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Optimizing Office Acoustics

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Optimizing Acoustics in Offices

By Gary Madaras, PhD, Assoc. AIA

Every day, people complain about the acoustic environments in the office buildings where they work. This is supported by the Center for the Built Environment at the University of California (UC) Berkeley, which maintains one of the most extensive post-occupancy building survey databases in the world. It reports noise levels and lack of sound privacy are among the factors leading to the most dissatisfaction in offices, and concludes "one of the most important parameters related to overall building satisfaction is satisfaction with noise level."[1]

Studies show 90 per cent of an organization's operating expenses are staff-related, and 62 per cent of the time they need to do quiet work.[2] This means acoustics affect 90 per cent of an organization's resources 62 per cent of the time.

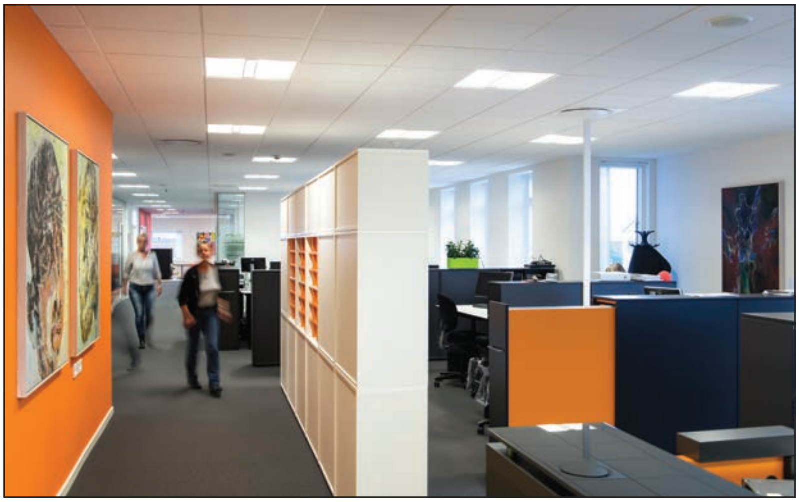
The old way of approaching office acoustics no longer works. This is partly due to the fact office buildings themselves have changed in significant ways. Walls have come down, creating large, open-concept spaces. There is now an abundance of glass and hard-finish floors, and the days of private offices, low ceilings, carpeting, high workstation dividers, and cushy furnishings are mostly gone.

At the same time, there are now stringent acoustic criteria in standards, guidelines, and building rating systems. For example, both the WELL Building Standard and the Leadership in Energy and Environmental Design program (LEED) v4 now require minimum performance levels of sound absorption and sound isolation in office buildings. As these are revised during the coming years, the required amounts of sound absorption and levels of sound blocking are likely to be set even higher, as has happened for other types of buildings such as schools and healthcare facilities. Further revisions seem likely—just four years ago, LEED did not even address office acoustics and the WELL Building Standard did not exist.

Back in the 1960s, ’70s, and ’80s, the typical office building layout featured long corridors and enclosed offices around the building’s perimeter. Floors were carpeted, and ceilings were low. Acoustical ceiling panels generally had poor sound absorption properties (*i.e.* a noise reduction co-efficient [NRC] of 0.50 to 0.65). Some conference rooms and boardrooms had decorative or tackable fabric wall surfaces that offered some sound absorption, but this alone was not enough.

To save money, demising walls sometimes stopped at ceiling height instead of extending up to the underside of the floor above. People physically attended meetings behind closed doors, as tele- and online-conferencing technology had not yet been introduced to the mainstream. As technology has changed office work, architectural design trends have led to significantly different spaces, and views on acoustic design should be revamped as well.

First and foremost in optimizing acoustic design is understanding the roles of walls and ceilings. Next, it is crucial to utilize the strengths of these features and avoid their weaknesses.

