Taller and Larger Wood Buildings: Midrise Wood Frame Construction:

Sound Insulation Performance of Elevator Shaft Walls Built with Nail-Laminated Timber Panels – Exploratory Tests and Preliminary Results

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SUMMARY

As 6-storey wood-frame, massive-timber and hybrid wood buildings are increasingly accepted by more jurisdictions across Canada, there is a need to develop reliable elevator shaft designs that meet the minimum structural, fire, and sound requirements in building codes. Elevator shaft walls constructed with wood-based materials have the advantages of material compatibility, use of sustainable materials, and ease of construction.

In this exploratory study, selected elevator shaft wall designs built with nail-laminated-timber (NLT) structural elements were tested to investigate their sound insulation performance because little is known about the sound insulation performance of such wall assemblies. The tests were carried out in an acoustic mock-up facility in accordance to standard requirements, and provide preliminary data on the sound insulation performance of elevator shaft walls built with NLT panels.

Four different elevator shaft walls built with NLT panels were tested and their measured apparent sound insulation class (ASTC) ratings ranged from 18 to 39 depending on their construction details. Some of the reasons that may have contributed to the ASTC ratings obtained for the elevator shaft walls described in this report as well as recommendations for future designs were provided.

It is recommended to continue improving the sound insulation of elevator shaft walls built with NLT panels to meet or exceed the minimum requirements in building codes.
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1 OBJECTIVES

- Investigate sound insulation performance of elevator shaft walls built with nail-laminated timber used to separate dwelling units from elevators in wood-frame, mass-timber, and hybrid wood buildings.
- Identify knowledge gaps for future research.

2 INTRODUCTION

Elevator shaft walls are assemblies with structural strength to withstand lateral loads and fire resistance to protect the enclosed elevators. As 6-storey wood-frame buildings, mass-timber and hybrid wood buildings are increasingly accepted by more jurisdictions across Canada, there is a need to develop reliable elevator shaft designs that meet the minimum structural, fire, and sound requirements in building codes. Elevator shaft walls constructed with wood-based materials have the advantages of material compatibility, use of sustainable materials, and ease of construction. Elevator shaft walls built with wood-based structural products are regarded as combustible shafts and are accepted by many local building codes if they have a minimum 1-hour fire-resistance.

Nail-laminated timber (NLT) panels are mass-timber systems used for floor, roof, and wall assemblies in a structure. They are made by fastening together single pieces of dimension lumber, which are oriented edgewise, with nails to create single solid structural elements. Typically, a layer of a structural sheathing panel is added atop the structural element in the case of a floor assembly or on one side of it in the case of a wall assembly. An NLT panel made of 2x6 lumber with 101 mm (4 in) long nails spaced at 400 mm (16 in) o.c. meets the minimum 1-hour fire-resistance rating required by the Building Code (Table D-2.4.1 in NBCC) and consequently it may be used for elevator shafts.

Aside from structural and fire requirements, elevator shaft walls are subject to noise control requirements in Canada. The 2015 National Building Code of Canada (NBCC) (NBCC, 2015) specifies an STC\(^1\) rating of minimum 55 for a dwelling unit separated from an elevator shaft. A similar requirement of STC 55 for elevator shaft walls is further enforced by the BC Building Code (BCBC, 2012). STC ratings do not take into account flanking, which accounts for all sound paths other than the direct sound path through the assembly.

Even though the 2015 NBCC specifies a minimum STC rating for elevator shaft walls, it does not provide an apparent sound transmission class\(^2\) (ASTC) requirement for this type of assemblies.

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1 Sound transmission class (STC) is a single-number rating that classifies airborne sound insulation of a building element. STC is calculated in accordance with ASTM E413 using values of sound transmission loss of the element measured in a laboratory chamber without flanking.

