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RESEARCH ARTICLES

A PROPOSED LEED STANDARD FOR INDOOR ACOUSTICAL QUALITY

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ABSTRACT

Acoustical quality of the indoor environment is increasingly being recognized as important in commercial, residential and institutional building design. Unwanted sound is the most prevalent annoyance in many modern structures, leading to increased stress, loss of productivity and decreased quality of life for building occupants. The authors propose a minimum LEED standard for acoustical quality which can be incorporated into initial design or employed as a post-construction evaluation tool.

KEY WORDS

acoustical quality, speech privacy, sound transmission class (STC), impact insulation class (IIC)

INTRODUCTION

From 1993 to 1998, a U.S. Green Building Council (USGBC) task force developed standards to evaluate a building's resource efficiency and environmental impact. These standards, which became known as Leadership in Energy and Environmental Design (LEED), were instrumental in quantifying the transition from conventional design and construction practices towards practices that produce high performance (or green) buildings. Green buildings enhance sustainability of the built environment through five practices:

- Minimal energy consumption
- Minimal atmospheric emissions
- Minimal discharge of harmful wastes
- Minimal negative impacts of site ecosystems
- Maximum quality of the indoor environment (ASHRAE Green Guide, 2006).

A statewide activity survey conducted in 1987–88 showed that individuals in California spend an average of 87% of their lives in an indoor environment (Jenkins et al., 1992). The National Human Activity Pattern Survey conducted in 1992–94 confirmed that the mean percentage of time that an individual spends indoors was approximately 87% (Klepeis, et al., 2001). Considering the relatively large percentage of time spent indoors, it is clear that quality of the indoor environment can have a significant impact on an individual's level of comfort, health and general well-being.

LEED buildings provide functional, safe, healthy and comfortable indoor environments that enhance the lives of their occupants (USGBC 2005). LEED standards address many specific aspects of the indoor environment including thermal comfort, natural lighting and air quality, but fail to include acoustics. It would seem difficult to provide a healthy and comfortable indoor environment without considering acoustics. A building's interior should provide conditions supportive of the occupants' health and well being. Acoustics is critical to the quality of almost every type of indoor environment, from offices and residences to worship centers. Unwanted sound has become a prevalent and pervasive annoyance within many modern structures, leading to increased stress for building occupants (Evans and Johnson 2000). Even a moderate level of office noise

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increases employee fatigue and has detrimental effects upon employee performance (Wittersell et al. 2004).

Designers currently concentrate on preventing obvious and extreme problems with unwanted sound, such as locating air conditioning compressors and fans away from sensitive areas such as conference rooms. More subtle concerns are often overlooked, such as neglecting to acoustically insulate a wall that separates restrooms from private offices. Quality of the indoor acoustical environment is typically given minimal attention during project planning and design, and is often among the first items to be eliminated when the construction budget becomes constrained. Poor acoustics in the working environment creates increased stress and fatigue for workers, lowers job performance and significantly contributes to environmental and job dissatisfaction (Sundstrom et al.1994).

A minimum acoustical standard should be applied when designing indoor spaces with common interior walls or partitions and in situations where walls, floors/ceilings are adjacent to public areas or other noise sources. The basic premise of creating a LEED acoustical standard is to ensure that sound levels in specific areas of a building remain at a level amenable to supporting the activities occurring within the enclosed space. Controlling the level of noise transmission between adjoining spaces facilitates acoustical comfort while contributing to the overall quality of the environment for the occupants.

BACKGROUND

Jensen et al. (2005) analyzed employee satisfaction with office environments in buildings surveyed by the Center for the Built Environment (CBE) at the University of California, Berkeley. For the past several years, the CBE has been conducting a survey that assesses indoor environmental quality of office buildings. The CBE's research focuses on occupant satisfaction with indoor environmental quality (IEQ). A survey measures occupant satisfaction and self-reported productivity in nine categories using an anonymous, web-based questionnaire (Zagreus et al. 2004).

When occupants express dissatisfaction with a survey category, the survey branches to a follow-up page where respondents can check-all-that-apply from a list of possible sources of dissatisfaction. By analyzing responses from the branching pages and comparing the distribution of complaints, researchers obtained a detailed view of factors contributing to occupants' dissatisfaction with their working environment.

