Course Number
AIACES802

Credit Designation: HSW

Learning Units 1 Hour

Acoustic Design of Green Buildings for Communications, Privacy, and Productivity

Offices, Healthcare Facilities, and Classrooms

AIA Registration

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GBCI CMP

Health & Welfare Credit

Approved for 1 GBCI CE Hours for LEED Professionals.

Interior Design Continuing Education Council, Inc

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Course Description

The reason we design and operate buildings….is for people. The indoor environment plays a critical role in our overall wellbeing, due to the amount of time spent indoors (~90%) and the ability of buildings to positively or negatively influence our health. Interior environmental quality is important to communications, health and productivity.

Green buildings do many things well — but noise control and speech privacy can't always be counted as part of that list. Some of the strategies that make green buildings higher performing in some areas, result in poor acoustics.

In this course, you will learn various strategies in office, education and healthcare environments to provide total acoustic design for occupant wellbeing as well as increased productivity.

Sections

Acoustics 101

Acoustical Design and LEED v4 Contributions

Acoustic Quality in Offices

Acoustic Quality in Healthcare

Acoustic Quality in Education

Ceiling Material Options

Learning Objectives

- Describe the importance of acoustical design and it's impact on indoor environmental quality (IEQ) in green buildings, including new LEED® v4 acoustical design criteria
- Understand the concepts of the WELL Building Standard®, which focuses on human health and comfort in the built environment.
- List solutions for both sound blocking and sound absorption in commercial office spaces
- Define a healthcare environment's needs and solutions for comprehensive acoustical quality
- Identify school and classroom needs and solutions for superior acoustics
- Review mineral fiber, fiberglass, wood, and metal ceiling options for both aesthetics, acoustic and sustainable performance

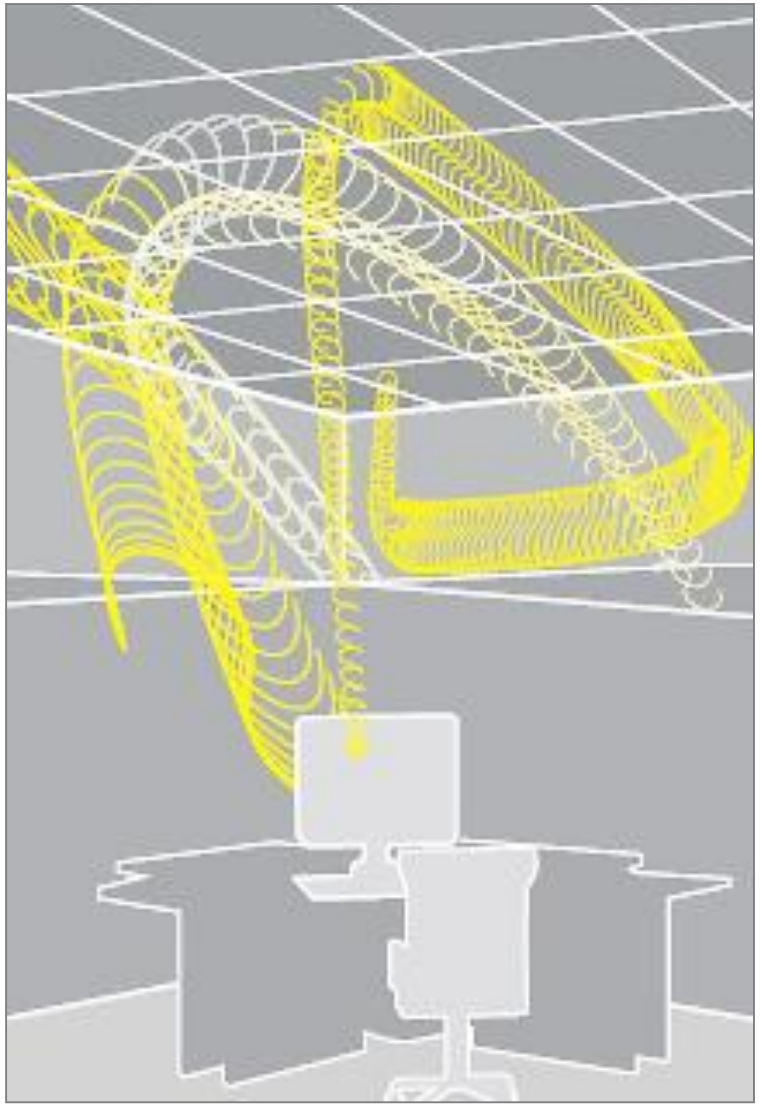
Acoustics 101

Unwanted Sound

Noise is unwanted sound.
It comes from:

- Overheard speech from private conversations
- Sounds from adjacent spaces
- Reverberation from hard indoor surfaces
- Building mechanical systems
- Traffic and environmental sources

Noise problems can be improved with a choice of enhanced ceiling materials that both absorb and block unwanted sound.



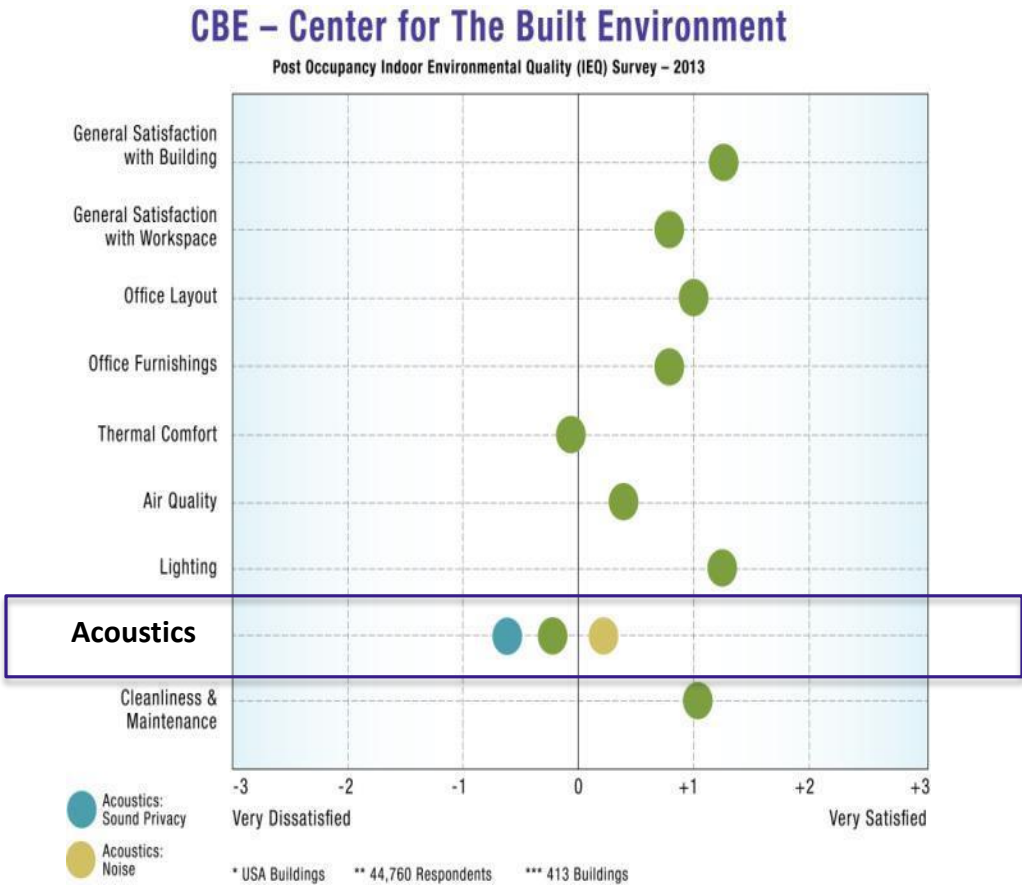
Gensler 2013 Workplace Survey

- U.S. workers are struggling to work effectively
- Overall work performance has dropped 6% since the last Gensler study in 2008
- Time spent focusing has increased since 2008, while time spent collaborating has decreased since then
- Effective workplaces balance focused work and collaboration.
- Choice drives performance and innovation
- Giving employees a choice of when and where to work increases their performance

Acoustic Satisfaction Study

Study Objective:

- More than 50% of cubicle occupants think acoustics interfere with their ability to get their job done
- 30% of those in private offices say acoustics interfere with their ability to work
- In indoor environmental quality, poor acoustics causes the most dissatisfaction

