Carleton UNIVERSITY
Canada's Capital University

Office of the Vice-Provost and
Associate Vice-President (Academic)

Institutional Quality Assurance Process

Master's and Ph.D. in Building Engineering

Volume 1

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Approvals Table

This table will record that the brief has been approved by: 1) the program lead on behalf of the team; 2) the head of the academic unit or chair of the program committee (in the case of interdisciplinary programs not administered exclusively by one academic unit) on behalf of the unit or program committee; 3) the Faculty Dean(s).

Program Lead	**Date**
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Chair/Director	**Date**
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Dean(s):	**Date**
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Committees Reviews and Approvals

Vice-Presidents' Academic Research Committee	
Financial Planning Group	
Curriculum Committee	
Faculty Board	
Carleton University Committee on Quality Assurance	
Senate Committee on Curriculum, Admissions on Studies Policy	
Senate Academic Program Committee	
Senate	
Quality Council	

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A. The Program

A.1. Program overview

In 2011, the Department of Civil and Environmental Engineering started a new undergraduate program titled Architectural Conservation and Sustainability Engineering (ACSE). While the ACSE program has demonstrated a track record for successful undergraduate teaching, it lacks vertical integration to the graduate level. Currently, graduates of the ACSE undergraduate program who want to pursue graduate studies at Carleton University have to enroll in one of the Civil or Environmental Engineering programs. While this is acceptable for students who like to specialize in, for example, structural engineering, it has not been an attractive option for students who would prefer to specialize in building performance or heritage conservation. These students are therefore discouraged from pursuing graduate studies. Similarly, the current Civil Engineering programs provide a very good path for students who would prefer to specialize in structural fire safety engineering. However, the specialization of fire safety engineering includes also fire chemistry, fire dynamics, smoke movement, fire alarms and sprinklers, and human behavior. These specializations are not well served through the Civil Engineering programs and would fit better through a Building Engineering program. There is a significant opportunity for students specializing in building performance, heritage conservation, and fire safety engineering to both enhance their knowledge of building engineering and specialize their skills and knowledge to supply the high demand in the private and public sectors. Accordingly, the proposed programs in Building Engineering will serve both students who graduate from Carleton's ACSE program as well as students from other engineering programs at Carleton and within and outside of Canada. There are three proposed programs, for which students may opt to specialize in one of three optional concentrations (Performance, Heritage Conservation, and Fire Safety Engineering) or generalize:

- MEng in Building Engineering (coursework or project pathways)
- MASc in Building Engineering
- PhD in Building Engineering

These program levels match those of other engineering departments at Carleton and elsewhere in Canada, while the concentrations reflect the unique offering of Building Engineering and the expertise of the faculty members.

Since the inception of ACSE in 2011, the four faculty members who were hired for that program have demonstrated exceptional graduate student training capacity and research activity. Meanwhile, three additional faculty provide complementary expertise and graduate training opportunities on fire safety engineering and numerous other faculty members complement this core group through topics such as structures and air quality. As of July 2021, an eighth faculty member will join and serve the heritage conservation engineering area. To date, graduates in building engineering-related areas have obtained prestigious positions in government laboratories, as university professors, and in consulting and R&D departments in the private sector.

While ACSE students obtain a general background on architectural conservation and sustainability engineering-related topics in the undergraduate program, there is significant benefit for its graduates

(and graduates from other engineering and non-engineering programs) to further gain expertise and specialize. Currently, the Civil Engineering graduate program provides a path to ACSE students who want to specialize in this area. Accordingly, we are seeking to create an opportunity for vertical integration for ACSE students who want to specialize in building performance, including fire safety, or heritage conservation and have graduate programs to retain ACSE graduates into graduate studies, while also attracting other students from Carleton and elsewhere. Therefore, there is a significant opportunity to formalize and enhance this graduate training opportunity through new graduate programs in Building Engineering.

Despite the increase in industry and research activity in the area of building engineering, only a few graduate (or undergraduate) programs of its type exist in Canada.

Background

Buildings are complex engineered systems that profoundly affect humans and the environment. Within the current ecosystem of post-secondary training opportunities, civil engineering addresses the structural and geotechnical aspects of buildings; mechanical engineering addresses heating, ventilation, and air-conditioning systems (HVAC) and renewable energy systems; electrical engineering addresses building control systems and lighting systems; architecture addresses building function and form, planning, non-technical design, culture, and history. However, several major interrelated niches remain that are not adequately addressed as a result of their interdisciplinary nature and the fact that traditional programs have not kept up with the needs of contemporary building design, operation, and restoration. These niches will be addressed by the proposed graduate programs in Building Engineering. Considering the strengths of the current faculty members, gaps in training opportunities, and employer needs, these areas have been identified as: building performance, heritage conservation, and fire safety engineering.

These areas are truly multidisciplinary (as are their associated faculty members) and cannot be adequately served by existing and traditional graduate programs. They are best taught and researched by faculty members who have formal or informal training through multiple disciplines: mechanical engineering, civil engineering, architecture, and math/computer science. They are each briefly summarized below.

Building performance is focused on improving all states of the building life-cycle (design, construction, operations, retrofit/demolition) with regards to energy, greenhouse gas emissions, and comfort. It requires an understanding of both passive and active building systems, energy, comfort, modelling and simulation, advanced data analysis, and in-situ/field measurement approaches.

Heritage conservation is focused on studying, measuring, analyzing existing and historic buildings – with the objective to conserve them through technical recommendations without compromising their authenticity and integrity. Key areas include advanced techniques for in-situ measurement (e.g. 3D scanning, photogrammetry, non-destructive techniques, material sampling and analysis), digital modelling of existing buildings, and restoration/retrofit analysis.

Fire safety engineering is a multidisciplinary area that encompasses structural fire engineering, which is a field of study in the Civil Engineering program, and fire dynamics and materials reaction to fire, which is under the Building Engineering program. Key areas of the non-structural aspects of fire safety engineering include combustion and fire dynamics, smoke management, fire modelling, fire detection and suppression, behavior of materials in fires and behavior of people in fires. These areas rely on both computer modelling and experimental approaches and require a strong background in heat transfer and fluid dynamics.

While these areas are often treated —and can be researched— independently, they have significant linkages and interdependencies. For example, rehabilitation of heritage buildings is a key strategy to improve life-cycle energy and carbon performance of buildings. Moreover, heritage conservation, energy performance, comfort, and fire safety may yield conflicting or mutualistic design opportunities. For energy performance, it is normally optimal to insulate historic masonry buildings on the outside, whereas this may compromise the heritage value of such buildings. Meanwhile, fire safety considerations have immediate implications for building energy performance and heritage conservation. For instance, while it may be desirable to provide operable windows to occupants to reduce cooling energy needs, operable windows can be consequential for the rate of combustion of fires. Finally, the study and modelling of human behaviour is a common thread across building energy performance and fire safety engineering. In summary, professionals in the area of building engineering must have an appreciation for individual topics as well as the relationship between them.

Accordingly, the vision of Building Engineering is to train students to have a broad understanding of building systems and concepts – mechanical and electrical systems, fire safety, energy and comfort performance, envelopes, controls and operations, structures, and heritage and existing building retrofit and rehabilitate – while also understanding how they relate to each other. With that foundational knowledge, combined with fundamental research skills, students will have the option to specialize in one of the concentrations for course-work and research alike: building performance, heritage conservation, and fire safety engineering.

The Department of Civil and Environmental Engineering (CEE) offers some of the most dynamic, innovative and cross-disciplinary undergraduate and graduate programs in Canada, leading to Bachelor, Master's and Doctoral degrees in both Civil Engineering and Environmental Engineering. Faculty and students regularly collaborate and engage with experts across academic units within Carleton University, at other universities and research institutes across Canada, and with industry, government and community partners.

In 2011, the Department introduced a new program, a BEng in Architectural Conservation and Sustainability Engineering (ACSE), which provides a unique, inventive focus on sustainable development and heritage conservation. With increased awareness of the importance of economic, social and environmental sustainability, expertise in sustainable building design, heritage conservation, and fire safety engineering is now in high demand across the private and public sectors. This program provides students with the opportunity to study within a first-class engineering faculty as well as be enriched by the program's close association with Carleton's well-known Azrieli School of Architecture & Urbanism.

The ACSE program has been very successful. The program exceeded its enrolment targets set forward in its original business plan. The fifth graduating class graduated in June 2019 and the program has undergone two successful accreditation visits. Faculty members hired in support of the program have been very successful in establishing strong research programs and developing strong interdisciplinary research collaborations across campus, in Canada and internationally. The next logical step is to create graduate programs that vertically align with the undergraduate ACSE program. It is important to introduce new graduate programs that properly reflect the training and research conducted by faculty and students associated with the ACSE program.

Currently, incoming graduate students who are interested in building engineering lack an appropriate program in which to register. They are mostly registered in the Civil Engineering and Environmental Engineering graduate programs, which require applicants to have backgrounds in those respective fields and if not, to take up to four undergraduate courses in those fields that typically have little relevance to their area of graduate studies. This requirement approximately doubles the number of courses required to complete a graduate degree. This significant barrier often detracts potential students from the Department or even graduate studies. For those students who have accepted this requirement, it can mean a significant delay in research progress as a result of the heavy course load. Finally, many students currently take advantage of the current faculty members' cross-appointments in other units and adjunct status at other institutions to register in programs that are aligned with their undergraduate degree but do not necessarily provide an ideal graduate program to meet their educational and future career aspirations. Table A1 illustrates the number of students currently supervised inside and outside of the department.

The proposed graduate programs in Building Engineering will accept students from numerous engineering disciplines, architectural engineering, and computer science and must therefore be more accommodating than the current CEE graduate programs, though still stringent to ensure that students have the necessary fundamental engineering skills to take the required and elective courses and conduct research in these areas. Section E.1 outlines the nominal educational expectation of admitted students. The Director of Building Engineering will assess all applicants to determine whether they are required to take additional courses.

Table A1. Current thesis-based graduate students and PDFs (0.5 indicates co-supervision) as of December 31, 2018. Students at other universities are indicated in the notes below the table.

Professor Name	Year professor started at Carleton	IN CEE			OUT CEE		
		Master	PhD	Post-Doc	Master	PhD	Post-Doc
Bucking	2015	2.5	1.5	0	1	1(1)	0.5(2)
Gunay	2017	1.5	1.5	1.5	0	0	0
Hadjisophocleous	2001	3~~0~~	2~~3~~	0~~2~~	0	0	0
Hajiloo	2019	0	0	0	0	0	0

O'Brien	2011	0	2	1.5	1[3]	1 [4]	0
Santana	2012	3	1	2	2	0.5 [5]	0
Zalok	2005	2	2	1	0	0	0
Total	**-**	**9**	**11**	**8**	**4**	**2.5**	**0.5**

[1] one co-supervised student at Concordia, [2] one co-supervised PDF at McMaster, [3] two co-supervised students at UofT, [4] two co-supervised students at UofT, [5] one co-supervised student at UQAM.