A total of 23,450 respondents from 142 buildings were included in the analysis. General categories of questions dealt with varying aspects of the workplace including general office layout, furnishings, thermal comfort, air quality, lighting, cleanliness and maintenance. Acoustic quality consistently received the lowest average satisfaction score of the nine core categories in the survey (Jensen et al. 2005).

Occupants of private offices were significantly more satisfied with acoustics than occupants working in cubicles. Among occupants expressing dissatisfaction with acoustics, the most prevalent complaints were "people talking on the phone", "people overhearing private conversations" and "people talking in surrounding offices". Over fifty percent of cubicle occupants believed that unsatisfactory acoustics hindered their ability to successfully accomplish their tasks (Jensen et al. 2005).

Acoustic satisfaction in the CBE survey is a function of satisfaction with both level of background noise and speech privacy. The acoustic score was calculated as an average of the scores of two questions, satisfaction with noise level and satisfaction with speech privacy. Respondents were significantly more dissatisfied with adequacy of speech privacy than with the background noise level (Jensen et al. 2005). The high level of speech privacy dissatisfaction was primarily responsible for the low acoustic satisfaction average. Occupants of private offices were far more satisfied than the occupants of either high wall or low wall cubicles with both noise level and speech privacy. The results of this study suggest that more emphasis on improving speech privacy and reducing interoffice noise is needed to increase the satisfaction level of employees working in all types of open-plan offices.

Abbaszadeh et al. (2006) summarized the results of a large indoor environmental quality survey of green office buildings and compared the results to similar surveys for non-green buildings. On average, occupants of green buildings were more satisfied with the thermal comfort and air quality of their work-space than employees in non-green office buildings. However, the average satisfaction scores in green buildings for lighting and acoustic quality were comparable to the non-green average. Comparing complaint profiles of those dissatisfied with lighting and acoustic quality, a higher percentage of occupants were dissatisfied with lighting and sound privacy in green buildings than in conventional buildings.

Occupants of LEED-rated/green buildings associated their acoustic dissatisfaction with, in descending order, “people talking in neighboring areas”, “people overhearing my private conversations”, “people talking on the phone”, and “telephones ringing”. Directly comparing the two groups, a higher percentage of people in LEED/green buildings complain about “people overhearing my private conversations”, “people talking on the phone”, and “telephones ringing”. Complaints follow the same relative order within both groups. The top three complaints in both groups were related to a lack of speech privacy and distractions from hearing others’ intelligible speech, rather than excessive distraction created by the background noise level within the building. These results suggest a need for improvement and/or innovative strategies to accommodate employees’ acoustical privacy needs in open plan and cubicle office layouts.

High efficiency heating, ventilating and air-conditioning (HVAC) systems designed and installed to acquire LEED credits in Energy and Atmosphere (EA Credit 1) and in Environmental Quality (EQ Credit 5) can sometimes exacerbate acoustical problems. Under-floor air delivery (UFAD) systems are being installed because of their high energy efficiency and their ability to introduce fresh air at multiple points throughout the room. UFAD systems produce very little noise as only low velocity air is transported. The authors are aware of one UFAD project where the owner found it necessary to take remedial action regarding complaints from building occupants about the lack of speech privacy due to the absence of noise generated by the building’s UFAD system. Installation of the white noise generators resulted in immediate cessation of complaints. In this instance, design and construction to LEED specifications resulted in high occupant satisfaction with air quality and thermal comfort, but low satisfaction with acoustical quality.

Occupants of green buildings are, on average, more satisfied with air quality and thermal comfort than occupants of non-green buildings. Although there are some green buildings where occupants express low satisfaction within the CBE database, overall results suggest that LEED design strategies commonly employed in green buildings have been effective in improving occupant satisfaction with both air quality and thermal comfort. Conversely, lighting and acoustic quality in green buildings do not show significant improvement in comparison to non-green buildings. Although LEED credits exist for daylighting (EQ Credit 8.1 and 8.2), the level of illumination commonly provided by natural lighting is insufficient for many tasks and must often be supplemented by artificial light. This paper proposes a LEED standard designed to accomplish for acoustical quality what existing LEED standards have accomplished for indoor air quality and thermal comfort.

METHODOLOGY

The methodology used to develop an acoustic standard was based on a review of literature on sound control, sound insulation and noise transmission, a review of current acoustical standards and noise criteria, and a review of journal and magazine articles related to quality of the indoor acoustical environment. Information and data concerning sound transmission and acoustical standards were compiled and analyzed. A draft proposal for the LEED standard was created and discussed with local engineers and architects. Intent, requirements and potential technologies and strategies to obtain credit for acoustical quality within the LEED certification system were subsequently finalized and are presented later in this paper.

