Impact Isolation Tests of Variations in Open-Web Wood Truss Assemblies

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This article examines data obtained while performing impact testing on different variations of typical fire-rated components in open-web wood truss assemblies. Data were obtained by performing ASTM E492 test methodology in a laboratory environment. A comparative analysis is presented for three different scenarios. The effects of changing the channel spacing of the drywall isolation clips in a ceiling, the effects of adhered vs. floating vinyl flooring with a resilient rubber underlayment, and the effects of an assembly with and without a layer of poured gypsum underlayment are examined. All data are presented in plot format, and the relevant 1/3-octave band data are analyzed.

This article examines the effects on impact insulation testing when using ASTM E492 test methodology on various configurations of different components in a typical wood-frame, floor-ceiling assembly. The airborne sound transmission was also tested but was not compared here. This was due to the fact that most of the differences came from the impact data, while the airborne data showed similar results. The significant 1/3-octave band data are analyzed and discussed. Comparisons between drywall isolation clips and resilient channels, assemblies with and without a gypsum topping layer, variation in drywall isolation clip spacing, and floating vs. adhered vinyl finished flooring are examined.

Methodology

ASTM E492 *Standard Test Method for Laboratory Measurement of Impact Sound Transmission Through Floor-Ceiling Assemblies Using the Tapping Machine* [1] test methodology was used to gather the data presented. Testing with this method will result in a single-value IIC number as well as 1/3-octave band plots. This article will examine the 1/3-octave band plots and discuss the differences. The IIC value does not offer insight into the performance at different 1/3 octave bands, so it is not discussed.

All measurements were taken at Intertek/ATI's IAS Accredited acoustical testing facility in York, Pennsylvania, on the same base assembly to obtain as true a comparison as possible. All testing was done within two days. This was done to reduce laboratory variations as much as possible.[2] The laboratory opening for the test assembly is 120 ft^2. The base assembly that was tested was constructed as follows (from top to bottom):

- One layer of 3/4-inch-thick oriented strand board (OSB), 48 × 96-inch sheets
- OSB nailed (8 inches on center) and adhered to top of open-web truss
- 18-inch-deep open-web trusses, 3.5 × 115.5-inch trusses (spaced 24 inches on center)
- 3.5-inch-thick fiberglass insulation (R-13), 23 × 116-inch rolled batts (in cavities between trusses, held directly against bottom of OSB subfloor by wire)
- A resilient element that was changed throughout testing
- 5/8-inch fire-rated type-C gypsum wall board

Seams and screw heads were filled with joint compound and taped. The perimeter of the gypsum wall board ceiling was filled with acoustical caulk. The base assembly is shown in Figure 1.

All changes made to the assembly to obtain the data presented here were done above the 3/4-inch OSB and below the open-web truss. The main structure of the assembly remained the same throughout the testing (OSB subfloor, open-web truss, and insulation). The gypsum wallboard ceiling was first tested with resilient channel and then removed to change to the drywall isolation clips and was then removed and replaced again for the different spacing of drywall isolation clips. The same type of drywall was used throughout all testing. The screws that attached the gypsum wallboard ceiling to the channels remained essentially the same

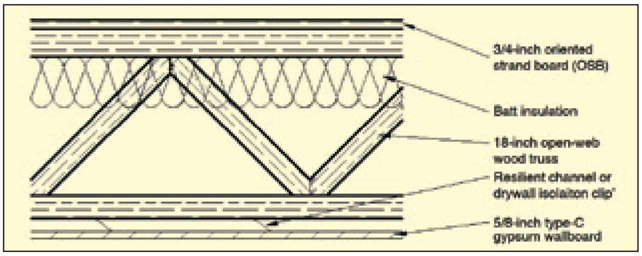

Figure 1. Baseline open-web truss assembly used in all testing.

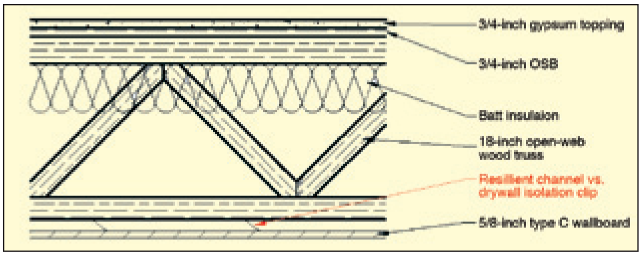

Figure 2. Drywall isolation clips vs. resilient channel assembly.