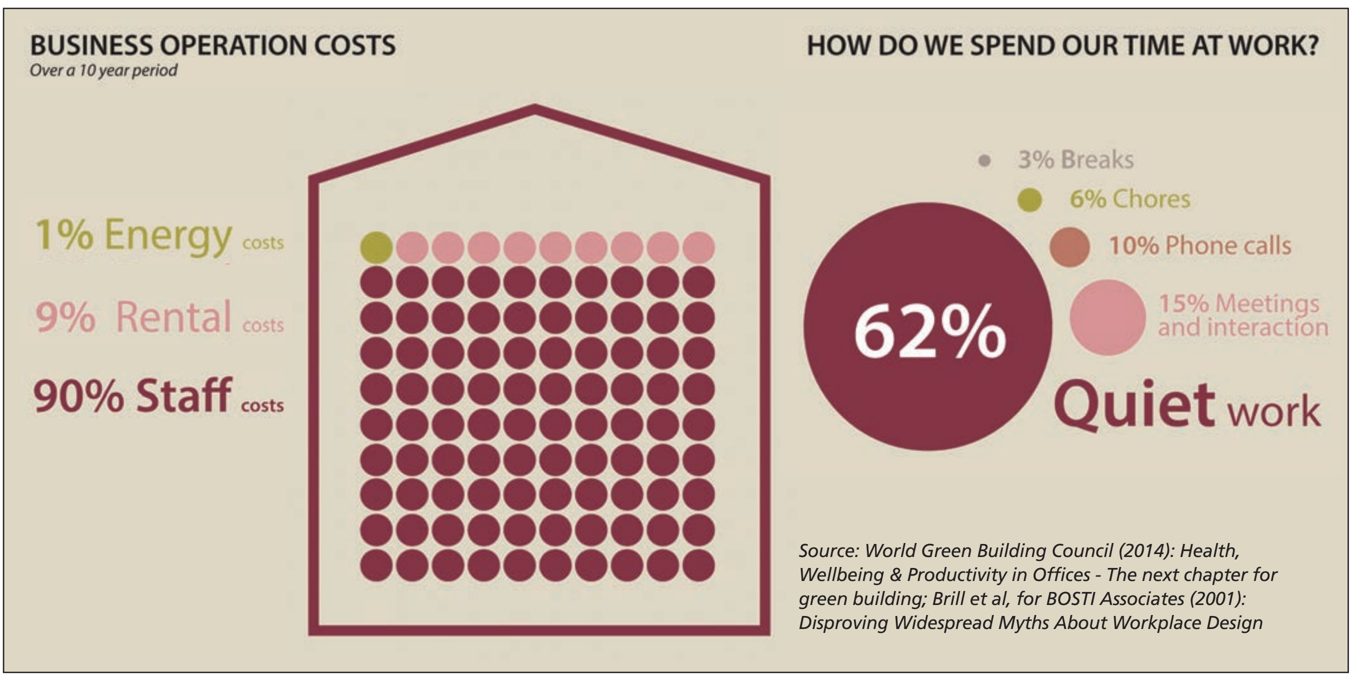


Modern offices largely tend to be open spaces. This means the role of the ceiling is one of high-performance sound absorption.

Ceilings are sound-absorbers

Acoustic ceiling panels are lightweight, weighing approximately 4.9 kg/m^2 (1 lb/sf) or less. They are fibrous and porous, which makes them great at absorbing sound. Modern ceiling panels can offer far greater sound absorption than those used decades ago. Materials achieving NRC ratings of 0.90 or higher are considered high-performing, and should be used in large, open areas where medium to large groups of people work or gather.

The WELL Building Standard requires that 100 per cent of the ceiling over open offices or collaboration spaces be at least NRC 0.90, but not



Studies show acoustics is integral to productivity, affecting 90 per cent of a company’s resources 62 per cent of the time.

Photo © Bochler Creative (Burlington, Ont.). Photo courtesy Rockfon

A high-performing, sound-absorptive ceiling with a noise reduction co-efficient (NRC) of 0.90 or higher is necessary, given today's general architectural trend toward more open spaces and sound-reflective wall and floor materials.

all spaces need values this high. Conference rooms, boardrooms, and training rooms can have ceilings with NRC ratings of 0.80 as long as the floor is also carpeted. In the past, a conference room with carpeting and acoustic wall panels may have required an NRC of only 0.60 for the ceiling—but if the carpeting and wall panels are removed, the ceiling now needs an NRC of 0.90 to maintain the same reverberation time. Private offices can have ceiling panels as low as NRC 0.70, but no one should use a ceiling panel below this level if people regularly occupy the space.

Modular acoustic ceiling systems are not massive enough to block sound. Additionally, ceilings are always penetrated by lights, open-air grilles, or loudspeakers that allow sound to leak through. This can likewise happen via gaps between the panels and the suspension grid. In fact, noise leaks can degrade the sound-blocking capability of the ceiling system by more than 20 decibels (dB) in the high frequencies that establish whether speech from an adjacent room is intelligible or disruptive.[3] If a sound is increased by 20 dB, it is subjectively perceived as being four times louder. Thus, a suspended acoustic ceiling should never be considered as a device for blocking sound. Ceilings are for sound absorption.

Walls are sound-blockers

Walls are constructed of dense, relatively nonporous materials such as gypsum board, concrete, and masonry. They are also painted, which seals the pores even further. It is this mass and impenetrability that make walls excellent at blocking sound and conversely poor at sound absorption. Walls are for sound-blocking.

Stopping wall construction at the height of the ceiling, leaving an open plenum above rooms, and relying on the ceiling to block sound is an antiquated approach. This strategy is not permitted in current standards, guidelines, and building rating systems because it does not work effectively. In the past, some designers sacrificed absorption by accepting lower NRC values of 0.50 to 0.65 so they could have a ceiling panel with a higher ceiling attenuation class (CAC) rating of 30 to 35.

