Whitepaper

Exploring the Link Between Building Acoustics, Health and Wellbeing

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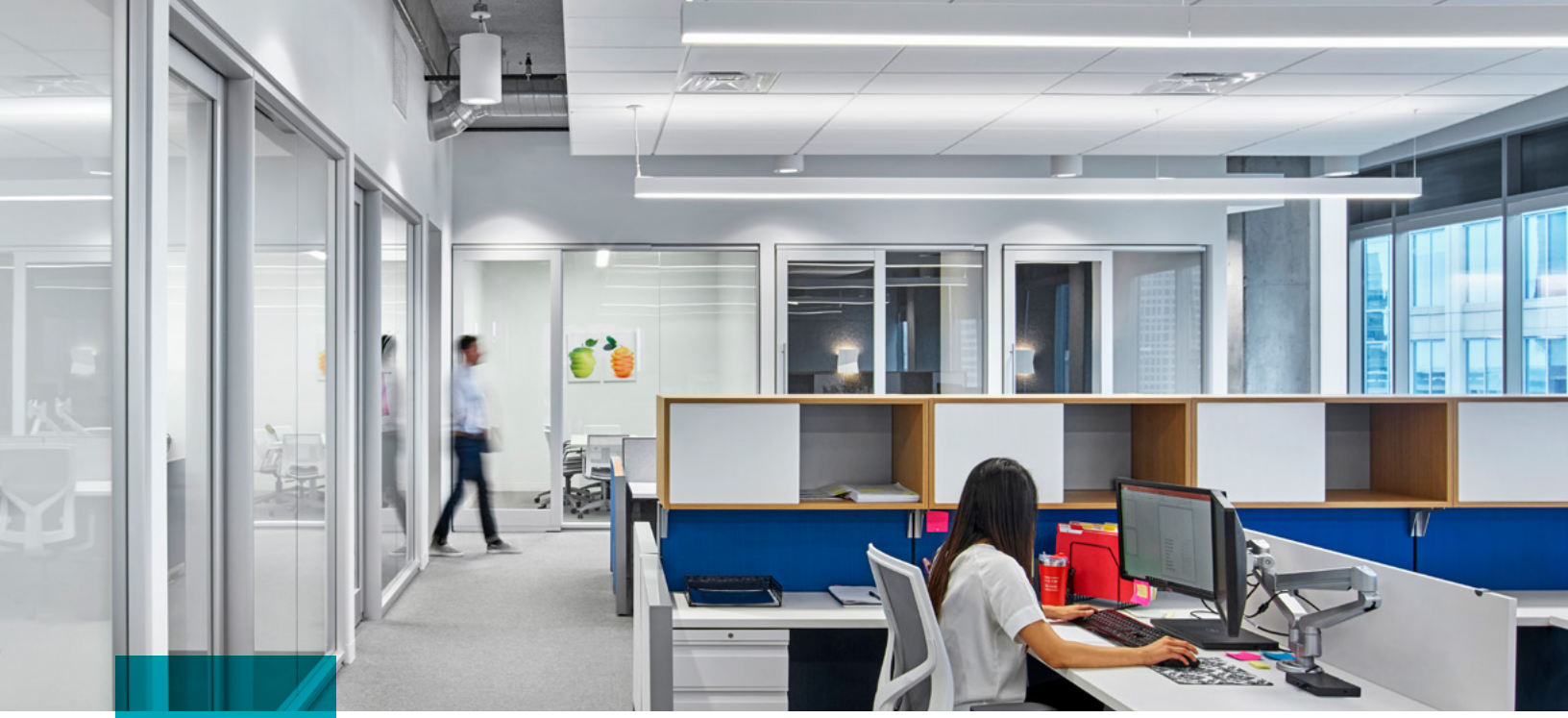


On average, people spend approximately 90% of their time inside buildings.[1] The design of buildings and how well they withstand use over time play a significant role in determining occupant health and wellbeing. But what aspects of buildings contribute the most to how people feel and ultimately their health and overall wellbeing? Most people think what buildings look like takes the top position, but they are incorrect.