The scientific study of sound is called acoustics. Sound is simply vibrations that travel through the air (in the case of airborne sound) which can be heard by humans. Scientists and engineers use a wider definition of sound that includes low and high frequency vibrations in air that cannot be heard by humans, and vibrations that travel through all forms of matter. Sound consists of mechanical energy that propagates through matter as a longitudinal wave, characterized by wavelength, period, amplitude, and speed. Sound propagates as waves of alternating pressure, causing local regions of compression and rarefaction in the medium. Particles in the medium are displaced by the sound wave and oscillate.

Sound is perceived through the sense of hearing. Humans and many animals use their ears to hear sound, but loud sounds and low-frequency sounds can be perceived through the body by the sense of touch as vibration. Humans can generally hear sounds with frequencies between 20 Hz and 20 kHz (the audio range), although this range varies significantly with age, occupational hearing damage and gender. A majority of people can no longer hear 20,000 Hz by the time they are teenagers and progressively lose the ability to hear higher frequencies as they age. Most human speech communication takes place between 200 and 8,000 Hz. The human ear is most sensitive to frequencies around 1,000 to 3,500 Hz.

The amplitude of a sound wave is specified in terms of its pressure. The human ear can detect sounds over a very wide range of amplitudes, so a logarithmic amplitude scale known as the decibel (dB) scale was developed. Sound pressure is the pressure deviation from the local ambient pressure caused by a sound wave. Sound pressure can be measured using a microphone in air or a hydrophone in water. The international metric system (SI) unit for sound pressure is the pascal (Pa). The quietest sound that a human can hear has an amplitude of approximately 20 µPa (micropascal) or a sound pressure level (SPL) of 0 dB. Prolonged exposure to a sound pressure level exceeding 85 dB can permanently damage the ear, resulting in tinnitus and hearing impairment. Sound levels in excess of 130 dB are more than the human ear can safely withstand and can result in serious pain and permanent damage. The human ear perceives a 10 dB reduction in sound as roughly half the volume, so a sound level of 30 dB seems only half as loud as a sound level of 40 dB.

Noise is a term which refers specifically to unwanted sound. Sound becomes noise when it is too loud, unexpected, uncontrolled, occurs at the wrong time, contains unwanted information, is unpleasant or any combination of the above (ASHRAE 2005). Noise creates both physiological and psychological changes in individuals, increases stress levels, and is known to disturb sleep.

ANALYSIS

Three basic properties of an enclosed space govern its acoustical characteristics. These include the degree of attenuation for sound propagating through partitions from adjoining spaces, the level of background noise (from within and outside of the space), and the reverberation of sound within the space. The International Building Code (IBC), like its predecessor the Uniform Building Code (UBC), provides standards for sound transmission class (STC) ratings between adjacent spaces within a structure and sound transmission along structural paths using the impact insulation class (IIC) system.

Sound transmission class (STC) is an integer used to compare doors, partitions, windows, etc. for their effectiveness in blocking the transmission of sound. Tests are conducted in accordance with ASTM E90 procedures in laboratories or ASTM E336 when field testing in actual buildings. The STC number is determined in accordance with ASTM E413 procedures, which allow room reverberance and the size of the room to be factored out. Tests are conducted in a manner so that each test is independent of its environment; the STC reflects the effectiveness of the partition only. The STC is weighted toward frequencies above 125 Hz but lower than 4,000 Hz, which roughly corresponds to frequencies associated with human speech. STC has been found to be a very effective measure of sound attenuation by partitions over the range of human speech.

A typical interior wall in a residence or office consisting of a single layer of drywall bound to each side of a wooden frame has a STC of about 33. This level of sound attenuation is often referred to as being “paper thin” and offers little in the way of privacy. Adding insulation to the wall cavity increases the STC to about 36 to 40, depending on the spacing of the studs and screws. Decoupling the panels from each other through the use of resilient channels or staggering the studs with internal insulation and two layers of drywall per side can yield a STC as high as 63. Concrete and block walls commonly have STC’s in the 40’s or 50’s. Because of the logarithmic scale used to measure decibel level, a wall with a STC of 63 will transmit approximately 1/1000 of the sound energy as a wall with an STC of 23 and will seem almost ninety percent quieter. Composite partitions (i.e. walls with doors, windows and penetrations) normally have a STC close to the lowest STC for any component of the partition. STC is applicable only to airborne sound and should not be used as a guideline for controlling noise from mechanical equipment, music or other noise that is weighted in frequencies lower than normal human speech.