CAC is the metric that indicates a ceiling panel's ability to block sound as it goes through the ceiling, over a partial-height wall, and back down through the ceiling in an adjacent room (*i.e.* double-pass). CAC only existed because of this compromised design approach, and may not be around much longer. It is no longer used in acoustic standards, guidelines, and rating systems.

The additional costs associated with extending the wall past ceiling height to the underside of the floor above is not always within the project construction budget. There is an alternative, optimal approach that achieves the desired acoustic performance at a significantly lower cost. Instead of extending up the entire wall construction, a lightweight plenum barrier can be installed vertically above the lower wall, which then blocks off the plenum acoustically. When combined with the use of a suspended ceiling, this approach provides effective sound blocking at the higher levels required by standards, guidelines, and building rating systems.

There are different material options for plenum barriers, some of which are likely to already be on the project site, such as a single layer of 16-mm

Figure 1

In selecting the optimal noise reduction co-efficient (NRC) for the ceiling in a room, one must consider both the potential for noise inside the room and the sensitivity of its occupants to noise.

NRC - Optimizing Good, Better, Best

Sensitivity to Noise	Low	Medium	High
High	BETTER NRC 0.80	BEST NRC 0.90	BEST NRC 0.90
Medium	GOOD NRC 0.70	BETTER NRC 0.80	BEST NRC 0.90
Low	GOOD NRC 0.70	GOOD NRC 0.70	BETTER NRC 0.80

Amount of noise inside the room

Figure 2

To select the optimal sound transmission class (STC) rating for the walls between rooms, both the potential for noise in the adjacent room and the sensitivity of the room's occupants to noise should be taken into account.

STC - Optimizing Good, Better, Best

Sensitivity to Noise	Low	Medium	High
High	BETTER STC 45	BEST STC 50	BEST STC 50
Medium	GOOD STC 40	BETTER STC 45	BEST STC 50
Low	GOOD STC 40	GOOD STC 40	BETTER STC 45

Amount of noise in adjacent rooms

($^5/_8$-in.) thick gypsum board or 30-mm (1.2-in.) thick foil-faced stone wool insulation. The installation of these barriers does not always need to be time-consuming. Recent research shows that taping and caulking is not required to achieve a sound transmission class (STC) 40 level of isolation. Large holes around elements that penetrate the plenum barrier (*i.e.* ducts, pipes, and conduits) can simply be stuffed with fibrous insulation. An isolation level of up to STC 50 can be achieved if the plenum barrier is caulked or taped around the perimeter, along joints, and around penetrations.[4]

Optimizing acoustics in larger, more-open commercial office buildings and compliance with standards and guidelines begins with effective noise absorption.

Optimizing absorption

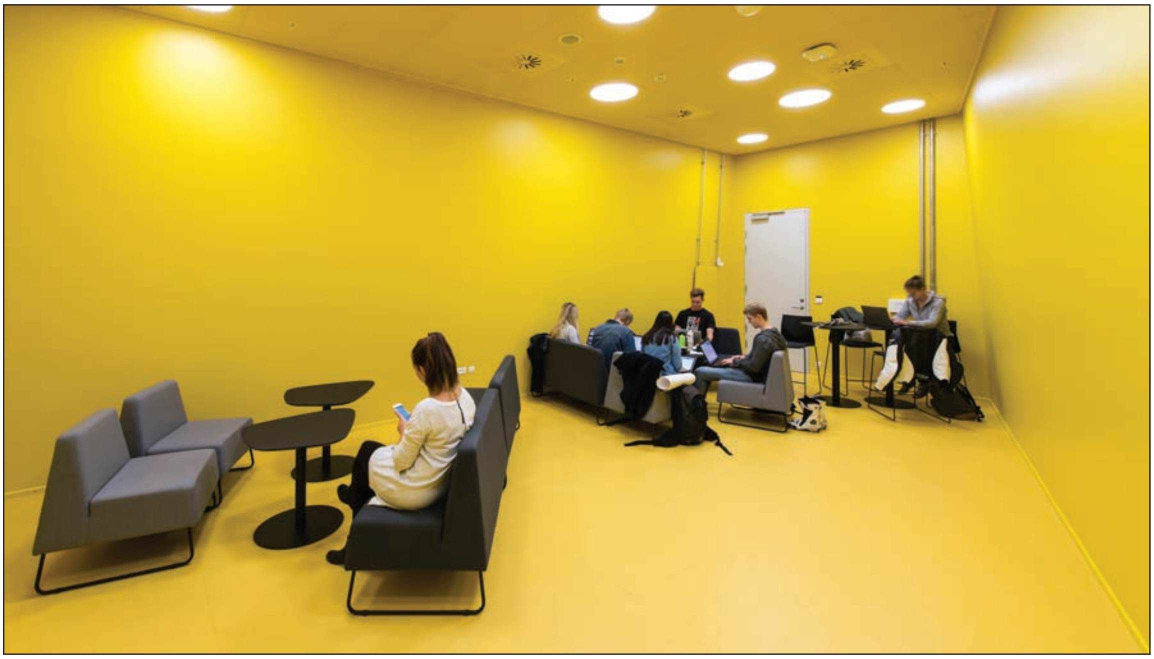
It is important to select the correct sound absorption level for the ceiling panels in each type of space. This value can come from the applicable standard, or from an acoustics consultant such as a member of the Canadian Acoustical Association (CAA).[5] Alternatively, it is possible to employ the optimizing absorption table (Figure 1) to determine the NRC value of the ceiling.