"According to research, the sense of smell affects our mood the most, but if you take health and wellbeing also into consideration, peoples' sense of hearing is number one," explains Pascal van Dort[2], Global Acoustics Ambassador at Rockfon, a leading, global, acoustic ceiling manufacturer. "People tend to get use to sounds, but they do not realize the impact those sounds still have on their health, behavior and wellbeing. Understanding the sonic environment is absolutely fundamental."

A recent analysis of data from the Center for the Built Environment's Occupant Survey[3], which included over 90,000 respondents from approximately 900 buildings over a 20-year span, revealed a serious problem. While more than two-thirds of respondents were satisfied with their buildings overall, the majority were dissatisfied with these same buildings' acoustic performance. In fact, of all the metrics surveyed, dissatisfaction was highest with sound privacy (54% dissatisfied), temperature (39%), and noise level (34%). A disparity exists between goals for human health and wellbeing and how many buildings were designed acoustically in the past.

"As always, noise is a top concern amongst those that have been surveyed. It is the main source of workplace dissatisfaction," says Ethan Bourdeau who is the Sound Concept Lead for the Standard Development team at the International WELL Building Institute (IWBI). "According to the Leesman Index, 75% of employees feel that better acoustics are an important quality in an effective workplace, however only 30% of employees were satisfied with noise levels in their workplace."

Not everyone works in an office. A workplace can also be a school or medical care facility. "In poor acoustic environments, patient rehospitalization rates are higher," adds Dr. Jo Solet, Assistant Professor in Medicine, Harvard Medical School, Division of Sleep Medicine. "Noise can disrupt patient sleep and impair communication leading to medical errors. Acoustics impact clinical outcomes."

Acoustics Standards

Because of the well-established relationship between building acoustics in offices, schools and medical care facilities and the health and wellbeing of the occupants, most building standards, guidelines and certification systems have at least minimum or prerequisite acoustics requirements. Some also have additional requirements for enhanced or optimized acoustic environments. Key topics include controlling indoor noise and reverberation with high-performing, sound absorbing surfaces, isolating enclosed rooms from adjacent areas with robust walls and floor slabs and ensuring that background sound is not too loud or too quiet. In European countries, complying with these acoustic requirements is typically federally legislated while in North American countries, compliance is mostly voluntary. Greater understanding about how the acoustics requirements in these standards can materialize inside actual buildings can be gained from looking at specific examples of an office building, school and medical care facility.

Acoustic Terms	Europe	North America
Sound Absorption Amount of sound absorption provided by a surface or material between 0.0 (no absorption) and 1.0+ (high absorption)	**Alpha$_w$ (or α_w)** Weighted Sound Absorption Coefficient	**NRC** Noise Reduction Coefficient
Sound Isolation (Barrier) Amount of sound isolation provided in a laboratory test by an architectural barrier such as a wall or door	**R_w** Weighted Sound Reduction	**STC** Sound Transmission Class
Sound Isolation (Room) Amount of sound isolation provided between two rooms or spaces inside a building	**D_nT** Standardized Level Difference	**NIC** Noise Isolation Class
Reverberance How long (seconds) a loud sound persists inside a room until it decays to inaudibility (60 decibels)	**RT_{60} (or T_{60})** Reverberation Time	**RT_{60} (or T_{60})** Reverberation Time
Loudness How loud common sounds are as perceived by people	**dB(A)** A-weighted Decibels	**dB(A)** A-weighted Decibels

Offices

Skanska's Parallel office building[4] in the new development district Hovinbyen in Loren, Oslo, is Norway's first health-certified building. The focus for the new 19,500-square-meter (210,000-square-feet) building was to create a good working environment where employees thrive and feel comfortable and happy. This meant that the design of the building, including the products and materials inside, had to support a healthy indoor climate by limiting the use of chemicals with unhealthy emissions, promoting good natural lighting which also relates to energy efficiency, and optimizing the acoustic environment.