2 Apparent sound transmission class (ASTC) is a single-number rating that classifies airborne sound insulation of a building element separating two rooms. ASTC is calculated by applying the classification procedure of ASTM E413 to apparent transmission loss data obtained from field measurements of the airborne sound transmission loss through an assembly including flanking.
However, the 2015 NBCC does provide a requirement for airborne sound insulation stipulating that a dwelling unit be separated from other space in a building by an assembly with an ASTC rating of no less than 47. The requirement for airborne sound insulation of a building assembly that separates a residential unit from other spaces in the building in the previous edition of the NBCC (2010 NBCC) was an STC rating of no less than 50.

Little is known about the sound insulation performance of building assemblies built with NLT panels. The intent of this exploratory study was to investigate the sound insulation performance of a few elevator shaft wall designs built with nail-laminated timber in an acoustic mock-up facility to obtain an indication of their ASTC ratings. The sound transmission ratings obtained by testing assemblies in mock-up facilities take into account flanking and correlate better with the level of sound transmission perceived by the occupants.

The report provides descriptions of the elevator shaft wall designs, the mock-up test facility and environment, the test method, and the acoustic equipment used in the tests. Test results, discussion, and recommendations are also reported.

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4 ELEVATOR SHAFT WALL DESIGNS

The construction details of four elevator shaft wall designs and a reference design used in this study are described below. All the walls were approximately 1.47 m (58 in) in length and 1.47 m (58 in) in height, while the thickness varied for each design. A single assembly was built for each design.

4.1 Design 1

Design 1 was a structural nail-laminated timber (NLT) panel built with 2x6 laminations of No. 2 SPF dimension lumber oriented edgewise and fastened with 89 mm (3 1/2 in) long nails spaced at 400 mm (16 in) o.c. On one side of the nail-laminated structural element there was a single layer of 16 mm (5/8 in) gypsum wallboard (GWB) attached with screws spaced at 300 mm (12 in) o.c. on 13 mm

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3 The NLT panels were fastened with 89 mm (3 1/2 in) long nails instead of 101 mm (4 in) long nails, as required by the NBCC to meet the 1-hour fire resistance rating, because the nail gun available in the laboratory was rated for nail lengths up to 89 mm (3 1/2 in). For the purpose of this exploratory study, it was deemed acceptable to assemble the NLT panels with 13 mm (1/2 in) shorter nails, which was assumed to not have an effect on sound transmission measurements.
(1/2 in) resilient channels (RC) located at about 368 mm (14 1/2 in) o.c. Construction details of design 1 are shown in Figure 1.

The other side of the NLT panel had a single layer of 13 mm (1/2 in) fire treated plywood (FTP) fastened with 51 mm (2 in) nails spaced at 150 mm (6 in) o.c. along the edges of the panel and at 300 mm (12 in) o.c. in-field. The total thickness of the elevator shaft wall assembly in design 1 was approximately 197 mm (7 3/4 in).

![Figure 1](image)

**Figure 1  Construction details of design 1 (cross-section)**

*Note: (a) one layer of 16 mm (5/8 in) GWB; (b) 13 mm (1/2 in) resilient channels; (c) solid nail-laminated timber wall built with 2x6 SPF lumber; (d) 13 mm (1/2 in) fire-treated plywood*

### 4.2 Design 2

Design 2 was a NLT panel built with 2x6 laminations of No. 2 dimension lumber oriented edgewise and fastened with 89 mm (3 1/2 in) long nails spaced at 400 mm (16 in) o.c. On one side of the NLT panel, a wood frame was built with 2x4 studs spaced at 400 mm (16 in) o.c. and with QuietZone® Pink® Fiberglas® acoustic insulation in cavities (89 mm (3 1/2 in)). Construction details of design 2 are shown in Figure 2.

The wood frame had two layers of 16 mm (5/8 in) GWB, the top layer on the outer side and the base layer on the inner side. The base layer was attached with screws spaced at about 493 mm (19 in) o.c. while the top layer was attached with screws at 300 mm (12 in) o.c. On the opposite side of the wood frame, a layer of common vapor barrier held the acoustic insulation in place. The wood frame assembly and NLT panel were separated by a 13 mm (1/2 in) air gap. The other side of the NLT panel had a single layer of 13 mm (1/2 in) FTP with 51 mm (2 in) nails spaced at 150 mm (6 in) o.c. along the edges of the panel and at 300 mm (12 in) o.c. in-field. The total thickness of the elevator shaft wall assembly in design 2 was about 286 mm (11 1/4 in).
Figure 2  Construction details of design 2 (cross-section)

