TEACHING ACOUSTICS TO ARCHITECTS

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1 Introduction

Teaching acoustics in most Canadian universities, with one exception, is an exercise in isolation. In many departments across Canada, acoustics is presented to suit the particular student population. Somewhat similar conditions exist in the Department of Architectural Science at Ryerson University. My colleague in the department will discuss his experiences of teaching an undergraduate course to third year architecture students. The current paper will focus on an elective building acoustics course taught at the graduate level. Even though the department is part of the engineering faculty, architects seem to impose a disconnect with engineers. In addition, when architects design spaces the focus is seen to be on possibilities rather than the potential implementation of the design. How to overcome this disconnect is the main obstacle for engineers. Can one still teach a useful and practical acoustics course? The answer to the above vexing problem is the main focus of the current paper.

2 Main courses

Currently, two courses are being taught in the Department of Architectural Science at Ryerson University. The undergraduate course ASC 521 is taught to the third year students and is a core course. ASC521 – Light/Sound in Architecture - presents the fundamentals of lighting and acoustic design in buildings. Subjective responses to light and sound are explored. Simple calculations are used to evaluate spatial acoustic and lighting performance. Natural lighting processes and energy management techniques are investigated. Fundamentals of acoustic separation are presented. Students will analyse case studies of a variety of room types, including interior office spaces, public galleries and performance spaces that present opportunities to evaluate sound and light in various applications. Model testing of room acoustic and lighting performances will be introduced.

The sound (acoustic) portion of the course is presented over six (6) 3-hour lectures and is currently being taught by Prof. Umberto Berardi and he will describe his experiences during his presentation.

The elective course (BL8206/ASC905), Advanced Acoustic Design, is taught for graduate students and 4th year undergraduate students. Students from other departments are also allowed to take the course. This course will provide students with opportunities to explore in depth how to provide appropriate acoustical environments within different building types, and their implications on materials and other aspects of performance.

Upon successful completion of this course, the students are expected to:

- Understand the basics of sound in buildings.
- Understand the concept of sound propagation outdoors.
- Understand the concept of acoustical regulations in buildings
- Become familiar with building noise sources and their description.
- Begin to understand the design applications for acoustical spaces.
- Begin to understand the simulation and site measurements of acoustical spaces.

The topics to be covered in the course include:

- Sound Basics- Definitions –decibel (dB) - Sound Descriptors.
- Outdoor Sound Propagation – Sound Perception
- Acoustic Instruments
- Room Acoustics -Absorption – Reverberation – Absorption Coefficient
- Sound Transmission: Transmission Loss
- Building Noise sources and control
- Open Plan Office acoustics
- Basics of Auditorium Acoustics
- Simulation of Performance Space acoustics

The above topics were taught over 13 weeks and the weekly breakdown is listed below.

W#1. Course Management and Introduction: Definitions – decibel (dB) - Sound Descriptors; Sound Propagation – Sound Perception
W#2. Outdoor Propagation; Room Acoustics -Absorption – Reverberation – Absorption Coefficient
W#3. Noise Control Criteria and Regulations
W#4. Instrumentation and Noise Sources
W#5. Walls and Enclosures
W#6. Midterm
W#7. Reading week
W#8. Vibration and Noise Control in Buildings and Building Noise Control – Case Study 1
W#9. HVAC System Control - Example
W#10. Open Plan Office Acoustics
W#11. Auditorium Design guidelines – Example and EASE
W#12. Site Visit
W#13. EASE Simulation – Contd.

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3 Discussion

The first thing to be noted is that the title is a misnomer. Most of the students, who sign for the course, have only an architectural degree with scant mathematical background. If the architectural degree is from a foreign country, such as Iran, it would have included some elementary mathematical courses. It can be seen therefore, that the students have difficulty in solving simple problems and considerable tutorial hours have to be expended to assist the students in understanding the materials. Hence, the 'Advanced' in the title of the course is not correct and the course materials have to be simplified as much as possible with the hope that architects can obtain a basic understanding of acoustics and noise control in buildings. It must be reiterated here that the course under discussion is a graduate level course.

