

Acoustic design of music rehearsal rooms

Erica Ryherd

An architectural acoustician relies on the physics of sound propagation, material properties, and noise control to craft a desired soundscape.

Erica Ryherd is an assistant professor of mechanical engineering at the Georgia Institute of Technology in Atlanta.

A top priority in designing music rehearsal rooms is the acoustical environment. Indeed, as noted by Edward McCue and Richard Talaske in their introduction to *Acoustical Design of Music Education Facilities* (Acoustical Society of America, 1990), “The acoustical response of a room becomes the very warp into which the threads of music are woven.” Paramount to a rehearsal environment’s success is that the space be conducive to discriminating listening, so that nuances of intonation, articulation, and other musical intricacies can be heard by the musicians and conductor. The science of architectural acoustics is involved in several aspects, ranging from the physical properties of materials to the design of the room itself.

Architectural acoustics seeks to optimize the acoustical conditions in the built environment. Those working in the field come from a broad range of backgrounds, including physics, engineering, and architecture. The distribution of sound within a space, the material properties of room surfaces and the surrounding envelope, and the control of intrusive noise sources are some of the key issues underlying architectural acoustics design. A music rehearsal facility usually includes a variety of spaces such as offices, storage rooms, performance halls, music labs, large areas for ensemble rehearsal, and smaller practice rooms for individuals or small groups. This Quick Study focuses primarily on ensemble rehearsal rooms, although many of the concepts apply to other spaces.

Music room acoustics

When sound is emitted from a musical instrument, it propagates in many directions as an acoustic wave, striking the surfaces in its path. The distribution of sound within a space therefore depends on the material properties of those surfaces. Portions of the incident sound energy can be absorbed, reflected, or transmitted. In general, soft, fibrous surfaces are more likely to absorb sound, whereas hard, dense surfaces are more likely to reflect sound. Coefficients of absorption, reflection, and transmission for different building materials and assemblies can be measured in an acoustic laboratory. They generally vary with frequency, as do many other acoustic metrics. Therefore, the design of music rehearsal rooms must be evaluated with regard to the range and distribution of frequencies produced by the ensemble using the space. In general, the frequency range of interest spans 31.5–8000 Hz, although that range may be reduced or

expanded in various circumstances.

Reverberation time is another key consideration in the interior design of a music rehearsal room. It is a measure of how quickly sound decays; specifically, the RT is the time needed for the sound energy to be reduced by a factor of 1 million. It is directly related to the volume of a space and inversely related to the space’s absorption. After all, sound strikes absorbing surfaces less often in larger volumes, so sound energy decays more slowly. Likewise, less intrinsic absorption leads to decreased depletion of sound energy. Longer RTs add a sense of richness and fullness to music. But excessive reverberance can blur a speech waveform in time, so shorter RTs are better if a speech is to be delivered. Typical RT recommendations for band or orchestral rehearsal spaces are 0.8–1.0 second; recommendations for choral rehearsal spaces may be slightly longer, 1.0–1.3 seconds, so that the voices can blend nicely.

The volume of a rehearsal space, in addition to affecting the RT, also directly influences the overall sound energy and pressure levels. Spaces that are too small can have dangerously high sound pressure levels that could increase a person’s stress level and lead to hearing loss. Conversely, excessively large spaces can negatively impact communication among the musicians. Suspended panels to diffuse or reflect sound can increase the number and strength of useful early reflections; that helps the musicians to hear each other and provide a sense of ensemble.

A combination of absorbing and diffusing elements helps to create an ideal listening environment in a music rehearsal room. As shown in the figure, such elements are typically placed on the walls and ceilings. Absorbing panels will soak up sound energy to help control reverberation time, reduce overall sound buildup, and control reflections. A good general-purpose absorber, often used in music rehearsal rooms, is a 2- to 4-inch-thick fiberglass panel.

