



Linking Noise and Vibration to Sick Building Syndrome in Office Buildings

by Sandi Schwartz

It is estimated that Americans spend more than 85% of their time indoors. For many, this involves working in an office building environment. The quality of the indoor environment can affect a person's health, comfort, and ability to perform on the job.¹ In recent years, several studies have linked excessive noise and vibration in the office to illnesses, such as headaches, dizziness, irritability, and stress. This is similar to the more well-known indoor air quality triggers associated with sick building syndrome (SBS), including temperature, humidity, and off-gassing of volatile organic compounds (VOCs) from building materials. This article explores the relationship between indoor environmental noise and SBS, focusing on how noise contributes to a number of SBS-related health symptoms and possible solutions for mitigating the effects of these illnesses, including whether sustainable building design principles can help.

WHAT IS SICK BUILDING SYNDROME?

In 1984, the World Health Organization reported that certain medical symptoms were occurring with increased frequency in buildings with indoor air problems. This collection of symptoms—including irritation of the eyes, nose, and throat; headaches; respiratory infections; fatigue; dizziness; and nausea—later became known as SBS. Symptoms were linked to a specific building or section of a building where occupants experienced them, but then decreased or disappeared after they left that environment.²

Since SBS was defined more than 20 years ago, concerns about the quality of the indoor office environment have grown. The National Institute for Occupational Safety and

Health (NIOSH) has seen the number of requests for the Institute's assistance rise. Through its Health Hazard Evaluation Program, NIOSH evaluates potential health hazards in workplaces in response to requests from employers, employees, state and local government agencies, and federal agencies. NIOSH investigators have found that concerns about the indoor building environment involve much more than air contamination; they have found comfort problems due to unacceptable noise and vibration levels.³

SBS is still poorly understood, according to Dr. Robert Niven, a consultant in respiratory medicine at Wythenshawe Hospital in Manchester, England.⁴ Although no one is certain how many buildings and people are affected, the syndrome can result in employee sickness and absenteeism, lower productivity, low job satisfaction, and high employee turnover.⁵ An employer may be forced to respond by investing time and financial resources to repair or replace building materials and equipment.⁶

HOW NOISE PLAYS A ROLE IN SICK BUILDING SYNDROME

Office buildings rely on mechanical systems to provide ventilation, heating, cooling, and water for occupants. However, these systems can also lead to noise and vibration problems. The size and placement of the heating, ventilation, and air conditioning (HVAC) system can create problems related to excessive noise if it is functioning poorly or is badly maintained or designed. The rapid flow of air through ventilation ductwork can also transmit noise throughout a building. Additionally, there are several other sources of noise in buildings, including office equipment, such as phones, computers, and fax machines; lights; noise from outside the building; and "people noise" from conversations and other activities.⁷

Both high and low levels of noise can lead to SBS. According to the Academy of Otolaryngology, workplace noise that

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is consistently louder than 85 decibels (dB)—similar to the sound level of normal conversation—can be irritating and affect a person's health.⁸ Low-level noise is also an important risk factor for SBS. Several studies have shown that people complained more in areas where there was low frequency noise, for example, buzzing from fans.⁹ Very low frequency sounds can also cause vibrations that fall in the range of inaudible infrasound—under 20 hertz (Hz). The vibration resonates through building materials, typically causing headaches and dizziness.¹⁰ Interestingly, high frequency noises—such as telephones, people talking, and computers—can actually mask the effects of low frequency noise.

HEALTH EFFECTS

Poor acoustics in the workplace can result in numerous health effects. Many studies over the past decade show that noise can cause stress and lead to symptoms such as high blood pressure, digestive disorders, headaches, muscle tension, fatigue, hypertension, and stomach ulcers.¹¹ High levels of background noise can also impair people's ability to concentrate and perform, causing them to become irritable. This increased stress can eventually lead to workplace accidents, stimulate aggression, and cause other antisocial behaviors.¹² Although not a comprehensive list, the following studies highlight some of the key findings related to noise and SBS.

A 1996 study published in *Indoor and Built Environment* examined low frequency noise of 7 Hz in several offices. Many occupants experienced the following symptoms as a result of exposure to the noise: fatigue, headache, nausea, concentration difficulties, disorientation, seasickness, digestive disorders, cough, vision problems, and dizziness.

This study demonstrated that low frequency noise from the ventilation system was amplified in the tightly sealed rooms and that repeated or long-term exposure to the sound triggered a number of physical symptoms.¹³

Next, a 1997 study published in the *International Journal of Epidemiology* examined the role of work-related stress as a factor in SBS. It tested the hypothesis that health complaints typical of the syndrome were stress-related in buildings with no environmental problems. A questionnaire was used to assess symptoms and the perception of the physical and the psychosocial environment among 2160 individuals in 67 Singapore offices. The study found that poor acoustics was a factor associated with the occurrence of SBS-related stress.¹⁴

In 1998, a paper was presented at the International Conference on Air Distribution in Rooms held in Stockholm, Sweden, that assessed the prevalence and nature of SBS symptoms and their possible causes. The symptoms were noted by 36 occupants working in a naturally ventilated building in Leicester, England. It was determined that headaches were specifically linked to the noise level.¹⁵

