Acoustical and Sustainable Design for Occupant well-being in EVERY SPACE

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Course Overview

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This course will focus on the key role acoustical ceiling and wall systems play in creating healthy interiors through acoustical, flexible, and sustainable design. In addition to providing a broad overview of the fundamental principles related to interior acoustic design, the course will identify the different acoustic needs and review case studies for three key design applications including educational spaces, office environments, and healthcare facilities to emphasize the many ways balanced acoustical design can impact the lives of people where they live, work, heal, learn, and play. The course will conclude by assessing the various characteristics of acoustical ceiling panel materials and how they can contribute to sustainable building design and green building standards and certifications.

Learning Objectives

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After completing this course, the participant should be able to:

- **Explore** and understand the fundamental principles related to interior acoustic design, and their relationship to green buildings and sustainable design
- **Recognize** and identify the acoustic needs for exposed structure spaces and different design applications to improve occupant well-being
- **Examine** the new acoustically appropriate and visually appealing flexible design ceiling options that provide acoustical treatment for interior spaces
- **Discuss** the various characteristics of high performance ceiling and wall solutions that can contribute to sustainability standards and certifications

This section will explain the basic principles related to interior acoustic design and discuss the solutions and benefits of proper balanced acoustical design: the ideal combination of sound absorption and sound blocking

The Basics: Sound and Noise

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- Sound is what we hear and is produced by vibrating objects that change air pressure and create sound waves
- The hearing mechanisms in the ear turn sound into information in the brain
- Noise is unwanted sound

Sounds are everywhere – and we hear different sounds in different environments throughout the day. When those sounds are unwanted or disruptive, we consider them to be noise. Take a minute to think about the sounds you experience throughout the day – at home, during your commute, in your workplace, and in recreational areas. In many cases, we tend to ignore daily sounds, but when those sounds are unwanted or disruptive, we consider them to be noise.

Sound is produced by vibrating objects – whether an audio speaker or headphone, a person's vocal chords, the thrum of an HVAC system, or a jackhammer against concrete. Those vibrations travel through the air or other media (e.g. ceilings, floors, walls) to the listener's ears. When the vibrations occur, they vary the air pressure through sound waves, which ultimately make it to a listener's ear and are interpreted by the brain as information. Ear mechanisms are very sensitive, and so sound can damage hearing if it is too loud. Spaces that are designed with acoustics in mind can drastically improve the well-being of building occupants. The combination of high performance acoustical designs and new, sustainable acoustical materials make it easier for architects and designers to address noise issues and to meet sustainability goals.

Noise – even relatively quiet noises – is distracting. When sounds become noise in indoor environments, it can become problematic and can negatively impact employee productivity and workplace satisfaction, limit how well students learn, and impact patient privacy in healthcare environments. Spaces that are designed with acoustics in mind can drastically improve the well-being of building occupants, and high performance acoustical designs and materials make it easy for architects and designers to address noise issues and meet sustainability goals.

Architectural Acoustics

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- Architectural acoustics is specifically related to the interactions of sound both within and between architectural spaces
- Sound is reflected, absorbed, or scattered in a space depending on the surface materials
- Poor architectural acoustics can impact performance, comprehension, confidentiality, healing , and learning

As architects and designers, we are all aware that people experience a building with our human senses. While designers often pay the most attention to what we see, our sense of hearing is also directly impacted as soon as someone or something makes a sound in a building. If the quality of sound is not factored into design, it can result in poor acoustic quality, distracting noises, or irritating experiences, all of which can impede concentration, confidentiality, healing, or learning.

Acoustics is the scientific study of sound in all its forms, and architectural acoustics is specifically related to the interactions of sound both within and between architectural spaces. Professionals, specialists, and scientists have studied sound in terms of its generation, its transmission through space and objects, and its reception by people. In all cases, sound radiates outwards from the source, of which there are many, both inside and outside of buildings.

Sound is typically characterized by its loudness and frequency content, such that loudness is measured in decibels (dB) and frequency is measured in Hertz (Hz). When sound enters a space and interacts with the objects in the room (such as the walls, ceilings, furniture, and fixtures), it will be reflected, absorbed, or it will scatter, depending on the surface materials. Highly reflective surfaces will redirect sound without significant changes except for direction, which in very “hard” rooms can result in long delay times for arrival at the listener, causing echoes. Highly sound-absorptive

surfaces on the other hand will diminish the reflected sound waves and reduce reverberation and echoes. Based on the sound behavior, people can experience different levels of speech intelligibility, speech privacy, or sound intrusion depending on the room size and shape and the acoustic treatments within or between spaces.

ABCs of Acoustical Design

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Three effective ways to achieve a balanced acoustical design:

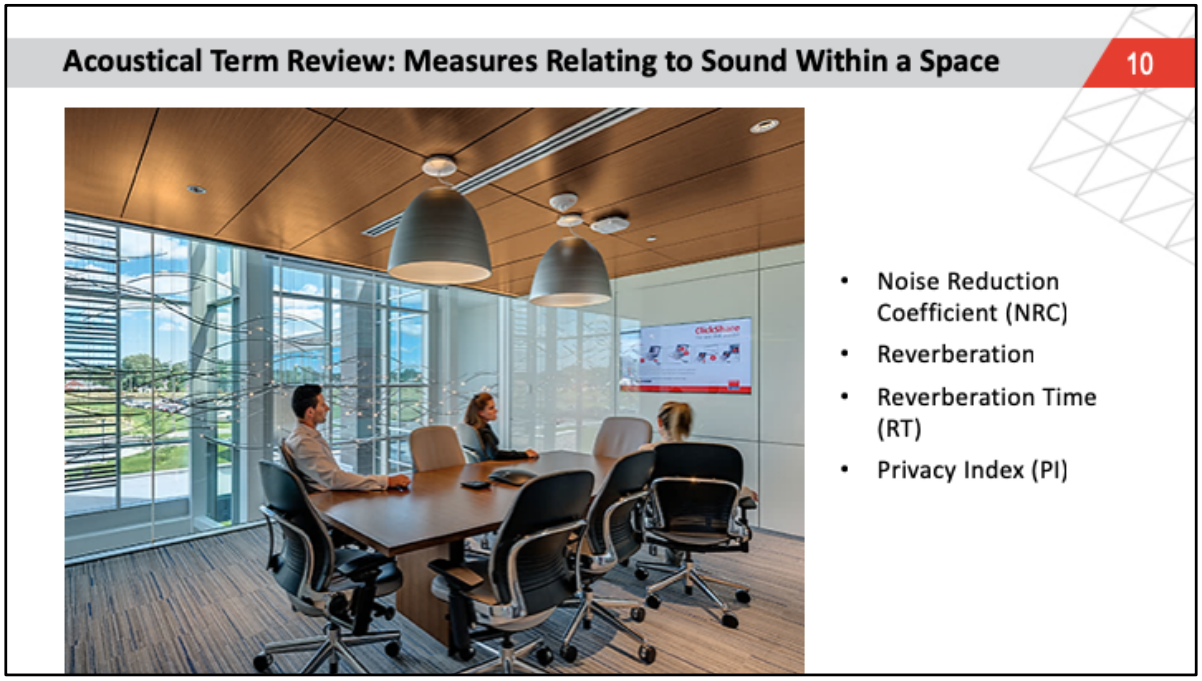
- **A**bsorb unwanted sound
- **B**lock sound transmission between spaces
- **C**over any remain sound

Designers can control sounds through deliberate, balanced, acoustical design, creating spaces that are more comfortable for building occupants. High performance ceiling and wall solutions, for example, can absorb sound, block sound transmission, and cover any remaining sounds in a space. These are commonly referred to as the ”ABCs of Balanced Acoustical Design.”

First, designers can use high performance acoustical ceiling and wall solutions to **absorb** any unwanted sound. This solution helps prevent sounds from reflecting off of surfaces and thus building up until they become distracting noise, or, in the case of privacy, allow confidential conversations to be heard by unintended listeners in adjacent spaces.

The second method is to use a combination of high performance ceilings and wall partitions of furniture panels designs and layouts to **block** sound transmission between spaces.

Finally, in cases where there is some remaining noise, designers can use electronic sound masking systems to **cover** sounds. These systems can be adjusted to meet the desired privacy levels.



When considering acoustic design, there are several key terms to understand:

Noise Reduction Coefficient (NRC) is a measure for rating the overall sound absorption of a material when used in an enclosed architectural space where sound is reflected at many angles of incidence. An NRC of 0 indicates perfect reflection while an NRC of 1 indicates perfect absorption. Generally, a ceiling system with an NRC < 0.50 is considered low performance, and an NRC > 0.70 is high performance. NRC is important in any space where reverberation time and noise levels are an issue. NRC is measured according to ASTM C423 and is generally used in the Americas

Reverberation is the persistence of sound in an enclosed space representative of multiple reflections off hard surfaces

Reverberation Time is the measure of the persistence of sound after it is made within a room, and is measured as the time in seconds that it takes for the sound level to decay by 60 dBs. Long reverberation can impair "speech intelligibility" since it creates garbled sounding words and poor verbal communication. Instructional spaces, such as classrooms, are best with short RTs—less than 0.6 second to ensure clarity and high speech intelligibility. Auditoriums, theaters, and other musical spaces will typically benefit from longer RTs, typically greater than 1.2 seconds. In schools, RT limitations are required according to ANSI S12.60.

Privacy Index is a measure for rating the speech privacy performance or lack of speech intelligibility of an architectural space. The general ratings are that a PI that is greater or equal to 95% to 100% will allow for confidential speech privacy, 95% to 80% is considered non-intrusive privacy, and less than 80% is considered poor privacy. We will discuss speech privacy in more depth later in the course.

