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03

Education Series
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Acoustics in the classroom: Hearing is believing

A safe and comfortable environment is key to the success of any occupant but is paramount in the development of children in learning settings. The choices that education, facilities and design professionals make in the design of a classroom affect the cultivation of the intellectual curiosity, learning and personal growth of our children and this is supported by industry research.

We at Tandus Centiva take our role in this process very seriously. Our mission is to help educators, facilities managers and design professionals provide the best environments for engaging children and inspiring them to learn.

Educators are embracing evidence-based design and asking design professionals to create spaces that optimize communication and learning.

Acoustical performance is a critical design objective that must be carefully addressed at the very beginning of the design process. Although there are many factors in a building's design that affect acoustical performance, the selection of interior finishes for the floors, walls and ceilings is of paramount importance. Fortunately, there is a wide body of credible research that provides clear guidance for design professionals and school administrators.

Excellent acoustics are essential in classrooms and learning environments where aural information and communication are fundamental to the education process. This is especially true in elementary schools, since for younger children, learning to hear and interpret speech and sounds is as much a part of the educational process as the actual content in the lessons being taught. Proper acoustics conducive to ease of communication can also lend itself to reduced vocal effort required by teachers.

- U.S. schools may lose as much as $2.5 billion annually in sick leave for teachers with vocal problems.
- As many as one-third of all students are missing up to 33% of verbal communication in class.[1]
- 75% of the school day involves istening activities.

[1] Source: Acoustical, School Construction News, March / April 2002

Adults vs Children

A child's hearing abilities are not fully developed until age 15. Therefore, children lack the knowledge and maturity to fill in missed words that can be rationalized by adult listeners. For instance, as adults, if we hear, "Don't bite the hand…" we would easily complete the sentence with, "…that feeds you." Children simply lack the knowledge to fill in the missing words, or draw from their own experiences. They may complete the sentence with, "...that is dirty." Or "…belongs to your sister."

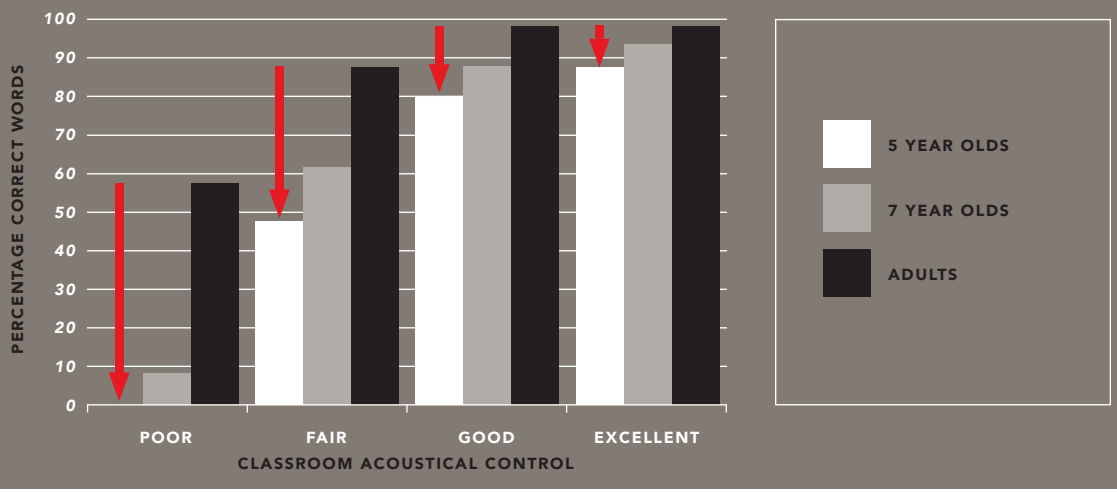
To further compound a child's ability to understand the teacher many students suffer from the following:

- Hearing impairments or learning disorders
- English as a second language
- Temporary hearing impairments (middle ear infections)

Any one of these concerns can create an unhealthy acoustical environment. Because these issues are most common among children, as adults we cannot judge the acoustical performance of a classroom but must rely solely on its acoustical design and product attributes.