To use this table, first consider how much noise will be in the room (a low, medium, or high level). Will there be a lot of people or equipment generating noise inside the room? Next, one must consider how sensitive the occupants and the room function are to noise. For example, a call centre that handles prescription medication orders for those with age-related hearing impairment has both high potential for noise and high sensitivity to noise. Therefore, the optimal acoustic ceiling has an NRC of 0.90 or higher.

Optimizing blocking

After optimizing sound absorption for each type of space, the question of whether sound blocking is relevant or not should be considered. For many medium or large spaces containing a lot of people or equipment (*e.g.* airport concourses, retail spaces, restaurants, casinos, lobbies, and factories), sound blocking is not relevant. Where it is important, the optimizing blocking table (Figure 2) can be used.

It is best to begin by considering the potential for noise in adjacent spaces and ranking it as high, medium, or low. Then, one should consider how sensitive to noise the people using the space



In enclosed spaces, sound privacy criteria can be met by using walls and plenum barriers above the ceiling.

The shift away from enclosed office spaces has indirectly eliminated outdated ratings like ceiling attenuation class (CAC).

may be and how disruptive noise from adjacent spaces might be. For example, a special education classroom adjacent to a teacher's lounge demonstrates both high sensitivity and high potential for noise. The demising wall should therefore achieve an STC rating of 50. Stopping the demising wall at the ceiling level and relying on the ceiling alone to block sound (CAC 20 to 35) is insufficient by 15 to 30 dB.

Other considerations

This article has focused on the architecture in office buildings—primarily walls and ceilings. However, other factors also contribute to good acoustics. For instance, the building's mechanical, electrical, and plumbing systems need to be engineered for quiet operation. Fortunately, modern HVAC systems are much quieter than those used decades ago. The building also needs to be protected from exterior environmental noise, either by site selection, exterior noise control, or building façade noise control. Finally, audio, video, and sound masking systems—if used—need to be designed and installed correctly. These topics are beyond this article's scope, but should still be considered in the pursuit of truly optimal acoustics.

Conclusion

Optimizing the acoustics of future buildings is straightforward. First, one should select the optimal level of absorption: NRC 0.70 (good), NRC 0.80 (better), or NRC 0.90 (best). Next, it is important to determine whether sound blocking is required. If so, one should optimize the level of blocking: STC 40 (good), STC 45 (better), or STC 50 and higher (best). Effective blocking can be achieved by placing lightweight plenum barriers above the walls, along with high-NRC acoustic ceilings. When this acoustic design approach is followed, not only will satisfaction be improved, but so will productivity and comfort.

Those contributing to the design and construction of future office buildings must consider how they want to move forward. Will they be part of the solution that increases worker satisfaction in offices? Or will they continue doing things the same old way? Those just starting their careers may want to think about these topics and begin to discuss the new way forward when they see an old specification or wall detail sheet that has been used ineffectively for the past decade.

Notes

[1] M. Frontczak led a team in the completion of a study on the quantitative relationships between occupant satisfaction and satisfaction aspects of indoor environmental quality and building design for the Center for the Built Environment at Berkeley in January 2012.

[2] This comes from the World Green Building Council's 2014 publication, "Health, Wellbeing & Productivity in Offices–The next chapter for green building," and BOSTI Associates' 2001 report, "Disproving Widespread Myths About Workplace Design."

[3] A study on the effects of noise flanking paths on ceiling attenuation class (CAC) ratings of ceiling systems and inter-room speech privacy can be found in the proceedings of InterNoise 2015, co-written by A. Heuer and this article's author.

[4] A study on the optimizing of ceiling systems and lightweight plenum barriers to achieve CAC ratings of 40, 45, and 50, by the authors in note 3, may be found in the proceedings of Noise-Con 2016.

[5] For more information, visit the Canadian Acoustical Association at www.caa-aca.ca.

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