Note: (a) & (b) two separate layers of 16 mm (5/8 in) GWB; (c) QuietZone® Pink® Fiberglas® acoustic insulation; (d) 2x4 SPF frame members; (e) vapor barrier; (f) 12.5 mm (1/2 in) air gap; (g) solid nail-laminated timber wall built with 2x6 SPF lumber; (h) 13 mm (1/2 in) fire-treated plywood

4.3 Design 3

Two similar wall designs, one with a 25 mm (1 in) air gap (design 3) and the other one with a 13 mm (1/2 in) resilient channel and a 13 mm (1/2 in) air gap (design 4) are described below.

Design 3 was a nail-laminated structural element built with 2x6 laminations of No. 2 SPF dimension lumber oriented edgewise and fastened with 89 mm (3 1/2 in) nails spaced at 400 mm (16 in) o.c. On one side of the NLT panel, a wood frame assembly was built with 2x3 studs spaced at about 483 mm (19 in) o.c. with QuietZone® Pink® Fiberglas® acoustic insulation in cavities (63.5 mm (2 1/2 in)).

Construction details of design 3 are shown in Figure 3.
Two layers of 16 mm (5/8 in) GWB were attached on the outer side of the wood frame. The base GWB layer was attached with screws at about 483 mm (19 in) o.c. while the top GWB layer was attached with screws at 300 mm (12 in) o.c. A common vapor barrier was stapled on the inner side of the wood wall to hold the acoustic insulation in place. The wood frame assembly and NLT panel were separated by a 25 mm (1 in) air gap. The other side of the nail-laminated structural element had a single layer of 13 mm (1/2 in) FTP with 51 mm (2 in) nails spaced at 150 mm (6 in) o.c. along the edges of the panel and at 300 mm (12 in) o.c. in-field. The total thickness of the elevator shaft wall assembly in design 3 was approximately 273 mm (10 3/4 in).

4.4 Design 4

Design 4 was a NLT panel built with 2x6 laminations of No. 2 SPF dimension lumber oriented edgewise and fastened with 89 mm (3 1/2 in) nails spaced at 400 mm (16 in) o.c. On one side of the NLT panel, a wood frame assembly was built with 2x3 studs spaced at about 483 mm (19 in) o.c. with QuietZone® Pink® Fiberglas® acoustic insulation in cavities (63.5 mm (2 1/2 in)).

Construction details of design 4 are shown in Figure 4.
Figure 4  Construction details of design 4 (cross-section)

Note: (a) & (b) two separate layers of 16 mm (5/8 in) GWB; (c) 13 mm (1/2 in) resilient channels; (d) QuietZone® Pink® Fiberglas® acoustic insulation; (e) 2x3 SPF frame members; (f) vapor barrier; (g) 13 mm (1/2 in) air gap; (h) solid nail-laminated timber wall built with 2x6 SPF lumber; (i) 13 mm (1/2 in) fire-treated plywood

Two layers of 16 mm (5/8 in) GWB were attached to 13 mm (1/2 in) resilient channels which were screwed on the outer side of the wood frame at approximately 368 mm (14.5 in) o.c. The GWB layers were attached with screws at about 305 mm (12 in) o.c. A common vapor barrier was stapled on the inner side of the wood wall to hold the acoustic insulation in place. The wood frame assembly and NLT panel were separated by a 25 mm (1 in) air gap. The other side of the nail-laminated wall element had a single layer of 13 mm (1/2 in) FTP with 51 mm (2 in) long nails spaced at 150 mm (6 in) o.c. along the edges of the panel and at 300 mm (12 in) o.c. in-field. The total thickness of the elevator shaft wall assembly in design 4 was about 273 mm (10 3/4 in).