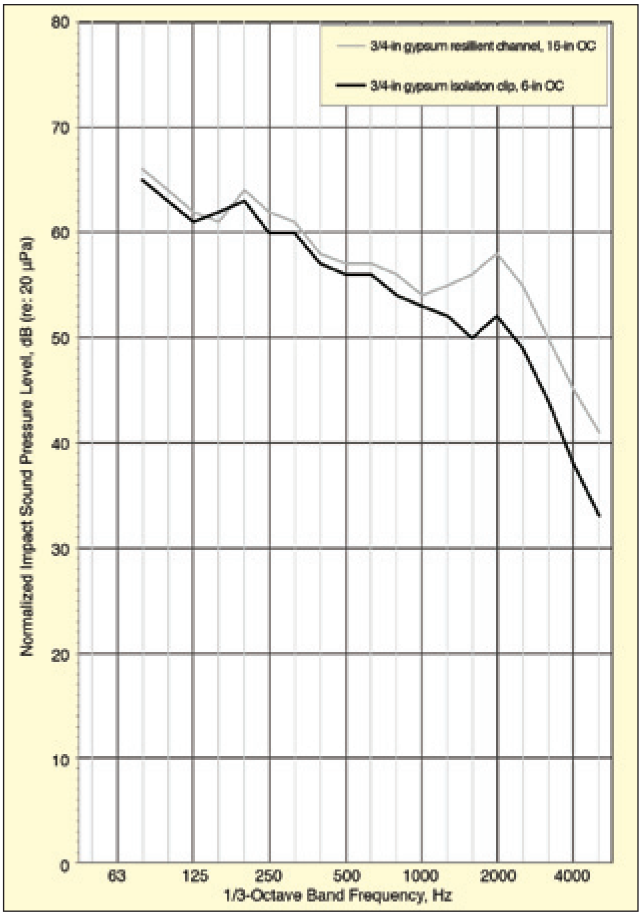

Figure 3. Drywall isolation clips vs. resilient channel NISPL plot.

Based on a paper presented at Inter-Noise 2015, 44th International Congress on Noise Control Engineering, San Francisco, CA, August, 2015.

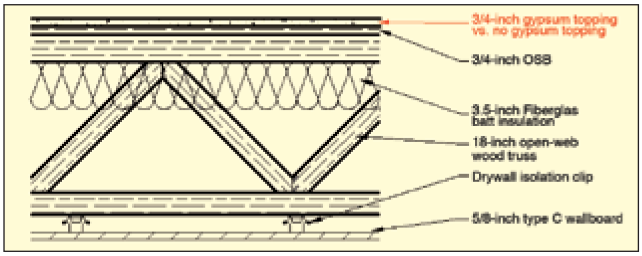

Figure 4. 3/4-inch gypsum topping layer vs. no gypsum topping layer assembly.

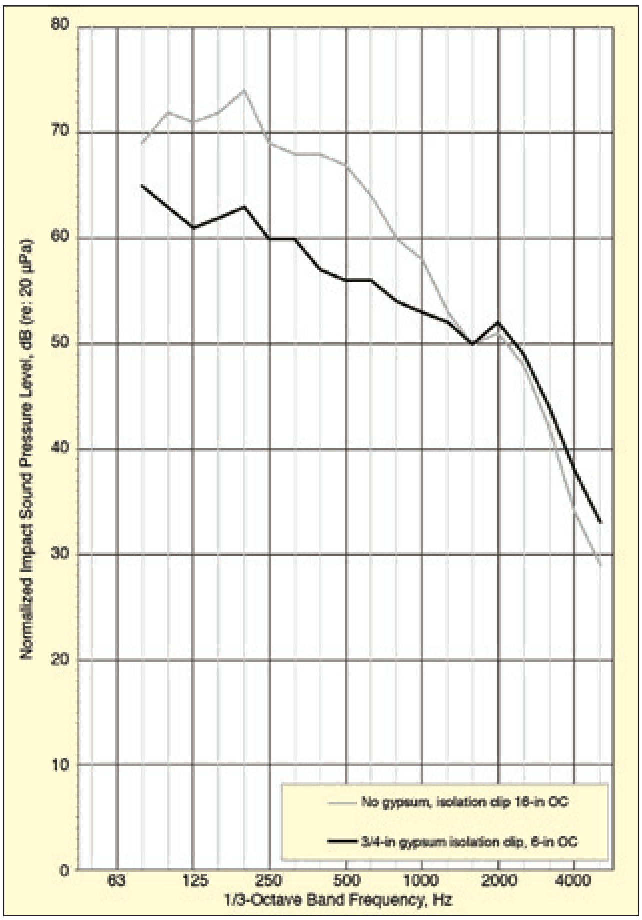

Figure 5. 3/4-inch gypsum topping layer vs. no gypsum topping layer NISPL plot.

throughout testing but varied slightly when the channel spacing was increased from 16 to 24 inches.