With occupant health and wellbeing at the forefront, Skanska identified achieving WELL Gold Certification as a priority. The WELL Building Standard by IWBI is a health and wellbeing focused building certification program with 11 concepts including *Air, Water, Light, Thermal Comfort* and *Nourishment*. The *Sound* concept has features, such as *Sound Reducing Surfaces, Reverberation Time* and *Sound Barriers* for which points toward WELL certification can be earned.

For example, maximum points are earned if the ceilings in open office areas have an Alpha$_w$ (Noise Reduction Coefficient) of 0.90 or greater and the reverberation times in conference rooms are no longer than 0.6 seconds. Compliance ensures that occupants in open office areas are not distracted too frequently by noises and conversations, leading to a more relaxed and productive setting. Similarly, people attending meetings in conference rooms, whether in person or remotely, can hear and be heard clearly without needing to repeat themselves.

Inside the Parallel office building, compliance with the noise absorption requirements in WELL's *Sound* features S04 and S05 was achieved by using suspended acoustic panel ceiling systems with high Alpha$_w$ (NRC) ratings and carpeting on the floors. Additionally, the ceilings were positioned at a traditional height, preventing excessive room volumes resulting in too much reverberance.

Schools

Education facilities have an equally important role in the health and wellbeing of students, teachers and administrative staff. "There's plenty of evidence out there that reduced literacy and numeracy occurs in education spaces with poor acoustic environments," states Amanda Robinson, Co-CEO of the global consultancy Marshall Day Acoustics and member of the IWBI Sound Advisory Committee. "Reading and math standards were 2.2 years lower for year 6 (6th grade) students in the noisiest schools. 37% of children with slight hearing loss repeat at least one year of school compared to only 3% with good hearing."

The WELL Building Standard Sound Concept requires that learning spaces have:

1. Noise Levels (S02)	35-40 dBA
2. Sound Barriers (S03)	Walls – R_w (STC) 55 and D_w (NIC) 50
3. Reverberation Time (S04)	0.6 seconds, rooms 283 cubic meters (10,000 cubic feet) or less
4. Noise Reducing Surfaces (S05)	$Alpha_w$ (NRC) 0.90 ceilings (100%) / 0.80 walls (25%)

Why is a good acoustic environment so important for students and teachers? "In a space with no acoustic treatment, the tails of some of the words start to run into the fronts of the other words and it really muddies the speech intelligibility," explains Robinson. "Effectively, if you can't hear, you can't learn – particularly for children. They don't have the linguistic skills to be able to fill in the blanks like adults do. By missing those key concepts, they have a hard time learning."

University of Toronto Scarborough Campus' new $52.5 million Environmental Science & Chemistry Building (ESCB)[5] welcomed its first students and teachers in 2015. It houses masters and doctoral programs addressing environmental issues, such as climate change, groundwater pollution in urban settings and rising sea levels. Conceived as a highly flexible research and teaching building, it connects laboratories and academic offices around a five-story, sky-lit atrium with access to a boardroom and meeting rooms. With respect to the promise of its discipline, the building achieves LEED® Gold certification through the Canadian Green Building Council.

LEED requires that learning spaces have:

1. Noise Levels	35-40 dBA
2. Sound Barriers	Walls - STC 50 between classrooms
3. Reverberation Time	0.6 seconds, rooms 283 cubic meters (10,000 cubic feet) or less
4. Ceiling Absorption	NRC 0.70 ceilings (100%) or equivalent absorption elsewhere

To ensure that the ESCB complied with the acoustic requirements in LEED, attractive, high-performing, suspended, acoustic ceilings with an $Alpha_w$ (NRC) of 0.90 were used in the meeting rooms, boardroom and atrium. Additionally, floors were carpeted and some wood walls were grooved to let the sound pass through and get absorbed by sound absorptive batts behind. Walls were constructed full height from structural floor to the undersides of the floors or roof above and according to the STC 50 requirement. This prevented noise from passing through a common plenum above the ceiling, which would occur if the walls stopped in height at the ceiling level – something neither the WELL Building Standard nor LEED permits.