Graduate degrees in Building Engineering, with optional concentrations in 1) performance, 2) heritage conservation, 3) fire safety engineering, would allow students with these backgrounds or related backgrounds and interest in these topics to enter this program and graduate with a degree title that reflects the focus of their program and concentration. The program will provide students with a necessary broad perspective of building design, retrofit and operations, considering aspects of energy and comfort, heritage, and fire safety. This broad perspective is essential because many of the research and industry challenges lie in the interaction between building systems (e.g., mechanical equipment, structures, fire systems, lighting, etc.). The traditional approach in graduate-level engineering (e.g., mechanical and civil engineering) lacks this interdisciplinary approach that is essential to train the next generation of practicing engineers and researchers. In addition, the proposed program in Building Engineering will offer a tailored set of graduate courses taught by the core faculty members and others, world-class facilities and training opportunities, and unique admissions and degree requirements.

In a very short period, Carleton University has become a leader in Canada in the area of heritage conservation given the NSERC CREATE in Heritage Engineering and the synergies Prof. Santana has created with colleagues in Architecture (e.g. Prof. Fai in the CIMS lab, Prof. Esponda Graduate Diploma on Conservation), School of Indigenous and Canadian Studies (e.g., Prof. Ross), School for Studies in Arts and Culture (e.g., Prof. Coffman), Mechanical and Aerospace Engineering (e.g., Prof. Laliberte), and School of Information Technology (e.g., Prof. Joslin). Meanwhile, Profs. O'Brien, Bucking and Gunay and their collaborations with colleagues in Mechanical and Aerospace Engineering (e.g. Profs. Beausoleil-Morrison, Cruickshank, and Duquette), have developed a strong building performance research group (Carleton Building Performance Research Centre) that rivals Concordia's (the largest concentration of building engineering professors in Canada). Prof. O'Brien also collaborates with Prof. Trudel (Industrial Design). This group of ACSE program professors and fire safety professors have attracted approximately $15-million in research funding over the past six years (see Table D1).

Program goals

The graduate programs will focus on improving new and existing buildings using novel simulation-aided design strategies, new materials and technologies, novel control and operating strategies, design retrofits, rehabilitation, additions, and other interventions that consider energy efficiency, occupant behaviour, health, and comfort, life-cycle analysis, and structural integrity, while respecting both environmental and heritage aspects. With traditional graduate programs focusing on narrower niches related to building engineering, graduates often lack an appreciation for the relationship between systems and aspects of buildings. In contrast, the Building Engineering graduate programs will expose

students to a wider array of topics and disciplines, while also allowing them to apply this broad knowledge to a specific concentration.

The programs will also offer training on the use of advanced digital surveying techniques (e.g., 3D scanning, photogrammetry), modelling, simulation, and experimental approaches, and integrated information systems (e.g., Building Information Systems). Furthermore, the programs will focus on buildings and their immediate surrounding communities. This program will be a potential outcome of the NSERC CREATE program on Engineering Students Supporting Heritage and Sustainability (Heritage Engineering). Also, the program will provide training on fire safety engineering, including fire protection engineering, research methods to study performance of buildings exposed to fires and evaluate the risk from fires to building occupants, advanced model-based structural design and material selection, advanced design strategies, and material behaviour at elevated temperatures.

The program goals of the masters and PhD programs fall under three themes: interdisciplinarity, research, and communication.

i. Interdisciplinarity: Students will be able to understand, discuss and design new approaches in the architecture, engineering and construction (AEC) field from multiple perspectives and an interdisciplinary approach. Students will be exposed to scientific literature and technical and practical aspects of all three main concentration areas, in addition to building structural engineering basics, to gain a broad view of the complexity of building systems through the ~~mandatory~~ required "Introduction to Building Engineering" course. Additionally, we envision research collaboration and interdisciplinary training through the co-supervision of graduate students by professors from different concentrations (e.g., energy efficiency considerations of heritage buildings). This collaboration will be further facilitated through availability of shared graduate student workspace.
ii. Research: Students will be able to conduct advanced research relevant to the built environment (e.g., new, existing, traditional and/or heritage buildings) within an established workflow or project and make original contributions to existing research projects/programs to enhance their relevance and/or scope. Students will gain the skills required to troubleshoot and enhance research methods and approaches as needed to maximize the relevance, reliability, and impact of their work. Special care will be given to issues of adaptability and resilience and not only provide an opportunity to reduce energy consumption and carbon emissions, but also to preserve these buildings for future generations.
iii. Communication: Students will be able to effectively develop research proposals and protocols, prepare summaries of previous research activities with brevity and clarity, and present their, or others', research to audiences across built environment disciplines and to the lay public or external partners.

The Building Engineering programs will not only provide an appropriate graduate degree that vertically aligns with the existing Bachelor's of Engineering on Architectural Conservation and Sustainability Engineering, but also offer innovative and interdisciplinary training that addresses the gaps within existing building engineering programs and provides unique opportunities to understand the built environment.

Our programs will bring together graduate students across built environment disciplines to learn about issues facing society, including high-performance building and community (comfortable and low-energy) design and operation, fire safety, and reuse, restoration, and retrofit of existing buildings.

Program Structure

The nominal path and name of all degree programs is Building Engineering. All programs (MEng-course or project, MASc, and PhD) offer students the option to select and be trained in a concentration in Performance, Heritage Conservation, or Fire Safety Engineering. Alternatively, they may opt to have no concentration and obtain more generalized training.

Due to the interdisciplinary nature and goals of our new graduate programs, as listed in Table A2, all students will be required to take a common course: Introduction to Building Engineering. This course will be co-taught by at least one professor specializing in each concentration area and will bring students together to foster knowledge translation across disciplines, and between students with different backgrounds, to discuss complex building engineering issues. The course will also enable students to develop core competencies such as basic research skills and communication of technical building engineering topics (writing and presentation). Experiential learning is a predominant teaching method of this course; examples include analysis of real building data, extensive use of case studies, field studies and technical tours, and guest lectures by practitioners and government researchers. To ensure coherence in course content and adherence to learning outcomes, the Director of Building Engineering or an appointee will serve to coordinate the Introduction to the Introduction to Building Engineering course.

An Introduction to Research Methods course will be developed to serve M.Eng. students and further enhance interdisciplinary aspects of the programs. This course is aimed at students without research experience and who will not receive informal research training through a thesis and supervisor.

The students are also required to take other courses, with greater restrictions for those wishing to have a concentration. The program structure and details are outlined in Tables A2 and described in more detail below.

Table A2. Building Engineering MEng, MASc and PhD Program Structure

Component/Activity	**MEng**	**MEng**	**MASc**	**PhD**
	coursework	project	thesis	thesis
~~Core~~ Required courses*, +,**	~~3~~1.0 credits	~~3~~1.0 credits	0.5~~2.0~~ credits	0~~1~~.5 credit
Building Engineering courses **+, †***	2.0 credits†****	2.0 credits	1.5 credits	1.0 credits
Elective courses	2.0 credits	1.0 credits	0.5 credit	
Project credit		1.0 credit		

Thesis proposal (with integrated comprehensive exam)				0.5 credit
Thesis			2.5 credits	8.0 credits
Total credits	5.0 credits	5.0 credits	5.0 credits	10.0 credits

* All students must take BLDG 5701: Introduction to Building Engineering; M.Eng. students must also take BLDG 5702: Introduction to Research Methods

**+ If a student has already taken the offered courses, s/he will be permitted to take relevant courses with the thesis supervisor's recommendation and the program Director's permission.

***‡ The Building Engineering courses for their respective concentrations are listed in Table B2. Students with no concentration must take at least 50% of courses requirements as those listed among the concentrations in Table B2.

† **** M.Eng. coursework students must take at least one course in each of the three concentrations

~~*The core courses for their respective concentrations are listed in Table B2.~~

~~**If a student has already taken the offered courses, s/he will be permitted to take relevant courses with the thesis supervisor's recommendation and the program Director's permission.~~

Current Provincial and National Profiles

The proposed graduate programs are unique to Canada because they will provide students with an understanding of the engineering required during the entire building life-cycle, considering new building design, building operations, and reuse of existing and heritage buildings. Meanwhile, students will have the option to focus on a topic of particular interest through the concentration structure. There are existing programs in Canada that focus on specific building-related topics, but they are not as comprehensive and most of them are not engineering. Existing programs related to building performance, heritage conservation, and fire safety engineering in Canada are provided in Table A3.

Table A3. Building engineering and related graduate programs in Canada.

University and program	**Unit**	**Other***	**MEng**	**MSc/ MASc**	**PhD**	**Area**	**Gaps not addressed in these programs**
Ryerson University: Building Sciences	Department of Architectural Science			X	X	"opportunity to explore the building science principles necessary to deliver sustainable buildings"	Heritage conservation and fire safety engineering are not considered; also, this is not an engineering program
Concordia University: Building Engineering	Department of Building, Civil & Environmental Engineering (BCEE)		X	X	X	building engineering falls into a number of categories, including: computer-aided design, performance of building envelope and materials,	Heritage conservation and fire safety engineering are not considered.

						building environment (HVAC, acoustics, illumination, air quality), building and energy, wind effects on buildings, building structures, and construction management.	
British Columbia Institute of Technology: Building Engineering/Building Science	School of Construction and the Environment		X	X		Building envelopes, building energy performance, indoor environmental quality,	Heritage conservation and fire safety engineering are not considered; no focus on mechanical systems or building controls
Athabasca University: Heritage Resources Management	Faculty of Humanities and Social Sciences	x				Oriented to the social dimension of cultural heritage, not only buildings	Concentration on different dimensions of heritage not to technical aspects of adaptive reuse, rehabilitation, conservation and/or retrofit
University of Victoria: Cultural Resource Management Program	Continuing studies	x				Oriented to conservation, planning, museums studies and cultural management	It is a diploma program and not research-oriented
Universite de Montreal: Maîtrise en aménagement, option Conservation du patrimoine bâti	Faculté de l'aménagement	x				Orientated to the built heritage, from policy to issues in architecture	It is the only program in Canada offering conservation of built heritage, in closely works with the school of architecture. It is a French speaking program
Willowbank	Diploma in Heritage Conservation	x				Oriented to conservation, planning, museums studies and cultural management	3-year non-academic program

*post-graduate diploma programs.