Acoustical Term Review: Measures Relating to Sound Transfer Between Spaces

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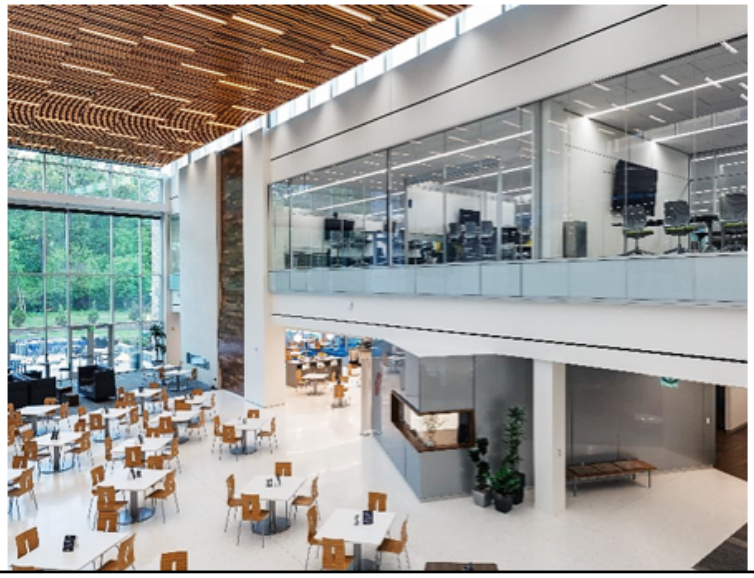

- Sound Transmission Class (STC)
- Ceiling Attenuation Class (CAC)
- Articulation Class (AC)

Sound Transmission Class (STC) A measure for rating the performance of a wall system as a barrier to airborne sound transmission between adjacent closed spaces, such as offices. A wall system with an STC ≤ 35 is considered low performance, whereas one with an STC ≥ 55 is high performance. STC is the wall equivalent of CAC. STC is important between closed spaces and in many open plan spaces, closed offices, corridors, open offices with dividers, etc. STC is measured according to ASTM E90

Ceiling Attenuation Class (CAC) A measure for rating the performance of a ceiling system as a barrier to airborne sound transmission through a common plenum between adjacent closed spaces, such as offices. A ceiling system with a CAC ≤ 25 is considered low performance, whereas one with CAC ≥ 35 is high performance. CAC is important between closed spaces and from closed rooms to adjacent spaces such as corridors and closed offices, conference, healthcare exam rooms, doctors' offices, etc. CAC is measured according to ASTM E1414.

Articulation Class (AC) A measure for rating the attenuation of reflected speech passing over the top of wall partitions or furniture into the adjoining work stations. A ceiling system with AC ≤ 150 is low performance, whereas one with AC ≥ 180 is high performance. AC is measured according to ASTM E1110 and E1111

Acoustical Design Challenges

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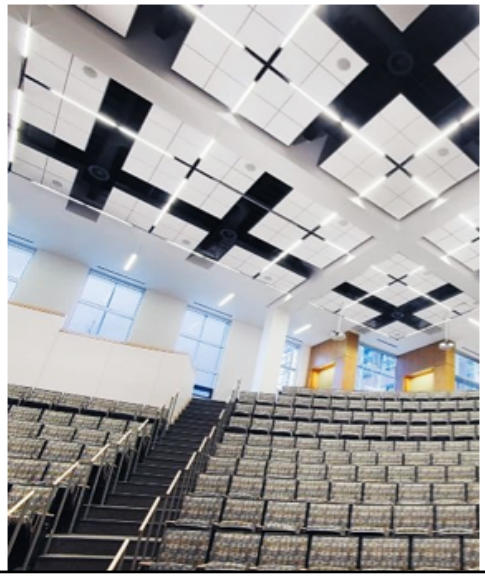

- Various spaces often require different acoustical treatment to meet the performance need of the space
- Furniture for the space is sometimes determined at the end of a project, impacting sound reflection
- Every situation is different: there is no “ideal” or “universal” measure for good acoustics

There’s no question that acoustical design can be a challenging aspect of a project. For one, many spaces in schools and workplaces are often used for different purposes, and so the acoustical needs may vary between purposes. For example, a school lunchroom also might be used as a gymnasium and auditorium, each of which has very different needs.

Another issues is that at the start of projects, designers typically don’t know what type of furniture will eventually be in the space. Furniture can play a major role in how sound is reflected, and so the initial design only can anticipate what may end up in the space.

Finally, designers need to recognize that every situation is different, and that there is no ideal or universal measure for good acoustics. That said, there are many standards with metrics that designers can use to help them with specific aspects of acoustical design.

This section will discuss acoustical ceiling and wall solutions for exposed structure applications as well as solutions for 3 specific segments: classrooms, office spaces, and healthcare facilities and how specifying acoustical ceiling and wall panels can address specific acoustical challenges to meet the performance needs of each space. Using case studies as support, we will illustrate how improved acoustical performance in various interior spaces can promote and increase occupant well-being and effectiveness and optimize the overall performance of the space.

Exposed Structure Applications

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Challenge: Exposed structure spaces with no ceiling can cause acoustical problems that lead to:

- Decreased employee satisfaction
- Inhibit students' ability to learn
- Leave patrons struggling to hear and be heard

Acoustical absorption in exposed structure spaces is important to:

- Reduce noise levels and reverberation time
- Enhance speech intelligibility

Exposed structural elements are a familiar design element for modern buildings, and allow for both more open space and also a specific "industrial" aesthetic. However, exposed girders, joists, and beams can also create an challenge when managing acoustic reverberation and general noise levels. Noise distractions can make the modern workplace less effective and lead to higher stress. It's also estimated that 1 in 4 students can't hear what's being taught, and it's a leading cause of dissatisfaction among restaurant clientele.

Acoustical absorption is important in these spaces to reduce noise levels and reverberation time and enhance speech intelligibility. Reverberation Time (RT) is the persistence of sound in an enclosed space after the source of the sound has stopped. The level of the reverberant sound within a room is dependent on both the volume of the room and the amount of sound absorption installed within the room, such that small hard-surfaced rooms are "louder" than large well-treated rooms.

Acoustical Design: Exposed Structure Spaces

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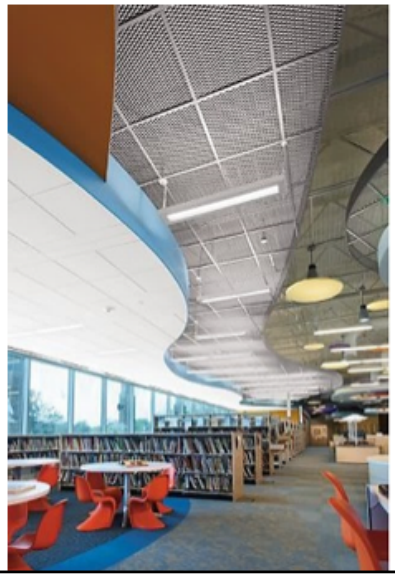

Solution: Installing acoustical Clouds, Canopies, Baffles, or Blades that cover 20% to 50% of the ceiling

- Provide significant reverberation time improvement to an exposed structure installation
- Sound is absorbed from both the front and back of these types of panels
- Address both acoustics and aesthetics

- Direct-to-deck acoustical solutions can also empower your exposed structure design while bringing quiet to your space

How do non-traditional shapes and forms affect noise levels? Acoustical solutions, like Canopies, Clouds, Baffles or Blades installed in a way that covers 20% to 50% of the ceiling, will provide significant reverberation time improvement to an exposed structure installation, since sound is absorbed from both the front and back of the panels. Blades are especially effective as the required coverage is much smaller to get the RT reduction because most of the surface area is vertical. In large, open environments where speech privacy is not a key requirement, these types of solutions address acoustics and aesthetics. Direct to deck acoustical solutions that have a high Noise Reduction Coefficient (NRC) can easily be attached to the deck of an exposed structure and thus almost disappear into the ceiling, leaving the unique character of the space intact.

Whether making a design statement that puts acoustical materials front and center, or opting for a more open, exposed structure look with a direct-attach solution, there are tons of options to help you get the look you want and control noise too.

Case Study: Exposed Structure – Bert's Bottle Shop

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- 2,200 square foot bar and restaurant that moved into a previously unoccupied space
- Exposed brick structure, hard surface of the industrial look caused excessive reverberation and high noise levels
- Acoustical panels designed for structural spaces absorbed the noise without disrupting the industrial aesthetic

The hospitality industry often faces challenges with spaces being too noisy. In restaurants and bars, for example, where patrons talk over drinks and dinner, voices reverberate through the space. More often than not, these spaces also have music piped in from speakers, or at times live music performances. The combination of customers, kitchen noise, wait staff, music, and possibly even outside noise can create an environment where no one can hear anything other than the ambient noise. We've all been in situation like this, and the frustration of not being able to hear or be heard can ruin an otherwise great experience.

Bert's Bottle Shop in Millersville, PA experienced this situation when they moved their bar and restaurant into a new, previously unoccupied 2,200 square foot space. The owners loved the exposed structure design, with brick walls and the open, industrial look. But it didn't take them long to realize that even just a few customers in the space would make their restaurant sound like it was full. On top of that, the noise included echoes, which just made matters worse.

When acoustical measurements were taken, they showed that the average reverberation time was 1.4 seconds. As a reference point, the industry standard recommendation for bars and restaurants is between 0.8 and 1.0 seconds.

