

THE ROLE OF ACOUSTICS IN SUSTAINABLE DESIGN

Zohreh Razavi, M.A.Sc. EIT, LEED AP

Stantec Consulting Ltd. 111 Dunsmuir Street, Vancouver, BC, V6B 6A3.

1. INTRODUCTION

Good acoustics contribute to a quality work environment but it can pose challenges for sustainable designers. In fact, some of the most common practices associated with green design can actually negatively impact the acoustical performance of our workspaces. The solution, however, could be right above us.

Some green buildings have insufficient sound-absorbing materials due to considerable use of radiant chilled and cooling slabs and transparent envelope. This may cause excessive reverberation, resulting in an acoustical environment which “feels” noisy and can result in impaired verbal communication.

As architects continually strive to incorporate sustainability into their designs, the need for integrated design of all systems, including acoustics, becomes increasingly important. Since it has been investigated that one of the most important factors in greening a building is to provide an environment in which people can perform at their optimum level, designers must acknowledge that acoustics is a fundamental concern that can greatly contribute to the overall comfort level of a space and employee productivity. The main purpose of this paper is to discuss some acoustical challenges in sustainable designs.

2. METHOD

2.1 Overview

Four projects with sustainable concepts of open-plan offices with reflected or acoustical ceiling were studied. The complaints from the occupants were the main reason for the studies. The size of the offices varied from 500 f² to 2000 f² with noise levels of NC 40 to > NC 65 at occupied situation.

2.2 Study cases

The projects were:

1. Open plan office, T-bar acoustical ceilings, carpeted floor, floor area of 1500 f² and adjacent to a transformer room, located in Fort Collins;
2. Open plan office, T-bar acoustical ceilings, carpeted floor, floor area of 1200 f² and adjacent to a mechanical room, located in Vancouver;
3. Open plan office, reflected ceilings, hard floor, floor area of 2000 f² and exposed ducting, located in Phoenix;
4. Home office, reflecting surfaces, floor area of 500 f², located in Richmond.

2.3 Project procedures

Each job site was visited in order to investigate the subjective perception of acoustical quality within the spaces. Prior to visit, plan drawings were reviewed to save time on sites. The noise measurements at a typical sitting positions for employees and at various operation levels for the noise sources were conducted. The measured octave band sound pressure levels were plotted and the equivalent NC levels within each space were found. The results were compared with NC levels recommended by ANSI standards for office environment. Recommendations for acoustical improvement within each space were provided.

2.4 Acoustical analysis procedure

During the acoustical measurements, noise sources (e.g. mechanical or electrical systems) were operating at different loads. The final recommendations were based on the normal operation at working hours. The recommendations were made in order to improve the acoustical environment in the open-plan office areas and increase the job performance of the employees which is the main objective of sustainable designs.

3. RESULTS

3.1 Acoustical measurements

Figure 1 shows the octave band sound pressure levels at octave band frequency of 63 Hz to 8000 Hz. These sound pressure levels were plotted along with NC curves in order to evaluate the noise criteria within each space. The sound pressure level values are the average sound pressure levels that have been measured within each space. As can be seen:

1. The NC level in the Vancouver office was NC 46 with the highest noise level at 125 Hz. Due to locating the office area adjacent to the mechanical room and locating the return air in the mechanical room beside the fan, the highest noise level in the office area was measured at blade pass frequency of the fan.
2. The NC level in the Phoenix office was NC 50 with higher noise levels at lower frequencies. All surfaces in this office were reflective with exposed ducting. The ducting was not internally lined and the “hum” out of the mechanical system was clearly perceptible by the employees.
3. The NC level in the Richmond home office was NC 55 with almost linear sound pressure level at all octave band frequencies. The noise sources in this office were the owner’s kids’ activities which was perceptible in the home office through

stairways. All surfaces in the office and stairways were reflective.

- The NC level in the Fort Collins office was exceeding NC 65 which is well over the ANSI standard for the open offices. The peak was measured at 250 Hz, which is the harmonic of the 60 Hz fundamental operating frequency of the transformer voltage. This was due to the relative location of the office area to the transformer room. The transformer room was adjacent to the open-plan office area with noise leaking a path around the perimeter of its door. No vibration isolations measures were provided underneath the transformers. Thus, low frequency vibration was perceptible by even touching the floors. Return air in the office area were terminated in the transformer room and provided another path for noise transmission into the office area.

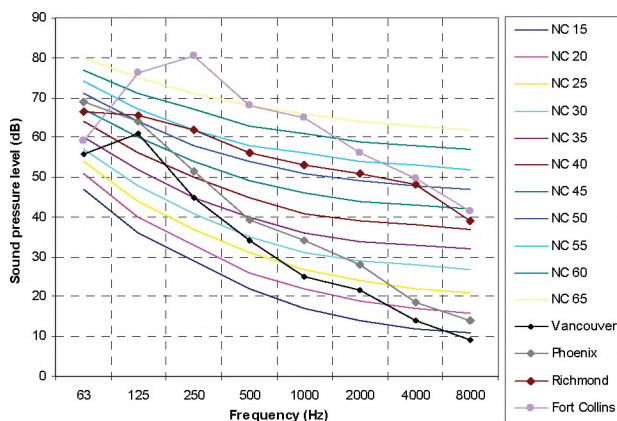


Figure 1. The sound pressure levels measured in dB, at octave band frequencies, in Vancouver, Phoenix, Richmond and Fort Collins open-plan offices.

3.2 Acoustical analysis

The high sound pressure level at 250 Hz in the Fort Collins office was an indication of noise transmission from the transformer room to the office area. This is an indication of not considering the basic principal of not locating noise sensitive areas adjacent to noisy areas, unless providing a buffer zone in between.

The same problem has been experienced in the Vancouver office by locating the mechanical room adjacent to the office areas. One common mistake would be considering mechanical noise for masking and ensuring speech privacy in open-plan offices. Mechanical systems have main components at lower frequencies; however, speech frequencies are at mid frequencies.

Eliminating absorptive panels from the office areas makes the offices echo and noisy. In an echo environment, concentration will be hard for employees which can

negatively affect the employees' job performances. Mechanical ducting without internal lining could be sources of noise, especially at higher air velocities. These problems were experienced in Phoenix open-office and made the employees feel frustrated after a few hours of working within this environment.

Conserving energy and working from home at home offices is one of the sustainable solutions for the environment as long as all office requirements are being met. In office areas, employees who rated their workplace acoustics negatively are dissatisfied with their working environment. No acoustical treatment in the home office, instead of all of the reflective surfaces that the Richmond office has experienced, made the place ineffective. Optimal acoustical quality is a must in the office area which is located close to noise source and is being used for conference calls.

4. DISCUSSION

Open-plan offices are always acoustical challenges, especially with sustainable design goals of eliminating pours materials or minimizing them, and exposed ducting. However, one of the most important benefits to "greening" a building, aside from reduced environmental impacts, is the ability to provide an environment in which people can perform at their optimum level. Any gain in occupant productivity translates into enhanced building sustainability. Widespread dissatisfaction with the acoustics in workplaces can lead to costly errors in communication and reduced productivity due to distractions. Nevertheless, sustainable design does not have to occur at the expense of appropriate acoustics. Many acoustical products, such as ceiling tiles, insulation and carpeting, are recyclable or manufactured from recycled content and can in fact help projects meet sustainability goals. New sustainable acoustical products can solve acoustical problems in working areas. They can improve working environments by contributing to optimal performance and communication, thus helping to meet the objectives of sustainable construction.

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