4.5 Reference Design

A wood frame wall assembly built with 2x6 No. 2 SPF studs spaced at approximately 203 mm (8 in) o.c. and with QuietZone® Pink® Fiberglas® acoustic insulation in cavities (140 mm (5 1/2 in)) was used as the reference design. Construction details of the reference design are shown in Figure 5.
Figure 5  Construction details of the reference design (cross-section)

Note: (a) one layer of 16 mm (5/8 in) GWB; (b) 13 mm (1/2 in) resilient channels; (c) QuietZone® Pink Fiberglas® acoustic insulation; (d) 2x6 SPF frame members; (e) vapor barrier; (f) 11 mm (7/16 in) OSB; (g) one layer of 16 mm (5/8 in) GWB.

A single layer of 16 mm (5/8 in) GWB was attached to 13 mm (1/2 in) resilient channels which were screwed on the outer side of the wood frame at approximately 368 mm (14.5 in) o.c. A common vapor barrier was stapled on the inner side of the wood wall, then a 11 mm (7/16 in) OSB sheathing was attached on the wood frame with 51 mm (2 in) nails at 150 mm (6 in) o.c. and a layer of 16 mm (5/8 in) GWB was attached to the OSB with screws at 300 mm (1/2 in) o.c. The total thickness of the elevator shaft wall assembly in the reference design was approximately 195 mm (7 11/16 in).

5 TEST FACILITY AND TEST ENVIRONMENT

The sound insulation tests were carried out in a mock-up facility with two adjacent rooms separated by an interior wall with a square opening centrally located on the wall. Figure 6 shows the source (S) and receiving (R) rooms of the test facility. The mock-up facility was located indoors inside a large warehouse built on a concrete floor slab. The exterior and interior walls of the mock-up facility were made of 200 mm (8 in) thick reinforced concrete. The volumes of the source and receiving rooms were 36.9 m$^3$ and 44.7 m$^3$, respectively. The volume of rooms differs to avoid modal matching. Each room had double doors.
The interior walls of each room were covered with sections of acoustical boards made of 12.5 mm (1/2 in) thick wood fibreboards with Acoustic-Tech Premium™ membranes on top. Sections of the acoustical boards may be seen through the interior wall opening shown in Figure 7. Both, the source and receiving rooms were carpeted. The source room was furnished with a simple table while no furnishings were found in the receiving room.

A square opening in the interior wall separating the two rooms was used to accommodate the wall assemblies for testing. A heavy plate steel perimeter frame enclosed in the square opening in the interior wall had a 102 mm (4 in) wide flange on one side and 12 steel brackets on the other side to secure the wall assemblies in the test frame. The area of the wall assembly exposed to direct sound was about 1.3 x 1.3 m (51 x 51 in). Details of the steel frame are shown in Figure 8.
Figure 7  Opening in the wall separating the source (S) and receiving (R) rooms of the mock-up facility that accommodates the assemblies for testing
6 TEST EQUIPMENT

For measurement of the airborne sound attenuation, the sound source generating pink noise was connected to a Larson Davis omnidirectional (dodecahedral) loudspeaker Model BAS001 though a Larson Davis 500 Watt 110-125 VAC noise source amplifier Model BAS002, which was remotely controlled. A single sound level meter Larson Davis Model 831-R1 Type I was used to measure sound levels during the tests. The sound level meter was equipped with a 12.5 mm (1/2 in) PSB microphone Model 377B20 with pre-amplifier. Calibration data sheet provided by Larson Davis, when the instruments were purchased in 2010, indicated that the sound level meter was laboratory calibrated in 2010 to the appropriate standards. Sensitivity checks on the sound level meter were performed with a Larson Davis field calibrator Model CAL200.

Data analysis was carried out with post-data analysis software, Larson Davis DNA4 version 4.6.4.0 that interfaces with the sound level meter. The software performs the frequency analysis to obtain the spectrums, single number ratings, and reverberation time spectrums.