The design solution for the space was to install acoustical ceiling panels specifically designed for exposed structure spaces as a simple retrofit. The panels had a Noise Reduction Coefficient (NRC) of 0.75, thus absorbing 75% of the sound that strikes them. Moreover, the panels could easily be attached to the deck, and thus were hidden from site. Acoustical measurements taken after the panels were installed showed a reverberation time of 0.9 seconds – a perfect balance that fell right where it should for the industry standards.

The building owners and patrons immediately noticed a difference, and helped the owner feel confident that he could use the space as a live music venue without having the noise level get to be too loud.

Places to Learn: Classroom Acoustics

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- Classroom chatter and noise impacts both students and teachers
- Interference with the ability to hear increases stress, decreases concentration, and effects learning
- Classroom acoustics are extremely important for younger children, students with learning disabilities, and hearing impaired students
- Teacher surveys consistently rank noisy classrooms and vocal fatigue as the main reasons for frustration

Classrooms come in all shapes, styles, and sizes, from primary school rooms to university lectures halls, labs, and studios. Regardless of whether we're talking about a classroom full of 10-year-olds or a lecture hall full of young adults, the basic goal is the same: the students need to be able to hear the teacher, and the teacher needs to be able to vocally connect with their students without straining their voice.

Classrooms for younger children have a special set of concerns, namely that the room quickly can become very noisy. This noise is especially problematic in older rooms with that have plaster or drywall ceilings and walls made of drywall or masonry. When these walls and ceilings are combined with tile floors, sounds reflect and scatter, and the result is a space where no one can focus. Teachers can't connect with students, and students can't hear teachers. This situation is especially difficult for younger children who are still learning language, and for children with learning disabilities.

Poorly designed classroom acoustics can cause many problems. For primary schools, where young children are just learning fundamentals such as speech, reading, and writing, a noisy classroom can mean the difference between them learning or not learning. Noise also affects how well children can concentrate, and that can be seen in both behavioral issues and in how well they are able to pay attention to the teacher. A quiet, acoustically balanced classroom can make a world of difference in student learning.

Older learners also are affected by bad acoustics, whether in high schools of universities. At this age, students are learning far more complex ideas, and they need to be able to hear the teacher and focus on and process the new information at a higher level. Distractions from background noise or other sounds in the room can detract from their learning, and in turn affect their academic success.

Lecture halls, especially older designs, often require teachers or professors to project their voice to the back of a

large space. If the space isn't well designed and the instructor doesn't have a microphone, students in the back of the room may not hear key information.

ANSI Standard S12.60 on Classroom Acoustics – Requirements

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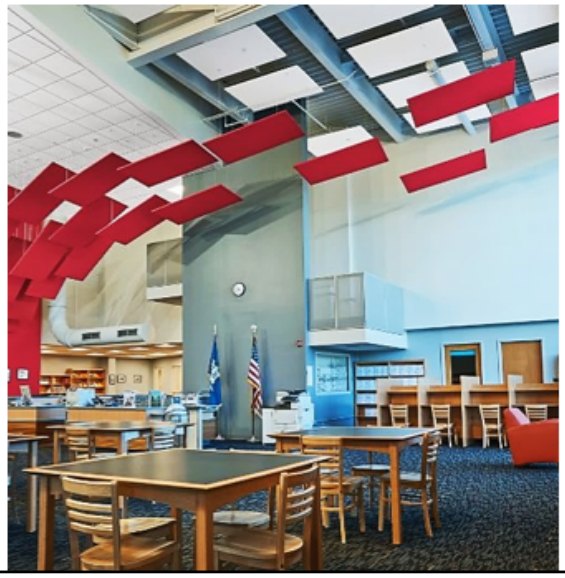

- Direct sound, reflected sound, reverberation time, background noise
- Standard addresses reverberation time and background noise
- Acoustical performance criteria and design requirements
  - New classrooms and learning spaces
  - Reconstruction or renovated spaces (when practical)
- Voluntary unless referenced by code, ordinance, or regulation

As a quick refresher, the main sound attributes found in classrooms that are known to affect a student's ability to hear and learn – and a teacher's ability to teach – include direct sound, reflected sound, reverberation time, and background noise. The new ANSI Standard S12.60 for Classroom Acoustics addresses the issues of reverberation time and background noise, and how both affect the ability of students to hear and understand teachers. The standard places maximum permissible levels on each issue.

The maximum reverberation time in an unoccupied, furnished classroom with a volume under 10,000 cubic feet is 0.6 seconds, and 0.7 seconds for larger classrooms up to 20,000 cubic feet. The maximum level of background noise allowed in the same classroom is 35 decibels (dBA).

The standard's acoustical performance criteria and design requirements apply during the design and construction of all new classrooms or learning spaces that are considered small-to-moderate size, and, as far as is practical, to the design and reconstruction of renovated spaces.

This ANSI standard is currently voluntary unless referenced by a code, ordinance, or regulation. However, school systems may require compliance with the standard as part of their construction documents for the new school.

Balanced Acoustical Design in Education Spaces

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- Promotes high speech intelligibility for understanding and learning
- Creates a better space for students to learn and teachers to teach
- Creates a healthier space for students and teachers

Acoustical considerations for schools vary by space and depending on the initial design, the space can be significantly improved by balancing the reverberation time of sound through sound-absorbing acoustical ceiling and wall panels to promote speech intelligibility. Classrooms and libraries will generally need to be quieter with higher NRC, CAC, and STC ratings versus larger, open spaces such as cafeterias, gymnasiums, or auditoriums, which may accept more reverberation.

A well balanced acoustical design in schools, especially classrooms, creates high performing learning environments for both students and teachers,. Students and teachers who function in a balanced acoustical environment will be more effective and happier, without the distractions of unwanted sound.

Noisy classrooms don't just make learning difficult, they can also impact the health and well-being of both students and teachers. For example, students can actually suffer from permanent hearing loss if a continual noise level is too high. Where the World Health Organization recommends a level of 35 decibels, some classrooms can be upwards of 65 decibels. This noise affects students, and it also can lead to teachers damaging their voices by having to talk over the noise. One study showed that 50% of teachers have damaged their voices in loud classroom situations.

Sustainability Contributions of Acoustical Ceiling and Wall Panels in Education Spaces

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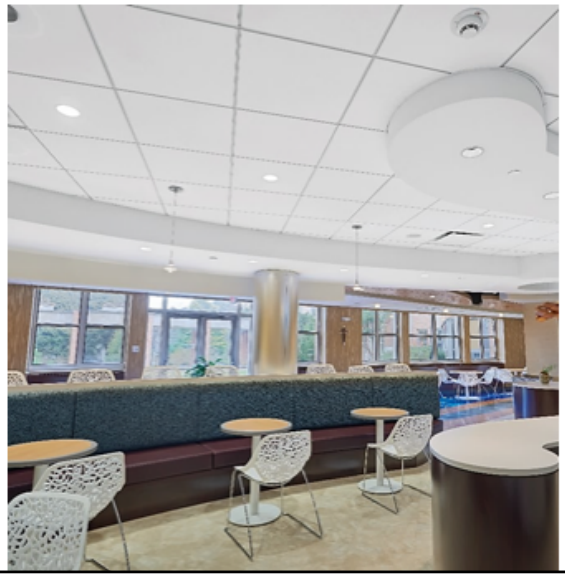

- High-LR (light-reflectant) ceiling and wall panels improve daylighting and create brighter, energy efficient spaces
- Ceiling and wall panels made with low VOC content improve indoor environmental quality (IEQ)
- Mold and mildew resistant ceiling and wall panels enhance air quality

Good classroom acoustical design can do more than just improve the sound quality in a space and help students learn. For example, sustainable acoustic solutions can improve the lighting within a space, with high reflectance ceiling panels that reduce eye strain and improve the overall daylight in the room and create brighter, more evenly lit spaces.

Ceiling panels can be designed to resist mold and mildew, which are problematic in high humidity environments or when HVAC systems are turned off for the summer. From an aesthetic sense, mold and mildew can cause panels to sag, but more importantly, they can quickly become a health issue that affects the air quality in the room.

Acoustic solutions that include ceiling and wall panels constructed with low-emission materials also help ensure that the indoor environment is healthy. Where older materials may have included Volatile Organic Compounds (VOCs) and ingredients such as formaldehyde, ceiling and wall panels that meet VOC and formaldehyde emission requires are now easily available.

New classrooms that are designed with acoustics in mind, and that use healthy, sustainable materials, can help make the learning environment better for everyone. Now there are third party programs that certify products for low emissions. The GREENGUARD Certification Program gives assurance that products designed for indoor use meet strict chemical emission limits, which contribute to healthier interiors. GREENGUARD Certified products meet stringent chemical emissions requirements such as being screened for more than 10,000 volatile organic compounds (VOCs) such as UL GreenGuard.

