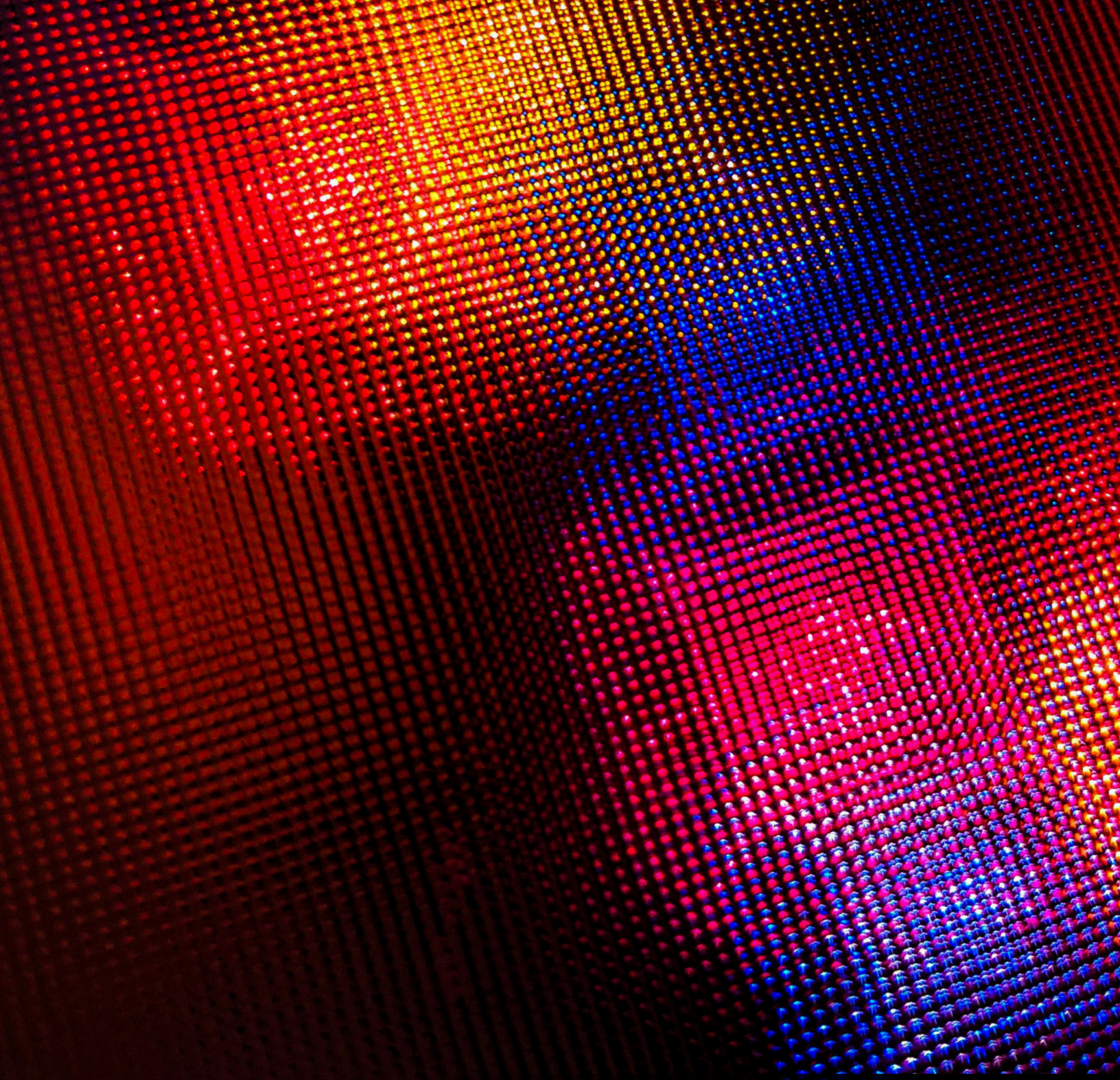

ACOUSTIC TESTING OF BIO-BASED MASS TIMBER FLOOR ASSEMBLIES

For Sustainable Mass Timber Technologies

UNIVERSITY OF OREGON

Acoustic Testing of Bio-Based Mass Timber Floor Assemblies

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27172

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Contents

00

INTRODUCTION

According to UN estimates, the world's population is increasingly dwelling in more densely populated urban areas, and by 2050 an estimated 2.5 billion additional people will live in cities.[1] Therefore, architects, engineers and contractors are developing new construction technologies that simultaneously support low-carbon building design and human health.

One such construction technology with increasing market adoption in North America is panelized mass timber. The structural material offers advantages; it is renewable, biophilic,[2] low-carbon, and it has the potential for off-site fabrication using digital workflows that can reduce construction schedules. Mass timber products are structurally well-suited for multifamily, multistory dwellings in floor-ceiling applications given their aesthetic properties, speed of construction, reduced weight and floor-to-floor heights; however, the monolithic bare wood material is resonant, which requires further acoustic isolation as a floor-ceiling assembly to meet jurisdictional requirements in many applications.

While mass timber panels in isolation have acoustic limitations, many mass timber panels that are part of an assembly can achieve high airborne and impact sound transmission performance. However, the design and construction industry is working to improve the environmental performance of the floor-ceiling assemblies, which includes consideration of individual components such as a reduction or elimination of concrete, higher content of bio-based materials, and designing assemblies for disassembly and reuse. For these alternate new assemblies to be adopted in construction projects, they must be tested to ASTM standards and meet or exceed code-required performance thresholds. With increasing population density, acoustic spatial isolation and freedom from urban noise intrusion will be important considerations for the satisfaction and long-term health of building occupants.[3,4]

This report defines several new mass timber floor-ceiling assemblies that are designed for disassembly and employ bio-based and lower carbon materials, while exposing the biophilic visual properties of mass timber. ASTM laboratory testing was performed to determine whether the assemblies meet or exceed housing code requirements.

ACOUSTICS

TIMBER ACOUSTICS + CODE REQUIREMENTS

Using wood to create spatial acoustic separation presents special problems and requires additional consideration to acoustic separation for room-to-room floor and wall assemblies. Long prized as a material for musical instruments, wood is a resonant material with low density and transmits sound readily. Therefore, mass timber for wall and floor construction needs to be designed as part of an assembly that includes a mixture of dense materials and decoupled sound pathways.

Adoption of mass timber construction in the United States requires meeting performance-based codes and standards for fire, seismic and acoustics. Acoustic standards are established by multiple groups, including American National Standards Institute (ANSI), American Society for Testing and Materials (ASTM), Facility Guidelines Institute (FGI), Housing and Urban Development (HUD), and International Code Council (ICC). Metrics used by these groups to evaluate acoustic performance include sound transmission class (STC), impact isolation class (IIC), and noise reduction coefficient (NRC) ratings.

STC, quantified in decibels (dB), measures how effective an assembly can reduce transmission of airborne sound from one space to another, i.e., block sound from getting through to the other side. IIC ratings, also measured in dB, are particular to floor-ceiling assemblies and gauge their effectiveness in reducing the transmission of impact sound, such as those generated from footsteps or fallen objects. Finally, NRC ratings are indicated by a number between 0 and 1, and are used to measure the ability for an assembly to absorb sound. NRC is often used in applications to reduce reverberations or echo inside a space. This study investigates acoustic performance of mass timber assemblies in terms of STC and IIC, but excludes NRC evaluation.

In multi-family housing buildings in the United States, minimum acoustic separation requirements exist for demising walls and floors, which separate tenant spaces, and the International Building Code (IBC) specifies either a field-tested rating of 45 dB or a lab-tested rating of 50 dB for impact transfer and sound transfer through floor and wall assemblies, using ASTM accepted test methods.[5] Other occupancy types generally benefit from similar STC and IIC values as minimum of “good performance” in support of indoor environmental quality.[6] Spaces generating higher noise (e.g., mechanical rooms), or spaces requiring additional privacy, may require STC

ratings above 60 dB. Alone, a 5-ply CLT floor with a thickness of 6.875" has an STC rating of 41.[7] Therefore, to be successfully integrated into buildings of all occupancy types, CLT assemblies must be augmented with sound attenuating materials or systems to improve their acoustic performance.

With projected population growth and increasing housing density in urban environments, noise control will be necessary for new building materials to ensure physical and mental health and well-being. For mass timber to simultaneously address environmental health, occupant wellness, and construction feasibility concerns, wall and floor assemblies need to be developed across multiple stakeholder groups and tested in field and laboratory settings for acoustic performance.

MASS TIMBER ACOUSTIC STRATEGIES

Primary strategies to increase the acoustic performance of an assembly include the addition of mass, sound barriers to close sound pathways, and decouplers.[7] Increasing mass and the use of sound barriers allow for better deflection and/or absorption of noise, providing better sound control. Utilization of decouplers, products that reduce the direct surface-to-surface area between connected materials in an assembly, limit the pathways available for sound to travel through that assembly. Light-frame construction assemblies provide room to incorporate such strategies above, below, and/or within the assembly, as structural elements are spaced apart and finishes with mass, such as gypsum board, are included for fire resistance. In mass timber assemblies, however, the solid structure limits acoustic materials to either side of the panel rather than within. In the case of floor-ceiling assemblies, for aesthetic and biophilic reasons, it is common for designers working with mass timber products to expose the ceiling side of the timber structure, further limiting placement of most acoustic components to above the panel.[7] These limitations set the parameters for developing unique solutions to address noise control in mass timber assemblies.

Timber alone does not adequately reduce sound transmission for most construction applications due to its inherent lack of mass. Therefore, concrete toppers are typically poured above floor-ceiling assemblies to add mass and improve acoustical performance. These concrete layers have environmental implications, as these cementitious products can counteract some of the embodied carbon benefits timber products provide. They also result in a composite

assembly whose layers are difficult, if not impossible to separate from one another, hindering the potential for material reuse or recycling at the end of a building's lifespan. Alternative strategies such as bio-based materials and sleeper studs with decouplers, as tested in this study, can significantly carry acoustic performance above STC and IIC required thresholds while reducing some of the drawbacks in traditional methods of increasing mass.

HEALTH + WELL BEING

As demand for new construction brings more people into urban areas, concerns surrounding environmental noise are to be expected. Sound becomes noise when it is unwanted, and there is evidence to support noise as an environmental stressor associated with adverse outcomes on psychological and physiological well-being.[8,9] A multitude of studies on environmental noise and its correlations to different negative health outcomes have been explored.

The most widespread and well understood response to noise is general annoyance which can affect quality of life.[3] Studies on sleep have found noise to negatively affect sleep quality in terms of falling asleep and waking during the night. Poor sleep has immediate next-day repercussions on mood and performance; chronic exposure to nighttime noise can be linked to both cognitive and cardiovascular problems.[10] Noise effects cognition, particularly in children, and has been shown to impair learning, reading comprehension and long-term memory.[11] Noise has also negatively correlations to emotional/conduct disorders and hyperactivity.[12] Studies linking noise to cardiovascular issues such as hypertension and heart disease have also been reported.[13] Quality evidence for other reported adverse correlations is limited by a low number of studies, and more robust studies are needed in these areas.

CARBON

EMBODIED CARBON

Embodied carbon of a material is defined by the total amount carbon emissions released during the lifecycle of that material, from extraction, manufacturing, transportation, construction, through disposal.[14] These emissions occur over the product's lifespan, and often have pronounced hotspots during the manufacturing stages.[15]

The building sector is responsible for about 42% of annual global CO_2 emissions. Of that, 27% comes from operational emissions, or services required to power a building such as heating, cooling, and lighting. The remainder is attributed to resource extraction, material production, construction, and waste. The embodied carbon of cement, iron, steel and aluminum alone account for 15% of annual global CO_2 emissions.[15] As building operational efficiency increases, embodied carbon emissions are expected to make up a larger share of the sector's carbon footprint. Increased demand for new building floor area in urban centers will further amplify the role of embodied carbon.

Mineral-based materials like concrete and steel generally require vast amounts of fossil fuel energy to process raw materials into desired products, making them materials with high embodied carbon. Fossil fuels require extremely long timelines to form, and their use as feedstock energy greatly exceeds their rate of renewal, creating one-way emissions of CO_2 to the atmosphere that are essentially permanent on a human timescale and increasing radiative forcing, or the rate of energy entering the atmosphere compared to the rate at which it leaves.[16]

Some emissions are caused by natural chemical processes. A notable example is the calcination of limestone to lime in clinker production, a process responsible for more than half of CO_2 emissions in the production of Portland cement.[17] Dependence on non-renewable resources and continued use of finite minerals will further reduce their availability, impact ecosystems, and contribute greenhouse gases emissions.

BIO-BASED MATERIALS

Photosynthesis allows vegetation to actively remove carbon dioxide from the atmosphere, sequestration carbon in their fibers, decreasing radiative forcing and producing a cooling effect. The accumulated carbon is stored as biomass, allowing plants to act as an atmospheric carbon sink. While the harvest of bio-based products stops their carbon intake at that point, the resulting products can store or sequester that biogenic carbon throughout their life. If and when these plants are replanted, carbon stocks can be stored in both urban and forest pools simultaneously. The longer the functional lifespan of these bio-based products, the longer carbon is securely stored away from the atmosphere.[18]

Another advantage of bio-based materials is their primary inputs are widely distributed resources, such as water, carbon dioxide, and energy from the sun, making them inherently low-embodied energy.[19] When low-carbon materials are substituted in place of high-embodied carbon ones, immediate emissions savings are achieved by reducing the one-way flow of fossil fuels.[20] The renewability of biomass offers resource security, and regrowth creates a potential for material turnover compared to the single-use nature of non-renewable resources. Emissions from bio-based materials are part of a two-way process between

the atmosphere and biosphere (aka the carbon cycle) and can slow the contribution to long-term increased concentrations of atmospheric CO_2. Biogenic emissions can be considered temporary if re-sequestration of those emissions, through re-planting, regrowth, and restoration, are assured in a rapid enough timeframe.[21]

FAST-GROWING BIO-BASED MATERIALS

Backed by sustainable forestry, mass timber construction in place of traditional concrete and steel can reduce the embodied carbon of a building's superstructure and offer significant climate change mitigation opportunities. The additional materials needed for insulation and acoustical properties of roof, wall, and floor assemblies should focus on low-carbon materials to reduce their negative impact.

A transition to bio-based materials with low embodied carbon, particularly fast-growing materials like straw or hemp, can radically decrease the carbon footprint of a building. While timber can offer a lower carbon alternative to concrete and steel, it needs time for new forests to compensate for its initial embodied emissions through carbon uptake. Due to the longer rotation periods of forests, sequestration lags behind emissions caused by harvest, and the longer payback period carries a greater carbon debt and risk. Fast-growing bio-based materials do not require long rotation periods. Their rapid carbon uptake offers greater assurance to carbon neutrality, a benchmark that can be achieved within a timeframe that may address the urgency of climate mitigation.[22]

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01

PROCESS METHODOLOGY

CLT FLOOR TESTS

This section defines the process of surveying and testing the acoustic performance of CLT floor assemblies for sound transmission (STC), impact isolation (IIC).

Laboratory testing was performed at Riverbank Acoustical Laboratories in Geneneva, Illinois. CLT samples were shipped to the lab wrapped and covered during transport.

CLT PROPERTIES & ACOUSTIC PERFORMANCE

CLT is a light-weight, high strength product. While these inherent properties provide structural advantages they can work against the product in terms of acoustic performance, as sound can travel easily through the light, rigid material. Therefore, to be successfully integrated into buildings of all occupancy types, CLT assemblies must be augmented with sound attenuating materials or systems to improve their acoustic performance.

In common CLT assemblies, materials used to augment acoustic performance (e.g., concrete topping slabs atop an acoustical separation mat), typically result in an integrated, composite system. One drawback to this approach, however, is the limited ability to disassemble, recycle, or reuse these composite panels at the end of a building's life. Additionally, these integrated materials are often high in embodied carbon[1], and/or made of fossil fuel-based synthetic materials.

CLT ACOUSTIC ASSEMBLY SURVEY & DEVELOPMENT OF BIO-BASED ALTERNATIVES

A review of over 600 published mass timber floor assemblies, as well as untested novel assemblies, was conducted to document known acoustic performance data and identify desirable CLT assemblies based on construction technique, performance, aesthetics, and cost. This review was used in consultation with industry stakeholders, including manufacturers, architects, engineers, acousticians, developers, and contractors, to develop nine (9) novel, previously untested assemblies in North America with publicly available ASTM test results for laboratory testing of acoustic performance.

The developed floor assemblies are

described in more detail in Section 02 of this report. All developed assemblies utilize 5-ply CLT panels as the wood substrate to provide a minimum baseline fire resistance regardless of sound attenuating materials added. For these remaining assembly layers, an emphasis was placed on bio-based, low-carbon, and easily disassembled materials in lieu of the more common mass timber floor assembly components that utilize synthetic or composite materials.

LABORATORY TESTING

North American accredited laboratories were considered for ASTM testing and one selected based on availability, timeline and equipment capacity, with particular attention given to accommodating the unique size and weight of mass timber panels and the ability to procure additional materials required for constructing the built-up assemblies. All floor assemblies were tested to ASTM E90-09 (2016) standards at Riverbank Acoustical Laboratories (Geneva, IL). The single number rating of the specimen was calculated according to ASTM E413-22. The transmission loss values are for a single direction of measurement.

Tested assemblies were constructed with within the laboratory test chamber. The CLT layer of the tested assemblies was constructed of two panels, with the joint between panels running parallel to the long dimension. CLT panels were laid on 6” wide knee walls across the test opening and butted to one another without sealant or adhesive. Each of the two panels received a 3/4” x 3” rabbet on the top side where they abut, and were joined by a 3/4” x 6” plywood spline across the panel joint. This testing configuration is reflective of a typical configuration of CLT products within floor assemblies in field installations. Subsequent floor assembly layers were installed per manufacturer guidelines. See below photos of the floor assembly “F03” installation at the testing facility. These large-scale photos are a representative example of the installation process for the CLT installation of all floor assemblies, with subsequent layers unqiue to each assembly. For images of each assembly installation, see Section 03 below.

Figure 1 - F03 Assembly - CLT installed in test aperture, with 3/4” x 3” rabbets each along panel-to-panel joint (from above)

Figure 2 - F03 Assembly - 3/4” x 6” plywood spline partially installed over CLT rabbets (from above)

*All images in Figures 1-2 credit Riverbank Acoustical Laboratories

Figure 3 - F03 Assembly - 2x4 sleepers partially installed, with Piano B 40/40 strips fastened to underside of sleepers (from above)

Figure 4 - F03 Assembly - Gravel partially installed in gaps between sleepers (from above)

*All images in Figures 3-4 credit Riverbank Acoustical Laboratories

Figure 5 - F03 Assembly - Gravel installed, Piano B 40/40 partially installed on top of sleepers (from above)

Figure 6 - F03 Assembly - Plywood subfloor partially installed (from above)

*All images in Figures 5-6 credit Riverbank Acoustical Laboratories

Figure 7 - F03 Assembly - Flooring adhesive, partially installed. Applied before flooring install (from above)

Figure 8 - F03 Assembly - Flooring partially installed (from above)

*All images in Figures 7-8 credit Riverbank Acoustical Laboratories

Figure 9 - F03 Assembly - CLT panels (from below)

*Image in Figures 9 credit Riverbank Acoustical Laboratories

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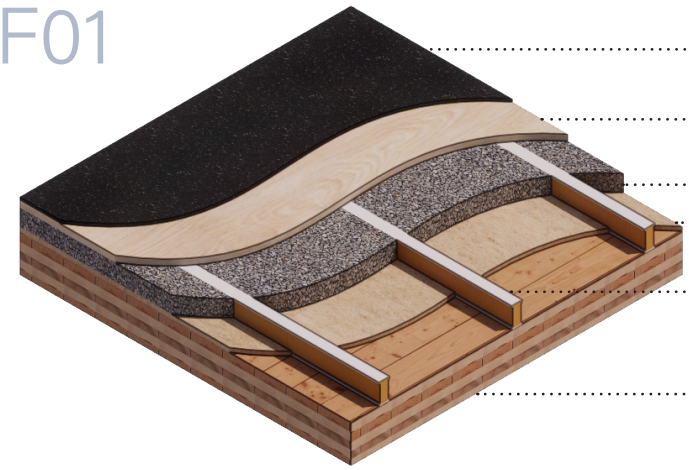
02

PROPOSED FLOOR ASSEMBLIES

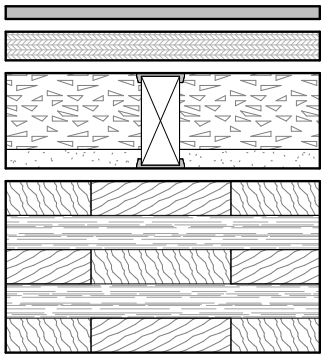
The following floor assemblies were tested by Riverbank Acoustical Laboratories™ is accredited by the U.S. Department of Commerce, National Institute of Standards and Technology (NIST) under the National Voluntary Laboratory Accreditation Program (NVLAP) as an ISO 17025:2005 Laboratory (NVLAP Lab Code: 100227-0) and for this test procedure.

These assemblies were developed as described in Section 01, above. Emphasis was placed on the use of bio-based materials. Materials were also selected based on their ability to be installed and ease of disassembly, aiming to minimize the physically or chemically bonded layers that create a composite panel and might impact the assembly's reuse potential at the end of its useful life.

F01

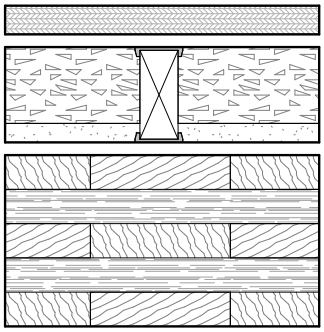


- Marmoleum Decibel adhered with Sustain 1195
- 1 1/8" Plywood T&G Subfloor screwed 24" OC with #9x3"
- 3" of 3/8" Limestone Chip
- Hempitecture 3/4" Hemp Fiber Board
- 2x4 Sleepers, 24" OC with Rothoblaas Piano B acoustic strips stapled top/bottom
- Vaagen Timbers 5-ply CLT 6.875"

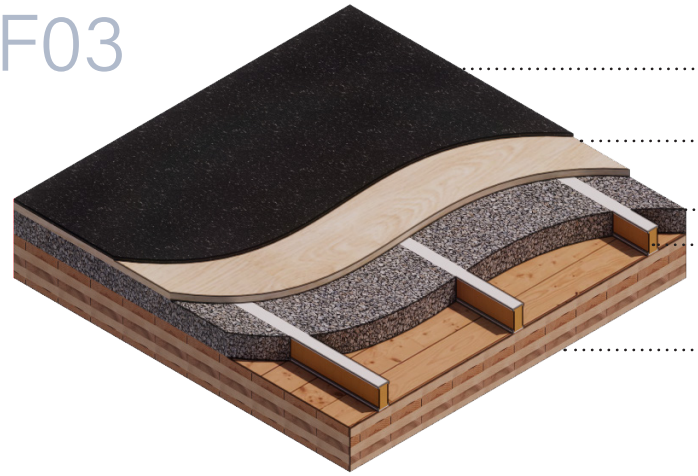


F02

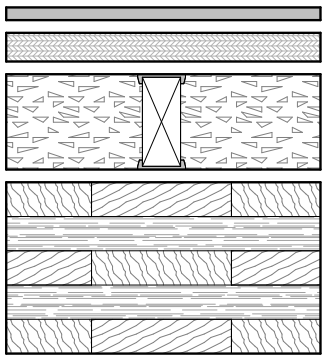
- 1 1/8" Plywood T&G Subfloor screwed 24" OC with #9x3"
- 3" of 3/8" Limestone Chip
- Hempitecture 3/4" Hemp Fiber Board
- 2x4 Sleepers, 24" OC with Rothoblaas Piano B acoustic strips stapled top/bottom
- Vaagen Timbers 5-ply CLT 6.875"



F03



- Marmoleum Decibel adhered with Sustain 1195
- 1 1/8" Plywood T&G Subfloor screwed 24" OC with #9x3"
- 3 3/4"of 3/8" Limestone Chip
- 2x4 Sleepers, 24" OC with Rothoblaas Piano B acoustic strips stapled top/bottom
- Vaagen Timbers 5-ply CLT 6.875"



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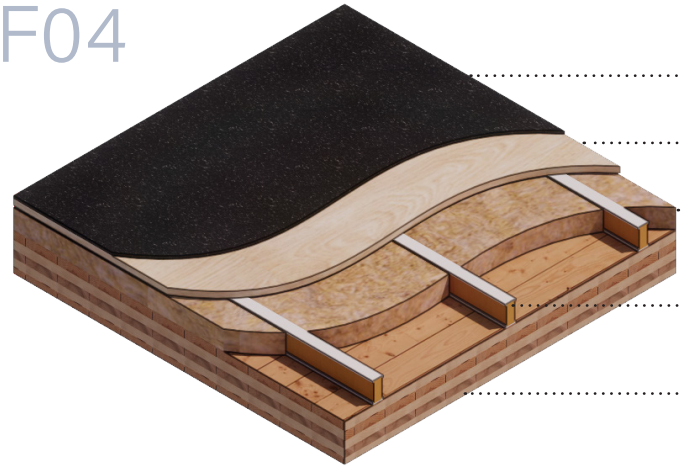


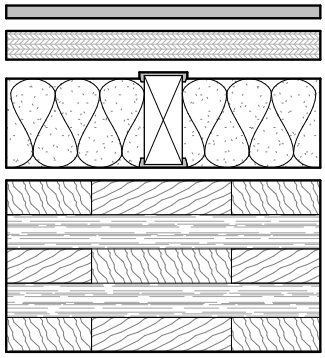
Marmoleum Decibel adhered with Sustain 1195

1 1/8" Plywood T&G Subfloor screwed 24" OC with #9x3"

HempWool Acoustibatt 3.5" hemp batt

2x4 Sleepers, 24" OC with Rothoblaas Piano B acoustic strips stapled top/bottom

Vaagen Timbers 5-ply CLT 6.875"



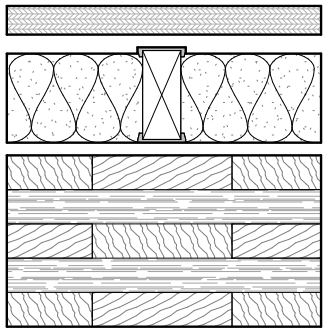
F05

1 1/8" Plywood T&G Subfloor screwed 24" OC with #9x3"

HempWool Acoustibatt 3.5" hemp batt

2x4 Sleepers, 24" OC with Rothoblaas Piano B acoustic strips stapled top/bottom

Vaagen Timbers 5-ply CLT 6.875"



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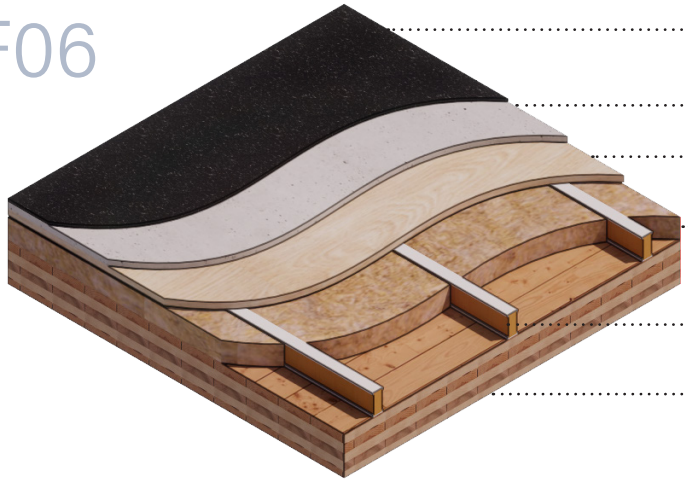


Marmoleum Decibel adhered with Sustain 1195

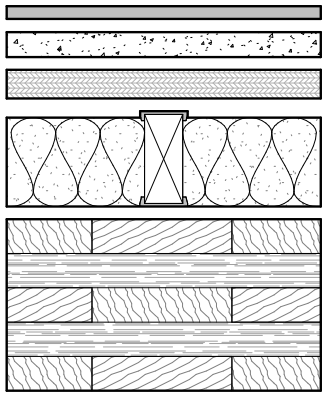
1" Maxxon Gypcrete 2000 Multifamily

1 1/8" Plywood T&G Subfloor screwed 24" OC with #9x3"

HempWool Acoustibatt 3.5" hemp batt

2x4 Sleepers, 24" OC with Rothoblaas Piano B acoustic strips stapled top/bottom

Vaagen Timbers 5-ply CLT 6.875"



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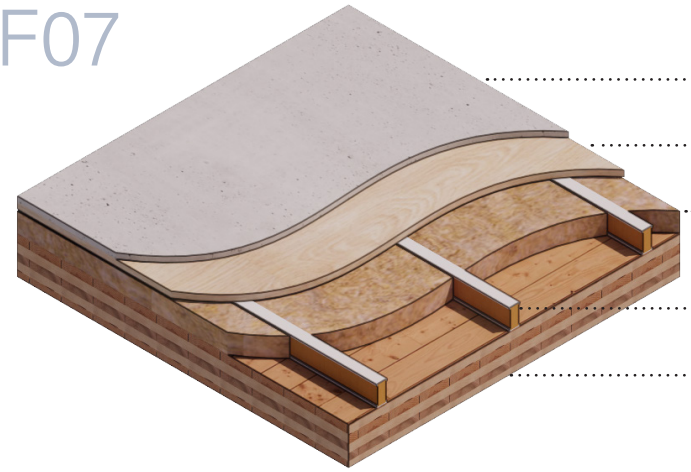
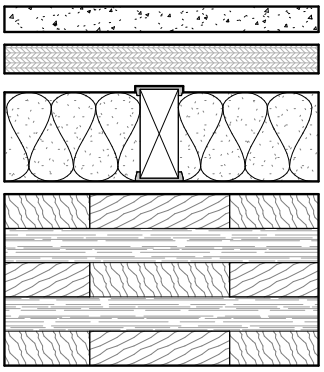
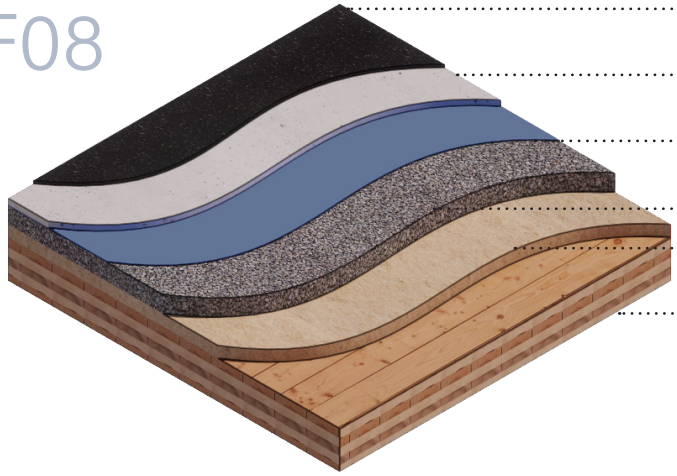


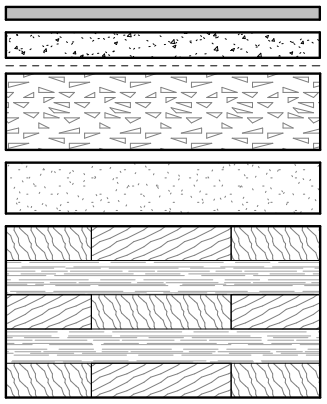
- 1″ Maxxon Gypcrete 2000 Multifamily
- 1 1/8″ Plywood T&G Subfloor screwed 24″ OC with #9x3″
- HempWool Acoustibatt 3.5″ hemp batt
- 2x4 Sleepers, 24″ OC with Rothoblaas Piano B acoustic strips stapled top/bottom
- Vaagen Timbers 5-ply CLT 6.875″



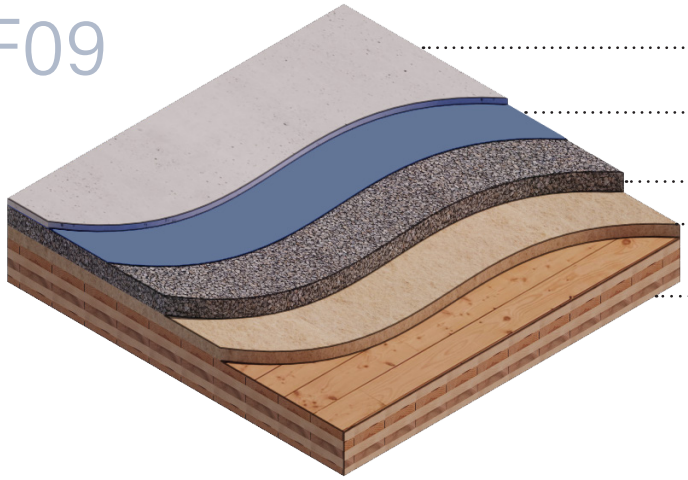
F08



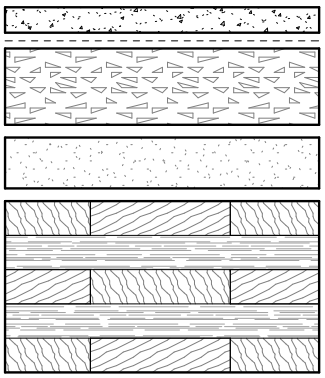
- Marmoleum Decibel adhered with Sustain 1195
- 1″ Maxxon Gypcrete 2000 Multifamily
- Certainteed MemBrain Vapor Retarder
- 3″of 3/8″ Limestone Chip
- Hempitecture 2″ Hemp Fiber Board
- Vaagen Timbers 5-ply CLT 6.875″



F09



- 1″ Maxxon Gypcrete 2000 Multifamily
- Certainteed MemBrain Vapor Retarder
- 3″of 3/8″ Limestone Chip
- 2″ Hemp Fiber Board (BOD: Hempitecture)
- Vaagen Timbers 5-ply CLT 6.875″



03

FLOOR ASSEMBLIES: DETAILED RESULTS

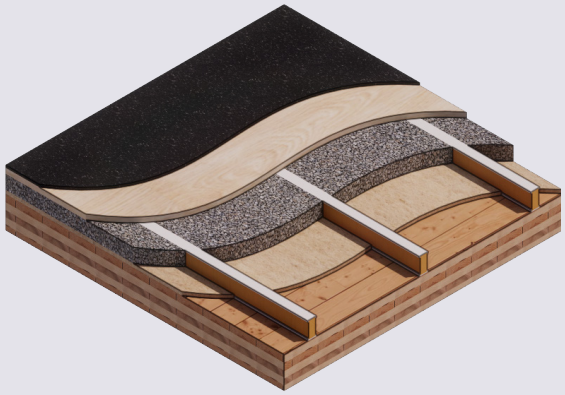
Riverbank Acoustical Laboratories™ is accredited by the U.S. Department of Commerce, National Institute of Standards and Technology (NIST) under the National Voluntary Laboratory Accreditation Program (NVLAP) as an ISO 17025:2005 Laboratory (NVLAP Lab Code: 100227-0) and for this test procedure. The 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.

Certified ASTM lab testing reports can be found in the appendix.

*Image credit Riverbank Acoustical Laboratories

FLOOR F01



SPECIMEN MEASUREMENTS

Dimensions: 2.44 m (96.0 in) wide by 3.86 m (152.0 in) high
Thickness: 0.31 m (12.125 in)
Weight: 2237.68 kg (4933.25 lbs)
Overall Area: 9.414 m^2 (101.33 ft^2)
Mass/Unit Area: 215.06 kg/m^2 (44.05 lbs/ft^2)

TEST APERTURE

Opening Size: 4.27 m (14.0 ft) x 6.10 m (20.0 ft)
Filler Wall: Yes
Aperture Size: 2.44 m (96.0 in) wide by 3.86 m (152.0 in) high
Transmission Area: 9.414 m^2 (101.33 ft^2)
Sealed: Entire periphery (both sides) with dense mastic

TEST ENVIRONMENT

Source Room
Volume: 131.12 m^3
Temperature: 22.8°C ±0.0°C
Relative Humidity: 62.5% ± 1.0%

Receive Room
Volume: 81.44 m^3
Temperature: 22.2°C ± 0.0°C
Relative Humidity: 62.5% ± 1.0%

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

LAYER 1 - CROSS LAMINATED TIMBER (CLT)

Material: 5-Ply Cross-Laminated Timber
Dimensions: 2 panels @ 1219 mm (48 in.) by 4229 mm (166.5 in.)
Thickness: 171 mm (6.75 in.)
Overall Weight: 953.45 kg (2102 lbs)
Mass / Unit Volume: 539 kg/m^3 (33.7 lbs/ft^3)
Installation: CLT panels laid on 152 mm (6 in.) wide knee walls in test opening and butted to one another without sealant/adhesive. 3/4"x3" Rabbet on top side of one edge of each panel where they butt allowing a loose plywood spline (above) to insert and join the two.

LAYER 2 - 3/4" CDX LOOSE SPLINE

Material: 3/4" x 6" plywood spline
Dimensions:
1 piece @ 151 mm (5.9375 in.) wide by 2438 mm (96 in.)
1 piece @ 151 mm (5.9375 in.) wide by 1791 mm (70.5 in.)
Thickness: 19 mm (0.75 in.)
Overall Weight: 6.46 kg (14.25 lbs)
Mass / Unit Length: 1.53 kg/m (1.03 lbs/ft)
Installation: Set in Rabbets of both CLT's and screwed in place.
Fasteners: WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing: 6" o.c. on a line 3" from each edge of the spline (Centered on the rabbet of the CLT)

LAYER 3 - PIANO B 40/40 (LOWER LAYER)

Manufacturer: Rothoblaas
Dimensions:
2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long
8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness: 6.76 mm (0.266 in.)
Overall Weight: 4.59 kg (10.125 lbs)
Mass/Unit Volume: 624 kg/m^3 (40.00 lbs/ft^3)
Installation: Fastened to underside of 2" x 4" wood sleepers with staples
Fasteners: Arrow staples, length @ 13 mm (0.5 in.)

LAYER 4 - 2x4 SPF FRAMING SLEEPERS

Material: Nominal 2x4 framing lumber
Dimensions:
2 pieces @ 38 mm (1.5 in.) wide by 4255 mm (167.5 in. long
8 pieces @ 2369 mm (93.25 in.) wide by 38 mm (1.5 in.) long
Depth: 89 mm (3.5 in.)
Overall Weight: 49.33 kg (108.75 lbs)
Mass / Unit Length: 1.80 kg/m (1.21 lbs/ft)
Installation: Sleepers laid over CLT, resting on lower layer Piano B 40/40. Longer sleepers parallel to CLT like a rim joist. Shorter sleepers set like floor joists between rim joists. Shorter sleepers spaced approx. 610 mm (24 in.) on center. Shorter sleepers fastened to longer sleepers with screws, 2 screws per connection point.
Fasteners: WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)

LAYER 5 - PIANO B 40/40 (UPPER LAYER)

Manufacturer: Rothoblaas
Dimensions:
2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long
8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness: 6.76 mm (0.266 in.)
Overall Weight: 4.59 kg (10.125 lbs)
Mass/Unit Volume: 624 kg/m^3 (40.0 lbs/ft^3)
Installation: Fastened to top of 2" x 4" wood sleepers with staples.
Fasteners: Arrow staples, length @ 13 mm (0.5 in.)

LAYER 6 - HEMPBOARD

Manufacturer: Hempitecture
Dimensions:
7 pieces @ 572 mm (22.5 in.) wide by 2369 mm (93.25 in.) long
Thickness: 19 mm (0.75in.)
Overall Weight: 24.38 kg (53.75 lbs)
Mass/Unit Volume: 135 kg/m^3 (8.43 lbs/ft^3)
Installation: Friction fit between sleepers on top of CLT.

LAYER 7 - CRUSHED LIMESTONE

Material: CA-16 3/8" chip crushed limestone
Dimensions: 2438 mm (96 in.) wide by 4267 mm (168 in.) long, as installed
Depth: 70 mm (2.75 in.)
Overall Weight: 986.56 kg (2175 lbs)
Installation: Filled stone in above hemp board and between sleepers and used a screed to level to the top of the sleepers.

LAYER 8 - PLYWOOD SUBFLOOR

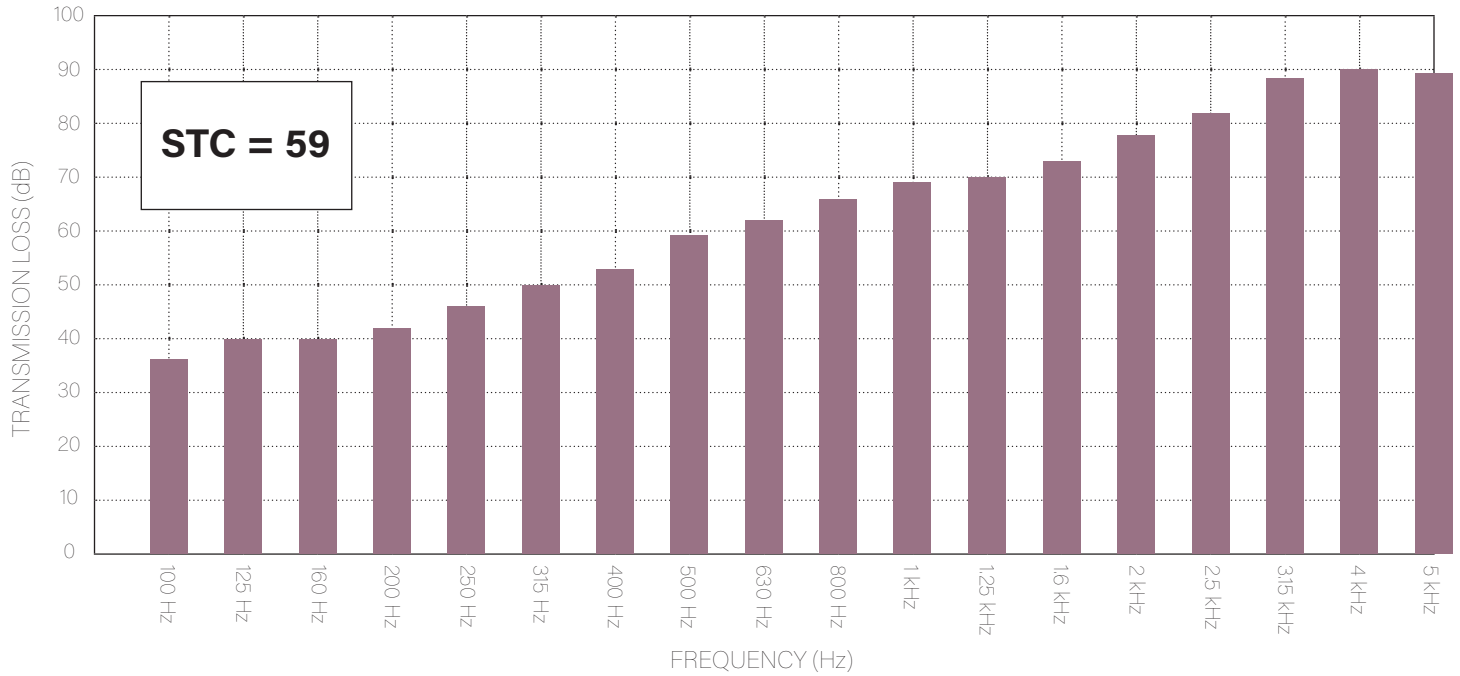
Material: T&G Plywood
Dimensions:
1 piece @ 1219 mm (48 in.) wide by 1829 mm (72 in.)
1 piece @ 1219 mm (48 in.) wide by 2438 mm (96 in.)
1 piece @ 1219 mm (48 in.) wide by 1822 mm (71.75 in.)
1 piece @ 1219 mm (48 in.) wide by 2432 mm (95.75 in.)
Thickness: 29 mm (1.125 in.)
Overall Weight: 170.66 kg (376.25 lbs)
Mass / Unit Volume: 575 kg/m^3 (35.9 lbs/ft^3)
Installation: Placed over upper layer Piano B 40/40 over sleepers. Fastened to sleepers through Piano B 40/40 with screws. Plywood piece joints staggered.
Fasteners: WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing: 610 mm (24 in.) on center

LAYER 9 - ADHESIVE

Material: Sustain 1195 Sheet and Tile adhesive
Manufacturer: Forbo
Dimensions: Approx. 2438 mm (96 in.) by 4267 mm (168 in.) as installed
Overall Weight: 5.44 kg (12 lbs)
Mass / Unit Area: 0.52 kg/m^2 (0.11 lbs/ft^2)
Installation: Troweled directly to plywood with a 1/16x1/16x1/16 square notch trowel
Once troweled, adhesive was left "open" for 15 min to allow it to "tack" before flooring was installed.

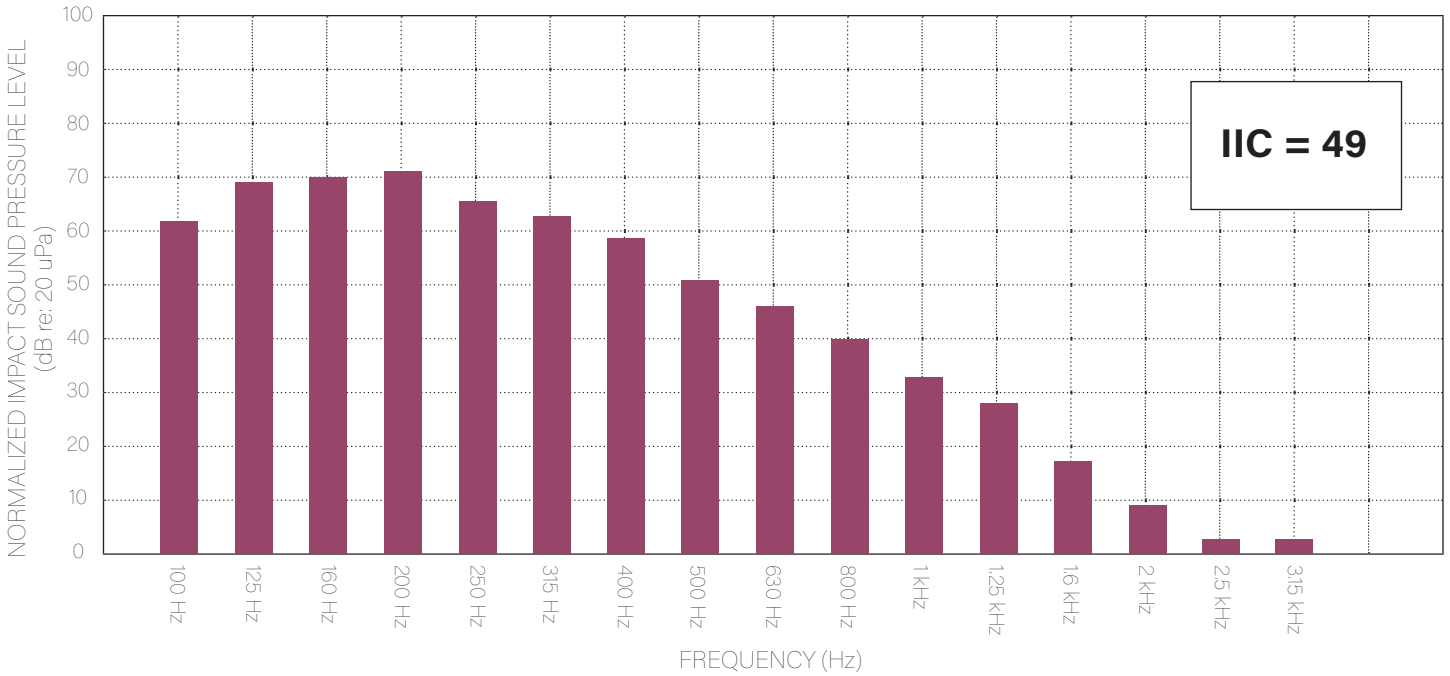
LAYER 10 - FLOORING

Material: Marmoleum Decibel
Manufacturer: Forbo
Dimensions: 2 pieces @ 2007 mm (79 in.) by 2464 mm (97 in.)
Thickness: 6 mm (0.25 in.)
Overall Weight: 32.21 kg (71 lbs)
Mass / Unit Volume: 482 kg/m^3 (30.1 lbs/ft^3)
Installation: Two (2) 79" segments perpendicular to Plywood 10" strip to complete. Joints staggered from parallel plywood joints by + 6". Rolled with 100lb roller in each direction.



FREQ. (Hz)	TL	ΔTL	DEF.
100	36	0.45	0
125	40	0.60	3
160	40	0.51	6
200	42	0.54	7
250	46	0.30	6
315	50	0.26	5
400	53	0.33	5
500	59	0.28	0
630	62	0.27	0
800	66	0.27	0
1000	69	0.13	0
1250	70	0.17	0
1600	73	0.18	0
2000	77	0.19	0
2500	82	0.70	0
3150	88	1.38	0
4000	90	2.70	0
5000	89	2.68	0

FREQ. = FREQUENCY (1/3 OCTAVE BAND, CENTER), HERTZ
TL = TRANSMISSION LOSS, dB
ΔTL = 95% CONFIDENCE INTERVAL FOR TL MEASUREMENTS, dB
DEF. = DEFICIENCIES, dB BELOW STC CONTOUR
STC **=** SOUND TRANSMISSION LOSS



FREQ. (Hz)	Ln	ΔLn	DEV.
80	--	--	--
100	62	1.23	0
125	69	3.03	6
160	70	1.68	7
200	71	1.59	8
250	66	2.30	3
315	63	3.73	0
400	58	2.47	0
500	51	1.68	0
630	46	1.68	0
800	40	2.49	0
1000	33	1.07	0
1250	28	2.45	0
1600	17	2.13	0
2000	9*	1.60	0
2500	3**	0.71	0
3150	3**	0.58	0
4000	--	--	--

FREQ. = FREQUENCY, HERTZ
Ln = NORMALIZED SOUND PRESSURE LEVEL, dB
ΔLn = 95% UNCERTAINTY LIMIT FOR Ln, dB
DEV. = DEVIATION FROM SHIFTED IIC COUNTOUR, dB
IIC = IMPACT INSULATION CLASS

*Level corrected due to background noise per E492 SEC 10.2.2
**Level corrected due to background noise per E492 SEC 10.2.3

Figure 1 - Specimen mounted in test aperture, as viewed from source room

Figure 2 - Specimen mounted in test aperture, as viewed from receive room

Figure 3 - CLT (1 of 2) prior to installation

Figure 4 - CLT installed in test aperture

Figure 5 - 3/4" x 6" plywood spline partially installed over CLT rabbets

Figure 6 - Detail of 3/4" x 6" plywood spline partially installed over CLT rabbets

Figure 7 - 2"x4" sleepers partially installed, with Piano B 40/40 fastened to underside of sleepers

Figure 8 - Piano B 40/40 strip fastened to sleeper prior to installation of sleeper

*All images in Figures 1-8 credit Riverbank Acoustical Laboratories

Figure 9 - Hemp boards prior to installation

Figure 10 - Hemp boards partially installed between sleepers, gravel partially installed over hemp boards

Figure 11 - Hemp boards, gravel, and sleepers installed, Piano B 40/40 strips partially installed over sleepers

Figure 12 - Plywood subfloor partially installed

Figure 13 - Plywood subfloor installed

Figure 14 - Trowel used for installation of adhesive

Figure 15 - Adhesive partially installed over plywood

Figure 16 - Flooring partially installed over adhesive

*All images in Figures 9-16 credit Riverbank Acoustical Laboratories

FLOOR
F02

SPECIMEN MEASUREMENTS

Dimensions: 2.44 m (96.0 in) wide by 3.86 m (152.0 in) high
Thickness: 0.3 m (11.875 in)
Weight: 2200.03 kg (4850.25 lbs)
Overall Area: 9.414 m^2 (101.33 ft^2)
Mass/Unit Area: 211.44 kg/m^2 (43.31 lbs/ft^2)

TEST APERTURE

Opening Size: 4.27 m (14.0 ft) x 6.10 m (20.0 ft)
Filler Wall: Yes
Aperture Size: 2.44 m (96.0 in) wide by 3.86 m (152.0 in) high
Transmission Area: 9.414 m^2 (101.33 ft^2)
Sealed: Entire periphery (both sides) with dense mastic

TEST ENVIRONMENT

Source Room
Volume: 131.12 m^3
Temperature: 23.1°C ±0.6°C
Relative Humidity: 60.5% ± 1.0%

Receive Room
Volume: 81.44 m^3
Temperature: 22.5°C ± 0.6°C
Relative Humidity: 60.5% ± 1.0%

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

LAYER 1 - CROSS LAMINATED TIMBER (CLT)

Material: 5-Ply Cross-Laminated Timber
Dimensions: 2 panels @ 1219 mm (48 in.) by 4229 mm (166.5 in.)
Thickness: 171 mm (6.75 in.)
Overall Weight: 953.45 kg (2102 lbs)
Mass / Unit Volume: 539 kg/m^3 (33.7 lbs/ft^3)
Installation: CLT panels laid on 152 mm (6 in.) wide knee walls in test opening and butted to one another without sealant/adhesive. 3/4"x3" Rabbet on top side of one edge of each panel where they butt allowing a loose spline (above) to insert and join the two.

LAYER 2 - 3/4" CDX LOOSE SPLINE

Material: 3/4" x 6" plywood spline
Dimensions:
1 piece @ 151 mm (5.9375 in.) wide by 2438 mm (96 in.)
1 piece @ 151 mm (5.9375 in.) wide by 1791 mm (70.5 in.)
Thickness: 19 mm (0.75 in.)
Overall Weight: 6.46 kg (14.25 lbs)
Mass / Unit Length: 1.53 kg/m (1.03 lbs/ft)
Installation: Set in Rabbets of both CLT's and screwed in place.
Fasteners: WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing: 6" o.c. on a line 3" from each edge of the spline (Centered on the rabbet of the CLT)

LAYER 3 - PIANO B 40/40 (LOWER LAYER)

Manufacturer: Rothoblaas
Dimensions:
2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long
8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness: 6.76 mm (0.266 in.)
Overall Weight: 4.59 kg (10.125 lbs)
Mass/Unit Volume: 624 kg/m^3 (40.00 lbs/ft^3)
Installation: Fastened to underside of 2" x 4" wood sleepers with staples
Fasteners: Arrow staples, length @ 13 mm (0.5 in.)

LAYER 4 - 2x4 SPF FRAMING SLEEPERS

Material: Nominal 2x4 framing lumber
Dimensions:
2 pieces @ 38 mm (1.5 in.) wide by 4255 mm (167.5 in. long
8 pieces @ 2369 mm (93.25 in.) wide by 38 mm (1.5 in.) long
Depth: 89 mm (3.5 in.)
Overall Weight: 49.33 kg (108.75 lbs)
Mass / Unit Length: 1.80 kg/m (1.21 lbs/ft)
Installation: Sleepers laid over CLT, resting on lower layer Piano B 40/40. Longer sleepers parallel to CLT like a rim joist. Shorter sleepers set like floor joists between rim joists. Shorter sleepers spaced approx. 610 mm (24 in.) on center. Shorter sleepers fastened to longer sleepers with screws, 2 screws per connection point.
Fasteners: WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)

LAYER 5 - PIANO B 40/40 (UPPER LAYER)

Manufacturer: Rothoblaas
Dimensions:
2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long
8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness: 6.76 mm (0.266 in.)
Overall Weight: 4.59 kg (10.125 lbs)
Mass/Unit Volume: 624 kg/m^3 (40.0 lbs/ft^3)
Installation: Fastened to top of 2" x 4" wood sleepers with staples.
Fasteners: Arrow staples, length @ 13 mm (0.5 in.)

LAYER 6 - HEMPBOARD

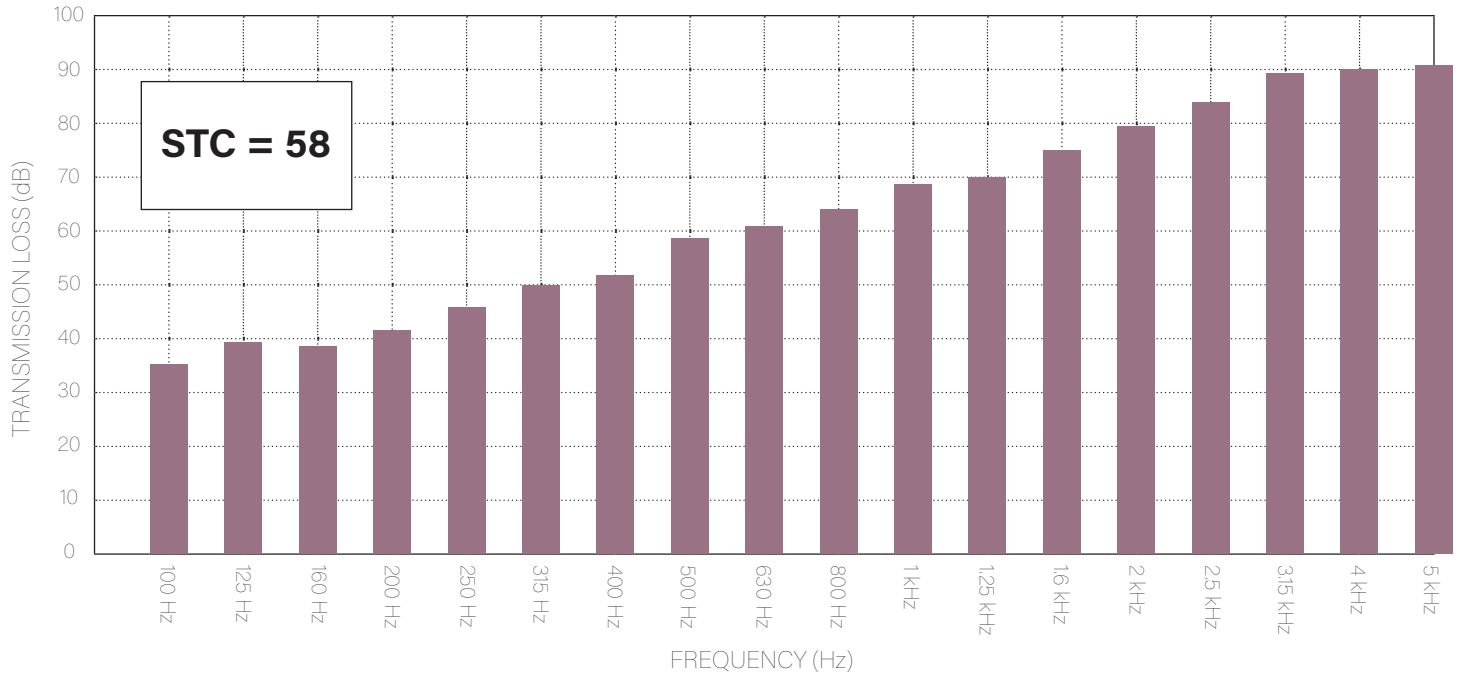
Manufacturer: Hempitecture
Dimensions:
7 pieces @ 572 mm (22.5 in.) wide by 2369 mm (93.25 in.) long
Thickness: 19 mm (0.75 in.)
Overall Weight: 24.38 kg (53.75 lbs)
Mass/Unit Volume: 135 kg/m^3 (8.43 lbs/ft^3)
Installation: Friction fit between sleepers on top of CLT.

LAYER 7 - CRUSHED LIMESTONE

Material: CA-16 3/8" chip crushed limestone
Dimensions: 2438 mm (96 in.) wide by 4267 mm (168 in.) long, as installed
Depth: 70 mm (2.75 in.)
Overall Weight: 986.56 kg (2175 lbs)
Installation: Filled stone in above hemp board and between sleepers and used a screed to level to the top of the sleepers.