7 TEST METHODS

Airborne sound insulation performance of the elevator shaft walls built with NLT panels was determined in mock-up facility according to the principles in ASTM E336-14 (ASTM, 2014). This test method allows
for measurement of airborne sound attenuation between rooms in buildings due to the direct sound transmission through the wall and the flanking through indirect sound transmission paths. The tests were carried out with a single sound source (i.e., omnidirectional loudspeaker) which was placed approximately in the centre of the source room. The tests were carried out with the sound level meter positioned at six fixed positions at minimum 1 m apart in each room. With the sound source operating at a constant level, the average sound pressure level at each frequency was measured in the receiving room. Similarly, with the sound source operating at a constant level, the average sound pressure level at each frequency was measured in the source room. The measurements were carried out in a single direction, from the source room to receiving room. With the sound source shut off, the average sound pressure level at each frequency was measured in the receiving room for an averaging time of 1 min at a single microphone position located approximately in the centre of the room.

Sensitivity checks were performed on the sound level meter before and after the measurements with a Larson Davis field calibrator Model CAL200. The calibration values were within the requirement of the ASTM E336-14 standard.

Decay rates were measured according to ASTM E2235-04 (ASTM, 2014). Fifteen decay rates were collected (3 microphone positions, 5 decays) per each test.

The ASTC ratings of the elevator shaft walls described in this report were determined as per the classification in ASTM E413-10 (ASTM, 2010) by using the DNA4 analysis software described in Section 6 of this report.

8 TEST RESULTS AND DISCUSSION

The test results for the wall designs described in this report are viewed as preliminary. These results were obtained specifically for the source and receiving rooms in the acoustic mock-up facility described in this report and shall not be used to characterize performance in other environment. The results stated in this report represent only the specific elevator shaft wall construction and acoustical conditions present at the time of the test. Measurements performed in accordance with the ASTM E336 test method on nominally identical assemblies in the field and under similar acoustical environment may produce different results.

A single replicate wall was tested for each wall design. The wall assemblies were tested in the following order: design 1, 2, 3, 4, and the reference design. After testing wall designs 1, 2, 3, and 4, the testing crew noticed a screw protruding from the steel test frame and pointing towards the wall assembly sitting in the test frame, which did not permit the wall assembly to sit tight against the test frame, and allowed sound leakage between the source and receiving rooms. The screw is shown in Figure 9. The screw was removed and wall designs 2, 3 and 4 were retested. Wall design 1 was not retested. The reference wall design was only tested after the screw was removed from the test frame. The ASTC rating for each test and the ASTC rating difference between the initial test and retest are shown in Table 1.
Figure 9  Screw protruding from the test frame allowing for sound leakage between the source and receiving rooms

Measured sound transmission loss through the elevator wall assemblies in one-third (1/3) octave band for frequencies ranging from 125 Hz to 4000 Hz are shown in Figures 9-13 (Appendix I). The figures show only the retests in the case of wall designs 2, 3, and 4. The blue line in these figures represents the measured sound transmission loss and the black line shows the reference sound insulation contour fitted to the data according to ASTM E413-10 (ASTM 2010).
<table>
<thead>
<tr>
<th>DESIGN #</th>
<th>CONSTRUCTION DETAILS</th>
<th>WALL THICKNESS [mm (in)]</th>
<th>ASTC</th>
<th>ASTC Difference Test-Retest</th>
</tr>
</thead>
</table>
| 1       | 1 layer of 16 mm (5/8 in) GWB  
13 mm (1/2 in) RC  
Solid wall of nail-laminated 2x6s  
13 mm (1/2 in) FTP | 197 (7 ¾) | 18 | N/A |
| 2       | 2 layers of 16 mm (5/8 in) GWB  
2x4 wood studs with QuietZone® Pink® Fiberglas® Acoustic Insulation in cavities  
Vapor barrier  
13 mm (1/2 in) air gap  
Solid wall of nail-laminated 2x6s  
13 mm (1/2 in) FTP | 286 (11 ¼) | 33 | 6 |
| 3       | 2 layers of 16 mm (5/8 in) GWB  
2x3 wood studs with QuietZone® Pink® Fiberglas® Acoustic Insulation in cavities  
Vapor barrier  
25 mm (1 in) air gap  
Solid wall of nail-laminated 2x6s  
13 mm (1/2 in) FTP | 273 (10 ¼) | 32 | 6 |
| 4       | 2 layers of 16 mm (5/8 in) [GWB  
13 mm (1/2 in) RC  
2x3 wood studs with QuietZone® Pink® Fiberglas® Acoustic Insulation in cavities  
Vapor barrier  
13 mm (1/2 in) air gap  
Solid wall of nail-laminated 2x6s  
13 mm (1/2 in) FTP | 273 (10 ¼) | 35 | 4 |
| Reference | 1 layer of 16 mm (5/8 in) GWB  
13 mm (1/2 in) RC  
2x6 wood studs with QuietZone® Pink® Fiberglas® Acoustic Insulation in cavities  
Vapor barrier  
11 mm (7/16 in) OSB  
1 layer of 16 mm (5/8 in) GWB | 195 (7 11/16) | - | N/A |