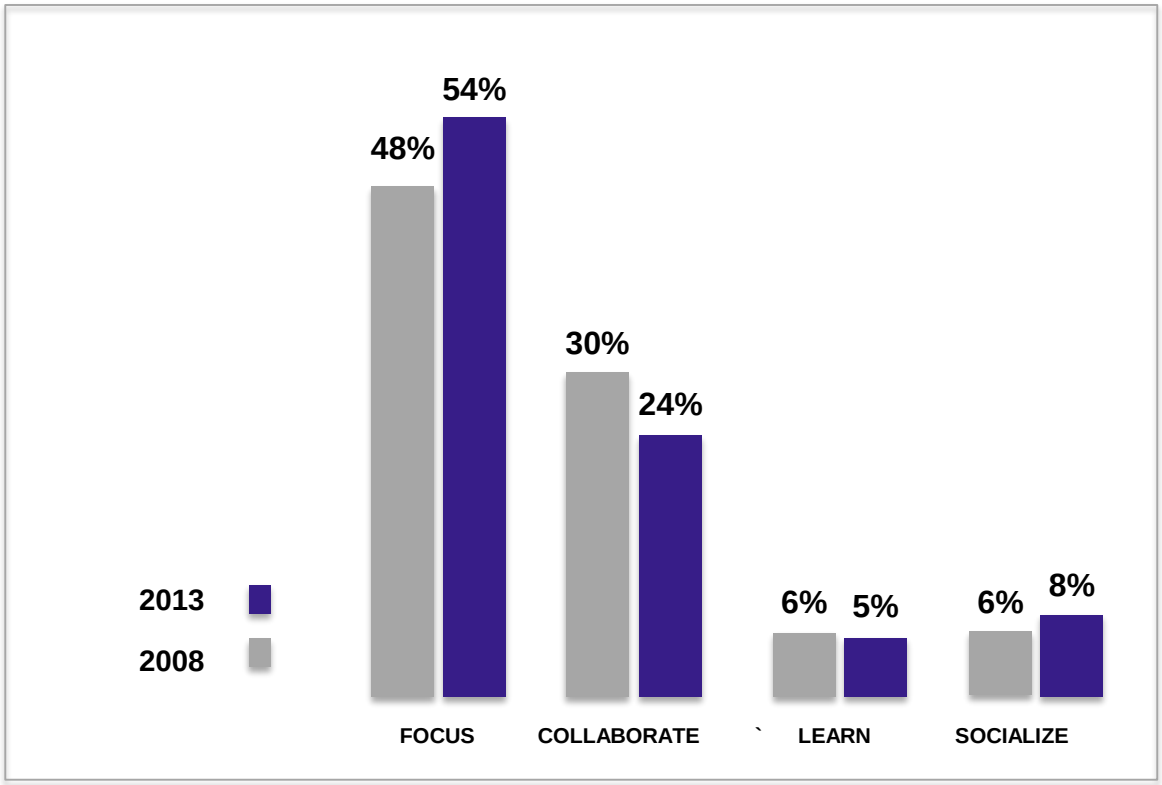


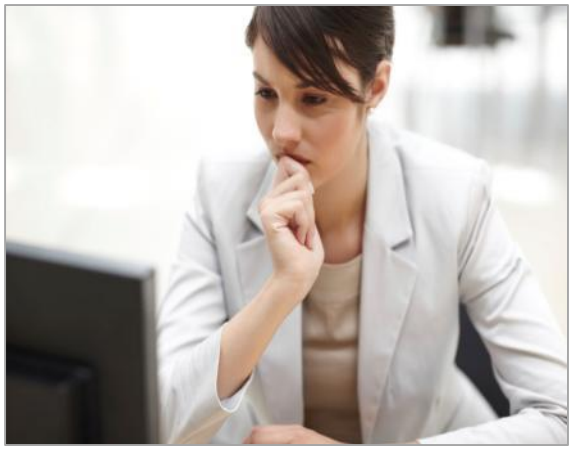
Poor Acoustics Not Adequately Understood

"Noise is probably the most prevalent annoyance source in offices, and that can lead to increased stress for occupants."

"Acoustics in most cases do not receive the level of design attention as thermal, ventilation, and other architectural and engineering considerations."

— Center for the Built Environment at UC Berkeley





Knowledge Workers Are Focusing More, Collaborating Less

Represents percentage of average workweek.
Time not accounted for in these percentages was listed as “other.”

Key Acoustics Terms

Noise Reduction Coefficient (NRC)

- A measure for rating the overall sound absorption performance of a material when used in an enclosed architectural space such as an office, where sound is being reflected at many angles of incidence

NRC < 0.50 = poor absorber

NRC > 0.70 = good absorber

Reverberation

- The buildup of sound within an architectural space, such as a room, as a result of repeated sound reflections at the surfaces of the room

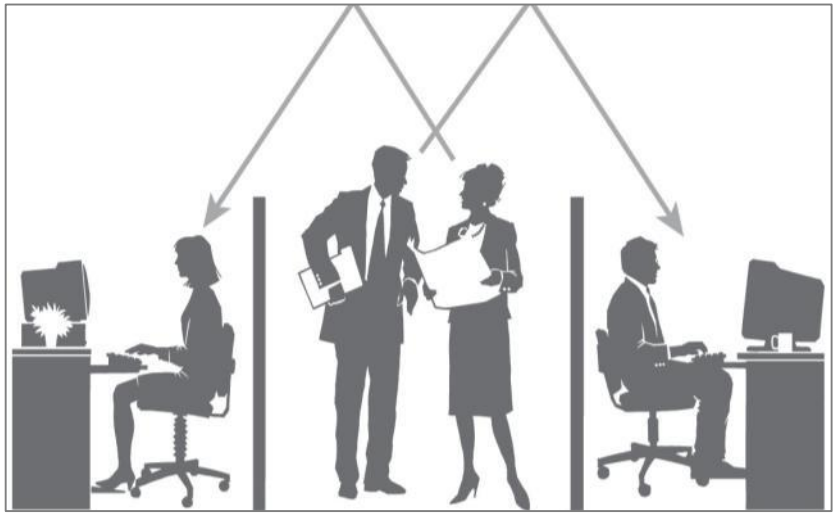
Reverberation Time (RT)

- A measure for rating the quality of the sound environment within an architectural space, and its appropriateness for various uses

Measures Relating to Sound Attenuation (Transfer) Between Open Spaces

Articulation Class (AC)

- A measure for rating the speech privacy performance of a ceiling in an open plan environment where sound is reflected off the ceiling between two adjacent spaces divided by partial-height furniture panels



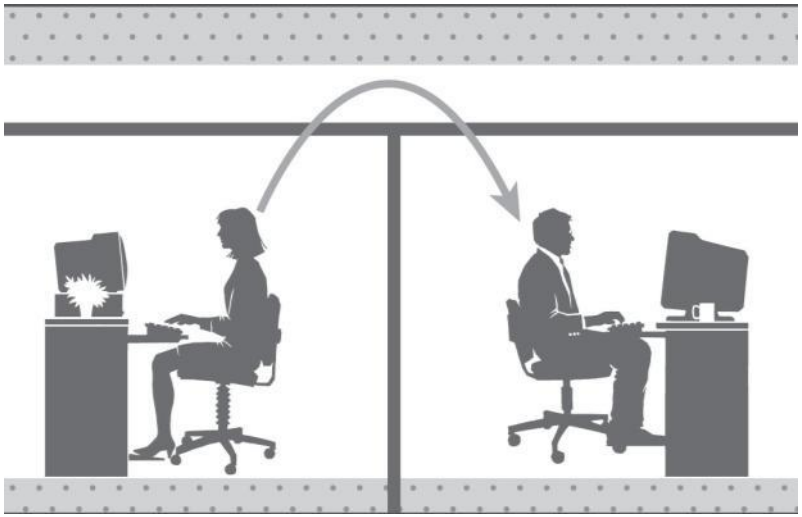
AC ≤ 150 = low performance

AC ≥ 180 = high performance

Measures Relating to Sound Blocking (Transfer) Between Closed Spaces

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



CAC ≤ 25 = low performance

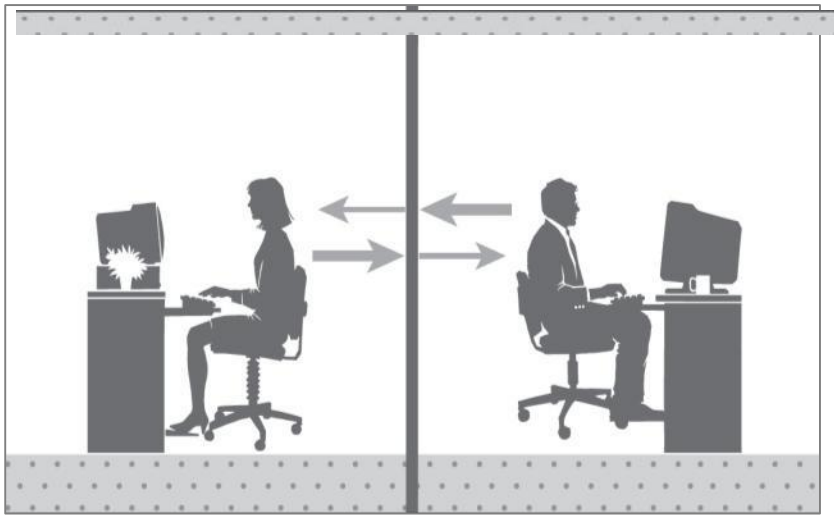
CAC ≥ 35 = high performance

Measures Relating to Sound Blocking (Transfer) Between Closed Spaces

Sound Transmission Class (STC)

- STC is the wall equivalent of CAC

- STC is a measure for rating the performance of a wall system as a barrier to airborne sound transmission between closed spaces and in many open plan spaces



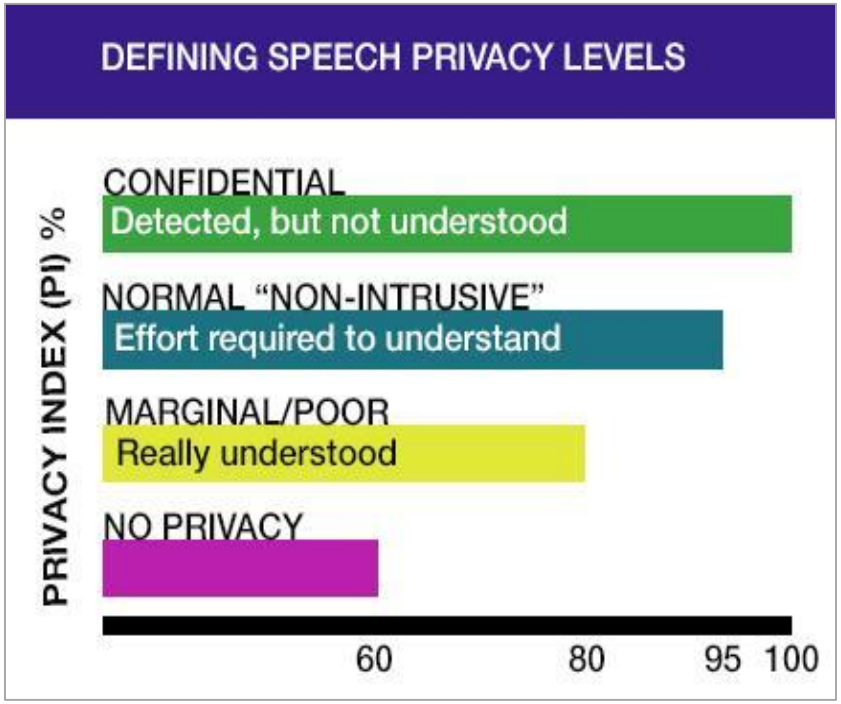
STC ≤ 35 = low performance

STC ≥ 55 = high performance

Privacy Index (PI)