Normalized-impact sound pressure level (NISPL) measurements were obtained at 1/3-octave band intervals between 50 Hz and 10 kHz as described in the ASTM E492 standard for the various assemblies tested. The data were then plotted for comparison.

Results

Drywall Isolation Clips vs. Resilient Channel. This set of data compares the effects of using drywall isolation clips attached to 7/8-inch drywall furring channel vs. using typical resilient channel. Figure 2 shows the details of the assemblies tested.

The only change between these two tests and the associated data sets is the method of attachment of the gypsum wallboard ceiling to the bottom of the open-web truss. Figure 2 illustrates the location of the drywall isolation clip/resilient channel. Both the resilient channel and drywall isolation clip furring channels were spaced at 16 inches on-center (OC) to compare similar points of attachment. There was no finished floor covering in either of these tests; therefore, the tapping machine was placed directly on the gypsum concrete.

Figure 3 shows the NISPL comparison plot of the assembly with drywall isolation clips vs. resilient channel at 1/3-octave band intervals.

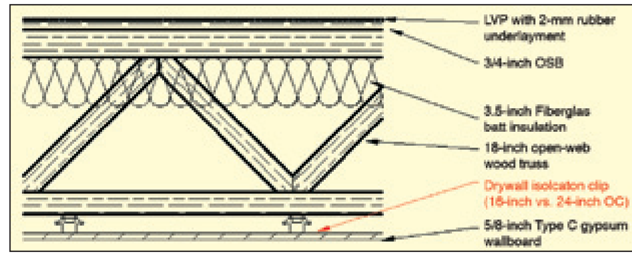

Figure 6. Drywall isolation clips 16-in OC vs. drywall isolation clips 24-in OC assembly.

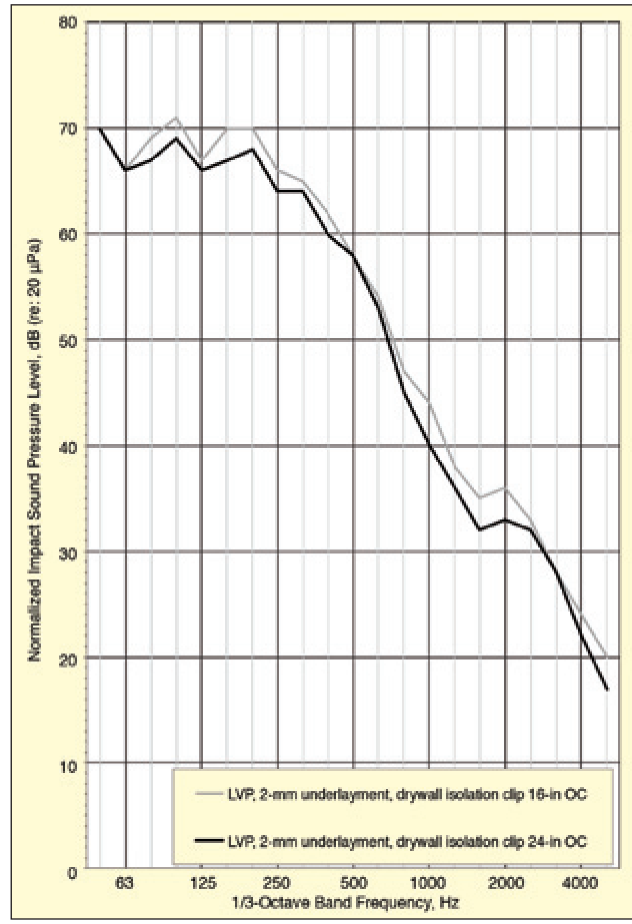

Figure 7. Drywall isolation clips 16-in OC vs. drywall isolation clips 24-in OC impact SPL plot.