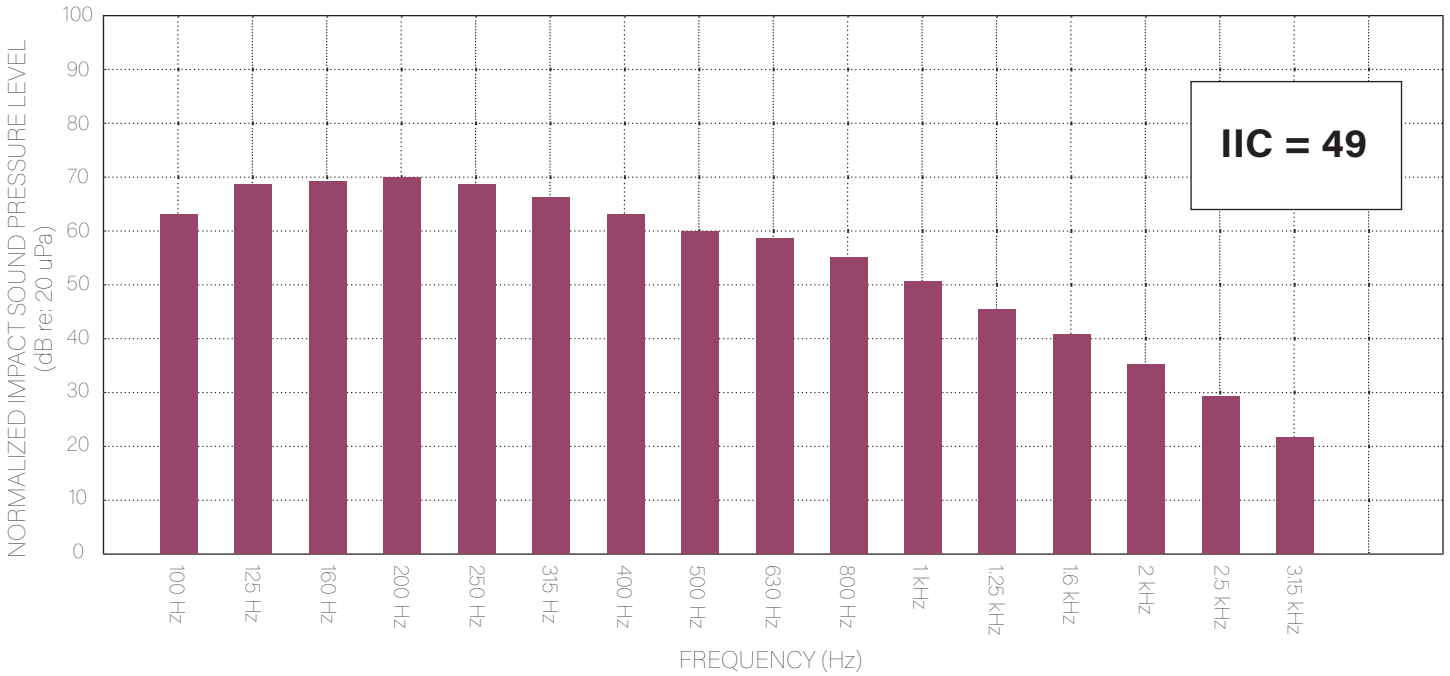
LAYER 8 - PLYWOOD SUBFLOOR

Material: T&G Plywood
Dimensions:
1 piece @ 1219 mm (48 in.) wide by 1829 mm (72 in.)
1 piece @ 1219 mm (48 in.) wide by 2438 mm (96 in.)
1 piece @ 1219 mm (48 in.) wide by 1822 mm (71.75 in.)
1 piece @ 1219 mm (48 in.) wide by 2432 mm (95.75 in.)
Thickness: 29 mm (1.125 in.)
Overall Weight: 170.66 kg (376.25 lbs)
Mass / Unit Volume: 575 kg/m^3 (35.9 lbs/ft^3)
Installation: Placed over upper layer Piano B 40/40 over sleepers. Fastened to sleepers through Piano B 40/40 with screws. Plywood piece joints staggered.
Fasteners: WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing: 610 mm (24 in.) on center



FREQ. (Hz)	TL	ΔTL	DEF.
100	35	0.61	0
125	39	0.61	3
160	38	0.47	7
200	42	0.31	6
250	46	0.31	5
315	50	0.26	4
400	52	0.33	5
500	58	0.24	0
630	61	0.25	0
800	64	0.24	0
1000	68	0.16	0
1250	70	0.12	0
1600	75	0.12	0
2000	79	0.07	0
2500	84	0.08	0
3150	89	0.10	0
4000	90	0.27	0
5000	91	0.18	0

FREQ. = FREQUENCY (1/3 OCTAVE BAND, CENTER), HERTZ
TL = TRANSMISSION LOSS, dB
ΔTL = 95% CONFIDENCE INTERVAL FOR TL MEASUREMENTS, dB
DEF. = DEFICIENCIES, dB BELOW STC CONTOUR
STC **=** SOUND TRANSMISSION LOSS



FREQ. (Hz)	Ln	ΔLn	DEV.
80	--	--	--
100	63	1.39	0
125	68	2.13	5
160	69	1.97	6
200	70	1.85	7
250	68	1.69	5
315	66	3.32	3
400	63	4.06	1
500	60	3.95	0
630	58	3.81	0
800	55	2.27	0
1000	51	2.16	0
1250	46	1.97	0
1600	41	1.31	0
2000	35	2.58	0
2500	29	1.72	0
3150	22	1.91	0
4000	--	--	--

FREQ. = FREQUENCY, HERTZ
Ln = NORMALIZED SOUND PRESSURE LEVEL, dB
ΔLn = 95% UNCERTAINTY LIMIT FOR Ln, dB
DEV. = DEVIATION FROM SHIFTED IIC COUNTOUR, dB
IIC **=** IMPACT INSULATION CLASS

Figure 1 - Specimen mounted in test aperture, as viewed from source room

Figure 2 - Specimen mounted in test aperture, as viewed from receive room

Figure 3 - CLT (1 of 2) prior to installation

Figure 4 - CLT installed in test aperture

Figure 5 - 3/4" x 6" plywood spline partially installed over CLT rabbets

Figure 6 - Detail of 3/4" x 6" plywood spline partially installed over CLT rabbets

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Figure 8 - Piano B 40/40 strip fastened to sleeper prior to installation of sleeper

*All images in Figures 1-8 credit Riverbank Acoustical Laboratories

Figure 9 - Hemp boards prior to installation

Figure 10 - Hemp boards partially installed between sleepers, gravel partially installed over hemp boards

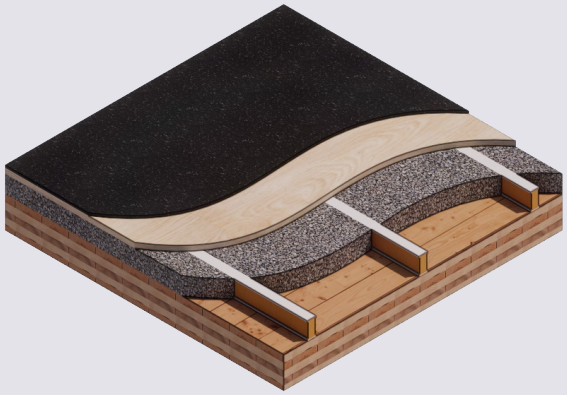
Figure 11 - Hemp boards, gravel, and sleepers installed, Piano B 40/40 strips partially installed over sleepers

Figure 12 - Plywood subfloor partially installed

Figure 13 - Plywood subfloor installed

*All images in Figures 9-13 credit Riverbank Acoustical Laboratories

FLOOR
F03



SPECIMEN MEASUREMENTS

Dimensions: 2.44 m (96.0 in) wide by 3.86 m (152.0 in) high
Thickness: 0.31 m (12.125 in)
Weight: 2493.96 kg (5498.25 lbs)
Overall Area: 9.414 m^2 (101.33 ft^2)
Mass/Unit Area: 264.92 kg/m^2 (54.26 lbs/ft^2)

TEST APERTURE

Opening Size: 4.27 m (14.0 ft) x 6.10 m (20.0 ft)
Filler Wall: Yes
Aperture Size: 2.44 m (96.0 in) wide by 3.86 m (152.0 in) high
Transmission Area: 9.414 m^2 (101.33 ft^2)
Sealed: Entire periphery (both sides) with dense mastic

TEST ENVIRONMENT

Source Room
Volume: 131.12 m^3
Temperature: 22.8°C ±0.0°C
Relative Humidity: 61.0% ± 0.0%

Receive Room
Volume: 81.44 m^3
Temperature: 21.1°C ± 0
Relative Humidity: 61.0% ± 0.0%

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

LAYER 1 - CROSS LAMINATED TIMBER (CLT)

Material: 5-Ply Cross-Laminated Timber
Dimensions: 2 panels @ 1219 mm (48 in.) by 4229 mm (166.5 in.)
Thickness: 171 mm (6.75 in.)
Overall Weight: 953.45 kg (2102 lbs)
Mass / Unit Volume: 539 kg/m^3 (33.7 lbs/ft^3)
Installation: CLT panels laid on 152 mm (6 in.) wide knee walls in test opening and butted to one another without sealant/adhesive. 3/4"x3" Rabbet on top side of one edge of each panel where they butt allowing a loose spline (below) to insert and join the two.

LAYER 2 - 3/4" CDX LOOSE SPLINE

Material: 3/4" x 6" plywood spline
Dimensions:
1 piece @ 151 mm (5.9375 in.) wide by 2438 mm (96 in.)
1 piece @ 151 mm (5.9375 in.) wide by 1791 mm (70.5 in.)
Thickness: 19 mm (0.75 in.)
Overall Weight: 6.46 kg (14.25 lbs)
Mass / Unit Length: 1.53 kg/m (1.03 lbs/ft)
Installation: Set in Rabbets of both CLT's and screwed in place.
Fasteners: WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing: 6" o.c. on a line 3" from each edge of the spline (Centered on the rabbet of the CLT)

LAYER 3- PIANO B 40/40 (LOWER LAYER)

Manufacturer: Rothoblaas
Dimensions:
2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long
8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness: 6.76 mm (0.266 in.)
Overall Weight: 4.59 kg (10.125 lbs)
Mass/Unit Volume: 624 kg/m^3 (40.00 lbs/ft^3)
Installation: Fastened to underside of 2" x 4" wood sleepers with staples
Fasteners: Arrow staples, length @ 13 mm (0.5 in.)

LAYER 4 - 2x4 SPF FRAMING SLEEPERS

Material: Nominal 2x4 framing lumber
Dimensions:
2 pieces @ 38 mm (1.5 in.) wide by 4255 mm (167.5 in. long
8 pieces @ 2369 mm (93.25 in.) wide by 38 mm (1.5 in.) long
Depth: 89 mm (3.5 in.)
Overall Weight: 49.33 kg (108.75 lbs)
Mass / Unit Length: 1.80 kg/m (1.21 lbs/ft)
Installation: Sleepers laid over CLT, resting on lower layer Piano B 40/40. Longer sleepers parallel to CLT like a rim joist. Shorter sleepers set like floor joists between rim joists. Shorter sleepers spaced approx. 610 mm (24 in.) on center. Shorter sleepers fastened to longer sleepers with screws, 2 screws per connection point.
Fasteners: WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)

LAYER 5 - PIANO B 40/40 (UPPER LAYER)

Manufacturer: Rothoblaas
Dimensions:
2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long
8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness: 6.76 mm (0.266 in.)
Overall Weight: 4.59 kg (10.125 lbs)
Mass / Unit Volume: 624 kg/m^3 (40.0 lbs/ft^3)
Installation: Fastened to top of 2" x 4" wood sleepers with staples.
Fasteners: Arrow staples, length @ 13 mm (0.5 in.)

LAYER 6 - CRUSHED LIMESTONE

Material: CA-16 3/8" chip crushed limestone
Dimensions: 2438 mm (96 in.) wide by 4267 mm (168 in.) long, as installed
Depth: 95 mm (3.75 in.)
Overall Weight: 1261.89 kg (2782 lbs)
Installation: Filled stone in between sleepers and used a screed to level to the top of the sleepers.

LAYER 7 - PLYWOOD SUBFLOOR

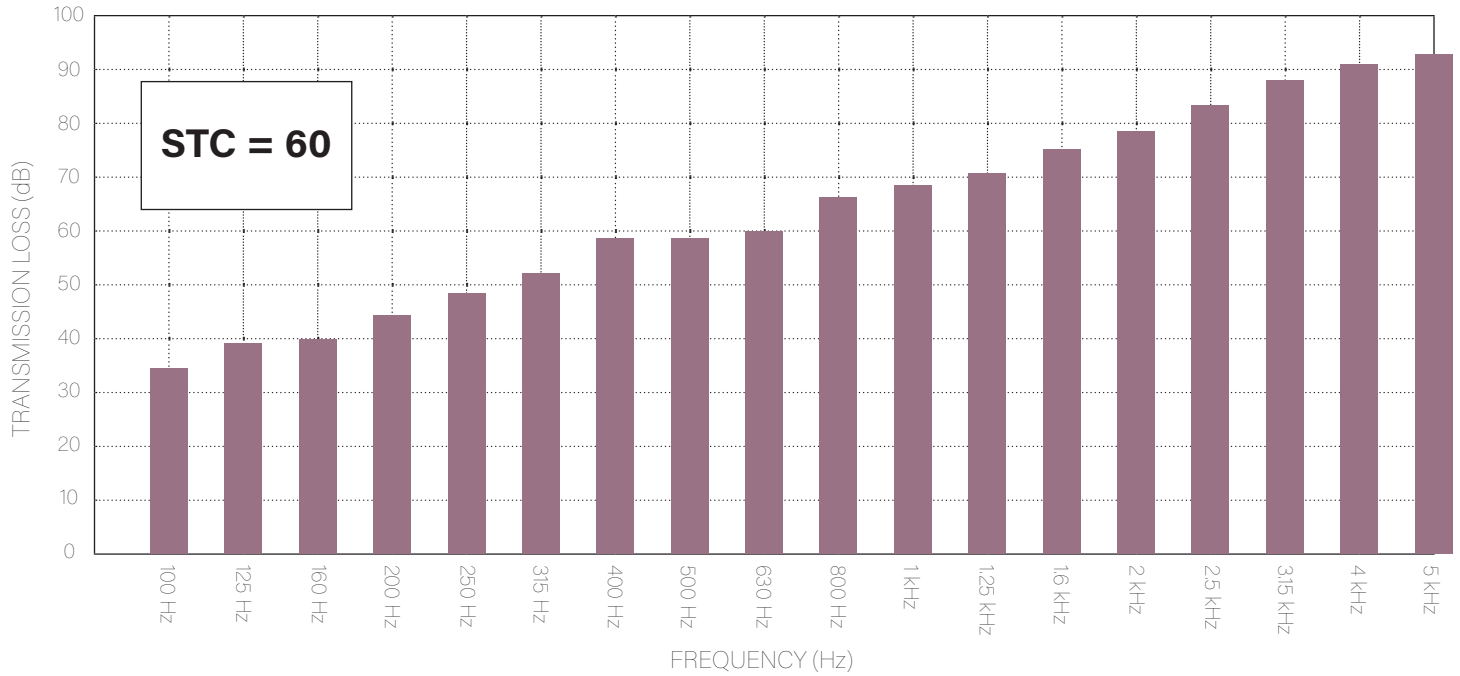
Material: T&G Plywood
Dimensions:
1 piece @ 1219 mm (48 in.) wide by 1829 mm (72 in.)
1 piece @ 1219 mm (48 in.) wide by 2438 mm (96 in.)
1 piece @ 1219 mm (48 in.) wide by 1813 mm (71.375 in.)
1 piece @ 1219 mm (48 in.) wide by 2426 mm (95.5 in.)
Thickness: 29 mm (1.125 in.)
Overall Weight: 176.33 kg (388.75 lbs)
Mass / Unit Volume: 595 kg/m^3 (37.1 lbs/ft^3)
Installation: Placed over upper layer Piano B 40/40 over sleepers. Fastened to sleepers through Piano B 40/40 with screws. Plywood piece joints staggered.
Fasteners: WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing: 610 mm (24 in.) on center

LAYER 8 - ADHESIVE

Material: Sustain 1195 Sheet and Tile adhesive
Manufacturer: Forbo
Dimensions: Approx. 2438 mm (96 in.) by 4267 mm (168 in.) as installed
Overall Weight: 4.54 kg (10 lbs)
Mass / Unit Area: 0.44 kg/m^2 (0.09 lbs/ft^2)
Installation: Troweled directly to plywood with a 1/16x1/16x1/16 square notch trowel
Once troweled, adhesive was left "open" for 7-10 min to allow it to "tack" before flooring was installed.

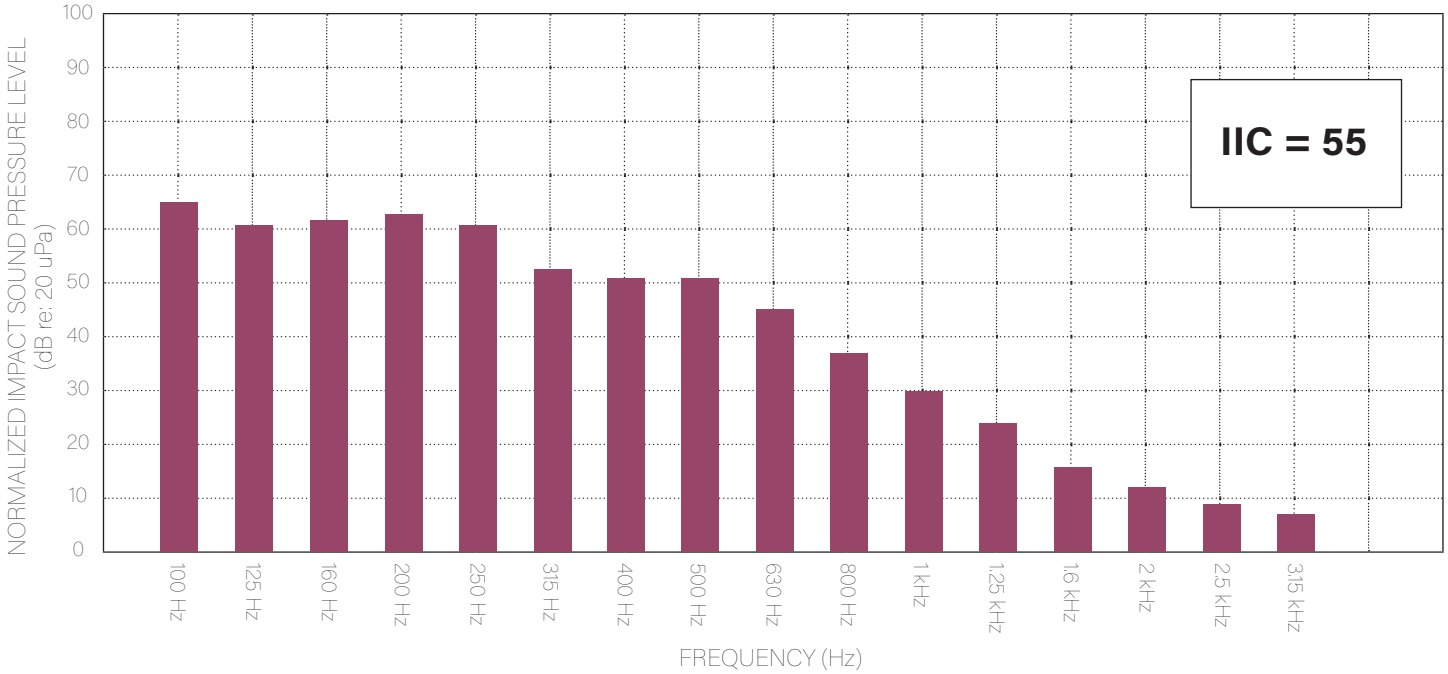
LAYER 9 - FLOORING

Material: Marmoleum Decibel
Manufacturer: Forbo
Dimensions: 2 pieces @ 2007 mm (79 in.) by 2464 mm (97 in.)
Thickness: 6 mm (0.25 in.)
Overall Weight: 32.77 kg (72.25 lbs)
Mass / Unit Volume: 522 kg/m^3 (32.6 lbs/ft^3)
Installation: Two (2) 79" segments perpendicular to Plywood 10" strip to complete. Joints staggered from parallel plywood joints by + 6". Rolled with 100lb roller in each direction.



FREQ. (Hz)	TL	ΔTL	DEF.
100	34	0.58	0
125	39	0.54	5
160	40	0.48	7
200	44	0.40	6
250	48	0.30	5
315	52	0.25	4
400	58	0.25	1
500	58	0.13	2
630	60	0.24	1
800	66	0.16	0
1000	68	0.11	0
1250	71	0.08	0
1600	75	0.09	0
2000	78	0.10	0
2500	83	0.12	0
3150	88	0.09	0
4000	91	0.08	0
5000	93	0.06	0

FREQ. = FREQUENCY (1/3 OCTAVE BAND, CENTER), HERTZ
TL = TRANSMISSION LOSS, dB
ΔTL = 95% CONFIDENCE INTERVAL FOR TL MEASUREMENTS, dB
DEF. = DEFICIENCIES, dB BELOW STC CONTOUR
STC **=** SOUND TRANSMISSION LOSS



FREQ. (Hz)	Ln	ΔLn	DEV.
80	--	--	--
100	65	2.37	8
125	61	1.71	4
160	62	1.33	5
200	63	1.54	6
250	61	2.48	4
315	53	1.56	0
400	51	1.92	0
500	51	1.15	0
630	45	2.12	0
800	37	2.08	0
1000	30	2.33	0
1250	24	3.16	0
1600	16	1.16	0
2000	12	0.88	0
2500	9*	1.02	0
3150	7**	1.31	0
4000	--	--	--

FREQ. = FREQUENCY, HERTZ
Ln = NORMALIZED SOUND PRESSURE LEVEL, dB
ΔLn = 95% UNCERTAINTY LIMIT FOR Ln, dB
DEV. = DEVIATION FROM SHIFTED IIC COUNTOUR, dB
IIC = IMPACT INSULATION CLASS

*Level corrected due to background noise per E492 SEC 10.2.2
**Level corrected due to background noise per E492 SEC 10.2.3

Figure 1 - Specimen mounted in test aperture, as viewed from source room

Figure 2 - Specimen mounted in test aperture, as viewed from receive room

Figure 3 - CLT (1 of 2) prior to installation

Figure 4 - CLT installed in test aperture

Figure 5 - 3/4" x 6" plywood spline partially installed over CLT rabbets

Figure 6 - Detail of 3/4" x 6" plywood spline partially installed over CLT rabbets

Figure 7 - 2"x4" sleepers partially installed, with Piano B 40/40 fastened to underside of sleepers

Figure 8 - Piano B 40/40 strip fastened to sleeper prior to installation of sleeper

*All images in Figures 1-8 credit Riverbank Acoustical Laboratories

Figure 9 - Gravel partially installed in gaps between sleepers

Figure 10 - Gravel installed; Piano B 40/40 partially installed to top of sleepers

Figure 11 - Gravel and sleepers with Piano B 40/40 installed

Figure 12 - Plywood subfloor partially installed

Figure 13 - Plywood subfloor installed

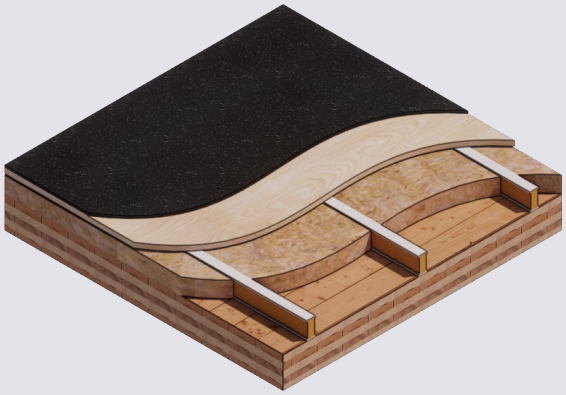
Figure 14 - Trowel used for installation of adhesive

Figure 15 - Adhesive being troweled over plywood prior to installation of flooring

Figure 16 - Flooring partially installed

*All images in Figures 9-16 credit Riverbank Acoustical Laboratories

FLOOR F04



SPECIMEN MEASUREMENTS

Dimensions: 2.44 m (96.0 in) wide by 3.86 m (152.0 in) high
Thickness: 0.31 m (12.125 in)
Weight: 1264.73 kg (2788.25 lbs)
Overall Area: 9.414 m^2 (101.33 ft^2)
Mass/Unit Area: 121.55 kg/m^2 (24.90 lbs/ft^2)

TEST APERTURE

Opening Size: 4.27 m (14.0 ft) x 6.10 m (20.0 ft)
Filler Wall: Yes
Aperture Size: 2.44 m (96.0 in) wide by 3.86 m (152.0 in) high
Transmission Area: 9.414 m^2 (101.33 ft^2)
Sealed: Entire periphery (both sides) with dense mastic

TEST ENVIRONMENT

Source Room
Volume: 131.12 m^3
Temperature: 23.3°C ±0.0°C
Relative Humidity: 60.0% ± 0.0%

Receive Room
Volume: 81.44 m^3
Temperature: 22.2°C ± 0.0°C
Relative Humidity: 62.0% ± 0.0%

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

LAYER 1 - CROSS LAMINATED TIMBER (CLT)

Material: 5-Ply Cross-Laminated Timber
Dimensions: 2 panels @ 1219 mm (48 in.) by 4229 mm (166.5 in.)
Thickness: 171 mm (6.75 in.)
Overall Weight: 953.45 kg (2102 lbs)
Mass / Unit Volume: 539 kg/m^3 (33.7 lbs/ft^3)
Installation: CLT panels laid on 152 mm (6 in.) wide knee walls in test opening and butted to one another without sealant/adhesive. 3/4"x3" Rabbet on top side of one edge of each panel where they butt allowing a loose spline (below) to insert and join the two.

LAYER 2 - 3/4" CDX LOOSE SPLINE

Material: 3/4" x 6" plywood spline
Dimensions:
1 piece @ 151 mm (5.9375 in.) wide by 2438 mm (96 in.)
1 piece @ 151 mm (5.9375 in.) wide by 1791 mm (70.5 in.)
Thickness: 19 mm (0.75 in.)
Overall Weight: 6.46 kg (14.25 lbs)
Mass / Unit Length: 1.53 kg/m (1.03 lbs/ft)
Installation: Set in Rabbets of both CLT's and screwed in place.
Fasteners: WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing: 6" o.c. on a line 3" from each edge of the spline (Centered on the rabbet of the CLT)

LAYER 3 - PIANO B 40/40 (LOWER LAYER)

Manufacturer: Rothoblaas
Dimensions:
2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long
8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness: 6.76 mm (0.266 in.)
Overall Weight: 4.59 kg (10.125 lbs)
Mass/Unit Volume: 624 kg/m^3 (40.00 lbs/ft^3)
Installation: Fastened to underside of 2" x 4" wood sleepers with staples
Fasteners: Arrow staples, length @ 13 mm (0.5 in.)

LAYER 4 - 2x4 SPF FRAMING SLEEPERS

Material: Nominal 2x4 framing lumber
Dimensions:
2 pieces @ 38 mm (1.5 in.) wide by 4255 mm (167.5 in. long
8 pieces @ 2369 mm (93.25 in.) wide by 38 mm (1.5 in.) long
Depth: 89 mm (3.5 in.)
Overall Weight: 49.33 kg (108.75 lbs)
Mass / Unit Length: 1.80 kg/m (1.21 lbs/ft)
Installation: Sleepers laid over CLT, resting on lower layer Piano B 40/40. Longer sleepers parallel to CLT like a rim joist. Shorter sleepers set like floor joists between rim joists. Shorter sleepers spaced approx. 610 mm (24 in.) on center. Shorter sleepers fastened to longer sleepers with screws, 2 screws per connection point.
Fasteners: WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)

LAYER 5 - PIANO B 40/40 (UPPER LAYER)

Manufacturer: Rothoblaas
Dimensions:
2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long
8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness: 6.76 mm (0.266 in.)
Overall Weight: 4.59 kg (10.125 lbs)
Mass/Unit Volume: 624 kg/m^3 (40.0 lbs/ft^3)
Installation: Fastened to top of 2" x 4" wood sleepers with staples.
Fasteners: Arrow staples, length @ 13 mm (0.5 in.)

LAYER 6 - HEMPBOARD

Manufacturer: Hempitecture
Dimensions:
7 pieces @ 572 mm (22.5 in.) wide by 2369 mm (93.25 in.) long
Thickness: 76 mm (3 in.)
Overall Weight: 37.53 kg (82.75 lbs)
Mass/Unit Volume: 52 kg/m^3 (3.25 lbs/ft^3)
Installation: Friction fit between sleepers on top of CLT.

LAYER 7 - PLYWOOD SUBFLOOR

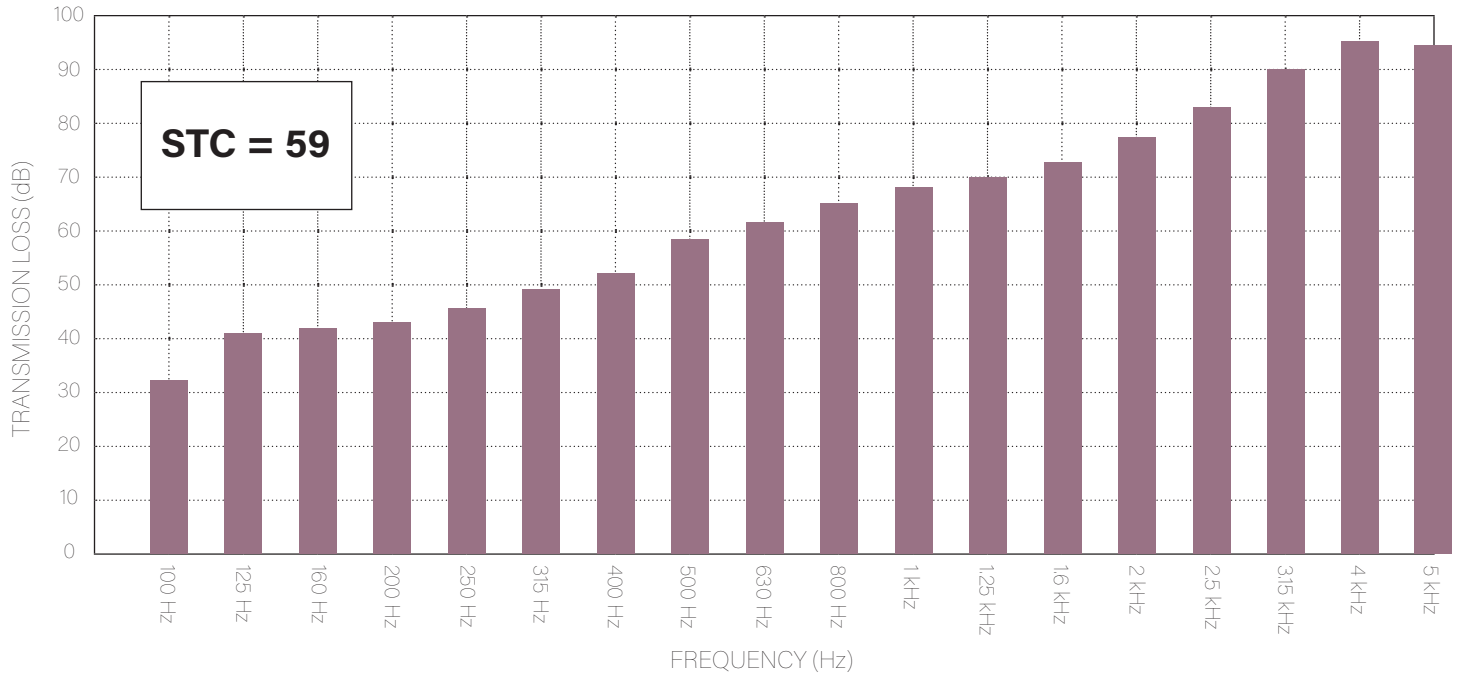
Material: T&G Plywood
Dimensions:
1 piece @ 1219 mm (48 in.) wide by 1829 mm (72 in.)
1 piece @ 1219 mm (48 in.) wide by 2438 mm (96 in.)
1 piece @ 1219 mm (48 in.) wide by 1822 mm (71.75 in.)
1 piece @ 1219 mm (48 in.) wide by 2432 mm (95.75 in.)
Thickness: 29 mm (1.125 in.)
Overall Weight: 172.25 kg (379.75 lbs)
Mass / Unit Volume: 580 kg/m^3 (36.2 lbs/ft^3)
Installation: Placed over upper layer Piano B 40/40 over sleepers. Fastened to sleepers through Piano B 40/40 with screws. Plywood piece joints staggered.
Fasteners: WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing: 610 mm (24 in.) on center

LAYER 8 - ADHESIVE

Material: Sustain 1195 Sheet and Tile adhesive
Manufacturer: Forbo
Dimensions: Approx. 2438 mm (96 in.) by 4267 mm (168 in.) as installed
Overall Weight: 4.2 kg (9.25 lbs)
Mass / Unit Area: 0.4 kg/m^2 (0.08 lbs/ft^2)
Installation: Troweled directly to plywood with a 1/16x1/16x1/16 square notch trowel
Once troweled, adhesive was left "open" for 15 min to allow it to "tack" before flooring was installed.

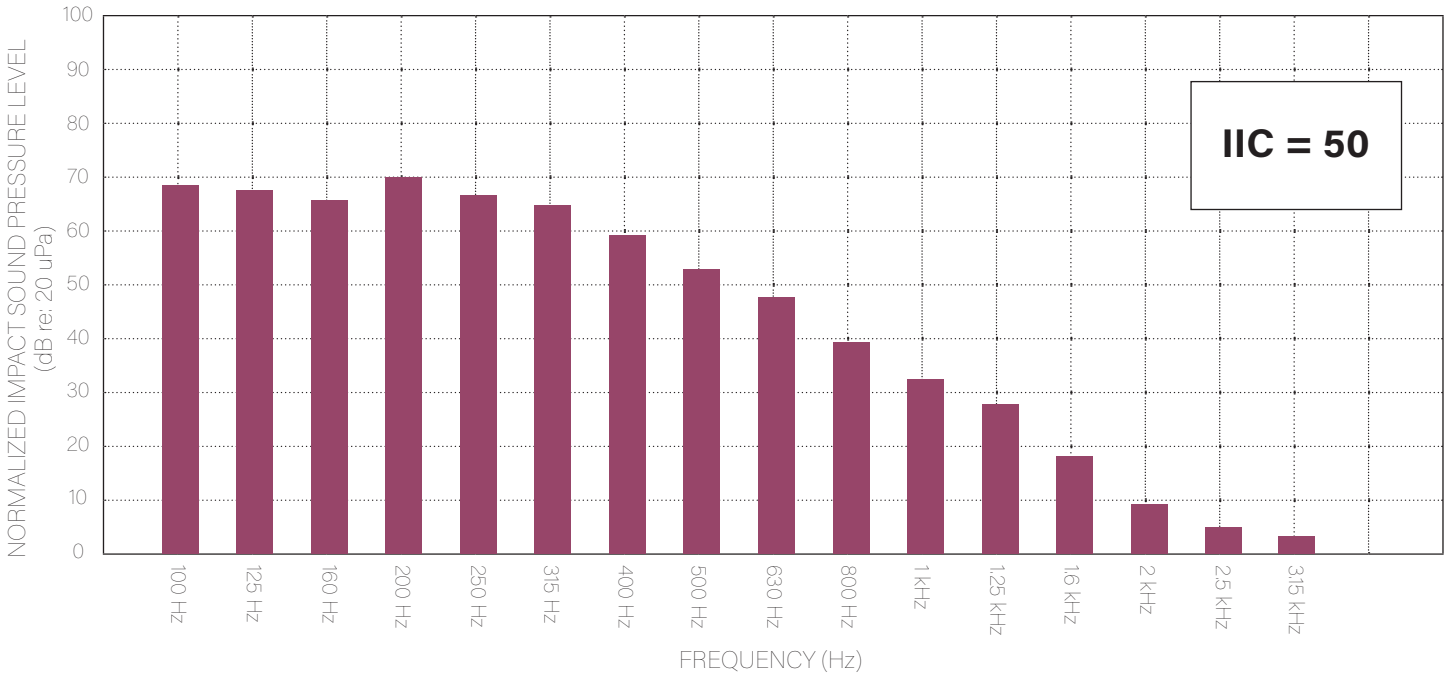
LAYER 9 - FLOORING

Material: Marmoleum Decibel
Manufacturer: Forbo
Dimensions: 2 pieces @ 2007 mm (79 in.) by 2464 mm (97 in.)
Thickness: 6 mm (0.25 in.)
Overall Weight: 32.32 kg (71.25 lbs)
Mass / Unit Volume: 484 kg/m^3 (30.2 lbs/ft^3)
Installation: Two (2) 79" segments perpendicular to Plywood 10" strip to complete. Joints staggered from parallel plywood joints by + 6". Rolled with 100lb roller in each direction.



FREQ. (Hz)	TL	ΔTL	DEF.
100	32	0.80	0
125	41	0.67	2
160	42	0.58	4
200	43	0.40	6
250	46	0.25	6
315	49	0.36	6
400	52	0.19	6
500	58	0.16	1
630	62	0.21	0
800	65	0.21	0
1000	68	0.11	0
1250	70	0.11	0
1600	73	0.10	0
2000	77	0.08	0
2500	83	0.08	0
3150	90	0.05	0
4000	95	0.09	0
5000	94	0.06	0

FREQ. = FREQUENCY (1/3 OCTAVE BAND, CENTER), HERTZ
TL = TRANSMISSION LOSS, dB
ΔTL = 95% CONFIDENCE INTERVAL FOR TL MEASUREMENTS, dB
DEF. = DEFICIENCIES, dB BELOW STC CONTOUR
STC **=** SOUND TRANSMISSION LOSS



FREQ. (Hz)	Ln	ΔLn	DEV.
80	--	--	--
100	68	1.66	
125	67	3.45	
160	65	3..12	
200	70	4.14	
250	66	2.19	
315	64	2.22	
400	59	1.47	
500	53	2.03	
630	47	1.73	
800	39	1.77	
1000	33	0.77	
1250	27	0.80	
1600	17	1.86	
2000	9**	1.03	
2500	5**	0.78	
3150	3**	0.95	
4000	--	--	--

FREQ. = FREQUENCY, HERTZ
Ln = NORMALIZED SOUND PRESSURE LEVEL, dB
ΔLn = 95% UNCERTAINTY LIMIT FOR Ln, dB
DEV. = DEVIATION FROM SHIFTED IIC COUNTOUR, dB
IIC = IMPACT INSULATION CLASS

*Level corrected due to background noise per E492 SEC 10.2.2
**Level corrected due to background noise per E492 SEC 10.2.3

Figure 1 - Specimen mounted in test aperture, as viewed from source room

Figure 2 - Specimen mounted in test aperture, as viewed from receive room

Figure 3 - CLT (1 of 2) prior to installation

Figure 4 - CLT installed in test aperture

Figure 5 - 3/4" x 6" plywood spline partially installed over CLT rabbets

Figure 6 - Detail of 3/4" x 6" plywood spline partially installed over CLT rabbets

Figure 7 - 2"x4" sleepers partially installed, with Piano B 40/40 fastened to underside of sleepers

Figure 8 - Piano B 40/40 strip fastened to sleeper prior to installation of sleeper

*All images in Figures 1-8 credit Riverbank Acoustical Laboratories

Figure 9 - Hemp boards prior to installation

Figure 10 - Hemp boards partially installed between sleepers

Figure 11 - Hemp boards partially installed between sleepers, plywood partially installed over sleepers

Figure 12 - Trowel used for installation of adhesive

Figure 13 - Plywood subfloor installed, adhesive partially installed over plywood

Figure 14 - Flooring partially installed over adhesive

*All images in Figures 9-14 credit Riverbank Acoustical Laboratories

FLOOR
F05

SPECIMEN MEASUREMENTS

Dimensions: 2.44 m (96.0 in) wide by 3.86 m (152.0 in) high
Thickness: 0.3 m (11.875 in)
Weight: 1228.21 kg (2707.75 lbs)
Overall Area: 9.414 m^2 (101.33 ft^2)
Mass/Unit Area: 118.04 kg/m^2 (24.18 lbs/ft^2)

TEST APERTURE

Opening Size: 4.27 m (14.0 ft) x 6.10 m (20.0 ft)
Filler Wall: Yes
Aperture Size: 2.44 m (96.0 in) wide by 3.86 m (152.0 in) high
Transmission Area: 9.414 m^2 (101.33 ft^2)
Sealed: Entire periphery (both sides) with dense mastic

TEST ENVIRONMENT

Source Room
Volume: 131.12 m^3
Temperature: 22.8°C ±0.0°C
Relative Humidity: 65.0% ± 0.0%

Receive Room
Volume: 81.44 m^3
Temperature: 22.2°C ± 0.0°C
Relative Humidity: 64.0% ± 0.0%

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

LAYER 1 - CROSS LAMINATED TIMBER (CLT)

Material: 5-Ply Cross-Laminated Timber
Dimensions: 2 panels @ 1219 mm (48 in.) by 4229 mm (166.5 in.)
Thickness: 171 mm (6.75 in.)
Overall Weight: 953.45 kg (2102 lbs)
Mass / Unit Volume: 539 kg/m^3 (33.7 lbs/ft^3)
Installation: CLT panels laid on 152 mm (6 in.) wide knee walls in test opening and butted to one another without sealant/adhesive. 3/4"x3" Rabbet on top side of one edge of each panel where they butt allowing a loose spline (below) to insert and join the two.

LAYER 2 - 3/4" CDX LOOSE SPLINE

Material: 3/4" x 6" plywood spline
Dimensions:
1 piece @ 151 mm (5.9375 in.) wide by 2438 mm (96 in.)
1 piece @ 151 mm (5.9375 in.) wide by 1791 mm (70.5 in.)
Thickness: 19 mm (0.75 in.)
Overall Weight: 6.46 kg (14.25 lbs)
Mass / Unit Length: 1.53 kg/m (1.03 lbs/ft)
Installation: Set in Rabbets of both CLT's and screwed in place.
Fasteners: WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing: 6" o.c. on a line 3" from each edge of the spline (Centered on the rabbet of the CLT)

LAYER 3 - PIANO B 40/40 (LOWER LAYER)

Manufacturer: Rothoblaas
Dimensions:
2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long
8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness: 6.76 mm (0.266 in.)
Overall Weight: 4.59 kg (10.125 lbs)
Mass/Unit Volume: 624 kg/m^3 (40.00 lbs/ft^3)
Installation: Fastened to underside of 2" x 4" wood sleepers with staples
Fasteners: Arrow staples, length @ 13 mm (0.5 in.)

LAYER 4 - 2x4 SPF FRAMING SLEEPERS

Material: Nominal 2x4 framing lumber
Dimensions:
2 pieces @ 38 mm (1.5 in.) wide by 4255 mm (167.5 in. long
8 pieces @ 2369 mm (93.25 in.) wide by 38 mm (1.5 in.) long
Depth: 89 mm (3.5 in.)
Overall Weight: 49.33 kg (108.75 lbs)
Mass / Unit Length: 1.80 kg/m (1.21 lbs/ft)
Installation: Sleepers laid over CLT, resting on lower layer Piano B 40/40. Longer sleepers parallel to CLT like a rim joist. Shorter sleepers set like floor joists between rim joists. Shorter sleepers spaced approx. 610 mm (24 in.) on center. Shorter sleepers fastened to longer sleepers with screws, 2 screws per connection point.
Fasteners: WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)

LAYER 5 - PIANO B 40/40 (UPPER LAYER)

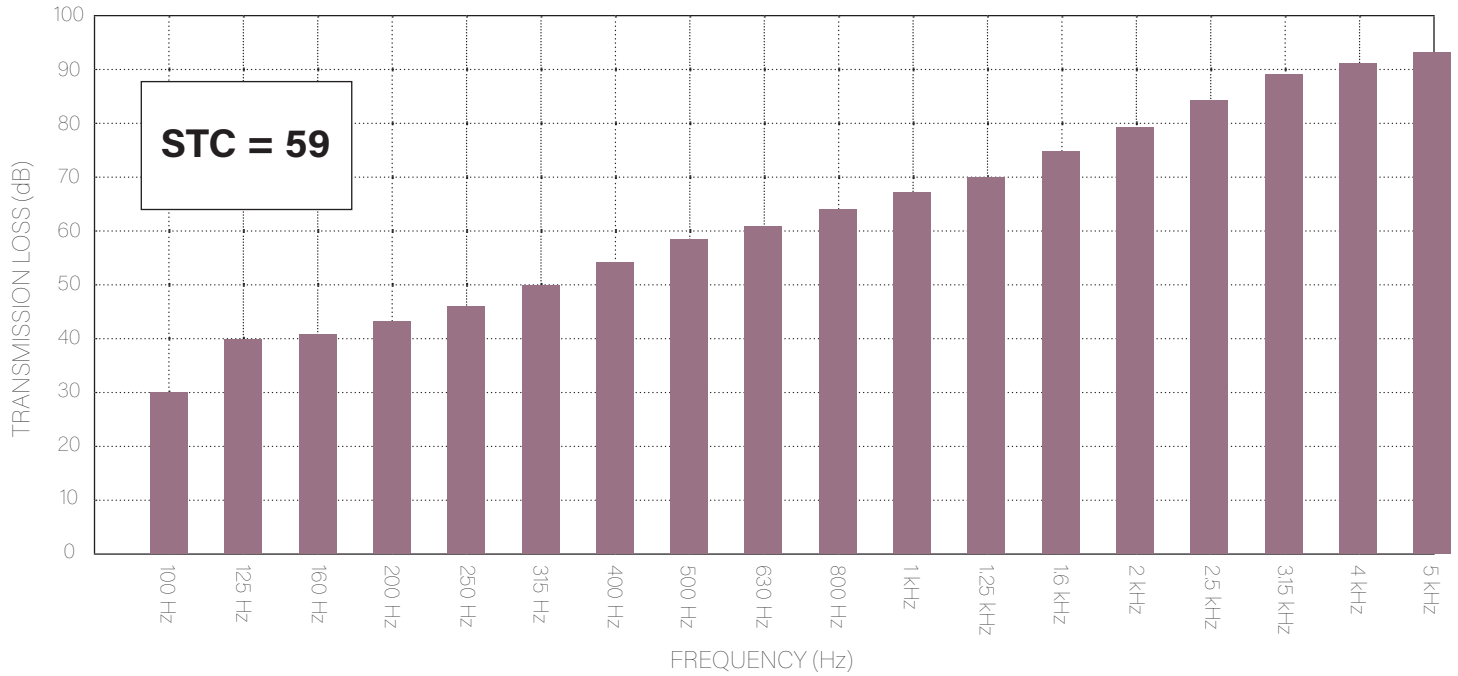
Manufacturer: Rothoblaas
Dimensions:
2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long
8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness: 6.76 mm (0.266 in.)
Overall Weight: 4.59 kg (10.125 lbs)
Mass/Unit Volume: 624 kg/m^3 (40.0 lbs/ft^3)
Installation: Fastened to top of 2” x 4” wood sleepers with staples.
Fasteners: Arrow staples, length @ 13 mm (0.5 in.)

LAYER 6 - HEMPBOARD

Manufacturer: Hempitecture
Dimensions:
7 pieces @ 572 mm (22.5 in.) wide by 2369 mm (93.25 in.) long
Thickness: 76 mm (3 in.)
Overall Weight: 37.53 kg (82.75 lbs)
Mass/Unit Volume: 52 kg/m^3 (3.25 lbs/ft^3)
Installation: Friction fit between sleepers on top of CLT.

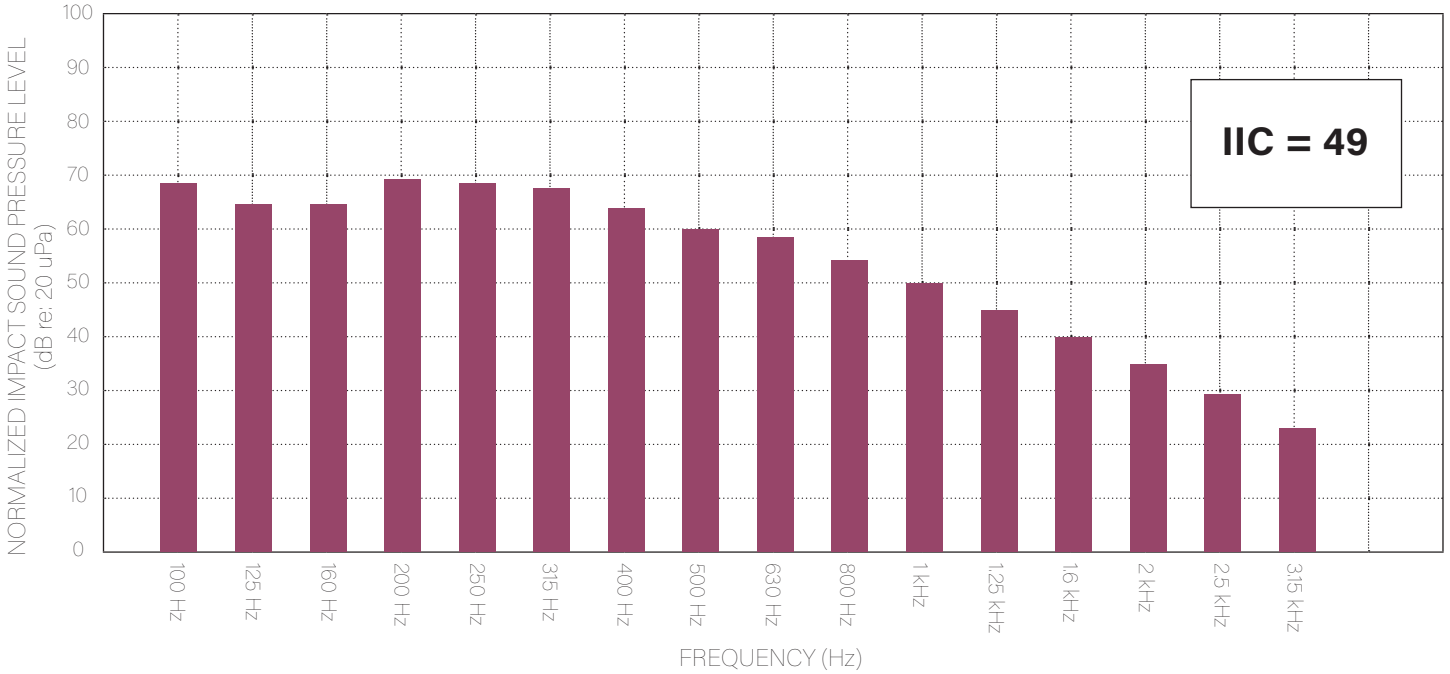
LAYER 7 - PLYWOOD SUBFLOOR

Material: T&G Plywood
Dimensions:
1 piece @ 1219 mm (48 in.) wide by 1829 mm (72 in.)
1 piece @ 1219 mm (48 in.) wide by 2438 mm (96 in.)
1 piece @ 1219 mm (48 in.) wide by 1822 mm (71.75 in.)
1 piece @ 1219 mm (48 in.) wide by 2432 mm (95.75 in.)
Thickness: 29 mm (1.125 in.)
Overall Weight: 172.25 kg (379.75 lbs)
Mass / Unit Volume: 580 kg/m^3 (36.2 lbs/ft^3)
Installation: Placed over upper layer Piano B 40/40 over sleepers. Fastened to sleepers through Piano B 40/40 with screws. Plywood piece joints staggered.
Fasteners: WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing: 610 mm (24 in.) on center



FREQ. (Hz)	TL	ΔTL	DEF.
100	30	0.46	0
125	40	0.58	3
160	41	0.52	5
200	43	0.31	6
250	46	0.19	6
315	50	0.24	5
400	54	0.21	4
500	58	0.20	1
630	61	0.16	0
800	64	0.12	0
1000	67	0.11	0
1250	70	0.13	0
1600	75	0.09	0
2000	79	0.08	0
2500	84	0.11	0
3150	89	0.08	0
4000	91	0.05	0
5000	93	0.07	0

FREQ. = FREQUENCY (1/3 OCTAVE BAND, CENTER), HERTZ
TL = TRANSMISSION LOSS, dB
ΔTL = 95% CONFIDENCE INTERVAL FOR TL MEASUREMENTS, dB
DEF. = DEFICIENCIES, dB BELOW STC CONTOUR
STC **=** SOUND TRANSMISSION LOSS



FREQ. (Hz)	Ln	ΔLn	DEV.
80	--	--	--
100	68	3.09	5
125	65	2.00	2
160	65	1.54	2
200	69	2.42	6
250	68	2.37	5
315	67	3.09	4
400	64	4.57	2
500	60	4.74	0
630	58	4.37	0
800	54	2.98	0
1000	50	2.82	0
1250	45	2.36	0
1600	40	1.71	0
2000	35	1.29	0
2500	29	0.94	0
3150	23	1.11	0
4000	--	--	--

FREQ. = FREQUENCY, HERTZ
Ln = NORMALIZED SOUND PRESSURE LEVEL, dB
ΔLn = 95% UNCERTAINTY LIMIT FOR Ln, dB
DEV. = DEVIATION FROM SHIFTED IIC COUNTOUR, dB
IIC **=** IMPACT INSULATION CLASS

Figure 1 - Specimen mounted in test aperture, as viewed from source room

Figure 2 - Specimen mounted in test aperture, as viewed from receive room

Figure 3 - CLT (1 of 2) prior to installation

Figure 4 - CLT installed in test aperture

Figure 5 - 3/4" x 6" plywood spline partially installed over CLT rabbets

Figure 6 - Detail of 3/4" x 6" plywood spline partially installed over CLT rabbets

Figure 7 - 2"x4" sleepers partially installed, with Piano B 40/40 fastened to underside of sleepers

Figure 8 - Piano B 40/40 strip fastened to sleeper prior to installation of sleeper

*All images in Figures 1-8 credit Riverbank Acoustical Laboratories

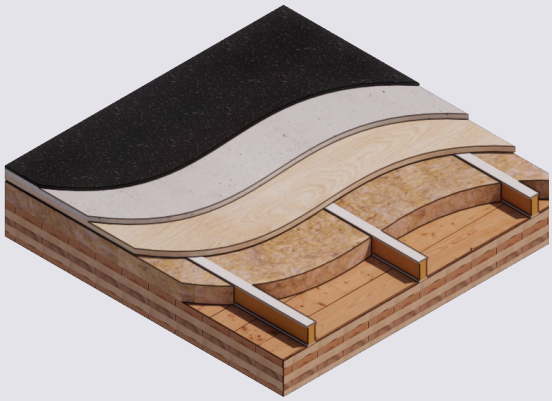
Figure 9 - Hemp boards prior to installation

Figure 10 - Hemp boards partially installed between sleepers

Figure 11 - Hemp boards partially installed between sleepers, plywood partially installed over sleepers

*All images in Figures 9-11 credit Riverbank Acoustical Laboratories

FLOOR
F06



SPECIMEN MEASUREMENTS

Dimensions: 2.44 m (96.0 in) wide by 3.86 m (152.0 in) high
Thickness: 0.33 m (13.125 in)
Weight: 1734.31 kg (3823.5 lbs)
Overall Area: 9.414 m^2 (101.33 ft^2)
Mass/Unit Area: 166.68 kg/m^2 (34.14 lbs/ft^2)

TEST APERTURE

Opening Size: 4.27 m (14.0 ft) x 6.10 m (20.0 ft)
Filler Wall: Yes
Aperture Size: 2.44 m (96.0 in) wide by 3.86 m (152.0 in) high
Transmission Area: 9.414 m^2 (101.33 ft^2)
Sealed: Entire periphery (both sides) with dense mastic

TEST ENVIRONMENT

Source Room
Volume: 130.9 m^3
Temperature: 22.2°C ±0.0°C
Relative Humidity: 62.0% ± 2.0%

Receive Room
Volume: 81.44 m^3
Temperature: 21.7°C ± 0.0°C
Relative Humidity: 64.0% ± 0.0%

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

LAYER 1 - CROSS LAMINATED TIMBER (CLT)

Material: 5-Ply Cross-Laminated Timber
Dimensions: 2 panels @ 1219 mm (48 in.) by 4229 mm (166.5 in.)
Thickness: 171 mm (6.75 in.)
Overall Weight: 953.45 kg (2102 lbs)
Mass / Unit Volume: 539 kg/m^3 (33.7 lbs/ft^3)
Installation: CLT panels laid on 152 mm (6 in.) wide knee walls in test opening and butted to one another without sealant/adhesive. 3/4"x3" Rabbet on top side of one edge of each panel where they butt allowing a loose spline (below) to insert and join the two.

LAYER 2 - 3/4" CDX LOOSE SPLINE

Material: 3/4" x 6" plywood spline
Dimensions:
1 piece @ 151 mm (5.9375 in.) wide by 2438 mm (96 in.)
1 piece @ 151 mm (5.9375 in.) wide by 1791 mm (70.5 in.)
Thickness: 19 mm (0.75 in.)
Overall Weight: 6.46 kg (14.25 lbs)
Mass / Unit Length: 1.53 kg/m (1.03 lbs/ft)
Installation: Set in Rabbets of both CLT's and screwed in place.
Fasteners: WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing: 6" o.c. on a line 3" from each edge of the spline (Centered on the rabbet of the CLT)

LAYER 3 - PIANO B 40/40 (LOWER LAYER)

Manufacturer: Rothoblaas
Dimensions:
2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long
8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness: 6.76 mm (0.266 in.)
Overall Weight: 4.59 kg (10.125 lbs)
Mass/Unit Volume: 624 kg/m^3 (40.00 lbs/ft^3)
Installation: Fastened to underside of 2" x 4" wood sleepers with staples
Fasteners: Arrow staples, length @ 13 mm (0.5 in.)

LAYER 4 - 2x4 SPF FRAMIN SLEEPERS

Material: Nominal 2x4 framing lumber
Dimensions:
2 pieces @ 38 mm (1.5 in.) wide by 4255 mm (167.5 in. long
8 pieces @ 2369 mm (93.25 in.) wide by 38 mm (1.5 in.) long
Depth: 89 mm (3.5 in.)
Overall Weight: 49.33 kg (108.75 lbs)
Mass / Unit Length: 1.80 kg/m (1.21 lbs/ft)
Installation: Sleepers laid over CLT, resting on lower layer Piano B 40/40. Longer sleepers parallel to CLT like a rim joist. Shorter sleepers set like floor joists between rim joists. Shorter sleepers spaced approx. 610 mm (24 in.) on center. Shorter sleepers fastened to longer sleepers with screws, 2 screws per connection point.
Fasteners: WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)

LAYER 5 - PIANO B 40/40 (UPPER LAYER)

Manufacturer: Rothoblaas
Dimensions:
2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long
8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness: 6.76 mm (0.266 in.)
Overall Weight: 4.59 kg (10.125 lbs)
Mass/Unit Volume: 624 kg/m^3 (40.0 lbs/ft^3)
Installation: Fastened to top of 2" x 4" wood sleepers with staples.
Fasteners: Arrow staples, length @ 13 mm (0.5 in.)

LAYER 6 - HEMPBOARD

Manufacturer: Hempitecture
Dimensions:
7 pieces @ 572 mm (22.5 in.) wide by 2369 mm (93.25 in.) long
Thickness: 76 mm (3 in.)
Overall Weight: 37.53 kg (82.75 lbs)
Mass/Unit Volume: 52 kg/m^3 (3.25 lbs/ft^3)
Installation: Friction fit between sleepers on top of CLT.

LAYER 7 - PLYWOOD SUBFLOOR

Material: T&G Plywood
Dimensions:
1 piece @ 1219 mm (48 in.) wide by 1829 mm (72 in.)
1 piece @ 1219 mm (48 in.) wide by 2438 mm (96 in.)
1 piece @ 1219 mm (48 in.) wide by 1822 mm (71.75 in.)
1 piece @ 1219 mm (48 in.) wide by 2432 mm (95.75 in.)
Thickness: 29 mm (1.125 in.)
Overall Weight: 173.5 kg (382.5 lbs)
Mass / Unit Volume: 584 kg/m^3 (36.5 lbs/ft^3)
Installation: Placed over upper layer Piano B 40/40 over sleepers. Fastened to sleepers through Piano B 40/40 with screws. Plywood piece joints staggered.
Fasteners: WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing: 610 mm (24 in.) on center

LAYER 8 - GYPCRETE

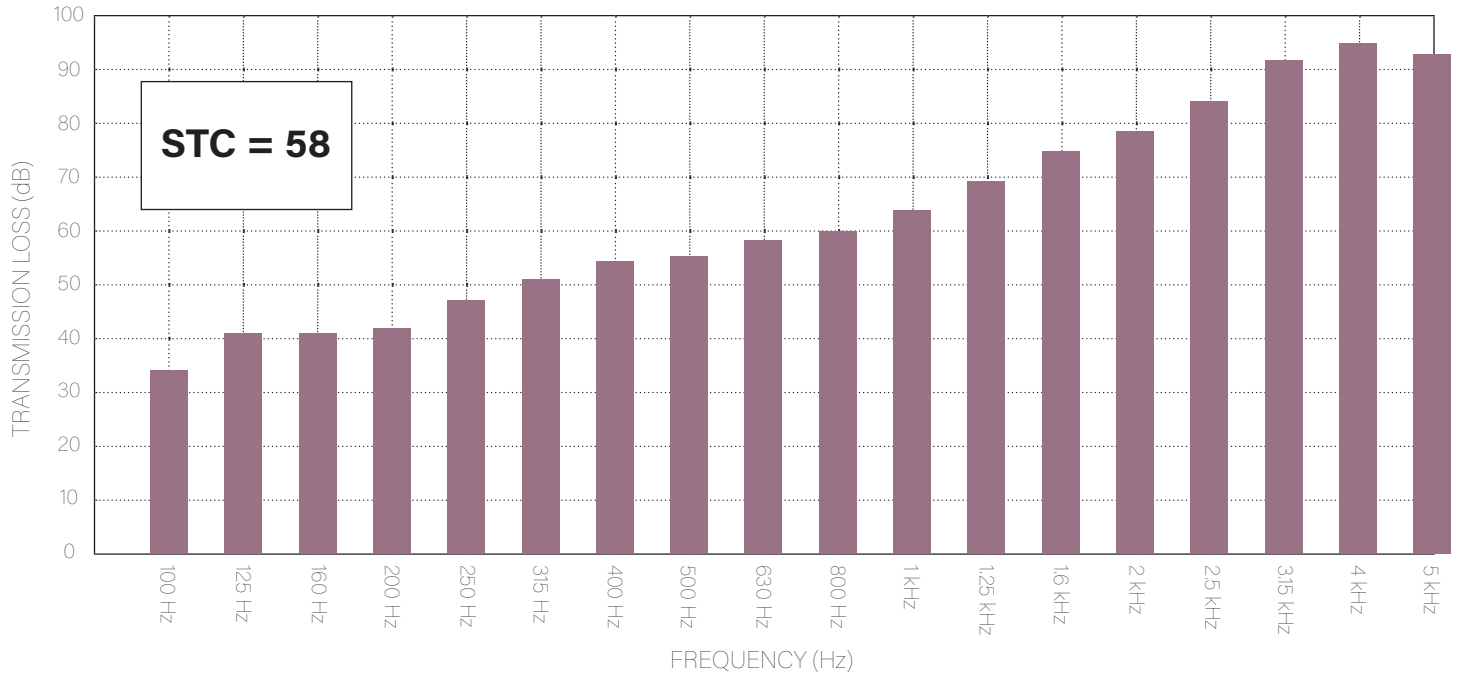
Manufacturer: Maxxon
Dimensions:
2438 mm (96 in.) by 4267 mm (168 in.) as installed
Thickness: Approx. 25 mm (1 in.)
Mix Ratio: 2.5 gal. water / 40 lbs gypcrete / 75 lbs. all-purpose sand
Overall Weight: 469.47 kg (1035 lbs)
Mass/Unit Volume: 1780 kg/m^3 (111 lbs/ft^3)
Installation: Poured over plywood subfloor. Gauge rake was used to level produt to 1" of thickness. Wet gypcrete mix was poured on (2024.07.01, approx. 3:40pm)

LAYER 9 - ADHESIVE

Material: Sustain 1195 Sheet and Tile adhesive
Manufacturer: Forbo
Dimensions: Approx. 2438 mm (96 in.) by 4267 mm (168 in.) as installed
Overall Weight: 2.95 kg (6.5 lbs)
Mass / Unit Area: 0.28 kg/m^2 (0.06 lbs/ft^2)
Installation: Troweled directly to plywood with a 1/16x1/16x1/16 square notch trowel
Once troweled, adhesive was left "open" for 15 min to allow it to "tack" before flooring was installed.