Case Study – Acoustics and Aesthetic Design: Berklee College of Music

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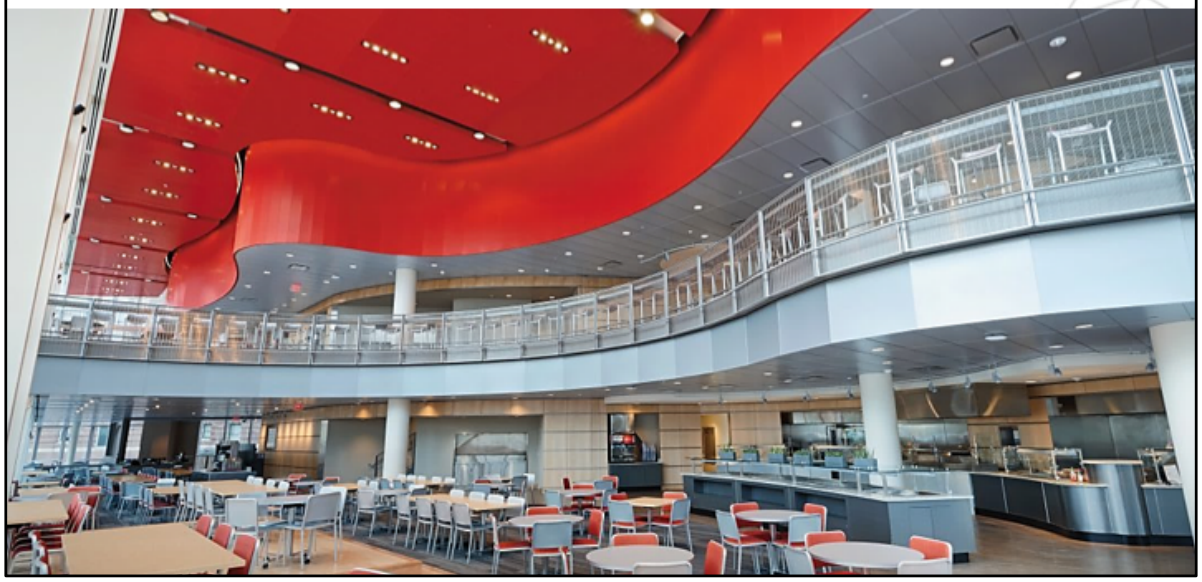

As part of its new 16-story, multi-use residence hall in the heart of Boston, the Berklee College of Music desired a space that would serve as a dining area during the day and a performance venue at night. Because of this dual function, both aesthetics and acoustics were key considerations in its design.

To meet the challenge, the design team created the "Caf," a two-story, 400-seat space featuring a 32-foot high ceiling, a gracefully curved second floor balcony, and a floor-to-ceiling glass wall overlooking busy Massachusetts Avenue. The design team chose custom color red metal panels to show the school color and to make the space highly visible from the street.

The ceiling panels were installed as a series of clouds that mirror the balcony's "ribbon wall", which seconds as an acoustic feature to deflect the sound away from the exterior glass wall. Performers would have their backs to the glass, so the design had to accommodate that feature as well.

The curvilinear nature of the wall's design also required custom-sized wall panels. In this case, the panels are all the same height, but they have different widths depending on the radius and arc length.

Places to Work: Office Acoustics

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- Unwanted noise is a leading source of workplace dissatisfaction
- Today's flexible work environments demand the ability to meet multiple needs in an open area
- Balanced acoustical design in contemporary office spaces addresses both quiet concentration and energetic collaboration

Office spaces come in all shapes and sizes, but no matter the design, the leading complaint from employees is that distracting noises make it difficult to concentrate, and disruptions make it hard for them to work. These noise-related impacts have been shown to lead directly to increased employee stress, decreased effectiveness, and ultimately contribute to a sense of workplace dissatisfaction. A classic 1998 study published in the British Journal of Psychology found that hearing just one single person talking while you are attempting to read or write will drop your productivity by up to 66%. Other studies have shown that office noise increased stress hormones. The impact of noise in the workplace is a known and proven problem.

The recent trend of designing office spaces to be more open means that noise can reverberate through the space for a longer time. When you pair that with increased team work, the noise levels can increase even more because of frequent team activities and loud conversations. The result of these two trends means that employees are often working in open, densely packed office areas where they have little privacy and a lot of noise. The result of these two trends means that employees are often working in open, densely packed office areas where they have little privacy and a lot of noise. Those factors can quickly create unhappy employees.

In addition to collaborative spaces, denser workstation placement, and team meetings, the recent architectural trend of designing offices with an exposed roof deck literally amplifies the noise problem with enhanced reverberation time. On the up side, these growing problems mean that the architectural and building industries are starting to pay attention to acoustical design and how it impacts the health, wellbeing, and productivity of employees.

Different Types of Office Environments

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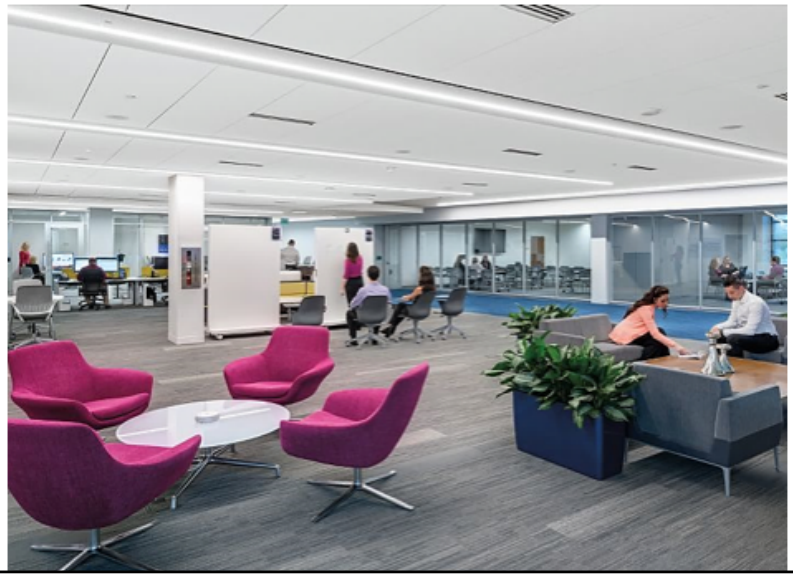

- Collaboration areas
- Focus areas
- Private Offices

Today's office's typically include a combination of different spaces such as collaboration areas, focus areas, and private offices, all of which have different acoustical needs in order to be effective work spaces.

Office Environments: Collaboration Areas

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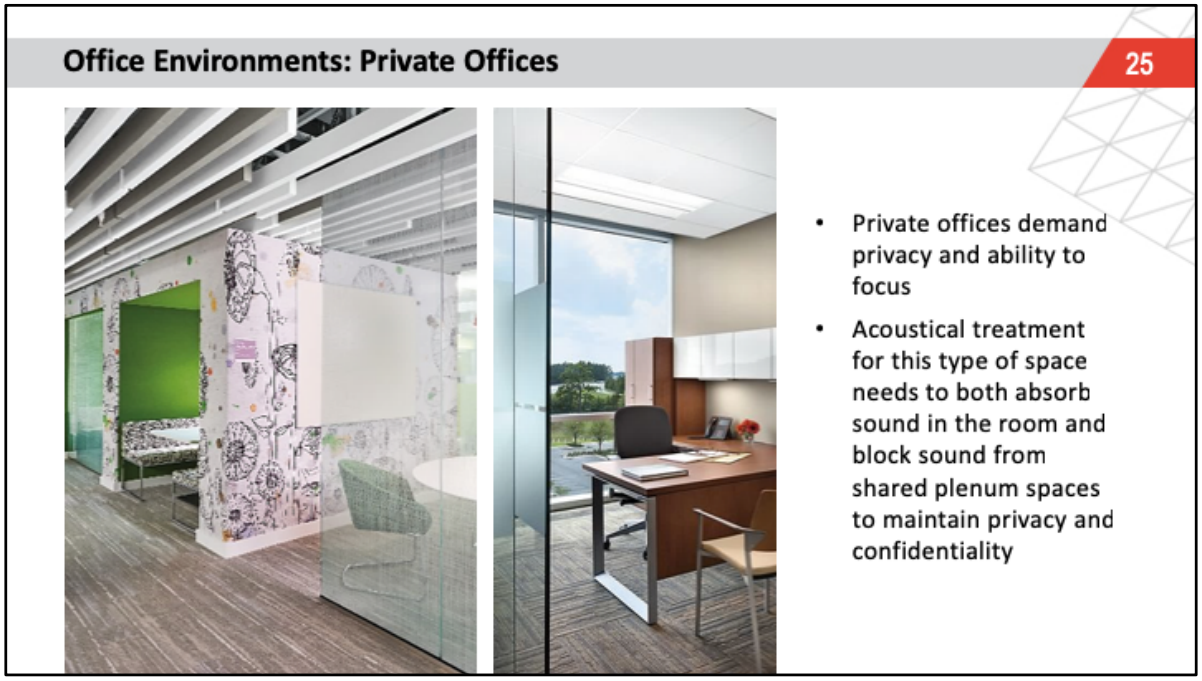
- Contributors of noise in open office spaces include:
  - Employee conversations
  - Workstations
  - Speaker phones
  - HVAC systems / plenum noise
- Collaboration areas need acoustical solutions that both absorb and block sound to provide the right balance

In open plan and collaboration spaces, the main function of the ceiling is to absorb sound that would normally bounce off the ceiling into a nearby space or cubicle and block sound from mechanicals in the plenum. Designing for these spaces requires the use of acoustical ceiling panels that have the ideal combination of sound absorption and sound blocking to provide the right balance, for when employees are concentrating one minute, and collaborating the next. For exposed structure office environments, where noise control can be a significantly greater challenge, consider strategically placing acoustical clouds and canopies over collaboration areas to control sound.



In addition to having collaboration areas, offices also have focus or private office spaces that demand speech privacy, ability to focus, and confidentiality.

When we talk about "speech privacy," we're referring to how well an overheard conversation is understood by unintended listeners. There are four commonly recognized levels of speech privacy. The first is "confidential," which has a Privacy Index (or PI) rating of 95%–100%. This means that unintended listeners may hear the conversation, but they definitely will not understand it, and co-workers are not likely to be distracted by the conversation. Non-intrusive (normal) has a PI rating between 80% and 95%, and while conversations may be partially heard, they generally will not distract co-workers. Marginal (poor) privacy levels have a PI rating between 60% and 80%, reflecting conversations that both can be heard and understood. Not only does this level pose problems if speakers exchange confidential information, it is also a problem when listeners can hear words and sentences, which become distracting. The final level of speech privacy is "no privacy," which represents a PI rating of 60% or less. In this case, co-workers can hear and understand all conversations, and the loudness of speech can be a constant distraction.