Gypsum Topping Layer vs. No Gypsum Topping Layer. This set of data compares the effects of the assembly with and without a gypsum topping layer. Figure 4 shows the details of the assemblies tested.

The only change between these two tests and the associated sets of data is the presence of the 3/4-inch gypsum topping layer. The gypsum wallboard ceiling was attached with 7/8-inch drywall furring channel supported by drywall isolation clips. The gypsum topping layer had a compressive strength of 2000-3200 psi when tested to ASTM C472.[3,4] Figure 4 illustrates the location of the gypsum topping layer. The assembly was first tested with the gypsum topping layer. The topping layer was then removed, and the assembly was tested directly on the OSB subfloor.

Figure 5 shows the NISPL comparison plot of the assembly with the gypsum topping layer and without at 1/3-octave band intervals.

16-in. OC vs. 24-in OC Drywall Isolation Clips. This set of data compares the effects of using drywall isolation clips with two different channel spacing configurations. Figure 6 shows the details of the assemblies tested.

The assembly that is compared differs only in the spacing of the furring channels that are attached to the drywall isolation clips. The channel spacing configurations of 16-inch OC and 24-inch

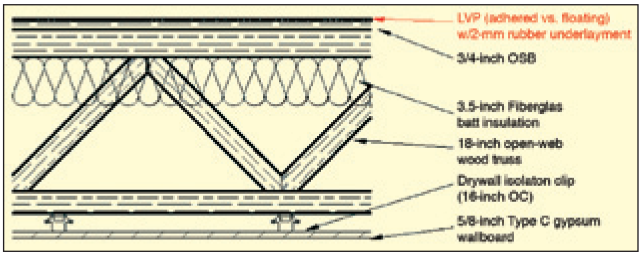

Figure 8. Floating LVP vs. adhered LVP assembly.

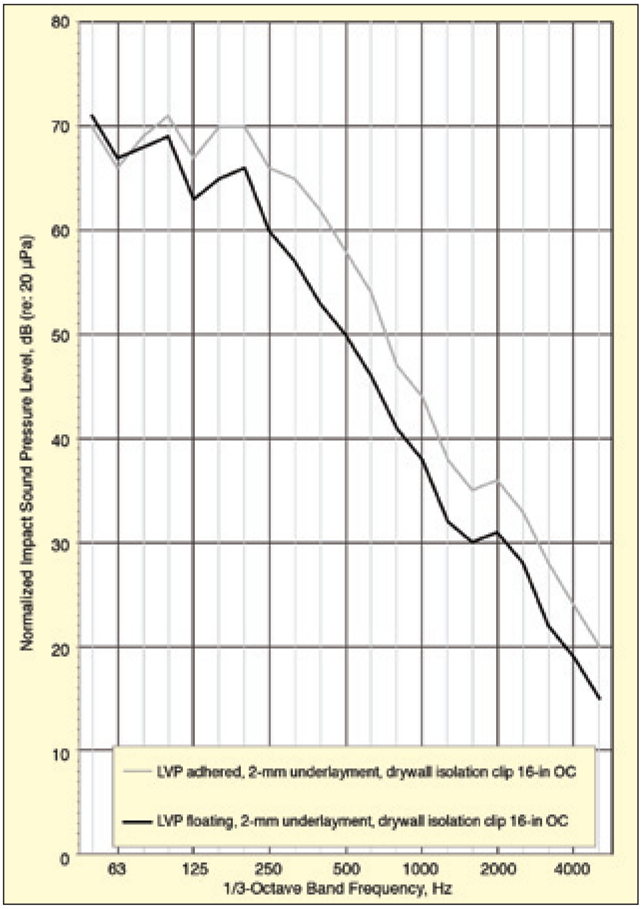

Figure 9. Floating LVP vs. adhered LVP NISPL plot.

OC were compared. This test set has a 2-mm rubber underlayment with luxury vinyl plank (LVP) on top, which makes up the finished floor above the 3/4-inch OSB subfloor. The 16-in OC setup had 32 clips for the 120 ft^2 test assembly, and the 24-in OC setup had 24 clips for the 120 ft^2 test assembly.

Figure 7 shows the NISPL comparison plot of the 16-in OC drywall isolation clip spacing assembly vs. 24-in OC drywall isolation clip spacing assembly at 1/3-octave band intervals.