Notes: 1 Refer to Section 4 for more construction details  2 Wall assemblies retested or tested after the screw protruding from the test frame was removed  3 Wall design 1 was not retested  4 Reference wall design was only tested after the screw protruding from the test frame was removed.
Four elevator shaft walls built with NLT panels were tested in an acoustic mock-up facility to investigate their sound insulation performance because test data on such nail laminated timber walls was unavailable. Aside from the four elevator shaft wall assemblies in designs 1, 2, 3, and 4, a wood frame wall assembly was tested in the reference design. STC ratings on wall assemblies similar to that in reference design are available for comparison as indicated in the first bullet below.

1. Several wall assemblies were tested at the National Research Council Canada (NRC-CNRC) under the Midrise Wood Research Project in an attempt to characterize sound insulation behaviour of common assemblies in midrise construction (Schoenwald et al., 2014). Two of the walls tested at the NRC-CNRC had similar construction details with the wood frame wall in the reference design, in that they were single stud frame walls with 2x6 studs at 200 mm (7 7/8 in) o.c. with two layers of 12.7 mm (1/2 in) GWB which were attached directly on one side the wood frame and mounted to RC on the other side of the wood frame. The difference between the wood frame walls tested at NRC-CNRC and the wall in the reference design was a layer of 11 mm (7/16 in) OSB (in the reference design). However, the measured STC rating of the NRC-CNRC walls was 51 in both cases, when the walls were built with or without wood sheathing (Table 1, Schoenwald et al., 2014).

2. GWB adds mass to a wood assembly and as such it contributes to the system's sound insulation performance. In another study at NRC-CNRC, Quirt et al. assessed sound transmission through walls with GWB. They obtained 11 point difference in the STC ratings of wood frame walls with 2x4 wood studs at 400 mm (15 1/4 in) o.c., with RC on one side of each assembly and with one layer of 15.9 mm (5/8 in) GWB on both sides and a similar system with two layers of 15.9 mm (5/8 in) GWB on both sides (Table WS-2 and WS-5, Quirt et al., 1995).

3. The minimum performance levels specified in the building codes for airborne sound insulation of wall assemblies are generally based on standard tests carried out in laboratory environment that assess the direct sound transmission through the assembly tested. After installation of assemblies in buildings, the sound insulation performance between adjacent rooms (which is what occupants normally hear) is typically less than that obtained in the laboratory tests (Quirt et al., 2006). This is typically due to flanking which depends on a variety of factors of which the most important are the floor surfaces (topping) of the two rooms on each side of the wall, and the structural details at the junction between the wall and floor. The tests described in this report were carried out in a mock-up facility which does not suppress flanking.

Based on the earlier studies indicated above, the ASTC rating of about 41 obtained for the reference design is reasonable. The measured ASTC ratings for the four elevator shaft walls with NLT panels ranged between 18 and 39 depending on their construction details.