Sound can be contained within each office, however there is still sound transfer from room to room if the walls are built to ceiling height only. In this case, high CAC products with a minimum rating of 35, are a must to prevent sound transfer through the ceilings of adjacent offices. Higher STC ratings are needed in the walls for the same sound containment reason.

Sustainability Contributions of Acoustical Ceiling and Wall Panels in Offices

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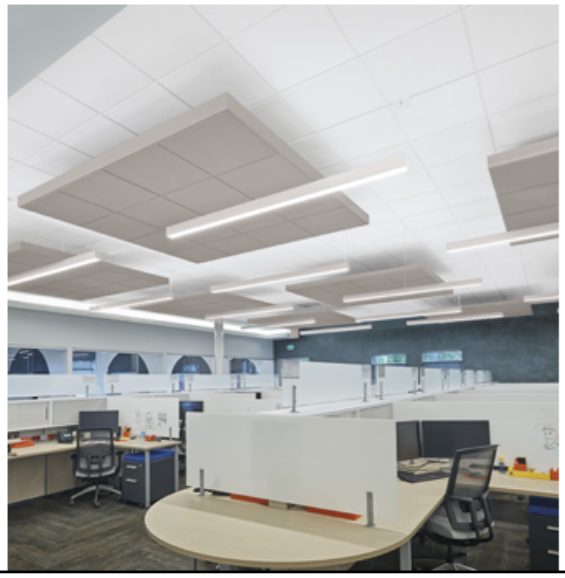

- High light-reflectant (LR) ceiling and wall panels create brighter spaces and can improve overall lighting uniformity, employee concentration, and worker effectiveness
- Ceiling and wall panels with high sag, mold, and mildew resistance enhance Indoor Environmental Quality (IEQ)
- Ceiling and wall solutions can contribute to LEED v4 IEQ credits and provide workspaces that promote occupant well-being, productivity, and communication

As with good, balanced acoustical design in classrooms, high performance acoustical ceiling and wall solutions can greatly improve the indoor working environment beyond controlling sound. Strategically placed acoustical ceiling and wall panels can extend the reach of daylighting in the room, which in turn can reduce employee eye strain and fatigue – and thus help concentration. High light reflective ceilings have a light reflectance value (LR) of 0.83 or higher.

In addition to improving the light quality of a space, high performance ceiling panels can be specifically designed to resist humidity, which is useful for times when HVAC systems need to be shut down. Not only will these panels reduce the possibility of eventually sagging, but panels that are painted with a fungicide also will resist any mold or mildew growth. Such systems play an important role in keeping the indoor air quality healthy for all building occupants.

Ceiling and wall solutions can also contribute to LEED v4 Indoor Environmental Quality (IEQ) credits by helping designers create workspaces that promote occupant well-being, productivity, and communication. New acoustical panels are available in materials that allow for better product transparency and disclosure, with Health Product Declarations (HPDs) and Declare, as well as the material impacts in Environmental Product Declarations (EPDs). All of these features help make for better indoor spaces, and help designers be confident about their product specification choices.

Places to Heal: Acoustics in Healthcare

27

- Excessive noise in healthcare facilities can create a stressful environment and decrease patient satisfaction and staff performance
- Privacy and noise reduction in healthcare facilities are vital to protect patient privacy and meet HIPPA requirements

Excessive noise in healthcare facilities – whether doctor's offices, clinics, or hospitals – has serious consequences on the health and well-being of not only patients but also on doctors, nurses, and staff. Intrusive noise is known to negatively impact patient healing time, and the constant sounds of machines and voices in operating rooms and corridors can increase stress on doctors, nurses, and other staff, which in turn can affect patient safety and staff performance. Moreover, noise imbalances can mean that confidential conversations can be overhead, breaching patient privacy.

The World Health Organization (WHO) recommends that the average patient room noise levels be around 30 - 35 decibels, with a maximum noise level of 40. However, the reality is that many hospitals are much louder than the maximum, sometimes with levels as high as 95 decibels. This is just 10 decibels *beyond* the noise level at which U.S. federal law requires ear protection for prolonged exposure. Patients need sleep to be able to heal, and hospital staff need an acoustically comfortable environment in which to work.

One reason hospitals and clinics are often noisy is because so many surfaces must be durable and easy to clean. Floors are often made of non-absorptive materials such as ceramic, and walls are often bare in order to keep them clean. As a result, sounds in the space are reflected, and there can be increased reverberation times. This tradeoff between durability and sanitary requirements and noise requirements can be tricky, but there are materials and techniques that designers can use to reduce noise and increase privacy. Before we look at those design options, let's look at some of the types of noises commonly found in healthcare facilities.

Acoustical Design to Improve Speech Privacy in Healthcare Facilities

28

- Acoustical ceiling and wall panels can create a space that results in optimum patient recuperation
- Ceiling and wall panels with high sound absorption can create peaceful, quieter places to recover while meeting healthcare privacy requirements

Healthcare facilities are increasingly requiring high performance acoustical design as a functional requirement for speech privacy under the federally mandated HIPPA privacy rule. That means that anywhere patient information is being discussed and there are other people in the vicinity, speech sound must be controlled or absorbed. Administrative areas where multiple patients are seen require areas to meet and talk that need acoustical ceiling and wall panels with high NRC (sound absorption), CAC (sound blocking), and STC ratings to prevent the unwanted dissemination of a patient's private information.

There are many different ways that hospitals can be redesigned to better accommodate the needs of the patient. In the context of this course, we're concerned with ways to reduce the noise impact as a way of improving the overall experience of patients who need to spend time in hospital rooms in order to recover. One obvious change is to provide patients with single-bed rooms when possible. Private rooms immediately remove noise sources related to other patients, such as visits from doctors, nurses, and visitors. Such rooms can be designed to be more acoustically balanced that larger, semi-private rooms. Regardless of the room design, however, spaces that include high performance sound-absorbing ceiling panels can have a considerably lower reverberation time of ongoing sounds, and that translates directly into better sleep for patients, and better sleep typically means faster healing times.

Acoustical design doesn't just apply to patient rooms, however. In more critical wards, such as the intensive care unit (ICU) and the neonatal intensive care unit (NICU), loud noise levels have been shown to increase blood pressure, heart rate, and heart rate variability. Neonatal patients can even suffer from decreased oxygen saturation as a result of being exposed to loud noises.

In any medical situation, acoustical design decisions that result in quieter, calmer spaces can speed patient recovery over loud or noisy environments.

Healthcare Privacy Requirements

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- Health Insurance Portability and Accountability Act (HIPAA)
  - Protects individually identifiable, orally transmitted health information
  - Relates to all healthcare providers, such as doctors' offices, pharmacies, hospitals, and more…
  - Requires policies to "reasonably minimize" privacy breaches
- Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS)
- Adult patient satisfaction survey
- Includes communication and overall hospital rating

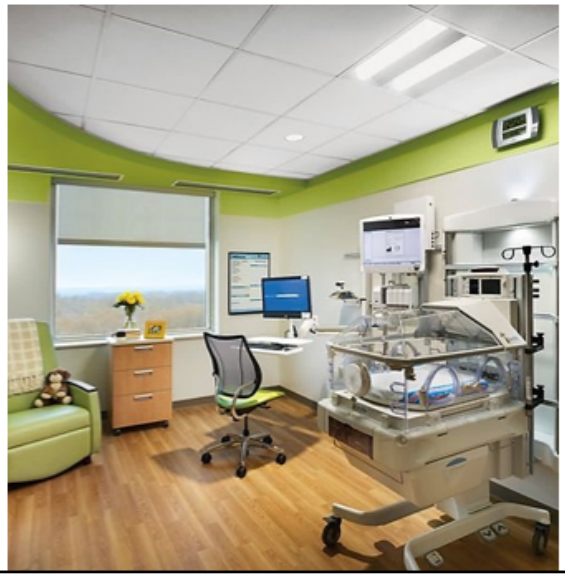
The Healthy Insurance Portability and Accountability Act of 1996 (HIPAA) is a standard designed to protect sensitive patient data. While we may think that this is relevant only in healthcare facilities such as hospitals and doctors' offices, it actually pertains to *any* company that deals with what is known as protected health information (PHI). This means that even a pharmacy in a grocery store or an insurance company must have measures put in place to "reasonably minimize" how well other people in the space can hear potentially private information about a patient's health information.

As an example, many healthcare providers have designated areas where confidential information can be shared. In some cases, there may be a sign that identifies where people in a line should stand; these signs are called "confidentiality compliance signs," and they can help limit conversations being overheard.

Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) is a patient satisfaction survey that is required by the Centers for Medicare and Medicaid Services (CMS) for all hospitals in the United States. The survey is given to all adult patients after they are discharged and asks questions about how well physicians, nurses, and staff communicated information, and on different ratings about the hospital in general. Noise is consistently ranked as the lowest rated area on the survey.

Acoustical Design to Improve Patient Experience and Staff Performance

30



- Design to acoustically separate patient rooms from sources of noise to improve patient experience
- Using ceiling and wall solutions with high sound absorption in areas that are generating excessive noise can:
  - reduce vocal fatigue
  - increase speech intelligibility
  - improve staff communication

Beyond this basic sound control need, there is evidence to indicate that optimum patient recuperation occurs when acoustics are taken into account in the design. Excessive noise is created by the 24/7 environment of corridor activity, busy nurse's stations, equipment, alarms, and activity in treatment rooms among other things. Studies indicate that on average, hospital noise levels from all of this activity exceed those set by the World Health Organization.