Until we achieve good to excellent acoustical control do we positively impact the ability of our children to achieve optimum learning in a classroom.

Fig A: ***EFFECTS OF AUDIBILITY ON CHILDREN'S UNDERSTANDING OF WORDS***

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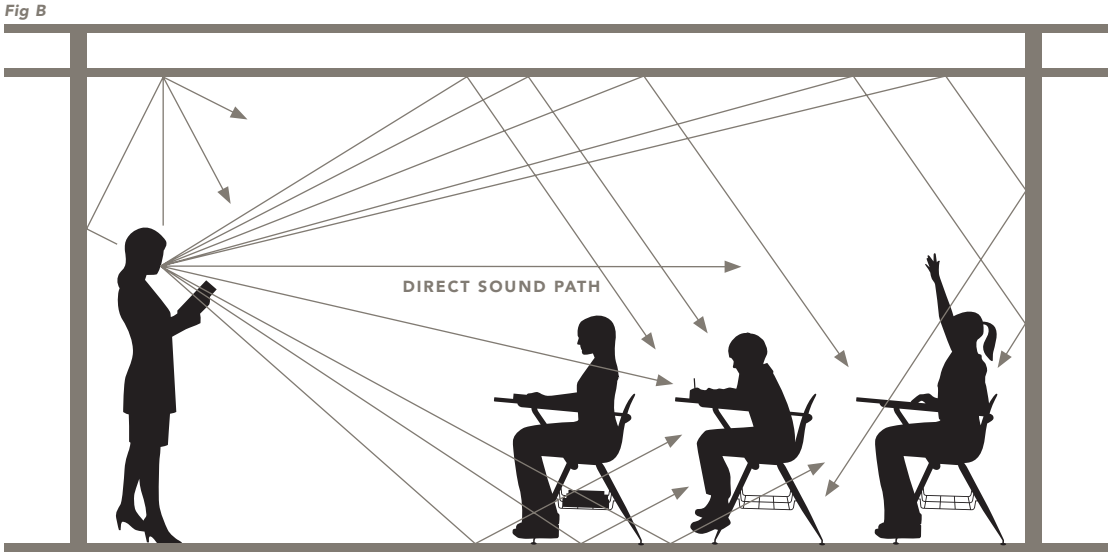
Direct/Reflective/Reverberation Sounds

06

Direct sound in a classroom is preferred since the source of the sound is unobstructed by flanking or reflective sounds. However, sound will eventually become reflective in a classroom. A build up of reflective sound begins to "mask" the direct sound and reduces its intelligibility. Further, direct sound can be heard first, followed by reflective sound since reflective sound takes longer to arrive. This echo effect from reflective sound is called reverberation. When the reflective sound takes too long to reach a student, both the direct and reverberation sound becomes unintelligible. Therefore, to control good acoustics in a classroom, "reverberation time" standards are specified in seconds. To improve speech intelligibility in a classroom requires more acoustical treatment to reduce the reverberation time.