Measurement of a building's structural sound paths is conducted in accordance with ASTM E492. This standard rates the effectiveness of floor and ceiling assemblies to mitigate the transmission of impact sound from a standard tapping machine, which simulates structure-borne or impact noise. ASTM E989 is subsequently used to calculate the impact insulation class (IIC) of the floor and/or ceiling assembly. This system simulates structure-borne noises such as footfalls or a ball being bounced on a floor. While IIC provides a quantitative method of measuring impact sound, almost any floor covered with carpet will meet most IIC requirements contained within modern building codes.

The International Building Code (IBC) requires that common interior walls, partitions and floor/ceiling assemblies between adjacent dwelling units or between dwelling units and adjacent public areas such as halls, corridors, stairs or service areas have a STC of not less than 50 (if laboratory tested) or 45 (if field tested) for airborne noise (IBC 2006). Penetrations or openings in partitions for piping, electrical conduit, or heating, ventilating or exhaust ducts must be sealed, lined, insulated or otherwise treated to maintain the required rating. The IBC contains further specifications for structure-borne sound, stating that floor/ceiling assemblies between dwelling units or between a dwelling unit and a public or service area shall have an impact insulation class (IIC) rating not less than 50 if laboratory tested or 45 if field tested.

Walls and floor/ceiling assemblies designed to comply with current code requirements do not always result in the constructed partitions meeting code, because, in practice, wall and floor assemblies seldom perform as well as expected. In the real world, assemblies are never installed perfectly; most walls, ceilings and floors will have or develop leaks and flanking paths, which will not allow them to achieve their design rating. Even when STC standards are achieved, there are often complaints from building occupants regarding noise. The traditional solution has been to overbuild by designing partitions with an acoustical rating significantly higher than required to meet code.

In most interior spaces, there is a combined level of noise generated by traffic, heating, ventilating and air conditioning equipment, plumbing and office equipment which is referred to as background noise. The level of background noise should not be so loud that it interferes with normal activities, nor should it be so quiet that sounds intruding into the space become annoying. There are several methods of measuring, specifying and adjusting the background level of noise.

Noise criteria (NC) are commonly used by acoustics professionals to rate the interior noise levels of enclosed spaces. The concept of noise criteria was originally developed to describe the relative loudness of a space by examining a range of frequencies instead of measuring a single decibel level. NC values are derived from a series of curves of octave-band sound pressure levels and indicate the extent to which background noise interferes with speech intelligibility. NC values can also be used to specify the continuous background noise levels needed to help achieve satisfactory sound isolation. NC levels should be specified in any setting where excessive noise might be irritating to occupants, especially when speech intelligibility is important. This is particularly true in lecture and performance halls, libraries, courtrooms, worship centers and educational facilities. NC levels vary from approximately 20 to 25 in performance halls and theaters, from 30 to 35 in boardrooms and conference rooms, from 35 to 40 in private offices and apartments, from 40 to 45 in lobbies, toilets, corridors and retail spaces and from 50 to 55 in kitchens and laundry facilities (Acoustical Solutions 2007).

Speech privacy potential (SPP) is a term used to quantify the level of speech privacy needed in an enclosed space. Table 1 identifies SPPs for several voice levels and associates a subjective definition with each category. To calculate the SPP level, the background noise level in a given space (its NC level) is added to the lowest level of acoustic separation between the adjacent spaces (its STC level). If a private office has

TABLE 1. Degrees of speech privacy for closed-plan offices.

Speech Privacy Rating	Speech Privacy Potential (SPP)	Description
Total	85	Shouting is barely audible
Highly Confidential	80	Normal voice is inaudible. Raised voices are barely audible but not intelligible.
Excellent	75	Normal voice is barely audible. Raised voices are mostly unintelligible.
Good	70	Normal voices are audible but unintelligible most of the time. Raised voices are partially intelligible.
Fair	65	Normal voices are audible and intelligible some of the time. Raised voices are intelligible.
Poor	60	Normal voices are audible and intelligible most of the time.
None	< 60	No speech privacy.