The significance is that these elevated noise levels are attributed to increasing patient stress and having an adverse effect on patient comfort. The design of healthcare spaces can sometimes make this worse by using hard, sound reflective surfaces, by not building walls all the way to the deck above, or by failing to treat and isolate high noise areas. Hence designing to acoustically separate patient rooms from sources of noise and using sound absorptive materials in areas that are generating the sound can directly contribute to the success of the hospital operations. This will not only help patients, but the healthcare staff as well who can benefit from a more pleasant work environment while reducing the possibility of missed communication due to better speech intelligibility.

Patients aren’t the only people affected by noise in hospitals and other healthcare facilities. Staff members –

doctors, nurses, receptionists, caretaking staff, and anyone who works in the building – are all subject to the noises in the workplace. Depending on a person's job, poorly designed acoustics can mean anything from noise-induced stress that causes them to feel fatigued, to unclear communication between staff and patients.

By including high performance acoustic ceiling and wall solutions throughout a hospital or medical facility, staff performance can be improved in many different ways. For example, there can be clearer communication with patients. Balanced acoustics also can help reduce medical errors by making sure that verbal information is clearly understood. Finally, an acoustically well-designed space can reduce vocal fatigue for staff members who need to talk a lot in their work. The difference between working against noise and not having to fight it can be significant on a daily basis and over time.

Case Study: Acoustical Design Solutions for Healthcare Facilities

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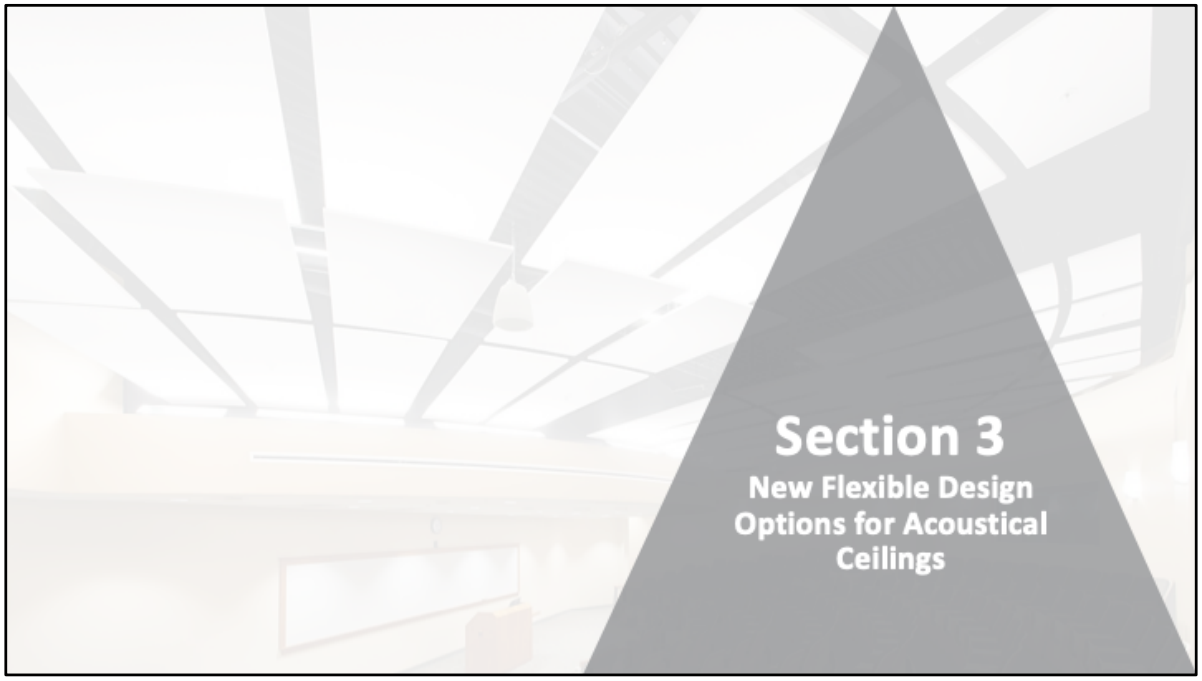
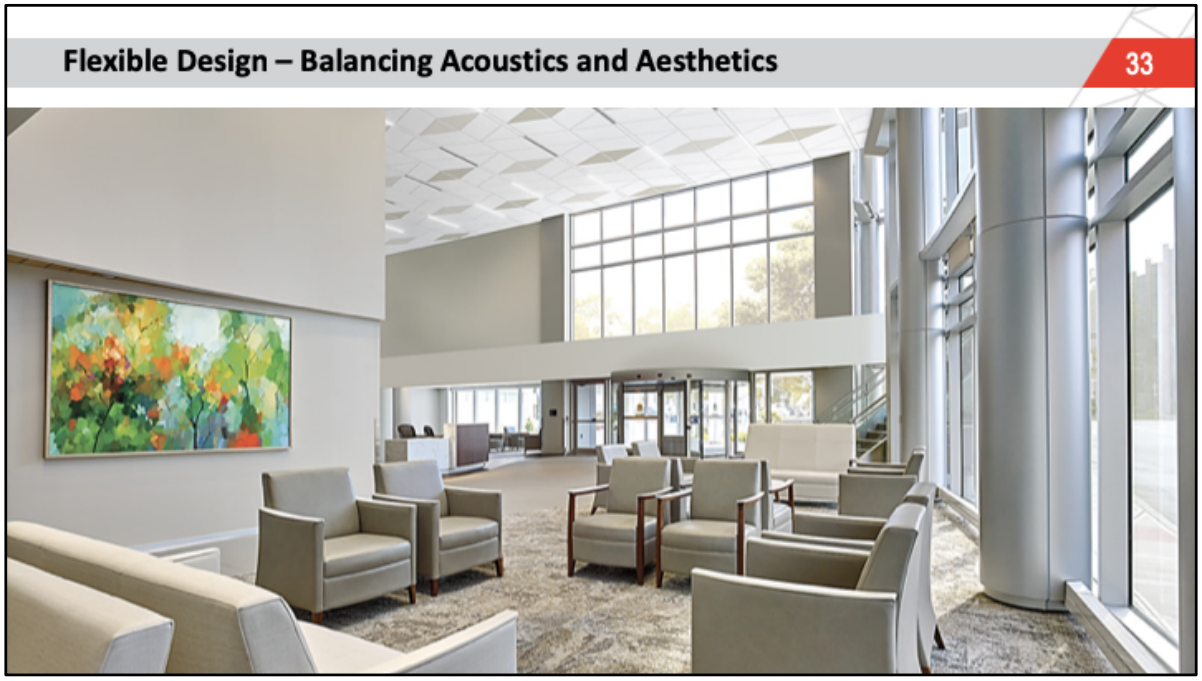
- Inova Women's Hospital / Inova Children's Hospital
- New, 12-story 660,000 sq. building that houses two separate facilities where acoustics were critical in health, safety, and well-being of patients and staff
- Designed team used balanced, high performance acoustical ceilings to reduce noise levels and protect speech privacy

The Inova Health System recently opened a new 12-story, 660,000 square-foot building that houses two distinct facilities. One is the Inova Women's Hospital and the other is the Inova Children's Hospital. The design team at Wilmot Sanz recognized how the important role of good acoustics was for the health, safety, and well-being of the patients and staff for these two spaces, they included acoustics as a key consideration for the interior environments.

The design team accomplished their acoustics goals by using high performance ceiling tiles that included both sound absorption and sound blocking in one panel. By using panels that focused on sound absorption and sound blocking, the team could ensure that the noise levels in the hospitals were low, which helped reduce the stress for both patients and staff. In this case, patients included newborn babies, small children, and women who were either there to give birth or recovering after giving birth. In all cases, a calm, quiet environment is ideal. Babies are often sensitive to noise, and so noise blocking tiles helped create a quiet, safe space. On the other end of the spectrum, women who come to the hospital to give birth are often under much stress, and so a space with a reduced noise level can help.



New options in color, shape, size, and installation layout methods offer a wide pallet of design choices, allowing architects to be creative in the ceiling, yet still providing the necessary levels of performance needed for a specific space. Included in this section will be an overview of flexible, acoustical, and aesthetic design options to personalize any space.

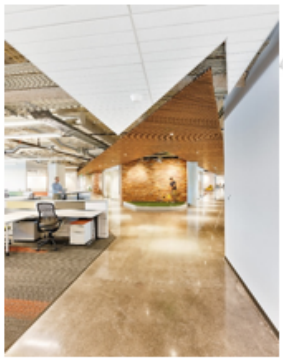


The new world of acoustical ceilings is all about flexibility. Whether it is Color, Shape, Size, Layout, or Pattern there are now products that allow for incredible amounts of creativity in the ceiling space, yet they still provide the levels of performance that you have learned about with traditional acoustical celling systems. The new visuals that you see here are just a very small portion of the design options that exist with new mix & match squares and rectangles and ceiling systems that utilize shaped panels such as Triangles, Parallelograms and Trapezoids. The panels that work in these new ceilings are the same materials that have been used in acoustical ceiling systems for years - with choices to absorb sound, block sound or do both depending on the environment. These new systems also use the same suspension system components that we have been using for decades, they are just being assembled together in a slightly different way with a few new accessories to created the angled grid connections.