Fig B

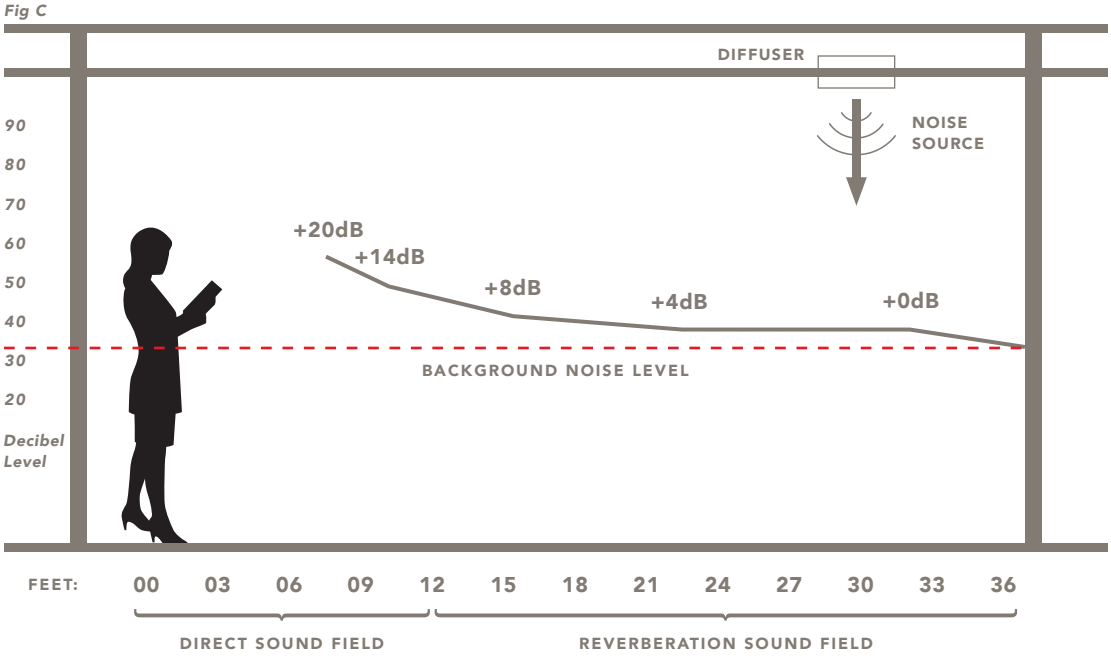


Signal-to-Noise-Ratio

07

A teacher's voice is considered a "signal." Noise that may interfere with understanding the signal is considered "background" noise. To help insure that the signal is intelligible and can be heard above the background noise is called the signal-to-noise-ratio. The average student requires that the signal be +15 decibels (dB) above the background noise, and that the background noise be no higher than 35 decibels. Unfortunately, sound dissipates the further it is from the signal source. Compound this with a constant background noise and the average signal-to-noise ratio is difficult to achieve without acoustical treatment to help reduce the background noise.

Fig C



Classroom Acoustical Guidelines

Efforts to impact good acoustics have been driven by the American National Standards Institute (ANSI 2002) Acoustical Standard S12.60 and the World Health Organization (WHO, 1999).Through their efforts, guidelines have been established for acoustical performance in schools and specifically unoccupied classroom acoustics.

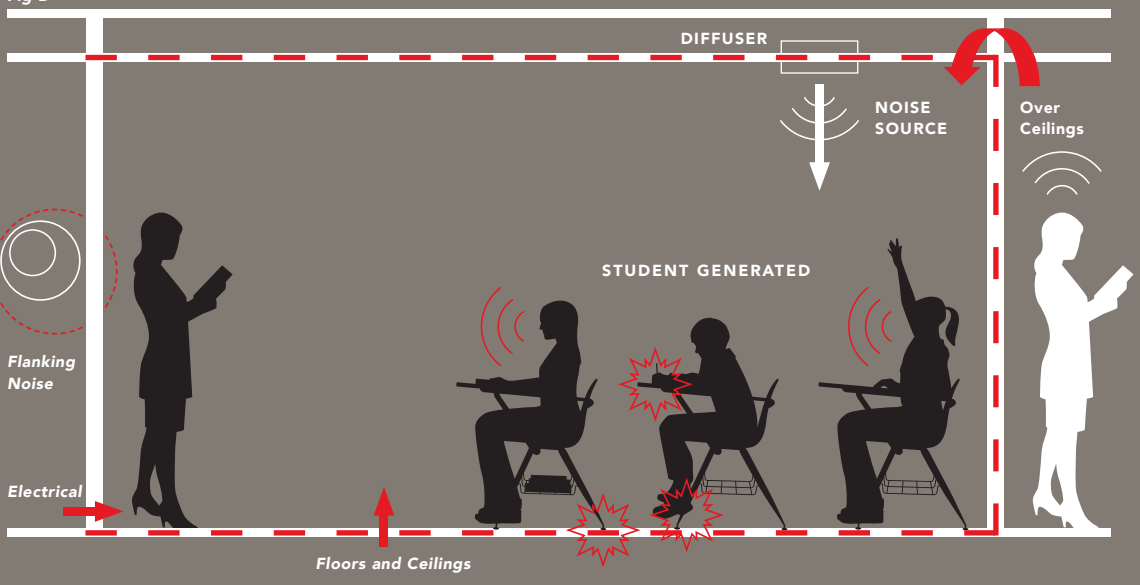
"Since the principles of acoustical design for good speech intelligibility are well established, it's possible to specify criteria for classroom acoustical environments in the same manner as specifying illumination, temperature, or any other environmental parameter." Dr. John Erdreich, FASA

