THE EFFECTS OF ACOUSTICAL CEILING PANEL TYPE AND PENETRATIONS FOR SERVICES ON VERTICAL SOUND ISOLATION INSIDE BUILDINGS

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1 Introduction

Preventing noise from transmitting between enclosed rooms is important inside buildings. Inter-room noise isolation applies to enclosed rooms horizontally adjacent to one another on the same floor as well as between vertically adjacent rooms on different floors. Much is known about constructing partitions to achieve the desired level of noise isolation. There have been multiple, comprehensive studies on the noise isolating performance of partitions.[1] There is far less information and test data about the noise isolation performance of floor-ceiling assemblies, especially in nonresidential buildings with concrete floors and suspended acoustic panel ceilings below them.

Without these tests, architects and acousticians have resorted to a few general 'rules of thumb.' One of these is to achieve greater vertical noise isolation—the acoustic ceiling panels suspended below the concrete slab should,

1. be made of a certain material, such as mineral fiber;
2. have a certain minimum weight of 5 kg/m2 (1 psf); and
3. have a minimum ceiling attenuation class (CAC) of 35.

Recent testing used a consistent, baseline, concrete floor slab and three suspended acoustic panel ceilings of different material types, weights, and acoustic performances to investigate the potential effects acoustic ceilings have on the noise isolation performance of floor-ceiling assemblies.

2 Method

Acoustic testing was performed at NGC Testing Services in Buffalo, New York, in January 2020 by a senior test engineer. The laboratory is accredited by the National Voluntary Laboratory Accreditation Program (NVLAP) (Laboratory Code 200291-0). STC tests were performed according to ASTM E90, *Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements,* and E413, *Classification for Rating Sound Insulation*.

A baseline STC test was performed on a 133-mm (5 ¼-in.) thick, normal weight, concrete floor slab (293 kg/m^2/60 psf) poured onto a steel deck with 38-mm (1 ½-in.) deep flutes (20 kg/m^2/2 psf). Vinyl composite tile (VCT, 4 kg/m^2/0.80 psf) flooring was adhered to the top of the concrete slab. The total weight of the floor construction was 307 kg/m^2 (62.8 psf). There was no acoustic panel ceiling suspended below the floor construction for the baseline test. Following the baseline test, a standard, 24-mm (15/16-in.), metal, tee-bar, ceiling grid was installed 508 mm (20 in.) below the concrete floor and remained in place for all subsequent STC tests.

Three different types of acoustic ceiling panels were installed in the suspension grid and tested independently. All three ceiling panel types were 610 mm (24 in.) wide (nominal) x 610 mm (24 in.) long (nominal) x 19 mm (3/4 in.) thick (nominal) with painted white finishes and square, lay-in edges. The main differences between the ceiling panel types were the core material types, panel weights, and acoustic performances.

	Material	Weight
Ceiling panel type 1	Mineral fiber	5.37 kg/m^2 (1.10 psf)
Ceiling panel type 2	Stone wool	3.37 kg/m^2 (0.69 psf)
Ceiling panel type 3	Glass fiber	1.86 kg/m^2 (0.38 psf)

CAC is a measure of a ceiling panel's ability to attenuate noise transmitting through a room's acoustic ceiling, over a partition terminating in height at the level of the suspended ceiling (creating a shared plenum space above the ceiling) and back down through the acoustic ceiling in the adjacent room. It is a double-pass rating as the sound passes through the ceiling two times. While CAC is not applicable directly to single-pass vertical noise isolation in the presence of a contiguous concrete slab, ratings are provided because industry rules of thumb, even though not technically accurate, include the use of CAC 35+ panels to help with controlling vertical transmission of noise through floor-ceiling assemblies. The CAC ratings of the ceiling panels ranged from 20 to 35, representing the most common performance range used in the industry.

The noise reduction coefficient (NRC) is the amount of sound absorbed by a surface like an acoustic ceiling panel. It varies between 0.0 (no sound absorption) and 1.0 (a lot of sound absorption). Ceiling panels with higher NRC ratings decrease noise levels and reverberation, making speech in enclosed rooms more intelligible and preventing noise from traveling farther distances in open spaces. The NRC ratings of the ceiling panels ranged from 0.75 to 0.95. This range represents the mid to high range available in the industry. Low performing panels of NRC 0.70 and below were excluded.

Two series of STC tests were performed. For the first series, all suspension grid modules were filled with only the acoustic ceiling panels. There were no light fixtures or air distribution devices implemented into the ceiling systems. For the second series of tests, nine ceiling panels were replaced by six recessed light troffers, two plaque-style supply air diffusers, and one eggcrate-style return air grille. These two series of tests, with and without building service penetrations, were conducted so that any effects of the noise leaking through the penetrations on overall vertical noise

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isolation, such as would be the case in real buildings, would be documented.