Privacy Index

- A measure for rating the speech privacy performance or lack of speech intelligibility of an architectural space

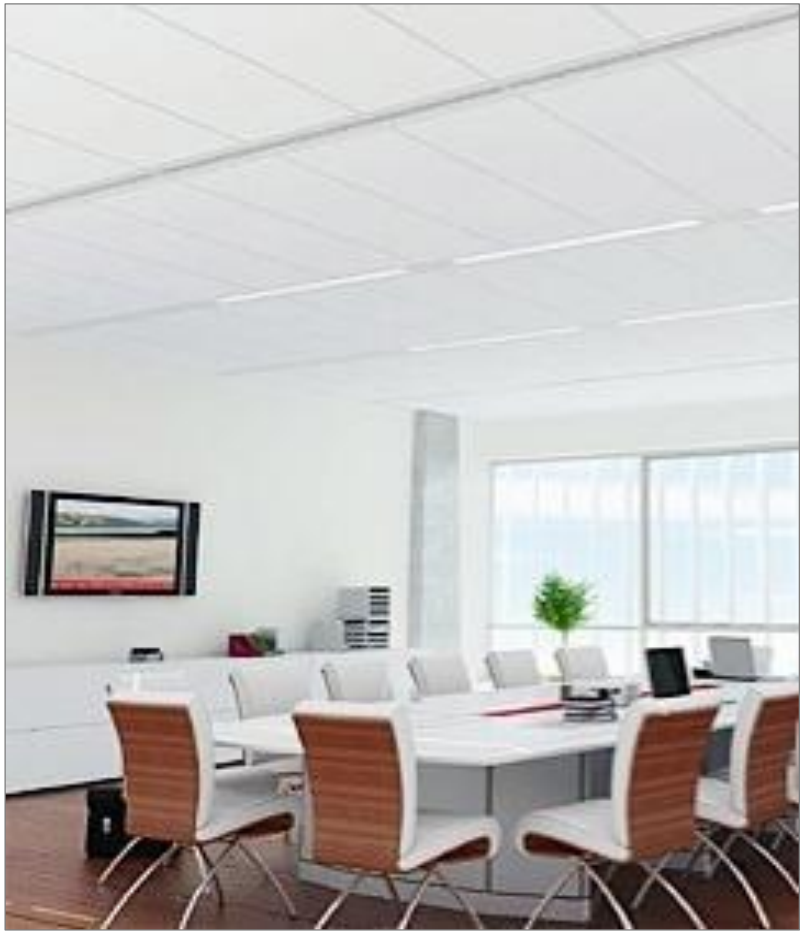


PI ≥ 95% – 100% = confidential speech privacy

PI of 95 – 80% = non-intrusive privacy

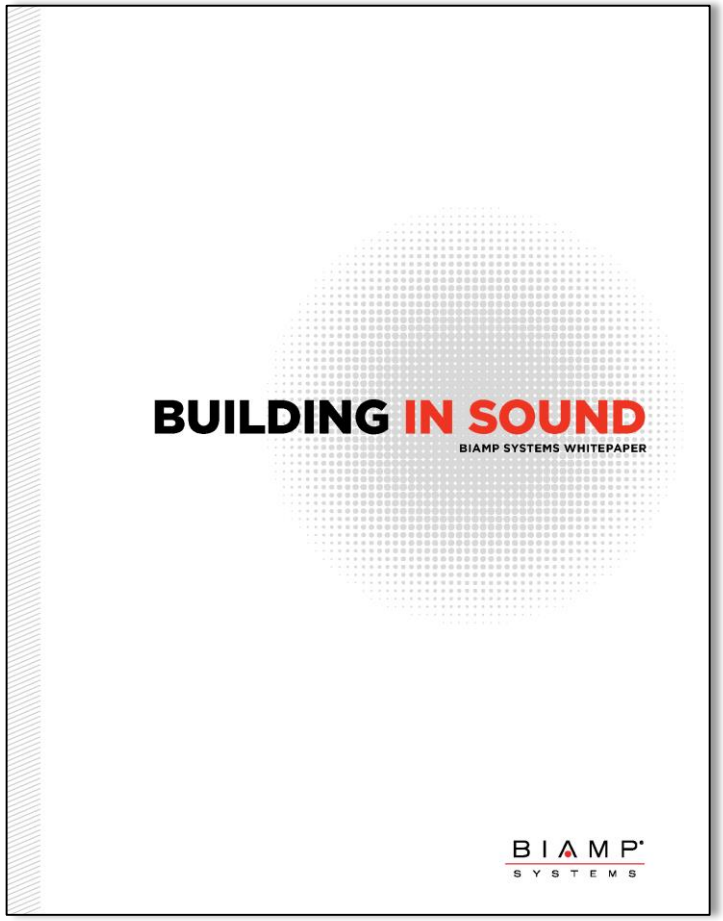
PI < 80% = poor privacy

There are now ceilings with combined high NRC and high CAC performance for an ideal combination of acoustical control in one panel.



Why Noise Must Be Managed

"…Over 40 years of research…which examines causes and impacts of sound on our health, recovery from illness our ability to learn, our productivity and general sense of wellbeing,"



Building in Sound is a White Paper developed by Julian Treasure in association with Biamp Systems. The document includes data linking sound and personal health and well-being

Facts about Noise Pollution*

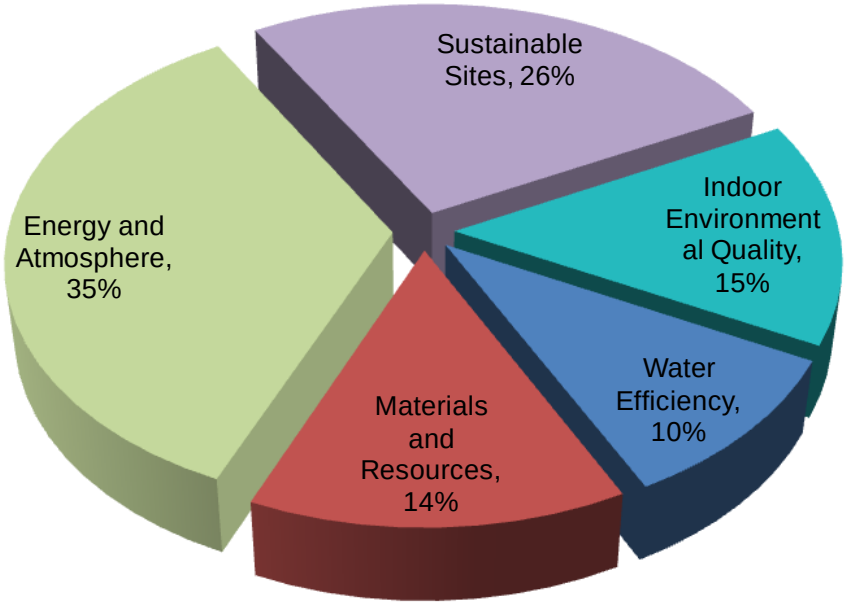
- If you can hear someone talking while you are reading or writing, your productivity dips by up to 66%
- Average noise level in many classrooms is not just associated with impaired learning, but with permanent hearing loss
- 50%of teachers have experienced damage to their voice from talking over classroom noise
- Estimated cost of noise pollution is $30.8 billion/year in Europe alone
- Each year noise pollution takes a day off the life of every adult and child in Europe
- Noise pollution may possibly even contribute to crime

***taken from "Building in Sound"**

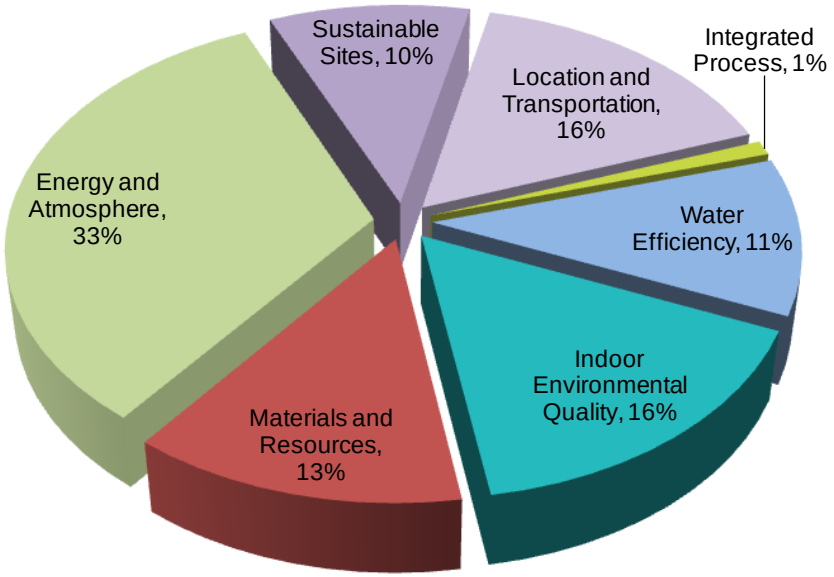
Acoustical Design and LEED® Contributions

New LEED v4 – What has Changed?

LEED 2009



LEED V4



What's changed regarding Acoustics:

- Added Acoustical Performance to all ratings systems

The driving factors behind LEED v4 Development

New LEED v4 Acoustics Credits

- Minimum Performance Acoustical Criteria for Schools in LEED v4 and continuing in LEED v4.1
- LEED Building Design and Construction (BD+C) expands acoustic performance to:
  - New Construction,
  - Data Centers
  - Hospitality
  - Retail
  - Schools
  - Healthcare
- Healthcare Criteria: (1) Address speech privacy, sound isolation, and background noise. (2) Acoustical finishes and site exterior noise (1 point)
- LEED Interior Design and Construction (ID+C) v4:
  - includes a new EQ credit for Acoustic Performance.

