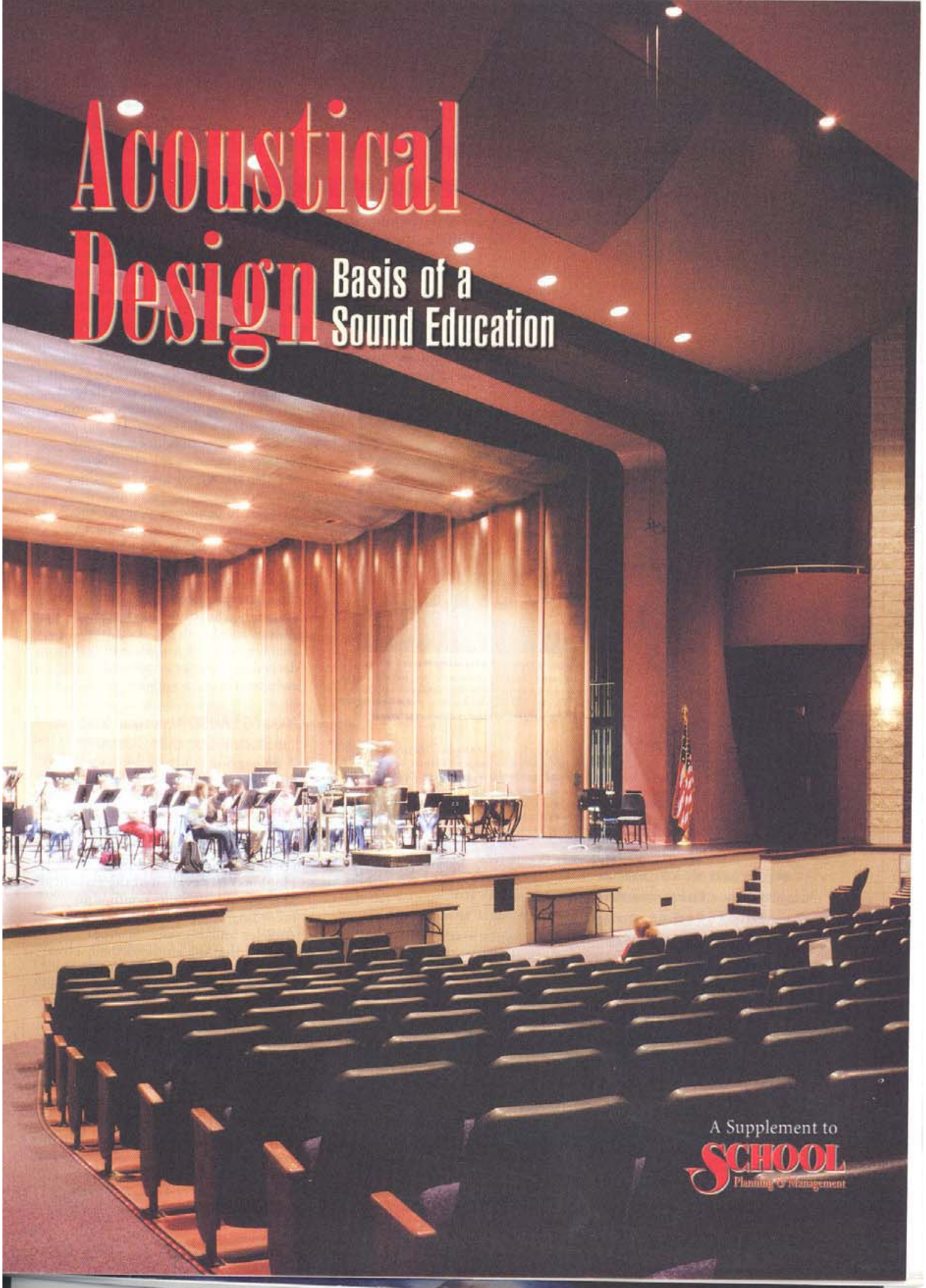
# Acoustical Design

## Basis of a Sound Education



A Supplement to

SCHOOL Planning & Management

# CLASSROOM LISTENING ENVIRONMENT ESSENTIAL TO SUCCESSFUL STUDENT ACHIEVEMENT

*Note: This university study is a first-time look at measuring the noise level in the student-occupied classroom. Previous acoustic measurements and studies have only looked at the physical properties of the room and have intentionally eliminated both the occupant-generated noise and the noise from educational equipment within the classroom.*

Students in today's classrooms are unable to understand 25 to 30 percent of what their teacher said because of excessive noise and reverberation. Students compete with computers humming, feet shuffling, air ventilation whistling, paper rustling, students talking, outside playground sounds and a busy street to stay focused on what teacher is saying. Research recently revealed that a typical classroom provides an inadequate environment when auditory learning is the primary tool of instruction. As many as one-third of all students miss 33 percent of verbal communication in a typical classroom. Transient external noise penetrates the building envelope and disrupts learning. Internal noise also penetrates the classroom. The problem of noise has become so important that the American National Standards Institute (ANSI) has developed background 35 decibel, A-weighted thresholds for the maximum sound level within a classroom. However, ANSI neglects to address not only noise generated in the classroom, but also the signal-to-noise ratio.