3 Results

TL and STC results are provided in Figure 1 (no penetrations in the ceilings for building systems devices) and Figure 2 (penetrations in the ceilings for building systems devices). The baseline concrete on steel deck with VCT flooring on top rated STC 47, which is three points below the minimum STC 50 requirement in standards such as the Facility Guidelines Institute (FGI) for healthcare buildings and ANSI/ASA S12.60, *Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools.*

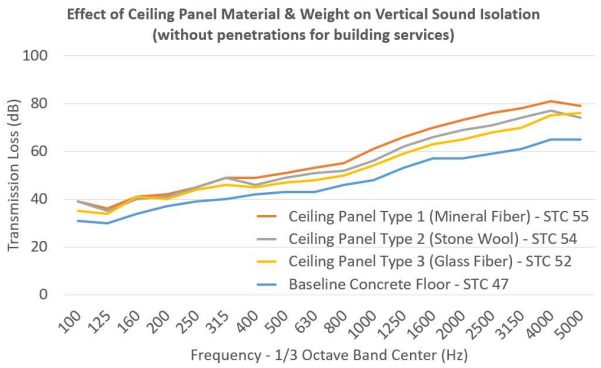

Figure 1: All three acoustic ceiling panel types increase noise isolation performance (STC 52-55) compared to the concrete floor slab alone (STC 47) and higher than the STC 50 rating in the standards. Without penetrations in the ceiling for building services, the variance in performance amongst the three ceiling types (3 STC points) was only slightly larger than when the penetrations were included (2 STC points).

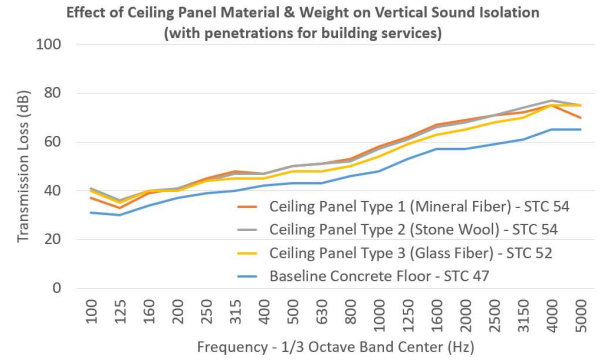

Figure 2: All three acoustic ceiling panel types increase noise isolation performance (STC 52-54) compared to the concrete floor slab alone (STC 47) and higher than the STC 50 rating in the standards even with the penetrations for building systems.

Adding an acoustic ceiling to the baseline floor increased the STC rating of the assembly, on average, six and a half STC points. Adding any of the three acoustic ceiling panel types resulted in assembly ratings that were two to five STC points higher than the minimum STC 50 in the standards. The three ceiling panel types varied by only three STC points when there were no penetrations for building systems and differed by only two STC points when the penetrations for lights, supply air, and return air were present.

4 Discussion

The results in Figures 1 and 2 show that, while adding a suspended acoustic ceiling below a concrete slab makes a significant improvement in noise isolation (STC), the actual type of ceiling panel (core material, weight, CAC rating, NRC rating) does not have a meaningful impact. While some might initially consider the two STC point difference for panel type 1 compared to panel types 2 and 3 meaningful, the author suggests the difference is immaterial and imperceptible, especially when considering the precision and bias of the test method as defined in the standard.

Adding an acoustic panel ceiling below the slab, on average, increases the vertical noise isolation six-and-a-half STC points. Since absorption in the rooms below may also be required to comply with maximum permissible reverberation times or minimum ceiling NRC ratings in the standards, the addition of an acoustic panel ceiling appears to be the wise approach for complying with both the vertical noise isolation and interior room acoustic requirements.

Since the acoustic ceilings, on average, increase the noise isolation performance of the floor-ceiling assembly to STC 53 to 54, three to four STC points higher than the goal STC 50 minimum in the standards, the thickness and weight of the concrete slab used in these tests could be decreased.

5 Conclusions

Testing shows current design rules of thumb, namely that acoustic ceiling panels should be of a certain material type, weight, or CAC rating for improved vertical noise isolation, do not hold true. In fact, these rules may be leading to worse overall acoustic conditions for building occupants and noncompliance with the absorption or reverberation time requirements if the ceiling panels have a low NRC of 0.70 or less.

While selecting and specifying acoustic ceiling panels for buildings, design professionals should focus on selecting the appropriate high NRC rating. [2] As long as the acoustic panel ceiling is included in the design, architects can be confident the ceiling panel material, weight, and CAC rating is not important to the overall floor-to-floor, airborne, noise isolation performance of the floor-ceiling assembly.

Acknowledgements

Gratitude is extended to Rockfon® and ROCKWOOL® for taking an interest in and dedicating resources toward furthering our industry-wide understanding of how sound and architecture interact.

References

[1] California Department of Health Services, *Catalogue of STC and IIC Ratings for Wall and Floor/Ceiling Assemblies*, Western Wall and Ceiling Contractors Association.

[2] Madaras, G. Specifying Ceiling Panels with a High NRC. *The Construction Specifier,* February 2020.