LEED BD+C v4 & v4.1 EQ Credit: Acoustic Performance

Credit Library:

- http://www.usgbc.org/credits

USGBC Acoustic Calculator:

- http://www.usgbc.org/resources/acoustic-performance-calculator

Criteria for Commercial Interiors:

- Minimize HVAC background noise and confirm compliance per the 2015 ASHRAE Handbook
- Meet composite STC, NIC ratings and reverberation time requirements tabulated in the LEED credit language.
- Requirements for sound masking by type of space

LEED O+M v4 EQ Credit: Occupant Comfort Survey

- Even the Occupant Comfort Survey credit within LEED Building Operations and Maintenance (O+M) v4 requires an acoustic evaluation.

- This underscores the green building industry's increasing understanding that our sense of hearing plays a significant factor in comfort, wellness, and the ability to perform in a space.

The driving factors behind LEED v4 Development

- Developed by the international Well Building Institute
- WELL: A performance-based system for measuring, certifying, and monitoring features of the built environment that impact human health and well-being,
- WELL is grounded in a body of medical research that explores the connection between the buildings where we spend more than 90 percent of our time, and the health and wellness impacts on us as occupants.

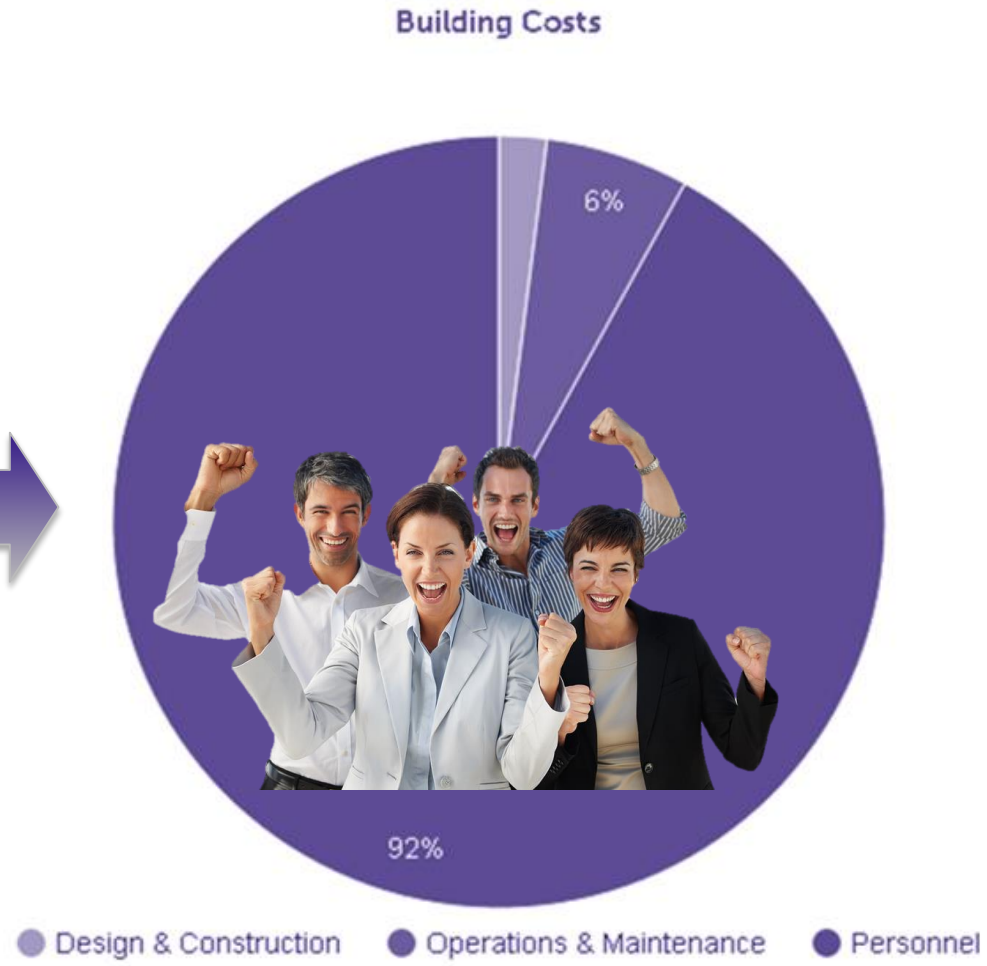
INTERNATIONAL WELL BUILDING INSTITUTE™

International Towers Sydney at Barangaroo to be the first buildings to integrate health and wellness with WELL ready workplaces

Why Focus on Human Wellbeing? ROI

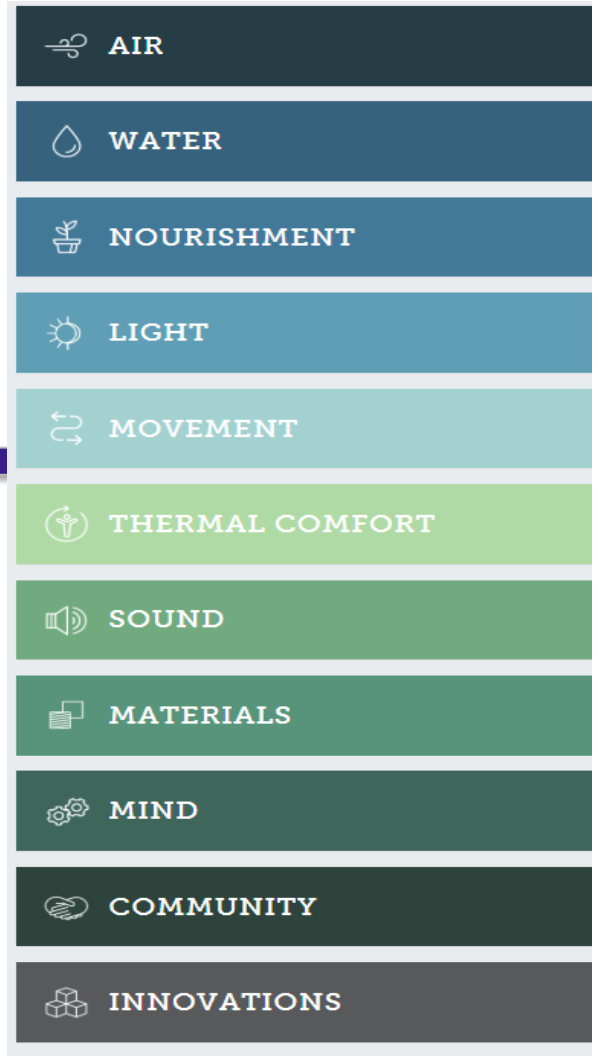
- **Business case for focus on human health and wellbeing**
  - Channel resources toward reducing the biggest line item costs of a building: **PEOPLE**

30-year building costs: Personnel costs significantly outweigh the costs for design and construction, operations and maintenance



The WELL Business Standard®

WELL is a performance-based system for measuring, certifying, and monitoring features of the built environment that impact human health and well-being, through air, water, nourishment, light, fitness, comfort and mind.



Comfort:

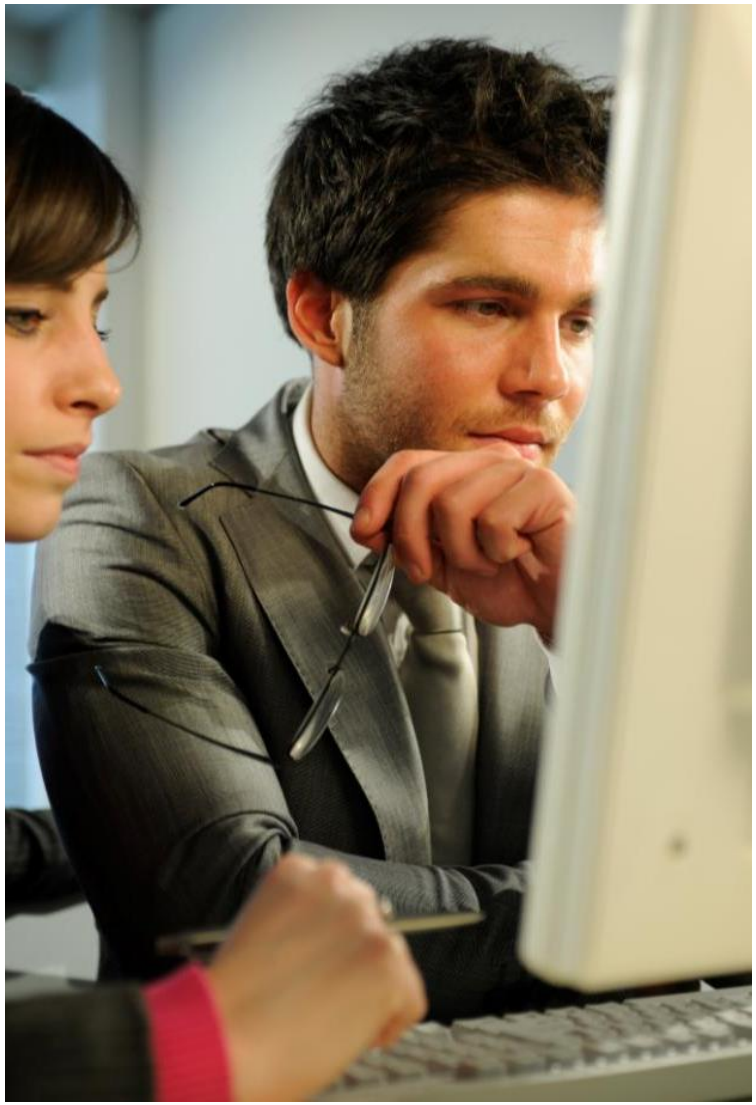
Create an indoor environment that is

- Distraction-free
- Productive
- Soothing.

Solutions include:

- Design standards and recommendations
- Thermal and acoustic controllability
- Policy implementation covering acoustic and thermal parameters that are known sources of discomfort.

Comprehensive Acoustical Quality in Offices



Office LEED Interior Design & Construction (ID&C)

Office Criteria

Intent:

To provide workspaces that promote occupants' well-being, productivity and communications through effective acoustic design

Requirements

For all occupied spaces to meet two of the following: (Meeting all three for exemplary performance point)

- HVAC background noise
- Sound Transmission
- Reverberation Time

Compliance is confirmed via calculations or measurements in representative rooms, and/or design documentation from a person experienced in the field of acoustics.

