EFFECTS OF NOISE FLANKING PATHS ON CEILING ATTENUATION CLASS (CAC) RATINGS OF CEILING SYSTEMS AND INTER-ROOM SPEECH PRIVACY

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1 Introduction

As a potential cost savings in some buildings, interior walls are stopped at the height of a suspended, modular ceiling. They do not extend full-height up to the structural floor slab or roof above. As a result, sound potentially can transmit more easily from room to room via the open plenum above the ceiling. The sound blocking capacity of the ceiling system then becomes an important factor in the overall room-to-room sound isolation. Ceiling manufacturers test the sound blocking capacity of their ceiling panels and report the results as ceiling attenuation class (CAC) ratings. However, suspended, modular ceilings typically have recessed light fixtures, open return air grilles, supply air diffusers and other miscellaneous penetrations for sprinkler heads, loudspeakers, security/surveillance devices and Wi-Fi devices. These openings and penetrations in the ceiling system create noise flanking paths whereby noise transmits more easily from room to room. The existence of these noise flanking paths are well-known in the architectural acoustics industry. One study[1] conducted by the Institute for Research in Construction, part of the National Research Council Canada, states that some ceiling systems provide little attenuation, and even if panels with high transmission loss are used, the attenuation commonly is limited by leaks (*i.e.*, noise flanking paths) such as openings for airflow. That study found that an opening in the ceiling of only 305 millimeters (mm) by 305 mm (1 square foot) decreased room-to-room isolation by up to 10 dB in the 2 kilohertz (kHz) and 4 kHz octave bands.

2 Method

A series of five CAC tests was performed per ASTM E 1414 and E 413 on various suspended, modular ceiling systems in a dual-room chamber with a common plenum above the ceiling. The tests were performed in Buffalo, New York, USA at NGC Testing Services (National Voluntary Laboratory Accreditation Program code 200291-0). The initial test represented how ceiling manufacturers typically test their ceiling panels. The test specimen comprised just the suspension grid and ceiling panels with no additional noise flanking paths. Subsequent tests had either one or more common noise flanking paths caused by light fixtures or air distribution devices.

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2.1 Ceiling Panels & Suspension System

The ceiling panels used in this study were common, white, wet-formed, mineral fiber ceiling panels measuring 610 mm (24") (nominal) in length and width and 19 mm (3/4") thick with square, lay-in edges. Their weight was approximately 5 kilograms per square meter (kg/m^2) (1 pound per square foot). They have a marketed noise reduction coefficient per ASTM C 423 of NRC 0.70 and a marketed ceiling attenuation class of CAC 35. The measured rating was CAC 37, two points higher than the marketed value.

All of the ceiling systems used a standard 24 mm (15/16") wide, 38 mm (1-1/2") high, steel, tee-bar suspension grid. It was installed in the laboratory test chamber so that a grid member ran along the center of the demising wall in the middle of the test chamber. Ceiling panels did not span across the center wall of the chamber. The grid ran continuously over the center wall of the chamber. It was not disjoined at the center wall.

2.2 Air Distribution System

The return air grilles were aluminum, 610 mm (24") (nominal) in length and width and had a 13 mm (1/2") by 13 mm (1/2") by 13 mm (1/2") open, egg-crate grille.

The square, plaque, supply-air diffusers were 610 mm (24") (nominal) in length and width by 89 mm (3-1/2") high. They were steel with a white powder coat finish and had a 254 mm (10") round duct connection. The supply air diffusers positioned in the adjacent sides of the test chamber were connected with supply air ductwork. A rigid metal duct measuring 406 mm (16") wide by 305 mm (12") high by 3658 mm (12') long and with no internal or external lining ran through the plenum from one side to the other over the demising wall. The supply diffusers were connected to the rigid metal duct above with insulated, round, flexible ducts with a 254 mm (10") inside diameter.

2.3 Lights

The light fixtures were general purpose T8 troffers and were 610 mm (24") (nominal) in length and width. They had an eggcrate louvre with openings that were 19 mm (3/4") by 19 mm (3/4") by 13 mm (1/2") high. No bulbs were installed in the lights and they did not have electrical connections. These were judged to have no effect on the parameters being studied.

2.4 Overall Layout

Figure 1 shows the reflected ceiling plan of the last test specimen with the locations of all air distribution devices and light fixtures. Each room of the test chamber had one return air grille, one supply air diffuser and four lights.