One of the aspects that we, as acousticians, have noted over the years, is that architects have ease of using simulation software to model typical building spaces such as auditoria and produce voluminous results such as reverberation time, STI, C_{80}, D_{50} etc. However, most of the architects have no clue as to the significance of these terms other than may be that of reverberation time. The above comments becomes self-evident when one reads about major auditoria in the media. The main spokesperson, at least in North America, to discuss and describe the auditorium acoustics is the architect and not the acoustician. So, one of the efforts, undertaken in BL8206, is to describe and define useful acoustic descriptors so that the students (and future architects) would have some semblance of understanding of the building acoustics and noise control.

The question then, "How does one teach a problem solving, technical course to architects?" At the outset, the students were informed that completing the course does not make them into acousticians. However, the course will provide sufficient fundamental information so that as architects they will be able to confer intelligently with acousticians and noise control specialists.

After teaching BL8206 five times over the past ten years, the consensus that can derived is that to teach architects acoustics has been a heart-breaking exercise at times. Since one has to simplify the materials as much as possible, the learning curve in applying the basic principles to complex situations is totally lacking. The following two examples of assignment problems will show the efforts needed to make architects to deal with building acoustical issues.

Example 1: the following outdoor propagation problem with a single source with octave band SPLs was easily solved by the students which was similar to one of the worked samples during the lecture.

A manufacturing facility will be testing its engines at a plant location which is 50 m from its property line. The tests will be conducted either at night or day time over a 2-hour period. The steady noise levels at the plant property line are given below. Residential development is located 100 m east of the plant property. Will the plant be allowed to test, without noise mitigation, if it is located, a) in an urban areas; b) in a rural area in Ontario?

However, when a multi-source situation, such as the one below with different operating times, more than 80% of the class was not able to solve the problem.

The plant consists of a bank of cooling towers. Due to the recession, the cooling towers operate only for 50% of the time in any given hour. The steady sound of the cooling towers is dominant in the following two frequencies -250 Hz and 500 Hz. The SPL at a distance of 100 m is 75 dB at 250 Hz and 68 dB at 500 Hz. At night time the plant releases steam through a vent for a period of 2 minutes. The steady SPL at 100 m for the steam vent is 70 dB at 1000 Hz and 65 dB at 2000 Hz. What is the one-hour L_{eq} in dBA a) during the day time and b) at night time?

Example 2: the following indoor problem with a single source with PWLs in two frequencies was easily solved by the students which was similar to one of the worked samples during the lecture.

The music room (no windows) of an apartment unit has dimensions 6 m X 5 m X 4 m high. The walls and the ceiling are made with gyproc with absorption coefficient of 0.15 at 250 Hz and 0.10 at 1000 Hz. The floor has thick carpet with absorption coefficient of 0.25 at 250 Hz and 0.65 at 1000 Hz. A small speaker with 0.1 watt sound power at 250 Hz and 1000 Hz was located on the floor at the centre of the 6 m by 4 m wall. Determine the diffused sound level in the room.

However, when a fan with a given sound power was placed inside a closet (the transmission loss properties of the closet were given) at one end of the room, the students had immense difficulty to solve the problem.

It must also be pointed out that only a single acoustics course to discuss building acoustics is being offered and to adequately do justice to the acoustic materials can be seen to be a tall order.

4 Conclusion

It is obvious, as it is at departments in other universities in Canada, that the main focus has been to provide acoustical information within a narrow focus. One would hope that the architects understand the acoustical requirements that would make the built environment is adequate from an acoustical comfort perspective. The main requirement, in Canada then, is to offer a full-fledged "Acoustics Program," similar to the ones at John Hopkins and Penn State Universities in the USA where one could obtain a Master's degree in Architectural Acoustics or Building Noise Control.