IEQ: Acoustic Performance Reverberation Time Requirements

Reverberation Time

Meet the reverberation time requirements adapted from Table 9.1 in the Performance Measurement Protocols for Commerical Buildings.[1]

Table 2. Reverberation time requirements

Room type	Application	T60 (sec), at 500 Hz, 1000 Hz, and 2000 Hz
Office building	Executive or private office	< 0.6
	Conference room	< 0.6
	Teleconference room	< 0.6
	Open-plan office without sound masking	< 0.8
	Open-plan office with sound masking	< 0.8

[1] Adapted from ASHRAE (2007d), ASA (2008), ANSI (2002), and CEN (2007)

Added STC

Sound Transmission: Categorize all occupied spaces by use and desired level of acoustic privacy. Meet the composite sound transmission class (STCC) ratings or noise insulation class (NIC) listed in Table 1. For NIC measurements, use ASTM E336-17a or Annex A.3 of ANSI S12.60-2010.

Table 1. Minimum composite sound transmission class ratings for adjacent spaces

Adjacency combinations		STC_c**	NIC**
Retail	Retail	50	
Collaborative / multi-use	Hallway, stairway	25	20
Private	Hallway, stairway	35	30
Confidential	Hallway, stairway	40	35
Collaborative / multi-use	Collaborative / multi-use	35	30
Collaborative / multi-use	Private	45	40
Collaborative / multi-use	Confidential	50	45
Private	Private	45	40
Private	Confidential	50	45
Confidential	Confidential	50	45
Conference room	Conference room	50	45
Mechanical equipment room*	Hallway, stairway	50	45
Mechanical equipment room	Occupied area	60	55

*Minimum STCc or NIC has to be met unless proven that the equipment noise in conjunction with the sound isolation performance of the partitions and doors will not exceed the maximum background noise requirements of the adjacent space.

*If a sound masking system is implemented at a minimum level of 40 dBA, the STCc ratings or NIC values in Table 1 may be lowered by 5 points. This applies to all space types except mechanical equipment rooms. T

Traditional Office

OPEN PLAN DESIGN

Professional
Goal: Non-intrusive

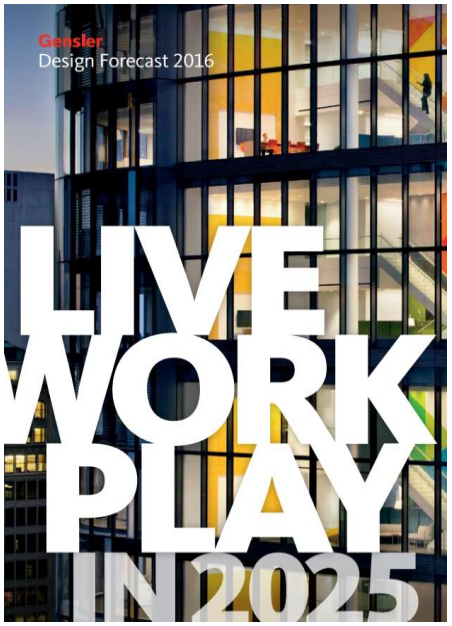
Administrative/Clerical
Goal: Moderate distraction zone

CLOSED PLAN DESIGN

Goal: Confidential privacy

Studies show that excessive noise at the office reduces worker effectiveness, raises stress and lowers employee satisfaction.

Today's Flexible spaces call for concentration one minute and collaboration the next.



http://www.gensler.com/uploads/document/429/file/gensler-design-forecast-2016.pdf

"…campuses will promote wellness, integrate and leverage smart technology to increase building performance. But often they'll do more—adding complementary, even community-serving uses and amenities, and melding non-office and office work together to drive innovation."

.

New Office Design Approach

Effective workspaces balance focus and collaboration.

OPEN PLAN

CLOSED PLAN

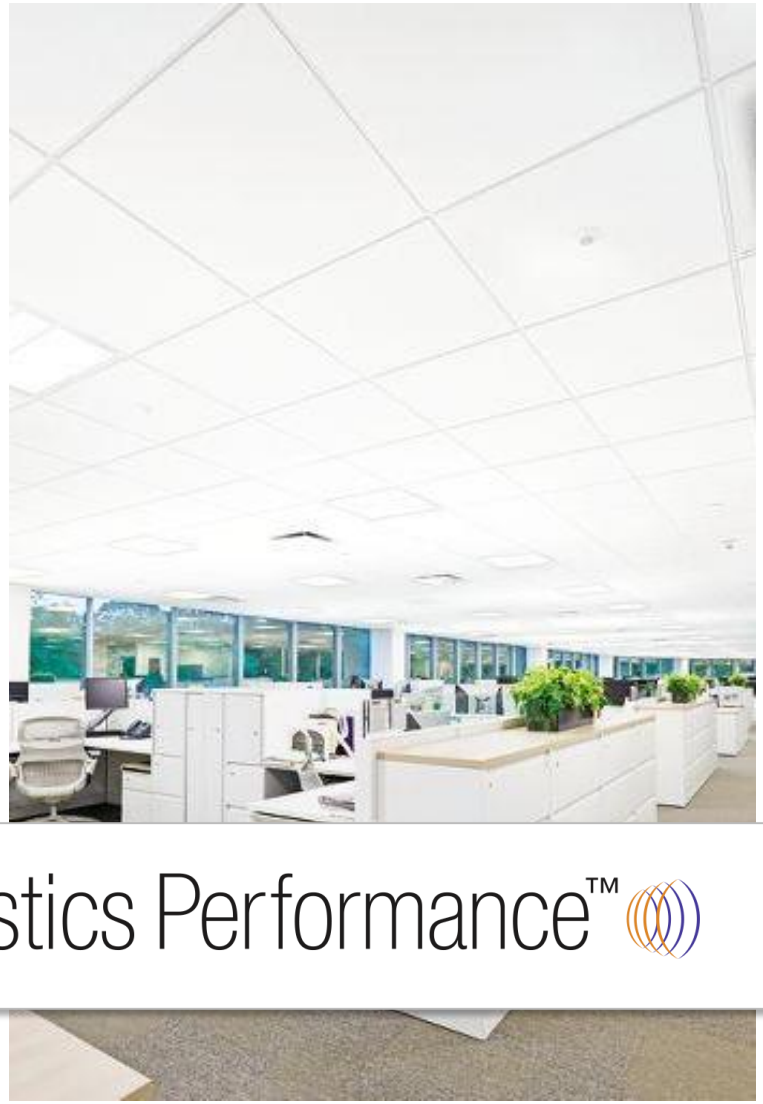
Focus Area

Collaboration Area

Privacy Area

Solutions for Office Acoustic Design: comprehensive acoustical quality

To achieve comprehensive acoustical quality – the ideal combination of sound blocking and absorption of unwanted sound – acoustical ceiling products should perform at a high level according to two essential measurements – CAC and NRC.



$NRC_{ABSORB} + CAC_{BLOCK} = \text{Total Acoustics Performance}^{TM}$

New Office Design: Focus Areas

- Knowledge workers can concentrate on individual work needs
- Important to minimize transfer of sound in all directions

Suggested Acoustical Solution

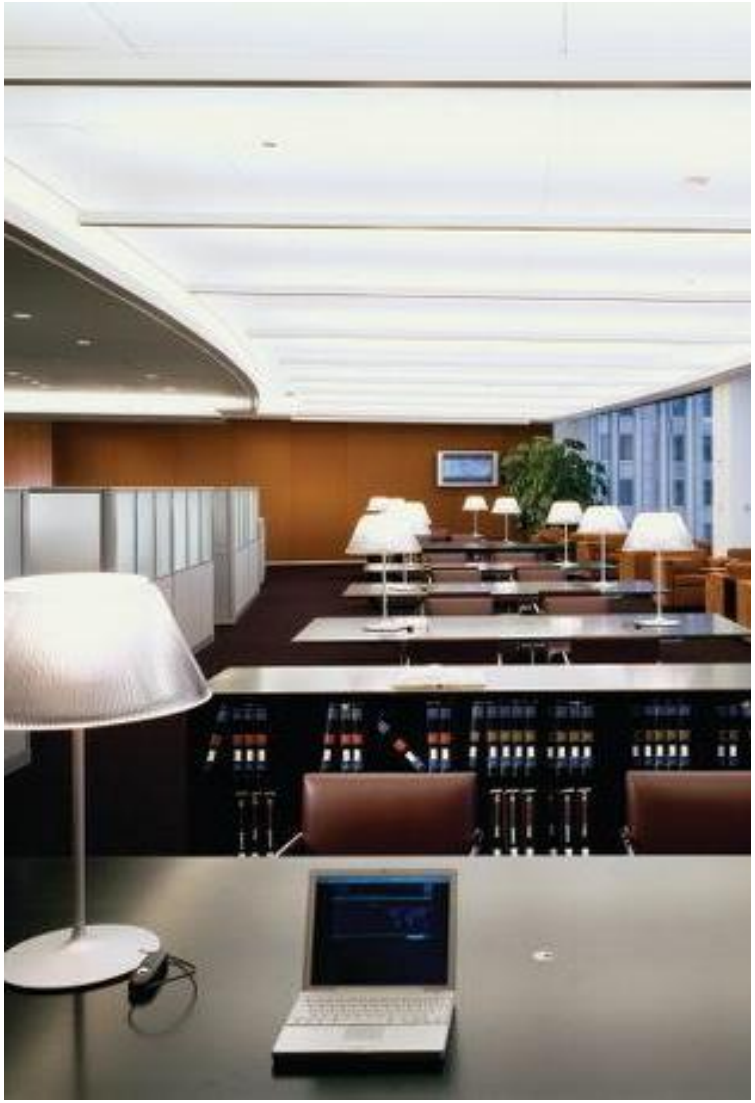
- High NRC rated ceilings to reduce distraction within the space
- CAC rated ceiling to reduce sound from the plenum and sound leakage into space

New Office Design: Collaboration Areas

- Interaction and teaming activities require open communications within groups
- Need moderate acoustic separation between different groups
- Need significant acoustic separation from focus areas and privacy areas

Suggested Acoustical Solution

- Moderate to high NRC rated panels to preserve and enhance speech clarity
- CAC to contain activity sound



New Office Design: Privacy Areas

- Workers can concentrate on individual work needs and have confidential discussions
- Important to minimize sound transfer in all directions

Suggested Acoustical Solution

- Moderate to high NRC rated ceiling to increase speech clarity
- High CAC rated ceiling to preserve confidentiality

Project Review: Open Office

Project: Beverage Company

Location: Purchase, NY

Architect: Granoff Architects

- **Challenge:** Contemporary open office space with low dividers between workstations. A productive work environment that eliminated unwanted noise from office equipment and other coworkers was needed.