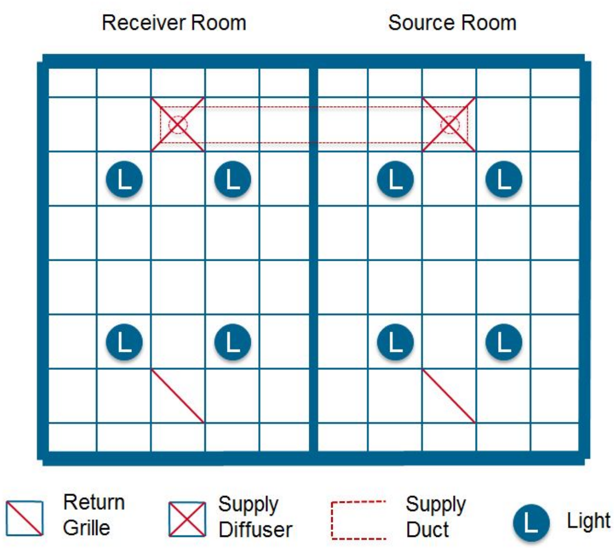

Figure 1: Reflected ceiling plan of the final ceiling system tested showing locations of the air distribution and lighting devices.

3 Results

A series of five CAC tests was performed by NGC Testing Services. The first ceiling system tested had no additional noise flanking paths; the suspension grid was filled only with ceiling panels. After this baseline test, each of three noise flanking paths (*i.e.*, lights, supply air system and return air grilles) was tested independently. Finally, all noise flanking paths were tested together. Figure 2 shows the test results in graphic form.

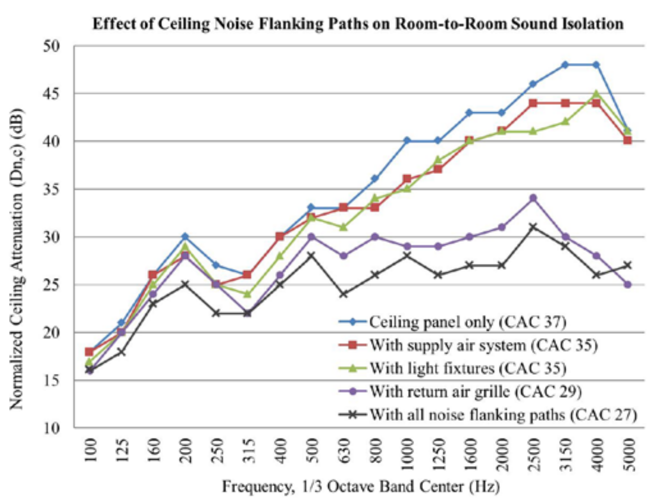

Figure 2: Normalized ceiling attenuation (transmission loss) values by 1/3 octave band for the various ceiling systems tested.

4 Discussion

The results of this study confirm that common noise flanking paths in ceiling systems created by light fixtures, supply air diffusers/ductwork and open return air grilles decrease room-to-room sound isolation compared to a ceiling system of only ceiling panels and suspension grid. The light fixtures and supply air system each degraded the room-to-room sound isolation by two CAC points. The degradation at each 1/3 octave band in the upper frequencies (800 Hz and above) was the largest and averaged 3 dB. At some frequencies, the degradation was as much as 5-6 dB.

The open return air grille resulted in a much greater degradation of room-to-room sound isolation. CAC decreased from 37 to 29 points. The degradation in the upper frequencies averaged 13 dB and at some frequencies was as much as 18-20 dB. This is subjectively equivalent to making the noise four times louder in the upper frequencies.

Combining all three flanking paths degraded the sound isolation even further. CAC decreased to 27, 10 points lower than for the ceiling panels without noise flanking paths. The degradation at the upper frequencies averaged 15 dB and at some frequencies was as much as 19-22 dB.

5 Conclusions

It can be concluded that common elements such as lights, air diffusers and grilles degrade the blocking capacity of the ceiling system and the resulting room-to-room sound isolation. The light fixtures and supply diffusers degraded the isolation to a lesser extent than did the return air grilles. However the lights and supply diffusers did contribute to further degradation when combined with the return air grilles. Overall, the noise flanking paths degraded wideband isolation 2-10 CAC points. More importantly though, they degraded high frequency isolation (1,000 Hz octave band and above), which is more relevant to whether speech is intelligible or not, by 15-22 dB. This is subjectively equivalent to making the transmitted speech four times louder.

Designers, specifiers, contractors and building owners should be aware of the common noise flanking paths that result from lights and air distribution devices in ceiling systems and the resulting degradation of sound isolation and speech privacy. They should not base their expectations of speech privacy on the CAC rating of the ceiling panel alone. Relying solely on a suspended, modular ceiling system with penetrations for sound isolation is a risky design approach.

References

[1] R.E. Halliwell and J.D. Quirt, Controlling Interoffice Sound Transmission through a Suspended Ceiling, *J. Acoust. Soc. of Am.*, **90** (3), September 1991.