In the ESCB's laboratories, which in a university building are still considered to be learning spaces according to LEED, the acoustic requirements were no less stringent than they are in standard classrooms. In addition, the laboratories had stringent requirements for clean rooms and contamination control. The use of porous, sound-absorbing materials on the floors and walls were not permissible. Instead, suspended acoustic ceilings with $Alpha_w$ (NRC) 0.90 had to control the noise levels and reverberation. Background noise generated by the building's mechanical systems was controlled below LEED's 40 dBA maximum using quiet equipment selection, slower air velocities and proper terminal devices.

"The reverberation time is the time it takes for sound to decay in a space, and it is very much related to the volume of the room as well as the surface finishes. For an education space, the reverberation time should be low, so less than 0.6 seconds for a typical classroom space," explains Robinson. "Speech at a meter is typically 60-65 dBA, and what we want to see is that the speech level is well above the background noise level of 35-40 dBA. The signal to noise differential should be at least 15 dB if not 20 dB."

Robinson concludes, "There are studies that show a strong correlation between higher education results and good acoustic environments. The United Kingdom was certainly a leader in this when they introduced legislated school standards back in 2003-2004. There was a clear improvement in learning outcomes there."

Healthcare

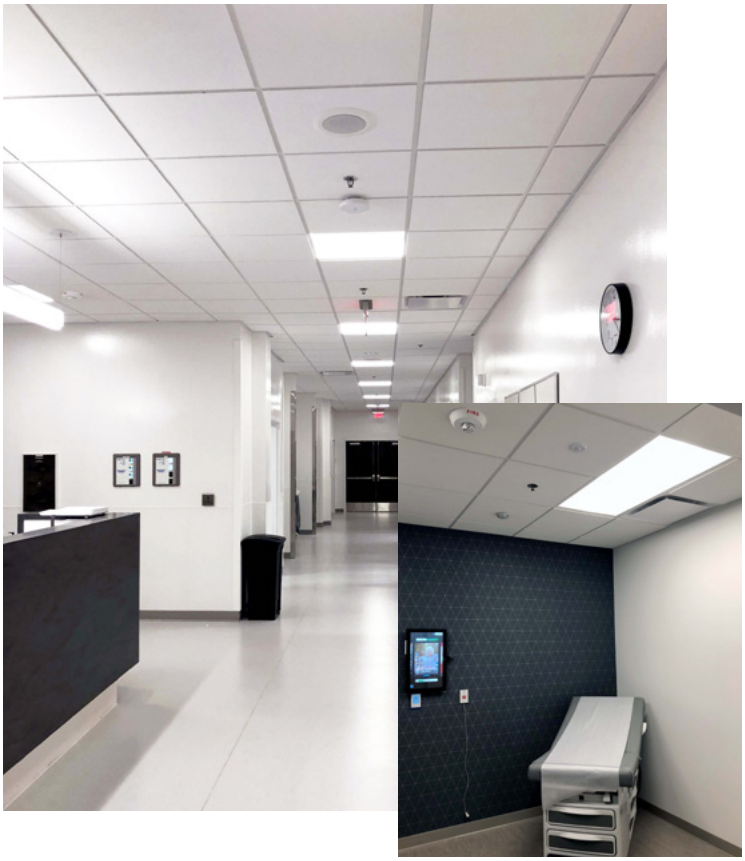
There is no stronger link between building acoustics and health and welling than in medical care facilities. How do acoustics affect medical outcomes? "Some of the mechanisms include impaired communication leading to medical errors, alarm fatigue - where staff learn to ignore them, patient sleep disruption and stress responses from the patients and also from the staff," says Solet.