ANSI Standard S12.60 for classroom acoustics establishes maximum standards for both reverberation time and background noise. These standards for a 10,000 cubic foot classroom is a reverberation time no greater than 0.6 seconds with a maximum allowed background noise of 35 decibels (dB). The standards for a 20,000 cubic foot classroom is a reverberation time of 0.7 seconds with a maximum allowed background noise of 35 decibels (dB).

While none of these standards are required, it is incumbent upon us all to consider these guidelines for students who ironically have no real voice in this decision.

The US Green Building Council has adopted a lesser version of these standards, LEED for Schools program, to help insure a quiet and controlled learning environment. Further, the Collaborative for High Performance Schools (CHPS) have also adopted acoustical requirements for architects and designers to follow that contribute to improved acoustical performance in classrooms.

Fig D



New Construction + Powerbond® Cushion = Solution

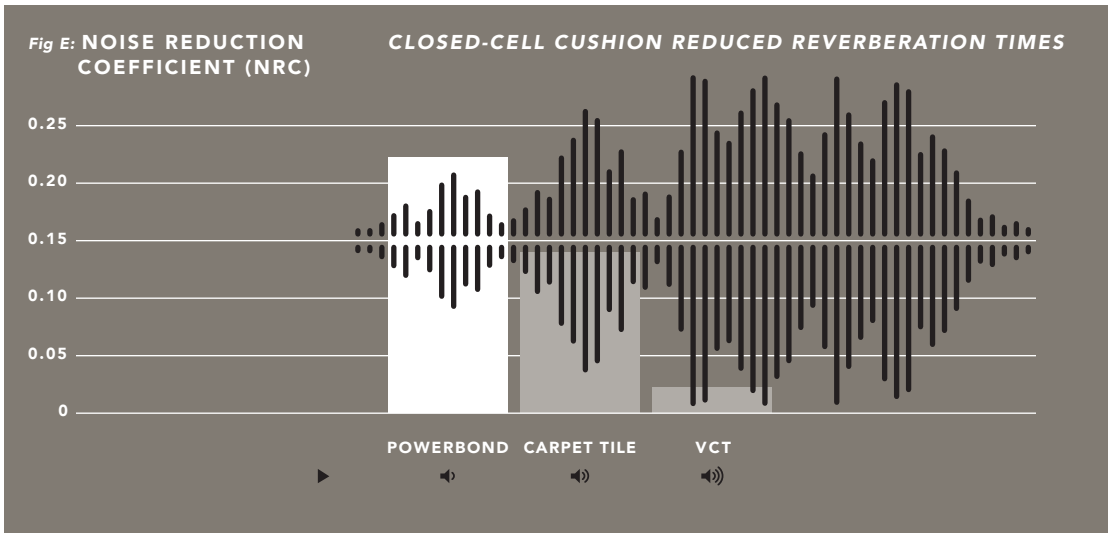
Until recently, flooring has historically been ignored to help reduce reverberation time in classrooms since its acoustical properties are relatively insignificant. However, any soft surface, including resilient floors with cushion can help with the following:

- Reduce background noise from chair impacts
- Reduce background noise from foot impacts
- Reduce background noise from scuffing

However, conventional broadloom carpet or modular carpet creates concerns related to maintenance and moisture management. Powerbond provides acoustical enhancements while improving overall moisture management and maintenance.