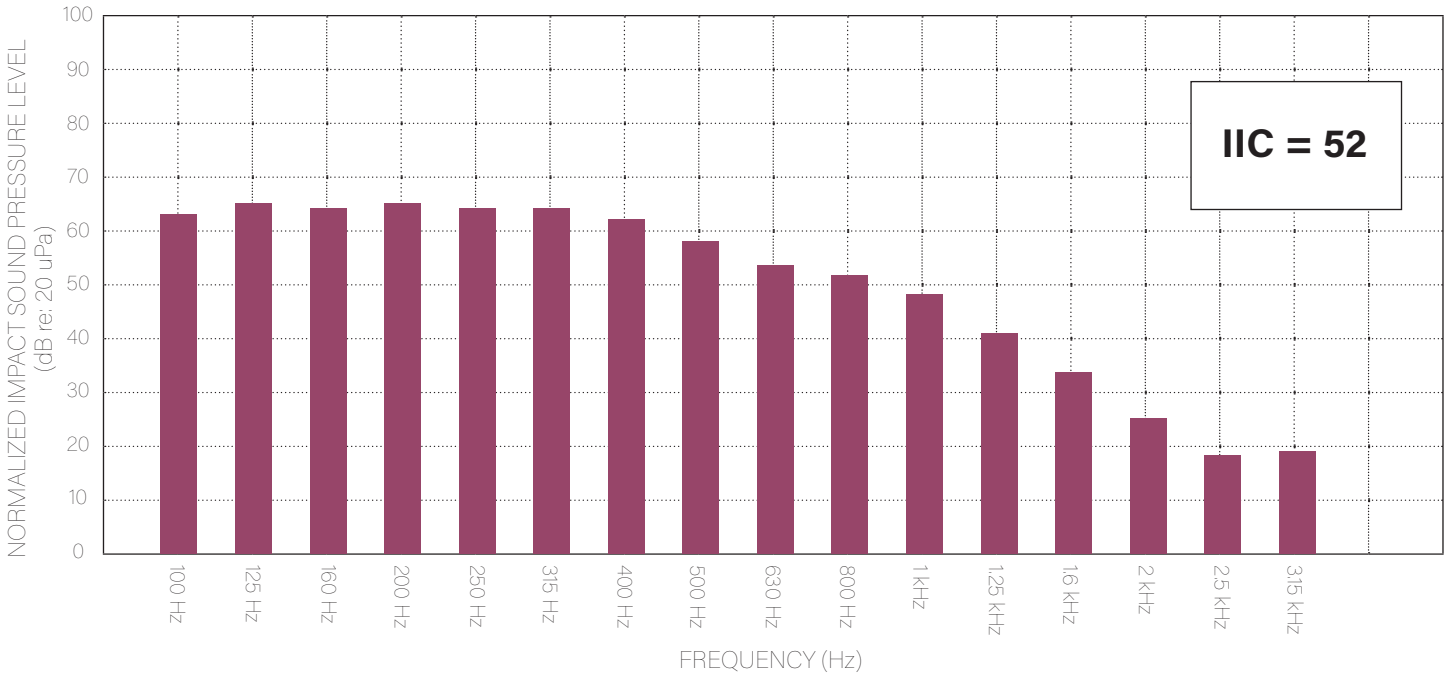
LAYER 10 - FLOORING

Material: Marmoleum Decibel
Manufacturer: Forbo
Dimensions: 2 pieces @ 2007 mm (79 in.) by 2464 mm (97 in.)
Thickness: 6 mm (0.25 in.)
Overall Weight: 35.38 kg (78 lbs)
Mass / Unit Volume: 529 kg/m^3 (33.0 lbs/ft^3)
Installation: Two (2) 79" segments perpendicular to Plywood 10" strip to complete. Joints staggered from parallel plywood joints by + 6". Rolled with 100lb roller in each direction.



FREQ. (Hz)	TL	ΔTL	DEF.
100	34	0.50	0
125	41	0.61	1
160	41	0.51	4
200	42	0.39	6
250	47	0.38	4
315	51	0.28	3
400	54	0.34	3
500	55	0.20	3
630	58	0.26	1
800	60	0.14	0
1000	64	0.17	0
1250	69	0.15	0
1600	75	0.14	0
2000	78	0.08	0
2500	84	0.06	0
3150	92	0.16	0
4000	95	0.21	0
5000	93	0.23	0

FREQ. = FREQUENCY (1/3 OCTAVE BAND, CENTER), HERTZ
TL = TRANSMISSION LOSS, dB
ΔTL = 95% CONFIDENCE INTERVAL FOR TL MEASUREMENTS, dB
DEF. = DEFICIENCIES, dB BELOW STC CONTOUR
STC **=** SOUND TRANSMISSION LOSS



FREQ. (Hz)	Ln	ΔLn	DEV.
80	--	--	--
100	63	1.23	3
125	65	2.44	5
160	64	2.31	4
200	65	1.75	5
250	64	2.05	4
315	64	2.04	4
400	62	1.01	3
500	58	1.65	0
630	54	2.05	0
800	52	0.76	0
1000	48	1.86	0
1250	41	2.08	0
1600	34	2.00	0
2000	25*	3.21	0
2500	18**	2.30	0
3150	19**	0.89	0
4000	--	--	--

FREQ. = FREQUENCY, HERTZ
Ln = NORMALIZED SOUND PRESSURE LEVEL, dB
ΔLn = 95% UNCERTAINTY LIMIT FOR Ln, dB
DEV. = DEVIATION FROM SHIFTED IIC COUNTOUR, dB
IIC = IMPACT INSULATION CLASS

*Level corrected due to background noise per E492 SEC 10.2.2
**Level corrected due to background noise per E492 SEC 10.2.3

Figure 1 - Specimen mounted in test aperture, as viewed from source room

Figure 2 - Specimen mounted in test aperture, as viewed from receive room

Figure 3 - CLT (1 of 2) prior to installation

Figure 4 - CLT installed in test aperture

Figure 5 - 3/4" x 6" plywood spline partially installed over CLT rabbets

Figure 6 - Detail of 3/4" x 6" plywood spline partially installed over CLT rabbets

Figure 7 - 2"x4" sleepers partially installed, with Piano B 40/40 fastened to underside of sleepers

Figure 8 - Piano B 40/40 strip fastened to sleeper prior to installation of sleeper

*All images in Figures 1-8 credit Riverbank Acoustical Laboratories

Figure 9 - Hemp boards prior to installation

Figure 10 - Hemp boards partially installed between sleepers

Figure 11 - Hemp boards installed between sleepers, plywood partially installed over sleepers

Figure 12 - Plywood subfloor partially installed

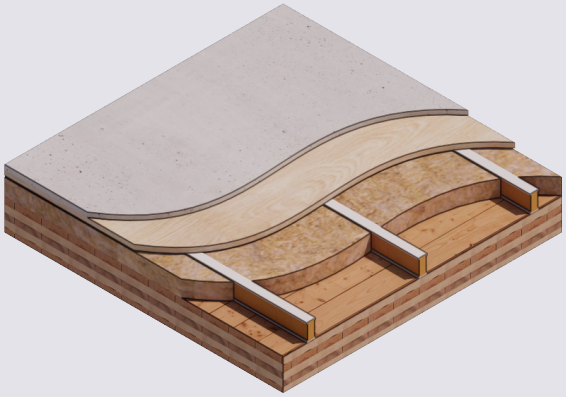
Figure 13 - Gypcrete installation

Figure 14 - Trowel used for installation of adhesive

Figure 15 - Adhesive installed over gypcrete, flooring partially installed over adhesive

*All images in Figures 9-15 credit Riverbank Acoustical Laboratories

FLOOR
F07



SPECIMEN MEASUREMENTS

Dimensions: 2.44 m (96.0 in) wide by 3.86 m (152.0 in) high
Thickness: 0.33 m (12.875 in)
Weight: 1698.93 kg (3745.5 lbs)
Overall Area: 9.414 m^2 (101.33 ft^2)
Mass/Unit Area: 163.28 kg/m^2 (33.44 lbs/ft^2)

TEST APERTURE

Opening Size: 4.27 m (14.0 ft) x 6.10 m (20.0 ft)
Filler Wall: Yes
Aperture Size: 2.44 m (96.0 in) wide by 3.86 m (152.0 in) high
Transmission Area: 9.414 m^2 (101.33 ft^2)
Sealed: Entire periphery (both sides) with dense mastic

TEST ENVIRONMENT

Source Room
Volume: 130.9 m^3
Temperature: 22.8°C ±0.0°C
Relative Humidity: 62.0% ± 0.0%

Receive Room
Volume: 81.44 m^3
Temperature: 22.2°C ± 1.1°C
Relative Humidity: 64.0% ± 2.0%

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

LAYER 1 - CROSS LAMINATED TIMBER (CLT)

Material: 5-Ply Cross-Laminated Timber
Dimensions: 2 panels @ 1219 mm (48 in.) by 4229 mm (166.5 in.)
Thickness: 171 mm (6.75 in.)
Overall Weight: 953.45 kg (2102 lbs)
Mass / Unit Volume: 539 kg/m^3 (33.7 lbs/ft^3)
Installation: CLT panels laid on 152 mm (6 in.) wide knee walls in test opening and butted to one another without sealant/adhesive. 3/4"x3" Rabbet on top side of one edge of each panel where they butt allowing a loose spline (below) to insert and join the two.

LAYER 2 - 3/4" CDX LOOSE SPLINE

Material: 3/4" x 6" plywood spline
Dimensions:
1 piece @ 151 mm (5.9375 in.) wide by 2438 mm (96 in.)
1 piece @ 151 mm (5.9375 in.) wide by 1791 mm (70.5 in.)
Thickness: 19 mm (0.75 in.)
Overall Weight: 6.46 kg (14.25 lbs)
Mass / Unit Length: 1.53 kg/m (1.03 lbs/ft)
Installation: Set in Rabbets of both CLT's and screwed in place.
Fasteners: WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing: 6" o.c. on a line 3" from each edge of the spline (Centered on the rabbet of the CLT)

LAYER 3 - PIANO B 40/40 (LOWER LAYER)

Manufacturer: Rothoblaas
Dimensions:
2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long
8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness: 6.76 mm (0.266 in.)
Overall Weight: 4.59 kg (10.125 lbs)
Mass/Unit Volume: 624 kg/m^3 (40.00 lbs/ft^3)
Installation: Fastened to underside of 2" x 4" wood sleepers with staples
Fasteners: Arrow staples, length @ 13 mm (0.5 in.)

LAYER 4 - 2x4 SPF FRAMING SLEEPERS

Material: Nominal 2x4 framing lumber
Dimensions:
2 pieces @ 38 mm (1.5 in.) wide by 4255 mm (167.5 in. long
8 pieces @ 2369 mm (93.25 in.) wide by 38 mm (1.5 in.) long
Depth: 89 mm (3.5 in.)
Overall Weight: 49.33 kg (108.75 lbs)
Mass / Unit Length: 1.80 kg/m (1.21 lbs/ft)
Installation: Sleepers laid over CLT, resting on lower layer Piano B 40/40. Longer sleepers parallel to CLT like a rim joist. Shorter sleepers set like floor joists between rim joists. Shorter sleepers spaced approx. 610 mm (24 in.) on center. Shorter sleepers fastened to longer sleepers with screws, 2 screws per connection point.
Fasteners: WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)

LAYER 5 - PIANO B 40/40 (UPPER LAYER)

Manufacturer: Rothoblaas
Dimensions:
2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long
8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness: 6.76 mm (0.266 in.)
Overall Weight: 4.59 kg (10.125 lbs)
Mass/Unit Volume: 624 kg/m^3 (40.0 lbs/ft^3)
Installation: Fastened to top of 2" x 4" wood sleepers with staples.
Fasteners: Arrow staples, length @ 13 mm (0.5 in.)

LAYER 6 - HEMPBOARD

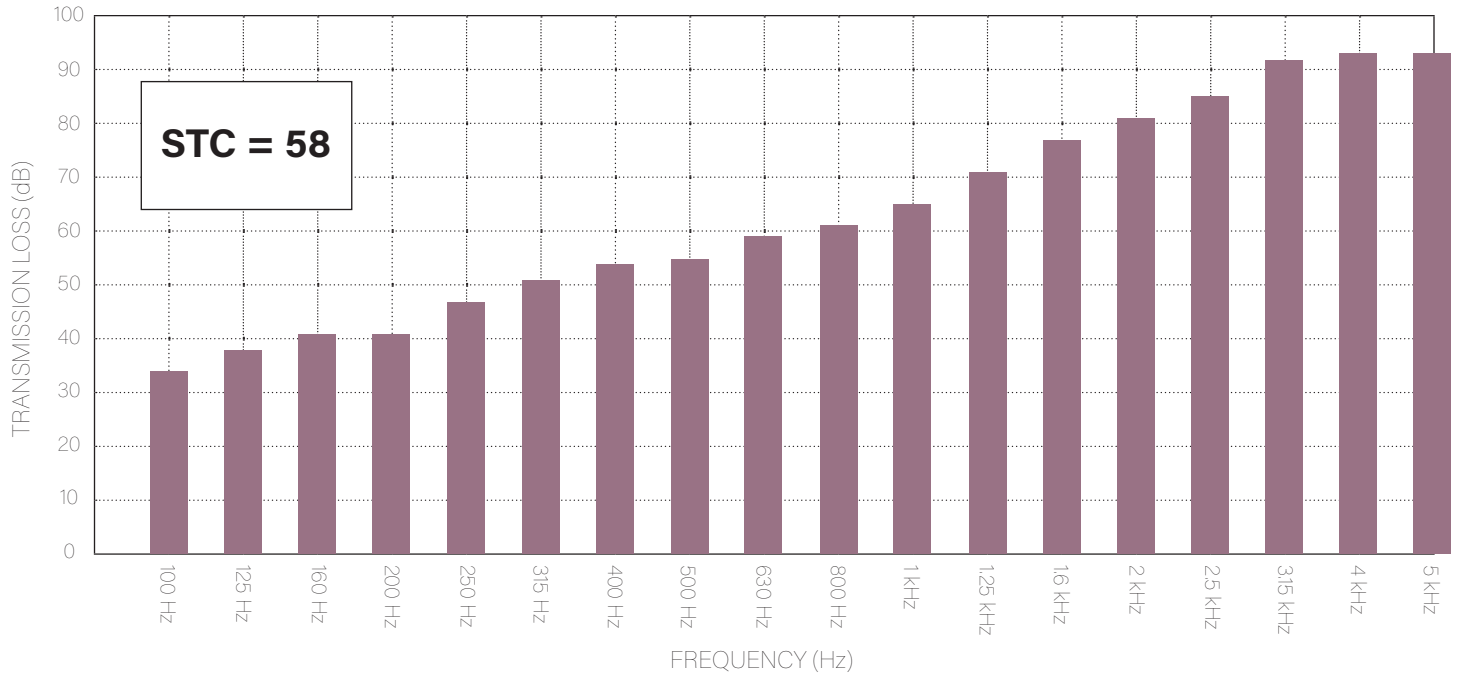
Manufacturer: Hempitecture
Dimensions:
7 pieces @ 572 mm (22.5 in.) wide by 2369 mm (93.25 in.) long
Thickness: 76 mm (3 in.)
Overall Weight: 37.53 kg (82.75 lbs)
Mass/Unit Volume: 52 kg/m^3 (3.25 lbs/ft^3)
Installation: Friction fit between sleepers on top of CLT.

LAYER 7 - PLYWOOD SUBFLOOR

Material: T&G Plywood
Dimensions:
1 piece @ 1219 mm (48 in.) wide by 1829 mm (72 in.)
1 piece @ 1219 mm (48 in.) wide by 2438 mm (96 in.)
1 piece @ 1219 mm (48 in.) wide by 1822 mm (71.75 in.)
1 piece @ 1219 mm (48 in.) wide by 2432 mm (95.75 in.)
Thickness: 29 mm (1.125 in.)
Overall Weight: 173.5 kg (382.5 lbs)
Mass / Unit Volume: 584 kg/m^3 (36.5 lbs/ft^3)
Installation: Placed over upper layer Piano B 40/40 over sleepers. Fastened to sleepers through Piano B 40/40 with screws. Plywood piece joints staggered.
Fasteners: WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing: 610 mm (24 in.) on center

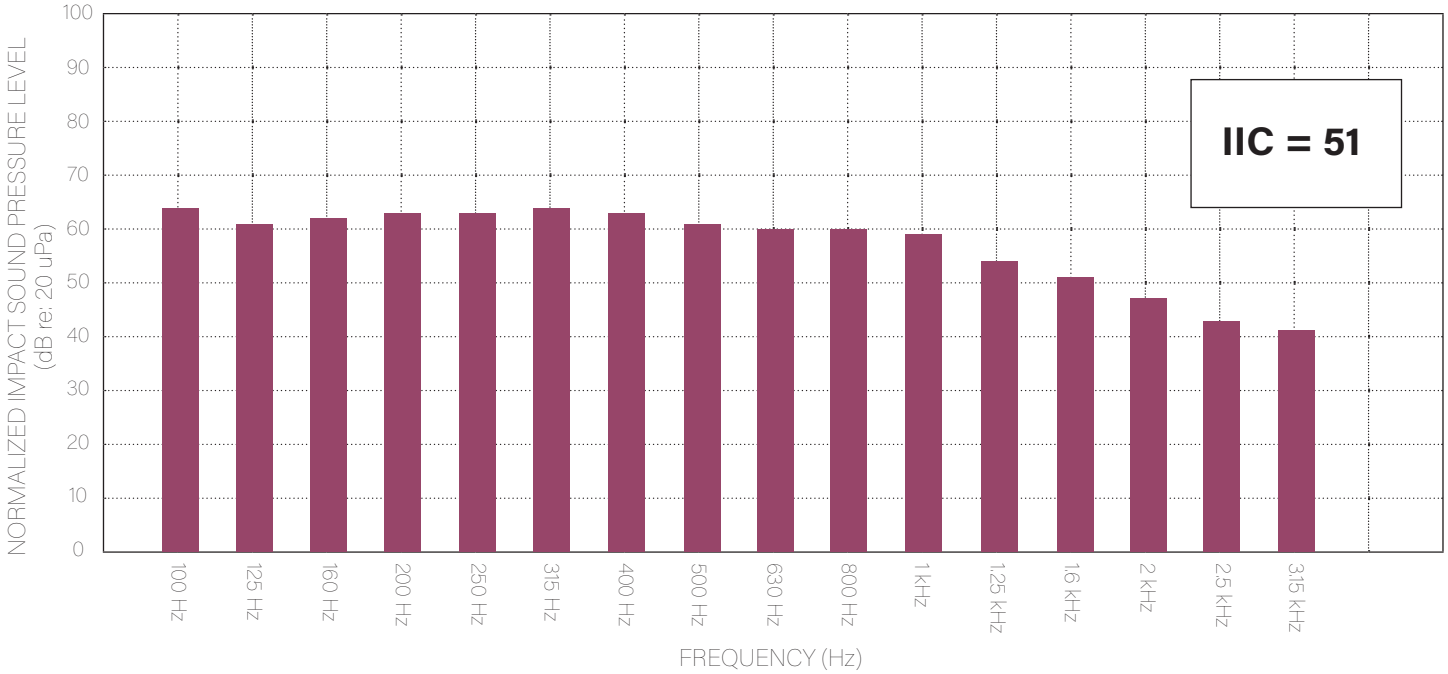
LAYER 8 - GYPCRETE

Manufacturer: Maxxon
Dimensions:
2438 mm (96 in.) by 4267 mm (168 in.) as installed
Thickness: Approx. 25 mm (1 in.)
Mix Ratio: 2.5 gal. water / 40 lbs gypcrete / 75 lbs. all-purpose sand
Overall Weight: 469.47 kg (1035 lbs)
Mass/Unit Volume: 1780 kg/m^3 (111 lbs/ft^3)
Installation: Poured over plywood subfloor. Gauge rake was used to level produt to 1" of thickness. Wet gypcrete mix was poured on (2024.07.01, approx. 3:40pm)



FREQ. (Hz)	TL	ΔTL	DEF.
100	34	0.78	0
125	38	0.67	4
160	41	0.52	4
200	41	0.45	7
250	47	0.40	4
315	51	0.23	3
400	54	0.32	3
500	55	0.15	3
630	59	0.24	0
800	61	0.18	0
1000	65	0.14	0
1250	71	0.14	0
1600	77	0.12	0
2000	81	0.13	0
2500	85	0.13	0
3150	92	0.13	0
4000	93	0.10	0
5000	93	0.10	0

FREQ. = FREQUENCY (1/3 OCTAVE BAND, CENTER), HERTZ
TL = TRANSMISSION LOSS, dB
ΔTL = 95% CONFIDENCE INTERVAL FOR TL MEASUREMENTS, dB
DEF. = DEFICIENCIES, dB BELOW STC CONTOUR
STC **=** SOUND TRANSMISSION LOSS



FREQ. (Hz)	Ln	ΔLn	DEV.
80	--	--	--
100	64	2.51	3
125	61	3.72	0
160	62	1.76	1
200	63	1.86	2
250	63	2.32	2
315	64	2.88	3
400	63	0.73	3
500	61	0.53	2
630	60	1.11	2
800	60	1.58	3
1000	59	1.17	3
1250	54	0.74	1
1600	51	0.64	1
2000	47	0.59	0
2500	43	1.35	0
3150	41	1.64	0
4000	--	--	--

FREQ. = FREQUENCY, HERTZ
Ln = NORMALIZED SOUND PRESSURE LEVEL, dB
ΔLn = 95% UNCERTAINTY LIMIT FOR Ln, dB
DEV. = DEVIATION FROM SHIFTED IIC COUNTOUR, dB
IIC **=** IMPACT INSULATION CLASS

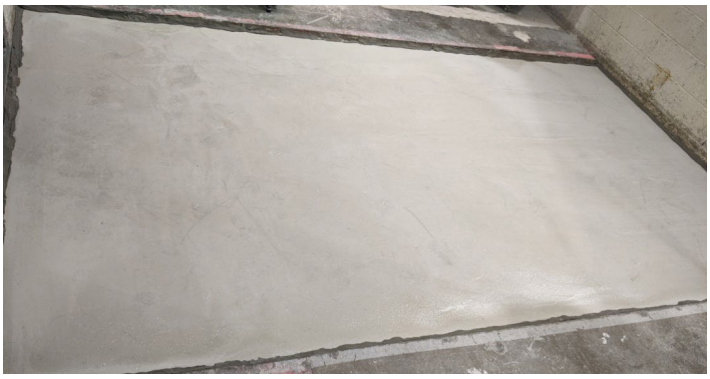


Figure 1 - Specimen mounted in test aperture, as viewed from source room

Figure 2 - Specimen mounted in test aperture, as viewed from receive room

Figure 3 - CLT (1 of 2) prior to installation

Figure 4 - CLT installed in test aperture

Figure 5 - 3/4" x 6" plywood spline partially installed over CLT rabbets

Figure 6 - Detail of 3/4" x 6" plywood spline partially installed over CLT rabbets

Figure 7 - 2"x4" sleepers partially installed, with Piano B 40/40 fastened to underside of sleepers

Figure 8 - Piano B 40/40 strip fastened to sleeper prior to installation of sleeper

*All images in Figures 1-8 credit Riverbank Acoustical Laboratories

Figure 9 - Hemp boards prior to installation

Figure 10 - Hemp boards partially installed between sleepers

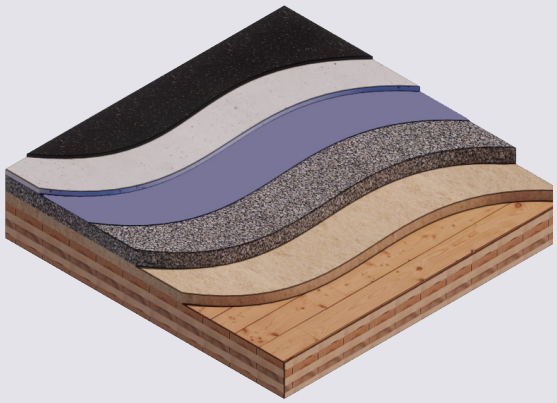
Figure 11 - Hemp boards installed between sleepers, plywood partially installed over sleepers

Figure 12 - Plywood subfloor partially installed

Figure 13 - Gypcrete installation

*All images in Figures 9-13 credit Riverbank Acoustical Laboratories

FLOOR F08



SPECIMEN MEASUREMENTS

Dimensions: 2.44 m (96.0 in) wide by 3.86 m (152.0 in) high
Thickness: 0.33 m (13.0 in)
Weight: 2811.14 kg (6197.5 lbs)
Overall Area: 9.414 m^2 (101.33 ft^2)
Mass/Unit Area: 270.17 kg/m^2 (55.33 lbs/ft^2)

TEST APERTURE

Opening Size: 4.27 m (14.0 ft) x 6.10 m (20.0 ft)
Filler Wall: Yes
Aperture Size: 2.44 m (96.0 in) wide by 3.86 m (152.0 in) high
Transmission Area: 9.414 m^2 (101.33 ft^2)
Sealed: Entire periphery (both sides) with dense mastic

TEST ENVIRONMENT

Source Room
Volume: 130.9 m^3
Temperature: 23.1°C ±0.6°C
Relative Humidity: 67.0% ± 2.0%

Receive Room
Volume: 81.44 m^3
Temperature: 22.5°C ± 0.6°C
Relative Humidity: 67.0% ± 2.0%

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

LAYER 1 - CROSS LAMINATED TIMBER (CLT)

Material: 5-Ply Cross-Laminated Timber
Dimensions: 2 panels @ 1219 mm (48 in.) by 4229 mm (166.5 in.)
Thickness: 171 mm (6.75 in.)
Overall Weight: 953.45 kg (2102 lbs)
Mass / Unit Volume: 539 kg/m^3 (33.7 lbs/ft^3)
Installation: CLT panels laid on 152 mm (6 in.) wide knee walls in test opening and butted to one another without sealant/adhesive. 3/4"x3" Rabbet on top side of one edge of each panel where they butt allowing a loose spline (below) to insert and join the two.

LAYER 2 - 3/4" CDX LOOSE SPLINE

Material: 3/4" x 6" plywood spline
Dimensions:
1 piece @ 151 mm (5.9375 in.) wide by 2438 mm (96 in.)
1 piece @ 151 mm (5.9375 in.) wide by 1791 mm (70.5 in.)
Thickness: 19 mm (0.75 in.)
Overall Weight: 6.46 kg (14.25 lbs)
Mass / Unit Length: 1.53 kg/m (1.03 lbs/ft)
Installation: Set in Rabbets of both CLT's and screwed in place.
Fasteners: WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing: 6" o.c. on a line 3" from each edge of the spline (Centered on the rabbet of the CLT)

LAYER 3 - HEMPBOARD

Manufacturer: Hempitecture
Dimensions:
3 pieces @ 1216 mm (47.875 in.) wide by 2448 mm (96.375 in.) long
1 piece @ 613 mm (24.125 in.) wide by 2448 mm (96.375 in.) long
Thickness: 51 mm (2 in.)
Overall Weight: 69.51 kg (153.25 lbs)
Mass/Unit Volume: 131 kg/m^3 (8.19 lbs/ft^3)
Installation: Loosely laid directly on top of CLT, perpendicular to CLT.

LAYER 4 - CRUSHED LIMESTONE

Material: CA-16 3/8" chip crushed limestone
Dimensions: 2438 mm (96 in.) wide by 4267 mm (168 in.) long, as installed
Depth: 76 mm (3 in.)
Overall Weight: 1224.02 kg (2698.5 lbs)
Installation: Loose laid on top of hemp fiberboard. 1/2" polystyrene used as an isolation around the perimeter.

LAYER 5 - VAPOR BARRIER

Material: Membrain Vapor Barrier
Manufacturer: Saint Gobain
Dimensions: Approx. 2438 mm (96in.) by 4267 mm (168 in.) as installed
Overall Weight: 0.79 kg (1.75 lbs)
Mass / Unit Area: 0.08 kg/m^2 (0.02 lbs/ft^2)
Installation: Loose laid over crushed limestone.

LAYER 6 - GYPCRETE

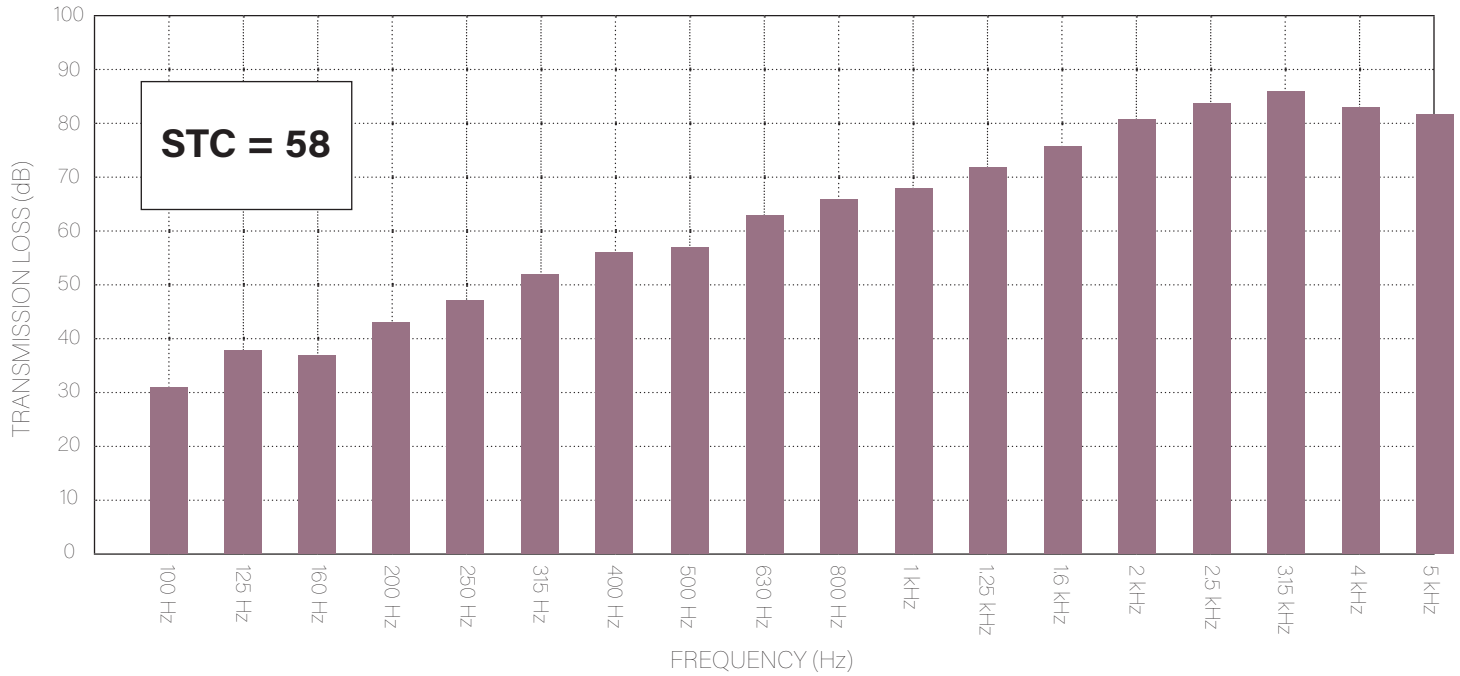
Manufacturer: Maxxon
Dimensions:
2438 mm (96 in.) by 4267 mm (168 in.) as installed
Thickness: Approx. 25 mm (1 in.)
Mix Ratio: 2.5 gal. water / 40 lbs gypcrete / 75 lbs. all-purpose sand
Overall Weight: 521.63 kg (1150 lbs)
Mass/Unit Volume: 1970 kg/m^3 (123 lbs/ft^3)
Installation: Poured over vapor barrier. A screed was used to spread the wet gypcrete mix. Wet gypcrete mix was poured on (2024.07.10, approx. 4:30pm)

LAYER 7 - ADHESIVE

Material: Sustain 1195 Sheet and Tile adhesive
Manufacturer: Forbo
Dimensions: Approx. 2438 mm (96 in.) by 4267 mm (168 in.) as installed
Overall Weight: 3.06 kg (6.75 lbs)
Mass / Unit Area: 0.29 kg/m^2 (0.06 lbs/ft^2)
Installation: Troweled directly to plywood with a 1/16x1/16x1/16 square notch trowel
Once troweled, adhesive was left "open" for 15 min to allow it to "tack" before flooring was installed.

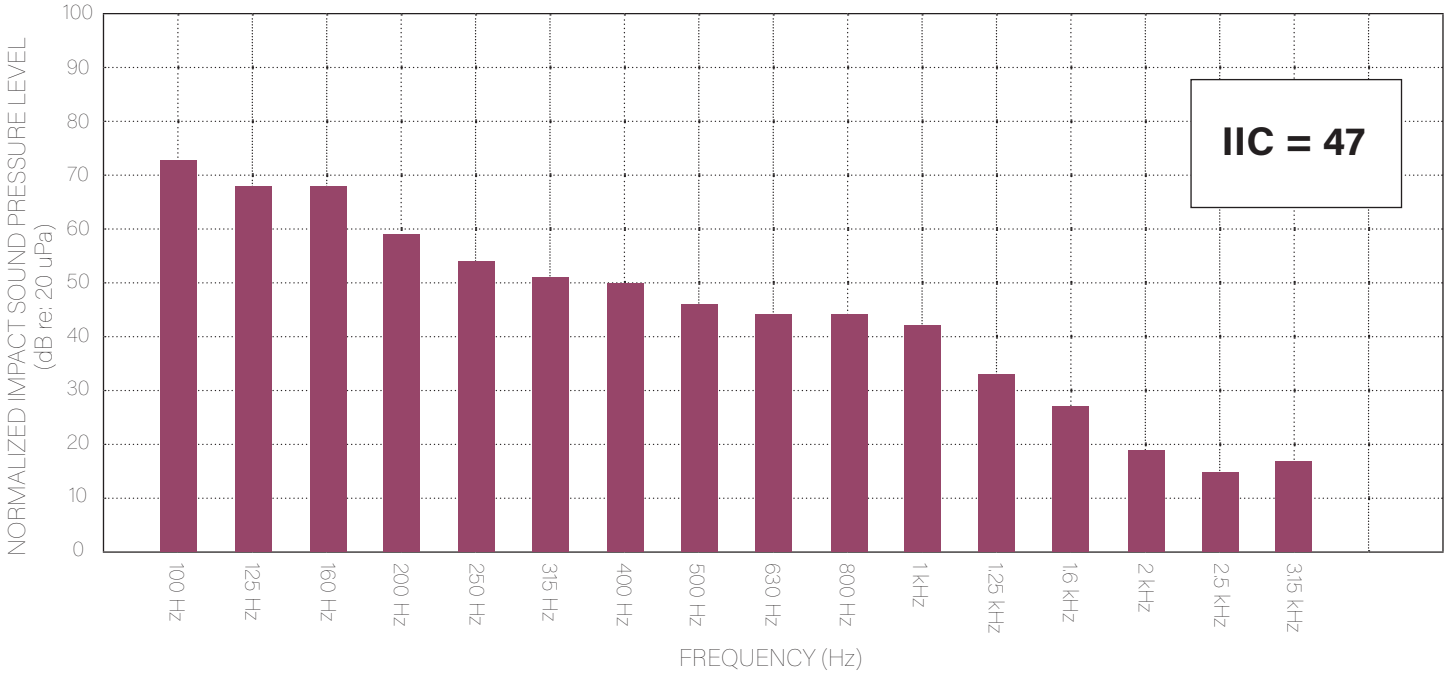
LAYER 10 - FLOORING

Material: Marmoleum Decibel
Manufacturer: Forbo
Dimensions: 2 pieces @ 2007 mm (79 in.) by 2464 mm (97 in.)
Thickness: 6 mm (0.25 in.)
Overall Weight: 32.21 kg (71 lbs)
Mass / Unit Volume: 482 kg/m^3 (30.1 lbs/ft^3)
Installation: Two (2) 79" segments perpendicular to Plywood 10" strip to complete. Rolled with 100lb roller in each direction.



FREQ. (Hz)	TL	ΔTL	DEF.
100	31	0.81	0
125	38	0.68	4
160	37	0.59	8
200	43	0.41	5
250	47	0.42	4
315	52	0.24	2
400	56	0.35	1
500	57	0.17	1
630	63	0.25	0
800	66	0.15	0
1000	68	0.12	0
1250	72	0.12	0
1600	76	0.12	0
2000	81	0.09	0
2500	84	0.12	0
3150	86	0.25	0
4000	83	0.16	0
5000	82	0.20	0

FREQ. = FREQUENCY (1/3 OCTAVE BAND, CENTER), HERTZ
TL = TRANSMISSION LOSS, dB
ΔTL = 95% CONFIDENCE INTERVAL FOR TL MEASUREMENTS, dB
DEF. = DEFICIENCIES, dB BELOW STC CONTOUR
STC **=** SOUND TRANSMISSION LOSS



FREQ. (Hz)	Ln	ΔLn	DEV.
80	--	--	--
100	73	2.25	8
125	68	2.11	3
160	68	3.01	3
200	59	.87	0
250	54	1.65	0
315	51	1.94	0
400	50	2.51	0
500	46	2.64	0
630	44	2.12	0
800	44	1.02	0
1000	42	1.39	0
1250	33	1.77	0
1600	27	1.47	0
2000	19**	2.10	0
2500	15**	0.66	0
3150	17**	0.61	0
4000	--	--	--

FREQ. = FREQUENCY, HERTZ
Ln = NORMALIZED SOUND PRESSURE LEVEL, dB
ΔLn = 95% UNCERTAINTY LIMIT FOR Ln, dB
DEV. = DEVIATION FROM SHIFTED IIC COUNTOUR, dB
IIC = IMPACT INSULATION CLASS

*Level corrected due to background noise per E492 SEC 10.2.2
**Level corrected due to background noise per E492 SEC 10.2.3

Figure 1 - Specimen mounted in test aperture, as viewed from source room

Figure 2 - Specimen mounted in test aperture, as viewed from receive room

Figure 3 - CLT (1 of 2) prior to installation

Figure 4 - CLT installed in test aperture

*All images in Figures 1-8 credit Riverbank Acoustical Laboratories

Figure 5 - 3/4" x 6" plywood spline partially installed over CLT rabbets

Figure 6 - Detail of 3/4" x 6" plywood spline partially installed over CLT rabbets

Figure 7 - Hemp board partially installed over CLT

Figure 8 - Polystyrene used as an isolation around the perimeter prior to installation of gravel

Figure 9 - Gravel partially installed over hemp board

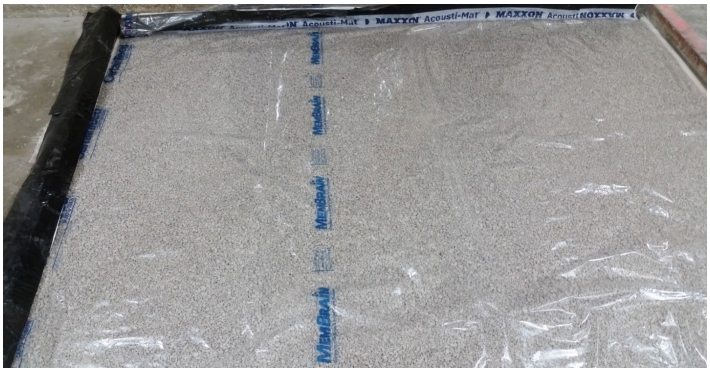


Figure 10 - Gravel installed; vapor barrier installed over gravel

Figure 11 - Gypcrete mixing prior to pouring

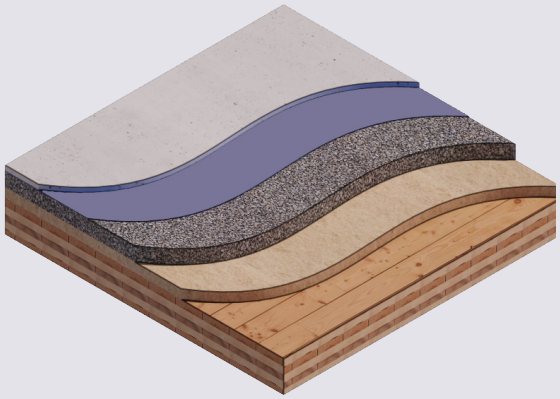
Figure 12 - Gypcrete partially installed over vapor barrier

Figure 13 - Trowel used for installation of adhesive

Figure 14 - Adhesive partially installed over gypcrete

*All images in Figures 9-14 credit Riverbank Acoustical Laboratories

FLOOR F09



SPECIMEN MEASUREMENTS

Dimensions: 2.44 m (96.0 in) wide by 3.86 m (152.0 in) high
Thickness: 0.32 m (12.75 in)
Weight: 2775.87 kg (6119.75 lbs)
Overall Area: 9.414 m^2 (101.33 ft^2)
Mass/Unit Area: 266.78 kg/m^2 (54.64 lbs/ft^2)

TEST APERTURE

Opening Size: 4.27 m (14.0 ft) x 6.10 m (20.0 ft)
Filler Wall: Yes
Aperture Size: 2.44 m (96.0 in) wide by 3.86 m (152.0 in) high
Transmission Area: 9.414 m^2 (101.33 ft^2)
Sealed: Entire periphery (both sides) with dense mastic

TEST ENVIRONMENT

Source Room
Volume: 130.9 m^3
Temperature: 23.3°C ±0.0°C
Relative Humidity: 67.5% ± 1.0%

Receive Room
Volume: 81.44 m^3
Temperature: 22.2°C ± 0.0°C
Relative Humidity: 67.0% ± 0.0%

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

LAYER 1 - CROSS LAMINATED TIMBER (CLT)

Material: 5-Ply Cross-Laminated Timber
Dimensions: 2 panels @ 1219 mm (48 in.) by 4229 mm (166.5 in.)
Thickness: 171 mm (6.75 in.)
Overall Weight: 953.45 kg (2102 lbs)
Mass / Unit Volume: 539 kg/m^3 (33.7 lbs/ft^3)
Installation: CLT panels laid on 152 mm (6 in.) wide knee walls in test opening and butted to one another without sealant/adhesive. 3/4"x3" Rabbet on top side of one edge of each panel where they butt allowing a loose spline (below) to insert and join the two.

LAYER 2 - 3/4" CDX LOOSE SPLINE

Material: 3/4" x 6" plywood spline
Dimensions:
1 piece @ 151 mm (5.9375 in.) wide by 2438 mm (96 in.)
1 piece @ 151 mm (5.9375 in.) wide by 1791 mm (70.5 in.)
Thickness: 19 mm (0.75 in.)
Overall Weight: 6.46 kg (14.25 lbs)
Mass / Unit Length: 1.53 kg/m (1.03 lbs/ft)
Installation: Set in Rabbets of both CLT's and screwed in place.
Fasteners: WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing: 6" o.c. on a line 3" from each edge of the spline (Centered on the rabbet of the CLT)

LAYER 3 - HEMPBOARD

Manufacturer: Hempitecture
Dimensions:
3 pieces @ 1216 mm (47.875 in.) wide by 2448 mm (96.375 in.) long
1 piece @ 613 mm (24.125 in.) wide by 2448 mm (96.375 in.) long
Thickness: 51 mm (2 in.)
Overall Weight: 69.51 kg (153.25 lbs)
Mass/Unit Volume: 131 kg/m^3 (8.19 lbs/ft^3)
Installation: Loosely laid directly on top of CLT, perpendicular to CLT.

LAYER 4 - CRUSHED LIMESTONE

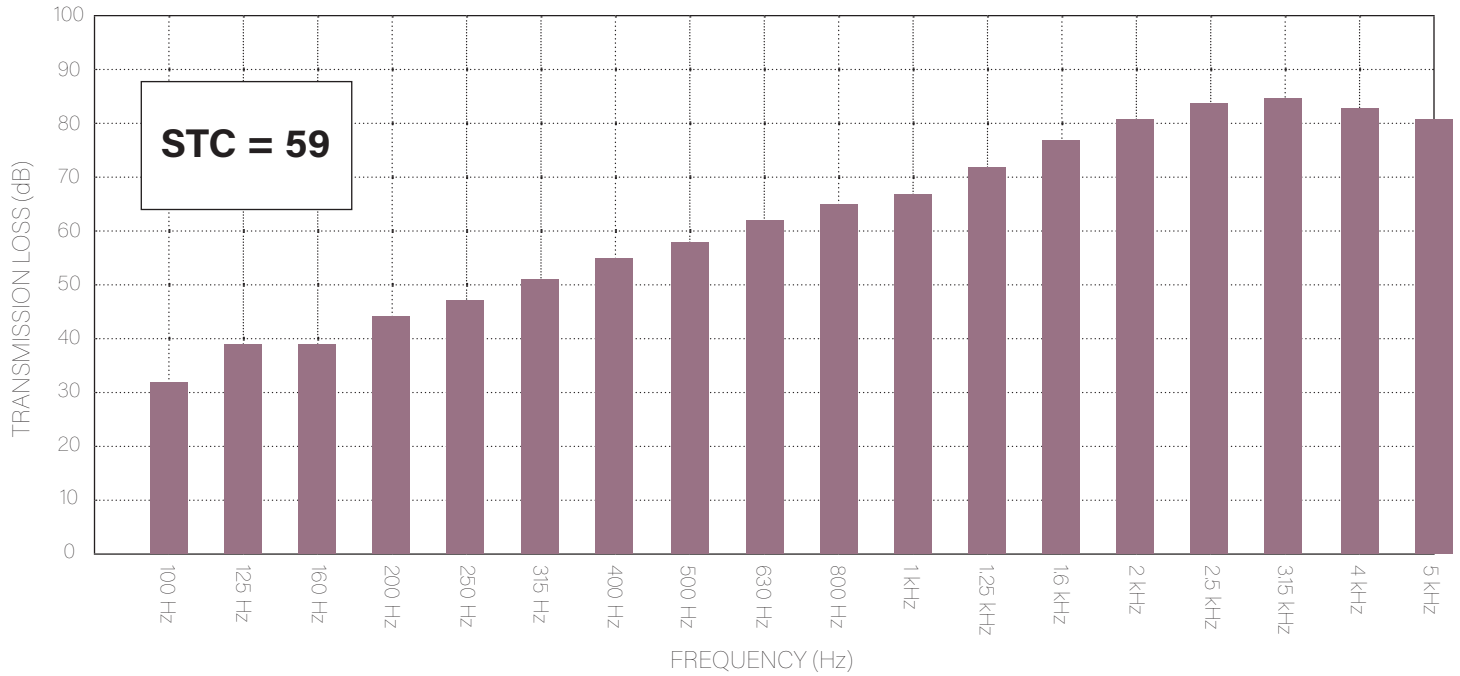
Material: CA-16 3/8” chip crushed limestone
Dimensions: 2438 mm (96 in.) wide by 4267 mm (168 in.) long, as installed
Depth: 76 mm (3 in.)
Overall Weight: 1224.02 kg (2698.5 lbs)
Installation: Loose laid on top of hemp fiberboard. 1/2” polystyrene used as an isolation around the perimeter.

LAYER 5 - VAPOR BARRIER

Material: Membrain Vapor Barrier
Manufacturer: Saint Gobain
Dimensions: Approx. 2438 mm (96in.) by 4267 mm (168 in.) as installed
Overall Weight: 0.79 kg (1.75 lbs)
Mass / Unit Area: 0.08 kg/m^2 (0.02 lbs/ft^2)
Installation: Loose laid over crushed limestone.

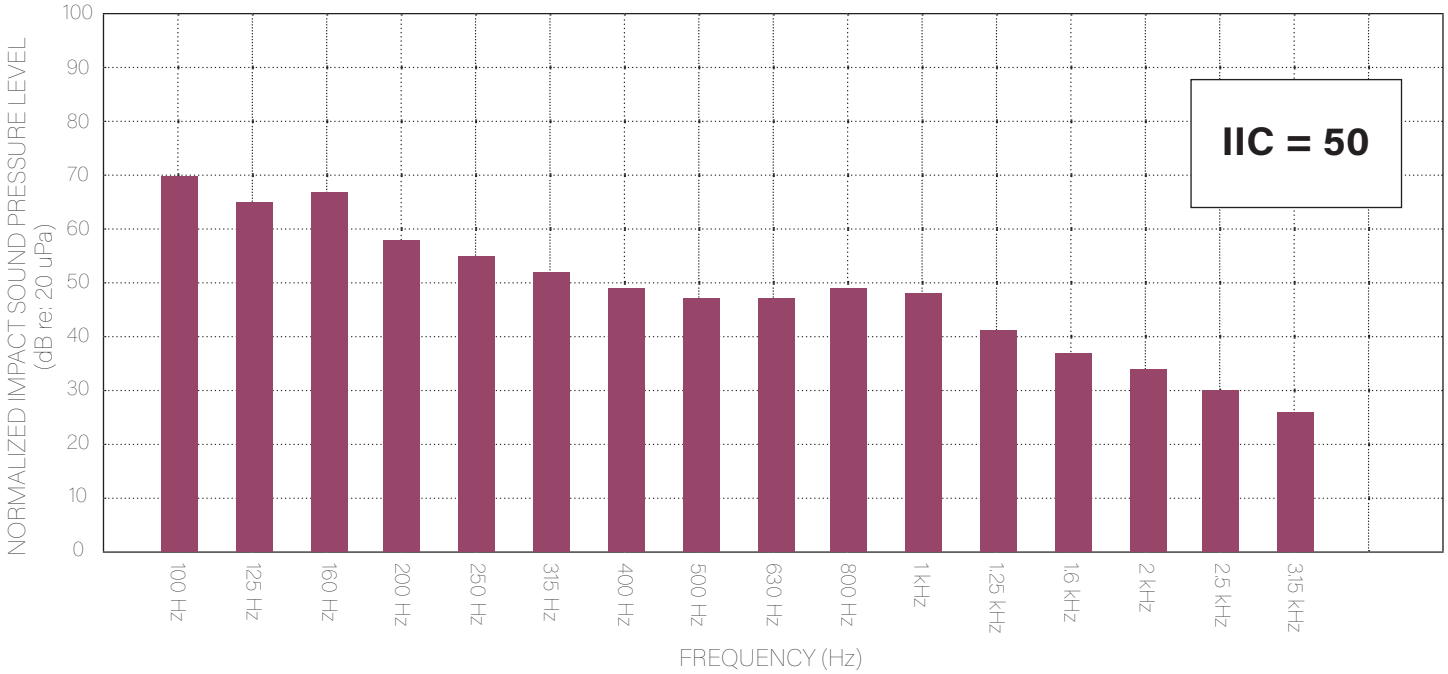
LAYER 6 - GYPCRETE

Manufacturer: Maxxon
Dimensions:
2438 mm (96 in.) by 4267 mm (168 in.) as installed
Thickness: Approx. 25 mm (1 in.)
Mix Ratio: 2.5 gal. water / 40 lbs gypcrete / 75 lbs. all-purpose sand
Overall Weight: 521.63 kg (1150 lbs)
Mass/Unit Volume: 1970 kg/m^3 (123 lbs/ft^3)
Installation: Poured over vapor barrier. A screed was used to spread the wet gypcrete mix. Wet gypcrete mix was poured on (2024.07.10, approx. 4:30pm)



FREQ. (Hz)	TL	ΔTL	DEF.
100	32	1.06	0
125	39	0.70	4
160	39	0.85	7
200	44	0.65	5
250	47	0.51	5
315	51	0.29	4
400	55	0.53	3
500	58	0.20	1
630	62	0.22	0
800	65	0.25	0
1000	67	0.11	0
1250	72	0.16	0
1600	77	0.12	0
2000	81	0.17	0
2500	84	0.15	0
3150	85	0.32	0
4000	83	0.25	0
5000	81	0.26	0

FREQ. = FREQUENCY (1/3 OCTAVE BAND, CENTER), HERTZ
TL = TRANSMISSION LOSS, dB
ΔTL = 95% CONFIDENCE INTERVAL FOR TL MEASUREMENTS, dB
DEF. = DEFICIENCIES, dB BELOW STC CONTOUR
STC **=** SOUND TRANSMISSION LOSS



FREQ. (Hz)	Ln	ΔLn	DEV.
80	--	--	--
100	70	2.65	8
125	65	2.01	3
160	67	3.44	5
200	58	1.21	0
250	55	2.01	0
315	52	0.86	0
400	49	0.96	0
500	47	1.37	0
630	47	0.66	0
800	49	0.79	0
1000	48	0.74	0
1250	41	0.36	0
1600	37	0.40	0
2000	34	0.49	0
2500	30	0.82	0
3150	26*	1.41	0
4000	--	--	--

FREQ. = FREQUENCY, HERTZ
Ln = NORMALIZED SOUND PRESSURE LEVEL, dB
ΔLn = 95% UNCERTAINTY LIMIT FOR Ln, dB
DEV. = DEVIATION FROM SHIFTED IIC COUNTOUR, dB
IIC = IMPACT INSULATION CLASS

*Level corrected due to background noise per E492 SEC 10.2.2
**Level corrected due to background noise per E492 SEC 10.2.3

Figure 1 - Specimen mounted in test aperture, as viewed from source room

Figure 2 - Specimen mounted in test aperture, as viewed from receive room

Figure 3 - CLT (1 of 2) prior to installation

Figure 4 - CLT installed in test aperture

Figure 5 - 3/4" x 6" plywood spline partially installed over CLT rabbets

Figure 6 - Detail of 3/4" x 6" plywood spline partially installed over CLT rabbets

Figure 7 - Hemp board partially installed over CLT

Figure 8 - Polystyrene used as an isolation around the perimeter prior to installation of gravel

*All images in Figures 1-8 credit Riverbank Acoustical Laboratories

Figure 9 - Gravel partially installed over hemp board

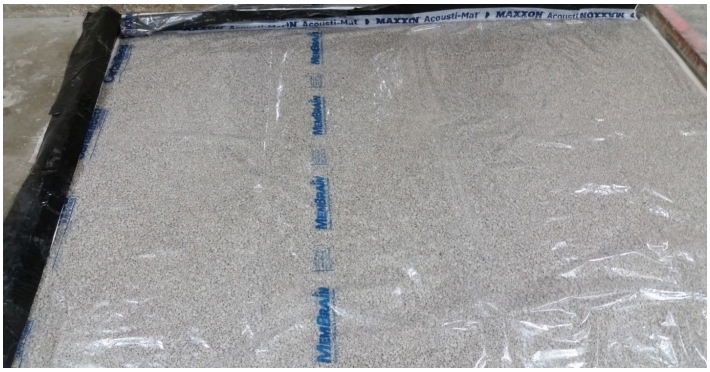


Figure 10 - Gravel installed; vapor barrier installed over gravel

Figure 11 - Gypcrete mixing prior to pouring

Figure 12 - Gypcrete partially installed over vapor barrier

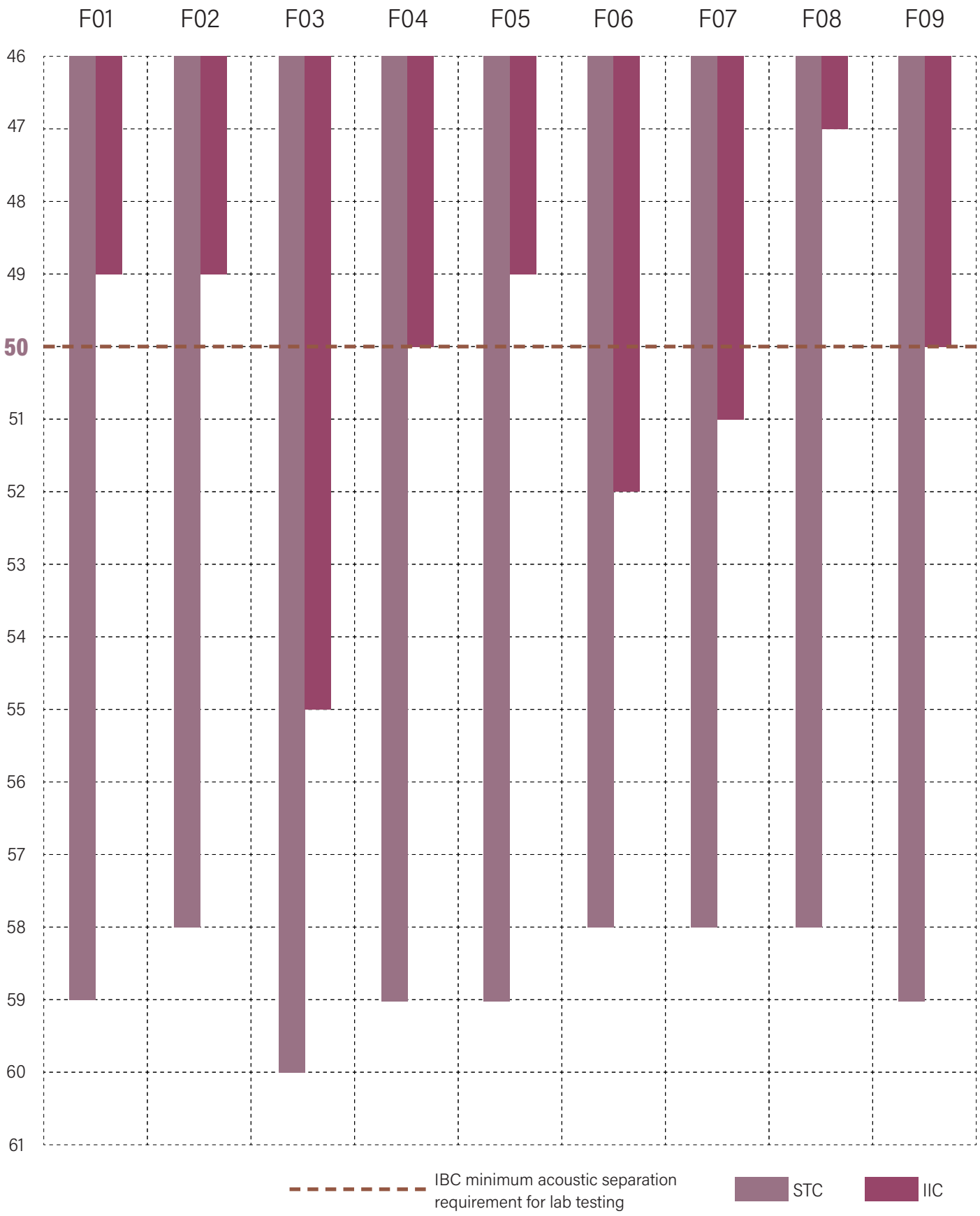
*All images in Figures 9-12 credit Riverbank Acoustical Laboratories

04

TEST RESULTS SUMMARY

All nine tested assemblies exceeded an STC rating of 50, the IBC minimum acoustic separation requirement for lab-tested assemblies, all reaching at least a rating of 58, with the highest performing reaching a rating of 60. Five of the nine tested floor/ceiling assemblies were able to achieve a performance level of 50 for both STC and IIC ratings. Three of those five assemblies were able to exceed a 50 rating for both indicators of acoustic performance (F03, F06, and F07). Floor assembly F03 had the best overall performance, with the highest STC and IIC ratings of all assemblies at 60 and 55, respectively.

Detailed acoustic performance results for both IIC and STC for each assembly can be found in Section 03, above, including respective spectral data.


F01
F02
F03
F04
F05
F06
F07
F08
F09
46
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59
60
61
IBC minimum acoustic separation requirement for lab testing
STC
IIC

05

CONCLUSION & DISCUSSION

The test results in this report demonstrate that it is possible to develop a lower carbon floor-ceiling assembly that, through the increased use of bio-based materials and elimination of concrete, is able to not only achieve acoustic code requirements for the separation of units in multifamily housing, but also surpass code required performance minimums for sound transmission and impact isolation class.

06

APPENDIX

This section includes the complete certified ASTM testing reports for transmission loss (TL) and impact sound transmission (IIC) by Riverbank Acoustical Laboratories™.

RIVERBANK ACOUSTICAL LABORATORIES

627 RIVERBANK DRIVE
GENEVA, IL 60134

630-232-0104

Test Report

www.riverbankacoustics.com

FOUNDED 1918 BY
WALLACE CLEMENT SABINE

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

Impact Sound Transmission
RAL™-IN24-015

CONDUCTED: 2024-06-21

ON: Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3.75" of 3/8" limestone chip, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC

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 17025:2017 Laboratory (NVLAP Lab Code: 100227-0) and for this test procedure. The test reported in this document conformed explicitly with ASTM E492-22: "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 E989-21: "Standard Classification for Determination of Single-Number Metrics for Impact Noise." A description of the measurement procedure and room specifications are 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 Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3.75" of 3/8" limestone chip, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC. 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

Provided Description:	Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3.75" of 3/8" limestone chip, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC
Manufacturer:	University of Oregon

SPECIMEN MEASUREMENTS & TEST CONDITIONS

The building contractor (Seth Priser) and RAL staff compiled a detailed construction specification as follows:

Cross-Laminated Timber (CLT)

Materials:	5-Ply Cross-Laminated Timber
Dimensions:	2 panels @ 1219 mm (48 in.) by 4229 mm (166.5 in.)
Thickness:	171 mm (6.75 in.)
Overall Weight:	953.45 kg (2102 lbs)
Mass Per Unit Volume:	539 kg/m^3 (33.7 lbs/ft^3)
Installation:	CLT panels laid on 152 mm (6 in.) wide knee walls in test opening and butted to one another without sealant/adhesive. 3/4"x3" Rabbet on top side of one edge of each panel where they butt allowing a loose spline (below) to insert and join the two

¾" CDX Loose Spline

Materials:	3/4" x 6" plywood spline
Dimensions:	1 piece @ 151 mm (5.9375 in.) wide by 2438 mm (96 in.) 1 piece @ 151 mm (5.9375 in.) wide by 1791 mm (70.5 in.)
Thickness:	19 mm (0.75 in.)
Overall Weight:	6.46 kg (14.25 lbs)
Mass Per Unit Length:	1.53 kg/m (1.03 lbs/ft)
Installation:	Set in Rabbets of both CLT's and screwed in place.
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing:	6" o.c. on a line 3" from each edge of the spline (Centered on the rabbet of the CLT)

Piano B 40/40 (Lower Layer)

Manufacturer:	Rothoblaas
Dimensions:	2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long 8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness:	6.76 mm (0.266 in.)
Overall Weight:	4.59 kg (10.125 lbs)
Mass Per Unit Volume:	624 kg/m^3 (40.0 lbs/ft^3)
Installation:	Fastened to underside of 2" x 4" wood sleepers with staples
Fasteners:	Arrow staples, length @ 13 mm (0.5 in.)