- **Solution:** Acoustical control in a mineral fiber ceiling with a smooth, drywall-like visual
  - Sound absorption (NRC 0.85) and sound blocking (CAC 35) in one acoustical panel

Project Review: Open Office with Adjoining Private Offices

Project: Chandler City Hall

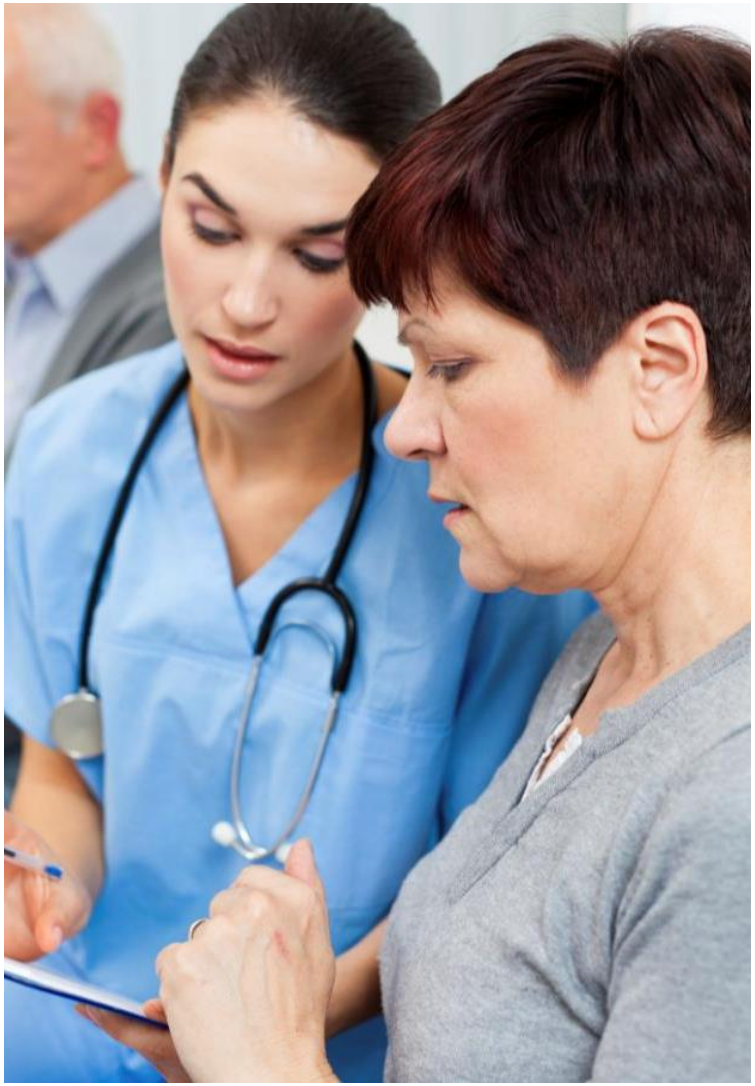
Location: Chandler, AZ

Architect: SmithGroupJJR, Phoenix, AZ

- **Challenge:** Open office space with adjoining private offices divided by glass walls not to deck

- **Solution:** A high NRC and high CAC product to reduce noise and block sound from traveling from open space to privacy spaces
  - Sound absorption (NRC 0.80) and sound blocking (CAC 35)

Comprehensive Acoustical Quality in Healthcare



Healthcare LEED Building design and Construction (BD+C)

Healthcare Criteria

Two basic options:

- Option 1: Address speech privacy, sound isolation and background noise to meet 2018 FGI guidelines
  - 2018 FGI Guidelines for Design and construction of Hospitals – Section 1.2-5.1.6 and Section 1.2-5.1.6.2
  - 2018 FGI Guidelines for Design and construction of Outpatient Facilities – Section 1.2.-5.1.6 and Section 1.2-5.1.6.2
  - 2018 FGI Guidelines for Design and construction of Residential Health, Care and Support Facilities – Section 2.5-8.6
- Option 2. Acoustical finishes and site exterior noise
  - 2018 FGI Guidelines for Design and construction of Hospitals – Section 1.2-5.1.3 (Table 1.2-4)
  - 2018 FGI Guidelines for Design and construction of Outpatient Facilities – Section 1.2.-5.1.3 (Table 1.2-4)
  - 2018 FGI Guidelines for Design and construction of Residential Health, Care and Support Facilities – Section 2.5-8.3 (Table 2.5-4)

Excessive noise in corridors and chaotic treatment rooms negatively affects patient's ability to heal and limits privacy.

Healthcare facilities are required to ensure speech privacy requirements (HIPAA), while improving patient well being during recuperation.

Need for Speech Privacy

- Information of a personal nature is often transmitted through speech; requires the need for speech privacy
- When information of a sensitive nature is verbalized, a patient within a closed room should feel certain that the information will not transmit beyond that space

The following strategies can be used to help improve HCAHPS scores and comply with HIPAA, and FGI requirements for oral privacy:

- Consider using cubicles or screens to block sound
- Install masking sound systems, sound-absorbent curtains
- Install ceiling panel with high noise reduction rating (NRC) to absorb sound
- The addition of a high CAC ceiling with sound blocking will further assist in avoiding transmission of sensitive information

Case Study: New England Hospital, Boston

Challenges:

- Sound control is a factor in the oncology unit because of equipment noise and long periods of time patients spend in the unit
- In the dialysis unit, patients are in close proximity; equipment noise
- Good acoustics are needed in both areas to improve privacy and keep noise at a comfortable level

Solution:

- A high-performing acoustical ceiling product for sound control
- A smooth, soil-resistant surface that can be washed with disinfectants for infection control

"The solution vastly improved acoustical control and aesthetics over other products we could have specified…without a significant cost increase." – Pamela Mace, Architect

Comprehensive Acoustical Quality for Classrooms

LEED BD+C v4 EQ Prerequisite: Minimum Acoustic Performance

- This schools-only prerequisite specifies a maximum HVAC background noise level of 40 dBA.
- Requires high-noise sites above 60 dBA to implement measures to mitigate sound transmission into core learning spaces (including between spaces).
  - Core learning spaces at or over 20,000 cubic feet
    - Need to reduce reverberation time in accordance with the 2002 NRC-CNRC (Construction Technology Update No. 51, Acoustical Design of Rooms for Speech, or local equivalent).
  - Core learning spaces under 20,000 cubic feet
    - Must either exhibit sound-absorbent finishes (NRC rating of 0.70 or higher) that equal or exceed the ceiling area, or teams must confirm conformance to ANSI Standard S12.60-2010.

LEED BD+C v4 EQ Credit: Acoustic Performance (1 point)

Credit Library:

- http://www.usgbc.org/credits
- Criteria for Schools:
  - HVAC background noise levels may not exceed 35 dBA.
  - Projects must meet ANSI Standard S12.60-2010, Part 1, except windows — which must have an STC rating of at least 35, unless noise levels can be verified to justify a lower rating

Acoustics in Schools

Each day thousands of students are unable to understand one out of every four words in classrooms due to inadequate ceiling acoustics.

Acoustics ceiling panels can help create a better place for teachers to teach and students to learn.

Classroom Environments

- A poor acoustical environment can increase stress and decrease concentration
- Those affected most include:
  - Students with hearing impairments
  - Students with learning disorders
  - Very young children
  - ESL Students
  - Students with temporary hearing impairment
  - Teachers at risk of burnout