Additional notes on Building Engineering or related graduate programs in Canada and elsewhere:

- There are other undergraduate degrees and diplomas offered in hands-on technical training in construction, replication and restoration techniques; history of Canadian architecture; principles of conservation; adapting buildings to meet current energy efficiency guidelines. One example is Algonquin College's Heritage Institute.

- Advanced Master of Conservation of Monuments and Sites: https://set.kuleuven.be/rlicc by the Raymond Lemaire International Centre for Conservation, University of Leuven focused on high-level research on a holistic approach in the preservation and management of Built Cultural Heritage, but mostly historic buildings.
- Advanced Masters in Structural Analysis of Monuments and Historical Constructions: http://www.msc-sahc.org/content.asp?startAt=2&categoryID=638 – Erasmus Mundus Masters Course by University of Minho (Guimarães, Portugal), Czech Technical University in Prague (Prague, Czech Republic), Technical University of Catalonia (Barcelona, Spain) and the University of Padova (Padova, Italy) - focused in the idea of energy and structural performance that meets the standards of contemporary living and respect for historic buildings, technical course.
- Master of Sciences on Built Environment: Sustainable Heritage: https://www.ucl.ac.uk/prospective-students/graduate/taught/degrees/built-environment-sustainable-heritage-msc by University College London, focuses on combining aspects of cultural heritage - historic buildings, museums, collections, sites and landscapes - with the best preventive conservation and heritage management policies, projects, methodologies and practices.

Student demand

Despite the demand and availability of graduate education studying the built environment and the growing need for such programs to position graduates for success in the rapidly changing job market, no graduate programs adequately address the performance of existing buildings (e.g., traditional and/or heritage). In addition, existing programs dealing with building engineering are not interdisciplinary as the proposed programs. It is critical that graduates pursuing research and practice careers have a broad understanding of buildings because of the interconnections between all building systems through the building life-cycle.

A number of students enrolled in the BEng program and other undergraduate programs at Carleton have expressed significant interest in pursuing a graduate degree in Building Engineering. As currently designed, there is a logical progression from the BEng in Architectural Conservation and Sustainability Engineering into the Building Engineering programs. For example, approximately 15% of ACSE graduates have pursued graduate studies following their degree, with approximately half of these opting to study in Europe or other Canadian universities – in part due to the lack of related programs at Carleton. However, the new programs are not limited to engineering students from this BEng program. We anticipate students from various backgrounds, including architectural engineering, mechanical engineering and other branches of engineering, or related disciplines, will enroll in our programs. There is other strong evidence for student interest in the Building Engineering programs. First, the NSERC CREATE titled Heritage Engineering (2015-2021), led by Prof. Mario Santana and involving Profs. O'Brien and Bucking, has maintained a steady-state MASc and PhD enrollment of approximately 15 with over half being in engineering. Second, the Carleton Building Performance Research Centre (BPRC) boasts one of the largest clusters of building engineering researchers in Canada, with six professors (including the three leading the Building Performance concentration of the proposed programs) and approximately 50 graduate students and post-doctoral fellows. Many of these students – particularly those currently in the Civil Engineering and Environmental Engineering graduate programs at Carleton – have expressed

interest in the Building Engineering programs. Those students are the ones who accepted to enroll in the Civil or Environmental engineering programs as a means to work on their research, but many more students opted not to pursue their graduate studies as the program of their first preference does not currently exist.

A.2. Mission and strategic directions

The new graduate programs (NGPs) in Building Engineering are directly tied to **Carleton's Strategic Mandate Agreement** (2017-2020). In this agreement, the Ministry of Advanced Education and Skills Development (MAESD) confirmed that Carleton's first listed Program Area of Strength is Environment and Sustainability. A second Program Area of Strength that is central to the NGPs is Advanced Technology and Design. The proposed programs also align with Carleton's fourth Program Area of Expansion; namely Advanced Technology and Innovation. The tools used for historic site documentation and restoration use advanced lasers and software. Building simulation and control systems rely on and improve upon advanced technologies and innovative sensors and simulation tools. This growth is within Carleton's focus and priorities (Strategic Integrated Plan and Strategic Research Plan, see below) and will be designed to be complementary to existing programs at Carleton related to architecture and buildings.

The proposed masters and PhD in Building Engineering are well aligned with **Carleton's Strategic Integrated Plan (2013-2018)**.

Academic Strengths (Goal 1-1): The NGPs will build upon the interdisciplinary strengths of our current undergraduate program (Bachelor of Engineering in Architectural Conservation and Sustainability) and contribute to the breadth of building environment, sustainability, heritage conservation, architecture, design, and renewable energy system research and expertise at Carleton. The NGPs will utilize our existing network of national and international collaborators and expand upon our existing relationships with municipal, provincial and federal government departments (e.g., Natural Resources Canada, Public Services and Procurement Canada, utilities), industry (Autodesk, Delta Controls), and organizations (ICOMOS, IBPSA, ASHRAE).

Societal Needs (Goal 1-1): With a rapidly expanding population and correspondingly high demands on sustainably designed and constructed buildings, there is a significant demand for professionals with skills in sustainable building and community design, existing and heritage building retrofits, and building operations. The proposed structure of the NGPs will provide students with disciplinary and technical expertise (thesis) as well interdisciplinary knowledge and skills (Building Engineering ~~core~~ courses), which are required for a variety of building engineering-related careers and employment outcomes.

Management of Resources (Goal 1-2): The proposed NGPs will build upon Carleton University's institutional strengths in sustainable buildings and heritage of the built environment and fire safety engineering. The University has made a significant investment in developing strengths in these research areas (with numerous new hires in the past decade), while also constructing new buildings that serve as a living lab (such as Canal and Health Sciences buildings). This infrastructure will provide state-of-the-art training and research opportunities for both undergraduate and graduate students. The proposed NGPs

will leverage these existing and newly acquired resources to deliver quality programs in an effective manner.

Research-intensive Institution (Goal 2-1): Faculty within the Department of Civil and Environmental Engineering have a strong record of research excellence, demonstrated by various indicators such as research publications, grants, community engagement and knowledge dissemination activities. For instance, Prof. Santana is the Vice President of ICOMOS; Prof. O'Brien is the President of the Canadian Chapter of the International Building Performance Simulation Association and Operating Agent of an International Energy Agency Annex on occupant behaviour. Prof Bucking is a sub task leader on community energy master planning of an International Energy Agency Annex 73 on net-zero energy communities. Moreover, they are heavily engaged with multidisciplinary research (e.g., with architecture, mechanical engineering, and Indigenous and Canadian studies), hands-on learning, and community engagement. Research interests of Building Engineering faculty members are closely aligned with Carleton University's strategic research plan including designing sustainable communities, campus sustainability, and living laboratories.

Employability and Future Success (Goal 3-1): The Department of Civil and Environmental Engineering is strongly committed to the student experience and experiential learning. The NGPs will provide students with a strong foundation in interdisciplinary building engineering research and specific knowledge and skills for their specific thesis topics (where applicable). The courses will provide students with fundamental skills and knowledge and a deep understanding of the complex and multidisciplinary aspects of building engineering. Courses will also consist of training in soft skills such as research skills (e.g., research design, writing reports, etc.) communication and presentation skills, and teamwork. The aforementioned courses will provide students with a strong foundation. For instance, the research methods courses will teach students to develop and pursue research questions, perform literature reviews, collect, analyze, and visualize data, and present results to a variety of audiences.

A.3. Relationship to other academic programs at Carleton

The NGPs are designed to serve students who lack vertical integration in graduate studies and/or do not see their specialization served well in the current graduate programs at Carleton University. It is noted that we are still attracting some students who want to specialize in building performance, fire safety, and heritage conservation into the existing Civil and Environmental Engineering programs. However, many potential students are discouraged to pursue graduate studies in the aforementioned specializations. Hence, while there may be some impact on the Civil and Environmental Engineering graduate programs, we expect this impact to be minor and the NGPs to primarily attract students who otherwise would not pursue graduate studies (i.e., a net overall increase in graduate students). Core faculty members in CEE, including those hired for the ACSE program who supervise graduate students in the area of building engineering, currently supervise or co-supervise numerous students in other units and programs due to the lack of a proper program within the department that reflects these students' training and expertise.

Presence of the Building Engineering programs at Carleton would attract graduate students that are studying elsewhere under the supervision of our faculty members (as per Table A1, the faculty members currently supervise 6.5 FTE HQP outside of Civil and Environmental Engineering; if these students were to enroll in the NGPs, this would translate to 10 HQP). Notably the Building Engineering programs would result in small net decrease in the number of students in programs in which the current faculty supervise students, as well as other related programs. These programs may include, but are not limited to: MEng, MASc, and PhD in Mechanical, Civil, and Environmental Engineering; MA, MEng, and MASc in Sustainable Energy; and MAS and PhD in Architecture; Graduate Diploma in Architectural Engineering. The Chairs/Directors of the units offering these programs have all supported the introduction of the Building Engineering program. Because none of these programs is the perfect fit for the research targets in the Building Engineering program, attracting students to these areas has been difficult. By establishing the natural fit for this research area, most of future students attracted to the program would be students who otherwise would not pursue graduate studies.

The programs in Building Engineering will be partially reliant on courses offered by other departments at Carleton, including Canadian Studies, Architecture, and Mechanical and Aerospace Engineering. The proponents of Building Engineering have obtained necessary written approvals and confirmation that these courses have the capacity to teach students in Building Engineering.

B. Program Learning Outcomes and Assessment

B.1. Program learning outcomes and degree level expectations

The Council of Ontario Universities has established a framework of Degree Level Expectations (DLEs) that specify what students should know, and be able to do, after successfully completing graduate degree programs. The DLEs for graduate programs are:

1. Depth and breadth of knowledge
2. Research and scholarship
3. Level of application of knowledge
4. Awareness of limits of knowledge
5. Level of communications skills
6. Professional capacity/autonomy
7. Experiential learning

In Tables B1a, B1b and B1c we describe the learning objectives of the MEng, MASc, and PhD in Building Engineering. These programs will equip the students with the highly marketable skills and knowledge within the architecture, engineering, and construction sector. The program learning outcomes are designed such that the students will acquire interdisciplinary skills that become the foundation for future career successes and life-long learning. The building engineering programs will provide students with a strong foundation in interdisciplinary building engineering research and specific knowledge and skills for their specific thesis or research project topics (where applicable). The courses will provide students with fundamental skills and knowledge and a deep understanding of the complex and multidisciplinary aspects of building engineering. Courses will also consist of training in transferable skills

such as research skills (e.g., research design, writing reports, etc.) communication and presentation skills, and teamwork.