The type, thickness, area, and mounting of the absorbing material influence the range of frequencies for which it is effective. Higher frequencies, such as those from flutes, are generally easier to absorb. Carpets, curtains, and other thinner materials can be effective for those higher frequencies. The lower frequencies that tubas and other instruments produce are more difficult to absorb and usually require thicker materials, larger surface areas, or airspace.

Diffusing panels redirect sound waves so as to create a more uniform distribution of sound energy. Large, flat sur-



Reflection, diffusion, and absorption all contribute to the sound quality in a music practice space. This choral rehearsal room features diffusers suspended from the ceiling and absorbing and diffusing panels attached to the walls. (Courtesy of Wenger Corp.)

faces tend to produce specular reflections, whereas diffusing surfaces tend to scatter sound. Various diffuser shapes are available, including pyramidal, convex, and more complicated geometric forms.

In addition to creating a desired sound distribution, the combination of diffusers and absorbers can help to eliminate unwanted reflections. The room's shape is also important in that regard. The goal is to create useful reflections that help musicians hear what they and their colleagues are doing and to direct sound to the conductor. At the same time, one needs to avoid undesirable reflections such as flutter echoes or standing waves. Flutter echoes can form when sound reflects back and forth between parallel walls. Standing waves can emerge if an interference pattern is set up between forward and backward traveling waves. Simply splaying walls or otherwise avoiding cube-shaped rooms will help minimize both types of problematic reflection.

Sound isolation and noise control

Excessive ambient noise makes it hard to discern the music or speech that one wants to hear. Space planning, sound isolation, and noise control of building systems are all tools that architectural acousticians use to achieve quiet spaces. They aim to keep unwanted sound out of the rehearsal space and to prevent rehearsal noise from intruding on nearby sound-sensitive spaces such as classrooms or practice rooms. For example, it makes sense to place a rehearsal space far from a mechanical equipment room, and buffers such as corridors and storage rooms can help protect sensitive spaces.

The goal of sound isolation is to prevent unwanted noise from entering a space via an airborne or structure-borne path. The noise may be due to other occupants, building systems, exterior traffic, and so forth. Airborne sound isolation generally takes advantage of the mass of control barriers; therefore, lightweight structural materials are discouraged. Good sound isolation requires that the barriers have high sound transmission loss. Wall seams, fenestrations such as doors and windows, and penetrations for ductwork, electrical outlets, and the like will all compromise airborne sound isolation. They also have acoustical impacts that must be

considered in the design of the barrier assembly.

Structure-borne sound isolation generally involves a resiliency, essentially a discontinuity introduced to avoid rigid structural connections and thereby diminish wave propagation through the structure. An example is the structural expansion joints used around the perimeter of a performance space or recording studio.

The design, isolation, and installation of building systems are also critical in achieving quiet rehearsal spaces. Heating, ventilating, and air-conditioning (HVAC) systems and other building services, such as electrical systems, must be thoroughly assessed in the design of any rehearsal space.

The acoustic environment of a music rehearsal room isn't an accidental creation. This Quick Study has touched on some of the issues considered by the architectural acoustician; they include reverberation time, loudness, and sound distribution. A host of other nuances such as tone color, warmth, brilliance, and support should also be considered in the acoustic design of music rehearsal rooms—a realm at the intersection of science and art.

Additional resources

- M. Mehta, J. Johnson, J. Rocafort, *Architectural Acoustics: Principles and Design*, Prentice Hall, Upper Saddle River, NJ (1999).
- L. Beranek, *Concert Halls and Opera Houses: Music, Acoustics, and Architecture*, Springer, New York (2004).
- Wenger Corp, *Planning Guide for Secondary School Music Facilities*, Wenger Corp, Owatonna, MN (2006), available online at <http://www.wengercorp.com/images/lit/lit/Wenger%20Planning%20Guide.pdf>.
- American Society of Heating, Refrigerating, and Air-Conditioning Engineers, *ASHRAE Handbook: HVAC Applications*, ASHRAE, Atlanta, GA (2007), chap. 47, "Sound and Vibration Control."