# Optimizing Acoustic Experiences in Schools

HOW TO OPTIMIZE ACOUSTIC PERFORMANCE USING DIFFERENT CEILING MATERIALS AND DESIGNS.

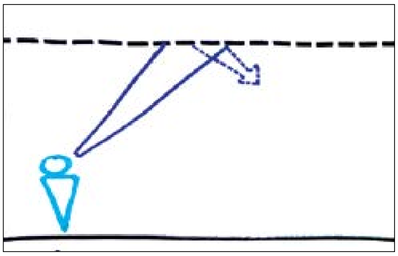
By Gary Madaras

All ceilings, regardless of their materials or design, are acoustic. They absorb, reflect or diffuse sound. Designers can optimize the acoustic experience in each room based on its function, the acoustic characteristics of different ceiling materials and the ceiling design itself. During the earliest stages of a project's design, forethought about the desired acoustic experience also can contribute to the aesthetic character of each space and the entire facility.

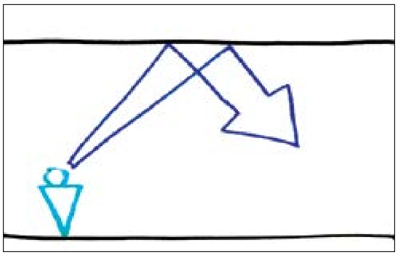
Schools serve as a perfect example of facilities that have a wide variety of room types and desired acoustic experiences. Educational facilities have many rooms where speech intelligibility is important, other rooms where music is meant to be rehearsed or performed, and still other spaces where acoustic comfort for relaxation, concentration or privacy are desired.

## Rooms for Speech

Making speech intelligible requires a loud sound source, such as the person speaking and strong, early arriving



ABSORPTION



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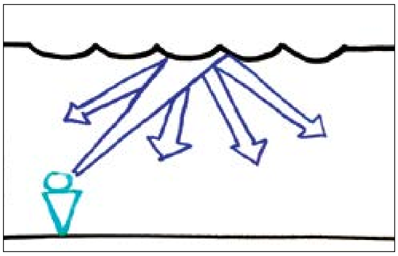


DIFFUSION


reflections off room surfaces close to the person speaking or the listener. It also requires attenuation of all noise. In other words, speech intelligibility requires a high signal to noise ratio.

Noise can come from many different sources including those on the exterior, in other interior spaces, building systems and late arriving, reverberant sound persisting inside the room itself. The appropriate reverberation time for speech—typically between 0.5 and 1.0 second (mid frequencies)—usually enables listeners to hear and understand each word, without the sound of the preceding words interfering. Therefore, in addition to designing the ceiling correctly, care must be taken to isolate the room and control building system noise.

One of the most common mistakes designers make is to place a sound absorptive ceiling over the entire speech room. Unfortunately, this is why electronic audio reinforcement systems are so common. Instead, the teacher's voice can be amplified passively with proper ceiling materials and design.

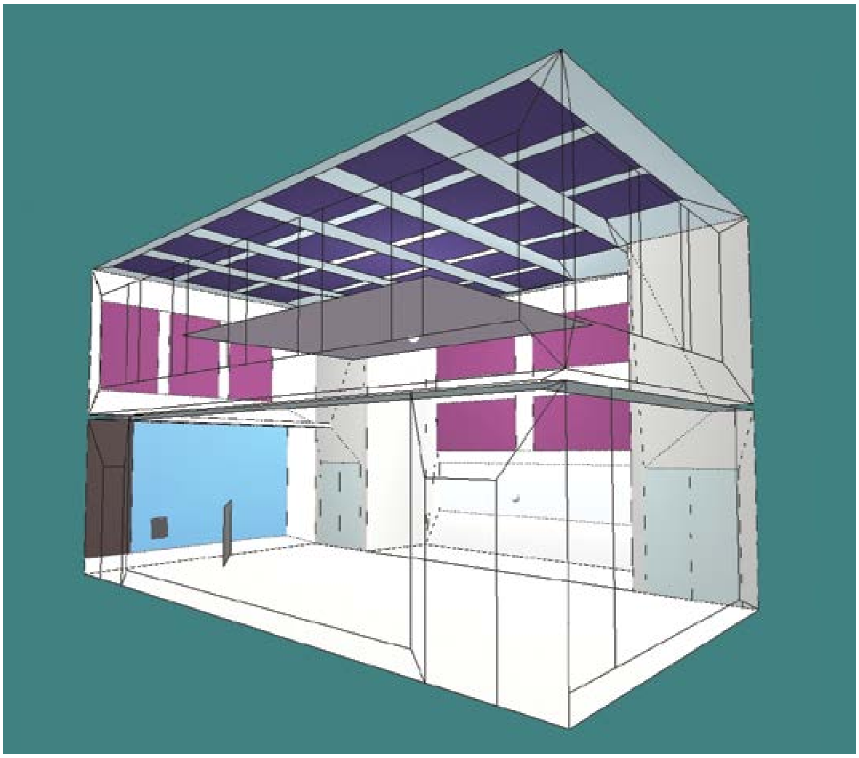
With approximately 25 percent of the ceiling area located over the teacher comprised of sound reflective or sound diffusive ceiling panels, the teacher's voice will project at a higher sound level out into the student seating area. This passive amplification of the teacher's voice will increase speech intelligibility, increase attention span by creating acoustic intimacy and decrease teacher voice fatigue.