Experiential learning is a prominent inherent trait in the Building Engineering programs. Experiential learning starts with the Introduction to Building Engineering course, while being commonplace throughout the other courses and research projects/theses. Project/thesis supervisors have a mandate to incorporate experiential learning in their training. For example, the research of all three concentrations frequently involves field studies, case studies, and in-situ measurements. The building performance area will provide students with long-term sensor measurements of several hundred buildings in Ottawa, including state-of-the-art monitoring systems in Carleton buildings. Students will be trained to analyze data to reveal operational insights as well as understand limitations of analytical methods. The heritage conservation concentration will involve advanced field techniques and site inspections (e.g., photogrammetry thermal photography, non-destructive detection techniques, and laser scanning) in historic and existing buildings in Canada and abroad. Finally, the fire safety area involves application of fire and smoke modelling techniques to new and existing buildings. The faculty members routinely work with industry and government to apply theory to practice and real buildings. Thus, graduate students will similarly be involved in and/or exposed to real projects, via access to and use of rich data sources, hands-on experience with existing buildings, application of theory to existing buildings, and technical tours on and off campus.

M.Eng. project and thesis students will acquire knowledge and skills in building engineering (i.e., under the seven DLEs) that are appropriate for their research via guidance from their supervisor and self-directed learning. This training normally occurs through weekly or biweekly meetings for the duration of the project or thesis (four months for projects, two years for MASc, and four years for PhD).

Table B1a. Learning outcomes and degree level expectations for MEng in Building Engineering

Learning outcomes	**DLEs met**
Be able to create, collect and/or analyze data related to the built environment in adherence with learned theory and best practices	Depth and breadth of knowledge; experiential learning
Be able to analyze, evaluate, and apply the most appropriate design or research method(s) to building engineering problems; be able to identify the most appropriate sources in the literature to obtain information on building engineering theory and methods	Research and scholarship
Be able to apply building codes, standards, and/or best practices to existing, heritage, and/or new buildings to safeguard the public interest and the natural and built environments	Level of application of knowledge; experiential learning
Be able to demonstrate a system-level understanding of existing, heritage, and/or new buildings and be aware of the limits of engineering methods	Awareness of limits of knowledge; experiential learning

Be able to conduct and apply engineering established methods for analysis using data and information from models and/or measurements from the built environment	Professional capacity/autonomy; experiential learning
Be able to effectively communicate a relevant body of knowledge to peers and/or stakeholders	Level of communications skills; experiential learning

Table B1b. Learning outcomes and degree level expectations for MASc in Building Engineering

Learning outcomes	**DLEs met**
Be able to create, collect and/or analyze data related to the built environment for application to research in adherence with learned theory and best practices	Depth and breadth of knowledge; experiential learning
Be able to analyze, evaluate, and apply the most appropriate research method(s) to building engineering problems; be able to identify the most appropriate sources in the literature to obtain information on building engineering theory and methods	Research and scholarship
Be able to apply building codes, standards, and/or best practices to existing, heritage, and/or new buildings to safeguard the public interest and the natural and built environments	Level of application of knowledge; experiential learning
Be able to demonstrate and apply a system-level understanding of existing, heritage, and/or new buildings and be aware of the limits of engineering methods	Awareness of limits of knowledge; experiential learning
Be able to conduct and apply engineering established methods for analysis using data and information from models and/or measurements from the built environment	Professional capacity/autonomy; experiential learning
Be able to synthesize and effectively communicate the state-of-the-art to peer researchers and/or stakeholders	Level of communications skills; experiential learning

Table B1c. Learning outcomes and degree level expectations for PhD in Building Engineering

Learning outcomes	**DLEs met**
Be able to create, collect and/or develop data and apply advanced analytics related to the built environment for application to research in adherence with learned theory and best practices	Depth and breadth of knowledge; experiential learning
Be able to analyze, evaluate, apply the most appropriate research method(s) in to building engineering problems and develop new methods as needed; be able to identify the most appropriate sources in the literature to obtain information on building engineering theory and methods; identify gaps in the scientific literature and contribute to them	Research and scholarship
Be able to apply and critically assess building codes, standards, and/or best practices to existing, heritage, and/or new buildings to safeguard the public interest and the natural and built environments	Level of application of knowledge; experiential learning

Be able to demonstrate and apply a system-level understanding of existing, heritage, and/or new buildings and be aware of the limits of engineering methods	Awareness of limits of knowledge; experiential learning
Be able to conduct research using existing methods –or develop new methods- for engineering analysis using data and information from models and/or measurements from the built environment	Professional capacity/autonomy; experiential learning
Be able to synthesize and effectively communicate the state-of-the-art to peer researchers and/or stakeholders	Level of communications skills; experiential learning

B.2. Program structure and curriculum map

Program structure

The program structure is shown in Table B2.1. The master's programs are nominally two years in length, while the PhD program is nominally four years.

Due to the interdisciplinary nature and goals of our new graduate programs, as listed in Table A2, all students will be required to take "Introduction to Building Engineering". This course will bring students together to foster knowledge translation across disciplines, and between students with different backgrounds, to discuss complex building engineering issues. The course will also have a significant experiential learning element where students will work with existing or new buildings as a case study for each of the major domains.

While the additional ~~core~~ Building Engineering courses required for the programs are generally domain specific, they will provide students with an understanding of the "big picture" and how the subject matter relates to building design, operations, and/or rehabilitation. Moreover, guest lectures between the concentrations' professors will be commonplace. As one example, professors from the performance concentration routinely provide guest lectures for the Advanced Building Characterization, Conservation and Rehabilitation Heritage course.

A compulsory Introduction to Research Methods course will be developed and delivered to serve M.Eng. students and further enhance interdisciplinary aspects of the programs. This course is aimed at students without research experience and who will not receive research training through the thesis-writing process under direct supervision of a professor. It will focus on specific scientific techniques in building performance, heritage conservation, fire safety, and structural engineering. Moreover, it will provide students with skills needed to design, implement, and present a research project. M.Eng. students wishing to further enhance their research skills (e.g., to support the project option) may also take the Advanced Research Methods for Building Engineering course after completing the Introduction to Building Engineering and Introduction to Research Methods courses.

As teaching resources become available, additional courses for M.Eng. students at Carleton are planned, including engineering economics and entrepreneurship. These Faculty of Engineering and Design-wide

courses will broaden the course offerings and improve the M.Eng. experience, while reducing the teaching load of the core faculty members.

Those wishing to specialize in an optional concentration will be required to take additional unique ~~core~~ Building Engineering courses in their respective concentration. Note that Building Engineering courses do not necessarily have the BLDG course code. Program structure and details are outlined in more detail below.

Table B2.1. Building Engineering MEng, MASc and PhD Program Structure

Component/Activity	**MEng**	**MEng**	**MASc**	**PhD**
	coursework	project	thesis	thesis
~~Core~~ Required courses *,**	~~3~~1.0 credits	~~3~~1.0 credits	~~2.0~~0.5 credits	0.5~~1.5~~ credits
Building Engineering courses**,***	2.0 credits****	2.0 credits	1.5 credits	1.0 credits
Elective courses	2.0 credits	1.0 credits	0.5 credit	
Project credit		1.0 credit		
Thesis proposal (with integrated comprehensive exam)				0.5 credit
Thesis			2.5 credits	8.0 credits
Total credits	5.0 credits	5.0 credits	5.0 credits	10.0 credits

* All students must take BLDG 5701: Introduction to Building Engineering; M.Eng. students must also take BLDG 5702: Introduction to Research Methods

** If a student has already taken the offered courses, s/he will be permitted to take relevant courses with the thesis supervisor's recommendation and the program Director's permission.

*** The Building Engineering courses for their respective concentrations are listed in Table B2. Students with no concentration must take at least 50% of courses requirements ~~as~~from those listed among the concentrations in Table B2.

**** M.Eng. coursework students must take at least one course in each of the three concentrations

~~*The core courses for their respective concentrations are listed in Table B2.~~

~~**If a student has already taken the offered courses, s/he will be permitted to take relevant courses with the thesis supervisor's recommendation and the program Director's permission.~~

Table B2.2 ~~Core~~ Building Engineering ~~course requirements for the general path or concentrations~~courses by concentration,***

~~**General (no concentration)**~~

~~BLDG 5701 (0.5 credit) Introduction to Building Engineering and at least 50% of the course requirements from the list of courses below.~~ ~~M.Eng. students must also take BLDG 5702 (0.5 credit) Introduction to Research Methods~~ ~~MEng coursework option to take at least one course in each of the three concentrations.~~
Concentration in Building Performance
~~BLDG 5701 (0.5 credit) Introduction to Building Engineering~~ ~~BLDG 5702 (0.5 credit) Introduction to Research Methods (M.Eng. only)~~ ~~1.0 credits for PhD; 1.5 credits for MASc; or 2.0 credits for MEng of the following *:~~ BLDG 5707 (0.5 credit) Building Energy Management and Optimization BLDG 5704 (0.5 credit) Advanced Research Methods in Building Engineering ENVE 5104 (0.5 credit) Indoor environmental quality BLDG 5107 (0.5 credit) Building Services Engineering MECH 5205 (0.5 credit) Building Performance Simulation
Concentration in Heritage Conservation
~~BLDG 5701 (0.5 credit) Introduction to Building Engineering~~ ~~BLDG 5702 (0.5 credit) Introduction to Research Methods (M.Eng. only)~~ ~~1.0 credits for PhD; 1.5 credits for MASc; or 2.0 credits for MEng of the following *:~~ BLDG 5705 (0.5 credit) Advanced Building Characterization, Conservation and Rehabilitation Heritage CDNS 5403 (0.5 credit) Heritage Conservation and Sustainability ARCN 5100 (0.5 credit) Representation and Documentation in Architectural Conservation ARCC 5401 (0.5 credit) Workshop: Technical Studies in Heritage Conservation BLDG 5704 (0.5 credit) Advanced Research Methods in Building Engineering
Concentration in Fire Safety
~~BLDG 5701 (0.5 credit) Introduction to Building Engineering~~ ~~BLDG 5702 (0.5 credit) Introduction to Research Methods (M.Eng. only)~~ ~~1.0 credits for PhD; 1.5 credits for MASc; or 2.0 credits for MEng of the following *:~~ CIVE 5609 (0.5 credit) Fundamentals of fire safety engineering CIVE 5610 (0.5 credit) Fire Dynamics I CIVE 5612 (0.5 credit) Fire Modelling CIVE 5613 (0.5 credit) Fire Dynamics II CIVE 5614 (0.5 credit) Design for Fire Resistance CIVE 5615 (0.5 credit) Behaviour of Materials in Fire

* students without a concentration also choose Building Engineering courses from this list, as per Table B2.1

**other courses can be taken outside the courses listed with the approval of the supervisor/advisor and the approval of the Director of Building Engineering.