Wall designs 2, 3, and 4 had similar ratings when retested (i.e. ASTC 38/39) because a 1 point difference between STC ratings is not considered significant. The wall thickness for designs 3 and 4 was about 12.7 mm (1/2 in) smaller than that for design 2. A narrower wall with similar or higher ASTC rating is preferred in design; therefore, walls 3 and 4 are viewed as improved designs.
Some of the reasons which may have contributed to the ASTC ratings obtained for the elevator shaft walls built with NLT panels tested in this exploratory study are given below:

- Acoustic tests in mock-up facilities provide an indication of the field sound insulation performance of a building assembly. The particular construction details of the mock-up facility used in this study allow for testing smaller samples, approximately one half the size of a full-size wall assembly (i.e. 2.4 x 2.4 m (8 x 8 ft)). Research has shown that sample area can play a significant role in the measured sound transmission loss (Guy et al. 1985, Wareing et al. 2014). Therefore, the walls tested in this exploratory study may not necessarily reflect the actual sound performance of a full-size wall.

- The results are based on testing a single replicate wall for each design. While testing two replicate walls per configuration would have improved the reliability of the test results, doubling the sample size was seen as an unnecessary additional expense for the purpose of this exploratory study.

- The walls were intentionally built slightly smaller so that they would fit in the wall opening between the source and receiving rooms of the mock-up facility. The small open gap between the walls and steel frame was filled with QuietZone® Pink® Fiberglas® Acoustic Insulation to minimize sound leakage between the two rooms. This was a tedious process and it may have not been done consistently for all walls, which could be a source of error.

The following construction details are based on the basic principles for sound insulation design of buildings and had a positive effect on the sound insulation performance of the elevator shaft walls built with NLT and tested in this study.

- Use of a double layer of type X GWB on each side of the wall assembly will contribute to improving thermal, fire, and sound insulation performance of an elevator shaft. Care should be taken to offset the joints from the outer and inner GWB layers.

- Use of a larger air gap (i.e. 25 mm (1 in)) or a combination of a smaller air gap and resilient channels to control vibrations caused by noise by decoupling adjacent elements.

9 CONCLUSIONS AND RECOMMENDATIONS

A few exploratory tests were undertaken to investigate the sound insulation performance of elevator shaft walls built with NLT panels, which separate dwelling units from elevators in wood-frame, mass-timber, and hybrid wood buildings. Standard tests on wall assemblies were carried out in an acoustic mock-up facility, and provided insight into the sound insulation performance of elevator shaft wall designs with NLT panels. Four different elevator shaft wall designs with NLT panels were tested. The measured ASTC ratings for the four elevator shaft walls tested ranged between 18 and 39 depending on their construction details.

Elevator shaft walls in wood-frame, mass-timber, and hybrid wood buildings, which are constructed with wood-based materials, have the advantages of material compatibility, use of sustainable materials, and
ease of construction. It is recommended to continue improving the sound insulation of elevator shaft walls to meet or exceed the minimum requirements in building codes.

10 REFERENCES


---------- ASTM E413-10. Classification for Rating Sound Insulation. ASTM International. West Conshohocken PA, USA.


Appendix I.
Test Results of Elevator Shaft Walls Tested in Acoustic Mock-Up Facility

Test specimen area $S$: 1.7 $m^2$
Source room volume: 36.9 $m^3$
Receiving room volume: 44.7 $m^3$
Sum of deficiencies: 25 dB

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<th>Frequency (Hz)</th>
<th>ATL (dB)</th>
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<tbody>
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Figure 10  Sound transmission loss in 1/3 octave frequency band spectrum measured through design 1. ASTC rating 18. In this graph, the scale of Y-axis was extended to show the complete contour of the ASTC reference curve.
Test specimen area $S$: 1.7 m$^2$
Source room volume: 36.9 m$^3$
Receiving room volume: 44.7 m$^3$

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Figure 11  Sound transmission loss in 1/3 octave frequency band spectrum measured through design 2. ASTC rating 39 (retest).
Test specimen area $S$: 1.7 m$^2$
Source room volume: 36.9 m$^3$
Receiving room volume: 44.7 m$^3$

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Figure 12  Sound transmission loss in 1/3 octave frequency band spectrum measured through design 3. ASTC rating 38 (retest).
Figure 13  Sound transmission loss in 1/3 octave frequency band spectrum measured through design 4. ASTC rating 39 (retest).
Figure 14  Sound transmission loss in 1/3 octave frequency band spectrum measured through the reference design. ASTC rating 41.
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