In order to be properly heard, the teacher's voice must be at least 15 decibels higher than the ambient noise. The higher the ambient noise level, the greater the strain on the teacher and the higher the probability that words are neither heard nor understood. This coupled with the acoustical characteristics of a classroom makes designing a proper acoustical environment a formidable task.

## 2004-05 LAUSD Acoustical Study in the Student Occupied Classroom

A pioneering study of the noise levels in public school classrooms sheds new light on the problem of making sure that students clearly hear the lessons and discussions. A recent yet-to-be-published joint university study (Brigham Young and Johns Hopkins) has evaluated the statistical analysis of a two-day continuous recording of all sounds in a Los Angeles fourth-grade classroom. It showed that the students themselves, even when most quiet, generate the noise that interferes with good speech intelligibility and learning.

Until now, efforts to reduce classroom noise have been focused on reducing the noise generated by air conditioning and traffic. Because there was no information on the noise generated by the occupants, their role in the problem was dismissed as an issue of classroom management. No prior studies of this kind could be found. John C. (Jack) Rollow, of Design Standards and Technical Specifications for the

*by Paul J. McCarty and Larry S. Rosen*

Los Angeles Unified School District, proposed the investigation of the Los Angeles classroom and the two-day recording and statistical analysis of the recorded sound data. The teacher logged the activities in the classroom — silent reading, working together/talking — and out of class activities — recess, lunch, library visit, etc. so that classroom activities could be correlated with sound levels.

The school was new and designed with good acoustical qualities, and the classroom was not considered a noisy room, even though the noise of traffic and air-conditioning could be heard and measured. The results showed that even with the classroom functioning in an extremely quiet mode, the natural sounds produced by 30 or more "quiet" students — breathing, coughing, yawning, shuffling and squirming — produces a noise level louder than the air conditioning and traffic combined. And, when the class is operating in an interactive mode, with students asking questions or talking among themselves in work groups, the noise level quickly rises to a loudness that makes it hard for teachers or students to be heard above the din. And a statistical measure of "background noise" — the sound level exceeded 95 percent of the time — jumped to more than double that of the quiet activities.

The chart on page A-5 compares the average sound level (Leq) in the classroom with a statistical calculation of the background level. The measurements were taken simultaneously. The ANSI standard requires a background level of 35 dBA in the unoccupied classroom. The premise of this standard is that because there will be 50 dBA at the back of the classroom with a standard 65 dBA voice, needing 35 dBA of background noise. However as this chart demonstrates, in the occupied classroom, the occupants and equipment in the classroom contribute significantly to the background level in the classroom. These factors are specifically excluded by the ANSI standard.

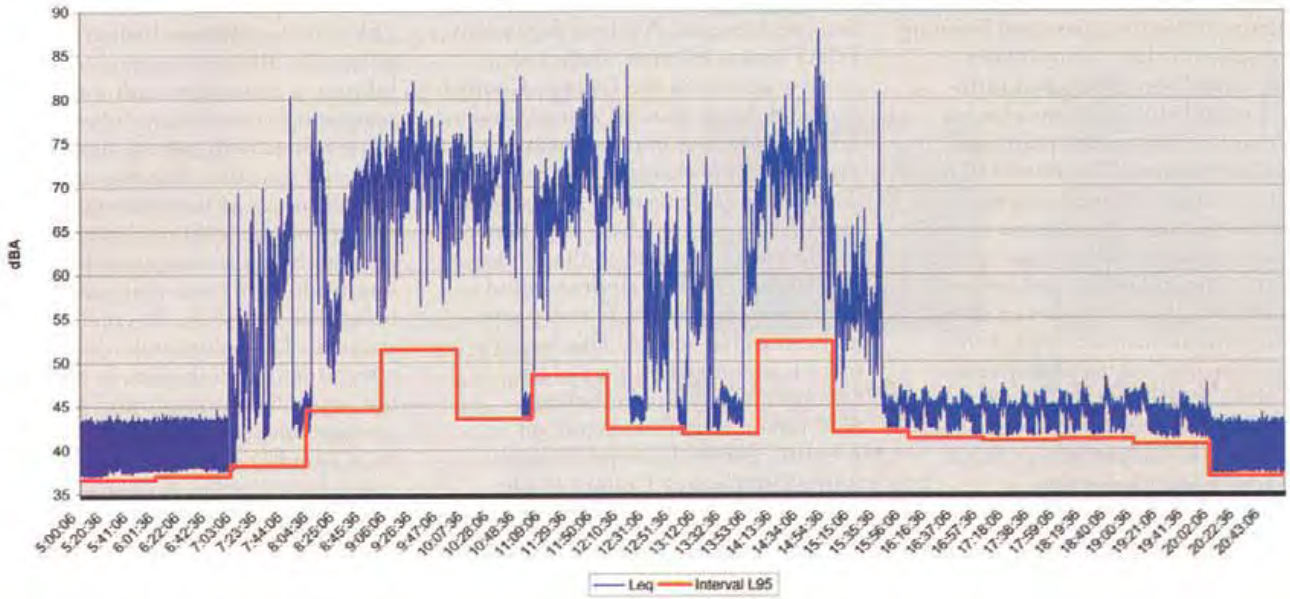
The ANSI standard requires a background level of 35 dBA. In this study, the measured L95 background level never dropped below 43 dBA in the occupied classroom, except during silent reading periods. The question is: How is the ANSI standard expected to make any improvements at all in the student occupied classroom?