In addition to the required ~~core~~ and Building Engineering courses, students will need to complete a number of elective courses depending on their program as per Table B2.1. Allowed elective courses are:

- All graduate courses at the Faculty of Engineering and Design.
- Other graduate courses with prior approval of the Director.

Thesis/project-based students (PhD, MASc, and MEng project option) are required to perform their thesis research in the same area as their concentration (i.e., Building Performance, Heritage Conservation Concentration, or Fire Safety). Students who do not opt to have a concentration may perform research in any area within the scope of Building Engineering

Program curriculum map

Table B.2.a: Program curriculum map summary for MEng program

Program Components	Learning Outcome						Additional information (including specific info on experiential learning)
	Be able to create, collect and/or analyze data related to the built environment in adherence with learned theory and best practices	**Be able to analyze, evaluate, and apply the most appropriate design or research method(s) to building engineering problems; be able to identify the most appropriate sources in the literature to obtain information on building engineering theory and methods**	**Be able to apply building codes, standards, and/or best practices to existing, heritage, and/or new buildings to safeguard the public interest and the natural and built environments**	**Be able to demonstrate a system-level understanding of existing, heritage, and/or new buildings and be aware of the limits of engineering methods**	**Be able to conduct and apply engineering established methods for analysis using data and information from models and/or measurements from the built environment**	**Be able to effectively communicate a relevant body of knowledge to peers and/or stakeholders**	
BLDG 5701: Introduction to Building Engineering	project report and/or assignments						Course involves at least one dataset, case study, or tour for each concentration area

BLDG 5702: Introduction to Research Methods	project report and/or assignments						Course involves application of methods to case studies and field data
Building Engineering courses ~~Core courses~~ listed in Table B.2.2	Exam, project report, and/or assignments						Varies by course, but likely to include real building studies, hands-on use of tools and data, and/or field study/technical tour
Project (applies to M.Eng. Project Stream only)	Project report						Most projects will involve a case study, field data, experimental work, and/or a modelling study of a real building
Degree Level Expectations	Depth and breadth of knowledge; experiential learning	Research and scholarship	Level of application of knowledge; experiential learning	Awareness of limits of knowledge; experiential learning	Professional capacity/ autonomy; experiential learning	Level of communications skills; experiential learning	N/A

Table B.2.b: Program curriculum map summary for MASc program.

Program Components	Learning Outcome						Additional information (including specific info on experiential learning)
	Be able to create, collect and/or analyze data related to the built environment for application to research in adherence with learned theory and best practices	**Be able to analyze, evaluate, and apply the most appropriate research method(s) to building engineering problems; be able to identify the most appropriate sources in the literature to obtain information on building engineering theory and methods**	**Be able to apply building codes, standards, and/or best practices to existing, heritage, and/or new buildings to safeguard the public interest and the natural and built environments**	**Be able to demonstrate and apply a system-level understanding of existing, heritage, and/or new buildings and be aware of the limits of engineering methods**	**Be able to conduct and apply engineering established methods for analysis using data and information from models and/or measurements from the built environment**	**Be able to synthesize and effectively communicate the state-of-the-art to peer researchers and/or stakeholders**	
BLDG 5701: Introduction to Building Engineering	Project report and/or assignments						Course involves at least one dataset, case study, or tour for each concentration area

BLDG 5702: Introduction to Research Methods	Project report and/or assignments						Course involves application of methods to case studies and field data
Building Engineering courses ~~Core courses~~ listed in Table B.2.2	Exam, project report, and/or assignments						Varies by course, but likely to include real building studies, hands-on use of tools and data, and/or field study/technical tour
Thesis	Data collection and analysis for the thesis project	Methods section of thesis	Results of thesis		Methods and results sections of thesis	Dissemination of thesis results through publications; at research meetings with peers, and/or public and private sector partners, conferences, and/symposia	Most projects will involve a case study, field data, experimental work, and/or a modelling study of a real building
Degree Level Expectations	Depth and breadth of knowledge; experiential learning	Research and scholarship	Level of application of knowledge; experiential learning	Awareness of limits of knowledge; experiential learning	Professional capacity/ autonomy; experiential learning	Level of communications skills; experiential learning	N/A

Table B.2.c: Program curriculum map summary for PhD program

	Learning Outcome						Additional information (including specific info on experiential learning)
Program Components	**Be able to create, collect and/or develop data and apply advanced analytics related to the built environment for application to research in adherence with learned theory and best practices**	**Be able to analyze, evaluate, apply the most appropriate research method(s) in to building engineering problems and develop new methods as needed; be able to identify the most appropriate sources in the literature to obtain information on building engineering theory and methods; identify gaps in the scientific literature and contribute to them**	**Be able to apply and critically assess building codes, standards, and/or best practices to existing, heritage, and/or new buildings to safeguard the public interest and the natural and built environments**	**Be able to demonstrate and apply a system-level understanding of existing, heritage, and/or new buildings and be aware of the limits of engineering methods**	**Be able to conduct research using existing methods –or develop new methods- for engineering analysis using data and information from models and/or measurements from the built environment**	**Be able to synthesize and effectively communicate the state-of-the-art to peer researchers and/or stakeholders**	

BLDG 5701: Introduction to Building Engineering	Project report and/or assignments	Course involves at least one dataset, case study, or tour for each concentration area
BLDG 5702: Introduction to Research Methods	Project report and/or assignments	Course involves application of methods to case studies and field data
Building Engineering courses ~~Core courses~~ listed in Table B.2.2	Exam, project report, and/or assignments	Varies by course, but likely to include real building studies, hands-on use of tools and data, and/or field study/technical tour

Thesis	Data collection and analysis for the thesis project	Methods section of thesis	Results of thesis		Methods and results sections of thesis	Dissemination of thesis results through publications; at research meetings with peers, and/or public and private sector partners, conferences, and/symposia	Most projects will involve a case study, field data, experimental work, and/or a modelling study of a real building
Degree Level Expectations	Depth and breadth of knowledge; experiential learning	Research and scholarship	Level of application of knowledge; experiential learning	Awareness of limits of knowledge; experiential learning	Professional capacity/ autonomy; experiential learning	Level of communications skills; experiential learning	N/A

B.3. Program learning outcomes assessment plan

B.3.1 Program Assessment Committee

The Department of Civil and Environmental Engineering has a Graduate Learning Outcomes Committee which is responsible for collecting LO data from graduate courses and activities in the Department and analysis of these data. One member from the core faculty members of the Building Engineering program will be added to the membership of this committee.

B.3.2 Program Assessment Methodology

Learning outcomes will be assessed using a number of sources of data. Each source of data will provide an indicator of the level of achievement for each learning outcome, using a four-point rubric (i.e., does not meet, minimally meets, meets, exceeds). Assessments may include:

- Assessment of student deliverables, such as course assignments, course exams, course project reports, thesis proposal, and thesis dissertation.
- Student self-evaluation via surveys
- Faculty evaluation based on oral thesis defenses for MASc and PhD students.
- Course instructor evaluations based on course work
- Focus groups with students and/or faculty members

The Graduate Learning Outcomes Committee will provide a written report every three years to the Director of the Building Engineering Programs and the Department Chair regarding the program learning outcomes analysis. The Director and the Department Chair will provide direction and oversight to program changes and can use the outcomes of the program learning assessments for continual program improvement. Program changes are operationalized by the Director and the Department Chair.

As the program length of the PhD will be four years, the first assessment, which is scheduled to be conducted in the third year, will only have partial data for the PhD program; however, the assessment will still be conducted to provide early indicators for program improvements.

B.4. Program essential requirements

Requirements essential for a student's success in completing the program include:

- A good foundation in at least one area relevant to building engineering. The program welcomes applicants from a wide variety of academic backgrounds, such as engineering, architecture, and computer science, but additional courses may be required. Capacity to conduct systematic research, including the ability to integrate and critique the literature related to their field of research.
- Capacity and commitment to learning, including independent learning and lifelong learning; this includes a willingness for learning outside their original field of expertise.
- Capacity to effectively communicate scientific ideas (e.g., methodology, results, conclusions) to a multidisciplinary audience.
- Intrinsic motivation and responsibility, including internal accountability, in organizing their work and fulfilling the obligations related to the program.

- Behavior consistent with academic integrity and the use of procedures for responsible, safe, and ethical conduct of research.

Program essential requirements are defined by the Ontario Human Rights Commission as "the knowledge and skills that must be acquired or demonstrated in order for a student to successfully meet the learning objectives of that… program." The program essential requirements are components that contribute to the achievement of the learning outcomes of the program.

Excerpt from the Ontario Human Rights Commission report: The opportunity to succeed: Achieving barrier-free education for students with disabilities - Post-secondary education

Appropriate accommodations should not lead to lowered standards or outcomes: rather, an appropriate accommodation will enable the student to successfully meet the essential requirements of the program, with no alteration in standards or outcomes, although the manner in which the student demonstrates mastery, knowledge and skills may be altered.

The aim of accommodation in a post-secondary educational context is to provide equal opportunities to all students to enjoy the same level of benefits and privileges and meet the requirements for acquiring an education. Based on these principles, an accommodation will be considered appropriate where it will result in equal opportunity to attain the same level of performance, or enjoy the same level of benefits and privileges experienced by others, or if it is proposed or adopted for the purpose of achieving equal opportunity and meets the individual's disability-related needs. - See more at: http://www.ohrc.on.ca/en/opportunity-succeed-achieving-barrier-free-education-students-disabilities

Paul Menton Centre

The Paul Menton Centre is responsible for assessing requests for academic accommodation of students with disabilities through evaluations that are carried out on an individual basis, in accordance with human rights legislation and University policy, and with the support of relevant, professional/medical documentation. Students will only receive academic accommodation if the functional limitations of their disability impact directly on their academic performance.

C. Governance

The Building Engineering Graduate programs will be administered by the Department of Civil and Environmental Engineering. The Director for the Building Engineering Graduate programs will be appointed by the Chair of the Civil and Environmental Engineering Department from among the faculty members of the Building Engineering programs. The Director, in collaboration with the Department Associate Chair of Graduate Studies, sets annual targets for intake of new students into the program. The Director also liaises with the Associate Chair of Graduate Studies, and other faculty members during the admissions process to ensure such targets are met. The Director is responsible for convening meetings as necessary to review and renew the graduate curriculum to update the list of courses as necessary and decide which courses are to be offered each year. The Director assists the Associate Chair

of Graduate Studies, in consultation with the student's Supervisor, in monitoring the progress of each student through the program and ensuring that all necessary courses are taken. The Director also assists the Associate Chair of Graduate Studies in ensuring the accuracy and completeness of each students' academic audit on an annual basis, or whenever necessary to enable graduation.