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

2" by 4" SPF Framing Sleepers

Materials:	Nominal 2"x 4" framing lumber
Dimensions:	2 pieces @ 38 mm (1.5 in.) wide by 4255 mm (167.5 in.) long 8 pieces @ 2369 mm (93.25 in.) wide by 38 mm (1.5 in.) long
Depth:	89 mm (3.5 in.)
Overall Weight:	49.33 kg (108.75 lbs)
Mass Per Unit Length:	1.80 kg/m (1.21 lbs/ft)
Installation:	Sleepers laid over CLT, resting on lower layer Piano B 40/40 Longer sleepers parallel to CLT like a rim joist Shorter sleepers set like floor joists between rim joists Shorter sleepers spaced approx. 610 mm (24 in.) on center Shorter sleepers fastened to longer sleepers with screws, 2 screws per connection point
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)

Piano B 40/40 (Upper Layer)

Manufacturer:	Rothoblaas
Dimensions:	2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long 8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness:	6.76 mm (0.266 in.)
Overall Weight:	4.59 kg (10.125 lbs)
Mass Per Unit Volume:	624 kg/m^3 (40.0 lbs/ft^3)
Installation:	Fastened to top of 2" x 4" wood sleepers with staples
Fasteners:	Arrow staples, length @ 13 mm (0.5 in.)

Crushed Limestone

Materials:	CA-16 3/8" chip crushed limestone
Dimensions:	2438 mm (96 in.) wide by 4267 mm (168 in.) long, as installed
Depth:	95 mm (3.75 in.)
Overall Weight:	1261.89 kg (2782 lbs)
Installation:	Filled stone in between sleepers and used a screed to level to the top of the sleepers.

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Plywood Subfloor

Materials:	T&G Plywood
Dimensions:	1 piece @ 1219 mm (48 in.) wide by 1829 mm (72 in.) 1 piece @ 1219 mm (48 in.) wide by 2438 mm (96 in.) 1 piece @ 1219 mm (48 in.) wide by 1813 mm (71.375 in.) 1 piece @ 1219 mm (48 in.) wide by 2426 mm (95.5 in.)
Thickness:	29 mm (1.125 in.)
Overall Weight:	176.33 kg (388.75 lbs)
Mass Per Unit Volume:	595 kg/m^3 (37.1 lbs/ft^3)
Installation:	Placed over upper layer Piano B 40/40 over sleepers Fastened to sleepers through Piano B 40/40 with screws Plywood piece joints staggered
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing:	610 mm (24 in.) on center

Adhesive

Materials:	Sustain 1195 Sheet and Tile adhesive
Manufacturer:	Forbo
Dimensions:	Approx. 2438 mm (96 in.) by 4267 mm (168 in.) as installed
Overall Weight:	4.54 kg (10 lbs)
Mass Per Unit Area:	0.44 kg/m^2 (0.09 lbs/ft^2)
Installation:	Troweled directly to plywood with a 1/16x1/16x1/16 square notch trowel Once troweled, adhesive was left “open” for 7-10 min to allow it to “tack” before flooring was installed.

Flooring

Materials:	Marmoleum Decibel
Manufacturer:	Forbo
Dimensions:	2 pieces @ 2007 mm (79 in.) by 2464 mm (97 in.) 1 piece @ 257 mm (10.125 in.) by 2438 mm (96 in.)
Thickness:	6 mm (0.25 in.)
Overall Weight:	32.77 kg (72.25 lbs)
Mass Per Unit Volume:	491 kg/m^3 (30.6 lbs/ft^3)
Installation:	Two (2) 79” segments perpendicular to Plywood 10” strip to complete Joints staggered from parallel plywood joints by + 6” Rolled with 100lb roller in each direction

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Overall Specimen Measurements

Dimensions:	2.44 m (96.0 in) wide by 3.86 m (152.0 in) long
Thickness:	0.31 m (12.125 in)
Weight:	2493.96 kg (5498.25 lbs)
Overall Area:	9.414 m² (101.33 ft²)
Mass per Unit Area:	239.69 kg/m² (49.09 lbs/ft²)

Test Aperture

Opening Size:	4.27 m (14.0 ft.) by 6.10 m (20 ft.)
Filler Wall:	Yes
Aperture Size:	2.44 m (96.0 in) wide by 3.86 m (152.0 in) long
Transmission Area:	9.414 m² (101.33 ft²)
Sealed:	Entire periphery (both sides) with dense mastic

Test Environment

Source Room

Volume:	131.12 m³
Temperature:	22.8 °C ± 0.0 °C
Relative Humidity:	59.0 % ± 0.0 %

Receive Room

Volume:	81.44 m³
Temperature:	21.1 °C ± 0.0 °C
Relative Humidity:	61.0 % ± 0.0 %

Requirements

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

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

Figure 2 – Specimen mounted in test chamber, as viewed from receive room

Figure 3 - CLT (1 of 2) prior to installation

Figure 4 - CLT installed in test aperture

Figure 5 - 3/4” x 6” plywood spline partially installed over CLT rabbets

Figure 6 - Detail of 3/4” x 6” plywood spline partially installed over CLT rabbets

Figure 7 - 2” by 4” sleepers partially installed, with Piano B 40/40 strips fastened to underside of sleepers

Figure 8 - Piano B 40/40 strip fastened to sleeper prior to installation of sleeper

Figure 9 - Gravel partially installed in gaps between sleepers

Figure 10 - Gravel installed; Piano B 40/40 partially installed to top of sleepers

Figure 11 - Gravel and sleepers with Piano B 40/40 installed

Figure 12 - Plywood subfloor partially installed

Figure 13 - Plywood subfloor installed

Figure 14 - Trowel used for installation of adhesive

Figure 15 - Adhesive being troweled over plywood prior to installation of flooring

Figure 16 - Flooring partially installed

Figure 17 - Flooring partially installed

University of Oregon
2024-06-21

RAL™-IN24-015

TEST RESULTS

The averaged sound pressure levels, normalized to a receive room reference absorption of 10 m^2, are tabulated at the sixteen frequency bands specified in ASTM E492-22 Section 9.5. A graphic presentation of the data and additional information appear on the following pages. The 95% confidence limit for the sound pressure level in the receive room is below the limits specified in ASTM E492-22 Section A1.4.

FREQ.	Ln	ΔLn	DEV	FREQ.	Ln	ΔLn	DEV
100	65	2.37	8	800	37	2.08	0
125	61	1.71	4	1000	30	2.33	0
160	62	1.33	5	1250	24	3.16	0
200	63	1.54	6	1600	16	1.16	0
250	61	2.48	4	2000	12	0.88	0
315	53	1.56	0	2500	9 *	1.02	0
400	51	1.92	0	3150	7 **	1.31	0
500	51	1.15	0				
630	45	2.12	0				

IIC=55

ABBREVIATION INDEX

FREQ. = 1/3 OCTAVE BAND CENTER FREQUENCY, Hz
Ln = NORMALIZED SOUND PRESSURE LEVEL, dB
ΔLn = 95% UNCERTAINTY LIMIT FOR Ln, dB
DEV. = DEVIATION FROM SHIFTED IIC CONTOUR, dB (SUM OF DEV = 27)
IIC = IMPACT INSULATION CLASS
* = LEVEL CORRECTED DUE TO BACKGROUND NOISE PER E492 SEC 10.2.2
** = LEVEL CORRECTED DUE TO BACKGROUND NOISE PER E492 SEC 10.2.3

Tested by _____
Marc Sciaky
Senior Experimentalist

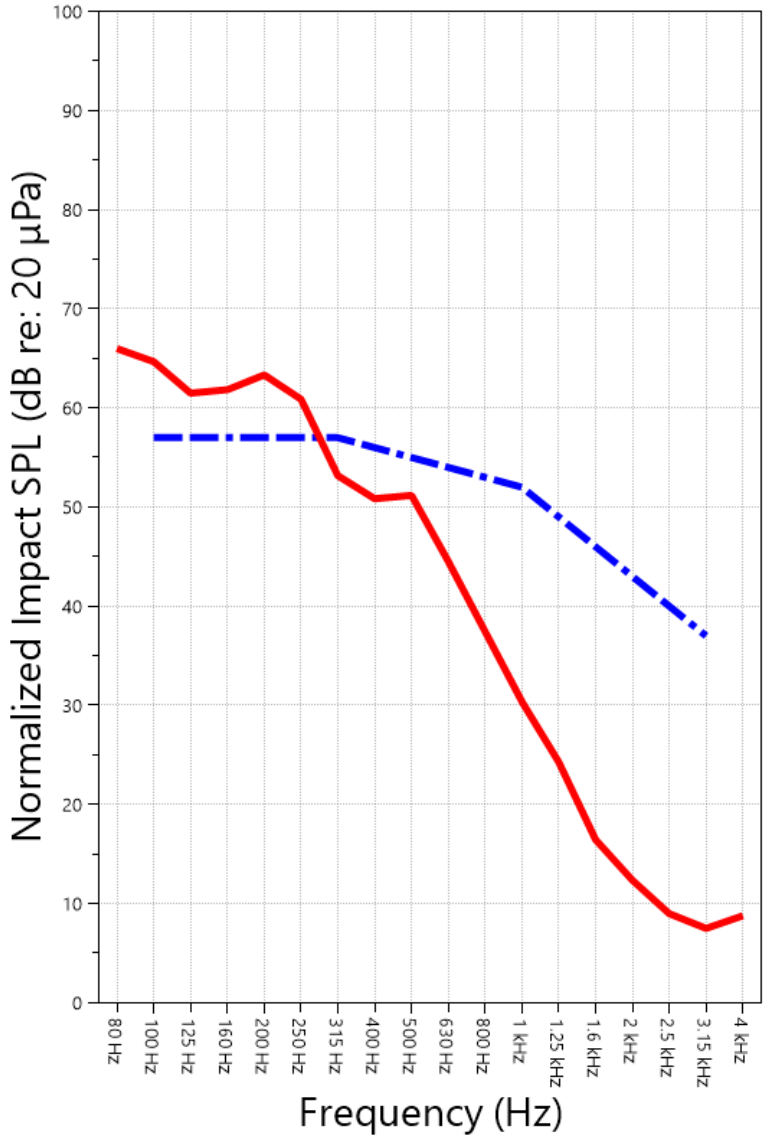
Report by _____
Keith Kimberling
Test Engineer

Approved by _____
Eric P. Wolfram
Laboratory Manager

University of Oregon
2024-06-21

IMPACT SOUND TRANSMISSION REPORT

Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3.75" of 3/8" limestone chip, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC



IIC=55

IMPACT SOUND PRESSURE LEVEL
IMPACT INSULATION CLASS CONTOUR

APPENDIX A: Extended Frequency Range Data

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3.75" of 3/8" limestone chip, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

The following non-accredited data were obtained in accordance with ASTM E492-22 but extend beyond the frequency range of 100 Hz to 3,150 Hz specified in Section 9.5. 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	67	6.85	4.45
40	68	16.30	3.47
50	67	10.34	2.55
63	67	7.42	5.07
80	66	4.33	2.23
100	65	2.37	3.47
125	61	1.71	2.85
160	62	1.33	2.46
200	63	1.54	1.93
250	61	2.48	0.73
315	53	1.56	0.79
400	51	1.92	2.17
500	51	1.15	1.93
630	45	2.12	0.21
800	37	2.08	1.41
1000	30	2.33	2.05
1250	24	3.16	1.49
1600	16	1.16	2.22
2000	12	0.88	2.51
2500	9 *	1.02	1.26
3150	7 **	1.31	1.51
4000	9 **	1.24	1.85
5000	8 **	1.01	1.82
6300	8 **	1.13	1.90
8000	8 **	1.10	0.88
10000	8 **	1.64	4.02
12500	9 **	1.72	5.26

* *Level corrected due to proximity to background noise per E492 Section 10.2.2*

** *Level corrected due to proximity to background noise per E492 Section 10.2.3, represents lower bound of specimen performance*

APPENDIX B: Glossary for Variability Metrics

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3.75" of 3/8" limestone chip, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

ΔL_n, the 95% confidence limit 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 varying sound pressure level in the receive room and changes in specimen response for different tapping machine locations.

Repeatability, expressed as a 95% confidence limit, 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 specimen composed of 152.4 mm (6 in.) thick concrete slabs, 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 vary with the construction type.

APPENDIX C: Single-Number Ratings for Low and High Frequency Ranges

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3.75" of 3/8" limestone chip, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Current priorities in the architectural acoustics community involve the development of impact insulation metrics corresponding to impact sources of varying frequency content. Standard Classification ASTM E3222-20a provides a method for calculating the **High-Frequency Impact Insulation Class (HIIC)**, using normalized impact sound pressure level (L_n) data at frequency bands from 400 Hz to 3150 Hz. Standard Classification ASTM E3207-21 provides a method for calculating the **Low-Frequency Impact Insulation Class (LIIC)** uses normalized impact sound pressure level (L_n) data at frequency bands from 50 Hz to 80 Hz.

Low-frequency impact noise correlates to the "thudding" of footfalls on lightweight structures, while high-frequency sound correlates to sources including the impacts of hard-heeled shoes, dragging furniture, dog toenails, and objects dropped on hard-surfaced flooring. When presented alongside the IIC rating, The LIIC and HIIC ratings can be used to predict how the nature of an impact source will affect the response of the floor-ceiling construction. A summary of impact insulation ratings, as calculated from the test results, is given below.

Referenced Standard	Rating	Calculated Value
ASTM E989-21	IIC	**55**
ASTM E3222-20a	HIIC	**67**
ASTM E3207-21	LIIC	**47**

APPENDIX D: Instruments of Traceability

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3.75" of 3/8" limestone chip, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Description	Model	Serial Number	Date of Certification	Calibration Due
System 2	Type 3160-A-042	3160-106974	2023-08-11	2024-08-11
Bruel & Kjaer Mic And Preamp C	Type 4943-B-001	2311439	2024-03-29	2025-03-29
Bruel & Kjaer Tapping Machine	Type 3207	3151105	2023-12-14	2024-12-14
Bruel & Kjaer Pistonphone	Type 4228	2781248	2023-07-12	2024-07-12
EXTECH Hygro 959	SD700	A.099959	2024-03-29	2025-03-29
EXTECH Hygro 639	SD700	A.103639	2023-12-01	2024-12-01

APPENDIX E: Revisions to Original Test Report

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3.75" of 3/8" limestone chip, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Date	Revision
2024-07-31	Original report issued
2024-09-19	Page 16: Tapping machine added to instruments of traceability. -EPW

END

RIVERBANK ACOUSTICAL LABORATORIES

627 RIVERBANK DRIVE
GENEVA, IL 60134

630-232-0104

Test Report

www.riverbankacoustics.com

FOUNDED 1918 BY
WALLACE CLEMENT SABINE

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

Impact Sound Transmission
RAL™-IN24-016

CONDUCTED: 2024-06-24

ON: 1-1/8” T&G plywood subfloor screwed 24” OC with #9x3”, cavity filled with: 3” of 3/8” limestone chip and Hempitecture 3/4” hemp fiber board, 2x4 sleepers 24”OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875”

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 17025:2017 Laboratory (NVLAP Lab Code: 100227-0) and for this test procedure. The test reported in this document conformed explicitly with ASTM E492-22: "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 E989-21: "Standard Classification for Determination of Single-Number Metrics for Impact Noise." A description of the measurement procedure and room specifications are 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 1-1/8” T&G plywood subfloor screwed 24” OC with #9x3”, cavity filled with: 3” of 3/8” limestone chip and Hempitecture 3/4” hemp fiber board, 2x4 sleepers 24”OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875”. 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

Provided Description:	1-1/8” T&G plywood subfloor screwed 24” OC with #9x3", cavity filled with: 3” of 3/8" limestone chip and Hempitecture 3/4” hemp fiber board, 2x4 sleepers 24”OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875"
Manufacturer:	University of Oregon

SPECIMEN MEASUREMENTS & TEST CONDITIONS

The building contractor (Seth Priser) and RAL staff compiled a detailed construction specification as follows:

Cross-Laminated Timber (CLT)

Materials:	5-Ply Cross-Laminated Timber
Dimensions:	2 panels @ 1219 mm (48 in.) by 4229 mm (166.5 in.)
Thickness:	171 mm (6.75 in.)
Overall Weight:	953.45 kg (2102 lbs)
Mass Per Unit Volume:	539 kg/m^3 (33.7 lbs/ft^3)
Installation:	CLT panels laid on 152 mm (6 in.) wide knee walls in test opening and butted to one another without sealant/adhesive. 3/4"x3" Rabbet on top side of one edge of each panel where they butt allowing a loose spline (below) to insert and join the two

¾" CDX Loose Spline

Materials:	3/4" x 6" plywood spline
Dimensions:	1 piece @ 151 mm (5.9375 in.) wide by 2438 mm (96 in.) 1 piece @ 151 mm (5.9375 in.) wide by 1791 mm (70.5 in.)
Thickness:	19 mm (0.75 in.)
Overall Weight:	6.46 kg (14.25 lbs)
Mass Per Unit Length:	1.53 kg/m (1.03 lbs/ft)
Installation:	Set in Rabbets of both CLT's and screwed in place.
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing:	6" o.c. on a line 3" from each edge of the spline (Centered on the rabbet of the CLT)

Piano B 40/40 (Lower Layer)

Manufacturer:	Rothoblaas
Dimensions:	2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long 8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness:	6.76 mm (0.266 in.)
Overall Weight:	4.59 kg (10.125 lbs)
Mass Per Unit Volume:	624 kg/m^3 (40.0 lbs/ft^3)
Installation:	Fastened to underside of 2" x 4" wood sleepers with staples
Fasteners:	Arrow staples, length @ 13 mm (0.5 in.)

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

2" by 4" SPF Framing Sleepers

Materials:	Nominal 2"x 4" framing lumber
Dimensions:	2 pieces @ 38 mm (1.5 in.) wide by 4255 mm (167.5 in.) long 8 pieces @ 2369 mm (93.25 in.) wide by 38 mm (1.5 in.) long
Depth:	89 mm (3.5 in.)
Overall Weight:	49.33 kg (108.75 lbs)
Mass Per Unit Length:	1.80 kg/m (1.21 lbs/ft)
Installation:	Sleepers laid over CLT, resting on lower layer Piano B 40/40 Longer sleepers parallel to CLT like a rim joist Shorter sleepers set like floor joists between rim joists Shorter sleepers spaced approx. 610 mm (24 in.) on center Shorter sleepers fastened to longer sleepers with screws, 2 screws per connection point
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)

Piano B 40/40 (Upper Layer)

Manufacturer:	Rothoblaas
Dimensions:	2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long 8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness:	6.76 mm (0.266 in.)
Overall Weight:	4.59 kg (10.125 lbs)
Mass Per Unit Volume:	624 kg/m^3 (40.0 lbs/ft^3)
Installation:	Fastened to top of 2" x 4" wood sleepers with staples
Fasteners:	Arrow staples, length @ 13 mm (0.5 in.)

Hemp Board

Materials:	1" Hemp fiber board
Manufacturer:	Hempitecture
Dimensions:	7 pieces @ 572 mm (22.5 in.) wide by 2369 mm (93.25 in.) long
Depth:	19 mm (0.75 in.)
Overall Weight:	24.38 kg (53.75 lbs)
Mass Per Unit Volume:	135 kg/m^3 (8.43 lbs/ft^3)
Installation:	Friction fit between sleepers and on top of CLT

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Crushed Limestone

Materials:	CA-16 3/8" chip crushed limestone
Dimensions:	2438 mm (96 in.) wide by 4267 mm (168 in.) long, as installed
Depth:	70 mm (2.75 in.)
Overall Weight:	986.56 kg (2175 lbs)
Installation:	Filled stone in above hemp board and between sleepers and used a screed to level to the top of the sleepers.

Plywood Subfloor

Materials:	T&G Plywood
Dimensions:	1 piece @ 1219 mm (48 in.) wide by 1829 mm (72 in.) 1 piece @ 1219 mm (48 in.) wide by 2438 mm (96 in.) 1 piece @ 1219 mm (48 in.) wide by 1822 mm (71.75 in.) 1 piece @ 1219 mm (48 in.) wide by 2432 mm (95.75 in.)
Thickness:	29 mm (1.125 in.)
Overall Weight:	170.66 kg (376.25 lbs)
Mass Per Unit Volume:	575 kg/m^3 (35.9 lbs/ft^3)
Installation:	Placed over upper layer Piano B 40/40 over sleepers Fastened to sleepers through Piano B 40/40 with screws Plywood piece joints staggered
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing:	610 mm (24 in.) on center

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Overall Specimen Measurements

Dimensions:	2.44 m (96.0 in) wide by 3.86 m (152.0 in) long
Thickness:	0.3 m (11.875 in)
Weight:	2200.03 kg (4850.25 lbs)
Overall Area:	9.414 m² (101.33 ft²)
Mass per Unit Area:	211.44 kg/m² (43.31 lbs/ft²)

Test Aperture

Opening Size:	4.27 m (14.0 ft.) by 6.10 m (20 ft.)
Filler Wall:	Yes
Aperture Size:	2.44 m (96.0 in) wide by 3.86 m (152.0 in) long
Transmission Area:	9.414 m² (101.33 ft²)
Sealed:	Entire periphery (both sides) with dense mastic

Test Environment

Source Room

Volume:	131.12 m³
Temperature:	23.1 °C ± 0.6 °C
Relative Humidity:	60.5 % ± 1.0 %

Receive Room

Volume:	81.44 m³
Temperature:	22.5 °C ± 0.6 °C
Relative Humidity:	60.5 % ± 1.0 %

Requirements

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

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

Figure 2 – Specimen mounted in test chamber, as viewed from receive room

Figure 3 - CLT (1 of 2) prior to installation

Figure 4 - CLT installed in test aperture

Figure 5 - 3/4” x 6” plywood spline partially installed over CLT rabbets

Figure 6 - Detail of 3/4” x 6” plywood spline partially installed over CLT rabbets

Figure 7 - 2” by 4” sleepers partially installed, with Piano B 40/40 strips fastened to underside of sleepers

Figure 8 - Piano B 40/40 strip fastened to sleeper prior to installation of sleeper

Figure 9 - Hemp boards prior to installation

Figure 10 - Hemp boards partially installed between sleepers, gravel partially installed over hemp boards

Figure 11 - Hemp boards, gravel, and sleepers installed, Piano B 40/40 strips partially installed over sleepers

Figure 12 - Plywood subfloor partially installed

TEST RESULTS

The averaged sound pressure levels, normalized to a receive room reference absorption of 10 m^2, are tabulated at the sixteen frequency bands specified in ASTM E492-22 Section 9.5. A graphic presentation of the data and additional information appear on the following pages. The 95% confidence limit for the sound pressure level in the receive room is below the limits specified in ASTM E492-22 Section A1.4.

FREQ.	Ln	ΔLn	DEV	FREQ.	Ln	ΔLn	DEV
100	63	1.39	0	800	55	2.27	0
125	68	2.13	5	1000	51	2.16	0
160	69	1.97	6	1250	46	1.97	0
200	70	1.85	7	1600	41	1.31	0
250	68	1.69	5	2000	35	2.58	0
315	66	3.32	3	2500	29	1.72	0
400	63	4.06	1	3150	22	1.91	0
500	60	3.95	0				
630	58	3.81	0				

IIC=49

ABBREVIATION INDEX

FREQ. = 1/3 OCTAVE BAND CENTER FREQUENCY, Hz
Ln = NORMALIZED SOUND PRESSURE LEVEL, dB
ΔLn = 95% UNCERTAINTY LIMIT FOR Ln, dB
DEV. = DEVIATION FROM SHIFTED IIC CONTOUR, dB (SUM OF DEV = 27)
IIC = IMPACT INSULATION CLASS
* = LEVEL CORRECTED DUE TO BACKGROUND NOISE PER E492 SEC 10.2.2
** = LEVEL CORRECTED DUE TO BACKGROUND NOISE PER E492 SEC 10.2.3

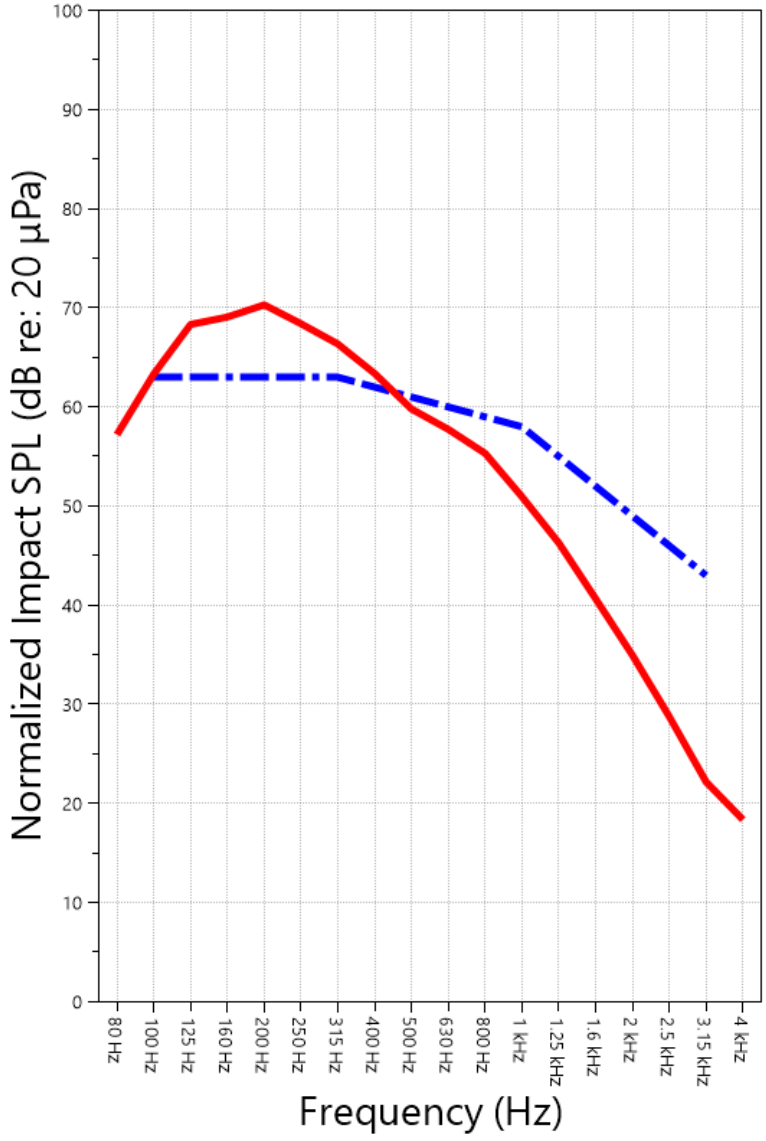
Tested by_____
Keith Kimberling
Test Engineer

Report by_____
Keith Kimberling
Test Engineer

Approved by_____
Eric P. Wolfram
Laboratory Manager

IMPACT SOUND TRANSMISSION REPORT

1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3" of 3/8" limestone chip and Hempitecture 3/4" hemp fiber board, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875"



IIC=49

IMPACT SOUND PRESSURE LEVEL
IMPACT INSULATION CLASS CONTOUR

APPENDIX A: Extended Frequency Range Data

Specimen: 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3" of 3/8" limestone chip and Hempitecture 3/4" hemp fiber board, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" (See Full Report)

The following non-accredited data were obtained in accordance with ASTM E492-22 but extend beyond the frequency range of 100 Hz to 3,150 Hz specified in Section 9.5. These unofficial results are representative of the RAL test environment only and intended for research & comparison purposes.

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63	58	4.01	5.07
80	57	4.31	2.23
100	63	1.39	3.47
125	68	2.13	2.85
160	69	1.97	2.46
200	70	1.85	1.93
250	68	1.69	0.73
315	66	3.32	0.79
400	63	4.06	2.17
500	60	3.95	1.93
630	58	3.81	0.21
800	55	2.27	1.41
1000	51	2.16	2.05
1250	46	1.97	1.49
1600	41	1.31	2.22
2000	35	2.58	2.51
2500	29	1.72	1.26
3150	22	1.91	1.51
4000	18	1.82	1.85
5000	13 *	3.87	1.82
6300	7 **	1.23	1.90
8000	7 **	1.02	0.88
10000	8 **	1.64	4.02
12500	9 **	1.75	5.26

* *Level corrected due to proximity to background noise per E492 Section 10.2.2*

** *Level corrected due to proximity to background noise per E492 Section 10.2.3, represents lower bound of specimen performance*

APPENDIX B: Glossary for Variability Metrics

Specimen: 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3" of 3/8" limestone chip and Hempitecture 3/4" hemp fiber board, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" (See Full Report)

ΔL_n, the 95% confidence limit 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 varying sound pressure level in the receive room and changes in specimen response for different tapping machine locations.

Repeatability, expressed as a 95% confidence limit, 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 specimen composed of 152.4 mm (6 in.) thick concrete slabs, 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 vary with the construction type.

APPENDIX C: Single-Number Ratings for Low and High Frequency Ranges

Specimen: 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3" of 3/8" limestone chip and Hempitecture 3/4" hemp fiber board, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" (See Full Report)

Current priorities in the architectural acoustics community involve the development of impact insulation metrics corresponding to impact sources of varying frequency content. Standard Classification ASTM E3222-20a provides a method for calculating the **High-Frequency Impact Insulation Class (HIIC)**, using normalized impact sound pressure level (L_n) data at frequency bands from 400 Hz to 3150 Hz. Standard Classification ASTM E3207-21 provides a method for calculating the **Low-Frequency Impact Insulation Class (LIIC)** uses normalized impact sound pressure level (L_n) data at frequency bands from 50 Hz to 80 Hz.

Low-frequency impact noise correlates to the "thudding" of footfalls on lightweight structures, while high-frequency sound correlates to sources including the impacts of hard-heeled shoes, dragging furniture, dog toenails, and objects dropped on hard-surfaced flooring. When presented alongside the IIC rating, The LIIC and HIIC ratings can be used to predict how the nature of an impact source will affect the response of the floor-ceiling construction. A summary of impact insulation ratings, as calculated from the test results, is given below.

Referenced Standard	Rating	Calculated Value
ASTM E989-21	IIC	**49**
ASTM E3222-20a	HIIC	**55**
ASTM E3207-21	LIIC	**66**

APPENDIX D: Instruments of Traceability

Specimen: 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3" of 3/8" limestone chip and Hempitecture 3/4" hemp fiber board, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" (See Full Report)

Description	Model	Serial Number	Date of Certification	Calibration Due
System 2	Type 3160-A-042	3160-106974	2023-08-11	2024-08-11
Bruel & Kjaer Mic And Preamp C	Type 4943-B-001	2311439	2024-03-29	2025-03-29
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EXTECH Hygro 959	SD700	A.099959	2024-03-29	2025-03-29
EXTECH Hygro 639	SD700	A.103639	2023-12-01	2024-12-01

APPENDIX E: Revisions to Original Test Report

Specimen: 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3" of 3/8" limestone chip and Hempitecture 3/4" hemp fiber board, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" (See Full Report)

Date	Revision
2024-07-31	Original report issued
2024-09-19	Page 16: Tapping machine added to instruments of traceability. -EPW

END

RIVERBANK ACOUSTICAL LABORATORIES

627 RIVERBANK DRIVE
GENEVA, IL 60134

630-232-0104

Test Report

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WALLACE CLEMENT SABINE

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

Impact Sound Transmission
RAL™-IN24-017

CONDUCTED: 2024-06-25

ON: Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3" of 3/8" limestone chip and Hempitecture 3/4" hemp fiber board, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC

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 17025:2017 Laboratory (NVLAP Lab Code: 100227-0) and for this test procedure. The test reported in this document conformed explicitly with ASTM E492-22: "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 E989-21: "Standard Classification for Determination of Single-Number Metrics for Impact Noise." A description of the measurement procedure and room specifications are 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 Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3" of 3/8" limestone chip and Hempitecture 3/4" hemp fiber board, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC. 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

Provided Description:	Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3" of 3/8" limestone chip and Hempitecture 3/4" hemp fiber board, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC
Manufacturer:	University of Oregon

SPECIMEN MEASUREMENTS & TEST CONDITIONS

The building contractor (Seth Priser) and RAL staff compiled a detailed construction specification as follows:

Cross-Laminated Timber (CLT)

Materials:	5-Ply Cross-Laminated Timber
Dimensions:	2 panels @ 1219 mm (48 in.) by 4229 mm (166.5 in.)
Thickness:	171 mm (6.75 in.)
Overall Weight:	953.45 kg (2102 lbs)
Mass Per Unit Volume:	539 kg/m^3 (33.7 lbs/ft^3)
Installation:	CLT panels laid on 152 mm (6 in.) wide knee walls in test opening and butted to one another without sealant/adhesive. 3/4"x3" Rabbet on top side of one edge of each panel where they butt allowing a loose spline (below) to insert and join the two

¾" CDX Loose Spline

Materials:	3/4" x 6" plywood spline
Dimensions:	1 piece @ 151 mm (5.9375 in.) wide by 2438 mm (96 in.) 1 piece @ 151 mm (5.9375 in.) wide by 1791 mm (70.5 in.)
Thickness:	19 mm (0.75 in.)
Overall Weight:	6.46 kg (14.25 lbs)
Mass Per Unit Length:	1.53 kg/m (1.03 lbs/ft)
Installation:	Set in Rabbets of both CLT's and screwed in place.
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing:	6" o.c. on a line 3" from each edge of the spline (Centered on the rabbet of the CLT)

Piano B 40/40 (Lower Layer)

Manufacturer:	Rothoblaas
Dimensions:	2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long 8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness:	6.76 mm (0.266 in.)
Overall Weight:	4.59 kg (10.125 lbs)
Mass Per Unit Volume:	624 kg/m^3 (40.0 lbs/ft^3)
Installation:	Fastened to underside of 2" x 4" wood sleepers with staples
Fasteners:	Arrow staples, length @ 13 mm (0.5 in.)

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

2" by 4" SPF Framing Sleepers

Materials:	Nominal 2"x 4" framing lumber
Dimensions:	2 pieces @ 38 mm (1.5 in.) wide by 4255 mm (167.5 in.) long 8 pieces @ 2369 mm (93.25 in.) wide by 38 mm (1.5 in.) long
Depth:	89 mm (3.5 in.)
Overall Weight:	49.33 kg (108.75 lbs)
Mass Per Unit Length:	1.80 kg/m (1.21 lbs/ft)
Installation:	Sleepers laid over CLT, resting on lower layer Piano B 40/40 Longer sleepers parallel to CLT like a rim joist Shorter sleepers set like floor joists between rim joists Shorter sleepers spaced approx. 610 mm (24 in.) on center Shorter sleepers fastened to longer sleepers with screws, 2 screws per connection point
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)

Piano B 40/40 (Upper Layer)

Manufacturer:	Rothoblaas
Dimensions:	2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long 8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness:	6.76 mm (0.266 in.)
Overall Weight:	4.59 kg (10.125 lbs)
Mass Per Unit Volume:	624 kg/m^3 (40.0 lbs/ft^3)
Installation:	Fastened to top of 2" x 4" wood sleepers with staples
Fasteners:	Arrow staples, length @ 13 mm (0.5 in.)

Hemp Board

Materials:	1" Hemp fiber board
Manufacturer:	Hempitecture
Dimensions:	7 pieces @ 572 mm (22.5 in.) wide by 2369 mm (93.25 in.) long
Depth:	19 mm (0.75 in.)
Overall Weight:	24.38 kg (53.75 lbs)
Mass Per Unit Volume:	135 kg/m^3 (8.43 lbs/ft^3)
Installation:	Friction fit between sleepers and on top of CLT

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Crushed Limestone

Materials:	CA-16 3/8" chip crushed limestone
Dimensions:	2438 mm (96 in.) wide by 4267 mm (168 in.) long, as installed
Depth:	70 mm (2.75 in.)
Overall Weight:	986.56 kg (2175 lbs)
Installation:	Filled stone in above hemp board and between sleepers and used a screed to level to the top of the sleepers.

Plywood Subfloor

Materials:	T&G Plywood
Dimensions:	1 piece @ 1219 mm (48 in.) wide by 1829 mm (72 in.) 1 piece @ 1219 mm (48 in.) wide by 2438 mm (96 in.) 1 piece @ 1219 mm (48 in.) wide by 1822 mm (71.75 in.) 1 piece @ 1219 mm (48 in.) wide by 2432 mm (95.75 in.)
Thickness:	29 mm (1.125 in.)
Overall Weight:	170.66 kg (376.25 lbs)
Mass Per Unit Volume:	575 kg/m^3 (35.9 lbs/ft^3)
Installation:	Placed over upper layer Piano B 40/40 over sleepers Fastened to sleepers through Piano B 40/40 with screws Plywood piece joints staggered
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing:	610 mm (24 in.) on center

Adhesive

Materials:	Sustain 1195 Sheet and Tile adhesive
Manufacturer:	Forbo
Dimensions:	Approx. 2438 mm (96 in.) by 4267 mm (168 in.) as installed
Overall Weight:	5.44 kg (12 lbs)
Mass Per Unit Area:	0.52 kg/m^2 (0.11 lbs/ft^2)
Installation:	Troweled directly to plywood with a 1/16x1/16x1/16 square notch trowel Once troweled, adhesive was left "open" for 15 min to allow it to "tack" before flooring was installed.

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Flooring

Materials:	Marmoleum Decibel
Manufacturer:	Forbo
Dimensions:	2 pieces @ 2007 mm (79 in.) by 2464 mm (97 in.) 1 piece @ 257 mm (10.125 in.) by 2438 mm (96 in.)
Thickness:	6 mm (0.25 in.)
Overall Weight:	32.21 kg (71 lbs)
Mass Per Unit Volume:	482 kg/m^3 (30.1 lbs/ft^3)
Installation:	Two (2) 79” segments perpendicular to Plywood 10” strip to complete Joints staggered from parallel plywood joints by + 6” Rolled with 100lb roller in each direction

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Overall Specimen Measurements

Dimensions:	2.44 m (96.0 in) wide by 3.86 m (152.0 in) long
Thickness:	0.31 m (12.125 in)
Weight:	2237.68 kg (4933.25 lbs)
Overall Area:	9.414 m² (101.33 ft²)
Mass per Unit Area:	215.06 kg/m² (44.05 lbs/ft²)

Test Aperture

Opening Size:	4.27 m (14.0 ft.) by 6.10 m (20 ft.)
Filler Wall:	Yes
Aperture Size:	2.44 m (96.0 in) wide by 3.86 m (152.0 in) long
Transmission Area:	9.414 m² (101.33 ft²)
Sealed:	Entire periphery (both sides) with dense mastic

Test Environment

Source Room

Volume:	131.12 m³
Temperature:	22.8 °C ± 0.0 °C
Relative Humidity:	62.5 % ± 1.0 %

Receive Room

Volume:	81.44 m³
Temperature:	22.2 °C ± 0.0 °C
Relative Humidity:	62.5 % ± 1.0 %

Requirements

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

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

Figure 2 – Specimen mounted in test chamber, as viewed from receive room

Figure 3 - CLT (1 of 2) prior to installation

Figure 4 - CLT installed in test aperture

Figure 5 - 3/4” x 6” plywood spline partially installed over CLT rabbets

Figure 6 - Detail of 3/4” x 6” plywood spline partially installed over CLT rabbets

Figure 7 - 2” by 4” sleepers partially installed, with Piano B 40/40 strips fastened to underside of sleepers

Figure 8 - Piano B 40/40 strip fastened to sleeper prior to installation of sleeper

Figure 9 - Hemp boards prior to installation

Figure 10 - Hemp boards partially installed between sleepers, gravel partially installed over hemp boards

Figure 11 - Hemp boards, gravel, and sleepers installed, Piano B 40/40 strips partially installed over sleepers

Figure 12 - Plywood subfloor partially installed

Figure 13 - Plywood subfloor installed

Figure 14 - Trowel used for installation of adhesive

Figure 15 - Adhesive partially installed over plywood

Figure 16 - Flooring partially installed over adhesive

TEST RESULTS

The averaged sound pressure levels, normalized to a receive room reference absorption of 10 m^2, are tabulated at the sixteen frequency bands specified in ASTM E492-22 Section 9.5. A graphic presentation of the data and additional information appear on the following pages. The 95% confidence limit for the sound pressure level in the receive room is below the limits specified in ASTM E492-22 Section A1.4.

FREQ.	Ln	ΔLn	DEV	FREQ.	Ln	ΔLn	DEV
100	62	1.23	0	800	40	2.49	0
125	69	3.03	6	1000	33	1.07	0
160	70	1.68	7	1250	28	2.45	0
200	71	1.59	8	1600	17	2.13	0
250	66	2.30	3	2000	9 *	1.60	0
315	63	3.73	0	2500	3 **	0.71	0
400	58	2.47	0	3150	3 **	0.58	0
500	51	1.68	0				
630	46	1.68	0				

IIC=49

ABBREVIATION INDEX

FREQ. = 1/3 OCTAVE BAND CENTER FREQUENCY, Hz
Ln = NORMALIZED SOUND PRESSURE LEVEL, dB
ΔLn = 95% UNCERTAINTY LIMIT FOR Ln, dB
DEV. = DEVIATION FROM SHIFTED IIC CONTOUR, dB (SUM OF DEV = 24)
IIC = IMPACT INSULATION CLASS
* = LEVEL CORRECTED DUE TO BACKGROUND NOISE PER E492 SEC 10.2.2
** = LEVEL CORRECTED DUE TO BACKGROUND NOISE PER E492 SEC 10.2.3

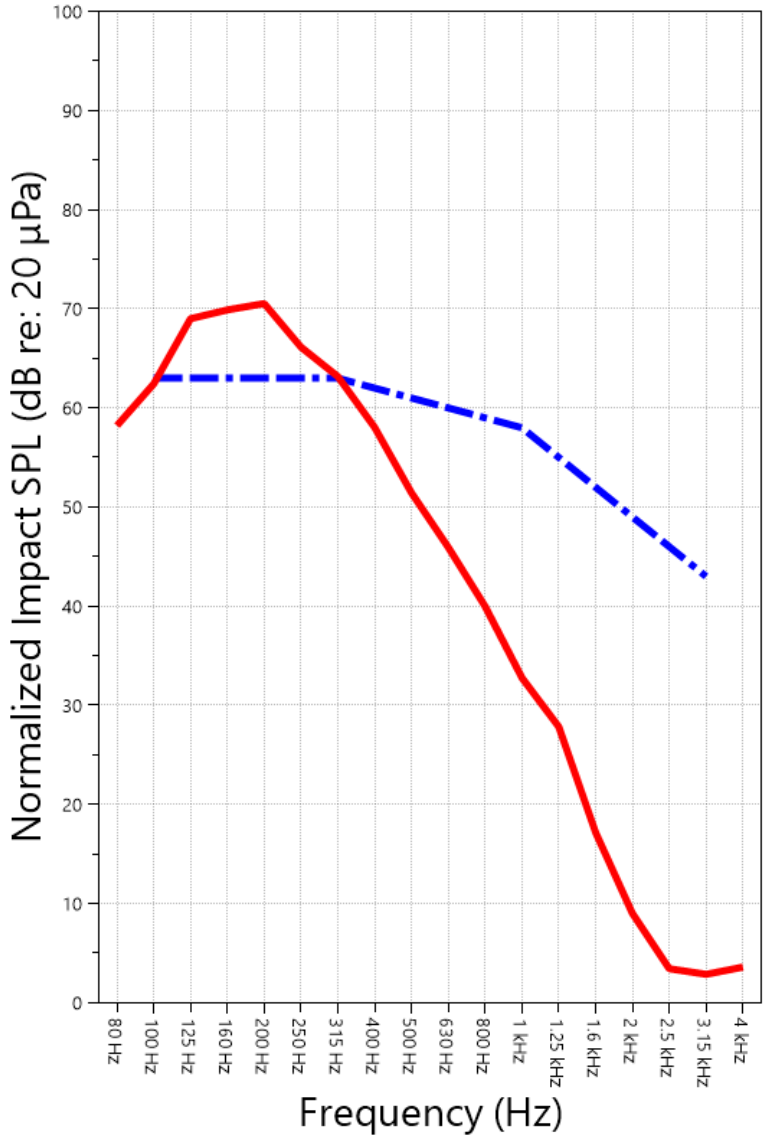
Tested by_____
Keith Kimberling
Test Engineer

Report by_____
Keith Kimberling
Test Engineer

Approved by_____
Eric P. Wolfram
Laboratory Manager

IMPACT SOUND TRANSMISSION REPORT

Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3" of 3/8" limestone chip and Hempitecture 3/4" hemp fiber board, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC



IIC=49

IMPACT SOUND PRESSURE LEVEL

IMPACT INSULATION CLASS CONTOUR

APPENDIX A: Extended Frequency Range Data

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3" of 3/8" limestone chip and Hempitecture 3/4" hemp fiber board, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

The following non-accredited data were obtained in accordance with ASTM E492-22 but extend beyond the frequency range of 100 Hz to 3,150 Hz specified in Section 9.5. 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	66	13.55	4.45
40	61	13.03	3.47
50	60	5.79	2.55
63	59	3.33	5.07
80	58	4.54	2.23
100	62	1.23	3.47
125	69	3.03	2.85
160	70	1.68	2.46
200	71	1.59	1.93
250	66	2.30	0.73
315	63	3.73	0.79
400	58	2.47	2.17
500	51	1.68	1.93
630	46	1.68	0.21
800	40	2.49	1.41
1000	33	1.07	2.05
1250	28	2.45	1.49
1600	17	2.13	2.22
2000	9 *	1.60	2.51
2500	3 **	0.71	1.26
3150	3 **	0.58	1.51
4000	4 **	0.47	1.85
5000	5 **	0.64	1.82
6300	6 **	0.80	1.90
8000	7 **	1.02	0.88
10000	8 **	1.62	4.02
12500	9 **	1.74	5.26

* *Level corrected due to proximity to background noise per E492 Section 10.2.2*

** *Level corrected due to proximity to background noise per E492 Section 10.2.3, represents lower bound of specimen performance*

APPENDIX B: Glossary for Variability Metrics

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3" of 3/8" limestone chip and Hempitecture 3/4" hemp fiber board, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

ΔL_n, the 95% confidence limit 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 varying sound pressure level in the receive room and changes in specimen response for different tapping machine locations.

Repeatability, expressed as a 95% confidence limit, 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 specimen composed of 152.4 mm (6 in.) thick concrete slabs, 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 vary with the construction type.

APPENDIX C: Single-Number Ratings for Low and High Frequency Ranges

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3" of 3/8" limestone chip and Hempitecture 3/4" hemp fiber board, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

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END

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Test Report

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WALLACE CLEMENT SABINE

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

Impact Sound Transmission
RAL™-IN24-018

CONDUCTED: 2024-06-26

ON: 1-1/8” T&G plywood subfloor screwed 24” OC with #9x3”, cavity filled with: HempWool Acoustibatt 3.5” hemp batt, 2x4 sleepers 24”OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875” with plywood spline 3/4”x6” at the joint secured with #9x3” screws at 6” OC

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Mass Per Unit Length:	1.53 kg/m (1.03 lbs/ft)
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Manufacturer:	Rothoblaas
Dimensions:	2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long 8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness:	6.76 mm (0.266 in.)
Overall Weight:	4.59 kg (10.125 lbs)
Mass Per Unit Volume:	624 kg/m^3 (40.0 lbs/ft^3)
Installation:	Fastened to underside of 2" x 4" wood sleepers with staples
Fasteners:	Arrow staples, length @ 13 mm (0.5 in.)

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

2" by 4" SPF Framing Sleepers

Materials:	Nominal 2"x 4" framing lumber
Dimensions:	2 pieces @ 38 mm (1.5 in.) wide by 4255 mm (167.5 in.) long 8 pieces @ 2369 mm (93.25 in.) wide by 38 mm (1.5 in.) long
Depth:	89 mm (3.5 in.)
Overall Weight:	49.33 kg (108.75 lbs)
Mass Per Unit Length:	1.80 kg/m (1.21 lbs/ft)
Installation:	Sleepers laid over CLT, resting on lower layer Piano B 40/40 Longer sleepers parallel to CLT like a rim joist Shorter sleepers set like floor joists between rim joists Shorter sleepers spaced approx. 610 mm (24 in.) on center Shorter sleepers fastened to longer sleepers with screws, 2 screws per connection point
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)

Piano B 40/40 (Upper Layer)

Manufacturer:	Rothoblaas
Dimensions:	2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long 8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness:	6.76 mm (0.266 in.)
Overall Weight:	4.59 kg (10.125 lbs)
Mass Per Unit Volume:	624 kg/m^3 (40.0 lbs/ft^3)
Installation:	Fastened to top of 2" x 4" wood sleepers with staples
Fasteners:	Arrow staples, length @ 13 mm (0.5 in.)

Hemp Board

Materials:	3" Hemp fiber board
Manufacturer:	Hempitecture
Dimensions:	7 pieces @ 572 mm (22.5 in.) wide by 2369 mm (93.25 in.) long
Depth:	76 mm (3 in.)
Overall Weight:	37.53 kg (82.75 lbs)
Mass Per Unit Volume:	52.0 kg/m^3 (3.25 lbs/ft^3)
Installation:	Friction fit between sleepers and on top of CLT

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Plywood Subfloor

Materials:	T&G Plywood
Dimensions:	1 piece @ 1219 mm (48 in.) wide by 1829 mm (72 in.)
	1 piece @ 1219 mm (48 in.) wide by 2438 mm (96 in.)
	1 piece @ 1219 mm (48 in.) wide by 1822 mm (71.75 in.)
	1 piece @ 1219 mm (48 in.) wide by 2432 mm (95.75 in.)
Thickness:	29 mm (1.125 in.)
Overall Weight:	172.25 kg (379.75 lbs)
Mass Per Unit Volume:	580 kg/m^3 (36.2 lbs/ft^3)
Installation:	Placed over upper layer Piano B 40/40 over sleepers
	Fastened to sleepers through Piano B 40/40 with screws
	Plywood piece joints staggered
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing:	610 mm (24 in.) on center

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Overall Specimen Measurements

Dimensions:	2.44 m (96.0 in) wide by 3.86 m (152.0 in) long
Thickness:	0.3 m (11.875 in)
Weight:	1228.21 kg (2707.75 lbs)
Overall Area:	9.414 m² (101.33 ft²)
Mass per Unit Area:	118.04 kg/m² (24.18 lbs/ft²)

Test Aperture

Opening Size:	4.27 m (14.0 ft.) by 6.10 m (20 ft.)
Filler Wall:	Yes
Aperture Size:	2.44 m (96.0 in) wide by 3.86 m (152.0 in) long
Transmission Area:	9.414 m² (101.33 ft²)
Sealed:	Entire periphery (both sides) with dense mastic

Test Environment

Source Room

Volume:	131.12 m³
Temperature:	22.8 °C ± 0.0 °C
Relative Humidity:	65.0 % ± 0.0 %

Receive Room

Volume:	81.44 m³
Temperature:	22.2 °C ± 0.0 °C
Relative Humidity:	64.0 % ± 0.0 %

Requirements

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

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

Figure 2 – Specimen mounted in test chamber, as viewed from receive room

Figure 3 - CLT (1 of 2) prior to installation

Figure 4 - CLT installed in test aperture

Figure 5 - 3/4” x 6” plywood spline partially installed over CLT rabbets

Figure 6 - Detail of 3/4” x 6” plywood spline partially installed over CLT rabbets

Figure 7 - 2” by 4” sleepers partially installed, with Piano B 40/40 strips fastened to underside of sleepers

Figure 8 - Piano B 40/40 strip fastened to sleeper prior to installation of sleeper

Figure 9 - Hemp boards prior to installation

Figure 10 - Hemp boards partially installed between sleepers

Figure 11 - Hemp boards partially installed between sleepers, plywood partially installed over sleepers

TEST RESULTS

The averaged sound pressure levels, normalized to a receive room reference absorption of 10 m^2, are tabulated at the sixteen frequency bands specified in ASTM E492-22 Section 9.5. A graphic presentation of the data and additional information appear on the following pages. The 95% confidence limit for the sound pressure level in the receive room is below the limits specified in ASTM E492-22 Section A1.4.

FREQ.	Ln	ΔLn	DEV	FREQ.	Ln	ΔLn	DEV
100	68	3.09	5	800	54	2.98	0
125	65	2.00	2	1000	50	2.82	0
160	65	1.54	2	1250	45	2.36	0
200	69	2.42	6	1600	40	1.71	0
250	68	2.37	5	2000	35	1.29	0
315	67	3.09	4	2500	29	0.94	0
400	64	4.57	2	3150	23	1.11	0
500	60	4.74	0				
630	58	4.37	0				

IIC=49

ABBREVIATION INDEX

FREQ. = 1/3 OCTAVE BAND CENTER FREQUENCY, Hz
Ln = NORMALIZED SOUND PRESSURE LEVEL, dB
ΔLn = 95% UNCERTAINTY LIMIT FOR Ln, dB
DEV. = DEVIATION FROM SHIFTED IIC CONTOUR, dB (SUM OF DEV = 26)
IIC = IMPACT INSULATION CLASS
* = LEVEL CORRECTED DUE TO BACKGROUND NOISE PER E492 SEC 10.2.2
** = LEVEL CORRECTED DUE TO BACKGROUND NOISE PER E492 SEC 10.2.3

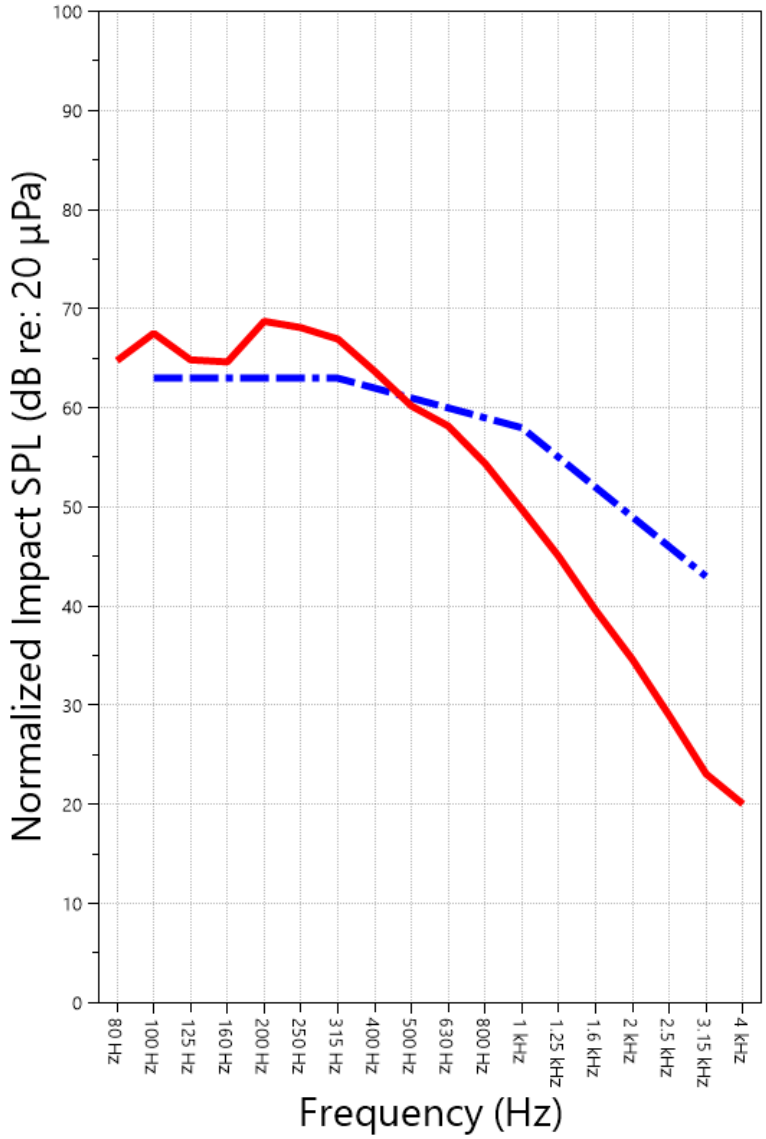
Tested by_____
Keith Kimberling
Test Engineer

Report by_____
Keith Kimberling
Test Engineer

Approved by_____
Eric P. Wolfram
Laboratory Manager

IMPACT SOUND TRANSMISSION REPORT

1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC



IIC=49

IMPACT SOUND PRESSURE LEVEL

IMPACT INSULATION CLASS CONTOUR

APPENDIX A: Extended Frequency Range Data

Specimen: 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

The following non-accredited data were obtained in accordance with ASTM E492-22 but extend beyond the frequency range of 100 Hz to 3,150 Hz specified in Section 9.5. 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	67	5.39	4.45
40	59	4.88	3.47
50	63	7.60	2.55
63	67	5.09	5.07
80	65	4.85	2.23
100	68	3.09	3.47
125	65	2.00	2.85
160	65	1.54	2.46
200	69	2.42	1.93
250	68	2.37	0.73
315	67	3.09	0.79
400	64	4.57	2.17
500	60	4.74	1.93
630	58	4.37	0.21
800	54	2.98	1.41
1000	50	2.82	2.05
1250	45	2.36	1.49
1600	40	1.71	2.22
2000	35	1.29	2.51
2500	29	0.94	1.26
3150	23	1.11	1.51
4000	20	1.11	1.85
5000	12 *	0.91	1.82
6300	6 **	0.81	1.90
8000	7 **	1.03	0.88
10000	8 **	1.62	4.02
12500	8 **	1.72	5.26

* *Level corrected due to proximity to background noise per E492 Section 10.2.2*

** *Level corrected due to proximity to background noise per E492 Section 10.2.3, represents lower bound of specimen performance*

APPENDIX B: Glossary for Variability Metrics

Specimen: 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

ΔL_n, the 95% confidence limit 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 varying sound pressure level in the receive room and changes in specimen response for different tapping machine locations.

Repeatability, expressed as a 95% confidence limit, 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 specimen composed of 152.4 mm (6 in.) thick concrete slabs, 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 vary with the construction type.

APPENDIX C: Single-Number Ratings for Low and High Frequency Ranges

Specimen: 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Current priorities in the architectural acoustics community involve the development of impact insulation metrics corresponding to impact sources of varying frequency content. Standard Classification ASTM E3222-20a provides a method for calculating the **High-Frequency Impact Insulation Class (HIIC)**, using normalized impact sound pressure level (L_n) data at frequency bands from 400 Hz to 3150 Hz. Standard Classification ASTM E3207-21 provides a method for calculating the **Low-Frequency Impact Insulation Class (LIIC)** uses normalized impact sound pressure level (L_n) data at frequency bands from 50 Hz to 80 Hz.

Low-frequency impact noise correlates to the "thudding" of footfalls on lightweight structures, while high-frequency sound correlates to sources including the impacts of hard-heeled shoes, dragging furniture, dog toenails, and objects dropped on hard-surfaced flooring. When presented alongside the IIC rating, The LIIC and HIIC ratings can be used to predict how the nature of an impact source will affect the response of the floor-ceiling construction. A summary of impact insulation ratings, as calculated from the test results, is given below.

Referenced Standard	Rating	Calculated Value
ASTM E989-21	IIC	**49**
ASTM E3222-20a	HIIC	**55**
ASTM E3207-21	LIIC	**50**

APPENDIX D: Instruments of Traceability

Specimen: 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Description	Model	Serial Number	Date of Certification	Calibration Due
System 2	Type 3160-A-042	3160-106974	2023-08-11	2024-08-11
Bruel & Kjaer Mic And Preamp C	Type 4943-B-001	2311439	2024-03-29	2025-03-29
Bruel & Kjaer Tapping Machine	Type 3207	3151105	2023-12-14	2024-12-14
Bruel & Kjaer Pistonphone	Type 4228	2781248	2023-07-12	2024-07-12
EXTECH Hygro 959	SD700	A.099959	2024-03-29	2025-03-29
EXTECH Hygro 639	SD700	A.103639	2023-12-01	2024-12-01

APPENDIX E: Revisions to Original Test Report

Specimen: 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Date	Revision
2024-07-31	Original report issued
2024-09-19	Page 16: Tapping machine added to instruments of traceability. -EPW

END

RIVERBANK ACOUSTICAL LABORATORIES

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GENEVA, IL 60134

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Test Report

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FOUNDED 1918 BY
WALLACE CLEMENT SABINE

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

Impact Sound Transmission
RAL™-IN24-019

CONDUCTED: 2024-06-28

ON: Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC

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 17025:2017 Laboratory (NVLAP Lab Code: 100227-0) and for this test procedure. The test reported in this document conformed explicitly with ASTM E492-22: "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 E989-21: "Standard Classification for Determination of Single-Number Metrics for Impact Noise." A description of the measurement procedure and room specifications are 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 Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC. 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

Provided Description:	Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC
Manufacturer:	University of Oregon

SPECIMEN MEASUREMENTS & TEST CONDITIONS

The building contractor (Seth Priser) and RAL staff compiled a detailed construction specification as follows:

Cross-Laminated Timber (CLT)

Materials:	5-Ply Cross-Laminated Timber
Dimensions:	2 panels @ 1219 mm (48 in.) by 4229 mm (166.5 in.)
Thickness:	171 mm (6.75 in.)
Overall Weight:	953.45 kg (2102 lbs)
Mass Per Unit Volume:	539 kg/m^3 (33.7 lbs/ft^3)
Installation:	CLT panels laid on 152 mm (6 in.) wide knee walls in test opening and butted to one another without sealant/adhesive. 3/4"x3" Rabbet on top side of one edge of each panel where they butt allowing a loose spline (below) to insert and join the two

¾" CDX Loose Spline

Materials:	3/4" x 6" plywood spline
Dimensions:	1 piece @ 151 mm (5.9375 in.) wide by 2438 mm (96 in.) 1 piece @ 151 mm (5.9375 in.) wide by 1791 mm (70.5 in.)
Thickness:	19 mm (0.75 in.)
Overall Weight:	6.46 kg (14.25 lbs)
Mass Per Unit Length:	1.53 kg/m (1.03 lbs/ft)
Installation:	Set in Rabbets of both CLT's and screwed in place.
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing:	6" o.c. on a line 3" from each edge of the spline (Centered on the rabbet of the CLT)

Piano B 40/40 (Lower Layer)

Manufacturer:	Rothoblaas
Dimensions:	2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long 8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness:	6.76 mm (0.266 in.)
Overall Weight:	4.59 kg (10.125 lbs)
Mass Per Unit Volume:	624 kg/m^3 (40.0 lbs/ft^3)
Installation:	Fastened to underside of 2" x 4" wood sleepers with staples
Fasteners:	Arrow staples, length @ 13 mm (0.5 in.)