(From Longman 1996)

a background noise level of 30 and a separation from its adjoining spaces of 40, the SPP rating would be 30 + 40 = 70. Adjustments to SPP levels can be made by either modifying the wall/ceiling attenuation or by changing the level of background noise.

When a sound abruptly ceases, the sound level in an enclosed space does not immediately fall to background levels. Hard surfaces cause sound energy to decay at a slower rate as sound continues to be reflected from one hard surface to another. This reflectance of sound energy is referred to as reverberation. To reduce reverberation, sound absorbing materials must be placed over one or more of the room surfaces. Sound absorbing materials commonly include carpet, furniture and acoustic ceiling tile. ASTM E2179 measures the effectiveness of floor coverings with regard to airborne sound. This test specifically measures the reduction in sound pressure level in the room below a concrete slab due to the installation of a floor covering. Measurements of sound absorption are made in accordance with ASTM C423 (2005). The rating obtained from ASTM C423 is the sound absorption average, which represents the absorption coefficients for the twelve one-third octave bands between 200 and 2500 Hz.

If an enclosed space is very quiet (its NC is less than about 35), normal conversation is usually audible to occupants of adjacent offices and cubicles. Overhearing conversations of others often reduces a person's concentration and can interfere with productivity. In these situations, a white noise system can be used to provide a constant level of background noise to ensure speech privacy. Some of these systems employ an array of speakers concealed above the ceiling to raise the background noise level. White noise systems are typically designed to provide an even background noise level of approximately NC 40. An acceptable level of white noise can sometimes be generated within an HVAC system designed specifically with that requirement in mind.

Designers constantly seek to balance code requirements, design procedures and materials that may actively conflict with one another in regard to environmental qualities they are striving to achieve within the structure. This is true within the confines of the LEED system as well. Introducing daylight throughout a structure to obtain credits under the LEED system often involves the use of clerestory or sidelight windows, or even entire walls of glass. This practice creates numerous hard surfaces within an enclosed space that must be attenuated if even a moderate level of sound isolation is to be achieved. Green buildings have been constructed which required extensive acoustical retrofit to become satisfactory work environments (Siebein et al. 2005).

Designers must develop the ability to translate a proposed design into a prediction of the acoustical satisfaction of occupants with the enclosed space. Acoustics consultants have found several speech privacy calculation methods useful for analyzing design documents and identifying problems with planned structures. One such method, called "speech privacy predictor", has been shown by case studies to produce general agreement between design calculations and measured acoustic conditions and employee satisfaction with acoustics after the structure has been completed (Salter et al. 2003).

FINDINGS

The proposed standard for acoustical comfort that follows could be included as Credit 9 under the IEQ category of the LEED rating system. Compliance will result in one additional credit being awarded, making sixteen total points available under the IEQ LEED category for new construction and major renovations.

(1 POINT) ACOUSTICAL QUALITY

Intent

Provide an acceptable level of sound attenuation and acoustical privacy for interior living and working spaces.

Requirements

To attenuate airborne sound, common interior walls, partitions and floor/ceiling assemblies located between adjacent dwelling units or between offices and adjacent public areas such as halls, corridors, stairs or service areas shall be designed to have a STC of not less than 50 if laboratory tested (or 45 if field tested) when tested in accordance with ASTM E90 procedures. Common interior walls, partitions and floor/ceiling assemblies located between offices or dwelling units and adjacent mechanical/equipment rooms shall have a STC of not less than 60 if laboratory tested (or 55 if field tested).

To attenuate structure-borne sound, the floor/ceiling assemblies shall be designed to provide an impact insulation class (IIC) rating greater than or equal to the design STC rating when tested in accordance with ASTM E492 procedures.

To provide a minimum level of speech privacy potential, the STC plus the expected NC of all interior spaces will be at least 70.

Submittals

- Provide a LEED Letter Template, signed by the designer, stating that interior partitions and floor assemblies have been designed in accordance with the required standards. The designer should include documentation showing that the speech privacy potential (SPP) for interior spaces is expected to be 70 or above.

OR

- Provide a LEED Letter Template, signed by an acoustical engineer or an acoustics testing organization, affirming that a field test has been performed and that the required acoustical standards have been verified by field testing. The acoustical engineer or agency should document that, with the planned NC level when occupied, the speech privacy potential for interior spaces is expected to be 70 or above.