The Building Engineering Graduate Program Committee consists of the core faculty members of the Programs in addition to other faculty in the Department of Civil and Environmental Engineering who supervise in the proposed program in a particular year. The committee makes decisions on matters regarding the programs, including curriculum changes, and articulates the vision for the programs. These decisions are then raised to the Department of Civil and Environmental Engineering for review and approval.

The Director for the Building Engineering Graduate programs is also responsible for all Quality Assurance requirements and activities and will be the point of contact for the Office of the Vice-Provost and Associate Vice-President (Academic) about these programs on Quality Assurance maters.

The Graduate Administrator is a full-time permanent staff position in the Department of Civil and Environmental Engineering. The Graduate Administrator carries out all administrative tasks associated with running the graduate programs, including liaising with FGPA regarding financial offers to students, ensuring that students payroll profiles are up to date, assisting students with registration as needed, and scheduling courses, thesis Graduate Advisory Committee meetings, mid-program reviews, thesis defences, and other events related to graduate studies in the Department. The Graduate Administrator is normally the first point of contact for students needing information regarding their status, funding, enrollments, and audits. Based on current and historical trends, the additional work of administering the Building Engineering programs falls well within capacity of the Graduate Administrator's office.

D. The Faculty

D.1. Faculty appointed to the unit or program

This program provides students with the opportunity to study within a first-class engineering faculty as well as be enriched by the program's close association with Carleton's well-known Azrieli School of Architecture & Urbanism. Faculty within the Department of Civil and Environmental Engineering have a strong record of research excellence, demonstrated by various indicators such as research publications, grants, community engagement and knowledge dissemination activities. This interdisciplinary program combines the teaching and research expertise from several areas: heritage conservation, energy management, building science, control, optimization and fire dynamics. The following sections describes the proposed faculty supporting the program, research funding, thesis supervision, present teaching assignments and utilization of contract instructors.

D.2. Faculty supporting the program

The core faculty includes one full professor, four associate professors, and ~~two~~ three tenure-track assistant professors. Table D1 lists all faculty associated with the department of Civil and Environmental Engineering who are authorized to supervise students in the proposed graduate research programs.

Table D1. Core Faculty

Name	Rank *	M/F	Appt Status	% Appt	Other Units	Supervision **	Adjunct Position(s)	Specializations
Scott Bucking	AC	M	Tenure Track	50/50/0	ARCH/MAE	D	Mechanical Engineering (McMaster University)	energy optimization communities
Burak Gunay	AS	M	Tenure Track	100	--	CD		building operations and control
George Hadjisophocleous	FP	M	Tenured	100	--	D	Visiting Professor, European University of Cyprus	Fire/smoke modelling; fire code, fire risk analysis, fire performance of combustible construction
Hamzeh Hajiloo	AS	M	Tenure Track	100	--	CD		Structural engineering; fire resistance, sustainable construction
Liam O'Brien	AC	M	Tenured	100/0	MAE	D	Mechanical and Industrial Engineering (University of Toronto)	Occupant behaviour, building performance simulation, building operations and controls, daylighting, passive and active solar systems
Bora Pulatsu* **	AS	M	Tenure Track	100		CD		Structural assessment of historical buildings
Mario Santana Quintero	AC	M	Tenured	100/0	ARCH	D	University of Leuven (Belgium)	Conservation, documentation, world heritage, historic places
Ehab Zalok	AC	M	Tenured	100	--	D		Structural fire safety; fire dynamics; behaviour of materials under fire conditions.

*AS=Assistant Professor; AC=Associate Professor; FP=Full Professor; **D=full privileges; M=full privileges at master's level only; CD=co-supervision privileges at doctoral level, full privileges at master's level; ***** Starting July 1, 2021**

D.3. Faculty research funding

All grants are shown in the year they were awarded and include in-kind contributions from industry partners.
Table D.2 shows the present operating budget of faculty research funding.

Table D2. Operating Researching Funding by Source and Year as of December 31, 2018

	Funding Source				
Year	**Canadian**	**Internal (Carleton)**	**International**	**Tri-agency**	**Grand Total**
2012-2013	$82,000	$0	$271,298	$373,000	**$726,298**
2013-2014	$94,580	$61,125	$50,156	$647,000	**$852,861**
2014-2015	$182,960	$0	$6,250	$741,700	**$930,910**
2015-2016	$2,124,860	$53,000	$25,008	$4,867,427	**$7,070,295**
2016-2017	$76,500	$7,000	$13,523	$828,000	**$925,023**
2017-2018	$495,950	$19,625	$29,513	$3,063,200	**$3,608,288**
2018-2019 (as of Dec. 31/2018)	$1,108,668	$21,625	$220,000	$525,000	**$1,875,293**
Total	**$4,165,5183,988,938**	**$162,375$101,250**	**$294,294615,748**	**$11,045,3270,025,327**	**$15,262,670988,968**

D.4. Distribution of thesis supervision

All proposed faculty play an active role in graduate student supervision. Students will be distributed among faculty members according to student interests, faculty funding availability, and faculty capacity. This distribution will not be centrally controlled;

thesis-based program students will require supervisor approval prior to enrollment (as is currently done across engineering graduate programs at Carleton). The primary faculty supervisors by student concentration for building performance, heritage conservation, and fire safety are: O'Brien, Bucking, Gunay; Santana; and Hadjisophocleous, Hajiloo, Zalok, respectively. However, co-supervisions between concentrations are expected (e.g., both Profs. Gunay and Bucking currently co-supervise students with Prof. Santana in the conservation area).

Core faculty members in CEE who presently supervise graduate students in the area of building engineering, currently supervise or co-supervise several students in other units and programs due to the lack of a proper program within the department that reflects these students' training and expertise. Table D.3 elaborates on current supervisory workloads for each faculty member supporting the program. These figures represent the minimum capacity of the faculty members; in several cases (e.g. Bucking, Gunay) the faculty members are junior and expected to have increased capacity in the coming years.

Table D3. Distribution of thesis supervision (as of December 31, 2018)

		Current				Past			
Faculty Name	**Rank**	**Undergrad**	**Master**	**PhD**	**PDF**	**Undergrad**	**Master**	**PhD**	**PDF**
Scott Bucking	AC	0	3.5	2.5	0.5	2	1	0	0
Burak Gunay	AS	1	1.5	1.5	1.5	0.5	0	0	0
George Hadjisophocleous	FP	0	3	2	0	3	33	12	1
Hamzeh Hajiloo	AS	0	0	0	0	0	0	0	0
Liam O'Brien	AC	0	1	3	1.5	15	4	4	1
Mario Santana	AC	1	5	1.5	2	3	17	3	1
Ehab Zalok	AC	0	2	2	1	3	15	0.5	2

Additional faculty may supervise students if approved by the graduate program committee. In particular, there are several faculty members- Stephen Fai (Architecture, and also cross-appointed with Civil and Environmental Engineering), Susan Ross (School of Indigenous and Canadian Studies), and Marianna Esponda (Architecture) – who could provide a supervisory role given that Mario Santana is currently the only professor assigned to the Heritage Conservation concentration. Note that at Year 3, a second professor is expected to be hired to further support this concentration. Additionally, three faculty members from the Department of Mechanical and Aerospace Engineering and who frequently co-supervise students with the Building Performance professors – Profs.

Ian Beausoleil-Morrison, Cynthia Cruickshank, and Jean Duquette – have confirmed availability and interest to (co-)supervise students in Building Engineering.

D.5 Current teaching assignments

The nominal teaching load for the core faculty is two undergraduate courses, one graduate course, and one set of supervisions for 4th year capstone engineering project. Faculty members who do not hold a P.Eng. license normally teach a third undergraduate course in place of the project supervision.

The past teaching assignments of the core faculty are summarized in Table D4. Note that Prof. Hajiloo is new as of summer 2019 and has not yet taught courses. The graduate course teaching capacity of these core professors is approximately six per year (on the basis of one faculty member being on sabbatical for any given year and one graduate course per faculty member). To increase the number of graduate courses accessible to a student while in their program, at least three of the core faculty could offer two different graduate courses in alternating years to effectively double the offering. In addition, graduate courses could be offered by qualified contract instructors as needed and these will be funded through the department's ELBA. Table D.4 details faculty teaching assignments over past three years.

Table D4. Past Teaching Assignments

Name	Courses Taught	Credit Value	2019-2020	2018-2019	2017-2018	Notes
BUCKING, Scott	ARCC 2202 /ARCC 5096 - Architectural Technology I	0.5	x	x	x	
Associate Professor	ARCC 5098 - Architectural Technology 3	0.5	x	x	x	
	CIVE 2004 - GIS, Surveying, and Graphics	0.5		x	x	
	CIVE 4918 - Design Project	0.5	x	x	x	
	ECOR 1055 - Eng. Disciplines I	0	x			
	ENVE 4107 - Building Services Engineering	0.5	x			
	Total		**2.0**	**2.0**	**2.0**	
GUNAY, Burak	CIVE 3209 - Building Science	0.5	x	x	x	

Assistant Professor	CIVE 4918 - Design Project	0.5	x			
	CIVE 5707 - Topics in Structures	0.5	x	x	x	
	ENVE 4105 - Green Building Design	0.5	x	x	x	
	ENVE 4106/5104 - Indoor Environmental Quality	0.5			x	
	Total		**2.0**	**1.5**	**2.0**	
O'BRIEN, Liam	ECOR 4995 - Professional Practice	0.5	x			Sabbatical 2017-18
Associate Professor	ENVE 4106 - Indoor Environmental Quality	0.5	x	x		
	ENVE 4918 - Design Project	0.5	x	x		
	ENVE 5104 - Indoor Environmental Quality	0.5	x	x		
	ENVE 5704 - Topics in Environmental Engineering	0.5	x	x		
	Total*		2.0	2.0		
HADJISOPHOCLEOUS, George	CIVE 4918 - Design Project	0.5	xx			
Professor	CIVE 5609/IPIS 5504 - Fundamentals of Fire Safety	0.5	x	x	x	
	ECOR 3800 - Engineering Economics	0.5	x	x	x	
	Total		1.5	1.0	1.0	
HAJILOO, Hamzeh	ECOR 1053 - Fundamentals of Engineering III	0.5	x			
Assistant Professor	**Total**		0.5			
SANTANA QUINTERO, Mario	ARCN 4100/ CIVE 3207 - Historic Site Recording & Assess	0.5	x		x	
	ARCN 4200/ CIVE 4601 - Building Pathology & Rehabilitation	0.5	x		x	
	CIVE 4918 - Design Project	0.5	x		x	
	CIVE 5705 - Topics in Structures	0.5	x		x	
	Total		2.0		2.0	
ZALOK, Ehab	CIVE 4614 - Building Fire Safety	0.5	x	x	x	
	CIVE 4918 - Design Project	0.5	x	x	x	

	CIVE 5614 - Design for Fire Resistance	0.5		x		
	CIVE 5615 - Fire Behaviour of Materials	0.5	x		x	
	ECOR 1101 - Mechanics I	0.5	x	x	x	
	Total		2.0	2.0	2.0	
* ECOR4995 and ENVE4918 coordination are combined as equivalent to 0.5 teaching credits due to their relatively low workload						

Only one new course is to be added to the program from existing faculty. With the proposed hire of a new faculty, two new courses will be added to graduate programming. The new program will utilize several existing graduate courses from the department of Mechanical and Aerospace engineering, Azrieli School of Architecture & Urbanism, School of Indigenous and Canadian Studies program and the department of Civil and Environment engineering. Table D.5 shows the contribution in teaching from other faculty.