The strong reflections off the ceiling, combined with the direct sound traveling from the teacher's mouth to the students' ears, create a loud and clear signal. The remaining 75 percent of the ceiling can be specified as highly sound absorptive to attenuate sound that would otherwise reverberate in the room and interfere with the original speech signal.

An example for successfully designing ceilings in classrooms would include approximately 25 percent of the total ceiling area comprised of sound reflective metal ceiling panels (no perforations) with a low Noise Reduction Coefficient over the front, center portion of the room; with the remainder of the ceiling being stone wool ceiling panels, which have an NRC of 0.85 to 0.90. All of the ceiling panels in this example would be suspended using 9/16-inch or 15/16-inch metal grid.

## Rooms for Music

The ceiling takes on a different role in rooms for music rehearsal and performance. Typically, the ceiling must be much higher compared with a classroom's ceiling because the increased room volume lengthens the reverberation time. The appropriate reverberation time for music is typically between 1.5 and 2.5 seconds. A higher ceiling is more appropriate in rooms for music as it decreases overall loudness and the harshness of brass and percussion instruments. How-



ever, higher ceilings potentially could hinder ensemble playing and singing.

To promote clarity for ensemble playing and singing, sound reflective or diffusive clouds can be suspended over the ensemble or the audience to provide the strong, early-arriving reflections from overhead. This approach creates an upper, contiguous ceiling that caps the room and a lower cloud or array of clouds suspended closer to the room's occupants. The acoustical characteristics of the upper ceiling can vary depending on the exact function of the room, the reverberance desired and loudness control required.

For example, in a choral rehearsal room, the upper ceiling may be composed entirely of sound reflective metal panels because a chorus is not as loud as an instrumental ensemble and the extra absorption is not needed. In an orchestral rehearsal room, more loudness control is needed along with reverberance, so a mixture of sound absorptive stone wool and sound reflective metal ceiling materials would be used.

In a band rehearsal room, the main concern is loudness control, not lengthy reverberance, so the upper ceiling would be entirely made of sound absorbing stone wool panels with a high NRC. NRC varies between 0.0, absorbs little sound, and 1.0, absorbs a lot of sound.

The clouds suspended lower in a room for music are typically a sound reflective material, such as metal, and perhaps a diffusive shape. Preferably, the panels are curved in one or both directions to distribute the sound uniformly. Curving the clouds also helps to decrease their size. Flat clouds have to be larger than curved ones to achieve the same coverage throughout the room.

An example for successfully designing ceilings in a band rehearsal room would include the upper ceiling, located perhaps 20 feet above the finished floor, using highly sound absorptive ceiling panels in a standard 15/16-inch or 9/16-inch suspension system installed right below the roof structure. Then, at a height of 12 feet above the finish floor, suspend curved metal clouds totaling approximately 50 percent of the ceiling area using solid metal ceiling panels.

## Rooms for Acoustic Comfort

Many rooms are not necessarily used for understanding speech or appreciating music. These include corridors, computer laboratories, cafeterias, natatoriums, gymnasiums, media centers and offices. But acoustics are still important from a comfort and privacy perspective. Excessively loud and reverberant spaces are stressful and negatively affect concentration and productivity.

To optimize acoustic comfort in spaces that are not primarily speech or music rooms, the ceiling should be as sound absorptive as possible. The ceilings should be as low as possible to decrease the volume of the room and to move the sound absorbing material as close as possible to the sound sources. Materials providing high NRC values include stone wool ceiling panels and perforated metal ceiling planks or panels with high percent openness and backed by sound absorptive batts.

It is important to remember that an ideal acoustic experience does not equate to higher and higher sound absorption. Instead, it results from the right recipe of absorption, reflection and diffusion.

A good acoustic experience is dependent on numerous acoustic factors, many of which are beyond the scope of this article. Rooms need to be constructed properly so noise from the exterior and other adjacent spaces do not interfere with the functions of the room. Building systems need to be designed properly with noise control measures when necessary. The size of the room, shape of the room and wall materials in the room all have equally important roles as the ceiling materials and design.

By following the ceiling concepts in this article, designers can begin to understand one of the most important acoustic design components shaping the built environment for a multitude of acoustic experiences. **W&C**

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