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

2" by 4" SPF Framing Sleepers

Materials:	Nominal 2"x 4" framing lumber
Dimensions:	2 pieces @ 38 mm (1.5 in.) wide by 4255 mm (167.5 in.) long 8 pieces @ 2369 mm (93.25 in.) wide by 38 mm (1.5 in.) long
Depth:	89 mm (3.5 in.)
Overall Weight:	49.33 kg (108.75 lbs)
Mass Per Unit Length:	1.80 kg/m (1.21 lbs/ft)
Installation:	Sleepers laid over CLT, resting on lower layer Piano B 40/40 Longer sleepers parallel to CLT like a rim joist Shorter sleepers set like floor joists between rim joists Shorter sleepers spaced approx. 610 mm (24 in.) on center Shorter sleepers fastened to longer sleepers with screws, 2 screws per connection point
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)

Piano B 40/40 (Upper Layer)

Manufacturer:	Rothoblaas
Dimensions:	2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long 8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness:	6.76 mm (0.266 in.)
Overall Weight:	4.59 kg (10.125 lbs)
Mass Per Unit Volume:	624 kg/m^3 (40.0 lbs/ft^3)
Installation:	Fastened to top of 2" x 4" wood sleepers with staples
Fasteners:	Arrow staples, length @ 13 mm (0.5 in.)

Hemp Board

Materials:	3" Hemp fiber board
Manufacturer:	Hempitecture
Dimensions:	7 pieces @ 572 mm (22.5 in.) wide by 2369 mm (93.25 in.) long
Depth:	76 mm (3 in.)
Overall Weight:	37.53 kg (82.75 lbs)
Mass Per Unit Volume:	52.0 kg/m^3 (3.25 lbs/ft^3)
Installation:	Friction fit between sleepers and on top of CLT

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Plywood Subfloor

Materials:	T&G Plywood
Dimensions:	1 piece @ 1219 mm (48 in.) wide by 1829 mm (72 in.) 1 piece @ 1219 mm (48 in.) wide by 2438 mm (96 in.) 1 piece @ 1219 mm (48 in.) wide by 1822 mm (71.75 in.) 1 piece @ 1219 mm (48 in.) wide by 2432 mm (95.75 in.)
Thickness:	29 mm (1.125 in.)
Overall Weight:	172.25 kg (379.75 lbs)
Mass Per Unit Volume:	580 kg/m^3 (36.2 lbs/ft^3)
Installation:	Placed over upper layer Piano B 40/40 over sleepers Fastened to sleepers through Piano B 40/40 with screws Plywood piece joints staggered
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing:	610 mm (24 in.) on center

Adhesive

Materials:	Sustain 1195 Sheet and Tile adhesive
Manufacturer:	Forbo
Dimensions:	Approx. 2438 mm (96 in.) by 4267 mm (168 in.) as installed
Overall Weight:	4.2 kg (9.25 lbs)
Mass Per Unit Area:	0.40 kg/m^2 (0.08 lbs/ft^2)
Installation:	Troweled directly to plywood with a 1/16x1/16x1/16 square notch trowel Once troweled, adhesive was left “open” for 15 min to allow it to “tack” before flooring was installed.

Flooring

Materials:	Marmoleum Decibel
Manufacturer:	Forbo
Dimensions:	2 pieces @ 2007 mm (79 in.) by 2464 mm (97 in.) 1 piece @ 257 mm (10.125 in.) by 2438 mm (96 in.)
Thickness:	6 mm (0.25 in.)
Overall Weight:	32.32 kg (71.25 lbs)
Mass Per Unit Volume:	484 kg/m^3 (30.2 lbs/ft^3)
Installation:	Two (2) 79” segments perpendicular to Plywood 10” strip to complete Joints staggered from parallel plywood joints by + 6” Rolled with 100lb roller in each direction

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Overall Specimen Measurements

Dimensions:	2.44 m (96.0 in) wide by 3.86 m (152.0 in) long
Thickness:	0.31 m (12.125 in)
Weight:	1264.73 kg (2788.25 lbs)
Overall Area:	9.414 m² (101.33 ft²)
Mass per Unit Area:	121.55 kg/m² (24.90 lbs/ft²)

Test Aperture

Opening Size:	4.27 m (14.0 ft.) by 6.10 m (20 ft.)
Filler Wall:	Yes
Aperture Size:	2.44 m (96.0 in) wide by 3.86 m (152.0 in) long
Transmission Area:	9.414 m² (101.33 ft²)
Sealed:	Entire periphery (both sides) with dense mastic

Test Environment

Source Room

Volume:	131.12 m³
Temperature:	23.3 °C ± 0.0 °C
Relative Humidity:	60.0 % ± 0.0 %

Receive Room

Volume:	81.44 m³
Temperature:	22.2 °C ± 0.0 °C
Relative Humidity:	62.0 % ± 0.0 %

Requirements

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

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

Figure 2 – Specimen mounted in test chamber, as viewed from receive room

Figure 3 - CLT (1 of 2) prior to installation

Figure 4 - CLT installed in test aperture

Figure 5 - 3/4” x 6” plywood spline partially installed over CLT rabbets

Figure 6 - Detail of 3/4” x 6” plywood spline partially installed over CLT rabbets

Figure 7 - 2” by 4” sleepers partially installed, with Piano B 40/40 strips fastened to underside of sleepers

Figure 8 - Piano B 40/40 strip fastened to sleeper prior to installation of sleeper

Figure 9 - Hemp boards prior to installation

Figure 10 - Hemp boards partially installed between sleepers

Figure 11 - Hemp boards partially installed between sleepers, plywood partially installed over sleepers

Figure 12 - Trowel used for installation of adhesive

Figure 13 - Plywood subfloor installed, adhesive partially installed over plywood

Figure 14 - Flooring partially installed over adhesive

University of Oregon
2024-06-28

RAL™-IN24-019

TEST RESULTS

The averaged sound pressure levels, normalized to a receive room reference absorption of 10 m^2, are tabulated at the sixteen frequency bands specified in ASTM E492-22 Section 9.5. A graphic presentation of the data and additional information appear on the following pages. The 95% confidence limit for the sound pressure level in the receive room is below the limits specified in ASTM E492-22 Section A1.4.

FREQ.	Ln	ΔLn	DEV	FREQ.	Ln	ΔLn	DEV
100	68	1.66	6	800	39	1.77	0
125	67	3.45	5	1000	33	0.77	0
160	65	3.12	3	1250	27	0.80	0
200	70	4.14	8	1600	17	1.86	0
250	66	2.19	4	2000	9 **	1.03	0
315	64	2.22	2	2500	5 **	0.78	0
400	59	1.47	0	3150	3 **	0.95	0
500	53	2.03	0				
630	47	1.73	0				

IIC=50

ABBREVIATION INDEX

FREQ. = 1/3 OCTAVE BAND CENTER FREQUENCY, Hz
Ln = NORMALIZED SOUND PRESSURE LEVEL, dB
ΔLn = 95% UNCERTAINTY LIMIT FOR Ln, dB
DEV. = DEVIATION FROM SHIFTED IIC CONTOUR, dB (SUM OF DEV = 28)
IIC = IMPACT INSULATION CLASS
* = LEVEL CORRECTED DUE TO BACKGROUND NOISE PER E492 SEC 10.2.2
** = LEVEL CORRECTED DUE TO BACKGROUND NOISE PER E492 SEC 10.2.3

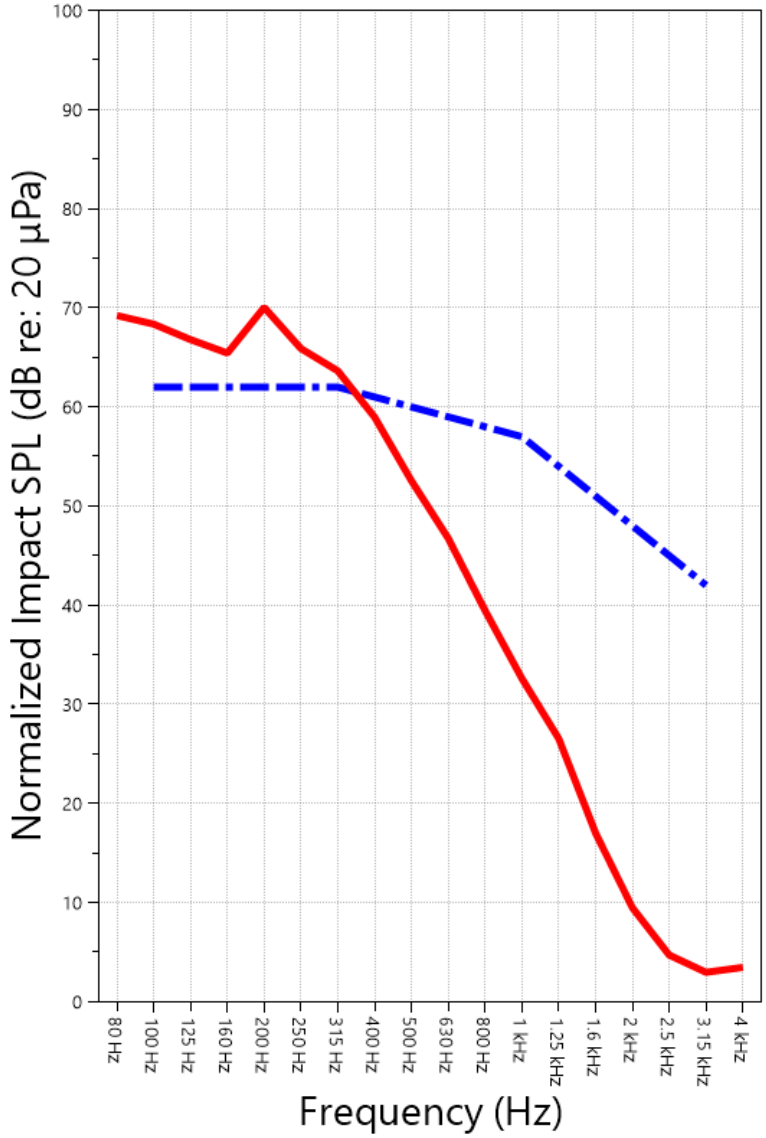
Tested by _____
Marc Sciaky
Senior Experimentalist

Report by _____
Keith Kimberling
Test Engineer

Approved by _____
Eric P. Wolfram
Laboratory Manager

IMPACT SOUND TRANSMISSION REPORT

Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC



IIC=50

IMPACT SOUND PRESSURE LEVEL

IMPACT INSULATION CLASS CONTOUR

University of Oregon
2024-06-28

RAL™-IN24-019

APPENDIX A: Extended Frequency Range Data

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

The following non-accredited data were obtained in accordance with ASTM E492-22 but extend beyond the frequency range of 100 Hz to 3,150 Hz specified in Section 9.5. 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	69	7.12	4.45
40	62	3.29	3.47
50	66	6.76	2.55
63	69	3.20	5.07
80	69	5.01	2.23
100	68	1.66	3.47
125	67	3.45	2.85
160	65	3.12	2.46
200	70	4.14	1.93
250	66	2.19	0.73
315	64	2.22	0.79
400	59	1.47	2.17
500	53	2.03	1.93
630	47	1.73	0.21
800	39	1.77	1.41
1000	33	0.77	2.05
1250	27	0.80	1.49
1600	17	1.86	2.22
2000	9 **	1.03	2.51
2500	5 **	0.78	1.26
3150	3 **	0.95	1.51
4000	3 **	0.69	1.85
5000	5 **	0.65	1.82
6300	6 **	0.82	1.90
8000	7 **	1.04	0.88
10000	8 **	1.61	4.02
12500	8 **	1.68	5.26

* *Level corrected due to proximity to background noise per E492 Section 10.2.2*

** *Level corrected due to proximity to background noise per E492 Section 10.2.3, represents lower bound of specimen performance*

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ΔL_n, the 95% confidence limit 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 varying sound pressure level in the receive room and changes in specimen response for different tapping machine locations.

Repeatability, expressed as a 95% confidence limit, 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 specimen composed of 152.4 mm (6 in.) thick concrete slabs, 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 vary with the construction type.

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Current priorities in the architectural acoustics community involve the development of impact insulation metrics corresponding to impact sources of varying frequency content. Standard Classification ASTM E3222-20a provides a method for calculating the **High-Frequency Impact Insulation Class (HIIC)**, using normalized impact sound pressure level (L_n) data at frequency bands from 400 Hz to 3150 Hz. Standard Classification ASTM E3207-21 provides a method for calculating the **Low-Frequency Impact Insulation Class (LIIC)** uses normalized impact sound pressure level (L_n) data at frequency bands from 50 Hz to 80 Hz.

Low-frequency impact noise correlates to the "thudding" of footfalls on lightweight structures, while high-frequency sound correlates to sources including the impacts of hard-heeled shoes, dragging furniture, dog toenails, and objects dropped on hard-surfaced flooring. When presented alongside the IIC rating, The LIIC and HIIC ratings can be used to predict how the nature of an impact source will affect the response of the floor-ceiling construction. A summary of impact insulation ratings, as calculated from the test results, is given below.

Referenced Standard	Rating	Calculated Value
ASTM E989-21	IIC	**50**
ASTM E3222-20a	HIIC	**63**
ASTM E3207-21	LIIC	**44**

APPENDIX D: Instruments of Traceability

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Description	Model	Serial Number	Date of Certification	Calibration Due
System 2	Type 3160-A-042	3160-106974	2023-08-11	2024-08-11
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Bruel & Kjaer Tapping Machine	Type 3207	3151105	2023-12-14	2024-12-14
Bruel & Kjaer Pistonphone	Type 4228	2781248	2023-07-12	2024-07-12
EXTECH Hygro 959	SD700	A.099959	2024-03-29	2025-03-29
EXTECH Hygro 639	SD700	A.103639	2023-12-01	2024-12-01

APPENDIX E: Revisions to Original Test Report

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Date	Revision
2024-07-31	Original report issued
2024-09-19	Page 17: Tapping machine added to instruments of traceability. -EPW

END

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Test Report

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

Impact Sound Transmission
RAL™-IN24-020

CONDUCTED: 2024-07-08

ON: 1” Maxxon gypcrete 2000 Multifamily, 1-1/8” T&G plywood subfloor screwed 24” OC with #9x3”, cavity filled with: HempWool Acoustibatt 3.5” hemp batt, 2x4 sleepers 24”OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875” with plywood spline 3/4”x6” at the joint secured with #9x3” screws at 6” OC

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 17025:2017 Laboratory (NVLAP Lab Code: 100227-0) and for this test procedure. The test reported in this document conformed explicitly with ASTM E492-22: "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 E989-21: "Standard Classification for Determination of Single-Number Metrics for Impact Noise." A description of the measurement procedure and room specifications are 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 1” Maxxon gypcrete 2000 Multifamily, 1-1/8” T&G plywood subfloor screwed 24” OC with #9x3”, cavity filled with: HempWool Acoustibatt 3.5” hemp batt, 2x4 sleepers 24”OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875” with plywood spline 3/4”x6” at the joint secured with #9x3” screws at 6” OC. 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

Provided Description:	1” Maxxon gypcrete 2000 Multifamily, 1-1/8” T&G plywood subfloor screwed 24” OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5” hemp batt, 2x4 sleepers 24”OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875” with plywood spline 3/4”x6” at the joint secured with #9x3” screws at 6” OC
Manufacturer:	University of Oregon

SPECIMEN MEASUREMENTS & TEST CONDITIONS

The building contractor (Seth Priser) and RAL staff compiled a detailed construction specification as follows:

Cross-Laminated Timber (CLT)

Materials:	5-Ply Cross-Laminated Timber
Dimensions:	2 panels @ 1219 mm (48 in.) by 4229 mm (166.5 in.)
Thickness:	171 mm (6.75 in.)
Overall Weight:	953.45 kg (2102 lbs)
Mass Per Unit Volume:	539 kg/m^3 (33.7 lbs/ft^3)
Installation:	CLT panels laid on 152 mm (6 in.) wide knee walls in test opening and butted to one another without sealant/adhesive. 3/4"x3" Rabbet on top side of one edge of each panel where they butt allowing a loose spline (below) to insert and join the two

¾" CDX Loose Spline

Materials:	3/4" x 6" plywood spline
Dimensions:	1 piece @ 151 mm (5.9375 in.) wide by 2438 mm (96 in.) 1 piece @ 151 mm (5.9375 in.) wide by 1791 mm (70.5 in.)
Thickness:	19 mm (0.75 in.)
Overall Weight:	6.46 kg (14.25 lbs)
Mass Per Unit Length:	1.53 kg/m (1.03 lbs/ft)
Installation:	Set in Rabbets of both CLT's and screwed in place.
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing:	6" o.c. on a line 3" from each edge of the spline (Centered on the rabbet of the CLT)

Piano B 40/40 (Lower Layer)

Manufacturer:	Rothoblaas
Dimensions:	2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long 8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness:	6.76 mm (0.266 in.)
Overall Weight:	4.59 kg (10.125 lbs)
Mass Per Unit Volume:	624 kg/m^3 (40.0 lbs/ft^3)
Installation:	Fastened to underside of 2" x 4" wood sleepers with staples
Fasteners:	Arrow staples, length @ 13 mm (0.5 in.)

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

2" by 4" SPF Framing Sleepers

Materials:	Nominal 2"x 4" framing lumber
Dimensions:	2 pieces @ 38 mm (1.5 in.) wide by 4255 mm (167.5 in.) long 8 pieces @ 2369 mm (93.25 in.) wide by 38 mm (1.5 in.) long
Depth:	89 mm (3.5 in.)
Overall Weight:	49.33 kg (108.75 lbs)
Mass Per Unit Length:	1.80 kg/m (1.21 lbs/ft)
Installation:	Sleepers laid over CLT, resting on lower layer Piano B 40/40 Longer sleepers parallel to CLT like a rim joist Shorter sleepers set like floor joists between rim joists Shorter sleepers spaced approx. 610 mm (24 in.) on center Shorter sleepers fastened to longer sleepers with screws, 2 screws per connection point
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)

Piano B 40/40 (Upper Layer)

Manufacturer:	Rothoblaas
Dimensions:	2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long 8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness:	6.76 mm (0.266 in.)
Overall Weight:	4.59 kg (10.125 lbs)
Mass Per Unit Volume:	624 kg/m^3 (40.0 lbs/ft^3)
Installation:	Fastened to top of 2" x 4" wood sleepers with staples
Fasteners:	Arrow staples, length @ 13 mm (0.5 in.)

Hemp Board

Materials:	3" Hemp fiber board
Manufacturer:	Hempitecture
Dimensions:	7 pieces @ 572 mm (22.5 in.) wide by 2369 mm (93.25 in.) long
Depth:	76 mm (3 in.)
Overall Weight:	37.53 kg (82.75 lbs)
Mass Per Unit Volume:	52.0 kg/m^3 (3.25 lbs/ft^3)
Installation:	Friction fit between sleepers and on top of CLT

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Plywood Subfloor

Materials:	T&G Plywood
Dimensions:	1 piece @ 1219 mm (48 in.) wide by 1829 mm (72 in.)
	1 piece @ 1219 mm (48 in.) wide by 2438 mm (96 in.)
	1 piece @ 1219 mm (48 in.) wide by 1822 mm (71.75 in.)
	1 piece @ 1219 mm (48 in.) wide by 2432 mm (95.75 in.)
Thickness:	29 mm (1.125 in.)
Overall Weight:	173.5 kg (382.5 lbs)
Mass Per Unit Volume:	584 kg/m^3 (36.5 lbs/ft^3)
Installation:	Placed over upper layer Piano B 40/40 over sleepers
	Fastened to sleepers through Piano B 40/40 with screws
	Plywood piece joints staggered
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing:	610 mm (24 in.) on center

Gypcrete

Materials:	Gypcrete mix
Manufacturer:	Maxxon
Dimensions:	2438 mm (96 in.) by 4267 mm (168 in.) as installed
Thickness:	Approx 25 mm (1 in.)
Mix Ratio:	2.5 gallons water / 40 lbs gypcrete / 75 lbs all-purpose sand
Overall Dry Weight:	469.47 kg (1035 lbs)
Mass Per Unit Volume:	1780 kg/m^3 (111 lbs/ft^3)
Installation:	Poured over plywood subfloor
	Gauge rake was used to level product to 1” of thickness
	Wet gypcrete mix was poured on (2024-07-01, approx. 3:40 PM)

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Overall Specimen Measurements

Dimensions:	2.44 m (96.0 in) wide by 3.86 m (152.0 in) long
Thickness:	0.33 m (12.875 in)
Weight:	1698.93 kg (3745.5 lbs)
Overall Area:	9.414 m² (101.33 ft²)
Mass per Unit Area:	163.28 kg/m² (33.44 lbs/ft²)

Test Aperture

Opening Size:	4.27 m (14.0 ft.) by 6.10 m (20 ft.)
Filler Wall:	Yes
Aperture Size:	2.44 m (96.0 in) wide by 3.86 m (152.0 in) long
Transmission Area:	9.414 m² (101.33 ft²)
Sealed:	Entire periphery (both sides) with dense mastic

Test Environment

Source Room

Volume:	130.9 m³
Temperature:	22.8 °C ± 0.0 °C
Relative Humidity:	62.0 % ± 0.0 %

Receive Room

Volume:	81.44 m³
Temperature:	22.2 °C ± 1.1 °C
Relative Humidity:	64.0 % ± 2.0 %

Requirements

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

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

Figure 2 – Specimen mounted in test chamber, as viewed from receive room

Figure 3 - CLT (1 of 2) prior to installation

Figure 4 - CLT installed in test aperture

Figure 5 - 3/4” x 6” plywood spline partially installed over CLT rabbets

Figure 6 - Detail of 3/4” x 6” plywood spline partially installed over CLT rabbets

Figure 7 - 2” by 4” sleepers partially installed, with Piano B 40/40 strips fastened to underside of sleepers

Figure 8 - Piano B 40/40 strip fastened to sleeper prior to installation of sleeper

Figure 9 - Hemp boards prior to installation

Figure 10 - Hemp boards partially installed between sleepers

Figure 11 - Hemp boards installed between sleepers, plywood partially installed over sleepers

Figure 12 - Plywood subfloor installed

Figure 13 - Gypcrete installation

University of Oregon
2024-07-08

RAL™-IN24-020

TEST RESULTS

The averaged sound pressure levels, normalized to a receive room reference absorption of 10 m^2, are tabulated at the sixteen frequency bands specified in ASTM E492-22 Section 9.5. A graphic presentation of the data and additional information appear on the following pages. The 95% confidence limit for the sound pressure level in the receive room is below the limits specified in ASTM E492-22 Section A1.4.

FREQ.	Ln	ΔLn	DEV	FREQ.	Ln	ΔLn	DEV
100	64	2.51	3	800	60	1.58	3
125	61	3.72	0	1000	59	1.17	3
160	62	1.76	1	1250	54	0.74	1
200	63	1.86	2	1600	51	0.64	1
250	63	2.32	2	2000	47	0.59	0
315	64	2.88	3	2500	43	1.35	0
400	63	0.73	3	3150	41	1.64	0
500	61	0.53	2				
630	60	1.11	2				

IIC=51

ABBREVIATION INDEX

FREQ. = 1/3 OCTAVE BAND CENTER FREQUENCY, Hz
Ln = NORMALIZED SOUND PRESSURE LEVEL, dB
ΔLn = 95% UNCERTAINTY LIMIT FOR Ln, dB
DEV. = DEVIATION FROM SHIFTED IIC CONTOUR, dB (SUM OF DEV = 26)
IIC = IMPACT INSULATION CLASS
* = LEVEL CORRECTED DUE TO BACKGROUND NOISE PER E492 SEC 10.2.2
** = LEVEL CORRECTED DUE TO BACKGROUND NOISE PER E492 SEC 10.2.3

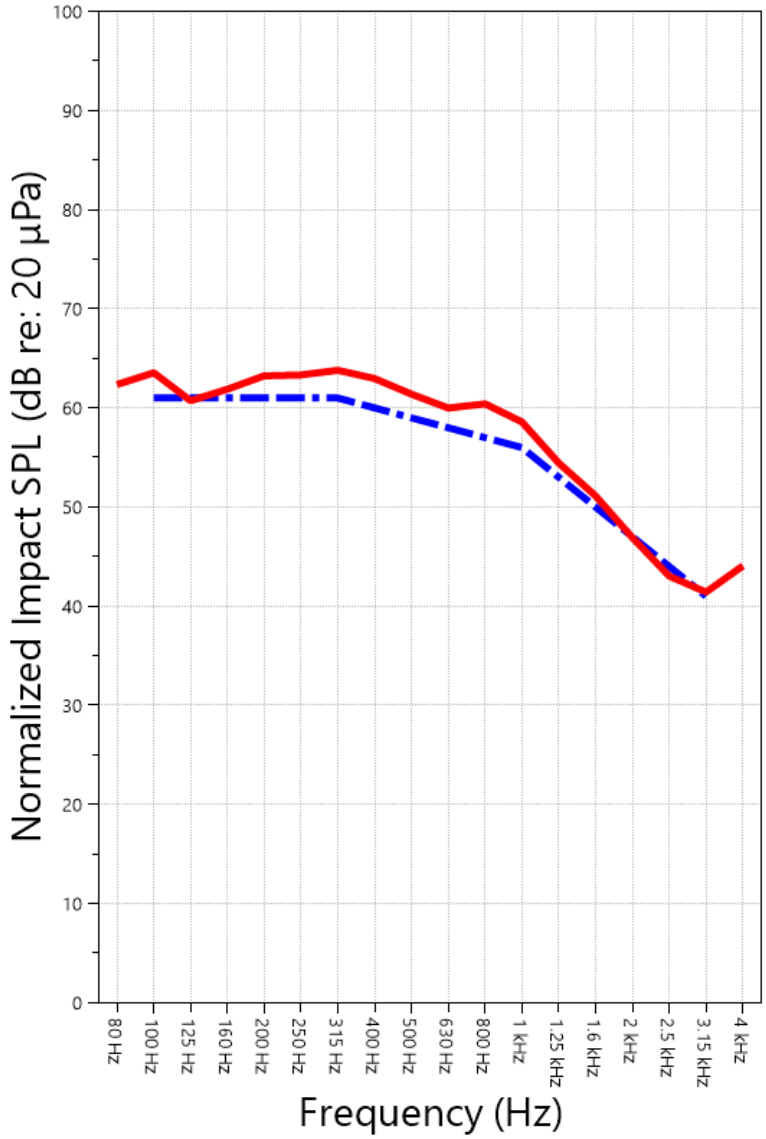
Tested by _____
Marc Sciaky
Senior Experimentalist

Report by _____
Keith Kimberling
Test Engineer

Approved by _____
Eric P. Wolfram
Laboratory Manager

IMPACT SOUND TRANSMISSION REPORT

1" Maxxon gypcrete 2000 Multifamily, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC



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IMPACT SOUND PRESSURE LEVEL

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Referenced Standard	Rating	Calculated Value
ASTM E989-21	IIC	**51**
ASTM E3222-20a	HIIC	**51**
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Test Report

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

Impact Sound Transmission
RAL™-IN24-021

CONDUCTED: 2024-07-09

ON: Marmoleum Decibel adhered with Sustain 1195, 1" Maxxon gypcrete 2000 Multifamily, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC

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 17025:2017 Laboratory (NVLAP Lab Code: 100227-0) and for this test procedure. The test reported in this document conformed explicitly with ASTM E492-22: "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 E989-21: "Standard Classification for Determination of Single-Number Metrics for Impact Noise." A description of the measurement procedure and room specifications are 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 Marmoleum Decibel adhered with Sustain 1195, 1" Maxxon gypcrete 2000 Multifamily, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC. 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

Provided Description:	Marmoleum Decibel adhered with Sustain 1195, 1" Maxxon gypcrete 2000 Multifamily, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC
Manufacturer:	University of Oregon

SPECIMEN MEASUREMENTS & TEST CONDITIONS

The building contractor (Seth Priser) and RAL staff compiled a detailed construction specification as follows:

Cross-Laminated Timber (CLT)

Materials:	5-Ply Cross-Laminated Timber
Dimensions:	2 panels @ 1219 mm (48 in.) by 4229 mm (166.5 in.)
Thickness:	171 mm (6.75 in.)
Overall Weight:	953.45 kg (2102 lbs)
Mass Per Unit Volume:	539 kg/m^3 (33.7 lbs/ft^3)
Installation:	CLT panels laid on 152 mm (6 in.) wide knee walls in test opening and butted to one another without sealant/adhesive. 3/4"x3" Rabbet on top side of one edge of each panel where they butt allowing a loose spline (below) to insert and join the two

¾" CDX Loose Spline

Materials:	3/4" x 6" plywood spline
Dimensions:	1 piece @ 151 mm (5.9375 in.) wide by 2438 mm (96 in.) 1 piece @ 151 mm (5.9375 in.) wide by 1791 mm (70.5 in.)
Thickness:	19 mm (0.75 in.)
Overall Weight:	6.46 kg (14.25 lbs)
Mass Per Unit Length:	1.53 kg/m (1.03 lbs/ft)
Installation:	Set in Rabbets of both CLT's and screwed in place.
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing:	6" o.c. on a line 3" from each edge of the spline (Centered on the rabbet of the CLT)

Piano B 40/40 (Lower Layer)

Manufacturer:	Rothoblaas
Dimensions:	2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long 8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness:	6.76 mm (0.266 in.)
Overall Weight:	4.59 kg (10.125 lbs)
Mass Per Unit Volume:	624 kg/m^3 (40.0 lbs/ft^3)
Installation:	Fastened to underside of 2" x 4" wood sleepers with staples
Fasteners:	Arrow staples, length @ 13 mm (0.5 in.)

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

2" by 4" SPF Framing Sleepers

Materials:	Nominal 2"x 4" framing lumber
Dimensions:	2 pieces @ 38 mm (1.5 in.) wide by 4255 mm (167.5 in.) long 8 pieces @ 2369 mm (93.25 in.) wide by 38 mm (1.5 in.) long
Depth:	89 mm (3.5 in.)
Overall Weight:	49.33 kg (108.75 lbs)
Mass Per Unit Length:	1.80 kg/m (1.21 lbs/ft)
Installation:	Sleepers laid over CLT, resting on lower layer Piano B 40/40 Longer sleepers parallel to CLT like a rim joist Shorter sleepers set like floor joists between rim joists Shorter sleepers spaced approx. 610 mm (24 in.) on center Shorter sleepers fastened to longer sleepers with screws, 2 screws per connection point
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)

Piano B 40/40 (Upper Layer)

Manufacturer:	Rothoblaas
Dimensions:	2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long 8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness:	6.76 mm (0.266 in.)
Overall Weight:	4.59 kg (10.125 lbs)
Mass Per Unit Volume:	624 kg/m^3 (40.0 lbs/ft^3)
Installation:	Fastened to top of 2" x 4" wood sleepers with staples
Fasteners:	Arrow staples, length @ 13 mm (0.5 in.)

Hemp Board

Materials:	3" Hemp fiber board
Manufacturer:	Hempitecture
Dimensions:	7 pieces @ 572 mm (22.5 in.) wide by 2369 mm (93.25 in.) long
Depth:	76 mm (3 in.)
Overall Weight:	37.53 kg (82.75 lbs)
Mass Per Unit Volume:	52.0 kg/m^3 (3.25 lbs/ft^3)
Installation:	Friction fit between sleepers and on top of CLT

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Plywood Subfloor

Materials:	T&G Plywood
Dimensions:	1 piece @ 1219 mm (48 in.) wide by 1829 mm (72 in.)
	1 piece @ 1219 mm (48 in.) wide by 2438 mm (96 in.)
	1 piece @ 1219 mm (48 in.) wide by 1822 mm (71.75 in.)
	1 piece @ 1219 mm (48 in.) wide by 2432 mm (95.75 in.)
Thickness:	29 mm (1.125 in.)
Overall Weight:	173.5 kg (382.5 lbs)
Mass Per Unit Volume:	584 kg/m^3 (36.5 lbs/ft^3)
Installation:	Placed over upper layer Piano B 40/40 over sleepers
	Fastened to sleepers through Piano B 40/40 with screws
	Plywood piece joints staggered
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing:	610 mm (24 in.) on center

Gypcrete

Materials:	Gypcrete mix
Manufacturer:	Maxxon
Dimensions:	2438 mm (96 in.) by 4267 mm (168 in.) as installed
Thickness:	Approx 25 mm (1 in.)
Mix Ratio:	2.5 gallons water / 40 lbs gypcrete / 75 lbs all-purpose sand
Overall Dry Weight:	469.47 kg (1035 lbs)
Mass Per Unit Volume:	1780 kg/m^3 (111 lbs/ft^3)
Installation:	Poured over plywood subfloor
	Gauge rake was used to level product to 1” of thickness
	Wet gypcrete mix was poured on (2024-07-01, approx. 3:40 PM)

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Adhesive

Materials:	Sustain 1195 Sheet and Tile adhesive
Manufacturer:	Forbo
Dimensions:	Approx. 2438 mm (96 in.) by 4267 mm (168 in.) as installed
Overall Weight:	2.95 kg (6.5 lbs)
Mass Per Unit Area:	0.28 kg/m^2 (0.06 lbs/ft^2)
Installation:	Troweled directly to gypcrete with a 1/16x1/16x1/16 square notch trowel Once troweled, adhesive was left “open” for 15 min to allow it to “tack” before flooring was installed.

Flooring

Materials:	Marmoleum Decibel
Manufacturer:	Forbo
Dimensions:	2 pieces @ 2007 mm (79 in.) by 2464 mm (97 in.) 1 piece @ 260 mm (10.25 in.) by 2464 mm (97 in.)
Thickness:	6 mm (0.25 in.)
Overall Weight:	35.38 kg (78 lbs)
Mass Per Unit Volume:	529 kg/m^3 (33.0 lbs/ft^3)
Installation:	Two (2) 79” segments perpendicular to Plywood 10” strip to complete Joints staggered from parallel plywood joints by + 6” Rolled with 100lb roller in each direction

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Overall Specimen Measurements

Dimensions:	2.44 m (96.0 in) wide by 3.86 m (152.0 in) long
Thickness:	0.33 m (13.125 in)
Weight:	1734.31 kg (3823.5 lbs)
Overall Area:	9.414 m² (101.33 ft²)
Mass per Unit Area:	166.68 kg/m² (34.14 lbs/ft²)

Test Aperture

Opening Size:	4.27 m (14.0 ft.) by 6.10 m (20 ft.)
Filler Wall:	Yes
Aperture Size:	2.44 m (96.0 in) wide by 3.86 m (152.0 in) long
Transmission Area:	9.414 m² (101.33 ft²)
Sealed:	Entire periphery (both sides) with dense mastic

Test Environment

Source Room

Volume:	130.9 m³
Temperature:	22.2 °C ± 0.0 °C
Relative Humidity:	62.0 % ± 2.0 %

Receive Room

Volume:	81.44 m³
Temperature:	21.7 °C ± 0.0 °C
Relative Humidity:	64.0 % ± 0.0 %

Requirements

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

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

Figure 2 – Specimen mounted in test chamber, as viewed from receive room

Figure 3 - CLT (1 of 2) prior to installation

Figure 4 - CLT installed in test aperture

Figure 5 - 3/4” x 6” plywood spline partially installed over CLT rabbets

Figure 6 - Detail of 3/4” x 6” plywood spline partially installed over CLT rabbets

Figure 7 - 2” by 4” sleepers partially installed, with Piano B 40/40 strips fastened to underside of sleepers

Figure 8 - Piano B 40/40 strip fastened to sleeper prior to installation of sleeper

Figure 9 - Hemp boards prior to installation

Figure 10 - Hemp boards partially installed between sleepers

Figure 11 - Hemp boards installed between sleepers, plywood partially installed over sleepers

Figure 12 - Plywood subfloor installed

Figure 13 - Gypcrete installation

Figure 14 - Trowel used for installation of adhesive

Figure 15 - Adhesive installed over gypcrete, flooring partially installed over adhesive

University of Oregon
2024-07-09

RAL™-IN24-021

TEST RESULTS

The averaged sound pressure levels, normalized to a receive room reference absorption of 10 m^2, are tabulated at the sixteen frequency bands specified in ASTM E492-22 Section 9.5. A graphic presentation of the data and additional information appear on the following pages. The 95% confidence limit for the sound pressure level in the receive room is below the limits specified in ASTM E492-22 Section A1.4.

FREQ.	Ln	ΔLn	DEV	FREQ.	Ln	ΔLn	DEV
100	63	1.23	3	800	52	0.76	0
125	65	2.44	5	1000	48	1.86	0
160	64	2.31	4	1250	41	2.08	0
200	65	1.75	5	1600	34	2.00	0
250	64	2.05	4	2000	25 *	3.21	0
315	64	2.04	4	2500	18 **	2.30	0
400	62	1.01	3	3150	19 **	0.89	0
500	58	1.65	0				
630	54	2.05	0				

IIC=52

ABBREVIATION INDEX

FREQ. = 1/3 OCTAVE BAND CENTER FREQUENCY, Hz
Ln = NORMALIZED SOUND PRESSURE LEVEL, dB
ΔLn = 95% UNCERTAINTY LIMIT FOR Ln, dB
DEV. = DEVIATION FROM SHIFTED IIC CONTOUR, dB (SUM OF DEV = 28)
IIC = IMPACT INSULATION CLASS
* = LEVEL CORRECTED DUE TO BACKGROUND NOISE PER E492 SEC 10.2.2
** = LEVEL CORRECTED DUE TO BACKGROUND NOISE PER E492 SEC 10.2.3

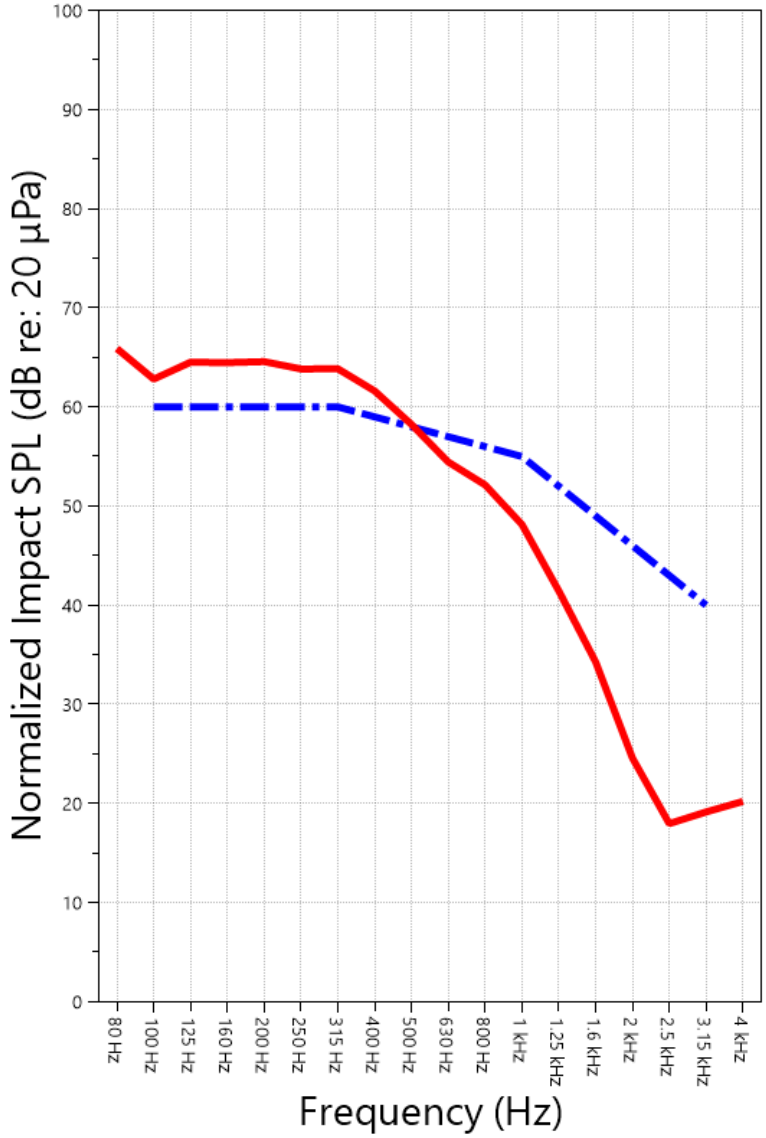
Tested by _____
Marc Sciaky
Senior Experimentalist

Report by _____
Keith Kimberling
Test Engineer

Approved by _____
Eric P. Wolfram
Laboratory Manager

IMPACT SOUND TRANSMISSION REPORT

Marmoleum Decibel adhered with Sustain 1195, 1" Maxxon gypcrete 2000 Multifamily, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC



IIC=52

IMPACT SOUND PRESSURE LEVEL
IMPACT INSULATION CLASS CONTOUR

APPENDIX A: Extended Frequency Range Data

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1" Maxxon gypcrete 2000 Multifamily, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

The following non-accredited data were obtained in accordance with ASTM E492-22 but extend beyond the frequency range of 100 Hz to 3,150 Hz specified in Section 9.5. 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	59	6.26	4.45
40	68	7.02	3.47
50	70	2.44	2.55
63	70	3.85	5.07
80	66	4.76	2.23
100	63	1.23	3.47
125	65	2.44	2.85
160	64	2.31	2.46
200	65	1.75	1.93
250	64	2.05	0.73
315	64	2.04	0.79
400	62	1.01	2.17
500	58	1.65	1.93
630	54	2.05	0.21
800	52	0.76	1.41
1000	48	1.86	2.05
1250	41	2.08	1.49
1600	34	2.00	2.22
2000	25 *	3.21	2.51
2500	18 **	2.30	1.26
3150	19 **	0.89	1.51
4000	20 **	0.66	1.85
5000	20 **	0.77	1.82
6300	21 **	0.96	1.90
8000	23 **	1.31	0.88
10000	26 **	1.66	4.02
12500	26 **	1.84	5.26

* *Level corrected due to proximity to background noise per E492 Section 10.2.2*

** *Level corrected due to proximity to background noise per E492 Section 10.2.3, represents lower bound of specimen performance*

APPENDIX B: Glossary for Variability Metrics

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1" Maxxon gypcrete 2000 Multifamily, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

ΔL_n, the 95% confidence limit 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 varying sound pressure level in the receive room and changes in specimen response for different tapping machine locations.

Repeatability, expressed as a 95% confidence limit, 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 specimen composed of 152.4 mm (6 in.) thick concrete slabs, 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 vary with the construction type.

APPENDIX C: Single-Number Ratings for Low and High Frequency Ranges

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1" Maxxon gypcrete 2000 Multifamily, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Current priorities in the architectural acoustics community involve the development of impact insulation metrics corresponding to impact sources of varying frequency content. Standard Classification ASTM E3222-20a provides a method for calculating the **High-Frequency Impact Insulation Class (HIIC)**, using normalized impact sound pressure level (L_n) data at frequency bands from 400 Hz to 3150 Hz. Standard Classification ASTM E3207-21 provides a method for calculating the **Low-Frequency Impact Insulation Class (LIIC)** uses normalized impact sound pressure level (L_n) data at frequency bands from 50 Hz to 80 Hz.

Low-frequency impact noise correlates to the "thudding" of footfalls on lightweight structures, while high-frequency sound correlates to sources including the impacts of hard-heeled shoes, dragging furniture, dog toenails, and objects dropped on hard-surfaced flooring. When presented alongside the IIC rating, The LIIC and HIIC ratings can be used to predict how the nature of an impact source will affect the response of the floor-ceiling construction. A summary of impact insulation ratings, as calculated from the test results, is given below.

Referenced Standard	Rating	Calculated Value
ASTM E989-21	IIC	**52**
ASTM E3222-20a	HIIC	**57**
ASTM E3207-21	LIIC	**43**

APPENDIX D: Instruments of Traceability

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1" Maxxon gypcrete 2000 Multifamily, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Description	Model	Serial Number	Date of Certification	Calibration Due
System 2	Type 3160-A-042	3160-106974	2023-08-11	2024-08-11
Bruel & Kjaer Mic And Preamp C	Type 4943-B-001	2311439	2024-03-29	2025-03-29
Bruel & Kjaer Tapping Machine	Type 3207	3151105	2023-12-14	2024-12-14
Bruel & Kjaer Pistonphone	Type 4228	2781248	2023-07-12	2024-07-12
EXTECH Hygro 959	SD700	A.099959	2024-03-29	2025-03-29
EXTECH Hygro 639	SD700	A.103639	2023-12-01	2024-12-01

APPENDIX E: Revisions to Original Test Report

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1" Maxxon gypcrete 2000 Multifamily, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Date	Revision
2024-07-31	Original report issued
2024-09-19	Page 19: Tapping machine added to instruments of traceability. -EPW

END

RIVERBANK ACOUSTICAL LABORATORIES

627 RIVERBANK DRIVE
GENEVA, IL 60134

630-232-0104

Test Report

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FOUNDED 1918 BY
WALLACE CLEMENT SABINE

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

Impact Sound Transmission
RAL™-IN24-022

CONDUCTED: 2024-07-22

ON: 1” Maxxon gypcrete 2000 Multifamily, Certainteed MemBrain vapor retarder, 3” of 3/8” limestone chip, Hempitecture 2” hemp fiber board, Vaagen Timbers 5-ply CLT 6.875” with plywood spline 3/4”x6” at the joint secured with #9x3” screws at 6” OC

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INFORMATION PROVIDED BY SPONSOR

The test specimen was designated by the sponsor as 1” Maxxon gypcrete 2000 Multifamily, Certainteed MemBrain vapor retarder, 3” of 3/8” limestone chip, Hempitecture 2” hemp fiber board, Vaagen Timbers 5-ply CLT 6.875” with plywood spline 3/4”x6” at the joint secured with #9x3” screws at 6” OC. 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

Provided Description:	1” Maxxon gypcrete 2000 Multifamily, Certainteed MemBrain vapor retarder, 3” of 3/8" limestone chip, Hempitecture 2” hemp fiber board, Vaagen Timbers 5-ply CLT 6.875” with plywood spline 3/4”x6” at the joint secured with #9x3” screws at 6” OC
Manufacturer:	University of Oregon

SPECIMEN MEASUREMENTS & TEST CONDITIONS

The building contractor (Seth Priser) and RAL staff compiled a detailed construction specification as follows:

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Thickness:	171 mm (6.75 in.)
Overall Weight:	953.45 kg (2102 lbs)
Mass Per Unit Volume:	539 kg/m^3 (33.7 lbs/ft^3)
Installation:	CLT panels laid on 152 mm (6 in.) wide knee walls in test opening and butted to one another without sealant/adhesive. 3/4"x3" Rabbet on top side of one edge of each panel where they butt allowing a loose spline (below) to insert and join the two

¾" CDX Loose Spline

Materials:	3/4" x 6" plywood spline
Dimensions:	1 piece @ 151 mm (5.9375 in.) wide by 2438 mm (96 in.) 1 piece @ 151 mm (5.9375 in.) wide by 1791 mm (70.5 in.)
Thickness:	19 mm (0.75 in.)
Overall Weight:	6.46 kg (14.25 lbs)
Mass Per Unit Length:	1.53 kg/m (1.03 lbs/ft)
Installation:	Set in Rabbets of both CLT's and screwed in place.
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing:	6" o.c. on a line 3" from each edge of the spline (Centered on the rabbet of the CLT)

Hemp Board

Materials:	2" Hemp fiber board
Manufacturer:	Hempitecture
Dimensions:	3 pieces @ 1216 mm (47.875 in.) wide by 2448 mm (96.375 in.) long 1 piece @ 613 mm (24.125 in.) wide by 2448 mm (96.375 in.) long
Depth:	51 mm (2 in.)
Overall Weight:	69.51 kg (153.25 lbs)
Mass Per Unit Volume:	131 kg/m^3 (8.19 lbs/ft^3)
Installation:	Loose laid directly on top of CLT Perpendicular to CLT

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Crushed Limestone

Materials:	CA-16 3/8" chip crushed limestone
Dimensions:	2438 mm (96 in.) wide by 4267 mm (168 in.) long, as installed
Depth:	76 mm (3 in.)
Overall Weight:	1224.02 kg (2698.5 lbs)
Installation:	Loose laid on top of the Hemp fiberboard
	½" polystyrene used as an isolation around the perimeter

Vapor Barrier

Materials:	Membrain Vapor barrier
Manufacturer:	Saint Gobain
Dimensions:	Approx. 2438 mm (96 in.) by 4267 mm (168 in.) as installed
Overall Weight:	0.79 kg (1.75 lbs)
Mass Per Unit Area:	0.08 kg/m^2 (0.02 lbs/ft^2)
Installation:	Loose laid over crushed limestone

Gypcrete

Materials:	Gypcrete mix
Manufacturer:	Maxxon
Dimensions:	2438 mm (96 in.) by 4267 mm (168 in.) as installed
Thickness:	25 mm (1 in.)
Mix Ratio:	2.5 gallons water / 40 lbs gypcrete / 75 lbs all-purpose sand
Overall Dry Weight:	521.63 kg (1150 lbs)
Mass Per Unit Volume:	1970 kg/m^3 (123 lbs/ft^3)
Installation:	Poured over vapor barrier
	A screed was used to spread the wet gypcrete mix
	Wet gypcrete mix was poured on (2024-07-10, approx. 4:30 PM)

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Overall Specimen Measurements

Dimensions:	2.44 m (96.0 in) wide by 3.86 m (152.0 in) long
Thickness:	0.32 m (12.75 in)
Weight:	2775.87 kg (6119.75 lbs)
Overall Area:	9.414 m² (101.33 ft²)
Mass per Unit Area:	266.78 kg/m² (54.64 lbs/ft²)

Test Aperture

Opening Size:	4.27 m (14.0 ft.) by 6.10 m (20 ft.)
Filler Wall:	Yes
Aperture Size:	2.44 m (96.0 in) wide by 3.86 m (152.0 in) long
Transmission Area:	9.414 m² (101.33 ft²)
Sealed:	Entire periphery (both sides) with dense mastic

Test Environment

Source Room

Volume:	130.9 m³
Temperature:	23.3 °C ± 0.0 °C
Relative Humidity:	67.5 % ± 1.0 %

Receive Room

Volume:	81.44 m³
Temperature:	22.2 °C ± 0.0 °C
Relative Humidity:	67.0 % ± 0.0 %

Requirements

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

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

Figure 2 – Specimen mounted in test chamber, as viewed from receive room

Figure 3 - CLT (1 of 2) prior to installation

Figure 4 - CLT installed in test aperture

Figure 5 - 3/4” x 6” plywood spline partially installed over CLT rabbets

Figure 6 - Detail of 3/4” x 6” plywood spline partially installed over CLT rabbets

Figure 7 - Hemp board partially installed over CLT

Figure 8 - Polystyrene used as an isolation around the perimeter prior to installation of gravel

Figure 9 - Gravel partially installed over hemp board

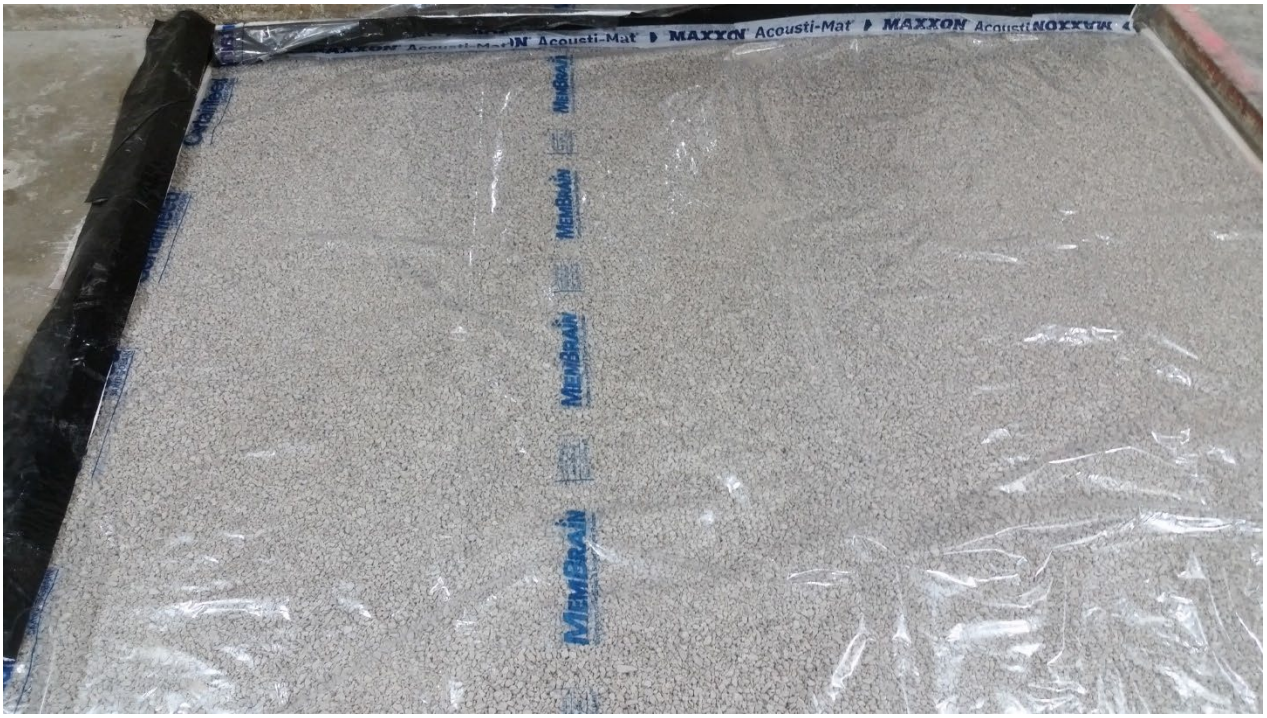


Figure 10 - Gravel installed; vapor barrier installed over gravel

Figure 11 - Gypcrete mixing prior to pouring

Figure 12 - Gypcrete partially installed over vapor barrier

University of Oregon
2024-07-22

RAL™-IN24-022

TEST RESULTS

The averaged sound pressure levels, normalized to a receive room reference absorption of 10 m^2, are tabulated at the sixteen frequency bands specified in ASTM E492-22 Section 9.5. A graphic presentation of the data and additional information appear on the following pages. The 95% confidence limit for the sound pressure level in the receive room is below the limits specified in ASTM E492-22 Section A1.4.

FREQ.	Ln	ΔLn	DEV	FREQ.	Ln	ΔLn	DEV
100	70	2.65	8	800	49	0.79	0
125	65	2.01	3	1000	48	0.74	0
160	67	3.44	5	1250	41	0.36	0
200	58	1.21	0	1600	37	0.40	0
250	55	2.01	0	2000	34	0.49	0
315	52	0.86	0	2500	30	0.82	0
400	49	0.96	0	3150	26 *	1.41	0
500	47	1.37	0				
630	47	0.66	0				

IIC=50

ABBREVIATION INDEX

FREQ. = 1/3 OCTAVE BAND CENTER FREQUENCY, Hz
Ln = NORMALIZED SOUND PRESSURE LEVEL, dB
ΔLn = 95% UNCERTAINTY LIMIT FOR Ln, dB
DEV. = DEVIATION FROM SHIFTED IIC CONTOUR, dB (SUM OF DEV = 16)
IIC = IMPACT INSULATION CLASS
* = LEVEL CORRECTED DUE TO BACKGROUND NOISE PER E492 SEC 10.2.2
** = LEVEL CORRECTED DUE TO BACKGROUND NOISE PER E492 SEC 10.2.3

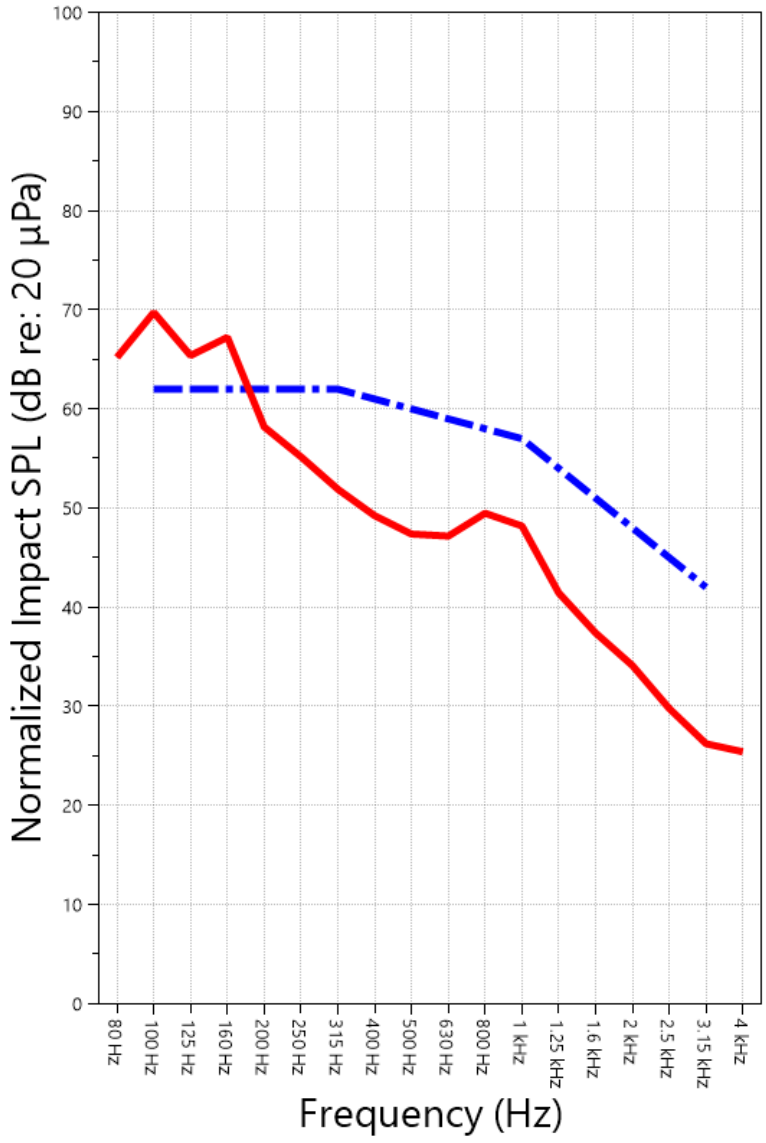
Tested by_____
Keith Kimberling
Test Engineer

Report by_____
Keith Kimberling
Test Engineer

Approved by_____
Eric P. Wolfram
Laboratory Manager

IMPACT SOUND TRANSMISSION REPORT

1" Maxxon gypcrete 2000 Multifamily, Certainteed MemBrain vapor retarder, 3" of 3/8" limestone chip, Hempitecture 2" hemp fiber board, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC



IIC=50

IMPACT SOUND PRESSURE LEVEL
IMPACT INSULATION CLASS CONTOUR

APPENDIX A: Extended Frequency Range Data

Specimen: 1" Maxxon gypcrete 2000 Multifamily, Certainteed MemBrain vapor retarder, 3" of 3/8" limestone chip, Hempitecture 2" hemp fiber board, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

The following non-accredited data were obtained in accordance with ASTM E492-22 but extend beyond the frequency range of 100 Hz to 3,150 Hz specified in Section 9.5. 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	61	5.58	4.45
40	55	6.88	3.47
50	58	2.16	2.55
63	62	4.09	5.07
80	65	4.39	2.23
100	70	2.65	3.47
125	65	2.01	2.85
160	67	3.44	2.46
200	58	1.21	1.93
250	55	2.01	0.73
315	52	0.86	0.79
400	49	0.96	2.17
500	47	1.37	1.93
630	47	0.66	0.21
800	49	0.79	1.41
1000	48	0.74	2.05
1250	41	0.36	1.49
1600	37	0.40	2.22
2000	34	0.49	2.51
2500	30	0.82	1.26
3150	26 *	1.41	1.51
4000	25 **	1.71	1.85
5000	22 **	1.14	1.82
6300	22 **	1.33	1.90
8000	24 **	1.04	0.88
10000	26 **	1.80	4.02
12500	25 **	1.69	5.26

* *Level corrected due to proximity to background noise per E492 Section 10.2.2*

** *Level corrected due to proximity to background noise per E492 Section 10.2.3, represents lower bound of specimen performance*

APPENDIX B: Glossary for Variability Metrics

Specimen: 1" Maxxon gypcrete 2000 Multifamily, Certainteed MemBrain vapor retarder, 3" of 3/8" limestone chip, Hempitecture 2" hemp fiber board, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

ΔL_n, the 95% confidence limit 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 varying sound pressure level in the receive room and changes in specimen response for different tapping machine locations.

Repeatability, expressed as a 95% confidence limit, 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 specimen composed of 152.4 mm (6 in.) thick concrete slabs, 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 vary with the construction type.

APPENDIX C: Single-Number Ratings for Low and High Frequency Ranges

Specimen: 1" Maxxon gypcrete 2000 Multifamily, Certainteed MemBrain vapor retarder, 3" of 3/8" limestone chip, Hempitecture 2" hemp fiber board, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Current priorities in the architectural acoustics community involve the development of impact insulation metrics corresponding to impact sources of varying frequency content. Standard Classification ASTM E3222-20a provides a method for calculating the **High-Frequency Impact Insulation Class (HIIC)**, using normalized impact sound pressure level (L_n) data at frequency bands from 400 Hz to 3150 Hz. Standard Classification ASTM E3207-21 provides a method for calculating the **Low-Frequency Impact Insulation Class (LIIC)** uses normalized impact sound pressure level (L_n) data at frequency bands from 50 Hz to 80 Hz.