## Why Is the Listening Environment Essential to Student Learning?

Children, especially the younger ones, need to hear the speaker clearly. If clarity of speech is masked by a general background noise, the children will not pick up the full message. The optimum learning environment is critically based on auditory-verbal responses. Children spend 45 percent of their day engaged in listening activities. Teachers spend most of their time talking, while students ask questions and listen to both the teacher and other students.

English-limited-proficiency (ELP) students, or students with English as a second language, have difficulty in recognizing words and consonant sounds. As time goes on, frustration sets in and gradually the voice of the teacher is replaced by daydreams. This is what happens to the students in the classroom. Everyday common noises effect students'

**Day 2 Leq Time History and Hourly Interval L95**




LAUSD Field Report

health and limit their learning abilities even to a much greater degree than adults. Why? How can adults filter out such unwanted noises in their learning and work environments when students cannot? Because children's brains are in the process of developing, they listen differently from adults. Learning is about brain access, with subsequent brain growth and development. For spoken instruction to be worthwhile, students must actually be able to hear and listen clearly to the words. Students' ability to learn centers on how well their brains receive the incoming signal of information. Students are rich in auditory designed neural tissue that makes up the child's auditory neurological network of the brain. However, this tissue needs stimulation in order to grow and develop since it is not fully developed until 15 years of age. Whenever we speak, there are gaps in the sounds and meanings of our words. The brains of adults can fill in the missing words, finish the train of thought or understand the underlying meaning of the speaker because of past knowledge or experience of the subject being discussed. This is known as automatic auditory-cognitive closure. Students have difficulty performing the automatic auditory-cognitive closures of missed information in the way adults do.

I had fun with a recent survey of first graders. They were asked to complete the following colloquial phrases that are well known by adults. Here are a few answers from the study:

"Better to be safe than..... punch a 5th grader."
"Don't bite the hand that..... looks dirty."
"You can't teach an old dog new..... math."
"Children should be seen and not..... spanked or grounded."
"If at first you don't succeed..... get new batteries."

This illustrates how our brains automatically fill in the end of the phrase based on our experiences. The humor lies in the answers given by first graders who base their answers on their own life experiences. This also illustrates how an adult can be in the same listening and learning environment, listening to the same instruction as the child, but they both can receive very different messages or both interpret what is spoken in different ways. And, in a noisy environment, the child may not receive any message at all because of his or her inability to fill in the missing pieces of information.

## What Happens When the Students' Classroom Listening/Learning Environment is Improved?

In these days of continuous high stakes testing and federal mandated accountability standards, those who have focused on improving the classroom acoustical environment have reported: 1) Improved student achievement gains, especially among No Child Left Behind (NCLB) targeted students' test

scores; and 2) Lower teacher absenteeism. Orange County Public School District (OCPS) in Orlando, Fla., may have found the answer to both challenges. OCPS administrators recognized that the classroom listening environment is key to improving urban school test scores and introduced sound enhancement systems into many of their elementary and secondary schools. The results of a multiyear study showed that students in audio enhanced classrooms scored 10 percent higher on average on the Florida Comprehensive Achievement Test (FCAT) than students in classrooms without teacher voice, audio enhancement. Teacher absenteeism was also 25 percent less in audio enhanced classrooms. An example of this dramatic student improvement was Ivey Lane Elementary in Orlando. Principal Darryl Weathers was given the assignment of turning around a failing, Title One School with a high minority population. Weathers installed audio enhancement equipment (beginning at $850 per classroom) that contributed to the school moving from an "F" to an "A" school. The teachers also experienced less vocal fatigue. Analysis of student FCAT scores in other district secondary schools in the Orange County Public Schools showed similar student achievement and improvement. Student comprehension increased and discipline problems in the classroom decreased while teachers experienced less fatigue at the end of the school day. Today, OCPS requires sound enhancement systems in every new and renovated school. This requirement is an important part of the Orange County Public Schools $2.7-billion school construction program that will extend through 2015. The Orange County Public Schools school design standard has become a model for other school districts throughout the nation. For example, Ohio has adopted Orange County's sound enhancement concepts for their construction standards for new and renovated schools.