Finally, a 2000 study published in *Occupational and*

Environmental Medicine examined three office buildings. A questionnaire was used to assess occupants' health symptoms, and a detailed environmental survey was performed in areas of the building where occupants experienced those symptoms. The study found that low-level noise may be an important risk factor for SBS. The health effects directly associated with the noise included stuffy nose, itchy eyes, and dry skin.¹⁶ According to Dr. Robert Niven, the study's lead researcher, "The prevalence of SBS symptoms varied from 7% to 30%, depending on the building. Noise seemed to contribute quite a bit to the symptoms compared to any other environmental parameter measured (with the exception of particulates). Low frequency noise at 32–128 Hz was the key factor that caused symptoms, and we felt that most of this came from air ducts. Higher frequency noise had a protective effect; we do not know if this was because it masked the harmful effects of low frequency noise. We concluded that low frequency noise is an irritant that might make people more aware of discomfort associated with environmental factors."¹⁷

WAYS TO ADDRESS EXCESSIVE NOISE AND VIBRATION

Once a problem is identified, it is critical to act quickly to minimize the impact on occupants. Although SBS is a result of the interrelationships of various factors, the systems used

and the management practices implemented are typically treated separately rather than in a holistic manner.¹⁸ This type of approach will need to change so that the most effective solutions can be identified. Additionally, Les Blomberg, executive director of the Noise Pollution Clearinghouse, recommends that building managers invest in an acoustical consultant to determine

specific solutions necessary to address the problems of a building. Each situation is unique and requires a tailored plan of action that considers multiple factors.¹⁹ The following approaches to addressing excessive noise and vibration are just some of the possible solutions available.

Noise Reduction and Absorption

Noise reduction is achieved by stopping the noise before it enters into a space. This can be done by building heavy walls with large air spaces to dampen the sound. Noise can also be absorbed by changing its characteristics and stopping reverberation using carpets, furniture, acoustic ceiling tiles, soundboard, or movable interior walls. According to the Center for Health Design, several studies have shown that installing high-performance sound-absorbing ceiling tiles and panels results in reduced noise. Though decibel levels were not greatly reduced as a result of the ceiling tiles (reduction of 5–6 dB), reverberation times and sound transmission were significantly reduced.²⁰ Unfortunately, all materials do not stop all types of noise, so it is important to consider the acoustical characteristics of a room and the design of walls, floors, and ceilings before purchasing materials.²¹

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Sound Masking

Sound masking, which involves using electronic background sound that blends into the environment to cover up or mask unwanted noise, has proven effective in some office environments. When installed properly, employees will not hear the noise, but they will be able to focus on their work without unwanted sound distractions. To be successful, sound masking should include a high-performance acoustical ceiling to absorb sounds that would otherwise bounce off the ceiling into nearby spaces.²² Masking should not exceed 45–50 dB(A) (A-weighted dB) because occupants tend to raise their voices to compensate, which defeats the intended purpose. Currently, 15% of new office buildings are equipped with masking systems, and the number is expected to rise over the next few years.²³

Flanking and Isolation

Noise generated by equipment, such as HVAC, is usually caused by poor sound isolation in floors and walls. This can be solved with acoustic barriers and isolation techniques, including extending partitions above the suspended ceiling; eliminating holes for ducts, pipes, conduits, and cables; providing appropriate acoustical treatment on doors; and minimizing or eliminating sound transmission from air ducts. It can also be controlled by blocking, or flanking, sound paths using fixed walls and floors, and isolating plumbing noise.²⁴

Window Protection

Traffic and other outside noise is also a common irritant in the workplace caused by poor sound isolation by windows. It is typically most severe on the lower floors of buildings in urban areas or near major transportation or industrial noise sources. Windows designed to reduce sound transmission are available and are an effective solution.²⁵

IS SUSTAINABLE BUILDING DESIGN THE ANSWER?

Many of the environmental and health goals of sustainable design, including improved indoor air quality, control of toxic exposures, and daylighting (i.e., enhancing natural lighting in a building), tend to compete with noise control. For example, noise reduction through the use of soft surfaces like carpeting, acoustic ceiling tiles, and panel systems may reduce air quality since the increased surface area attracts particulates.²⁶ According to Blomberg, green building design can present more acoustical challenges than it solves. He points out that there are currently no good acoustical criteria in green building certifications, such as the well-known U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) rating system. He also explains that daylighting and using windows for ventilation is a source of noise: "Opening up a building for improved air flow results in opening it up for noise flow as well."²⁷

Although a major challenge, design and architecture professionals should strive to incorporate noise control into their sustainable building projects. This can be accomplished using a number of approaches and by seeking new, creative ones that will work. One example is to use recycled or green

acoustic products, which can have a substantial impact since acoustic products typically account for a large percentage of the materials in a space—the ceiling, flooring, and walls.²⁸ In *Sick Building Syndrome: Fact or Fiction?* author James Hewitt provided a case study in which a woman used a large house plant to block noise from a printer near her desk to reduce headaches that she was experiencing. These are just a couple of examples demonstrating how the marriage of sustainable design and noise control can lead to a healthy building environment for its occupants. With additional research, effort, and innovation, office buildings of the future can be designed to provide safe, healthy, sustainable environments for people all over the world who are spending more and more time indoors. **em**

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