Low-frequency impact noise correlates to the "thudding" of footfalls on lightweight structures, while high-frequency sound correlates to sources including the impacts of hard-heeled shoes, dragging furniture, dog toenails, and objects dropped on hard-surfaced flooring. When presented alongside the IIC rating, The LIIC and HIIC ratings can be used to predict how the nature of an impact source will affect the response of the floor-ceiling construction. A summary of impact insulation ratings, as calculated from the test results, is given below.

Referenced Standard	Rating	Calculated Value
ASTM E989-21	IIC	**50**
ASTM E3222-20a	HIIC	**64**
ASTM E3207-21	LIIC	**55**

APPENDIX D: Instruments of Traceability

Specimen: 1" Maxxon gypcrete 2000 Multifamily, Certainteed MemBrain vapor retarder, 3" of 3/8" limestone chip, Hempitecture 2" hemp fiber board, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Description	Model	Serial Number	Date of Certification	Calibration Due
System 2	Type 3160-A-042	3160-106974	2023-08-11	2024-08-11
Bruel & Kjaer Mic And Preamp C	Type 4943-B-001	2311439	2024-03-29	2025-03-29
Bruel & Kjaer Sound Level Calibrator	Type 4230	861609	2023-12-20	2024-12-20
Bruel & Kjaer Tapping Machine	Type 3207	3151105	2023-12-14	2024-12-14
EXTECH Hygro 959	SD700	A.099959	2024-03-29	2025-03-29
EXTECH Hygro 639	SD700	A.103639	2023-12-01	2024-12-01

APPENDIX E: Revisions to Original Test Report

Specimen: 1" Maxxon gypcrete 2000 Multifamily, Certainteed MemBrain vapor retarder, 3" of 3/8" limestone chip, Hempitecture 2" hemp fiber board, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Date	Revision
2024-07-31	Original report issued
2024-09-19	Page 15: Calibrator device description corrected in Instruments of Traceability. Tapping machine added to Instruments of Traceability. -EPW

END

RIVERBANK ACOUSTICAL LABORATORIES

627 RIVERBANK DRIVE
GENEVA, IL 60134

630-232-0104

Test Report

www.riverbankacoustics.com

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

Impact Sound Transmission
RAL™-IN24-023

CONDUCTED: 2024-07-25

ON: Marmoleum Decibel adhered with Sustain 1195, 1" Maxxon gypcrete 2000 Multifamily, Certainteed MemBrain vapor retarder, 3" of 3/8" limestone chip, Hempitecture 2" hemp fiber board, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC

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 17025:2017 Laboratory (NVLAP Lab Code: 100227-0) and for this test procedure. The test reported in this document conformed explicitly with ASTM E492-22: "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 E989-21: "Standard Classification for Determination of Single-Number Metrics for Impact Noise." A description of the measurement procedure and room specifications are 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 Marmoleum Decibel adhered with Sustain 1195, 1" Maxxon gypcrete 2000 Multifamily, Certainteed MemBrain vapor retarder, 3" of 3/8" limestone chip, Hempitecture 2" hemp fiber board, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC. 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

Provided Description:	Marmoleum Decibel adhered with Sustain 1195, 1" Maxxon gypcrete 2000 Multifamily, Certainteed MemBrain vapor retarder, 3" of 3/8" limestone chip, Hempitecture 2" hemp fiber board, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC
Manufacturer:	University of Oregon

SPECIMEN MEASUREMENTS & TEST CONDITIONS

The building contractor (Seth Priser) and RAL staff compiled a detailed construction specification as follows:

Cross-Laminated Timber (CLT)

Materials:	5-Ply Cross-Laminated Timber
Dimensions:	2 panels @ 1219 mm (48 in.) by 4229 mm (166.5 in.)
Thickness:	171 mm (6.75 in.)
Overall Weight:	953.45 kg (2102 lbs)
Mass Per Unit Volume:	539 kg/m^3 (33.7 lbs/ft^3)
Installation:	CLT panels laid on 152 mm (6 in.) wide knee walls in test opening and butted to one another without sealant/adhesive. 3/4"x3" Rabbet on top side of one edge of each panel where they butt allowing a loose spline (below) to insert and join the two

¾" CDX Loose Spline

Materials:	3/4" x 6" plywood spline
Dimensions:	1 piece @ 151 mm (5.9375 in.) wide by 2438 mm (96 in.) 1 piece @ 151 mm (5.9375 in.) wide by 1791 mm (70.5 in.)
Thickness:	19 mm (0.75 in.)
Overall Weight:	6.46 kg (14.25 lbs)
Mass Per Unit Length:	1.53 kg/m (1.03 lbs/ft)
Installation:	Set in Rabbets of both CLT's and screwed in place.
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing:	6" o.c. on a line 3" from each edge of the spline (Centered on the rabbet of the CLT)

Hemp Board

Materials:	2" Hemp fiber board
Manufacturer:	Hempitecture
Dimensions:	3 pieces @ 1216 mm (47.875 in.) wide by 2448 mm (96.375 in.) long 1 piece @ 613 mm (24.125 in.) wide by 2448 mm (96.375 in.) long
Depth:	51 mm (2 in.)
Overall Weight:	69.51 kg (153.25 lbs)
Mass Per Unit Volume:	131 kg/m^3 (8.19 lbs/ft^3)
Installation:	Loose laid directly on top of CLT Perpendicular to CLT

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Crushed Limestone

Materials:	CA-16 3/8" chip crushed limestone
Dimensions:	2438 mm (96 in.) wide by 4267 mm (168 in.) long, as installed
Depth:	76 mm (3 in.)
Overall Weight:	1224.02 kg (2698.5 lbs)
Installation:	Loose laid on top of the Hemp fiberboard
	½" polystyrene used as an isolation around the perimeter

Vapor Barrier

Materials:	Membrain Vapor barrier
Manufacturer:	Saint Gobain
Dimensions:	Approx. 2438 mm (96 in.) by 4267 mm (168 in.) as installed
Overall Weight:	0.79 kg (1.75 lbs)
Mass Per Unit Area:	0.08 kg/m^2 (0.02 lbs/ft^2)
Installation:	Loose laid over crushed limestone

Gypcrete

Materials:	Gypcrete mix
Manufacturer:	Maxxon
Dimensions:	2438 mm (96 in.) by 4267 mm (168 in.) as installed
Thickness:	25 mm (1 in.)
Mix Ratio:	2.5 gallons water / 40 lbs gypcrete / 75 lbs all-purpose sand
Overall Dry Weight:	521.63 kg (1150 lbs)
Mass Per Unit Volume:	1970 kg/m^3 (123 lbs/ft^3)
Installation:	Poured over vapor barrier
	A screed was used to spread the wet gypcrete mix
	Wet gypcrete mix was poured on (2024-07-10, approx. 4:30 PM)

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Adhesive

Materials:	Sustain 1195 Sheet and Tile adhesive
Manufacturer:	Forbo
Dimensions:	Approx. 2438 mm (96 in.) by 4267 mm (168 in.) as installed
Overall Weight:	3.06 kg (6.75 lbs)
Mass Per Unit Area:	0.29 kg/m^2 (0.06 lbs/ft^2)
Installation:	Troweled directly to plywood with a 1/16x1/16x1/16 square notch trowel Once troweled, adhesive was left “open” for 15 min to allow it to “tack” before flooring was installed.

Flooring

Materials:	Marmoleum Decibel
Manufacturer:	Forbo
Dimensions:	2 pieces @ 2007 mm (79 in.) by 2464 mm (97 in.) 1 piece @ 260 mm (10.25 in.) by 2464 mm (97 in.)
Thickness:	6 mm (0.25 in.)
Overall Weight:	32.21 kg (71 lbs)
Mass Per Unit Volume:	482 kg/m^3 (30.1 lbs/ft^3)
Installation:	Two (2) 79” segments. 10” strip to complete Rolled with 100lb roller in each direction

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Overall Specimen Measurements

Dimensions:	2.44 m (96.0 in) wide by 3.86 m (152.0 in) long
Thickness:	0.33 m (13.0 in)
Weight:	2811.14 kg (6197.5 lbs)
Overall Area:	9.414 m² (101.33 ft²)
Mass per Unit Area:	270.17 kg/m² (55.33 lbs/ft²)

Test Aperture

Opening Size:	4.27 m (14.0 ft.) by 6.10 m (20 ft.)
Filler Wall:	Yes
Aperture Size:	2.44 m (96.0 in) wide by 3.86 m (152.0 in) long
Transmission Area:	9.414 m² (101.33 ft²)
Sealed:	Entire periphery (both sides) with dense mastic

Test Environment

Source Room

Volume:	130.9 m³
Temperature:	23.1 °C ± 0.6 °C
Relative Humidity:	67.0 % ± 2.0 %

Receive Room

Volume:	81.44 m³
Temperature:	22.5 °C ± 0.6 °C
Relative Humidity:	67.0 % ± 2.0 %

Requirements

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

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

Figure 2 – Specimen mounted in test chamber, as viewed from receive room

Figure 3 - CLT (1 of 2) prior to installation

Figure 4 - CLT installed in test aperture

Figure 5 - 3/4” x 6” plywood spline partially installed over CLT rabbets

Figure 6 - Detail of 3/4” x 6” plywood spline partially installed over CLT rabbets

Figure 7 - Hemp board partially installed over CLT

Figure 8 - Polystyrene used as an isolation around the perimeter prior to installation of gravel

Figure 9 - Gravel partially installed over hemp board

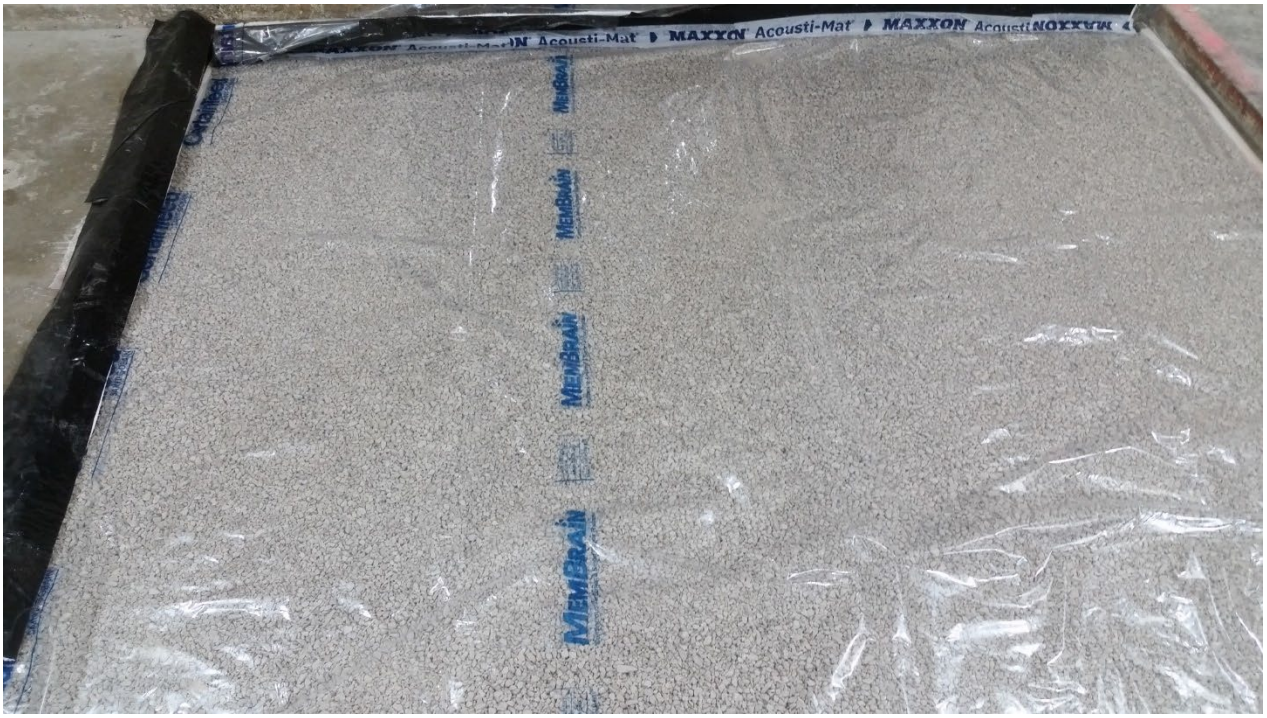

Figure 10 - Gravel installed; vapor barrier installed over gravel

Figure 11 - Gypcrete mixing prior to pouring

Figure 12 - Gypcrete partially installed over vapor barrier

Figure 13 - Trowel used for installation of adhesive

Figure 14 - Adhesive partially installed over gypcrete

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Test Report

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University of Oregon
2024-07-25

RAL™-IN24-023

TEST RESULTS

The averaged sound pressure levels, normalized to a receive room reference absorption of 10 m^2, are tabulated at the sixteen frequency bands specified in ASTM E492-22 Section 9.5. A graphic presentation of the data and additional information appear on the following pages. The 95% confidence limit for the sound pressure level in the receive room is below the limits specified in ASTM E492-22 Section A1.4.

FREQ.	Ln	ΔLn	DEV	FREQ.	Ln	ΔLn	DEV
100	73	2.25	8	800	44	1.02	0
125	68	2.11	3	1000	42	1.39	0
160	68	3.01	3	1250	33	1.77	0
200	59	1.87	0	1600	27	1.47	0
250	54	1.65	0	2000	19 **	2.10	0
315	51	1.94	0	2500	15 **	0.66	0
400	50	2.51	0	3150	17 **	0.61	0
500	46	2.64	0				
630	44	2.12	0				

IIC=47

ABBREVIATION INDEX

FREQ. = 1/3 OCTAVE BAND CENTER FREQUENCY, Hz
Ln = NORMALIZED SOUND PRESSURE LEVEL, dB
ΔLn = 95% UNCERTAINTY LIMIT FOR Ln, dB
DEV. = DEVIATION FROM SHIFTED IIC CONTOUR, dB (SUM OF DEV = 14)
IIC = IMPACT INSULATION CLASS
* = LEVEL CORRECTED DUE TO BACKGROUND NOISE PER E492 SEC 10.2.2
** = LEVEL CORRECTED DUE TO BACKGROUND NOISE PER E492 SEC 10.2.3

Tested by _____
Keith Kimberling
Test Engineer

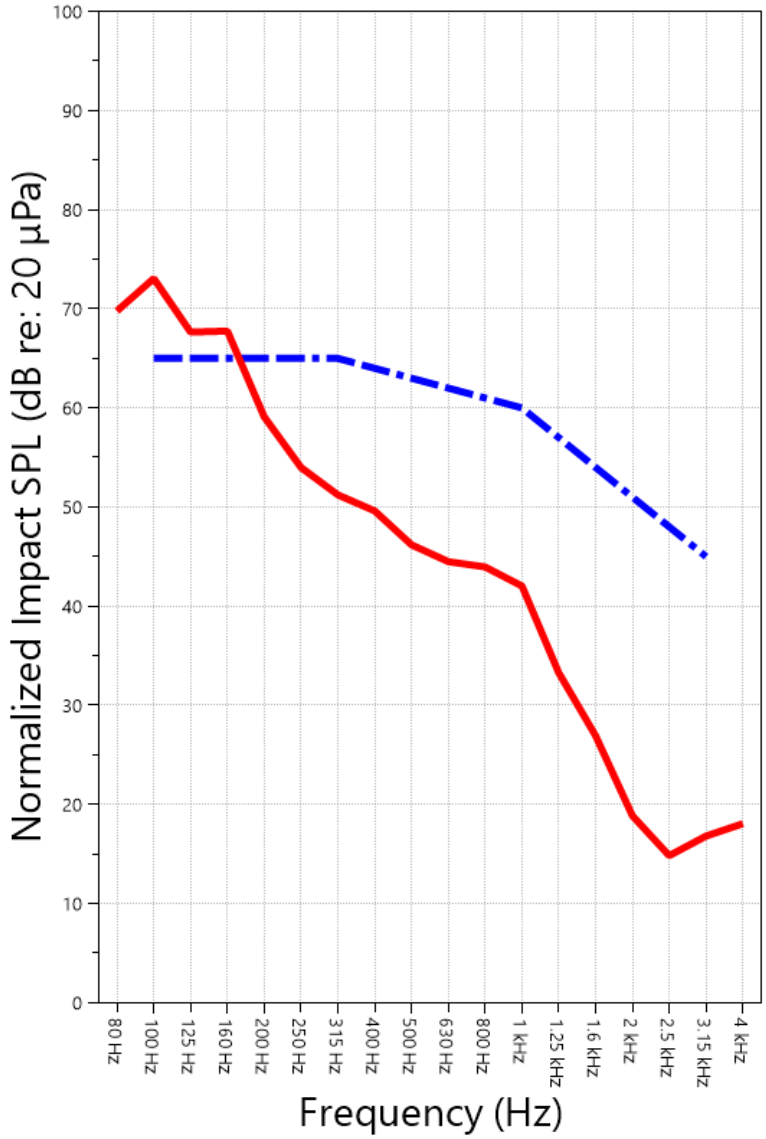
Report by _____
Keith Kimberling
Test Engineer

Approved by _____
Eric P. Wolfram
Laboratory Manager

NVLAP TESTING
NVLAP LAB CODE 100227-0

IMPACT SOUND TRANSMISSION REPORT

Marmoleum Decibel adhered with Sustain 1195, 1" Maxxon gypcrete 2000 Multifamily, Certainteed MemBrain vapor retarder, 3" of 3/8" limestone chip, Hempitecture 2" hemp fiber board, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC



IIC=47

IMPACT SOUND PRESSURE LEVEL

IMPACT INSULATION CLASS CONTOUR

APPENDIX A: Extended Frequency Range Data

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1" Maxxon gypcrete 2000 Multifamily, Certainteed MemBrain vapor retarder, 3" of 3/8" limestone chip, Hempitecture 2" hemp fiber board, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

The following non-accredited data were obtained in accordance with ASTM E492-22 but extend beyond the frequency range of 100 Hz to 3,150 Hz specified in Section 9.5. 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	62	10.65	4.45
40	64	5.75	3.47
50	65	1.65	2.55
63	63	2.42	5.07
80	70	4.19	2.23
100	73	2.25	3.47
125	68	2.11	2.85
160	68	3.01	2.46
200	59	1.87	1.93
250	54	1.65	0.73
315	51	1.94	0.79
400	50	2.51	2.17
500	46	2.64	1.93
630	44	2.12	0.21
800	44	1.02	1.41
1000	42	1.39	2.05
1250	33	1.77	1.49
1600	27	1.47	2.22
2000	19 **	2.10	2.51
2500	15 **	0.66	1.26
3150	17 **	0.61	1.51
4000	18 **	0.46	1.85
5000	18 **	0.66	1.82
6300	20 **	0.81	1.90
8000	23 **	1.07	0.88
10000	25 **	1.62	4.02
12500	30 **	1.68	5.26

* *Level corrected due to proximity to background noise per E492 Section 10.2.2*

** *Level corrected due to proximity to background noise per E492 Section 10.2.3, represents lower bound of specimen performance*

APPENDIX B: Glossary for Variability Metrics

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1" Maxxon gypcrete 2000 Multifamily, Certainteed MemBrain vapor retarder, 3" of 3/8" limestone chip, Hempitecture 2" hemp fiber board, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

ΔL_n, the 95% confidence limit 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 varying sound pressure level in the receive room and changes in specimen response for different tapping machine locations.

Repeatability, expressed as a 95% confidence limit, 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 specimen composed of 152.4 mm (6 in.) thick concrete slabs, 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 vary with the construction type.

APPENDIX C: Single-Number Ratings for Low and High Frequency Ranges

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1" Maxxon gypcrete 2000 Multifamily, Certainteed MemBrain vapor retarder, 3" of 3/8" limestone chip, Hempitecture 2" hemp fiber board, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Current priorities in the architectural acoustics community involve the development of impact insulation metrics corresponding to impact sources of varying frequency content. Standard Classification ASTM E3222-20a provides a method for calculating the **High-Frequency Impact Insulation Class (HIIC)**, using normalized impact sound pressure level (L_n) data at frequency bands from 400 Hz to 3150 Hz. Standard Classification ASTM E3207-21 provides a method for calculating the **Low-Frequency Impact Insulation Class (LIIC)** uses normalized impact sound pressure level (L_n) data at frequency bands from 50 Hz to 80 Hz.

Low-frequency impact noise correlates to the "thudding" of footfalls on lightweight structures, while high-frequency sound correlates to sources including the impacts of hard-heeled shoes, dragging furniture, dog toenails, and objects dropped on hard-surfaced flooring. When presented alongside the IIC rating, The LIIC and HIIC ratings can be used to predict how the nature of an impact source will affect the response of the floor-ceiling construction. A summary of impact insulation ratings, as calculated from the test results, is given below.

Referenced Standard	Rating	Calculated Value
ASTM E989-21	IIC	**47**
ASTM E3222-20a	HIIC	**67**
ASTM E3207-21	LIIC	**47**

APPENDIX D: Instruments of Traceability

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1" Maxxon gypcrete 2000 Multifamily, Certainteed MemBrain vapor retarder, 3" of 3/8" limestone chip, Hempitecture 2" hemp fiber board, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

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Bruel & Kjaer Sound Level Calibrator	Type 4230	861609	2023-12-20	2024-12-20
Bruel & Kjaer Tapping Machine	Type 3207	3151105	2023-12-14	2024-12-14
EXTECH Hygro 959	SD700	A.099959	2024-03-29	2025-03-29
EXTECH Hygro 639	SD700	A.103639	2023-12-01	2024-12-01

APPENDIX E: Revisions to Original Test Report

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1" Maxxon gypcrete 2000 Multifamily, Certainteed MemBrain vapor retarder, 3" of 3/8" limestone chip, Hempitecture 2" hemp fiber board, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Date	Revision
2024-07-31	Original report issued
2024-09-19	Page 17: Calibrator device description corrected and tapping machine added to instruments of traceability -EPW

END

627 RIVERBANK DRIVE
GENEVA, IL 60134

630-232-0104

Test Report

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

Sound Transmission Loss
RAL™-TL24-278

CONDUCTED: 2024-06-21

ON: Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3.75" of 3/8" limestone chip, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC

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 17025:2017 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 E413-22: "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 Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3.75" of 3/8" limestone chip, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC. 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

Provided Description:	Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3.75" of 3/8" limestone chip, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC
Manufacturer:	University of Oregon

SPECIMEN MEASUREMENTS & TEST CONDITIONS

The building contractor (Seth Priser) and RAL staff compiled a detailed construction specification as follows:

Cross-Laminated Timber (CLT)

Materials:	5-Ply Cross-Laminated Timber
Dimensions:	2 panels @ 1219 mm (48 in.) by 4229 mm (166.5 in.)
Thickness:	171 mm (6.75 in.)
Overall Weight:	953.45 kg (2102 lbs)
Mass Per Unit Volume:	539 kg/m^3 (33.7 lbs/ft^3)
Installation:	CLT panels laid on 152 mm (6 in.) wide knee walls in test opening and butted to one another without sealant/adhesive. 3/4"x3" Rabbet on top side of one edge of each panel where they butt allowing a loose spline (below) to insert and join the two

¾" CDX Loose Spline

Materials:	3/4" x 6" plywood spline
Dimensions:	1 piece @ 151 mm (5.9375 in.) wide by 2438 mm (96 in.) 1 piece @ 151 mm (5.9375 in.) wide by 1791 mm (70.5 in.)
Thickness:	19 mm (0.75 in.)
Overall Weight:	6.46 kg (14.25 lbs)
Mass Per Unit Length:	1.53 kg/m (1.03 lbs/ft)
Installation:	Set in Rabbets of both CLT's and screwed in place.
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing:	6" o.c. on a line 3" from each edge of the spline (Centered on the rabbet of the CLT)

Piano B 40/40 (Lower Layer)

Manufacturer:	Rothoblaas
Dimensions:	2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long 8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness:	6.76 mm (0.266 in.)
Overall Weight:	4.59 kg (10.125 lbs)
Mass Per Unit Volume:	624 kg/m^3 (40.0 lbs/ft^3)
Installation:	Fastened to underside of 2" x 4" wood sleepers with staples
Fasteners:	Arrow staples, length @ 13 mm (0.5 in.)

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

2" by 4" SPF Framing Sleepers

Materials:	Nominal 2"x 4" framing lumber
Dimensions:	2 pieces @ 38 mm (1.5 in.) wide by 4255 mm (167.5 in.) long 8 pieces @ 2369 mm (93.25 in.) wide by 38 mm (1.5 in.) long
Depth:	89 mm (3.5 in.)
Overall Weight:	49.33 kg (108.75 lbs)
Mass Per Unit Length:	1.80 kg/m (1.21 lbs/ft)
Installation:	Sleepers laid over CLT, resting on lower layer Piano B 40/40 Longer sleepers parallel to CLT like a rim joist Shorter sleepers set like floor joists between rim joists Shorter sleepers spaced approx. 610 mm (24 in.) on center Shorter sleepers fastened to longer sleepers with screws, 2 screws per connection point
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)

Piano B 40/40 (Upper Layer)

Manufacturer:	Rothoblaas
Dimensions:	2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long 8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness:	6.76 mm (0.266 in.)
Overall Weight:	4.59 kg (10.125 lbs)
Mass Per Unit Volume:	624 kg/m^3 (40.0 lbs/ft^3)
Installation:	Fastened to top of 2" x 4" wood sleepers with staples
Fasteners:	Arrow staples, length @ 13 mm (0.5 in.)

Crushed Limestone

Materials:	CA-16 3/8" chip crushed limestone
Dimensions:	2438 mm (96 in.) wide by 4267 mm (168 in.) long, as installed
Depth:	95 mm (3.75 in.)
Overall Weight:	1261.89 kg (2782 lbs)
Installation:	Filled stone in between sleepers and used a screed to level to the top of the sleepers.

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Plywood Subfloor

Materials:	T&G Plywood
Dimensions:	1 piece @ 1219 mm (48 in.) wide by 1829 mm (72 in.) 1 piece @ 1219 mm (48 in.) wide by 2438 mm (96 in.) 1 piece @ 1219 mm (48 in.) wide by 1813 mm (71.375 in.) 1 piece @ 1219 mm (48 in.) wide by 2426 mm (95.5 in.)
Thickness:	29 mm (1.125 in.)
Overall Weight:	176.33 kg (388.75 lbs)
Mass Per Unit Volume:	595 kg/m^3 (37.1 lbs/ft^3)
Installation:	Placed over upper layer Piano B 40/40 over sleepers Fastened to sleepers through Piano B 40/40 with screws Plywood piece joints staggered
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing:	610 mm (24 in.) on center

Adhesive

Materials:	Sustain 1195 Sheet and Tile adhesive
Manufacturer:	Forbo
Dimensions:	Approx. 2438 mm (96 in.) by 4267 mm (168 in.) as installed
Overall Weight:	4.54 kg (10 lbs)
Mass Per Unit Area:	0.44 kg/m^2 (0.09 lbs/ft^2)
Installation:	Troweled directly to plywood with a 1/16x1/16x1/16 square notch trowel Once troweled, adhesive was left “open” for 7-10 min to allow it to “tack” before flooring was installed.

Flooring

Materials:	Marmoleum Decibel
Manufacturer:	Forbo
Dimensions:	2 pieces @ 2007 mm (79 in.) by 2464 mm (97 in.) 1 piece @ 257 mm (10.125 in.) by 2438 mm (96 in.)
Thickness:	6 mm (0.25 in.)
Overall Weight:	32.77 kg (72.25 lbs)
Mass Per Unit Volume:	491 kg/m^3 (30.6 lbs/ft^3)
Installation:	Two (2) 79” segments perpendicular to Plywood 10” strip to complete Joints staggered from parallel plywood joints by + 6” Rolled with 100lb roller in each direction

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Overall Specimen Measurements

Dimensions:	2.44 m (96.0 in) wide by 3.86 m (152.0 in) high
Thickness:	0.31 m (12.125 in)
Weight:	2493.96 kg (5498.25 lbs)
Overall Area:	9.414 m² (101.33 ft²)
Mass per Unit Area:	239.69 kg/m² (49.09 lbs/ft²)

Test Aperture

Opening Size:	4.27 m (14.0 ft) x 6.10 m (20.0 ft)
Filler Wall:	Yes
Aperture Size:	2.44 m (96.0 in) wide by 3.86 m (152.0 in) high
Transmission Area:	9.414 m² (101.33 ft²)
Sealed:	Entire periphery (both sides) with dense mastic

Test Environment

Source Room

Volume:	131.12 m³
Temperature:	22.8 °C ± 0.0 °C
Relative Humidity:	58.5 % ± 1.0 %

Receive Room

Volume:	81.44 m³
Temperature:	21.1 °C ± 0.0 °C
Relative Humidity:	61.0 % ± 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.

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

Figure 2 – Specimen mounted in test aperture, as viewed from receive room

Figure 3 – CLT (1 of 2) prior to installation

Figure 4 – CLT installed in test aperture

Figure 5 – 3/4” x 6” plywood spline partially installed over CLT rabbets

Figure 6 – Detail of 3/4” x 6” plywood spline partially installed over CLT rabbets

Figure 7 – 2” by 4” sleepers partially installed, with Piano B 40/40 strips fastened to underside of sleepers

Figure 8 – Piano B 40/40 strip fastened to sleeper prior to installation of sleeper

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Figure 9 – Gravel partially installed in gaps between sleepers

Figure 10 – Gravel installed; Piano B 40/40 partially installed to top of sleepers

Figure 11 – Gravel and sleepers with Piano B 40/40 installed

Figure 12 – Plywood subfloor partially installed

Figure 13 – Plywood subfloor installed

Figure 14 – Trowel used for installation of adhesive

Figure 15 – Adhesive being troweled over plywood prior to installation of flooring

Figure 16 – Flooring partially installed

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Figure 17 – Flooring partially installed

University of Oregon
2024-06-21

RAL™-TL24-278

TEST RESULTS

Sound transmission loss values are tabulated at the eighteen standard frequency bands. 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). See Appendix A for identification of corrections applied to the reported data.

FREQ.	TL	ΔTL	DEF.	FREQ.	TL	ΔTL	DEF.
100	34	0.58	0	800	66	0.16	0
125	39	0.54	5	1000	68	0.11	0
160	40	0.48	7	1250	71	0.08	0
200	44	0.40	6	1600	75	0.09	0
250	48	0.30	5	2000	78	0.10	0
315	52	0.25	4	2500	83	0.12	0
400	58	0.25	1	3150	88	0.09	0
500	58	0.13	2	4000	91	0.08	0
630	60	0.24	1	5000	93	0.06	0

STC=60

ABBREVIATION INDEX

FREQ. = 1/3 OCTAVE BAND CENTER FREQUENCY, Hz
TL = TRANSMISSION LOSS, dB
ΔTL = 95% CONFIDENCE INTERVAL FOR TL MEASUREMENTS, dB
DEF. = DEFICIENCIES, dB BELOW SHIFTED STC CONTOUR (SUM OF DEF = 31)
STC = SOUND TRANSMISSION CLASS

Tested by _____
Marc Sciaky
Senior Experimentalist

Report by _____
Keith Kimberling
Test Engineer

Approved by _____
Eric P. Wolfram
Laboratory Manager

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Test Report

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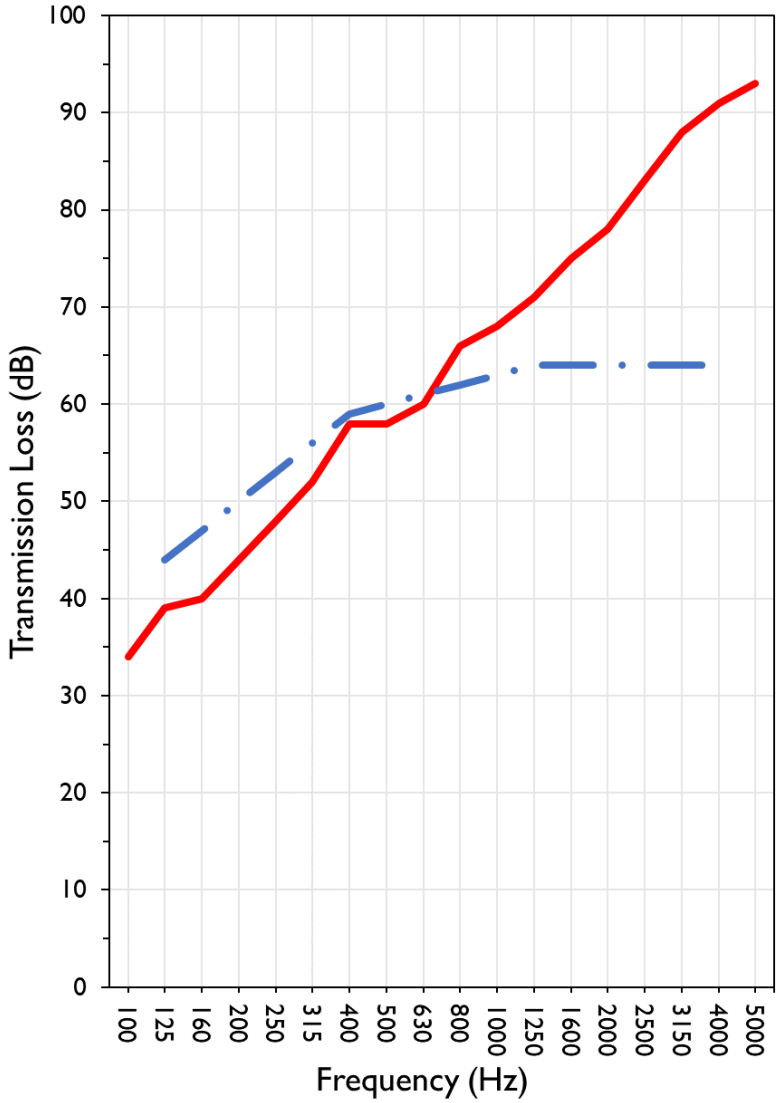
RAL™-TL24-278

SOUND TRANSMISSION REPORT

Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3.75" of 3/8" limestone chip, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC



STC=60
OITC=47

TRANSMISSION LOSS
SOUND TRANSMISSION CLASS CONTOUR

NVLAP TESTING
NVLAP LAB CODE 100227-0

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2024-06-21

APPENDIX A: Extended Frequency Range Data

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3.75" of 3/8" limestone chip, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (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. Corrections are detailed in Appendix B.

1/3 Octave Band Center Frequency (Hz)	**Sound Transmission Loss** (dB)	**Applicable Corrections**	**ΔTL (Eq. A2.5)** (dB)	**Repeatability** (dB)
31.5	37	*ZZ F*	1.03	16.75
40	34	*ZZ F*	1.34	5.77
50	36	*ZZ F*	0.45	3.98
63	36	*ZZ F*	0.28	0.75
80	34	*ZZ F*	0.65	1.46
100	34	*ZZ F*	0.58	3.83
125	39	*Z F*	0.54	0.97
160	40	*Z F*	0.48	1.35
200	44	*ZZ F*	0.40	1.21
250	48	*ZZ F*	0.30	0.56
315	52	*Z F*	0.25	0.61
400	58	*ZZ F*	0.25	0.76
500	58	*Z F*	0.13	0.58
630	60	*Z F*	0.24	1.03
800	66	*ZZ F*	0.16	0.34
1000	68	*Z F*	0.11	0.78
1250	71	*Z F*	0.08	1.09
1600	75	*Z F*	0.09	1.47
2000	78	*ZZ F*	0.10	1.14
2500	83	*ZZ F*	0.12	0.87
3150	88	*ZZ F*	0.09	0.90
4000	91	*ZZ A F*	0.08	1.95
5000	93	*ZZ AA F*	0.06	3.09
6300	85	*ZZ A F*	0.06	5.31
8000	77	*Z A F*	0.05	7.87
10000	67	*Z F*	0.08	6.75
12500	54		0.06	6.94

APPENDIX B: Glossary of Standardized Corrections and Adjustments

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3.75" of 3/8" limestone chip, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Mark	Interpretation
A	Measured sound pressure levels in the receive room are within 10 dB of the ambient noise level at the marked frequency band. Receive room levels used to calculate Transmission Loss are corrected according to ASTM E90 Section 10.3.
AA	Measured sound pressure levels in the receive room are within 5 dB of the ambient noise level at the marked frequency band. Receive room levels used to calculate Transmission Loss are corrected according to ASTM E90 Section 10.3.1. Transmission Loss values calculated from levels corrected this way will be less than or equal to Transmission Loss values from a hypothetical test using the same specimen and a receive room with idealized ambient sound levels of (-∞) dB.
F	The reported Transmission Loss is within 10 dB of the laboratory flanking limit at the marked frequency band. The measured performance of the specimen may be limited by the performance of the laboratory building structure at this frequency band.
Z	The reported Transmission Loss at the marked frequency band has been corrected according to ASTM E90 Section A3.2.7 to account for possible sound transmission through the filler assembly.
ZZ	The reported Transmission Loss at the marked frequency band has been corrected according to ASTM E90 Section A3.2.8 to account for possible sound transmission through the filler assembly. Transmission Loss values corrected this way will be less than or equal to Transmission Loss values from a hypothetical test using the same specimen and an idealized filler assembly with a Sound Transmission Class rating of (∞).

APPENDIX C: Glossary of Variability Metrics

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3.75" of 3/8" limestone chip, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

ΔTL, the 95% confidence interval for reported transmission loss values, is calculated from the standard deviation of the sets of measurements for source room sound pressure level, receive room sound pressure level, and receive room sound absorption. This metric is calculated in an effort to quantify the combined influences of room geometry, microphone positioning, and other varying environmental conditions on reported results.

Repeatability, expressed as a 95% confidence interval, is calculated from the standard deviation of transmission loss as obtained from a set of six (6) consecutive tests conducted according to this test method by RAL from 2021-02-25 through 2021-03-04. The tests were performed on a specimen composed of a 6 in. thick concrete slab, using the same test opening as used in this report. 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 vary with the construction type.

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2024-06-21

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APPENDIX D: Determination of Outdoor Indoor Transmission Class (OITC)

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3.75" of 3/8" limestone chip, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

The determination of the Outdoor Indoor Transmission Class (OITC) as reported below was made with explicit conformity to the procedures described in the ASTM E1332-22 test standard. Test Method ASTM E90-09 (2016) was used to obtain the sound transmission loss data. This rating is based on an average transportation noise source spectrum and an A-weighted sound level reduction, either of which may be inappropriate for some applications.

One-third Octave Band Center Frequency, Hz	Reference Sound Spectrum, dB	Test Specimen Transmission Loss, dB
80	103	34
100	102	34
125	101	39
160	98	40
200	97	44
250	95	48
315	94	52
400	93	58
500	93	58
630	91	60
800	90	66
1000	89	68
1250	89	71
1600	88	75
2000	88	78
2500	87	83
3150	85	88
4000	84	91

OITC = 47

APPENDIX E: Instruments of Traceability

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3.75" of 3/8" limestone chip, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Description	Model	Serial Number	Date of Certification	Calibration Due
System 2	Type 3160-A-042	3160-106974	2023-08-11	2024-08-11
Bruel & Kjaer Mic And Preamp C	Type 4943-B-001	2311439	2024-03-29	2025-03-29
Bruel & Kjaer Pistonphone	Type 4228	2781248	2023-07-12	2024-07-12
EXTECH Hygro 663	SD700	A083663	2023-12-28	2024-12-28
EXTECH Hygro 639	SD700	A.103639	2023-12-01	2024-12-01

APPENDIX F: Revisions to Original Test Report

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3.75" of 3/8" limestone chip, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Date	Revision
2024-07-31	Original report issued

END

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Test Report

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

Sound Transmission Loss
RAL™-TL24-279

CONDUCTED: 2024-06-24

ON: 1-1/8” T&G plywood subfloor screwed 24” OC with #9x3”, cavity filled with: 3” of 3/8” limestone chip and Hempitecture 3/4” hemp fiber board, 2x4 sleepers 24”OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875” with plywood spline 3/4”x6” at the joint secured with #9x3” screws at 6” OC

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 17025:2017 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 E413-22: "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 1-1/8” T&G plywood subfloor screwed 24” OC with #9x3”, cavity filled with: 3” of 3/8” limestone chip and Hempitecture 3/4” hemp fiber board, 2x4 sleepers 24”OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875” with plywood spline 3/4”x6” at the joint secured with #9x3” screws at 6” OC. 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

Provided Description:	1-1/8” T&G plywood subfloor screwed 24” OC with #9x3", cavity filled with: 3” of 3/8" limestone chip and Hempitecture 3/4” hemp fiber board, 2x4 sleepers 24”OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875"
Manufacturer:	University of Oregon

SPECIMEN MEASUREMENTS & TEST CONDITIONS

The building contractor (Seth Priser) and RAL staff compiled a detailed construction specification as follows:

Cross-Laminated Timber (CLT)

Materials:	5-Ply Cross-Laminated Timber
Dimensions:	2 panels @ 1219 mm (48 in.) by 4229 mm (166.5 in.)
Thickness:	171 mm (6.75 in.)
Overall Weight:	953.45 kg (2102 lbs)
Mass Per Unit Volume:	539 kg/m^3 (33.7 lbs/ft^3)
Installation:	CLT panels laid on 152 mm (6 in.) wide knee walls in test opening and butted to one another without sealant/adhesive. 3/4"x3" Rabbet on top side of one edge of each panel where they butt allowing a loose spline (below) to insert and join the two

¾" CDX Loose Spline

Materials:	3/4" x 6" plywood spline
Dimensions:	1 piece @ 151 mm (5.9375 in.) wide by 2438 mm (96 in.) 1 piece @ 151 mm (5.9375 in.) wide by 1791 mm (70.5 in.)
Thickness:	19 mm (0.75 in.)
Overall Weight:	6.46 kg (14.25 lbs)
Mass Per Unit Length:	1.53 kg/m (1.03 lbs/ft)
Installation:	Set in Rabbets of both CLT's and screwed in place.
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing:	6" o.c. on a line 3" from each edge of the spline (Centered on the rabbet of the CLT)

Piano B 40/40 (Lower Layer)

Manufacturer:	Rothoblaas
Dimensions:	2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long 8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness:	6.76 mm (0.266 in.)
Overall Weight:	4.59 kg (10.125 lbs)
Mass Per Unit Volume:	624 kg/m^3 (40.0 lbs/ft^3)
Installation:	Fastened to underside of 2" x 4" wood sleepers with staples
Fasteners:	Arrow staples, length @ 13 mm (0.5 in.)

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

2" by 4" SPF Framing Sleepers

Materials:	Nominal 2"x 4" framing lumber
Dimensions:	2 pieces @ 38 mm (1.5 in.) wide by 4255 mm (167.5 in.) long 8 pieces @ 2369 mm (93.25 in.) wide by 38 mm (1.5 in.) long
Depth:	89 mm (3.5 in.)
Overall Weight:	49.33 kg (108.75 lbs)
Mass Per Unit Length:	1.80 kg/m (1.21 lbs/ft)
Installation:	Sleepers laid over CLT, resting on lower layer Piano B 40/40 Longer sleepers parallel to CLT like a rim joist Shorter sleepers set like floor joists between rim joists Shorter sleepers spaced approx. 610 mm (24 in.) on center Shorter sleepers fastened to longer sleepers with screws, 2 screws per connection point
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)

Piano B 40/40 (Upper Layer)

Manufacturer:	Rothoblaas
Dimensions:	2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long 8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness:	6.76 mm (0.266 in.)
Overall Weight:	4.59 kg (10.125 lbs)
Mass Per Unit Volume:	624 kg/m^3 (40.0 lbs/ft^3)
Installation:	Fastened to top of 2" x 4" wood sleepers with staples
Fasteners:	Arrow staples, length @ 13 mm (0.5 in.)

Hemp Board

Materials:	1" Hemp fiber board
Manufacturer:	Hempitecture
Dimensions:	7 pieces @ 572 mm (22.5 in.) wide by 2369 mm (93.25 in.) long
Depth:	19 mm (0.75 in.)
Overall Weight:	24.38 kg (53.75 lbs)
Mass Per Unit Volume:	135 kg/m^3 (8.43 lbs/ft^3)
Installation:	Friction fit between sleepers and on top of CLT

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Crushed Limestone

Materials:	CA-16 3/8” chip crushed limestone
Dimensions:	2438 mm (96 in.) wide by 4267 mm (168 in.) long, as installed
Depth:	70 mm (2.75 in.)
Overall Weight:	986.56 kg (2175 lbs)
Installation:	Filled stone in above hemp board and between sleepers and used a screed to level to the top of the sleepers.

Plywood Subfloor

Materials:	T&G Plywood
Dimensions:	1 piece @ 1219 mm (48 in.) wide by 1829 mm (72 in.) 1 piece @ 1219 mm (48 in.) wide by 2438 mm (96 in.) 1 piece @ 1219 mm (48 in.) wide by 1822 mm (71.75 in.) 1 piece @ 1219 mm (48 in.) wide by 2432 mm (95.75 in.)
Thickness:	29 mm (1.125 in.)
Overall Weight:	170.66 kg (376.25 lbs)
Mass Per Unit Volume:	575 kg/m^3 (35.9 lbs/ft^3)
Installation:	Placed over upper layer Piano B 40/40 over sleepers Fastened to sleepers through Piano B 40/40 with screws Plywood piece joints staggered
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing:	610 mm (24 in.) on center

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2024-06-24

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Overall Specimen Measurements

Dimensions:	2.44 m (96.0 in) wide by 3.86 m (152.0 in) high
Thickness:	0.3 m (11.875 in)
Weight:	2200.03 kg (4850.25 lbs)
Overall Area:	9.414 m² (101.33 ft²)
Mass per Unit Area:	211.44 kg/m² (43.31 lbs/ft²)

Test Aperture

Opening Size:	4.27 m (14.0 ft) x 6.10 m (20.0 ft)
Filler Wall:	Yes
Aperture Size:	2.44 m (96.0 in) wide by 3.86 m (152.0 in) high
Transmission Area:	9.414 m² (101.33 ft²)
Sealed:	Entire periphery (both sides) with dense mastic

Test Environment

Source Room

Volume:	131.12 m³
Temperature:	23.3 °C ± 0.0 °C
Relative Humidity:	60.0 % ± 0.0 %

Receive Room

Volume:	81.44 m³
Temperature:	22.2 °C ± 0.0 °C
Relative Humidity:	61.5 % ± 1.0 %

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.

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

Figure 2 – Specimen mounted in test aperture, as viewed from receive room

Figure 3 – CLT (1 of 2) prior to installation

Figure 4 – CLT installed in test aperture

Figure 5 – 3/4” x 6” plywood spline partially installed over CLT rabbets

Figure 6 – Detail of 3/4” x 6” plywood spline partially installed over CLT rabbets

Figure 7 – 2” by 4” sleepers partially installed, with Piano B 40/40 strips fastened to underside of sleepers

Figure 8 – Piano B 40/40 strip fastened to sleeper prior to installation of sleeper

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Figure 9 – Hemp boards prior to installation

Figure 10 – Hemp boards partially installed between sleepers, gravel partially installed over hemp boards

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Figure 11 – Hemp boards, gravel, and sleepers installed, Piano B 40/40 strips partially installed over sleepers

Figure 12 – Plywood subfloor partially installed

TEST RESULTS

Sound transmission loss values are tabulated at the eighteen standard frequency bands. 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). See Appendix A for identification of corrections applied to the reported data.

FREQ.	TL	ΔTL	DEF.	FREQ.	TL	ΔTL	DEF.
100	35	0.61	0	800	64	0.24	0
125	39	0.61	3	1000	68	0.16	0
160	38	0.47	7	1250	70	0.12	0
200	42	0.31	6	1600	75	0.12	0
250	46	0.31	5	2000	79	0.07	0
315	50	0.26	4	2500	84	0.08	0
400	52	0.33	5	3150	89	0.10	0
500	58	0.24	0	4000	90	0.27	0
630	61	0.25	0	5000	91	0.18	0

STC=58

ABBREVIATION INDEX

FREQ. = 1/3 OCTAVE BAND CENTER FREQUENCY, Hz
TL = TRANSMISSION LOSS, dB
ΔTL = 95% CONFIDENCE INTERVAL FOR TL MEASUREMENTS, dB
DEF. = DEFICIENCIES, dB BELOW SHIFTED STC CONTOUR (SUM OF DEF = 30)
STC = SOUND TRANSMISSION CLASS

Tested by_____
Keith Kimberling
Test Engineer

Report by_____
Keith Kimberling
Test Engineer

Approved by_____
Eric P. Wolfram
Laboratory Manager

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Test Report

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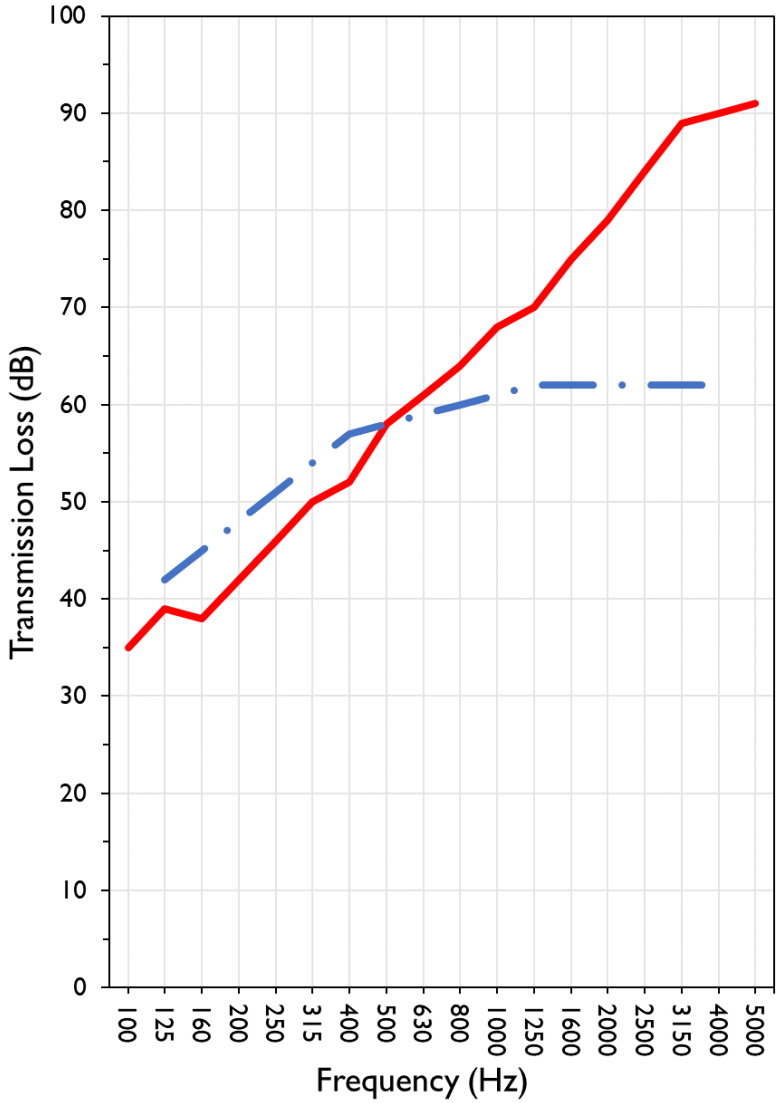
RAL™-TL24-279

SOUND TRANSMISSION REPORT

1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3" of 3/8" limestone chip and Hempitecture 3/4" hemp fiber board, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC



STC=58
OITC=47

TRANSMISSION LOSS
SOUND TRANSMISSION CLASS CONTOUR

NVLAP TESTING
NVLAP LAB CODE 100227-0

APPENDIX A: Extended Frequency Range Data

Specimen: 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3" of 3/8" limestone chip and Hempitecture 3/4" hemp fiber board, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (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. Corrections are detailed in Appendix B.

1/3 Octave Band Center Frequency (Hz)	**Sound Transmission Loss** (dB)	**Applicable Corrections**	**ΔTL (Eq. A2.5)** (dB)	**Repeatability** (dB)
31.5	37	*ZZ F*	0.85	16.75
40	33	*ZZ F*	1.05	5.77
50	39	*ZZ F*	0.77	3.98
63	35	*ZZ F*	0.65	0.75
80	36	*ZZ F*	0.56	1.46
100	35	*ZZ F*	0.61	3.83
125	39	*ZZ F*	0.61	0.97
160	38	*Z F*	0.47	1.35
200	42	*Z F*	0.31	1.21
250	46	*Z F*	0.31	0.56
315	50	*Z F*	0.26	0.61
400	52	*Z F*	0.33	0.76
500	58	*Z F*	0.24	0.58
630	61	*Z F*	0.25	1.03
800	64	*Z F*	0.24	0.34
1000	68	*Z F*	0.16	0.78
1250	70	*Z F*	0.12	1.09
1600	75	*Z F*	0.12	1.47
2000	79	*ZZ F*	0.07	1.14
2500	84	*ZZ F*	0.08	0.87
3150	89	*ZZ F*	0.10	0.90
4000	90	*ZZ A F*	0.27	1.95
5000	91	*ZZ A F*	0.18	3.09
6300	84	*ZZ A F*	0.15	5.31
8000	77	*Z A F*	0.04	7.87
10000	67	*Z F*	0.08	6.75
12500	54		0.05	6.94

APPENDIX B: Glossary of Standardized Corrections and Adjustments

Specimen: 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3" of 3/8" limestone chip and Hempitecture 3/4" hemp fiber board, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Mark	Interpretation
A	Measured sound pressure levels in the receive room are within 10 dB of the ambient noise level at the marked frequency band. Receive room levels used to calculate Transmission Loss are corrected according to ASTM E90 Section 10.3.
AA	Measured sound pressure levels in the receive room are within 5 dB of the ambient noise level at the marked frequency band. Receive room levels used to calculate Transmission Loss are corrected according to ASTM E90 Section 10.3.1. Transmission Loss values calculated from levels corrected this way will be less than or equal to Transmission Loss values from a hypothetical test using the same specimen and a receive room with idealized ambient sound levels of (-∞) dB.
F	The reported Transmission Loss is within 10 dB of the laboratory flanking limit at the marked frequency band. The measured performance of the specimen may be limited by the performance of the laboratory building structure at this frequency band.
Z	The reported Transmission Loss at the marked frequency band has been corrected according to ASTM E90 Section A3.2.7 to account for possible sound transmission through the filler assembly.
ZZ	The reported Transmission Loss at the marked frequency band has been corrected according to ASTM E90 Section A3.2.8 to account for possible sound transmission through the filler assembly. Transmission Loss values corrected this way will be less than or equal to Transmission Loss values from a hypothetical test using the same specimen and an idealized filler assembly with a Sound Transmission Class rating of (∞).

APPENDIX C: Glossary of Variability Metrics

Specimen: 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3" of 3/8" limestone chip and Hempitecture 3/4" hemp fiber board, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

ΔTL, the 95% confidence interval for reported transmission loss values, is calculated from the standard deviation of the sets of measurements for source room sound pressure level, receive room sound pressure level, and receive room sound absorption. This metric is calculated in an effort to quantify the combined influences of room geometry, microphone positioning, and other varying environmental conditions on reported results.

Repeatability, expressed as a 95% confidence interval, is calculated from the standard deviation of transmission loss as obtained from a set of six (6) consecutive tests conducted according to this test method by RAL from 2021-02-25 through 2021-03-04. The tests were performed on a specimen composed of a 6 in. thick concrete slab, using the same test opening as used in this report. 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 vary with the construction type.

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APPENDIX D: Determination of Outdoor Indoor Transmission Class (OITC)

Specimen: 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3" of 3/8" limestone chip and Hempitecture 3/4" hemp fiber board, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

The determination of the Outdoor Indoor Transmission Class (OITC) as reported below was made with explicit conformity to the procedures described in the ASTM E1332-22 test standard. Test Method ASTM E90-09 (2016) was used to obtain the sound transmission loss data. This rating is based on an average transportation noise source spectrum and an A-weighted sound level reduction, either of which may be inappropriate for some applications.

One-third Octave Band Center Frequency, Hz	Reference Sound Spectrum, dB	Test Specimen Transmission Loss, dB
80	103	36
100	102	35
125	101	39
160	98	38
200	97	42
250	95	46
315	94	50
400	93	52
500	93	58
630	91	61
800	90	64
1000	89	68
1250	89	70
1600	88	75
2000	88	79
2500	87	84
3150	85	89
4000	84	90

OITC = 47

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APPENDIX E: Instruments of Traceability

Specimen: 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3" of 3/8" limestone chip and Hempitecture 3/4" hemp fiber board, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Description	Model	Serial Number	Date of Certification	Calibration Due
System 2	Type 3160-A-042	3160-106974	2023-08-11	2024-08-11
Bruel & Kjaer Mic And Preamp C	Type 4943-B-001	2311439	2024-03-29	2025-03-29
Bruel & Kjaer Pistonphone	Type 4228	2781248	2023-07-12	2024-07-12
EXTECH Hygro 663	SD700	A083663	2023-12-28	2024-12-28
EXTECH Hygro 639	SD700	A.103639	2023-12-01	2024-12-01

APPENDIX F: Revisions to Original Test Report

Specimen: 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3" of 3/8" limestone chip and Hempitecture 3/4" hemp fiber board, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Date	Revision
2024-07-31	Original report issued

END

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Test Report

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

Sound Transmission Loss
RAL™-TL24-280

CONDUCTED: 2024-06-25

ON: Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3" of 3/8" limestone chip and Hempitecture 3/4" hemp fiber board, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC

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 17025:2017 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 E413-22: "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 Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3" of 3/8" limestone chip and Hempitecture 3/4" hemp fiber board, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC. 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

Provided Description:	Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3" of 3/8" limestone chip and Hempitecture 3/4" hemp fiber board, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC
Manufacturer:	University of Oregon

SPECIMEN MEASUREMENTS & TEST CONDITIONS

The building contractor (Seth Priser) and RAL staff compiled a detailed construction specification as follows:

Cross-Laminated Timber (CLT)

Materials:	5-Ply Cross-Laminated Timber
Dimensions:	2 panels @ 1219 mm (48 in.) by 4229 mm (166.5 in.)
Thickness:	171 mm (6.75 in.)
Overall Weight:	953.45 kg (2102 lbs)
Mass Per Unit Volume:	539 kg/m^3 (33.7 lbs/ft^3)
Installation:	CLT panels laid on 152 mm (6 in.) wide knee walls in test opening and butted to one another without sealant/adhesive. 3/4"x3" Rabbet on top side of one edge of each panel where they butt allowing a loose spline (below) to insert and join the two

¾" CDX Loose Spline

Materials:	3/4" x 6" plywood spline
Dimensions:	1 piece @ 151 mm (5.9375 in.) wide by 2438 mm (96 in.) 1 piece @ 151 mm (5.9375 in.) wide by 1791 mm (70.5 in.)
Thickness:	19 mm (0.75 in.)
Overall Weight:	6.46 kg (14.25 lbs)
Mass Per Unit Length:	1.53 kg/m (1.03 lbs/ft)
Installation:	Set in Rabbets of both CLT's and screwed in place.
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing:	6" o.c. on a line 3" from each edge of the spline (Centered on the rabbet of the CLT)

Piano B 40/40 (Lower Layer)

Manufacturer:	Rothoblaas
Dimensions:	2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long 8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness:	6.76 mm (0.266 in.)
Overall Weight:	4.59 kg (10.125 lbs)
Mass Per Unit Volume:	624 kg/m^3 (40.0 lbs/ft^3)
Installation:	Fastened to underside of 2" x 4" wood sleepers with staples
Fasteners:	Arrow staples, length @ 13 mm (0.5 in.)

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

2" by 4" SPF Framing Sleepers

Materials:	Nominal 2"x 4" framing lumber
Dimensions:	2 pieces @ 38 mm (1.5 in.) wide by 4255 mm (167.5 in.) long 8 pieces @ 2369 mm (93.25 in.) wide by 38 mm (1.5 in.) long
Depth:	89 mm (3.5 in.)
Overall Weight:	49.33 kg (108.75 lbs)
Mass Per Unit Length:	1.80 kg/m (1.21 lbs/ft)
Installation:	Sleepers laid over CLT, resting on lower layer Piano B 40/40 Longer sleepers parallel to CLT like a rim joist Shorter sleepers set like floor joists between rim joists Shorter sleepers spaced approx. 610 mm (24 in.) on center Shorter sleepers fastened to longer sleepers with screws, 2 screws per connection point
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)

Piano B 40/40 (Upper Layer)

Manufacturer:	Rothoblaas
Dimensions:	2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long 8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness:	6.76 mm (0.266 in.)
Overall Weight:	4.59 kg (10.125 lbs)
Mass Per Unit Volume:	624 kg/m^3 (40.0 lbs/ft^3)
Installation:	Fastened to top of 2" x 4" wood sleepers with staples
Fasteners:	Arrow staples, length @ 13 mm (0.5 in.)

Hemp Board

Materials:	1" Hemp fiber board
Manufacturer:	Hempitecture
Dimensions:	7 pieces @ 572 mm (22.5 in.) wide by 2369 mm (93.25 in.) long
Depth:	19 mm (0.75 in.)
Overall Weight:	24.38 kg (53.75 lbs)
Mass Per Unit Volume:	135 kg/m^3 (8.43 lbs/ft^3)
Installation:	Friction fit between sleepers and on top of CLT

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Crushed Limestone

Materials:	CA-16 3/8" chip crushed limestone
Dimensions:	2438 mm (96 in.) wide by 4267 mm (168 in.) long, as installed
Depth:	70 mm (2.75 in.)
Overall Weight:	986.56 kg (2175 lbs)
Installation:	Filled stone in above hemp board and between sleepers and used a screed to level to the top of the sleepers.