Adhered LVP Finished Floor vs. Floating LVP Finished Floor. This set of data compares the effects of having an LVP finished floor adhered to the rubber underlayment below vs. having an LVP floating finished floor on the rubber underlayment below. Figure 6 shows the details of the assemblies tested.

Note that the LVP used for the floating test was a click-lock vinyl plank 4 mm thick. The adhered test was done with a 3-mm-thick vinyl plank. Every other component of the assembly was identical to those of the first assembly. The planks were adhered with a typical urethane-based adhesive. Both vinyl planks had similar stiffness and mass.

Figure 9 shows the NISPL comparison plot of the floating LVP assembly vs. adhered LVP assembly at 1/3-octave band intervals.

Discussion

Drywall Isolation Clips vs. Resilient Channel. The data in Figure 3 show that the drywall isolation clip generally performs 1-2 dB better at low to mid frequencies and 2-6 dB better at higher frequencies than resilient channel. This is likely due to the added resilience and extra damping provided by the rubber isolator that is part of the isolation clip.

Gypsum Topping Layer vs. No Gypsum Topping Layer. The plot in Figure 5 shows that the main differences between having a 3/4-inch gypsum topping layer and not having a topping layer come at low to mid frequencies. In these 1/3-octave bands (between 80 and 1000 Hz), differences of 4-11 dB can be seen. This shows that lower frequency attenuation is improved by adding a gypsum topping layer. This is likely due to the stiffness and mass that is added to the assembly with the gypsum topping layer.

16-in. OC vs. 24-in OC Drywall Isolation Clips. An improvement can be seen across low- and high-frequency 1/3-octave bands when the spacing of the furring channels is increased. The data show that reducing the number of clips used (and therefore the number of contact points between the gypsum wall board ceiling and trusses), produces a significant reduction in impact SPL at lower frequencies. By reducing the number of clips, the overall stiffness of the drywall/clip system is reduced. For a simple spring/mass system, the natural frequency is determined by Equation 1:

$$f = \frac{1}{2\pi}\sqrt{\left(\frac{k}{m}\right)} \qquad (1)$$

where f is the natural frequency, k is dynamic stiffness and m is the mass.

Since the mass of the ceiling remains constant and the stiffness of the clips is reduced by a factor of 0.75, the natural frequency is reduced by a factor of 0.87. This reduction shifts the transmissibility curve over slightly, which corresponds to the reduction in the NISPL. These results are important, because the particular clip used in this testing needs only to be placed at 24 inches to meet certain Underwriter's Laboratory (UL), fire-rated, assembly requirements.

Although no test was performed between a similar resilient channel assembly (spaced at 16 inches OC as required by UL) and a drywall isolation clip assembly (spaced at 24 inches OC as required by UL), it is likely that more improvement would be seen than that shown.

Adhered LVP-Finished Floor vs. Floating LVP-Finished Floor. When comparing the effects of adhering the LVP to that of floating the LVP, it can be seen from Figure 9 that a significant improvement comes from floating the LVP. Very-low-frequency performance is similar, but around 80 Hz, the curves on Figure 9 start to deviate in favor of the floating LVP. This could be because the floating floor is able to attenuate energy due of its freedom to vibrate independently of the structure below. An adhered LVP will likely be more prone to pass vibrations to the structure beneath.

Conclusions

Although many of the impact isolation strategies are well known in the acoustical community, it is still interesting to see that acoustical assemblies do in fact perform as expected in a laboratory setting. By minimizing laboratory variation, a true comparison of minor changes in an assembly can be made. This is the only way such assembly variations can be assessed. It was evident that drywall isolation clips perform better than a resilient channel, which is not surprising given the added resiliency and damping.

The performance of the assembly showed better impact isolation with a gypsum topping layer. This is also expected due to the added mass and stiffness that the topping layer adds to the assembly. By decreasing isolation clip spacing, performance was shown to increase due to the decrease in dynamic stiffness of the drywall attachment. Testing a floating LVP floor vs. an adhered LVP floor shows greater performance for the floating LVP floor. This is likely because of its ability to attenuate energy due to the physical isolation from the structure below.

Overall, this series of tests was successful in showing the differences of changing various components in a lightweight wood-frame assembly in a laboratory setting. Furthermore, these comparisons must be conducted in the same laboratory and on the same base assembly without removing or disturbing the base assembly and within a short period of time.

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