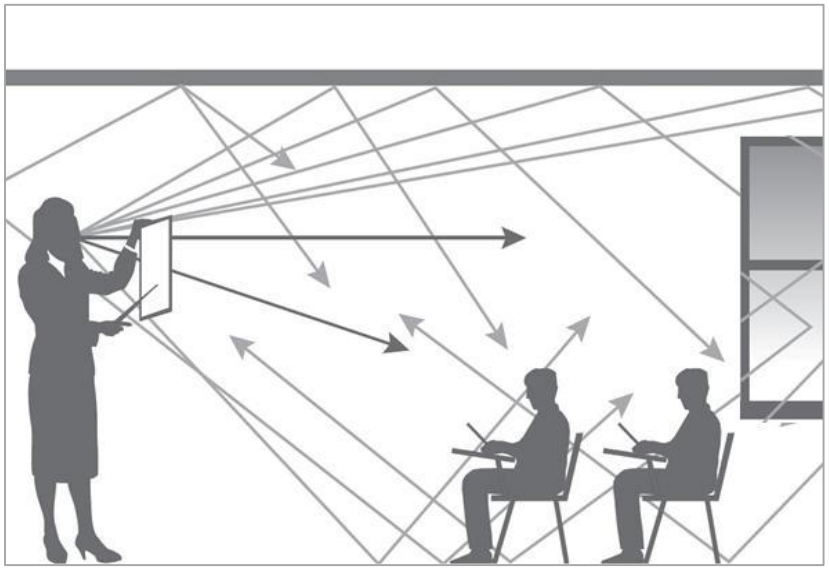
Types of Classroom Noise

Reverberation

- Short reverberation times are good for speech intelligibility

Background Noise

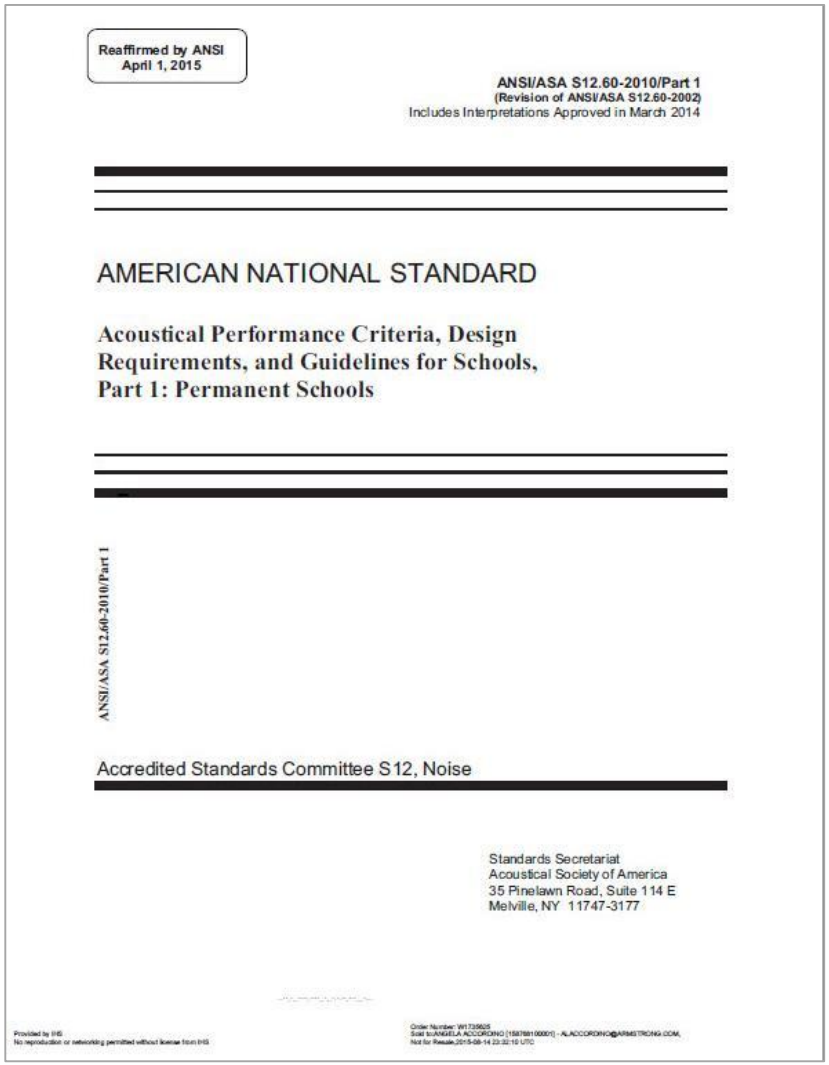
- This may include interior noise sources such as HVAC system and corridor noise plus environmental noise generated outside the building, such as playground activity, traffic, and planes



The American Standard: S12.60

ANSI Standard S12.60 for classroom acoustics addresses the issues of both reverberation time and background noise and their effect on speech intelligibility.

- **0.6 seconds** − Maximum reverberation time in an unoccupied, furnished classroom with a volume less than 10,000 cubic feet
- **35 decibels** − Maximum level of background noise allowed in the same classroom



Reaffirmed by ANSI
April 1, 2015

ANSI/ASA S12.60-2010/Part 1
(Revision of ANSI/ASA S12.60-2002)
Includes Interpretations Approved in March 2014

AMERICAN NATIONAL STANDARD

Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools, Part 1: Permanent Schools

ANSI/ASA S12.60-2010/Part 1

Accredited Standards Committee S12, Noise

Standards Secretariat
Acoustical Society of America
35 Pinelawn Road, Suite 114 E
Melville, NY 11747-3177

http://asa.aip.org.

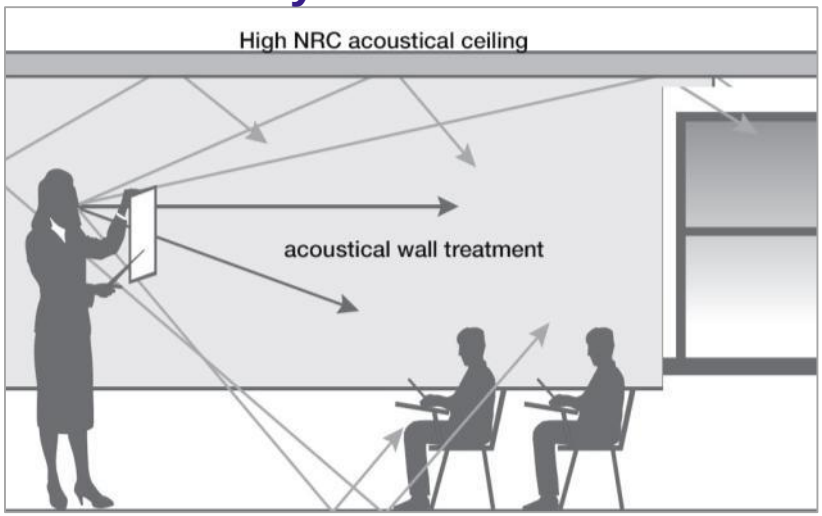
When Does It Apply?

- During the design and construction of all new classrooms or learning spaces of small-to-moderate size
- As far as is practical, to the design and reconstruction of renovated spaces

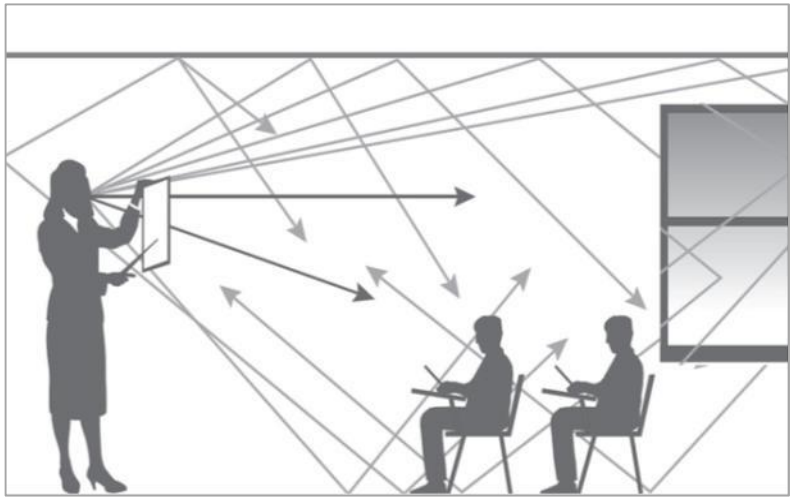
Complying with ANSI S12.60

- For classrooms where ceiling heights are less than 10 feet, the best option is to place most, if not all, the sound-absorbing material on the ceiling
- To reduce reverberation, specify a ceiling panel with an NRC of at least 0.70

Acoustically Treated Classroom



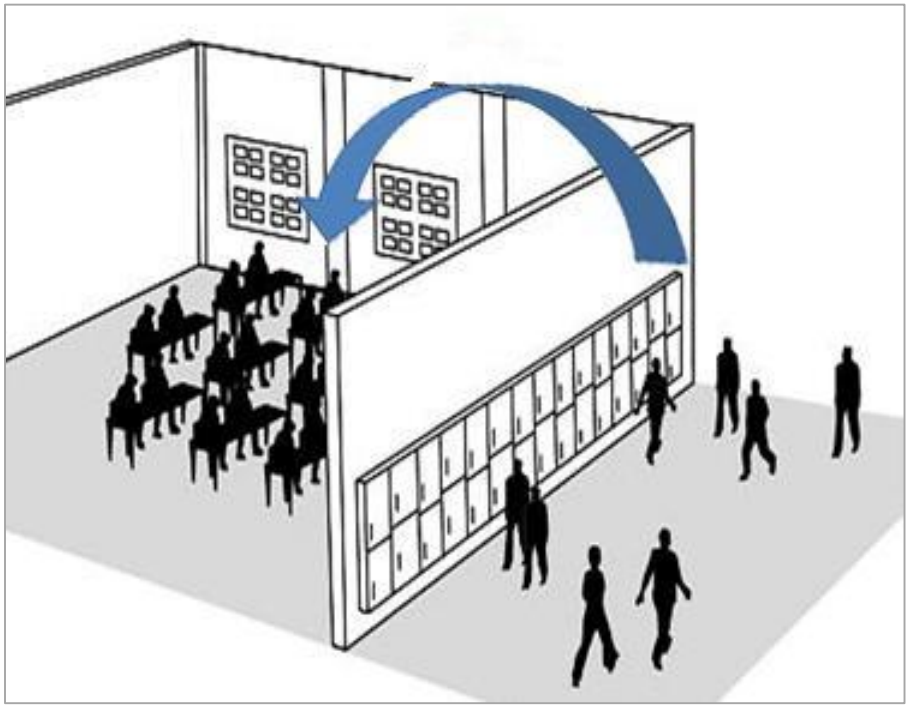
Hard Surface Classroom



The addition of sound -absorbing materials reduces late arriving reflected sound, lowers reverberation time, and improves speech intelligibility.