Plywood Subfloor

Materials:	T&G Plywood
Dimensions:	1 piece @ 1219 mm (48 in.) wide by 1829 mm (72 in.) 1 piece @ 1219 mm (48 in.) wide by 2438 mm (96 in.) 1 piece @ 1219 mm (48 in.) wide by 1822 mm (71.75 in.) 1 piece @ 1219 mm (48 in.) wide by 2432 mm (95.75 in.)
Thickness:	29 mm (1.125 in.)
Overall Weight:	170.66 kg (376.25 lbs)
Mass Per Unit Volume:	575 kg/m^3 (35.9 lbs/ft^3)
Installation:	Placed over upper layer Piano B 40/40 over sleepers Fastened to sleepers through Piano B 40/40 with screws Plywood piece joints staggered
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing:	610 mm (24 in.) on center

Adhesive

Materials:	Sustain 1195 Sheet and Tile adhesive
Manufacturer:	Forbo
Dimensions:	Approx. 2438 mm (96 in.) by 4267 mm (168 in.) as installed
Overall Weight:	5.44 kg (12 lbs)
Mass Per Unit Area:	0.52 kg/m^2 (0.11 lbs/ft^2)
Installation:	Troweled directly to plywood with a 1/16x1/16x1/16 square notch trowel Once troweled, adhesive was left "open" for 15 min to allow it to "tack" before flooring was installed.

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SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Flooring

Materials:	Marmoleum Decibel
Manufacturer:	Forbo
Dimensions:	2 pieces @ 2007 mm (79 in.) by 2464 mm (97 in.) 1 piece @ 257 mm (10.125 in.) by 2438 mm (96 in.)
Thickness:	6 mm (0.25 in.)
Overall Weight:	32.21 kg (71 lbs)
Mass Per Unit Volume:	482 kg/m^3 (30.1 lbs/ft^3)
Installation:	Two (2) 79” segments perpendicular to Plywood 10” strip to complete Joints staggered from parallel plywood joints by + 6” Rolled with 100lb roller in each direction

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SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Overall Specimen Measurements

Dimensions:	2.44 m (96.0 in) wide by 3.86 m (152.0 in) high
Thickness:	0.31 m (12.125 in)
Weight:	2237.68 kg (4933.25 lbs)
Overall Area:	9.414 m² (101.33 ft²)
Mass per Unit Area:	215.06 kg/m² (44.05 lbs/ft²)

Test Aperture

Opening Size:	4.27 m (14.0 ft) x 6.10 m (20.0 ft)
Filler Wall:	Yes
Aperture Size:	2.44 m (96.0 in) wide by 3.86 m (152.0 in) high
Transmission Area:	9.414 m² (101.33 ft²)
Sealed:	Entire periphery (both sides) with dense mastic

Test Environment

Source Room

Volume:	131.12 m³
Temperature:	22.8 °C ± 0.0 °C
Relative Humidity:	62.0 % ± 0.0 %

Receive Room

Volume:	81.44 m³
Temperature:	22.2 °C ± 0.0 °C
Relative Humidity:	63.0 % ± 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 aperture, as viewed from source room

Figure 2 – Specimen mounted in test aperture, as viewed from receive room

Figure 3 – CLT (1 of 2) prior to installation

Figure 4 – CLT installed in test aperture

Figure 5 – 3/4” x 6” plywood spline partially installed over CLT rabbets

Figure 6 – Detail of 3/4” x 6” plywood spline partially installed over CLT rabbets

Figure 7 – 2” by 4” sleepers partially installed, with Piano B 40/40 strips fastened to underside of sleepers

Figure 8 – Piano B 40/40 strip fastened to sleeper prior to installation of sleeper

Figure 9 – Hemp boards prior to installation

Figure 10 – Hemp boards partially installed between sleepers, gravel partially installed over hemp boards

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Figure 11 – Hemp boards, gravel, and sleepers installed, Piano B 40/40 strips partially installed over sleepers

Figure 12 – Plywood subfloor partially installed

Figure 13 – Plywood subfloor installed

Figure 14 – Trowel used for installation of adhesive

Figure 15 – Adhesive partially installed over plywood

Figure 16 – Flooring partially installed over adhesive

TEST RESULTS

Sound transmission loss values are tabulated at the eighteen standard frequency bands. 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). See Appendix A for identification of corrections applied to the reported data.

FREQ.	TL	ΔTL	DEF.	FREQ.	TL	ΔTL	DEF.
100	36	0.45	0	800	66	0.27	0
125	40	0.60	3	1000	69	0.13	0
160	40	0.51	6	1250	70	0.17	0
200	42	0.54	7	1600	73	0.18	0
250	46	0.30	6	2000	77	0.19	0
315	50	0.26	5	2500	82	0.70	0
400	53	0.33	5	3150	88	1.38	0
500	59	0.28	0	4000	90	2.70	0
630	62	0.27	0	5000	89	2.68	0

STC=59

ABBREVIATION INDEX

FREQ. = 1/3 OCTAVE BAND CENTER FREQUENCY, Hz
TL = TRANSMISSION LOSS, dB
ΔTL = 95% CONFIDENCE INTERVAL FOR TL MEASUREMENTS, dB
DEF. = DEFICIENCIES, dB BELOW SHIFTED STC CONTOUR (SUM OF DEF = 32)
STC = SOUND TRANSMISSION CLASS

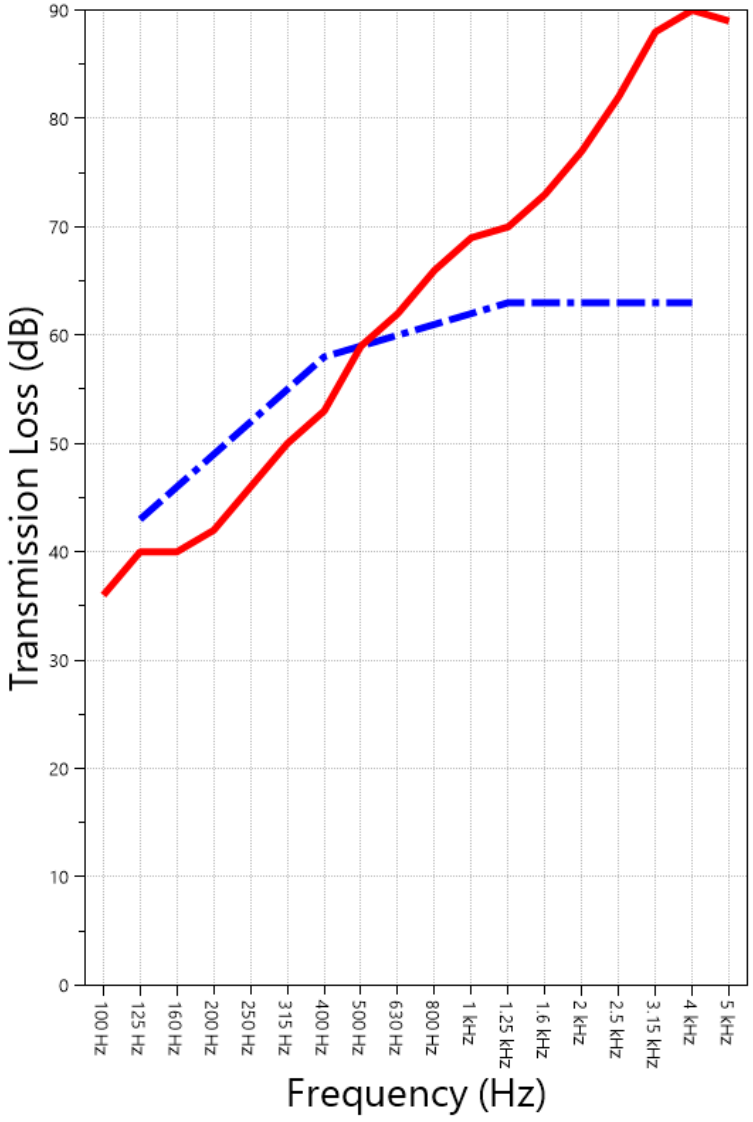
Tested by _____
Keith Kimberling
Test Engineer

Report by _____
Keith Kimberling
Test Engineer

Approved by _____
Eric P. Wolfram
Laboratory Manager

SOUND TRANSMISSION REPORT

Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3" of 3/8" limestone chip and Hempitecture 3/4" hemp fiber board, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC



STC=59
OITC=47

TRANSMISSION LOSS
SOUND TRANSMISSION CLASS CONTOUR

APPENDIX A: Extended Frequency Range Data

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3" of 3/8" limestone chip and Hempitecture 3/4" hemp fiber board, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC

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. Corrections are detailed in Appendix B.

1/3 Octave Band Center Frequency (Hz)	**Sound Transmission Loss** (dB)	**Applicable Corrections**	**ΔTL (Eq. A2.5)** (dB)	**Repeatability** (dB)
31.5	36	*ZZ A F*	1.25	16.75
40	34	*ZZ F*	1.02	5.77
50	39	*ZZ F*	0.94	3.98
63	36	*ZZ F*	0.54	0.75
80	36	*ZZ F*	0.75	1.46
100	36	*ZZ F*	0.45	3.83
125	40	*ZZ F*	0.60	0.97
160	40	*Z F*	0.51	1.35
200	42	*Z F*	0.54	1.21
250	46	*ZZ F*	0.30	0.56
315	50	*Z F*	0.26	0.61
400	53	*Z F*	0.33	0.76
500	59	*Z F*	0.28	0.58
630	62	*Z F*	0.27	1.03
800	66	*ZZ F*	0.27	0.34
1000	69	*Z F*	0.13	0.78
1250	70	*Z F*	0.17	1.09
1600	73	*Z F*	0.18	1.47
2000	77	*Z F*	0.19	1.14
2500	82	*ZZ F*	0.70	0.87
3150	88	*ZZ F*	1.38	0.90
4000	90	*ZZ A F*	2.70	1.95
5000	89	*ZZ A F*	2.68	3.09
6300	82	*Z A F*	2.02	5.31
8000	74	*Z F*	1.19	7.87
10000	65	*Z*	0.91	6.75
12500	53		0.62	6.94

APPENDIX B: Glossary of Standardized Corrections and Adjustments

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3" of 3/8" limestone chip and Hempitecture 3/4" hemp fiber board, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Mark	Interpretation
A	Measured sound pressure levels in the receive room are within 10 dB of the ambient noise level at the marked frequency band. Receive room levels used to calculate Transmission Loss are corrected according to ASTM E90 Section 10.3.
AA	Measured sound pressure levels in the receive room are within 5 dB of the ambient noise level at the marked frequency band. Receive room levels used to calculate Transmission Loss are corrected according to ASTM E90 Section 10.3.1. Transmission Loss values calculated from levels corrected this way will be less than or equal to Transmission Loss values from a hypothetical test using the same specimen and a receive room with idealized ambient sound levels of (-∞) dB.
F	The reported Transmission Loss is within 10 dB of the laboratory flanking limit at the marked frequency band. The measured performance of the specimen may be limited by the performance of the laboratory building structure at this frequency band.
Z	The reported Transmission Loss at the marked frequency band has been corrected according to ASTM E90 Section A3.2.7 to account for possible sound transmission through the filler assembly.
ZZ	The reported Transmission Loss at the marked frequency band has been corrected according to ASTM E90 Section A3.2.8 to account for possible sound transmission through the filler assembly. Transmission Loss values corrected this way will be less than or equal to Transmission Loss values from a hypothetical test using the same specimen and an idealized filler assembly with a Sound Transmission Class rating of (∞).

APPENDIX C: Glossary of Variability Metrics

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3" of 3/8" limestone chip and Hempitecture 3/4" hemp fiber board, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

ΔTL, the 95% confidence interval for reported transmission loss values, is calculated from the standard deviation of the sets of measurements for source room sound pressure level, receive room sound pressure level, and receive room sound absorption. This metric is calculated in an effort to quantify the combined influences of room geometry, microphone positioning, and other varying environmental conditions on reported results.

Repeatability, expressed as a 95% confidence interval, is calculated from the standard deviation of transmission loss as obtained from a set of six (6) consecutive tests conducted according to this test method by RAL from 2021-02-25 through 2021-03-04. The tests were performed on a specimen composed of a 6 in. thick concrete slab, using the same test opening as used in this report. 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 vary with the construction type.

APPENDIX D: Determination of Outdoor Indoor Transmission Class (OITC)

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3" of 3/8" limestone chip and Hempitecture 3/4" hemp fiber board, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

The determination of the Outdoor Indoor Transmission Class (OITC) as reported below was made with explicit conformity to the procedures described in the ASTM E1332-22 test standard. Test Method ASTM E90-09 (2016) was used to obtain the sound transmission loss data. This rating is based on an average transportation noise source spectrum and an A-weighted sound level reduction, either of which may be inappropriate for some applications.

One-third Octave Band Center Frequency, Hz	Reference Sound Spectrum, dB	Test Specimen Transmission Loss, dB
80	103	36
100	102	36
125	101	40
160	98	40
200	97	42
250	95	46
315	94	50
400	93	53
500	93	59
630	91	62
800	90	66
1000	89	69
1250	89	70
1600	88	73
2000	88	77
2500	87	82
3150	85	88
4000	84	90

OITC = 47

APPENDIX E: Instruments of Traceability

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3" of 3/8" limestone chip and Hempitecture 3/4" hemp fiber board, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Description	Model	Serial Number	Date of Certification	Calibration Due
System 2	Type 3160-A-042	3160-106974	2023-08-11	2024-08-11
Bruel & Kjaer Pistonphone	Type 4228	2781248	2023-07-12	2024-07-12
EXTECH Hygro 663	SD700	A083663	2023-12-28	2024-12-28
EXTECH Hygro 639	SD700	A.103639	2023-12-01	2024-12-01

APPENDIX F: Revisions to Original Test Report

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: 3" of 3/8" limestone chip and Hempitecture 3/4" hemp fiber board, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Date	Revision
2024-07-31	Original report issued

END

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Test Report

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

Sound Transmission Loss
RAL™-TL24-281

CONDUCTED: 2024-06-26

ON: 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC

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 17025:2017 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 E413-22: "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 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC. 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

Provided Description:	1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC
Manufacturer:	University of Oregon

SPECIMEN MEASUREMENTS & TEST CONDITIONS

The building contractor (Seth Priser) and RAL staff compiled a detailed construction specification as follows:

Cross-Laminated Timber (CLT)

Materials:	5-Ply Cross-Laminated Timber
Dimensions:	2 panels @ 1219 mm (48 in.) by 4229 mm (166.5 in.)
Thickness:	171 mm (6.75 in.)
Overall Weight:	953.45 kg (2102 lbs)
Mass Per Unit Volume:	539 kg/m^3 (33.7 lbs/ft^3)
Installation:	CLT panels laid on 152 mm (6 in.) wide knee walls in test opening and butted to one another without sealant/adhesive. 3/4"x3" Rabbet on top side of one edge of each panel where they butt allowing a loose spline (below) to insert and join the two

¾" CDX Loose Spline

Materials:	3/4" x 6" plywood spline
Dimensions:	1 piece @ 151 mm (5.9375 in.) wide by 2438 mm (96 in.) 1 piece @ 151 mm (5.9375 in.) wide by 1791 mm (70.5 in.)
Thickness:	19 mm (0.75 in.)
Overall Weight:	6.46 kg (14.25 lbs)
Mass Per Unit Length:	1.53 kg/m (1.03 lbs/ft)
Installation:	Set in Rabbets of both CLT's and screwed in place.
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing:	6" o.c. on a line 3" from each edge of the spline (Centered on the rabbet of the CLT)

Piano B 40/40 (Lower Layer)

Manufacturer:	Rothoblaas
Dimensions:	2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long 8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness:	6.76 mm (0.266 in.)
Overall Weight:	4.59 kg (10.125 lbs)
Mass Per Unit Volume:	624 kg/m^3 (40.0 lbs/ft^3)
Installation:	Fastened to underside of 2" x 4" wood sleepers with staples
Fasteners:	Arrow staples, length @ 13 mm (0.5 in.)

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

2" by 4" SPF Framing Sleepers

Materials:	Nominal 2"x 4" framing lumber
Dimensions:	2 pieces @ 38 mm (1.5 in.) wide by 4255 mm (167.5 in.) long 8 pieces @ 2369 mm (93.25 in.) wide by 38 mm (1.5 in.) long
Depth:	89 mm (3.5 in.)
Overall Weight:	49.33 kg (108.75 lbs)
Mass Per Unit Length:	1.80 kg/m (1.21 lbs/ft)
Installation:	Sleepers laid over CLT, resting on lower layer Piano B 40/40 Longer sleepers parallel to CLT like a rim joist Shorter sleepers set like floor joists between rim joists Shorter sleepers spaced approx. 610 mm (24 in.) on center Shorter sleepers fastened to longer sleepers with screws, 2 screws per connection point
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)

Piano B 40/40 (Upper Layer)

Manufacturer:	Rothoblaas
Dimensions:	2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long 8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness:	6.76 mm (0.266 in.)
Overall Weight:	4.59 kg (10.125 lbs)
Mass Per Unit Volume:	624 kg/m^3 (40.0 lbs/ft^3)
Installation:	Fastened to top of 2" x 4" wood sleepers with staples
Fasteners:	Arrow staples, length @ 13 mm (0.5 in.)

Hemp Board

Materials:	3" Hemp fiber board
Manufacturer:	Hempitecture
Dimensions:	7 pieces @ 572 mm (22.5 in.) wide by 2369 mm (93.25 in.) long
Depth:	76 mm (3 in.)
Overall Weight:	37.53 kg (82.75 lbs)
Mass Per Unit Volume:	52.0 kg/m^3 (3.25 lbs/ft^3)
Installation:	Friction fit between sleepers and on top of CLT

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Plywood Subfloor

Materials:	T&G Plywood
Dimensions:	1 piece @ 1219 mm (48 in.) wide by 1829 mm (72 in.)
	1 piece @ 1219 mm (48 in.) wide by 2438 mm (96 in.)
	1 piece @ 1219 mm (48 in.) wide by 1822 mm (71.75 in.)
	1 piece @ 1219 mm (48 in.) wide by 2432 mm (95.75 in.)
Thickness:	29 mm (1.125 in.)
Overall Weight:	172.25 kg (379.75 lbs)
Mass Per Unit Volume:	580 kg/m^3 (36.2 lbs/ft^3)
Installation:	Placed over upper layer Piano B 40/40 over sleepers
	Fastened to sleepers through Piano B 40/40 with screws
	Plywood piece joints staggered
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing:	610 mm (24 in.) on center

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Overall Specimen Measurements

Dimensions:	2.44 m (96.0 in) wide by 3.86 m (152.0 in) high
Thickness:	0.3 m (11.875 in)
Weight:	1228.21 kg (2707.75 lbs)
Overall Area:	9.414 m² (101.33 ft²)
Mass per Unit Area:	118.04 kg/m² (24.18 lbs/ft²)

Test Aperture

Opening Size:	4.27 m (14.0 ft) x 6.10 m (20.0 ft)
Filler Wall:	Yes
Aperture Size:	2.44 m (96.0 in) wide by 3.86 m (152.0 in) high
Transmission Area:	9.414 m² (101.33 ft²)
Sealed:	Entire periphery (both sides) with dense mastic

Test Environment

Source Room

Volume:	131.12 m³
Temperature:	22.8 °C ± 0.0 °C
Relative Humidity:	64.5 % ± 1.0 %

Receive Room

Volume:	81.44 m³
Temperature:	22.2 °C ± 0.0 °C
Relative Humidity:	64.0 % ± 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.

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

Figure 2 – Specimen mounted in test aperture, as viewed from receive room

Figure 3 – CLT (1 of 2) prior to installation

Figure 4 – CLT installed in test aperture

Figure 5 – 3/4” x 6” plywood spline partially installed over CLT rabbets

Figure 6 – Detail of 3/4” x 6” plywood spline partially installed over CLT rabbets

Figure 7 – 2” by 4” sleepers partially installed, with Piano B 40/40 strips fastened to underside of sleepers

Figure 8 – Piano B 40/40 strip fastened to sleeper prior to installation of sleeper

Figure 9 – Hemp boards prior to installation

Figure 10 – Hemp boards partially installed between sleepers

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Figure 11 – Hemp boards partially installed between sleepers, plywood partially installed over sleepers

TEST RESULTS

Sound transmission loss values are tabulated at the eighteen standard frequency bands. 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). See Appendix A for identification of corrections applied to the reported data.

FREQ.	TL	ΔTL	DEF.	FREQ.	TL	ΔTL	DEF.
100	30	0.46	0	800	64	0.12	0
125	40	0.58	3	1000	67	0.11	0
160	41	0.52	5	1250	70	0.13	0
200	43	0.31	6	1600	75	0.09	0
250	46	0.19	6	2000	79	0.08	0
315	50	0.24	5	2500	84	0.11	0
400	54	0.21	4	3150	89	0.08	0
500	58	0.20	1	4000	91	0.05	0
630	61	0.16	0	5000	93	0.07	0

STC=59

ABBREVIATION INDEX

FREQ. = 1/3 OCTAVE BAND CENTER FREQUENCY, Hz
TL = TRANSMISSION LOSS, dB
ΔTL = 95% CONFIDENCE INTERVAL FOR TL MEASUREMENTS, dB
DEF. = DEFICIENCIES, dB BELOW SHIFTED STC CONTOUR (SUM OF DEF = 30)
STC = SOUND TRANSMISSION CLASS

Tested by_____
Keith Kimberling
Test Engineer

Report by_____
Keith Kimberling
Test Engineer

Approved by_____
Eric P. Wolfram
Laboratory Manager

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GENEVA, IL 60134

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Test Report

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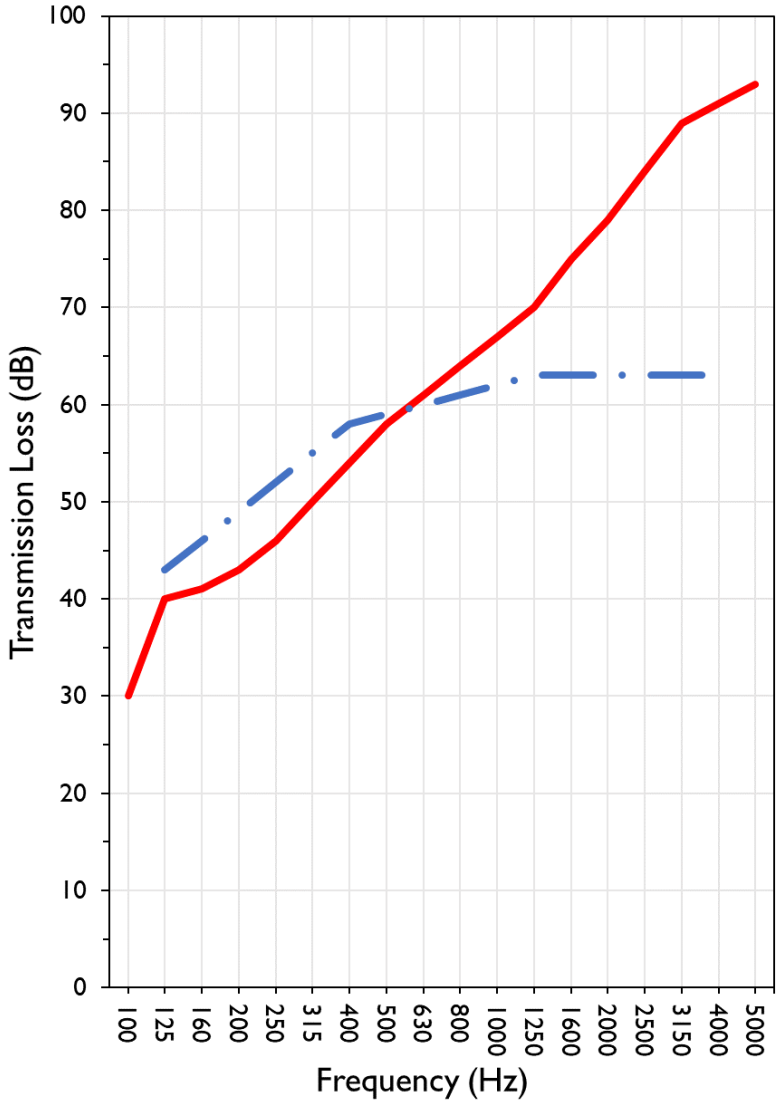
University of Oregon
2024-06-26

RAL™-TL24-281

SOUND TRANSMISSION REPORT

1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC



STC=59
OITC=44

TRANSMISSION LOSS
SOUND TRANSMISSION CLASS CONTOUR

APPENDIX A: Extended Frequency Range Data

Specimen: 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (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. Corrections are detailed in Appendix B.

1/3 Octave Band Center Frequency (Hz)	**Sound Transmission Loss** (dB)	**Applicable Corrections**	**ΔTL (Eq. A2.5)** (dB)	**Repeatability** (dB)
31.5	35	*ZZ F*	0.78	16.75
40	36	*ZZ F*	0.66	5.77
50	34	*ZZ F*	0.83	3.98
63	29	*Z F*	0.61	0.75
80	29	*Z F*	0.69	1.46
100	30	*Z F*	0.46	3.83
125	40	*ZZ F*	0.58	0.97
160	41	*Z F*	0.52	1.35
200	43	*ZZ F*	0.31	1.21
250	46	*ZZ F*	0.19	0.56
315	50	*Z F*	0.24	0.61
400	54	*Z F*	0.21	0.76
500	58	*Z F*	0.20	0.58
630	61	*Z F*	0.16	1.03
800	64	*Z F*	0.12	0.34
1000	67	*Z F*	0.11	0.78
1250	70	*Z F*	0.13	1.09
1600	75	*Z F*	0.09	1.47
2000	79	*ZZ F*	0.08	1.14
2500	84	*ZZ F*	0.11	0.87
3150	89	*ZZ F*	0.08	0.90
4000	91	*ZZ A F*	0.05	1.95
5000	93	*ZZ A F*	0.07	3.09
6300	86	*ZZ A F*	0.07	5.31
8000	77	*Z A F*	0.07	7.87
10000	67	*Z F*	0.06	6.75
12500	54		0.09	6.94

APPENDIX B: Glossary of Standardized Corrections and Adjustments

Specimen: 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Mark	Interpretation
A	Measured sound pressure levels in the receive room are within 10 dB of the ambient noise level at the marked frequency band. Receive room levels used to calculate Transmission Loss are corrected according to ASTM E90 Section 10.3.
AA	Measured sound pressure levels in the receive room are within 5 dB of the ambient noise level at the marked frequency band. Receive room levels used to calculate Transmission Loss are corrected according to ASTM E90 Section 10.3.1. Transmission Loss values calculated from levels corrected this way will be less than or equal to Transmission Loss values from a hypothetical test using the same specimen and a receive room with idealized ambient sound levels of (-∞) dB.
F	The reported Transmission Loss is within 10 dB of the laboratory flanking limit at the marked frequency band. The measured performance of the specimen may be limited by the performance of the laboratory building structure at this frequency band.
Z	The reported Transmission Loss at the marked frequency band has been corrected according to ASTM E90 Section A3.2.7 to account for possible sound transmission through the filler assembly.
ZZ	The reported Transmission Loss at the marked frequency band has been corrected according to ASTM E90 Section A3.2.8 to account for possible sound transmission through the filler assembly. Transmission Loss values corrected this way will be less than or equal to Transmission Loss values from a hypothetical test using the same specimen and an idealized filler assembly with a Sound Transmission Class rating of (∞).

APPENDIX C: Glossary of Variability Metrics

Specimen: 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

ΔTL, the 95% confidence interval for reported transmission loss values, is calculated from the standard deviation of the sets of measurements for source room sound pressure level, receive room sound pressure level, and receive room sound absorption. This metric is calculated in an effort to quantify the combined influences of room geometry, microphone positioning, and other varying environmental conditions on reported results.

Repeatability, expressed as a 95% confidence interval, is calculated from the standard deviation of transmission loss as obtained from a set of six (6) consecutive tests conducted according to this test method by RAL from 2021-02-25 through 2021-03-04. The tests were performed on a specimen composed of a 6 in. thick concrete slab, using the same test opening as used in this report. 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 vary with the construction type.

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APPENDIX D: Determination of Outdoor Indoor Transmission Class (OITC)

Specimen: 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

The determination of the Outdoor Indoor Transmission Class (OITC) as reported below was made with explicit conformity to the procedures described in the ASTM E1332-22 test standard. Test Method ASTM E90-09 (2016) was used to obtain the sound transmission loss data. This rating is based on an average transportation noise source spectrum and an A-weighted sound level reduction, either of which may be inappropriate for some applications.

One-third Octave Band Center Frequency, Hz	Reference Sound Spectrum, dB	Test Specimen Transmission Loss, dB
80	103	29
100	102	30
125	101	40
160	98	41
200	97	43
250	95	46
315	94	50
400	93	54
500	93	58
630	91	61
800	90	64
1000	89	67
1250	89	70
1600	88	75
2000	88	79
2500	87	84
3150	85	89
4000	84	91

OITC = 44

APPENDIX E: Instruments of Traceability

Specimen: 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Description	Model	Serial Number	Date of Certification	Calibration Due
System 2	Type 3160-A-042	3160-106974	2023-08-11	2024-08-11
Bruel & Kjaer Mic And Preamp C	Type 4943-B-001	2311439	2024-03-29	2025-03-29
Bruel & Kjaer Pistonphone	Type 4228	2781248	2023-07-12	2024-07-12
EXTECH Hygro 663	SD700	A083663	2023-12-28	2024-12-28
EXTECH Hygro 639	SD700	A.103639	2023-12-01	2024-12-01

APPENDIX F: Revisions to Original Test Report

Specimen: 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Date	Revision
2024-07-31	Original report issued

END

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Test Report

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

Sound Transmission Loss
RAL™-TL24-294

CONDUCTED: 2024-06-28

ON: Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC

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 17025:2017 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 E413-22: "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 Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC. 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

Provided Description:	Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC
Manufacturer:	University of Oregon

SPECIMEN MEASUREMENTS & TEST CONDITIONS

The building contractor (Seth Priser) and RAL staff compiled a detailed construction specification as follows:

Cross-Laminated Timber (CLT)

Materials:	5-Ply Cross-Laminated Timber
Dimensions:	2 panels @ 1219 mm (48 in.) by 4229 mm (166.5 in.)
Thickness:	171 mm (6.75 in.)
Overall Weight:	953.45 kg (2102 lbs)
Mass Per Unit Volume:	539 kg/m^3 (33.7 lbs/ft^3)
Installation:	CLT panels laid on 152 mm (6 in.) wide knee walls in test opening and butted to one another without sealant/adhesive. 3/4"x3" Rabbet on top side of one edge of each panel where they butt allowing a loose spline (below) to insert and join the two

¾" CDX Loose Spline

Materials:	3/4" x 6" plywood spline
Dimensions:	1 piece @ 151 mm (5.9375 in.) wide by 2438 mm (96 in.) 1 piece @ 151 mm (5.9375 in.) wide by 1791 mm (70.5 in.)
Thickness:	19 mm (0.75 in.)
Overall Weight:	6.46 kg (14.25 lbs)
Mass Per Unit Length:	1.53 kg/m (1.03 lbs/ft)
Installation:	Set in Rabbets of both CLT's and screwed in place.
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing:	6" o.c. on a line 3" from each edge of the spline (Centered on the rabbet of the CLT)

Piano B 40/40 (Lower Layer)

Manufacturer:	Rothoblaas
Dimensions:	2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long 8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness:	6.76 mm (0.266 in.)
Overall Weight:	4.59 kg (10.125 lbs)
Mass Per Unit Volume:	624 kg/m^3 (40.0 lbs/ft^3)
Installation:	Fastened to underside of 2" x 4" wood sleepers with staples
Fasteners:	Arrow staples, length @ 13 mm (0.5 in.)

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

2" by 4" SPF Framing Sleepers

Materials:	Nominal 2"x 4" framing lumber
Dimensions:	2 pieces @ 38 mm (1.5 in.) wide by 4255 mm (167.5 in.) long 8 pieces @ 2369 mm (93.25 in.) wide by 38 mm (1.5 in.) long
Depth:	89 mm (3.5 in.)
Overall Weight:	49.33 kg (108.75 lbs)
Mass Per Unit Length:	1.80 kg/m (1.21 lbs/ft)
Installation:	Sleepers laid over CLT, resting on lower layer Piano B 40/40 Longer sleepers parallel to CLT like a rim joist Shorter sleepers set like floor joists between rim joists Shorter sleepers spaced approx. 610 mm (24 in.) on center Shorter sleepers fastened to longer sleepers with screws, 2 screws per connection point
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)

Piano B 40/40 (Upper Layer)

Manufacturer:	Rothoblaas
Dimensions:	2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long 8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness:	6.76 mm (0.266 in.)
Overall Weight:	4.59 kg (10.125 lbs)
Mass Per Unit Volume:	624 kg/m^3 (40.0 lbs/ft^3)
Installation:	Fastened to top of 2" x 4" wood sleepers with staples
Fasteners:	Arrow staples, length @ 13 mm (0.5 in.)

Hemp Board

Materials:	3" Hemp fiber board
Manufacturer:	Hempitecture
Dimensions:	7 pieces @ 572 mm (22.5 in.) wide by 2369 mm (93.25 in.) long
Depth:	76 mm (3 in.)
Overall Weight:	37.53 kg (82.75 lbs)
Mass Per Unit Volume:	52.0 kg/m^3 (3.25 lbs/ft^3)
Installation:	Friction fit between sleepers and on top of CLT

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Plywood Subfloor

Materials:	T&G Plywood
Dimensions:	1 piece @ 1219 mm (48 in.) wide by 1829 mm (72 in.) 1 piece @ 1219 mm (48 in.) wide by 2438 mm (96 in.) 1 piece @ 1219 mm (48 in.) wide by 1822 mm (71.75 in.) 1 piece @ 1219 mm (48 in.) wide by 2432 mm (95.75 in.)
Thickness:	29 mm (1.125 in.)
Overall Weight:	172.25 kg (379.75 lbs)
Mass Per Unit Volume:	580 kg/m^3 (36.2 lbs/ft^3)
Installation:	Placed over upper layer Piano B 40/40 over sleepers Fastened to sleepers through Piano B 40/40 with screws Plywood piece joints staggered
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing:	610 mm (24 in.) on center

Adhesive

Materials:	Sustain 1195 Sheet and Tile adhesive
Manufacturer:	Forbo
Dimensions:	Approx. 2438 mm (96 in.) by 4267 mm (168 in.) as installed
Overall Weight:	4.2 kg (9.25 lbs)
Mass Per Unit Area:	0.40 kg/m^2 (0.08 lbs/ft^2)
Installation:	Troweled directly to plywood with a 1/16x1/16x1/16 square notch trowel Once troweled, adhesive was left “open” for 15 min to allow it to “tack” before flooring was installed.

Flooring

Materials:	Marmoleum Decibel
Manufacturer:	Forbo
Dimensions:	2 pieces @ 2007 mm (79 in.) by 2464 mm (97 in.) 1 piece @ 257 mm (10.125 in.) by 2438 mm (96 in.)
Thickness:	6 mm (0.25 in.)
Overall Weight:	32.32 kg (71.25 lbs)
Mass Per Unit Volume:	484 kg/m^3 (30.2 lbs/ft^3)
Installation:	Two (2) 79” segments perpendicular to Plywood 10” strip to complete Joints staggered from parallel plywood joints by + 6” Rolled with 100lb roller in each direction

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Overall Specimen Measurements

Dimensions:	2.44 m (96.0 in) wide by 3.86 m (152.0 in) high
Thickness:	0.31 m (12.125 in)
Weight:	1264.73 kg (2788.25 lbs)
Overall Area:	9.414 m² (101.33 ft²)
Mass per Unit Area:	121.55 kg/m² (24.90 lbs/ft²)

Test Aperture

Opening Size:	4.27 m (14.0 ft) x 6.10 m (20.0 ft)
Filler Wall:	Yes
Aperture Size:	2.44 m (96.0 in) wide by 3.86 m (152.0 in) high
Transmission Area:	9.414 m² (101.33 ft²)
Sealed:	Entire periphery (both sides) with dense mastic

Test Environment

Source Room

Volume:	131.12 m³
Temperature:	23.3 °C ± 0.0 °C
Relative Humidity:	60.0 % ± 0.0 %

Receive Room

Volume:	81.44 m³
Temperature:	22.2 °C ± 0.0 °C
Relative Humidity:	62.0 % ± 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.

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

Figure 2 – Specimen mounted in test aperture, as viewed from receive room

Figure 3 – CLT (1 of 2) prior to installation

Figure 4 – CLT installed in test aperture

Figure 5 – 3/4” x 6” plywood spline partially installed over CLT rabbets

Figure 6 – Detail of 3/4” x 6” plywood spline partially installed over CLT rabbets

Figure 7 – 2” by 4” sleepers partially installed, with Piano B 40/40 strips fastened to underside of sleepers

Figure 8 – Piano B 40/40 strip fastened to sleeper prior to installation of sleeper

Figure 9 – Hemp boards prior to installation

Figure 10 – Hemp boards partially installed between sleepers

Figure 11 – Hemp boards partially installed between sleepers, plywood partially installed over sleepers

Figure 12 – Trowel used for installation of adhesive

Figure 13 – Plywood subfloor installed, adhesive partially installed over plywood

Figure 14 – Flooring partially installed over adhesive

University of Oregon
2024-06-28

RAL™-TL24-294

TEST RESULTS

Sound transmission loss values are tabulated at the eighteen standard frequency bands. 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). See Appendix A for identification of corrections applied to the reported data.

FREQ.	TL	ΔTL	DEF.	FREQ.	TL	ΔTL	DEF.
100	32	0.80	0	800	65	0.21	0
125	41	0.67	2	1000	68	0.11	0
160	42	0.58	4	1250	70	0.11	0
200	43	0.40	6	1600	73	0.10	0
250	46	0.25	6	2000	77	0.08	0
315	49	0.36	6	2500	83	0.08	0
400	52	0.19	6	3150	90	0.05	0
500	58	0.16	1	4000	95	0.09	0
630	62	0.21	0	5000	94	0.06	0

STC=59

ABBREVIATION INDEX

FREQ. = 1/3 OCTAVE BAND CENTER FREQUENCY, Hz
TL = TRANSMISSION LOSS, dB
ΔTL = 95% CONFIDENCE INTERVAL FOR TL MEASUREMENTS, dB
DEF. = DEFICIENCIES, dB BELOW SHIFTED STC CONTOUR (SUM OF DEF = 31)
STC = SOUND TRANSMISSION CLASS

Tested by _____
Marc Sciaky
Senior Experimentalist

Report by _____
Keith Kimberling
Test Engineer

Approved by _____
Eric P. Wolfram
Laboratory Manager

627 RIVERBANK DRIVE
GENEVA, IL 60134

630-232-0104

Test Report

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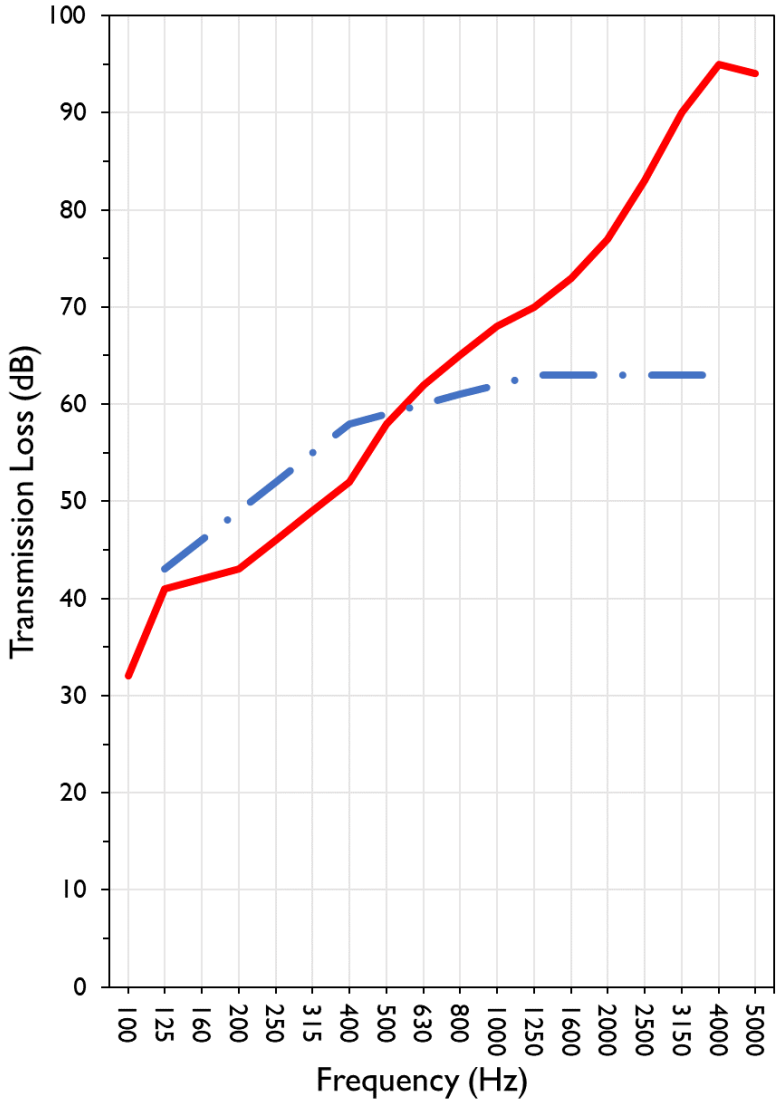
University of Oregon
2024-06-28

RAL™-TL24-294

SOUND TRANSMISSION REPORT

Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC



STC=59
OITC=45

TRANSMISSION LOSS
SOUND TRANSMISSION CLASS CONTOUR

NVLAP TESTING
NVLAP LAB CODE 100227-0

APPENDIX A: Extended Frequency Range Data

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (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. Corrections are detailed in Appendix B.

1/3 Octave Band Center Frequency (Hz)	**Sound Transmission Loss** (dB)	**Applicable Corrections**	**ΔTL (Eq. A2.5)** (dB)	**Repeatability** (dB)
31.5	36	*ZZ F*	1.30	16.75
40	35	*ZZ F*	1.40	5.77
50	34	*ZZ F*	0.76	3.98
63	28	*Z F*	0.34	0.75
80	29	*Z F*	0.59	1.46
100	32	*Z F*	0.80	3.83
125	41	*ZZ F*	0.67	0.97
160	42	*ZZ F*	0.58	1.35
200	43	*ZZ F*	0.40	1.21
250	46	*Z F*	0.25	0.56
315	49	*Z F*	0.36	0.61
400	52	*Z F*	0.19	0.76
500	58	*Z F*	0.16	0.58
630	62	*Z F*	0.21	1.03
800	65	*ZZ F*	0.21	0.34
1000	68	*Z F*	0.11	0.78
1250	70	*Z F*	0.11	1.09
1600	73	*Z F*	0.10	1.47
2000	77	*Z F*	0.08	1.14
2500	83	*ZZ F*	0.08	0.87
3150	90	*ZZ A F*	0.05	0.90
4000	95	*ZZ AA F*	0.09	1.95
5000	94	*ZZ AA F*	0.06	3.09
6300	87	*ZZ AA F*	0.07	5.31
8000	79	*ZZ A F*	0.07	7.87
10000	69	*Z F*	0.11	6.75
12500	55		0.11	6.94

APPENDIX B: Glossary of Standardized Corrections and Adjustments

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Mark	Interpretation
A	Measured sound pressure levels in the receive room are within 10 dB of the ambient noise level at the marked frequency band. Receive room levels used to calculate Transmission Loss are corrected according to ASTM E90 Section 10.3.
AA	Measured sound pressure levels in the receive room are within 5 dB of the ambient noise level at the marked frequency band. Receive room levels used to calculate Transmission Loss are corrected according to ASTM E90 Section 10.3.1. Transmission Loss values calculated from levels corrected this way will be less than or equal to Transmission Loss values from a hypothetical test using the same specimen and a receive room with idealized ambient sound levels of (-∞) dB.
F	The reported Transmission Loss is within 10 dB of the laboratory flanking limit at the marked frequency band. The measured performance of the specimen may be limited by the performance of the laboratory building structure at this frequency band.
Z	The reported Transmission Loss at the marked frequency band has been corrected according to ASTM E90 Section A3.2.7 to account for possible sound transmission through the filler assembly.
ZZ	The reported Transmission Loss at the marked frequency band has been corrected according to ASTM E90 Section A3.2.8 to account for possible sound transmission through the filler assembly. Transmission Loss values corrected this way will be less than or equal to Transmission Loss values from a hypothetical test using the same specimen and an idealized filler assembly with a Sound Transmission Class rating of (∞).

APPENDIX C: Glossary of Variability Metrics

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

ΔTL, the 95% confidence interval for reported transmission loss values, is calculated from the standard deviation of the sets of measurements for source room sound pressure level, receive room sound pressure level, and receive room sound absorption. This metric is calculated in an effort to quantify the combined influences of room geometry, microphone positioning, and other varying environmental conditions on reported results.

Repeatability, expressed as a 95% confidence interval, is calculated from the standard deviation of transmission loss as obtained from a set of six (6) consecutive tests conducted according to this test method by RAL from 2021-02-25 through 2021-03-04. The tests were performed on a specimen composed of a 6 in. thick concrete slab, using the same test opening as used in this report. 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 vary with the construction type.

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2024-06-28

APPENDIX D: Determination of Outdoor Indoor Transmission Class (OITC)

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

The determination of the Outdoor Indoor Transmission Class (OITC) as reported below was made with explicit conformity to the procedures described in the ASTM E1332-22 test standard. Test Method ASTM E90-09 (2016) was used to obtain the sound transmission loss data. This rating is based on an average transportation noise source spectrum and an A-weighted sound level reduction, either of which may be inappropriate for some applications.

One-third Octave Band Center Frequency, Hz	Reference Sound Spectrum, dB	Test Specimen Transmission Loss, dB
80	103	29
100	102	32
125	101	41
160	98	42
200	97	43
250	95	46
315	94	49
400	93	52
500	93	58
630	91	62
800	90	65
1000	89	68
1250	89	70
1600	88	73
2000	88	77
2500	87	83
3150	85	90
4000	84	95

OITC = 45

APPENDIX E: Instruments of Traceability

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Description	Model	Serial Number	Date of Certification	Calibration Due
System 2	Type 3160-A-042	3160-106974	2023-08-11	2024-08-11
Bruel & Kjaer Mic And Preamp C	Type 4943-B-001	2311439	2024-03-29	2025-03-29
Bruel & Kjaer Pistonphone	Type 4228	2781248	2023-07-12	2024-07-12
EXTECH Hygro 663	SD700	A083663	2023-12-28	2024-12-28
EXTECH Hygro 639	SD700	A.103639	2023-12-01	2024-12-01

APPENDIX F: Revisions to Original Test Report

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Date	Revision
2024-07-31	Original report issued

END

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Test Report

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

Sound Transmission Loss
RAL™-TL24-302

CONDUCTED: 2024-07-08

ON: 1” Maxxon gypcrete 2000 Multifamily, 1-1/8” T&G plywood subfloor screwed 24” OC with #9x3”, cavity filled with: HempWool Acoustibatt 3.5” hemp batt, 2x4 sleepers 24”OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875” with plywood spline 3/4”x6” at the joint secured with #9x3” screws at 6” OC

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 17025:2017 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 E413-22: "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 1” Maxxon gypcrete 2000 Multifamily, 1-1/8” T&G plywood subfloor screwed 24” OC with #9x3”, cavity filled with: HempWool Acoustibatt 3.5” hemp batt, 2x4 sleepers 24”OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875” with plywood spline 3/4”x6” at the joint secured with #9x3” screws at 6” OC. 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

Provided Description:	1” Maxxon gypcrete 2000 Multifamily, 1-1/8” T&G plywood subfloor screwed 24” OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5” hemp batt, 2x4 sleepers 24”OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875” with plywood spline 3/4”x6” at the joint secured with #9x3” screws at 6” OC
Manufacturer:	University of Oregon

SPECIMEN MEASUREMENTS & TEST CONDITIONS

The building contractor (Seth Priser) and RAL staff compiled a detailed construction specification as follows:

Cross-Laminated Timber (CLT)

Materials:	5-Ply Cross-Laminated Timber
Dimensions:	2 panels @ 1219 mm (48 in.) by 4229 mm (166.5 in.)
Thickness:	171 mm (6.75 in.)
Overall Weight:	953.45 kg (2102 lbs)
Mass Per Unit Volume:	539 kg/m^3 (33.7 lbs/ft^3)
Installation:	CLT panels laid on 152 mm (6 in.) wide knee walls in test opening and butted to one another without sealant/adhesive. 3/4"x3" Rabbet on top side of one edge of each panel where they butt allowing a loose spline (below) to insert and join the two

¾" CDX Loose Spline

Materials:	3/4" x 6" plywood spline
Dimensions:	1 piece @ 151 mm (5.9375 in.) wide by 2438 mm (96 in.) 1 piece @ 151 mm (5.9375 in.) wide by 1791 mm (70.5 in.)
Thickness:	19 mm (0.75 in.)
Overall Weight:	6.46 kg (14.25 lbs)
Mass Per Unit Length:	1.53 kg/m (1.03 lbs/ft)
Installation:	Set in Rabbets of both CLT's and screwed in place.
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing:	6" o.c. on a line 3" from each edge of the spline (Centered on the rabbet of the CLT)

Piano B 40/40 (Lower Layer)

Manufacturer:	Rothoblaas
Dimensions:	2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long 8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness:	6.76 mm (0.266 in.)
Overall Weight:	4.59 kg (10.125 lbs)
Mass Per Unit Volume:	624 kg/m^3 (40.0 lbs/ft^3)
Installation:	Fastened to underside of 2" x 4" wood sleepers with staples
Fasteners:	Arrow staples, length @ 13 mm (0.5 in.)

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

2" by 4" SPF Framing Sleepers

Materials:	Nominal 2"x 4" framing lumber
Dimensions:	2 pieces @ 38 mm (1.5 in.) wide by 4255 mm (167.5 in.) long 8 pieces @ 2369 mm (93.25 in.) wide by 38 mm (1.5 in.) long
Depth:	89 mm (3.5 in.)
Overall Weight:	49.33 kg (108.75 lbs)
Mass Per Unit Length:	1.80 kg/m (1.21 lbs/ft)
Installation:	Sleepers laid over CLT, resting on lower layer Piano B 40/40 Longer sleepers parallel to CLT like a rim joist Shorter sleepers set like floor joists between rim joists Shorter sleepers spaced approx. 610 mm (24 in.) on center Shorter sleepers fastened to longer sleepers with screws, 2 screws per connection point
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)

Piano B 40/40 (Upper Layer)

Manufacturer:	Rothoblaas
Dimensions:	2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long 8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness:	6.76 mm (0.266 in.)
Overall Weight:	4.59 kg (10.125 lbs)
Mass Per Unit Volume:	624 kg/m^3 (40.0 lbs/ft^3)
Installation:	Fastened to top of 2" x 4" wood sleepers with staples
Fasteners:	Arrow staples, length @ 13 mm (0.5 in.)

Hemp Board

Materials:	3" Hemp fiber board
Manufacturer:	Hempitecture
Dimensions:	7 pieces @ 572 mm (22.5 in.) wide by 2369 mm (93.25 in.) long
Depth:	76 mm (3 in.)
Overall Weight:	37.53 kg (82.75 lbs)
Mass Per Unit Volume:	52.0 kg/m^3 (3.25 lbs/ft^3)
Installation:	Friction fit between sleepers and on top of CLT

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Plywood Subfloor

Materials:	T&G Plywood
Dimensions:	1 piece @ 1219 mm (48 in.) wide by 1829 mm (72 in.)
	1 piece @ 1219 mm (48 in.) wide by 2438 mm (96 in.)
	1 piece @ 1219 mm (48 in.) wide by 1822 mm (71.75 in.)
	1 piece @ 1219 mm (48 in.) wide by 2432 mm (95.75 in.)
Thickness:	29 mm (1.125 in.)
Overall Weight:	173.5 kg (382.5 lbs)
Mass Per Unit Volume:	584 kg/m^3 (36.5 lbs/ft^3)
Installation:	Placed over upper layer Piano B 40/40 over sleepers
	Fastened to sleepers through Piano B 40/40 with screws
	Plywood piece joints staggered
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing:	610 mm (24 in.) on center

Gypcrete

Materials:	Gypcrete mix
Manufacturer:	Maxxon
Dimensions:	2438 mm (96 in.) by 4267 mm (168 in.) as installed
Thickness:	Approx 25 mm (1 in.)
Mix Ratio:	2.5 gallons water / 40 lbs gypcrete / 75 lbs all-purpose sand
Overall Dry Weight:	469.47 kg (1035 lbs)
Mass Per Unit Volume:	1780 kg/m^3 (111 lbs/ft^3)
Installation:	Poured over plywood subfloor
	Gauge rake was used to level product to 1” of thickness
	Wet gypcrete mix was poured on (2024-07-01, approx. 3:40 PM)

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SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Overall Specimen Measurements

Dimensions:	2.44 m (96.0 in) wide by 3.86 m (152.0 in) high
Thickness:	0.33 m (12.875 in)
Weight:	1698.93 kg (3745.5 lbs)
Overall Area:	9.414 m² (101.33 ft²)
Mass per Unit Area:	163.28 kg/m² (33.44 lbs/ft²)

Test Aperture

Opening Size:	4.27 m (14.0 ft) x 6.10 m (20.0 ft)
Filler Wall:	Yes
Aperture Size:	2.44 m (96.0 in) wide by 3.86 m (152.0 in) high
Transmission Area:	9.414 m² (101.33 ft²)
Sealed:	Entire periphery (both sides) with dense mastic

Test Environment

Source Room

Volume:	130.9 m³
Temperature:	22.8 °C ± 0.0 °C
Relative Humidity:	62.0 % ± 0.0 %

Receive Room

Volume:	81.44 m³
Temperature:	21.4 °C ± 0.6 °C
Relative Humidity:	65.0 % ± 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.

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

Figure 2 – Specimen mounted in test aperture, as viewed from receive room

Figure 3 – CLT (1 of 2) prior to installation

Figure 4 – CLT installed in test aperture

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Figure 5 – 3/4” x 6” plywood spline partially installed over CLT rabbets

Figure 6 – Detail of 3/4” x 6” plywood spline partially installed over CLT rabbets

Figure 7 – 2” by 4” sleepers partially installed, with Piano B 40/40 strips fastened to underside of sleepers

Figure 8 – Piano B 40/40 strip fastened to sleeper prior to installation of sleeper

Figure 9 – Hemp boards prior to installation

Figure 10 – Hemp boards partially installed between sleepers

Figure 11 – Hemp boards installed between sleepers, plywood partially installed over sleepers

Figure 12 – Plywood subfloor installed

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Figure 13 – Gypcrete installation

TEST RESULTS

Sound transmission loss values are tabulated at the eighteen standard frequency bands. 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). See Appendix A for identification of corrections applied to the reported data.

FREQ.	TL	ΔTL	DEF.	FREQ.	TL	ΔTL	DEF.
100	34	0.78	0	800	61	0.18	0
125	38	0.67	4	1000	65	0.14	0
160	41	0.52	4	1250	71	0.14	0
200	41	0.45	7	1600	77	0.12	0
250	47	0.40	4	2000	81	0.13	0
315	51	0.23	3	2500	85	0.13	0
400	54	0.32	3	3150	92	0.13	0
500	55	0.15	3	4000	93	0.10	0
630	59	0.24	0	5000	93	0.10	0

STC=58

ABBREVIATION INDEX

FREQ. = 1/3 OCTAVE BAND CENTER FREQUENCY, Hz
TL = TRANSMISSION LOSS, dB
ΔTL = 95% CONFIDENCE INTERVAL FOR TL MEASUREMENTS, dB
DEF. = DEFICIENCIES, dB BELOW SHIFTED STC CONTOUR (SUM OF DEF = 28)
STC = SOUND TRANSMISSION CLASS

Tested by _____
Marc Sciaky
Senior Experimentalist

Report by _____
Keith Kimberling
Test Engineer

Approved by _____
Eric P. Wolfram
Laboratory Manager

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Test Report

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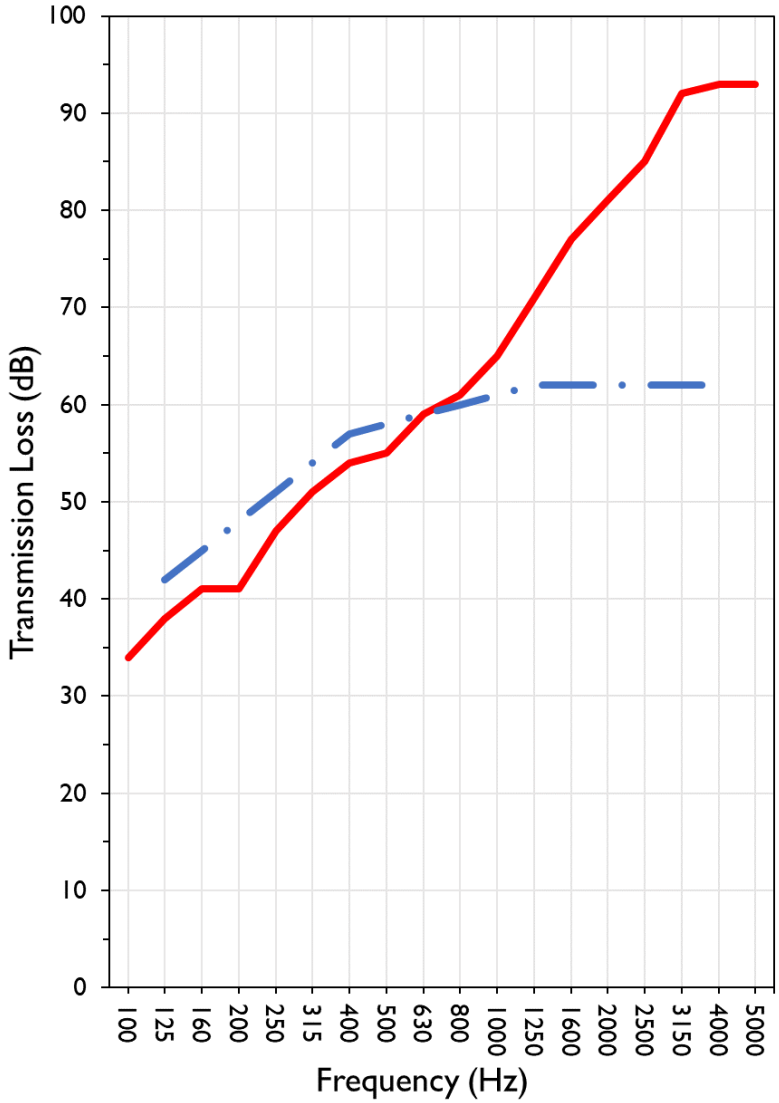
RAL™-TL24-302

SOUND TRANSMISSION REPORT

1" Maxxon gypcrete 2000 Multifamily, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC



STC=58
OITC=46

TRANSMISSION LOSS
SOUND TRANSMISSION CLASS CONTOUR

NVLAP TESTING
NVLAP LAB CODE 100227-0

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2024-07-08

APPENDIX A: Extended Frequency Range Data

Specimen: 1" Maxxon gypcrete 2000 Multifamily, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (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. Corrections are detailed in Appendix B.

1/3 Octave Band Center Frequency (Hz)	**Sound Transmission Loss** (dB)	**Applicable Corrections**	**ΔTL (Eq. A2.5)** (dB)	**Repeatability** (dB)
31.5	49	*ZZ F*	2.17	16.75
40	32	*Z F*	1.32	5.77
50	36	*ZZ F*	0.93	3.98
63	34	*ZZ F*	1.27	0.75
80	33	*ZZ F*	0.77	1.46
100	34	*ZZ F*	0.78	3.83
125	38	*Z F*	0.67	0.97
160	41	*Z F*	0.52	1.35
200	41	*Z F*	0.45	1.21
250	47	*ZZ F*	0.40	0.56
315	51	*Z F*	0.23	0.61
400	54	*Z F*	0.32	0.76
500	55	*Z F*	0.15	0.58
630	59	*Z F*	0.24	1.03
800	61	*Z F*	0.18	0.34
1000	65	*Z F*	0.14	0.78
1250	71	*Z F*	0.14	1.09
1600	77	*ZZ F*	0.12	1.47
2000	81	*ZZ F*	0.13	1.14
2500	85	*ZZ F*	0.13	0.87
3150	92	*ZZ A F*	0.13	0.90
4000	93	*ZZ A F*	0.10	1.95
5000	93	*ZZ AA F*	0.10	3.09
6300	87	*ZZ AA F*	0.24	5.31
8000	80	*ZZ A F*	0.15	7.87
10000	69	*Z A F*	0.19	6.75
12500	55		0.22	6.94

APPENDIX B: Glossary of Standardized Corrections and Adjustments

Specimen: 1" Maxxon gypcrete 2000 Multifamily, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Mark	Interpretation
A	Measured sound pressure levels in the receive room are within 10 dB of the ambient noise level at the marked frequency band. Receive room levels used to calculate Transmission Loss are corrected according to ASTM E90 Section 10.3.
AA	Measured sound pressure levels in the receive room are within 5 dB of the ambient noise level at the marked frequency band. Receive room levels used to calculate Transmission Loss are corrected according to ASTM E90 Section 10.3.1. Transmission Loss values calculated from levels corrected this way will be less than or equal to Transmission Loss values from a hypothetical test using the same specimen and a receive room with idealized ambient sound levels of (-∞) dB.
F	The reported Transmission Loss is within 10 dB of the laboratory flanking limit at the marked frequency band. The measured performance of the specimen may be limited by the performance of the laboratory building structure at this frequency band.
Z	The reported Transmission Loss at the marked frequency band has been corrected according to ASTM E90 Section A3.2.7 to account for possible sound transmission through the filler assembly.
ZZ	The reported Transmission Loss at the marked frequency band has been corrected according to ASTM E90 Section A3.2.8 to account for possible sound transmission through the filler assembly. Transmission Loss values corrected this way will be less than or equal to Transmission Loss values from a hypothetical test using the same specimen and an idealized filler assembly with a Sound Transmission Class rating of (∞).