Table D5. Contribution of Faculty from other Carleton Units and Programs

BEAUSOLEIL-MORRISON, Ian	MAAE 2400 - Thermodynamics and Heat Transfer			x		
Professor	MAAE 3400 - Applied Thermodynamics				x	
	MAAE 4907 - Engineering Design Project			xx	xx	
	MECH 5205 - Building Performance Simulation			xx	x	
	SERG 5002 - Sustainable Energy Engineering Policy				x	
	SREE 4907 - Energy Engineering Project			xx		
	Total			**2.0**	**2.0**	
DUQUETTE, Jean	MAAE 4907 - Engineering Design Project	0.5	x	xx	xx	
Assistant Professor	MECH 4403 - Power Generation Systems	0.5	x	x	x	
	MECH 4408 - Thermofluids & Energy Syst. Des.	0.5		x	x	
	SERG 5002 - Sustainable Energy Engineering Policy	0.5	x	x		
	SREE 4001 - Efficient Energy Conversion	0.5	x	x	x	
	SREE 4907 - Energy Engineering Project	0.5	x	x		
	Total		2.5	3.0	2.0	

ROSS, Susan	CDNS 2400 - Heritage Conservation in Canada	0.5	x	x	x	
Associate Professor	CDNS 4400 - Cultural Landsc. & Cultural Ident.	0.5		x		
	CDNS 4403/5403 - HCON Sustainability	0.5	x		x	
	CDNS 5003 - Selected Topics	0.5			x	
	CDNS 5402 - Heritage Conserv II: Theory & Pract.	0.5	x	x	x	
	Total		1.5	1.5	2.0	

D.6. Contract instructors

Contract instructors will be relied upon, though are not essential, for offering courses that are complementary to those offered by the full-time faculty members. They may also be hired to teach courses when key faculty members are on sabbatical. Due to the government laboratories and thriving construction industry in Ottawa, there is a large supply of potential contract instructors with advanced degrees and complementary expertise and credentials to teach at the graduate level. Moreover, contract instructors can offer non-academic perspectives (e.g., government policy and practical issues). Some examples follow. A contract instructor, E. Dikel Ph.D., from NRC is expected to teach a *Daylighting* course starting in Winter 2020. The course introduces the lighting sources, variations and design implications. Daylighting is a common component to an architectural/building engineering curriculum. A contract instructor Yoon Ko Ph.D., from NRC will teach two fire dynamics courses: *Fire Dynamics I* and *Fire Dynamics II*. Sabah Ali Ph.D**.,** will teach *Wood Structures*. The *Fire and Practical Applications* course of Fire Safety Engineering will be taught by contract instructor Amer Al-Merabi.

E. Program Admission and Enrollment

E.1. Admissions requirements

Admission into the Building Engineering programs will be judged primarily on the applicant's potential to undertake research successfully (for all project/thesis-based degrees), completion of required and elective courses, and his/her prospects for completion of the program. Applicants to thesis-based programs (i.e., MASc, PhD) will submit a research proposal statement on applying to the program. The requirements for admission for the MEng and MASc programs will be to hold an undergraduate degree from an engineering or related program (deemed acceptable by the Director and supervisor(s)) with at least a B+ average. The requirements for admission for the PhD program will be to hold a master's degree from an engineering program with at least an A- average.

In the event that the Director deems applicants' educational background inadequate, students may be admitted on the condition that they take one or more courses to complete their Building Engineering degree program. The following courses (or equivalents, as evaluated by the Director) are required for admission into any of the programs (example Carleton course codes provided):

- Calculus I (MATH 1004)
- Linear Algebra I (MATH 1104)
- Thermodynamics and/or heat transfer (MAAE 2400)
- General or applied physics (e.g., statics or dynamics) (PHYS 1004))
- A course with a substantial technical computer and/or hand-drawing element (ECOR 1054, CIVE2004, CIVE3209)
- A course with at least an element of basic computer programming or demonstration of programming skills (ECOR 1051, ECOR1606, ECOR2606)

An exception to the general admission procedure for the PhD program will be the fast-tracking from MASc to PhD. Students enrolled in the MASc in Building Engineering program at Carleton University may be permitted to transfer into the PhD program without completing the master's program provided they meet the following conditions:

- Completion of 2.5 credits of master's courses with a minimum average of A-;
- Demonstration of exceptional research potential;
- Formal application for admission to the PhD program no later than the fourth semester of initial registration in the MASc program;
- Permission from the Director of the Building Engineering Programs.

The funding offer of the fast-tracking MASc students shall be re-evaluated and considered to the same level of departmental financial support that normal PhD applicants will be eligible for. An undergraduate and/or graduate degree in engineering will ensure a solid foundation to meet discipline specific & knowledge-based learning outcomes (LOs 1 to 5). University level requirements for language requirements for international students and research proposal statement will ensure the applicants meet LO 6 (Synthesize and effectively communicate the state-of-the-art to peer researchers and/or stakeholders). Applicants who do not meet the normal requirements for admission will be required to complete additional courses, extra to the normal program requirements. These courses will be recommended by the Director in consultation with the core faculty.

E.2. Class sizes and course and program capacity

Average class size is expected to be approximately 10 to 30 students, including MEng, MASc, and PhD program students enrolled in Building Engineering – and those who are taking Building Engineering courses from other engineering programs such as Civil, Environmental, and Mechanical Engineering. This will help reduce the possibility of cancellation of courses because of low enrolment. Further, at least two of the graduate courses will be piggybacked on an existing fourth-year undergraduate course: Indoor Environmental Quality and Building Services Engineering. These piggybacked classes will foster collaboration with senior undergraduate and graduate students such that undergraduate students will learn more about graduate research in the Building Engineering programs.

E.3. Projected enrolment

The projected enrolment over the next 5 years can be found in Table E3. At year five, this translates into the following steady-state enrollment levels:

- 20 PhD (10 domestic, 10 international, combined 4 years)
- 12 MASc (10 domestic, 2 international, combined 2 years)
- 20 MEng (4 domestic, 16 international, combined 2 years)

Table E3. Projected 5-year new registrations, based on above enrollment values

	Year 1	Year 2	Year 3	Year 4	Year 5
Domestic MEng	2	2	2	2	2
International MEng	8	8	8	8	8
Domestic MASc	4	4	5	5	5
International MASc	1	1	1	1	1
Domestic PhD	2	2	2	3	3

International PhD	1	2	2	3	3

The values in Table E3 are estimates based on the recent past and the expectation of growth as a result of the relatively junior profile of the core faculty, plus the potential for growth as a result of a program that better serves applicants. The six more established professors (i.e., excluding Prof. Hajiloo who just began at Carleton) currently supervise 23 MASc students and 15 PhD students. Among the current faculty, the more senior ones (associate and full professor) generally supervise more students, indicating significant potential for short-term (next 3-5 years) growth for the more recent hires. The new programs are also expected to cause a shift away from the significant number of students who are co-supervised in different departments, universities, or even provinces.

The current M.Eng. programs (Civil Eng. and Environmental Eng.) have 95 registered students in the Fall 2019 term and 81 in the Winter 2020 term. Over the past five years, the existing M.Eng. programs have received between 200 and 400 applicants per year (with an upward trend), 83% of whom are international, on average. A recent detailed analysis showed that the number of offers to these applicants could be greatly increased without sacrificing quality of student. These numbers do not include the potential growth as a result of the Building Engineering programs, which would distinguish Carleton from most universities, and also serve as a natural next step for students in related international programs such as architectural engineering and building physics.

The projected balance between international and domestic students for each program is based on historical averages for Carleton's Civil Engineering and Environmental Engineering graduate programs. The M.Eng. programs' applications and enrollment are predominantly from international students, while MASc student are largely recruited from Carleton or within Canada. At the PhD level, the numbers are more balanced, owing to a mix of domestic MASc students continuing with their supervisor and international students coming to Canada to pursue a PhD.

F. Student Experience and Satisfaction

F.1. Student orientation, advising, and mentoring

The home unit of the students is the Department of Civil and Environmental Engineering. Co-supervisors of the students may reside in other units, such as Department of Mechanical and Aerospace Engineering, School of Indigenous and Canadian Studies and the School of Architecture and Urban Planning.

Graduate student orientation will be delivered through the Faculty of Graduate Studies and Postdoctoral Affairs (FGPA). The Department of Civil and Environmental Engineering, overseen by the Associate Chair Graduate Studies, will also provide a department-specific graduate orientation for all new graduate students enrolled in the Building Engineering programs.

Each student in the MASc and PhD programs will have a supervisor who will advise them through their progress in the programs, and in their research activities. The students enrolled in the PhD program will have a Graduate Advisory Committee that will be chosen by the Supervisor, in consultation with the student, and signed off by the Graduate Supervisor. This committee will assess the student's progress, provide expert feedback on the project direction and results, and may play a general or supplementary role in advising the student on career goals. Normally this committee will form the Thesis Examination Committee (and Proposal Examination Committee in the case of PhD students). Each MEng student will be assigned to an Advisor who will serve provide feedback on courses selection, on an ad hoc basis.

There is an active intellectual community in building engineering, cross-cutting several departments, who run seminars, workshops, and other social events that bring together experts from across campus and beyond. Graduate students will participate in this community actively (ASHRAE Ottawa Valley Chapter, IBPSA Ottawa, Association for Preservation Technology (APT) Ottawa Chapter, the International Council of Monuments and Sites (ICOMOS) national committee of Canada, Building Performance Research Centre, SFPE Society of Fire Protection Engineers in the National Capital Region etc.).