Reduce Noise Traveling Through the Plenum From Adjacent Spaces

- Noise in an adjacent space can reflect off the deck and bounce back down through the ceiling into an adjoining classroom
- Choose an acoustical ceiling panel that has a high CAC value to help block the sound between two rooms that share a common plenum

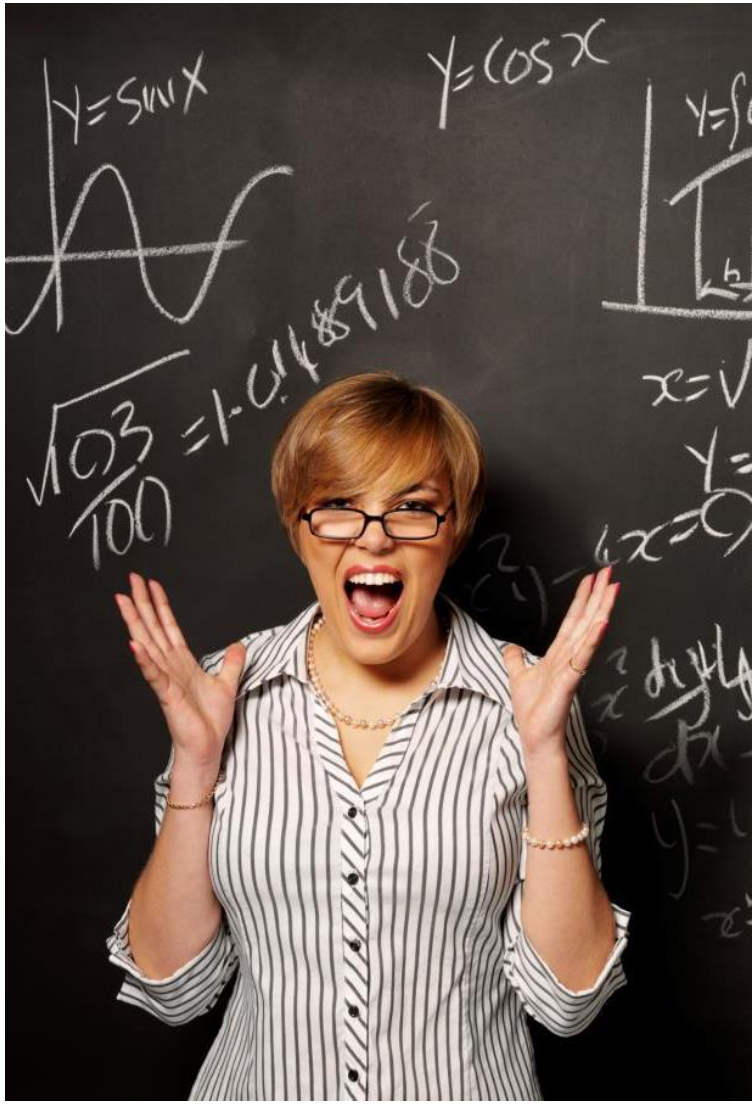


Test Study: Four Classrooms

Project: Test of four identical classrooms.

- **Challenge:** Teachers complaining about vocal effort needed to teach due to reverberation and background noise

- **Test:** Treat two classrooms for acoustical performance, leave two classrooms as control rooms



Test Results: Four Classrooms

In the two acoustically treated classrooms:

- Reverberation time went from 2.6 seconds to 0.6 seconds
- Level of background noise went from 66 dBA during peak street hours to 38 dBA
- 80% increase in teacher satisfaction
- 23% fewer teacher absences due to voice and throat problems

School Solution: Ceiling Panels

Ceiling panels with high NRC and CAC ratings help absorb and block unwanted sound to create environments more conducive to teaching and learning.

University High School, Morgantown, WV.

Case Study: Learning Center

Project: Springmill Learning Center

Location: Mansfield, Ohio

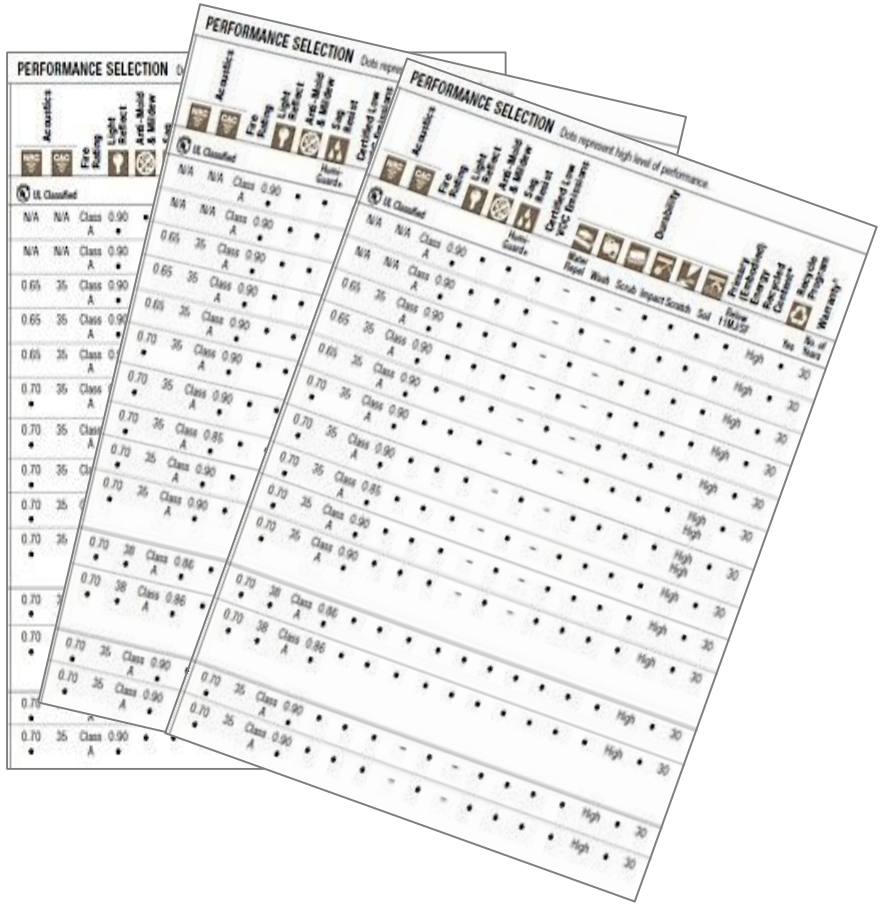
- **Challenge:** Create a ceiling with high acoustic performance that excited and inspired the students

- **Solution:** High performing mineral fiber panels printed with 24 ft. x 32 ft. full color map of the earth
  - Sound absorption (NRC 0.70) and sound blocking (CAC 35)

Material Options for High Performing Ceilings

Specifying to Achieve Ratings

- How do you specify properly to achieve desired ratings?
- Let's view four types of ceiling materials:
  - Mineral fiber
  - Fiberglass
  - Metal
  - Wood



Mineral Fiber Ceilings

- Best combination of sound absorption and sound blocking
- Good choice where noise from occupants is likely to reach high decibel levels

LEED®

- energy management
- construction waste mgmt
- regional materials
- design for flexibility
- EPD
- recyclable/ extended producer resp.
- biobased materials
- recycled content
- sourcing of raw materials
- material ingredient reporting
- low emitting/ materials
- lighting quality
- acoustics

Fiberglass Ceilings

Provide high sound absorption and are available in standard and high AC (Articulation Class of 170 or greater)

- Good choice for some open plan spaces
- Variety of larger size panels available

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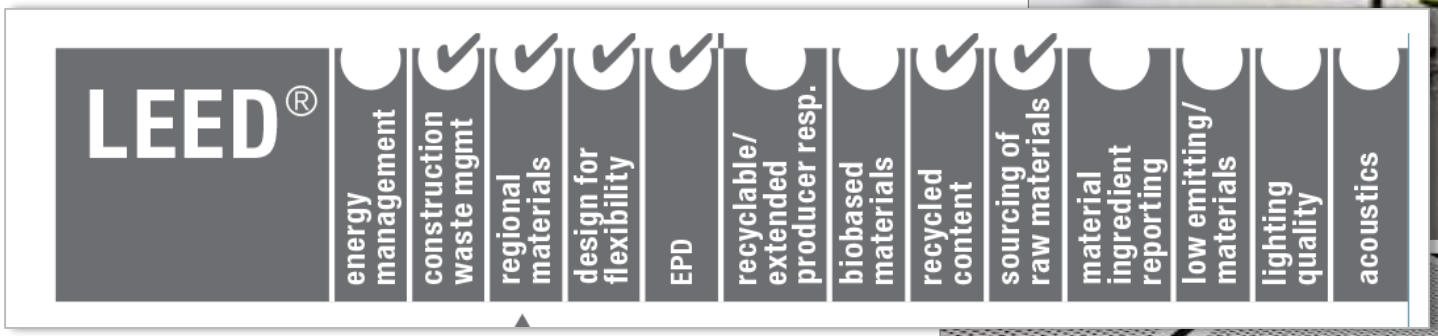
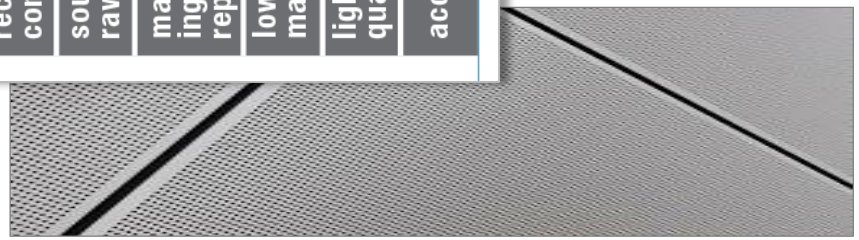
Metal Ceilings

- Variety of finishes
- Panels with acoustical fleece backing have excellent NRC ratings (up to 0.85 NRC)





Wood Ceilings

- Variety of rich, natural finishes, wood ceilings also provide access to the plenum
- Wood ceiling panels can achieve high NRC (up to 0.80 NRC) values when an infill panel is used.

LEED®	energy management	construction waste mgmt	regional materials	design for flexibility	EPD	recyclable/ extended producer resp.	biobased materials	FSC (for wood)	recycled content	sourcing of raw materials	material ingredient reporting	low emitting/ materials	lighting quality	acoustics
	○	○	✓	✓	✓	○	✓	✓	✓	✓	○	✓	○	✓

Conclusion/Questions

- The problem of noise inside offices, healthcare settings, and classrooms is pervasive and destructive to productivity, privacy, and learning
- Learn about guidelines, standards, and Green Rating Systems that address acoustic design and performance
- Specifying high-performing acoustical ceiling products with the ideal combination of NRC and CAC is often the best solution an architect can use to address the problem. But, you can't just go by those numbers individually; it's the combination of both the NRC and CAC that provide ideal acoustic performance.
- Manufacturers' data sheets reveal both the ceiling panel's sound-absorbing and sound-blocking capacities. Some are now providing new acoustical classifications, making it easier to realize the combined acoustical performance of a ceiling.
- As the studies cited here indicate, poor indoor environmental quality is often caused by the lack of attention to acoustical quality. Getting the acoustics right goes a long way in making the built environment healthy for the occupant, and allow for maximum productivity, privacy, and learning.

Contact Information

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