Proposed Technologies and Strategies

- **Incorporate acoustic criteria into a project during the planning phase.** Careful placement of building elements can prevent the need for costly mitigation later. Noise-producing spaces including mechanical rooms, fitness centers, manufacturing facilities, kitchens, and laboratories should be geographically isolated from offices, conference rooms and living areas whenever possible.
- **Determine acoustical specifications for mechanical equipment that has been specified.** Heating, ventilating and air conditioning equipment can be a significant source of noise. Consider the sound power or sound pressure levels reported by the manufacturers for each specified model. Determine if the noise levels of mechanical equipment specified meet the project's acoustical criteria for adjacent spaces. If equipment specified is acoustically unsuitable, equipment that is quieter can sometimes be selected, lining can be installed in the ductwork or different types of sound attenuating construction can be utilized.
- **Reduce transmission of noise through partitions, walls, floors and ceilings by specifying partitions with appropriate STC and IIC ratings.**
- **Consider construction details which attenuate noise such as the height of partitions, sealing tops and bottoms of partitions/walls to adjacent assemblies/surfaces with flexible sealants,**

use of off-set studs, resilient channels and/or double-layer drywall.

- **Consider acoustical properties of surface finishes when specifying details of enclosed spaces.**
- **Determine if additional acoustical treatment is required to increase sound absorption. Consider specifying acoustical ceiling tiles, fabric-wrapped wall panels or spray-on surface treatments if needed.**
- **Select ceiling tiles based on appropriate ceiling sound transmission class rating.** Ceiling tile can be specified according to its ability to absorb sound, which is measured by a ceiling sound transmission class (CSTC) rating. Higher CSTC values provide greater ability to mitigate sound transmission. Acoustical ceiling tile can have a CSTC rating as high as 35 to 39, while less expensive fiberglass tile commonly has a CSTC rating of 20 to 25.
- **Consider including white noise generators other type of active sound-masking system to increase the level of speech privacy if needed.**
- **Verify that acoustical design standards have been met as part of the building commissioning process.**

CONCLUSIONS

The average individual spends close to 90% of his/her time in an indoor environment. Specific aspects of indoor environmental quality have a significant impact on an occupant's level of comfort, health and general well-being. One aspect that has long been overlooked is acoustics.

The causes and consequences of poor acoustics are often not appreciated by designers and constructors. Acoustics have a significant impact upon indoor environmental quality in all types of structures. Levels of background noise, privacy, and acoustical separation between different uses of space have important implications for the quality of the indoor environment, and directly affect all building occupants.

Building designers should compare acoustical performance criteria with the building's intended use and provide at least the minimum level of noise attenuation and speech privacy required for occupant satisfaction. In an open office layout, background noise that is too loud or conveys information easily distracts occupants and can significantly reduce productivity. Other types of office space such as executive suites and conference rooms have even more stringent speech privacy requirements.

Mechanical rooms and other noise-producing activities should be geographically isolated, whenever possible, from areas where maximum acoustical privacy is required. There exist numerous standards and methods for measuring acoustic quality in traditional building spaces. Specialty acoustical standards are also available which address critical areas, such as sound studios and audio production rooms, where acoustical quality is extremely important.

During the planning phase, the design team should consult acoustical performance criteria to establish requirements for background noise levels, sound isolation, and speech privacy. Designers should ensure that sufficient levels of each are afforded to all interior spaces. Incorporating acoustic considerations into the design of a project during the planning phase can result in significant benefits and can avert costly and difficult corrective measures later during construction. By carefully locating interior space at the start of the project, the designer can reduce the need for expensive and specialized construction to mitigate noise problems. In noise sensitive areas, particularly when working on building renovation, white noise or other types of active sound systems can be employed to provide additional speech privacy.

Surface finishes are also important in the acoustic environment and can influence the character of the enclosed space as significantly as color or shape. Selecting the correct balance between hard, acoustically reflective materials and soft, absorptive ones facilitates the projection of speech to intended areas and prevents echoes or the excessive buildup of unwanted sound in others. Designers and constructors have the option of selecting materials and construction techniques at their own discretion or employing the assistance of specialty consultants who are experienced in working with acoustical design issues.

Each project will have its own unique set of problems and range of possible solutions. Design and construction professionals will increasingly be called upon to expand their mindset to provide acoustical quality as an integral component of the built environment. The LEED standard proposed in this paper can be used as a basic guideline toward providing a minimum acceptable level of acoustical quality for many enclosed spaces.

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