The creativity and flexibility with these new systems also extends beyond the module sizes of 2'x2' and 2'x4' panels with numerous panel size options that allow for flexible layout options that will fit with the appropriate scale of the space. Lastly, the combination of NRC and CAC performance is supreme - as buildings change, and flexibility continues to expand, ceiling performance can meet all acoustical requirements and really change the look of the space.

Flexible Design – New Color, Shape, and Size Options

34



- Variety of shaped panel options offered in varying angle degrees
- Mix and match different shapes with various colors and panels to create dynamic ceiling patterns
- Flexible Design panels still offer the same acoustical, sustainability, and accessibility benefits as traditional ceiling panels

Mineral Fiber, Fiberglass, Metal, and Wood panels are now available in a variety of different shapes, such as Triangles, Parallelograms, and Trapezoids and each shape is offered in varying angle degrees, such as 45, 60, and 75 degrees. The configurations for these shaped panels use the same 2’ or 4’ on-center main beam spacing as the mix and match square and rectangle layouts on the next slide. Shaped ceiling panels also install on a standard 15/16” or 9/16” ceiling suspension system along with various cross tees and brackets to achieve the designated angles of the system.

Mixing and matching these different shapes with various colors and panels can create dynamic ceiling patterns that offer acoustical, sustainability, and accessibility benefits.

Flexible design panels have many different attributes and options, all while offering the same acoustical, sustainability, and accessibility benefits as traditional ceiling panels.

Flexible Design – New Color, Shape, and Size Options

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Here's a traditional acoustical ceiling and a new take on it. These still deliver the same acoustics- with choices to absorb sound, block sound or do both depending on the space. You have the ability to mix and match various panel sizes, materials, and colors to create interesting patterns that will personalize the design, offer acoustical control, and meet sustainability standards, in essence reinventing the ceiling.

Panels can range from long, narrow sizes such as 48 or 60 inches long by 4 inches wide to large 30 inch square panels. Configurations for these mix and match square and rectangle panel layouts use 2' or 4' on-center main beam spacing and install on standard 15/16" or 9/16" ceiling suspension system. Integrated lighting solutions can also be used, such as pendant lights or on-center linear lighting.

This section will explore common sustainability standards and certifications and discuss how acoustical ceiling and wall solutions can meet the most stringent sustainability standards today.

Acoustical Ceiling Solutions Meet Sustainability Compliance Standards

37

- High light reflective ceilings reduce energy consumption and aid in extending daylighting
- High recycled content ceilings achieve LEED credit
- Ceilings with low VOC content improve Indoor Environmental Quality (IEQ)

Ceilings are a big part of any building interior so it only makes sense that their sustainability should be addressed.

When designing an energy-efficient building, there is a tendency to focus on things like insulation and windows, but ceiling systems can also play a role in effective energy conservation. Typical acoustical ceilings have a Light Reflectance (LR) rating of 0.75 meaning that they reflect 75 percent of the light striking is surface. High LR ceilings are made to reflect up to 90 percent of the light striking their surface. This means that the light coming from either natural daylighting or electrical lighting systems can be dispersed and spread further with a high LR ceiling, making the space appear brighter with less fixtures needed, reducing electrical light output, maintenance costs, and cooling loads.

Under LEED 2009, MR credit 4, Recycled Content, allows points for recycled material content in a new or renovated building. Ceiling products can have a recycled content from 47 percent up to 92 percent depending on the material specified. There are also a growing number of ceiling products that are being made from bio-based rapidly renewable materials meaning they may qualify under MR credit 6 for one point.

Most ceiling products are pre-finished and qualify as low emitting materials due to low or no VOC content in the ceiling panels, enhancing the indoor environmental quality (IEQ) of a space. Further, no paints, coatings,

adhesives, or harmful sealants are typically needed for ceilings so those concerns are eliminated.

Green Building Standards and Certifications

38

- LEED v4
- LEED for Schools
- WELL
- Living Building Challenge

LEED v4, LEED for Schools, WELL, and the Living Building Challenge are all common green building standards and certifications that architects and designers strive to achieve with their projects. Acoustic solutions, such as the high performance ceiling and wall systems discussed earlier in this course, can help earn particular credits while ensuring that the project is as sustainable as possible.

LEED v4

39

- Minimum performance acoustical criteria for schools
- Acoustic performance includes new construction, data centers, and hospitality sites
- Healthcare criteria that address:
  - Speech privacy, sound isolation, and background noise
  - Acoustical finishes and site exterior noise
- LEED Interior Design and Construction
  - Includes environmental quality (EQ) credit for acoustic performance

LEED v4 addresses issues of indoor environmental quality (IEQ), which most people tend to associate just with healthy indoor air, good daylighting, and thermal comfort. As we have seen, however, noise also plays an important role in the environmental quality and health of a space.

LEED v4 specifically addresses the acoustical needs of schools. We will look at that in more depth in the next slide.

In addition to schools, there are specific performance requirements for new construction, data centers, and hospitality sites, each of which have unique acoustical needs. Healthcare facilities are also highlighted, with a focus on speech privacy, sound isolation, and background noise as ways to protect patient confidentiality, and to make sure that the spaces are healthy for staff to work in and patients to recover.

LEED for Building Design and Construction (LEED BD+C) also includes a credit for acoustic performance. LEED BD+C applies to buildings that are being newly constructed, or that are going through a major renovation. The credit contains several different standards, such as HVAC sound levels, minimum composite sound transmission class ratings for different spaces, and reverberation time requirements. The related LEED for Operations and Maintenance requires users to include acoustics in occupant satisfaction surveys.

Finally, the LEED Interior Design and Construction (ID+C)v4 includes a new environmental quality (EQ) credit for Acoustic Performance.

LEED for Schools

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- Launched in 2007
- Addresses the unique nature of K-12 school design and use
- First of the USGBC Rating Systems to recognize the importance of acoustics
  - Requires a maximum 0.60 second reverberation time
  - Background noise at a maximum of 45 dBA
- Requirements can be met through ceiling and wall panels designed for classrooms

In 2007, LEED for Schools was launched to address the unique aspects of how K-12 school are designed and used. The rating is the first of the USGBC Rating Systems to recognize acoustics as an integral and important element of indoor environmental quality.

LEED for Schools has two key requirements that help improve teacher-to-student communication in the classroom. The first is that classrooms and core learning spaces need to be designed to include sound-absorptive finishes that limit the maximum reverberation time to 0.60 seconds for classrooms that are less than 20,000 cubic feet. Second, the background noise levels from HVAC systems in classrooms and core learning spaces must be no more than 45 dBA.

The acoustical requirements can be attained by considering acoustics in the design process early on, and by using sound-absorbing materials for ceiling and wall panels. Panels that are specially designed for classrooms can be more durable overall and will address the specific types of noise common in educational facilities, as compared to general use.

WELL Building Standard®

41

- Balanced acoustics help people by:
  - Reducing stress
  - Increasing comfort
  - Improving focus and productivity

The WELL Building Standard® is all about changing the way people think about buildings, and the overall focus is on how design, operations, and behaviors can improve overall human health and well-being in the places where people live, work, learn, and play. Two concept areas covered in WELL are “comfort” and “mind”. The impact of noise, and thus the importance of good acoustics plays a big role in comfort and cognitive and emotional health.

Of the many issues that impact the comfort of a space, acoustics is usually listed as the top problem, and the WELL Building Standard® aims to help designers create spaces that reduce unwanted interior and exterior noises, which in turn can enhance social interaction, learning, and satisfaction.

Comfort in an interior space is directly linked to another other concept that WELL addresses, which is “mind”, and mind is linked directly to physical well-being. The stress of an overly noisy environment, whether in a school, an office, or in a hospital, can prompt stress and depression, which in turn can lead to more significant physical ailments, such as heart disease.

Well balanced acoustical systems can counter all of those problems, and help make interior spaces less stressful, more comfortable, and help people focus and be more productive. Spaces with good acoustics can drastically improve the health and well-being of the people who live, work, learn, and play – and heal – in certain spaces.

WELL Building Standard®

42

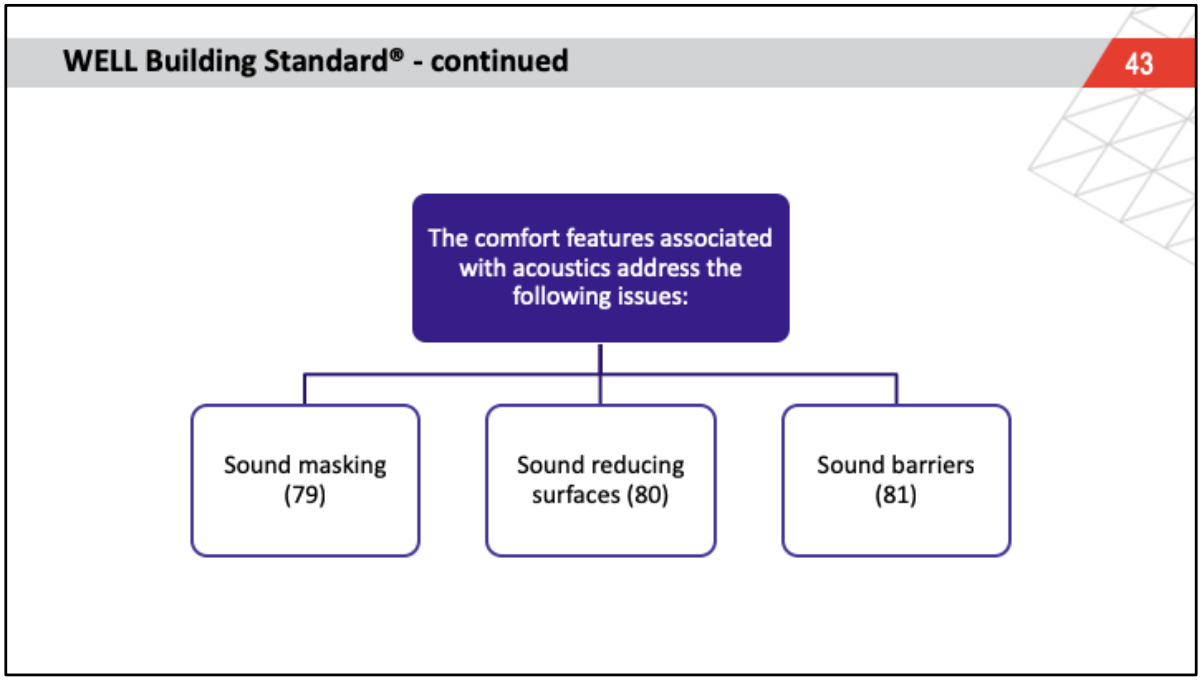
- The comfort features associated with acoustics address the following issues:
  - Exterior noise intrusion (Feature 74)
  - Internally generated noise (75)
  - Reverberation time (78)



The WELL Building Standard® has requirements designed to create a "distraction-free, productive and comfortable indoor environment," and acoustics play a big role in meeting these requirements.