APPENDIX C: Glossary of Variability Metrics

Specimen: 1" Maxxon gypcrete 2000 Multifamily, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

ΔTL, the 95% confidence interval for reported transmission loss values, is calculated from the standard deviation of the sets of measurements for source room sound pressure level, receive room sound pressure level, and receive room sound absorption. This metric is calculated in an effort to quantify the combined influences of room geometry, microphone positioning, and other varying environmental conditions on reported results.

Repeatability, expressed as a 95% confidence interval, is calculated from the standard deviation of transmission loss as obtained from a set of six (6) consecutive tests conducted according to this test method by RAL from 2021-02-25 through 2021-03-04. The tests were performed on a specimen composed of a 6 in. thick concrete slab, using the same test opening as used in this report. 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 vary with the construction type.

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APPENDIX D: Determination of Outdoor Indoor Transmission Class (OITC)

Specimen: 1" Maxxon gypcrete 2000 Multifamily, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

The determination of the Outdoor Indoor Transmission Class (OITC) as reported below was made with explicit conformity to the procedures described in the ASTM E1332-22 test standard. Test Method ASTM E90-09 (2016) was used to obtain the sound transmission loss data. This rating is based on an average transportation noise source spectrum and an A-weighted sound level reduction, either of which may be inappropriate for some applications.

One-third Octave Band Center Frequency, Hz	Reference Sound Spectrum, dB	Test Specimen Transmission Loss, dB
80	103	33
100	102	34
125	101	38
160	98	41
200	97	41
250	95	47
315	94	51
400	93	54
500	93	55
630	91	59
800	90	61
1000	89	65
1250	89	71
1600	88	77
2000	88	81
2500	87	85
3150	85	92
4000	84	93

OITC = 46

APPENDIX E: Instruments of Traceability

Specimen: 1" Maxxon gypcrete 2000 Multifamily, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Description	Model	Serial Number	Date of Certification	Calibration Due
System 2	Type 3160-A-042	3160-106974	2023-08-11	2024-08-11
Bruel & Kjaer Mic And Preamp C	Type 4943-B-001	2311439	2024-03-29	2025-03-29
Bruel & Kjaer Pistonphone	Type 4228	2781248	2023-07-12	2024-07-12
EXTECH Hygro 663	SD700	A083663	2023-12-28	2024-12-28
EXTECH Hygro 639	SD700	A.103639	2023-12-01	2024-12-01

APPENDIX F: Revisions to Original Test Report

Specimen: 1" Maxxon gypcrete 2000 Multifamily, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Date	Revision
2024-07-31	Original report issued

END

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Test Report

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

Sound Transmission Loss
RAL™-TL24-303

CONDUCTED: 2024-07-09

ON: Marmoleum Decibel adhered with Sustain 1195, 1" Maxxon gypcrete 2000 Multifamily, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC

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 17025:2017 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 E413-22: "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 Marmoleum Decibel adhered with Sustain 1195, 1" Maxxon gypcrete 2000 Multifamily, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC. 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

Provided Description:	Marmoleum Decibel adhered with Sustain 1195, 1" Maxxon gypcrete 2000 Multifamily, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC
Manufacturer:	University of Oregon

SPECIMEN MEASUREMENTS & TEST CONDITIONS

The building contractor (Seth Priser) and RAL staff compiled a detailed construction specification as follows:

Cross-Laminated Timber (CLT)

Materials:	5-Ply Cross-Laminated Timber
Dimensions:	2 panels @ 1219 mm (48 in.) by 4229 mm (166.5 in.)
Thickness:	171 mm (6.75 in.)
Overall Weight:	953.45 kg (2102 lbs)
Mass Per Unit Volume:	539 kg/m^3 (33.7 lbs/ft^3)
Installation:	CLT panels laid on 152 mm (6 in.) wide knee walls in test opening and butted to one another without sealant/adhesive. 3/4"x3" Rabbet on top side of one edge of each panel where they butt allowing a loose spline (below) to insert and join the two

¾" CDX Loose Spline

Materials:	3/4" x 6" plywood spline
Dimensions:	1 piece @ 151 mm (5.9375 in.) wide by 2438 mm (96 in.) 1 piece @ 151 mm (5.9375 in.) wide by 1791 mm (70.5 in.)
Thickness:	19 mm (0.75 in.)
Overall Weight:	6.46 kg (14.25 lbs)
Mass Per Unit Length:	1.53 kg/m (1.03 lbs/ft)
Installation:	Set in Rabbets of both CLT's and screwed in place.
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing:	6" o.c. on a line 3" from each edge of the spline (Centered on the rabbet of the CLT)

Piano B 40/40 (Lower Layer)

Manufacturer:	Rothoblaas
Dimensions:	2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long 8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness:	6.76 mm (0.266 in.)
Overall Weight:	4.59 kg (10.125 lbs)
Mass Per Unit Volume:	624 kg/m^3 (40.0 lbs/ft^3)
Installation:	Fastened to underside of 2" x 4" wood sleepers with staples
Fasteners:	Arrow staples, length @ 13 mm (0.5 in.)

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

2" by 4" SPF Framing Sleepers

Materials:	Nominal 2"x 4" framing lumber
Dimensions:	2 pieces @ 38 mm (1.5 in.) wide by 4255 mm (167.5 in.) long 8 pieces @ 2369 mm (93.25 in.) wide by 38 mm (1.5 in.) long
Depth:	89 mm (3.5 in.)
Overall Weight:	49.33 kg (108.75 lbs)
Mass Per Unit Length:	1.80 kg/m (1.21 lbs/ft)
Installation:	Sleepers laid over CLT, resting on lower layer Piano B 40/40 Longer sleepers parallel to CLT like a rim joist Shorter sleepers set like floor joists between rim joists Shorter sleepers spaced approx. 610 mm (24 in.) on center Shorter sleepers fastened to longer sleepers with screws, 2 screws per connection point
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)

Piano B 40/40 (Upper Layer)

Manufacturer:	Rothoblaas
Dimensions:	2 strips @ 40 mm (1.5625 in.) wide by 4267 mm (168 in.) long 8 strips @ 2362 mm (93 in.) wide by 40 mm (1.5625 in.) long
Thickness:	6.76 mm (0.266 in.)
Overall Weight:	4.59 kg (10.125 lbs)
Mass Per Unit Volume:	624 kg/m^3 (40.0 lbs/ft^3)
Installation:	Fastened to top of 2" x 4" wood sleepers with staples
Fasteners:	Arrow staples, length @ 13 mm (0.5 in.)

Hemp Board

Materials:	3" Hemp fiber board
Manufacturer:	Hempitecture
Dimensions:	7 pieces @ 572 mm (22.5 in.) wide by 2369 mm (93.25 in.) long
Depth:	76 mm (3 in.)
Overall Weight:	37.53 kg (82.75 lbs)
Mass Per Unit Volume:	52.0 kg/m^3 (3.25 lbs/ft^3)
Installation:	Friction fit between sleepers and on top of CLT

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Plywood Subfloor

Materials:	T&G Plywood
Dimensions:	1 piece @ 1219 mm (48 in.) wide by 1829 mm (72 in.)
	1 piece @ 1219 mm (48 in.) wide by 2438 mm (96 in.)
	1 piece @ 1219 mm (48 in.) wide by 1822 mm (71.75 in.)
	1 piece @ 1219 mm (48 in.) wide by 2432 mm (95.75 in.)
Thickness:	29 mm (1.125 in.)
Overall Weight:	173.5 kg (382.5 lbs)
Mass Per Unit Volume:	584 kg/m^3 (36.5 lbs/ft^3)
Installation:	Placed over upper layer Piano B 40/40 over sleepers
	Fastened to sleepers through Piano B 40/40 with screws
	Plywood piece joints staggered
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing:	610 mm (24 in.) on center

Gypcrete

Materials:	Gypcrete mix
Manufacturer:	Maxxon
Dimensions:	2438 mm (96 in.) by 4267 mm (168 in.) as installed
Thickness:	Approx 25 mm (1 in.)
Mix Ratio:	2.5 gallons water / 40 lbs gypcrete / 75 lbs all-purpose sand
Overall Dry Weight:	469.47 kg (1035 lbs)
Mass Per Unit Volume:	1780 kg/m^3 (111 lbs/ft^3)
Installation:	Poured over plywood subfloor
	Gauge rake was used to level product to 1” of thickness
	Wet gypcrete mix was poured on (2024-07-01, approx. 3:40 PM)

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Adhesive

Materials:	Sustain 1195 Sheet and Tile adhesive
Manufacturer:	Forbo
Dimensions:	Approx. 2438 mm (96 in.) by 4267 mm (168 in.) as installed
Overall Weight:	2.95 kg (6.5 lbs)
Mass Per Unit Area:	0.28 kg/m^2 (0.06 lbs/ft^2)
Installation:	Troweled directly to gypcrete with a 1/16x1/16x1/16 square notch trowel Once troweled, adhesive was left “open” for 15 min to allow it to “tack” before flooring was installed.

Flooring

Materials:	Marmoleum Decibel
Manufacturer:	Forbo
Dimensions:	2 pieces @ 2007 mm (79 in.) by 2464 mm (97 in.) 1 piece @ 260 mm (10.25 in.) by 2464 mm (97 in.)
Thickness:	6 mm (0.25 in.)
Overall Weight:	35.38 kg (78 lbs)
Mass Per Unit Volume:	529 kg/m^3 (33.0 lbs/ft^3)
Installation:	Two (2) 79” segments perpendicular to Plywood 10” strip to complete Joints staggered from parallel plywood joints by + 6” Rolled with 100lb roller in each direction

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SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Overall Specimen Measurements

Dimensions:	2.44 m (96.0 in) wide by 3.86 m (152.0 in) high
Thickness:	0.33 m (13.125 in)
Weight:	1734.31 kg (3823.5 lbs)
Overall Area:	9.414 m² (101.33 ft²)
Mass per Unit Area:	166.68 kg/m² (34.14 lbs/ft²)

Test Aperture

Opening Size:	4.27 m (14.0 ft) x 6.10 m (20.0 ft)
Filler Wall:	Yes
Aperture Size:	2.44 m (96.0 in) wide by 3.86 m (152.0 in) high
Transmission Area:	9.414 m² (101.33 ft²)
Sealed:	Entire periphery (both sides) with dense mastic

Test Environment

Source Room

Volume:	130.9 m³
Temperature:	22.2 °C ± 0.0 °C
Relative Humidity:	62.0 % ± 2.0 %

Receive Room

Volume:	81.44 m³
Temperature:	21.7 °C ± 0.0 °C
Relative Humidity:	63.0 % ± 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.

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

Figure 2 – Specimen mounted in test aperture, as viewed from receive room

Figure 3 – CLT (1 of 2) prior to installation

Figure 4 – CLT installed in test aperture

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Figure 5 – 3/4” x 6” plywood spline partially installed over CLT rabbets

Figure 6 – Detail of 3/4” x 6” plywood spline partially installed over CLT rabbets

Figure 7 – 2” by 4” sleepers partially installed, with Piano B 40/40 strips fastened to underside of sleepers

Figure 8 – Piano B 40/40 strip fastened to sleeper prior to installation of sleeper

Figure 9 – Hemp boards prior to installation

Figure 10 – Hemp boards partially installed between sleepers

Figure 11 – Hemp boards installed between sleepers, plywood partially installed over sleepers

Figure 12 – Plywood subfloor installed

Figure 13 – Gypcrete installation

Figure 14 – Trowel used for installation of adhesive

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Figure 15 – Adhesive installed over gypcrete, flooring partially installed over adhesive

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TEST RESULTS

Sound transmission loss values are tabulated at the eighteen standard frequency bands. 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). See Appendix A for identification of corrections applied to the reported data.

FREQ.	TL	ΔTL	DEF.	FREQ.	TL	ΔTL	DEF.
100	34	0.50	0	800	60	0.14	0
125	41	0.61	1	1000	64	0.17	0
160	41	0.51	4	1250	69	0.15	0
200	42	0.39	6	1600	75	0.14	0
250	47	0.38	4	2000	78	0.08	0
315	51	0.28	3	2500	84	0.06	0
400	54	0.34	3	3150	92	0.16	0
500	55	0.20	3	4000	95	0.21	0
630	58	0.26	1	5000	93	0.23	0

STC=58

ABBREVIATION INDEX

FREQ. = 1/3 OCTAVE BAND CENTER FREQUENCY, Hz
TL = TRANSMISSION LOSS, dB
ΔTL = 95% CONFIDENCE INTERVAL FOR TL MEASUREMENTS, dB
DEF. = DEFICIENCIES, dB BELOW SHIFTED STC CONTOUR (SUM OF DEF = 25)
STC = SOUND TRANSMISSION CLASS

Tested by _____
Marc Sciaky
Senior Experimentalist

Report by _____
Keith Kimberling
Test Engineer

Approved by _____
Eric P. Wolfram
Laboratory Manager

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Test Report

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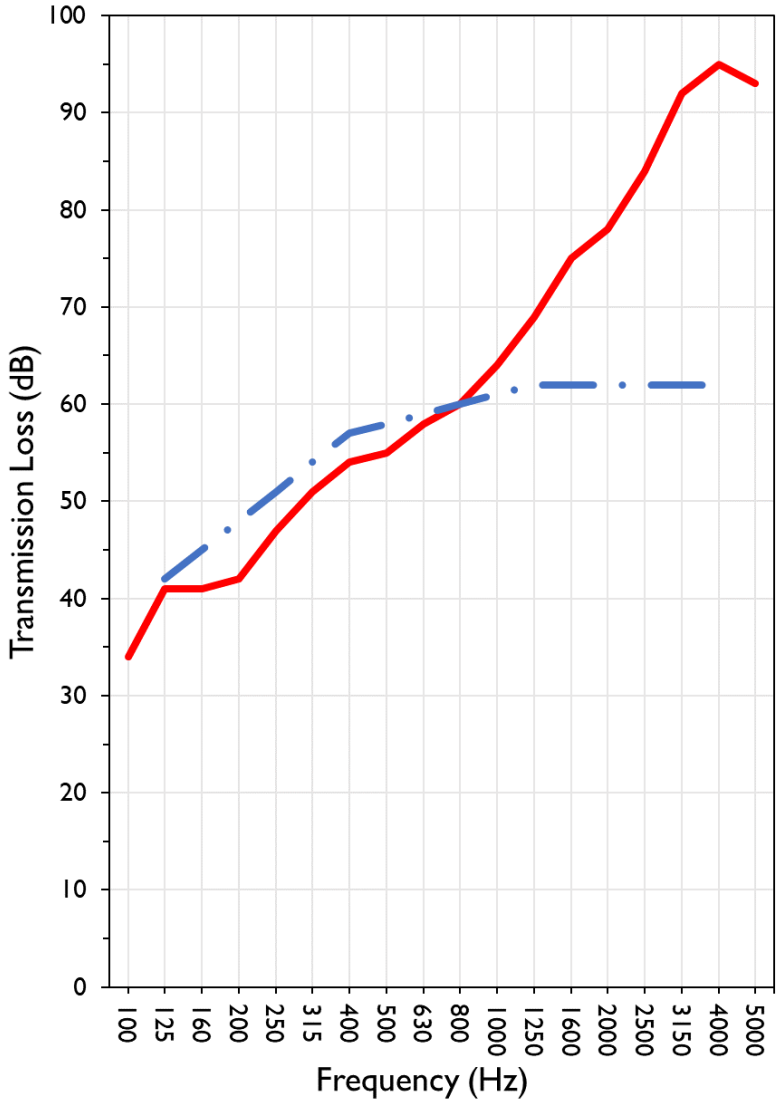
RAL™-TL24-303

SOUND TRANSMISSION REPORT

Marmoleum Decibel adhered with Sustain 1195, 1" Maxxon gypcrete 2000 Multifamily, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC



STC=58
OITC=46

TRANSMISSION LOSS
SOUND TRANSMISSION CLASS CONTOUR

NVLAP TESTING
NVLAP LAB CODE 100227-0

APPENDIX A: Extended Frequency Range Data

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1" Maxxon gypcrete 2000 Multifamily, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (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. Corrections are detailed in Appendix B.

1/3 Octave Band Center Frequency (Hz)	**Sound Transmission Loss** (dB)	**Applicable Corrections**	**ΔTL (Eq. A2.5)** (dB)	**Repeatability** (dB)
31.5	48	*ZZ F*	1.77	16.75
40	32	*Z F*	1.34	5.77
50	35	*ZZ F*	1.08	3.98
63	33	*ZZ F*	0.90	0.75
80	32	*ZZ F*	0.72	1.46
100	34	*ZZ F*	0.50	3.83
125	41	*ZZ F*	0.61	0.97
160	41	*Z F*	0.51	1.35
200	42	*Z F*	0.39	1.21
250	47	*ZZ F*	0.38	0.56
315	51	*Z F*	0.28	0.61
400	54	*Z F*	0.34	0.76
500	55	*Z F*	0.20	0.58
630	58	*Z F*	0.26	1.03
800	60	*Z F*	0.14	0.34
1000	64	*Z F*	0.17	0.78
1250	69	*Z F*	0.15	1.09
1600	75	*Z F*	0.14	1.47
2000	78	*ZZ F*	0.08	1.14
2500	84	*ZZ F*	0.06	0.87
3150	92	*ZZ A F*	0.16	0.90
4000	95	*ZZ AA F*	0.21	1.95
5000	93	*ZZ AA F*	0.23	3.09
6300	85	*ZZ A F*	0.26	5.31
8000	78	*Z A F*	0.17	7.87
10000	67	*Z F*	0.12	6.75
12500	54		0.17	6.94

APPENDIX B: Glossary of Standardized Corrections and Adjustments

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1" Maxxon gypcrete 2000 Multifamily, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Mark	Interpretation
A	Measured sound pressure levels in the receive room are within 10 dB of the ambient noise level at the marked frequency band. Receive room levels used to calculate Transmission Loss are corrected according to ASTM E90 Section 10.3.
AA	Measured sound pressure levels in the receive room are within 5 dB of the ambient noise level at the marked frequency band. Receive room levels used to calculate Transmission Loss are corrected according to ASTM E90 Section 10.3.1. Transmission Loss values calculated from levels corrected this way will be less than or equal to Transmission Loss values from a hypothetical test using the same specimen and a receive room with idealized ambient sound levels of (-∞) dB.
F	The reported Transmission Loss is within 10 dB of the laboratory flanking limit at the marked frequency band. The measured performance of the specimen may be limited by the performance of the laboratory building structure at this frequency band.
Z	The reported Transmission Loss at the marked frequency band has been corrected according to ASTM E90 Section A3.2.7 to account for possible sound transmission through the filler assembly.
ZZ	The reported Transmission Loss at the marked frequency band has been corrected according to ASTM E90 Section A3.2.8 to account for possible sound transmission through the filler assembly. Transmission Loss values corrected this way will be less than or equal to Transmission Loss values from a hypothetical test using the same specimen and an idealized filler assembly with a Sound Transmission Class rating of (∞).

APPENDIX C: Glossary of Variability Metrics

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1" Maxxon gypcrete 2000 Multifamily, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

ΔTL, the 95% confidence interval for reported transmission loss values, is calculated from the standard deviation of the sets of measurements for source room sound pressure level, receive room sound pressure level, and receive room sound absorption. This metric is calculated in an effort to quantify the combined influences of room geometry, microphone positioning, and other varying environmental conditions on reported results.

Repeatability, expressed as a 95% confidence interval, is calculated from the standard deviation of transmission loss as obtained from a set of six (6) consecutive tests conducted according to this test method by RAL from 2021-02-25 through 2021-03-04. The tests were performed on a specimen composed of a 6 in. thick concrete slab, using the same test opening as used in this report. 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 vary with the construction type.

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APPENDIX D: Determination of Outdoor Indoor Transmission Class (OITC)

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1" Maxxon gypcrete 2000 Multifamily, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

The determination of the Outdoor Indoor Transmission Class (OITC) as reported below was made with explicit conformity to the procedures described in the ASTM E1332-22 test standard. Test Method ASTM E90-09 (2016) was used to obtain the sound transmission loss data. This rating is based on an average transportation noise source spectrum and an A-weighted sound level reduction, either of which may be inappropriate for some applications.

One-third Octave Band Center Frequency, Hz	Reference Sound Spectrum, dB	Test Specimen Transmission Loss, dB
80	103	32
100	102	34
125	101	41
160	98	41
200	97	42
250	95	47
315	94	51
400	93	54
500	93	55
630	91	58
800	90	60
1000	89	64
1250	89	69
1600	88	75
2000	88	78
2500	87	84
3150	85	92
4000	84	95

OITC = 46

APPENDIX E: Instruments of Traceability

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1" Maxxon gypcrete 2000 Multifamily, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Description	Model	Serial Number	Date of Certification	Calibration Due
System 2	Type 3160-A-042	3160-106974	2023-08-11	2024-08-11
Bruel & Kjaer Mic And Preamp C	Type 4943-B-001	2311439	2024-03-29	2025-03-29
Bruel & Kjaer Pistonphone	Type 4228	2781248	2023-07-12	2024-07-12
EXTECH Hygro 663	SD700	A083663	2023-12-28	2024-12-28
EXTECH Hygro 639	SD700	A.103639	2023-12-01	2024-12-01

APPENDIX F: Revisions to Original Test Report

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1" Maxxon gypcrete 2000 Multifamily, 1-1/8" T&G plywood subfloor screwed 24" OC with #9x3", cavity filled with: HempWool Acoustibatt 3.5" hemp batt, 2x4 sleepers 24"OC with Rothoblaas Piano B acoustic strips stapled top/bottom, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Date	Revision
2024-07-31	Original report issued

END

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Test Report

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

Sound Transmission Loss
RAL™-TL24-326

CONDUCTED: 2024-07-22

ON: 1” Maxxon gypcrete 2000 Multifamily, Certainteed MemBrain vapor retarder, 3” of 3/8” limestone chip, Hempitecture 2” hemp fiber board, Vaagen Timbers 5-ply CLT 6.875” with plywood spline 3/4”x6” at the joint secured with #9x3” screws at 6” OC

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 17025:2017 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 E413-22: "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 1” Maxxon gypcrete 2000 Multifamily, Certainteed MemBrain vapor retarder, 3” of 3/8” limestone chip, Hempitecture 2” hemp fiber board, Vaagen Timbers 5-ply CLT 6.875” with plywood spline 3/4”x6” at the joint secured with #9x3” screws at 6” OC. 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

Provided Description:	1” Maxxon gypcrete 2000 Multifamily, Certainteed MemBrain vapor retarder, 3” of 3/8" limestone chip, Hempitecture 2” hemp fiber board, Vaagen Timbers 5-ply CLT 6.875” with plywood spline 3/4”x6” at the joint secured with #9x3” screws at 6” OC
Manufacturer:	University of Oregon

SPECIMEN MEASUREMENTS & TEST CONDITIONS

The building contractor (Seth Priser) and RAL staff compiled a detailed construction specification as follows:

Cross-Laminated Timber (CLT)

Materials:	5-Ply Cross-Laminated Timber
Dimensions:	2 panels @ 1219 mm (48 in.) by 4229 mm (166.5 in.)
Thickness:	171 mm (6.75 in.)
Overall Weight:	953.45 kg (2102 lbs)
Mass Per Unit Volume:	539 kg/m^3 (33.7 lbs/ft^3)
Installation:	CLT panels laid on 152 mm (6 in.) wide knee walls in test opening and butted to one another without sealant/adhesive. 3/4"x3" Rabbet on top side of one edge of each panel where they butt allowing a loose spline (below) to insert and join the two

¾" CDX Loose Spline

Materials:	3/4" x 6" plywood spline
Dimensions:	1 piece @ 151 mm (5.9375 in.) wide by 2438 mm (96 in.) 1 piece @ 151 mm (5.9375 in.) wide by 1791 mm (70.5 in.)
Thickness:	19 mm (0.75 in.)
Overall Weight:	6.46 kg (14.25 lbs)
Mass Per Unit Length:	1.53 kg/m (1.03 lbs/ft)
Installation:	Set in Rabbets of both CLT's and screwed in place.
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing:	6" o.c. on a line 3" from each edge of the spline (Centered on the rabbet of the CLT)

Hemp Board

Materials:	2" Hemp fiber board
Manufacturer:	Hempitecture
Dimensions:	3 pieces @ 1216 mm (47.875 in.) wide by 2448 mm (96.375 in.) long 1 piece @ 613 mm (24.125 in.) wide by 2448 mm (96.375 in.) long
Depth:	51 mm (2 in.)
Overall Weight:	69.51 kg (153.25 lbs)
Mass Per Unit Volume:	131 kg/m^3 (8.19 lbs/ft^3)
Installation:	Loose laid directly on top of CLT Perpendicular to CLT

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Crushed Limestone

Materials:	CA-16 3/8" chip crushed limestone
Dimensions:	2438 mm (96 in.) wide by 4267 mm (168 in.) long, as installed
Depth:	76 mm (3 in.)
Overall Weight:	1224.02 kg (2698.5 lbs)
Installation:	Loose laid on top of the Hemp fiberboard
	½" polystyrene used as an isolation around the perimeter

Vapor Barrier

Materials:	Membrain Vapor barrier
Manufacturer:	Saint Gobain
Dimensions:	Approx. 2438 mm (96 in.) by 4267 mm (168 in.) as installed
Overall Weight:	0.79 kg (1.75 lbs)
Mass Per Unit Area:	0.08 kg/m^2 (0.02 lbs/ft^2)
Installation:	Loose laid over crushed limestone

Gypcrete

Materials:	Gypcrete mix
Manufacturer:	Maxxon
Dimensions:	2438 mm (96 in.) by 4267 mm (168 in.) as installed
Thickness:	25 mm (1 in.)
Mix Ratio:	2.5 gallons water / 40 lbs gypcrete / 75 lbs all-purpose sand
Overall Dry Weight:	521.63 kg (1150 lbs)
Mass Per Unit Volume:	1970 kg/m^3 (123 lbs/ft^3)
Installation:	Poured over vapor barrier
	A screed was used to spread the wet gypcrete mix
	Wet gypcrete mix was poured on (2024-07-10, approx. 4:30 PM)

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Overall Specimen Measurements

Dimensions:	2.44 m (96.0 in) wide by 3.86 m (152.0 in) high
Thickness:	0.32 m (12.75 in)
Weight:	2775.87 kg (6119.75 lbs)
Overall Area:	9.414 m² (101.33 ft²)
Mass per Unit Area:	266.78 kg/m² (54.64 lbs/ft²)

Test Aperture

Opening Size:	4.27 m (14.0 ft) x 6.10 m (20.0 ft)
Filler Wall:	Yes
Aperture Size:	2.44 m (96.0 in) wide by 3.86 m (152.0 in) high
Transmission Area:	9.414 m² (101.33 ft²)
Sealed:	Entire periphery (both sides) with dense mastic

Test Environment

Source Room

Volume:	130.9 m³
Temperature:	23.3 °C ± 0.0 °C
Relative Humidity:	68.0 % ± 0.0 %

Receive Room

Volume:	81.44 m³
Temperature:	22.2 °C ± 0.0 °C
Relative Humidity:	68.0 % ± 2.0 %

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.

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

Figure 2 – Specimen mounted in test aperture, as viewed from receive room

Figure 3 – CLT (1 of 2) prior to installation

Figure 4 – CLT installed in test aperture

Figure 5 – 3/4” x 6” plywood spline partially installed over CLT rabbets

Figure 6 – Detail of 3/4” x 6” plywood spline partially installed over CLT rabbets

Figure 7 – Hemp board partially installed over CLT

Figure 8 – Polystyrene used as an isolation around the perimeter prior to installation of gravel

Figure 9 – Gravel partially installed over hemp board

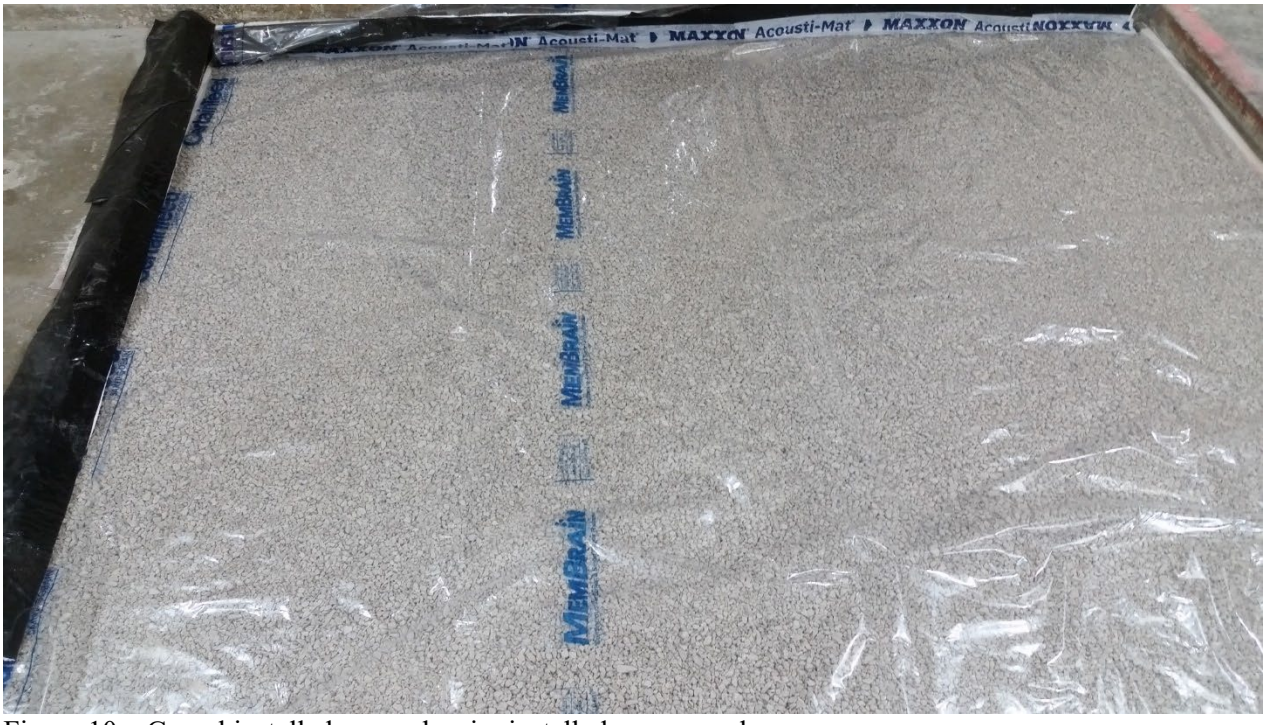

Figure 10 – Gravel installed; vapor barrier installed over gravel

Figure 11 – Gypcrete mixing prior to pouring

Figure 12 – Gypcrete partially installed over vapor barrier

University of Oregon
2024-07-22

RAL™-TL24-326

TEST RESULTS

Sound transmission loss values are tabulated at the eighteen standard frequency bands. 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). See Appendix A for identification of corrections applied to the reported data.

FREQ.	TL	ΔTL	DEF.	FREQ.	TL	ΔTL	DEF.
100	32	1.06	0	800	65	0.25	0
125	39	0.70	4	1000	67	0.11	0
160	39	0.85	7	1250	72	0.16	0
200	44	0.65	5	1600	77	0.12	0
250	47	0.51	5	2000	81	0.17	0
315	51	0.29	4	2500	84	0.15	0
400	55	0.53	3	3150	85	0.32	0
500	58	0.20	1	4000	83	0.25	0
630	62	0.22	0	5000	81	0.26	0

STC=59

ABBREVIATION INDEX

FREQ. = 1/3 OCTAVE BAND CENTER FREQUENCY, Hz
TL = TRANSMISSION LOSS, dB
ΔTL = 95% CONFIDENCE INTERVAL FOR TL MEASUREMENTS, dB
DEF. = DEFICIENCIES, dB BELOW SHIFTED STC CONTOUR (SUM OF DEF = 29)
STC = SOUND TRANSMISSION CLASS

Tested by _____
Keith Kimberling
Test Engineer

Report by _____
Keith Kimberling
Test Engineer

Approved by _____
Eric P. Wolfram
Laboratory Manager

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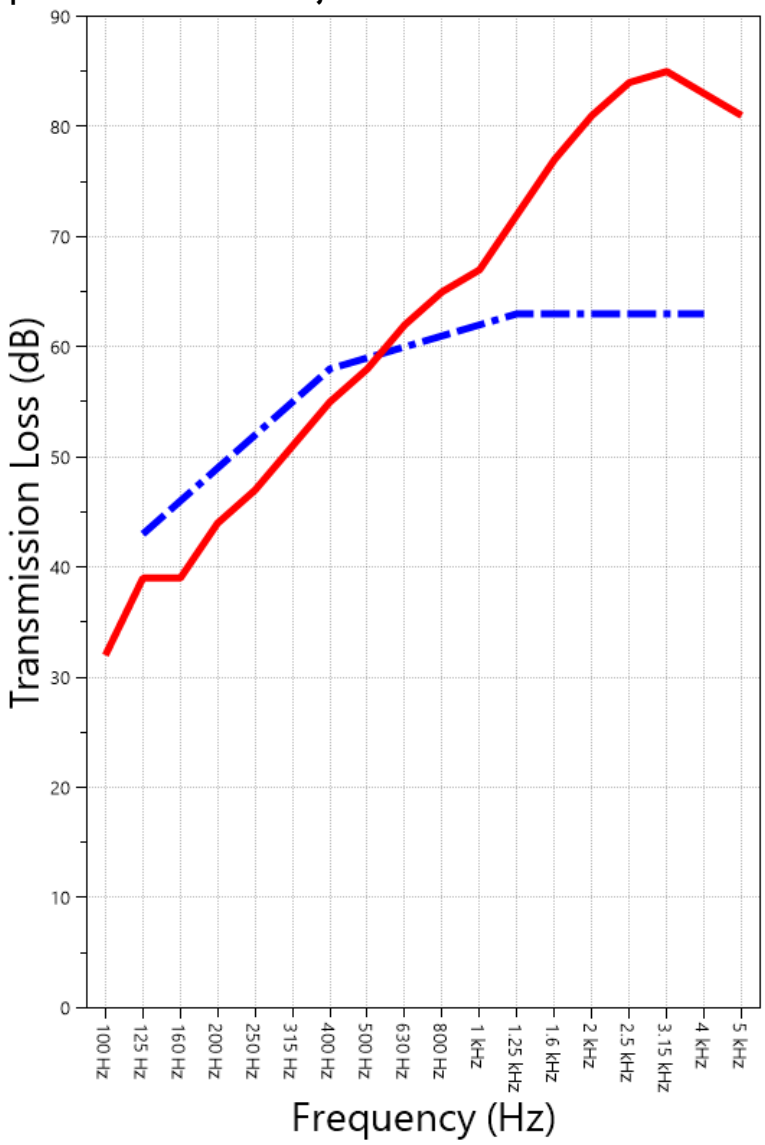
University of Oregon
2024-07-22

RAL™-TL24-326

SOUND TRANSMISSION REPORT

1" Maxxon gypcrete 2000 Multifamily, Certainteed MemBrain vapor retarder, 3" of 3/8" limestone chip, Hempitecture 2" hemp fiber board, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC



STC=59
OITC=45

TRANSMISSION LOSS
SOUND TRANSMISSION CLASS CONTOUR

NVLAP TESTING
NVLAP LAB CODE 100227-0

APPENDIX A: Extended Frequency Range Data

Specimen: 1" Maxxon gypcrete 2000 Multifamily, Certainteed MemBrain vapor retarder, 3" of 3/8" limestone chip, Hempitecture 2" hemp fiber board, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (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. Corrections are detailed in Appendix B.

1/3 Octave Band Center Frequency (Hz)	**Sound Transmission Loss** (dB)	**Applicable Corrections**	**ΔTL (Eq. A2.5)** (dB)	**Repeatability** (dB)
31.5	37	*ZZ F*	1.53	16.75
40	36	*ZZ F*	1.90	5.77
50	37	*ZZ F*	2.22	3.98
63	35	*ZZ F*	1.25	0.75
80	31	*ZZ F*	1.26	1.46
100	32	*Z F*	1.06	3.83
125	39	*ZZ F*	0.70	0.97
160	39	*Z F*	0.85	1.35
200	44	*ZZ F*	0.65	1.21
250	47	*ZZ F*	0.51	0.56
315	51	*Z F*	0.29	0.61
400	55	*Z F*	0.53	0.76
500	58	*Z F*	0.20	0.58
630	62	*Z F*	0.22	1.03
800	65	*Z F*	0.25	0.34
1000	67	*Z F*	0.11	0.78
1250	72	*Z F*	0.16	1.09
1600	77	*ZZ A F*	0.12	1.47
2000	81	*ZZ A F*	0.17	1.14
2500	84	*ZZ AA F*	0.15	0.87
3150	85	*Z AA F*	0.32	0.90
4000	83	*Z AA F*	0.25	1.95
5000	81	*Z AA F*	0.26	3.09
6300	75	*Z AA*	0.29	5.31
8000	68	*AA*	0.36	7.87
10000	60	*AA*	0.50	6.75
12500	50	*AA*	0.63	6.94

APPENDIX B: Glossary of Standardized Corrections and Adjustments

Specimen: 1" Maxxon gypcrete 2000 Multifamily, Certainteed MemBrain vapor retarder, 3" of 3/8" limestone chip, Hempitecture 2" hemp fiber board, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Mark	Interpretation
A	Measured sound pressure levels in the receive room are within 10 dB of the ambient noise level at the marked frequency band. Receive room levels used to calculate Transmission Loss are corrected according to ASTM E90 Section 10.3.
AA	Measured sound pressure levels in the receive room are within 5 dB of the ambient noise level at the marked frequency band. Receive room levels used to calculate Transmission Loss are corrected according to ASTM E90 Section 10.3.1. Transmission Loss values calculated from levels corrected this way will be less than or equal to Transmission Loss values from a hypothetical test using the same specimen and a receive room with idealized ambient sound levels of (-∞) dB.
F	The reported Transmission Loss is within 10 dB of the laboratory flanking limit at the marked frequency band. The measured performance of the specimen may be limited by the performance of the laboratory building structure at this frequency band.
Z	The reported Transmission Loss at the marked frequency band has been corrected according to ASTM E90 Section A3.2.7 to account for possible sound transmission through the filler assembly.
ZZ	The reported Transmission Loss at the marked frequency band has been corrected according to ASTM E90 Section A3.2.8 to account for possible sound transmission through the filler assembly. Transmission Loss values corrected this way will be less than or equal to Transmission Loss values from a hypothetical test using the same specimen and an idealized filler assembly with a Sound Transmission Class rating of (∞).

APPENDIX C: Glossary of Variability Metrics

Specimen: 1" Maxxon gypcrete 2000 Multifamily, Certainteed MemBrain vapor retarder, 3" of 3/8" limestone chip, Hempitecture 2" hemp fiber board, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

ΔTL, the 95% confidence interval for reported transmission loss values, is calculated from the standard deviation of the sets of measurements for source room sound pressure level, receive room sound pressure level, and receive room sound absorption. This metric is calculated in an effort to quantify the combined influences of room geometry, microphone positioning, and other varying environmental conditions on reported results.

Repeatability, expressed as a 95% confidence interval, is calculated from the standard deviation of transmission loss as obtained from a set of six (6) consecutive tests conducted according to this test method by RAL from 2021-02-25 through 2021-03-04. The tests were performed on a specimen composed of a 6 in. thick concrete slab, using the same test opening as used in this report. 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 vary with the construction type.

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Test Report

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2024-07-22

APPENDIX D: Determination of Outdoor Indoor Transmission Class (OITC)

Specimen: 1" Maxxon gypcrete 2000 Multifamily, Certainteed MemBrain vapor retarder, 3" of 3/8" limestone chip, Hempitecture 2" hemp fiber board, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

The determination of the Outdoor Indoor Transmission Class (OITC) as reported below was made with explicit conformity to the procedures described in the ASTM E1332-22 test standard. Test Method ASTM E90-09 (2016) was used to obtain the sound transmission loss data. This rating is based on an average transportation noise source spectrum and an A-weighted sound level reduction, either of which may be inappropriate for some applications.

One-third Octave Band Center Frequency, Hz	Reference Sound Spectrum, dB	Test Specimen Transmission Loss, dB
80	103	31
100	102	32
125	101	39
160	98	39
200	97	44
250	95	47
315	94	51
400	93	55
500	93	58
630	91	62
800	90	65
1000	89	67
1250	89	72
1600	88	77
2000	88	81
2500	87	84
3150	85	85
4000	84	83

OITC = 45

APPENDIX E: Instruments of Traceability

Specimen: 1" Maxxon gypcrete 2000 Multifamily, Certainteed MemBrain vapor retarder, 3" of 3/8" limestone chip, Hempitecture 2" hemp fiber board, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Description	Model	Serial Number	Date of Certification	Calibration Due
System 2	Type 3160-A-042	3160-106974	2023-08-11	2024-08-11
Bruel & Kjaer Mic And Preamp C	Type 4943-B-001	2311439	2024-03-29	2025-03-29
Bruel & Kjaer Sound Level Calibrator	Type 4230	861609	2023-12-20	2024-12-20
EXTECH Hygro 663	SD700	A083663	2023-12-28	2024-12-28
EXTECH Hygro 639	SD700	A.103639	2023-12-01	2024-12-01

APPENDIX F: Revisions to Original Test Report

Specimen: 1" Maxxon gypcrete 2000 Multifamily, Certainteed MemBrain vapor retarder, 3" of 3/8" limestone chip, Hempitecture 2" hemp fiber board, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Date	Revision
2024-07-31	Original report issued
2024-09-17	Page 16: Calibrator added to instruments of traceability -EPW

END

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

Sound Transmission Loss
RAL™-TL24-338

CONDUCTED: 2024-07-25

ON: Marmoleum Decibel adhered with Sustain 1195, 1" Maxxon gypcrete 2000 Multifamily, Certainteed MemBrain vapor retarder, 3" of 3/8" limestone chip, Hempitecture 2" hemp fiber board, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC

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 17025:2017 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 E413-22: "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 Marmoleum Decibel adhered with Sustain 1195, 1" Maxxon gypcrete 2000 Multifamily, Certainteed MemBrain vapor retarder, 3" of 3/8" limestone chip, Hempitecture 2" hemp fiber board, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC. 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

Provided Description:	Marmoleum Decibel adhered with Sustain 1195, 1" Maxxon gypcrete 2000 Multifamily, Certainteed MemBrain vapor retarder, 3" of 3/8" limestone chip, Hempitecture 2" hemp fiber board, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC
Manufacturer:	University of Oregon

SPECIMEN MEASUREMENTS & TEST CONDITIONS

The building contractor (Seth Priser) and RAL staff compiled a detailed construction specification as follows:

Cross-Laminated Timber (CLT)

Materials:	5-Ply Cross-Laminated Timber
Dimensions:	2 panels @ 1219 mm (48 in.) by 4229 mm (166.5 in.)
Thickness:	171 mm (6.75 in.)
Overall Weight:	953.45 kg (2102 lbs)
Mass Per Unit Volume:	539 kg/m^3 (33.7 lbs/ft^3)
Installation:	CLT panels laid on 152 mm (6 in.) wide knee walls in test opening and butted to one another without sealant/adhesive. 3/4"x3" Rabbet on top side of one edge of each panel where they butt allowing a loose spline (below) to insert and join the two

¾" CDX Loose Spline

Materials:	3/4" x 6" plywood spline
Dimensions:	1 piece @ 151 mm (5.9375 in.) wide by 2438 mm (96 in.) 1 piece @ 151 mm (5.9375 in.) wide by 1791 mm (70.5 in.)
Thickness:	19 mm (0.75 in.)
Overall Weight:	6.46 kg (14.25 lbs)
Mass Per Unit Length:	1.53 kg/m (1.03 lbs/ft)
Installation:	Set in Rabbets of both CLT's and screwed in place.
Fasteners:	WSV Bugle head sub-floor screws, length @ 76 mm (3 in.)
Fastener Spacing:	6" o.c. on a line 3" from each edge of the spline (Centered on the rabbet of the CLT)

Hemp Board

Materials:	2" Hemp fiber board
Manufacturer:	Hempitecture
Dimensions:	3 pieces @ 1216 mm (47.875 in.) wide by 2448 mm (96.375 in.) long 1 piece @ 613 mm (24.125 in.) wide by 2448 mm (96.375 in.) long
Depth:	51 mm (2 in.)
Overall Weight:	69.51 kg (153.25 lbs)
Mass Per Unit Volume:	131 kg/m^3 (8.19 lbs/ft^3)
Installation:	Loose laid directly on top of CLT Perpendicular to CLT

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Crushed Limestone

Materials:	CA-16 3/8" chip crushed limestone
Dimensions:	2438 mm (96 in.) wide by 4267 mm (168 in.) long, as installed
Depth:	76 mm (3 in.)
Overall Weight:	1224.02 kg (2698.5 lbs)
Installation:	Loose laid on top of the Hemp fiberboard
	½" polystyrene used as an isolation around the perimeter

Vapor Barrier

Materials:	Membrain Vapor barrier
Manufacturer:	Saint Gobain
Dimensions:	Approx. 2438 mm (96 in.) by 4267 mm (168 in.) as installed
Overall Weight:	0.79 kg (1.75 lbs)
Mass Per Unit Area:	0.08 kg/m^2 (0.02 lbs/ft^2)
Installation:	Loose laid over crushed limestone

Gypcrete

Materials:	Gypcrete mix
Manufacturer:	Maxxon
Dimensions:	2438 mm (96 in.) by 4267 mm (168 in.) as installed
Thickness:	25 mm (1 in.)
Mix Ratio:	2.5 gallons water / 40 lbs gypcrete / 75 lbs all-purpose sand
Overall Dry Weight:	521.63 kg (1150 lbs)
Mass Per Unit Volume:	1970 kg/m^3 (123 lbs/ft^3)
Installation:	Poured over vapor barrier
	A screed was used to spread the wet gypcrete mix
	Wet gypcrete mix was poured on (2024-07-10, approx. 4:30 PM)

SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Adhesive

Materials:	Sustain 1195 Sheet and Tile adhesive
Manufacturer:	Forbo
Dimensions:	Approx. 2438 mm (96 in.) by 4267 mm (168 in.) as installed
Overall Weight:	3.06 kg (6.75 lbs)
Mass Per Unit Area:	0.29 kg/m^2 (0.06 lbs/ft^2)
Installation:	Troweled directly to plywood with a 1/16x1/16x1/16 square notch trowel Once troweled, adhesive was left “open” for 15 min to allow it to “tack” before flooring was installed.

Flooring

Materials:	Marmoleum Decibel
Manufacturer:	Forbo
Dimensions:	2 pieces @ 2007 mm (79 in.) by 2464 mm (97 in.) 1 piece @ 260 mm (10.25 in.) by 2464 mm (97 in.)
Thickness:	6 mm (0.25 in.)
Overall Weight:	32.21 kg (71 lbs)
Mass Per Unit Volume:	482 kg/m^3 (30.1 lbs/ft^3)
Installation:	Two (2) 79” segments. 10” strip to complete Rolled with 100lb roller in each direction

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SPECIMEN MEASUREMENTS & TEST CONDITIONS (continued)

Overall Specimen Measurements

Dimensions:	2.44 m (96.0 in) wide by 3.86 m (152.0 in) high
Thickness:	0.33 m (13.0 in)
Weight:	2811.14 kg (6197.5 lbs)
Overall Area:	9.414 m² (101.33 ft²)
Mass per Unit Area:	270.17 kg/m² (55.33 lbs/ft²)

Test Aperture

Opening Size:	4.27 m (14.0 ft) x 6.10 m (20.0 ft)
Filler Wall:	Yes
Aperture Size:	2.44 m (96.0 in) wide by 3.86 m (152.0 in) high
Transmission Area:	9.414 m² (101.33 ft²)
Sealed:	Entire periphery (both sides) with dense mastic

Test Environment

Source Room

Volume:	130.9 m³
Temperature:	22.8 °C ± 0.0 °C
Relative Humidity:	68.0 % ± 0.0 %

Receive Room

Volume:	81.44 m³
Temperature:	21.9 °C ± 0.6 °C
Relative Humidity:	68.5 % ± 1.0 %

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.

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

Figure 2 – Specimen mounted in test aperture, as viewed from receive room

Figure 3 – CLT (1 of 2) prior to installation

Figure 4 – CLT installed in test aperture

Figure 5 – 3/4” x 6” plywood spline partially installed over CLT rabbets

Figure 6 – Detail of 3/4” x 6” plywood spline partially installed over CLT rabbets

Figure 7 – Hemp board partially installed over CLT

Figure 8 – Polystyrene used as an isolation around the perimeter prior to installation of gravel

Figure 9 – Gravel partially installed over hemp board

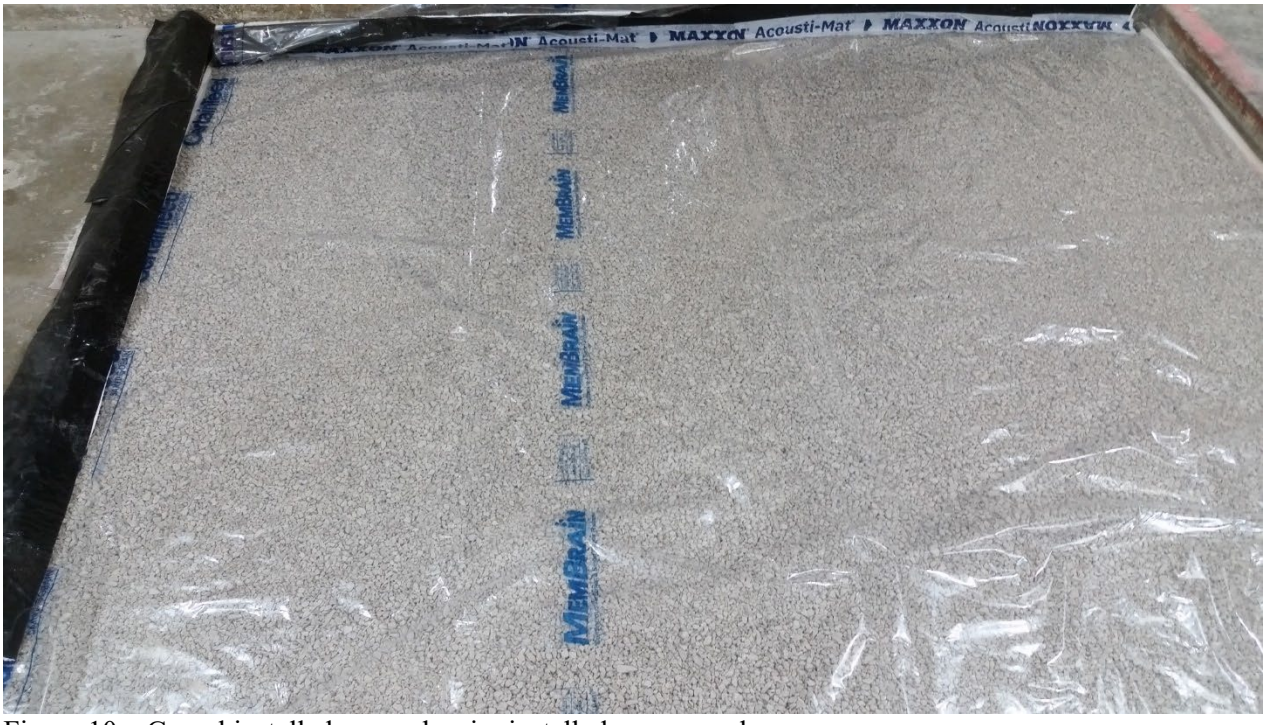

Figure 10 – Gravel installed; vapor barrier installed over gravel

Figure 11 – Gypcrete mixing prior to pouring

Figure 12 – Gypcrete partially installed over vapor barrier

Figure 13 – Trowel used for installation of adhesive

Figure 14 – Adhesive partially installed over gypcrete

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TEST RESULTS

Sound transmission loss values are tabulated at the eighteen standard frequency bands. 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). See Appendix A for identification of corrections applied to the reported data.

FREQ.	TL	ΔTL	DEF.	FREQ.	TL	ΔTL	DEF.
100	31	0.81	0	800	66	0.15	0
125	38	0.68	4	1000	68	0.12	0
160	37	0.59	8	1250	72	0.12	0
200	43	0.41	5	1600	76	0.12	0
250	47	0.42	4	2000	81	0.09	0
315	52	0.24	2	2500	84	0.12	0
400	56	0.35	1	3150	86	0.25	0
500	57	0.17	1	4000	83	0.16	0
630	63	0.25	0	5000	82	0.20	0

STC=58

ABBREVIATION INDEX

FREQ. = 1/3 OCTAVE BAND CENTER FREQUENCY, Hz
TL = TRANSMISSION LOSS, dB
ΔTL = 95% CONFIDENCE INTERVAL FOR TL MEASUREMENTS, dB
DEF. = DEFICIENCIES, dB BELOW SHIFTED STC CONTOUR (SUM OF DEF = 25)
STC = SOUND TRANSMISSION CLASS

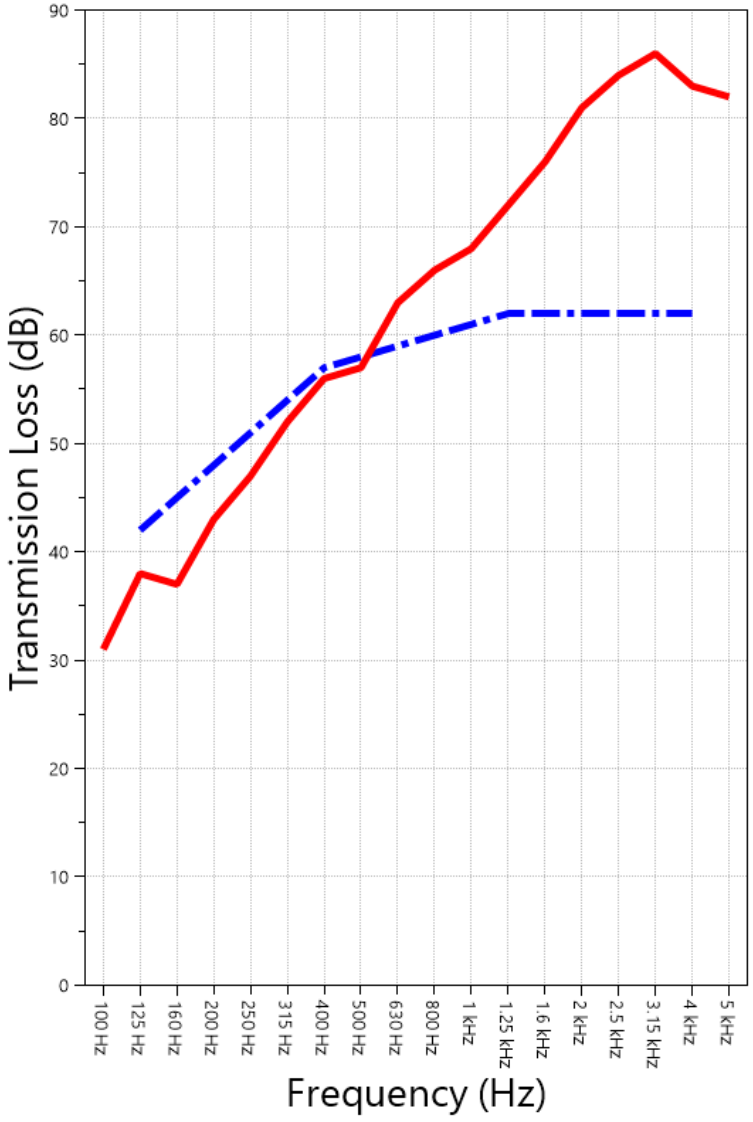
Tested by _____
Keith Kimberling
Test Engineer

Report by _____
Keith Kimberling
Test Engineer

Approved by _____
Eric P. Wolfram
Laboratory Manager

SOUND TRANSMISSION REPORT

Marmoleum Decibel adhered with Sustain 1195, 1" Maxxon gypcrete 2000 Multifamily, Certainteed MemBrain vapor retarder, 3" of 3/8" limestone chip, Hempitecture 2" hemp fiber board, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC



STC=58
OITC=44

TRANSMISSION LOSS
SOUND TRANSMISSION CLASS CONTOUR

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RAL™-TL24-338

APPENDIX A: Extended Frequency Range Data

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1" Maxxon gypcrete 2000 Multifamily, Certainteed MemBrain vapor retarder, 3" of 3/8" limestone chip, Hempitecture 2" hemp fiber board, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

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1/3 Octave Band Center Frequency (Hz)	**Sound Transmission Loss** (dB)	**Applicable Corrections**	**ΔTL (Eq. A2.5)** (dB)	**Repeatability** (dB)
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50	37	*ZZ F*	1.13	3.98
63	35	*ZZ F*	0.99	0.75
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100	31	*Z F*	0.81	3.83
125	38	*Z F*	0.68	0.97
160	37	*Z F*	0.59	1.35
200	43	*Z F*	0.41	1.21
250	47	*ZZ F*	0.42	0.56
315	52	*Z F*	0.24	0.61
400	56	*ZZ F*	0.35	0.76
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1600	76	*ZZ F*	0.12	1.47
2000	81	*ZZ AA F*	0.09	1.14
2500	84	*ZZ AA F*	0.12	0.87
3150	86	*Z AA F*	0.25	0.90
4000	83	*Z AA F*	0.16	1.95
5000	82	*Z AA F*	0.20	3.09
6300	76	*Z AA F*	0.12	5.31
8000	69	*Z AA*	0.16	7.87
10000	61	*AA*	0.11	6.75
12500	47	*AA*	0.09	6.94

APPENDIX B: Glossary of Standardized Corrections and Adjustments

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1" Maxxon gypcrete 2000 Multifamily, Certainteed MemBrain vapor retarder, 3" of 3/8" limestone chip, Hempitecture 2" hemp fiber board, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Mark	Interpretation
A	Measured sound pressure levels in the receive room are within 10 dB of the ambient noise level at the marked frequency band. Receive room levels used to calculate Transmission Loss are corrected according to ASTM E90 Section 10.3.
AA	Measured sound pressure levels in the receive room are within 5 dB of the ambient noise level at the marked frequency band. Receive room levels used to calculate Transmission Loss are corrected according to ASTM E90 Section 10.3.1. Transmission Loss values calculated from levels corrected this way will be less than or equal to Transmission Loss values from a hypothetical test using the same specimen and a receive room with idealized ambient sound levels of (-∞) dB.
F	The reported Transmission Loss is within 10 dB of the laboratory flanking limit at the marked frequency band. The measured performance of the specimen may be limited by the performance of the laboratory building structure at this frequency band.
Z	The reported Transmission Loss at the marked frequency band has been corrected according to ASTM E90 Section A3.2.7 to account for possible sound transmission through the filler assembly.
ZZ	The reported Transmission Loss at the marked frequency band has been corrected according to ASTM E90 Section A3.2.8 to account for possible sound transmission through the filler assembly. Transmission Loss values corrected this way will be less than or equal to Transmission Loss values from a hypothetical test using the same specimen and an idealized filler assembly with a Sound Transmission Class rating of (∞).

APPENDIX C: Glossary of Variability Metrics

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1" Maxxon gypcrete 2000 Multifamily, Certainteed MemBrain vapor retarder, 3" of 3/8" limestone chip, Hempitecture 2" hemp fiber board, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

ΔTL, the 95% confidence interval for reported transmission loss values, is calculated from the standard deviation of the sets of measurements for source room sound pressure level, receive room sound pressure level, and receive room sound absorption. This metric is calculated in an effort to quantify the combined influences of room geometry, microphone positioning, and other varying environmental conditions on reported results.

Repeatability, expressed as a 95% confidence interval, is calculated from the standard deviation of transmission loss as obtained from a set of six (6) consecutive tests conducted according to this test method by RAL from 2021-02-25 through 2021-03-04. The tests were performed on a specimen composed of a 6 in. thick concrete slab, using the same test opening as used in this report. 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 vary with the construction type.

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APPENDIX D: Determination of Outdoor Indoor Transmission Class (OITC)

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1" Maxxon gypcrete 2000 Multifamily, Certainteed MemBrain vapor retarder, 3" of 3/8" limestone chip, Hempitecture 2" hemp fiber board, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

The determination of the Outdoor Indoor Transmission Class (OITC) as reported below was made with explicit conformity to the procedures described in the ASTM E1332-22 test standard. Test Method ASTM E90-09 (2016) was used to obtain the sound transmission loss data. This rating is based on an average transportation noise source spectrum and an A-weighted sound level reduction, either of which may be inappropriate for some applications.

One-third Octave Band Center Frequency, Hz	Reference Sound Spectrum, dB	Test Specimen Transmission Loss, dB
80	103	32
100	102	31
125	101	38
160	98	37
200	97	43
250	95	47
315	94	52
400	93	56
500	93	57
630	91	63
800	90	66
1000	89	68
1250	89	72
1600	88	76
2000	88	81
2500	87	84
3150	85	86
4000	84	83

OITC = 44

APPENDIX E: Instruments of Traceability

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1" Maxxon gypcrete 2000 Multifamily, Certainteed MemBrain vapor retarder, 3" of 3/8" limestone chip, Hempitecture 2" hemp fiber board, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Description	Model	Serial Number	Date of Certification	Calibration Due
System 2	Type 3160-A-042	3160-106974	2023-08-11	2024-08-11
Bruel & Kjaer Mic And Preamp C	Type 4943-B-001	2311439	2024-03-29	2025-03-29
Bruel & Kjaer Sound Level Calibrator	Type 4230	861609	2023-12-20	2024-12-20
EXTECH Hygro 663	SD700	A083663	2023-12-28	2024-12-28
EXTECH Hygro 639	SD700	A.103639	2023-12-01	2024-12-01

APPENDIX F: Revisions to Original Test Report

Specimen: Marmoleum Decibel adhered with Sustain 1195, 1" Maxxon gypcrete 2000 Multifamily, Certainteed MemBrain vapor retarder, 3" of 3/8" limestone chip, Hempitecture 2" hemp fiber board, Vaagen Timbers 5-ply CLT 6.875" with plywood spline 3/4"x6" at the joint secured with #9x3" screws at 6" OC (See Full Report)

Date	Revision
2024-07-31	Original report issued
2024-09-17	Page 18: Calibrator added to instruments of traceability -EPW

END