## LAUSD Acoustical Study Conclusions

Other factors beside background noise also affect the speech intelligibility in a classroom. But most contemporary schools have overcome those issues with careful design and material selection, leaving background noise as the primary issue. But spending additional money to reduce the building-generated noise is nonproductive once that noise falls below the sound levels created by the students.The solution, as described by educational audiologists, is to increase the "speech-to-noise ratio," or SNR, to overcome the interference of the background noise. The teacher's voice, heard at the student's ear, must be enough louder than the background noise for the student to hear and understand. If not enough, the student may miss some sounds, and speech intelligibility will be lost.

Audiologists and acousticians have, in general, agreed that "enough loudness" is reached when the speech-to-noise (SNR) ratio is at least 15 decibels. So, if the background noise is 45 decibels — a typical occupied classroom level — the loudness of the voice needs to be 60 decibels (dB). This is just about the level of a teacher's voice at six feet away. And since sound level decreases by six decibels each time the distance from the source doubles, the loudness of the voice at the rear of the classroom is just about 48 decibels. This is a SNR of only three — not enough for students to hear and fully understand what is being spoken. The only way to overcome this barrier is to distribute the teacher's voice through small, strategically placed speakers throughout the classroom. An effective and inexpensive way of doing this is with a teacher voice enhancement system, which takes the speaker's voice from a wireless infrared microphone and distributes it through four to six ceiling speakers. With students sitting no more than 10 ft. from one of the ceiling speakers, this allows every student the acoustical advantage of sitting in the front row of the classroom. A Cornell University study alerted our

team as to how students physiologically, educationally and psychologically focus and learn in the classroom. The implications to the success of student achievement and teacher instruction are significant. The Cornell study, a recent Yale research in Biological Psychiatry and our BYU/Johns Hopkins study investigated the relationship sound and language has on student comprehension and achievement, and teacher instruction in the classroom-learning environment. We have found these to be essential factors for successful learning to take place in the classroom so that all students may achieve. Unfortunately they are frequently overlooked.

## LAUSD Acoustical Study Recommendations

This study recommends the creation of a new standard or methodology that defines the process by which the occupied classroom can be objectively evaluated, data collected and analyzed to reach a conclusion regarding the quality of the listening learning environment in the occupied classroom.

Teacher audio enhanced classrooms encourages us to give serious consideration to an area of student learning that is often neglected — the auditory instructional and learning environment. Many superintendents, principals and teachers who have successfully implemented such teacher voice enhancement systems have reported that the benefits of these systems make common sense — if students can't hear and thus focus on what the teacher is saying, how do we expect them to stay on task, listen and learn.



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*Larry S. Rosen is director of the Institute for School Facility Planning at Johns Hopkins University and a professor at Stetson University.*

### ◆ Tackable and acoustical walls

from **Fabricmate** cut down on maintenance and improve acoustics. Free yourself from the limitations of pre-wrapped and vinyl panels, using the fabric of your choice. The coverings are not glued to the core and can easily be changed at a fraction of the original cost.

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### ◆ Acoustical products

from **CMA** answer the need for moderately priced, modular-sized, easy-to-install systems especially designed for applications in education and recreational environments.

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### ◆ Modular practice rooms

from **Acoustic Systems** are laboratory certified for acoustic performance and are designed to meet the practice and performing needs of music programs at all levels. CaseRight Instrument Storage Cabinets' attractive and extraordinarily sturdy design meets your storage needs.

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### ◆ Sound amplification

from **Audio Enhancement** is a proven technology tool for improving the listening learning environment. By focusing on the goal of ANSI s12.60 — to ensure all students have a good signal to noise ratio in the classroom — this product has dramatically effected thousands of children throughout the nation.

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### ◆ Lay-in ceiling panels

from **Parkland Plastics** are 100 percent guaranteed not to water stain, reducing overhead maintenance costs. SpectraTiles fit into two-ft. by two-ft. and two-ft. by four-ft. grids, resist mold and mildew, and are ideal in moist environments where sanitation is important.

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### ◆ Ceiling line

from **Armstrong** is designed specifically for educational facilities where greater impact resistance and better noise absorption are important. The School Zone Fine Fissured line of ceilings is sag resistant and treated with BioBlock, a fungicide paint that inhibits the growth of mold and mildew.

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