The comfort features associated with acoustics address issues of exterior noise intrusion (Feature 74) and internally generated noise (Feature 75). Exterior noise intrusion is most common in urban areas, where loud repetitive noises are known to generate stress responses that can lead to very real health implications, such as increased risk of diabetes, stroke, and heart attack, as well as hypertension. By preventing excessive outside noise from entering a building interior, designers can improve occupant comfort and wellbeing. Indoor noises such as HVAC systems, mechanical equipment, and noisy office devices – as well as other people – all contribute to an environment that can reduce productivity. Feature 75 of the standard helps designers identify loud and quiet zones within a building and design accordingly.

The standard for reverberation time (RT60) varies on room volume and intended use of the space, but it sets metrics for the maximum in different spaces including learning spaces.



The WELL standard for sound masking is intended "to reduce acoustic disruptions and increase speech privacy by implementing sound masking into the building design." The standard addresses issues of ambient silence, too, noting that it can be just as distracting as a loud environment because it highlights noises when they happen. Silence also makes it easier for unintended listeners to overhear private conversations. Sound masking systems are designed to provide low-level background noise that improves the ability to speak privately without being heard.

Another way that the standard addresses noise issues is by ensuring that designers aim to reduce sound reverberation and maintain comfortable sound levels through ceiling and wall solutions. These solutions can address the many acoustic issues such as sound from both external and internal sources, and they can improve overall indoor comfort.

Finally, sound barriers such as indoor partitions and doors can help reduce sound from moving through a building, limiting acoustic disruptions. By doing so, designers can help control unwanted sounds and improve the indoor comfort for building occupants.

Case Study: American Society of Interior Designers (ASID) HQ

44

- New HQ designed as a living laboratory of impact of design on human experience
- Create the office of the future
- Incorporate solutions for health, wellness, and sustainability

When the American Society of Interior Designers (ASID) decided to build their new headquarters in Washington, DC, they chose to create the space as a living laboratory that could demonstrate the impact of design on the human experience. The design goal was to create the office of the future, and to incorporate design solutions that addressed health, wellness, and sustainability organizing principles.

ASID created a space that reflects their core believes – that design directly impacts lives. They accomplished this by applying principles that improve the health and wellness of their staff, with the goal of positively improving employee productivity, efficiency, and creativity. As part of this initiative, ASID plans to evaluate the success of the space and share their findings with the larger designer community to help advance the future of workplace design.

The 8,500 square foot ASID headquarters includes multiple innovations in interior design, all to improve the health and wellness of employees. For example, there is a circadian lighting system that mimics the daily cycle of natural light. This lighting system is paired with fully automatic shades that adjust height depending on the position of the sun throughout the day. In addition, the design includes biophilic strategies such as including plants in every window, all to help reduce employee stress by giving them immediate access to nature.

In addition to many other design features, the space is acoustically designed to ensure that collaboration areas reduce sound levels, and different room designs that allow employees to choose spaces that best meet their needs.

Case Study: American Society of Interior Designers (ASID) HQ

45

- Design solution highlighted acoustical ceiling products
- Incorporated biophilic design strategies and the WELL Building Standard
- High performance acoustic ceiling tiles provided NAC and CAC dampening attributes

The design solution for the headquarters highlighted acoustical ceiling systems in key areas of the 7,200 square foot space. The ceiling system was a big part of supporting key goals of health and wellness, with the intent to improve occupant comfort and acoustical quality with organization metrics of engagement, retention, and productivity.

In addition to the acoustical ceiling, the space includes several other tactics, such as biophilic design strategies to help reduce stress and increase air quality; strict water quality standards; and a fine-tuned lighting system designed to improve productivity by regulating physiological processes such as circadian rhythms. The office was designed to the WELL Building Standard.

The acoustic element of the high performance ceiling tiles helped showcase how such building products could deliver sound absorption (NAC) and sound blocking (CAC) dampening attributes in a flexible and cost-efficient design. While designed as a living laboratory, the office space has provided an excellent example of how a workplace can be good for the environment and good for people.

Living Building Challenge

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LIVING BUILDING CHALLENGE

- Focuses on the most important environmental conditions to create robust, healthy spaces
- Contributes to improved indoor environmental quality (IEQ) which can optimize occupant effectiveness

High performance acoustics systems constructed from healthy, sustainable materials can contribute to the Living Building Challenge under the Health + Happiness Petal, which focuses on the most important environmental conditions that must be present to create robust, healthy spaces rather than to address all of the potential ways that an interior environment could be compromised.

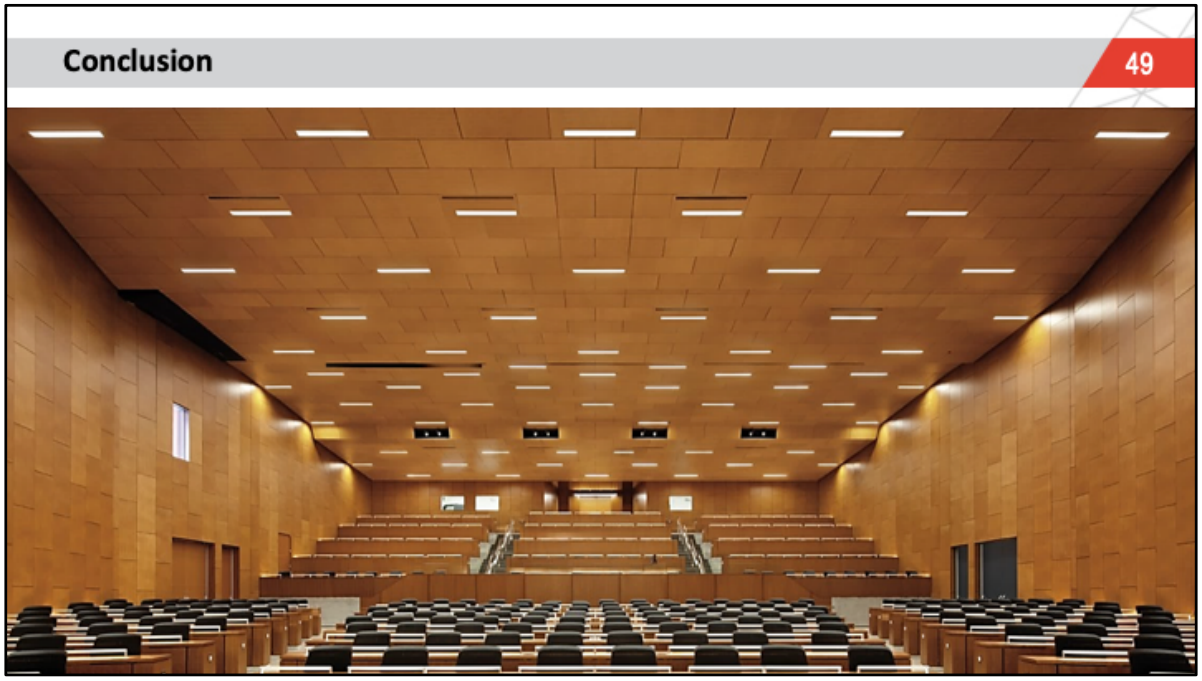
As we have seen earlier in the course, thoughtfully designed interiors that address the acoustical needs of the occupants can do far more than just manage sound. The systems can improve the overall indoor environmental quality (IEQ) through improved daylighting, which can reduce eyestrain and fatigue, and the materials themselves can improve the indoor air quality. All of these considerations can directly improve occupant productivity, whether that productivity is learning, working, or healing.

Julian Treasure Video: Better Spaces

47

Julian Treasure Video: No Compromises

48



There are several take-aways from this course, including that high performance acoustic systems are incredibly important to the health and wellbeing of building occupants. As researchers continue to gather evidence on the impacts of interior spaces on people, it is becoming increasingly clear that good acoustical design can address indoor environmental issues beyond sound and noise control. For example, it can improve daylighting and bolster good indoor air quality. These aspects can help improve productivity, learning, and even healing.

Furthermore, new acoustic systems are increasingly being manufactured with certified healthy and sustainable materials that are also cost-effective. Finally, new materials and products make it easy for designers to simultaneously achieve acoustic and aesthetic design goals in their projects while creating some amazing spaces.

Thank You

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This concludes the continuing education unit on the Acoustical and Sustainable Design for Occupant Well-Being in Every Space.

Please take the quiz to receive your credits.

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