

# ACOUSTICS SPECIALIZATION FOR BUILDING ENGINEERS

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## 1 Introduction

The Department of Building, Civil and Environmental Engineering at Concordia University offers undergraduate and graduate acoustic courses for students who want to pursue a career in architectural acoustics. This paper describes an overview of the architectural acoustics specialization program, the acoustics curriculum for building engineers, lab facilities, and research areas developed at Concordia University. The program guides students to gain fundamental knowledge in acoustics and analysis skills of indoor environments to achieve optimal acoustic performance in buildings. The acoustic courses cover topics from acoustic principles to professional applications in room acoustics and noise control methods.

The building engineering program at Concordia University is designed to encompass the body of knowledge pertaining to all aspects of a building with an understanding of their impact on the environment including acoustics. The building engineering program at Concordia started in 1977. The Department of Building, Civil and Environmental Engineering is located at Sir George Williams campus in Montreal, QC. Currently, there are 40 tenured (or tenure-track) professors and 4 part-time affiliated professors in the department. The department provides Bachelor of Engineering (BEng), Master of Applied Science (MASc), Master of Engineering (MEng) and Doctor of Philosophy (PhD) degrees in building engineering. There are approximately 350 undergraduate and 300 graduate students in the program. The program at Concordia is the only building engineering program, which is accredited by the Canadian Engineering Accreditation Board (CEAB).

## 2 Acoustic curriculum at Concordia

The building engineering program at Concordia currently offers two acoustic courses for students and two additional courses are offered by other departments in the faculty of Engineering and Computer Science. Brief course descriptions and teaching strategies for each course are as follows.

### Acoustics and lighting

The Acoustics and Lighting (BLDG366) course is a core course for junior level students in the building engineering program. The course provides fundamental knowledge in acoustics and key design principles for acoustically sensitive spaces. Laboratory experiments and design projects are

essential components of this course for students' engagement. The main objectives of this course are:

- 1) understanding fundamental aspects of sound, hearing, acoustic measurement device and architectural acoustic design practices,
- 2) attaining the competence to solve complex acoustic problems by using measurement data and theoretical calculations,
- 3) and presenting acoustical design strategies with clarity and professionalism.

In this course, the students acquire skills in four CEAB attributes; investigation, use of engineering tools, professionalism and impact of engineering on society and the environment. For building engineering major students, the most important aspect of teaching strategy is disseminating significance of acoustics in building design. Sharing daily experiences about acoustic quality in space are highly encouraged in the class and through a social networking service like Twitter. Audio samples are the valuable resource as students learn theories more effectively when they can hear the acoustics. In a team project, students are asked to measure acoustics of existing spaces at Concordia, analyze the acoustic quality, and write a report on how to improve them. In the project, students can apply the acoustic theories they learned in actual spaces.

### Building acoustics

The Building Acoustics course (BLDG 474/6721) is a crosslisted course for undergraduate and graduate student who are interested in acoustics for understanding advanced room acoustics. Topics covered in the course include a threedimensional wave equation, sound sources, room acoustics, noise control methods in buildings, acoustic measurement methods such as a room impulse response, transmission loss and sound power measurement. Students are required to practice room acoustic simulation and parameter analysis through case studies and a project. For the project, students are highly encouraged to participate in Acoustical Society of America student design competition with the project outcomes [1].

### Other courses

Noise and Vibration (ENGR 6311) - engineering acoustics course provided by the Department of Mechanical, Industrial and Aerospace Engineering for understanding of wave phenomena in general

Acoustics (ELEC 6361) - electro-acoustics course provided by The Department of Electrical and Computer Engineering mainly for understanding mechanism of loudspeakers, microphones, and communication systems.

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### 3 Acoustic research at Concordia

#### 3.1 Laboratory facilities

There are two main acoustic lab facilities in the building engineering program at Concordia. The acoustics and lighting lab is mainly for the laboratory experiments for the course BLDG366. In this class, students attended the lab bi-weekly for acoustic experiments. The laboratory experiments include measurement of the speed of sound, absorption coefficients using a standing wave tube, and reverberation times using an interrupted noise method and an impulse method. The students also learn how to use sound level meters accurately to calculate community noise levels. B&K Impedance tube and Norsonic 140 sound level meters are utilized.

The acoustics research lab is mainly used for research by graduate students. The research lab is equipped with a 2-channel room impulse response measurement system, 3 class 1 sound level meters, a sound intensity probe, 2 tapping machines, an impedance tube, a series of vibration sensors and a reverberation chamber. The volume of the reverberation chamber (Fig. 1) is 15.4 m<sup>3</sup> with wall absorption coefficients of 0.06 or less from 250 Hz and upwards. The chamber acts as a source room for random sound absorption coefficient, sound power assessment, and for sound transmission loss measurement. The equipment and lab can be used for acoustic measurements of music venues, transmission loss, sound power, impact isolation, sound source localization, vibration measurement, and sound quality analysis in time and frequency domains. More detailed description can be found in the laboratory and research group homepages [2, 3].



**Figure 1:** Reverberation chamber at Concordia acoustic research laboratory

There are also assorted facilities and resources in the collaboration with the acoustic research group at Concordia. There is a fabrication facility to build acoustic scaled models and material, technical staff with experiences in the acoustic laboratory environment, control systems and signal processing specialist, Building Material Laboratory, and Heating, Ventilation and Air Conditioning (HVAC)

laboratory for testing of noise from building mechanical systems.

#### 3.2 Research areas

Current research project at Concordia are:

- 1) perception-based acoustic building design,
- 2) noise exposure monitoring in acoustically critical spaces.

Potential research interests of our group are:

- 3) sound quality analysis of HVAC system to develop effective noise control methods,
- 4) sound source localization and transmission loss using intensity measurement,
- 5) speech intelligibility and classroom acoustics,
- 6) concert hall acoustic measurement and analysis.

### 4 Conclusions

The acoustics specialization has been revitalized in the building engineering program at Concordia University to help students to gain knowledge in acoustics as building engineers and pursue further research and professional careers in acoustics. The acoustics courses and research activities support students to engage in acoustic areas.

Building Acoustic Research Group at Concordia University offers prospective graduate and undergraduate students theoretical and practical hands-on academic and research experience in architectural acoustics and noise control methods for design of buildings for optimal acoustics performance.

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### References

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