The floor surface provides the single largest medium to apply acoustical treatment since it is the single largest area within the classroom. Ceilings may appear to be as large but they actually are discounted by as much as 30% due to the non-acoustical areas occupied by light fixtures and HVAC diffusers. For this reason, new construction should incorporate pendent mounted light fixtures and where possible, displacement ventilation to allow more acoustical performance to be realized from the ceiling.

Powerbond Cushion provides more acoustical properties than other flooring options when comparing the sound absorption factors in the speech frequency range. Powerbond absorbs 20% of the sound that strikes its surface (NRC 0.20) and is approximately 36% of the acoustical performance achieved through conventional school mineral fiber acoustical ceilings.



In rooms with no acoustical treatment, Powerbond can reduce the reverberation time by 55% and further reduce the reverberation time by 15% when combined with acoustically treated ceilings (Shen Milson Wilke, LLC).

These reverberations time can enhance the total learning experience for teachers staff and students and can be designed into the construction documents with predictable outcomes. With Powerbond, and acoustical ceiling panels with an NRC of 0.55, the reverberation times are well below the new ANSI Standards for Classroom Acoustics specific to reverberation. Further, Powerbond may provide LEED Innovation points for other considerations.

Powerbond Cushion can also contribute to reduce total ambient sound, however this is harder to predict since ambient sound can be introduced by intruding noise from outside the building as well as noise generated inside the building. To help reduce outside ambient noise consider outside sources like parking lots, playgrounds, air traffic patterns, ball fields, sidewalks, etc. For interior sources of sound consider the following: corridors, common areas,
electrical outlets, ceiling plenums, full height walls, door construction, door spacing at floor, HVAC diffusers, hard floors, audio-visual equipment, music rooms, gymnasiums and cafeteria locations and traffic patterns.

Fig F: ***ABSORPTION COEFFICIENTS—SABINS/FT²***
ONE-THIRD OCTAVE BAND CENTER FREQUENCY, Hz

125	*250*	*500*	*1000*	*2000*	*4000*	*NRC*
0.04	***0.04***	***0.25***	***0.24***	***0.27***	***0.40***	***0.20***

CLASSROOM		SIMULATED REVERBERATION TIME (RT) IN SECONDS						
FLOOR	CEILING	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	AVERAGE 500 & 1000 Hz
POWERBOND	ACT	1.22	1.08	0.48	0.42	0.40	0.36	0.45
HARD	ACT	1.22	1.19	0.54	0.52	0.52	0.53	0.53
POWERBOND	HARD	1.48	1.82	1.83	1.32	1.18	0.78	1.58
HARD	HARD	1.52	2.21	3.49	3.44	3.57	2.54	3.47

Remodel + Powerbond® Cushion = Solution

The majority of our schools have already been designed and built. Therefore the need to meet new acoustical standards can pose a significant obstacle. Powerbond Cushion provides an economical and viable solution to enhance acoustics in a classroom. Powerbond provides the needed reduction of sound generated within the classroom from chairs, scuffing and foot impacts, and also provides added acoustical treatment at nearly the same cost as a new enhanced acoustical ceiling.

In a recent acoustical analysis comparing two classrooms; one room with VCT floors and acoustical ceilings (ACT), and the other with Powerbond floors and acoustical ceilings. Powerbond clearly made a significant difference in the acoustical outcome of the learning environment in both an unoccupied and occupied classroom. The Powerbond reduced the reverberation times from 8% to 23% in an unoccupied classroom and 15% to 20% in an occupied classroom. These improvements are considered significant. It should also be noted that some of the chairs in the VCT classroom had felt pads on the legs and yet the impact noise of the chairs moving across the floors showed an 8 to 13 dB improvement when using Powerbond.