At their new Premier Medical Plaza[6] in Little Rock, Arkansas, Premier Gastroenterology Associates (PGA), a physician owned healthcare practice, repurposed a long-vacant big box retail space into a patient-centered healthcare facility serving multiple medical groups in 9,290 square meters (100,000 square feet) of space. The vision was a welcoming, comfortable experience for the wellbeing of both patients and staff. Along with a generous use of natural light and a palette of calming colors, materials were carefully selected to support safety, health and acoustic privacy.

"We wanted to create a whole new culture in healthcare. A culture where our patients and our employees feel like they're family and feel like they're coming home when they come to Premier Gastroenterology," said Premier's CEO William E. Greene III, ACHE.

At Premier, Greene explained, the patient is not just a name on a chart. Medical expertise should go hand-in-hand with compassionate care. A trip to the doctor's office can be an unnerving experience for many people. Premier Gastroenterology's doctors are all known for their kindness, empathy and attentiveness – attributes that go a long way in putting their patients at ease and making the experience at Premier a great one.

In the more open and shared spaces, sound absorption was achieved primarily through a variety of high $Alpha_w$ (NRC) ceiling systems. In the emergency department and waiting areas, an acoustic metal ceiling that looks likes natural wood was used. The metal is perforated and there are open spaces between the linear planks to let sound through and get absorbed above. The use of this aesthetic-acoustic approach provides a cozy feeling along with the required quietness and auditory calmness.



In the more private and enclosed exam and treatment rooms, walls are built full height from floor slab to roof of high R_w (STC) construction for acoustic privacy. Reverberation is controlled in the exam and treatment rooms with high $Alpha_w$ (NRC) suspended acoustic ceiling systems. In healthcare facilities, it is common practice to avoid porous sound-absorptive finishes on lower walls and floors where they are more difficult to disinfect and more likely to transfer pathogens. The ceiling plays the major role in meeting the rooms' acoustic requirements.

"A quieter work environment for medical staff delivers greater control in high demand situations, a sense that they and their missions are respected, less burnout, less staff turnover, and increase in speech intelligibility, which results in fewer medical errors," lists Solet.

Key Takeaways

The link between building acoustics and health and wellbeing is established. Post occupancy surveys inside most buildings constructed over the past 20 years do not typically show that their designs and materials contribute as much as they could to occupant health and wellbeing. That is changing, slowly.

New and updated building standards, guidelines and certification systems with more stringent acoustic criteria are leading the way. More building owners, who now appreciate the link between acoustics and wellbeing and who are willing to invest in it, are opting to design their spaces per the acoustic requirements in these evolved standards. Product manufacturers are responding too with innovation, technology and engineering to provide higher performing options that are also favorable from the perspectives of fire safety, natural light reflection, low emissions/indoor air quality and sustainability/recyclability. The building industry appears to be on the right path for the next 20 years.

Citations

1. U.S. Environmental Protection Agency. 1989. Report to Congress on indoor air quality: Volume 2. EPA/400/1-89/001C. Washington, DC.
2. van Dort, Pascal, Bourdeau, Ethan, Solet, Jo & Robinson, Amanda. Design for the Senses: The link between acoustics and wellbeing. 29 Sept. 2021, https://go.rockwool.com/Design-for-the-senses-The-link-between-acoustics-and-wellbeing.html.
3. Graham, L. T., Parkinson, T., & Schiavon, S. (2021). Lessons learned from 20 years of CBE's occupant surveys. *Buildings and Cities*, 2(1), 166–184. DOI: http://doi.org/10.5334/bc.76
4. For more information on the Parallel office building project in Oslo, Norway, including the acoustics products used, refer to the online case study.
5. For more information on the University of Toronto Scarborough Campus' Environmental Science & Chemistry Building project in Toronto, Canada, including the acoustics products used, refer to the online case study.
6. For more information on the Premier Medical Plaza[5] project in Little Rock, Arkansas, including the acoustics products used, refer to the online case study.

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