Fig G: **REVERBERATION TIME IMPROVEMENT**

UNOCCUPIED CLASSROOM		*PERCENTAGE IMPROVEMENT*		
FLOOR	*CEILING*	*500 Hz*	*1000 Hz*	*2000 Hz*
POWERBOND	ACT	22.5%	8.0%	8.3%
OCCUPIED CLASSROOM		*PERCENTAGE IMPROVEMENT*		
POWERBOND	ACT	18.9%	20.0%	14.7%


ELCOME
Let the
Learning
Begin

Remodel + Powerbond® Cushion = Solution

After exhausting efforts to “experiment” with floor products (ranging from broadloom, carpet tile, linoleum and VCT) to find a balance between cost of ownership and acoustical performance, the acoustical analysis convinced schools to standardize on Powerbond Cushion as the only viable alternative. As a result of this acoustical analysis, they have introduced Powerbond Cushion into their corridors where one principle stated, “With Powerbond, you have transformed my school back into a learning environment.”

Every aspect of classroom design should be taken into account before you make final decisions, as those decisions will directly affect the future of our students and the wellbeing of your staff.

Tandus Centiva is proud to offer solutions that enhance places where we live, work, learn and heal. For more information on how Tandus Centiva can help you make your classrooms a success, please contact your local Tandus Centiva Account Executive or visit tandus-centiva.com

Glossary

NOISE REDUCTION COEFFICIENT
(NRC) is based upon how well a surface will absorb the human voice (speech frequency). Zero equals no absorption and one equals total absorption. NRC ratings are depicted as a coefficient and represent a percent of acoustical absorption. Powerbond Cushion has an NRC of 0.20 or 20% sound absorbtion.

IMPACT INSULATION CLASS (IIC)
rates a floor/ceiling assembly's ability to block impact sound. The Uniform Building Code (UBC) contains requirements for sound isolation for dwelling units in Group-R occupancies (including hotels, motels, apartments, condominiums, monasteries and convents). UBC requirements for floor/ceiling assemblies: IIC ratings of 50 (if tested in a laboratory) or 45 (if tested in the field*). Almost all carpeted floors meet the IIC test requirements. Powerbond Cushion tested per ASTM E492-90 range from 54 – 57.

ANSI STANDARD S12.60-2002 CLASSROOM ACOUSTIC STANDARDS
provide the maximum reverberation time in an unoccupied, furnished classroom with a volume under 10,000 cubic feet is 0.6 seconds, 0.7 seconds for a classroom between 10,000 and 20,000 cubic feet. The maximum level of background noise allowed in the above classrooms is 35 decibels (dBA).

SOUND TRANSMISSION CLASS (STC)
The amount of airborne sound blocked from transmitting through a partition is measured in a Sound Transmission Class (STC) rating. A one-number rating of the sound-blocking ability of a partition, door, window, etc., calculated in accordance with ASTM E413 from measurements of one-third-octave band sound pressure levels and sound absorption made in a laboratory and in accordance with ASTM E90, abbreviation STC. A higher STC rating will reduce sound transmission through walls but will add to the background noise level in the space, degrading the ability to hear and understand speech.

BACKGROUND NOISE
is comprised of noise from building systems, exterior sound transmission, and sound transmission from adjacent spaces. Excessive background noise can seriously degrade the ability to communicate.

REVERBERATION
An acoustical phenomenon that occurs in an enclosed space, such as a classroom, when sound persists in that space as a result of repeated reflection or scattering from surfaces enclosing the space or objects in the space such as chairs, desks, or cabinets.

REVERBERATION NOISE
is the overall effect of reflective sound. The time it takes for reflective sound to become inaudible is called reverberation time. Although some reverberation within a space can aide in speech distribution, longer reverberation times will cause a build-up of noise and degrade speech intelligibility. Reverberation time for spaces with more than 20,000 cubic feet of internal volume is not specified, however, guidelines are given in Annex C of the standard.

BACKGROUND NOISE IN CORRIDORS PER ANSI STANDARD S12.60-2002
When corridors adjacent to classrooms are used solely for conveyance of occupants within the school building and structured learning activities do not occur there, the one-hour average A-weighted background noise level in such corridors shall not exceed 45 dB.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No. 3 in a series

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