Thus, the graduate students in the proposed program will find an active pre-existing community to join, and will enrich it through their diverse interests, backgrounds, and through sheer numbers. We expect the students to form a graduate student society, parallel to the existing societies in engineering. On the assumption that there will be a physical space, such as a graduate lounge and labs, where students can congregate and work, the graduate community in building engineering will be a tightly-knit and active one.

F.2. Career paths of graduates

There is an increasing demand for building engineering nation-wide, with approximately seven percent of Canadian workers in the construction industry. This demand has resulted in the creation of various employment opportunities in fields related to research, innovation, technology, and delivery. Previous graduates from the current faculty members are rapidly hired and currently hold positions as researchers in government labs, consulting, and professors.

A key objective of the Building Engineering programs is to provide students with the skills and knowledge (disciplinary and interdisciplinary) to make them highly marketable within the architecture, engineering, and construction (AEC) sector. Our students will be immersed in a culture of collaboration and inter-professional learning. These diverse interdisciplinary opportunities will allow students to develop the important professional skills that become the foundation for future career successes and life-long learning.

Career paths of graduates of the programs are anticipated to be diverse, given the interdisciplinary nature of the program and research performed in the Department of Civil and Environmental Engineering. Graduates from the programs will find jobs as retrofit engineers, energy modelers, building science engineers, indoor environmental quality engineers, sustainability experts, energy managers, energy systems auditors, building automation and controls engineers, fire safety engineers, data

analysts at utility service providers, and policy makers and researchers for government agencies (NRC, NRCan, PSPC, etc.). The programs will also prepare students for further study in AEC-related professions including doctoral programs, architecture, mechanical engineering, and other engineering branches. Graduates from the PhD program may move towards more research focused careers in public and private sectors, post-secondary institutions, industry (building sciences companies and manufacturing), non-governmental organizations (WHO, UNESCO, UNDP) and/or governmental agencies (Public Services and Procurement Canada, Heritage Conservation Services, Parliament Precinct Branch, etc.).

G. Resources

G.1. Support and technical staff

Professors Santana, Hadjisophocleous, Hajiloo, Zalok, O'Brien, Bucking, and Gunay are the primary faculty in the department with research and graduate students focused on building engineering. As of July 2021, an additional professor, Dr. Bora Palatsu, will serve the program. The current teaching load and capacity to teach graduate courses is described in Section D.1.

In order to address a current gap in expertise and to increase both graduate course offerings and supervisory capacity, an additional faculty position (assistant professor level) is planned for the third year of the program. The additional faculty position will be requested earlier if enrollment targets are met before the third year of the program. The proposed new faculty member's expertise would be in the retrofit and rehabilitation of existing buildings (particularly structures and/or envelope). The Dean of the Faculty of Engineering and Design has confirmed strong support for the proposed programs, including intent to fund an additional faculty position as described above. He acknowledges that the business plan projections for the proposed programs assume a new hire in year 3 if enrollment targets have been met. For this faculty hire and beyond, as for all hires, we are committed to the principles and policies of the Carleton University Equity, Diversity, and Inclusion Action Plan. As per all University hires, we will adhere to the Employment Equity Policy.

The department has sufficient administrative staff resources to handle the increase in students.

The existing Civil and Environmental Engineering laboratories staff – and particularly the technician who was added to the laboratories staff with the introduction of the undergraduate ACSE program - is able to accommodate the new program, and will be able to handle the administration of the new program. There are no additional support and technical staff required at launch.

G.2. Space

Thesis-based graduate students in Building Engineering will be provided shared office space managed by the Department of Civil and Environmental Engineering in one of three existing engineering buildings or in the Carleton Immersive Media Studio (CIMS) in the Visualization and Simulation Building. Students will be able to utilize software for which the university has a site license and will be able to access the electronic resources of the Carleton library. On the basis of typical graduate student workspaces and the projected enrollment, the Faculty of Engineering and Design has confirmed that 1320 sq. ft. of additional space will be provided to the Department of Civil and Environmental Engineering. In addition to the importance of space for thesis-based students, the shared nature of the space will facilitate knowledge

sharing and potential collaboration between concentrations. MEng students will not receive dedicated space for their studies, though they will for teaching assistant duties, if applicable.

Laboratory facilities

The current faculty members and graduate students in the Building Engineering-related research areas are reliant on laboratory facilities that are nominally allocated to Civil Engineering and Environmental Engineering. This includes a structural engineering lab and two environmental engineering laboratories. Additional research is performed off-site, e.g., in partnership with government laboratories or using an in-situ approach to study buildings.

G.3. Library Resources

An analysis of Carleton University Library's information resources and services in support of the program demonstrates that the Library does not require any additional funds to support it. This program does not require increased library holdings at launch. The library has subscriptions to the top journals related to this program, and many journals in these and related fields are now open access. The Report from the Library is included as **Appendix 4** of the self-study.

The Library report is prepared by the librarian or subject specialist responsible for the subject area(s) covered by the program, using a common template developed from guidelines established by the Ontario Council of University Libraries. The main purpose of the report is to specify whether any new resources or services are necessary in order to support the program, for example, whether the Library needs to purchase new books or subscribe to new journals or electronic resources.

The librarians and subject specialists preparing the reports rely on their own professional experience with collecting resources in the subject areas in order to make assessments about whether there are gaps in the collection that need to be filled in order to provide the appropriate teaching and research support for new, modified, or reviewed programs. They consult various sources for information about published resources in the subject area, including the database maintained by the Library's main monographs vendor, publishers' lists and websites, handbooks and guides to the literature, the library collections of universities that offer the program, various specialized sites relevant to the subject from professional societies and organizations, as well as basic information available in tools such as Google Scholar or generally on the web. They also generally consult faculty members (e.g., the Library representative or the department chair) to discuss their assessment of the strengths and gaps. The Library makes a clear distinction between those resources which are essential to the program and those which are simply "nice to have." Generally speaking, the reports list only the essential resources, with costing obtained from the vendors or agents from which the Library would obtain the materials: each item is listed and costed individually and the total amount is recorded in the report.

The report also provides context by providing information about the following, when possible or applicable: percentage of top-ranked journals which the Library subscribes to in the subject area(s); how much funds have been spent in the past fiscal year on e-resources, journals, and printed books in support of the subjects covered by the program; how much funds have been spent in the past 8 years on printed monographs for the program; specialized collections in archives, maps, data, and government

information; instruction, teaching, and practicums carried out by Library staff in the classroom or in the Library; highlights from the Library website (e.g., links for subject and course guides and to online tutorials); research partnerships between the Library and the department or program; research consultations; help desk visits; and selected detailed statistical information about the Library.

H. Development of the Self-Study

A Graduate Program Committee consisting of the following members developed the self-study.

- Liam O'Brien, Associate Professor (Lead), Civil and Environmental Engineering
- Mario Santana, Associate Professor, Civil and Environmental Engineering
- Scott Bucking, Assistant Professor, Civil and Environmental Engineering/Azrieli School of Architecture and Urbanism
- Burak Gunay, Assistant Professor, Civil and Environmental Engineering
- Paul Van Geel, Professor, Civil and Environmental Engineering
- George Hadjisophocleous, Professor, Civil and Environmental Engineering
- Ehab Zalok, Associate Professor, Civil and Environmental Engineering
- Hamzeh Hajiloo, Assistant Professor, Civil and Environmental Engineering
- Yasser Hassan, Professor and Chair, Civil and Environmental Engineering

This document was authored by the above professors.

The following provided advice and feedback in the process of developing the self-study:

- Sandra Bauer, Program Officer, FGPA
- Larry Kostiuk, Dean, FED
- Adrian Chan, Assistant Vice-President (Academic), OVPAVPA
- Robyn Green, Program Officer, QA (Academic), OVPAVPA
- Leslie MacDonald-Hicks, Program Officer, FGPA
- Patrice Smith, Dean, FGPA
- James Opp, Associate Dean (Programs), FGPA
- Andrea Thompson, Program Assessment Specialist, QA (Academic), OVPAVPA
- Sara Wills, Program Assessment Specialist, QA (Academic), OVPAVPA

Appendix 1. Proposed Calendar Program Descriptions

This section presents the requirements for programs in:

- M.A.Sc. Building Engineering
- M.A.Sc. Building Engineering with Concentration in Building Performance
- M.A.Sc. Building Engineering with Concentration in Fire Safety
- M.A.Sc. Building Engineering with Concentration in Heritage Conservation
- M.Eng. Building Engineering
- M.Eng. Building Engineering with Concentration in Building Performance
- M.Eng. Building Engineering with Concentration in Fire Safety
- M.Eng. Building Engineering with Concentration in Heritage Conservation
- Ph.D. Building Engineering
- Ph.D. Building Engineering with Concentration in Building Performance
- Ph.D. Building Engineering with Concentration in Fire Safety
- Ph.D. Building Engineering with Concentration in Heritage Conservation

M.A.Sc. Building Engineering (5.0 credits)

Requirements:		
1. 0.5 credit in:		0.5
BLDG 5701 [0.0]	Introduction to Building Engineering	
2. 1.0 credit from the following list. Other courses may be used, with Supervisor recommendation and Director approval.		1.0
ARCN 5100 [0.5]	Representation and Documentation in Architectural Conservation	
ARCC 5401 [0.5]	Workshop: Technical Studies in Heritage Conservation	
BLDG 5107 [0.0]	Building Services Engineering	
BLDG 5704 [0.0]	Advanced Research Methods for Building Engineering	
BLDG 5705 [0.0]	Advanced Building Characterization, Conservation and Rehabilitation Heritage	
CDNS 5403 [0.5]	Heritage Conservation and Sustainability	
CIVE 5609 [0.5]	Fundamentals of Fire Safety Engineering	
CIVE 5610 [0.5]	Fire Dynamics I	
CIVE 5612 [0.5]	Fire Modeling	
CIVE 5613 [0.5]	Fire Dynamics II	
CIVE 5614 [0.5]	Design for Fire Resistance	
CIVE 5615 [0.5]	Fire Behaviour of Materials	
ENVE 5104 [0.5]	Indoor Environmental Quality	
MECH 5205 [0.5]	Building Performance Simulation	
3. 1.0 credit in approved electives		1.0

4. 2.5 credits in:		2.5
BLDG 5909 [0.0]	M.A.Sc. Thesis (in the area of the concentration)	
Total Credits		5.0

M.A.Sc. Building Engineering
with Concentration in Building Performance (5.0 credits)

Requirements:

1. 0.5 credit in:		0.5
BLDG 5701 [0.0]	Introduction to Building Engineering	
2. 1.5 credits in the concentration, from the following list. Other courses may be used, with Supervisor recommendation and Director approval.		1.5
BLDG 5107 [0.0]	Building Services Engineering	
BLDG 5704 [0.0]	Advanced Research Methods for Building Engineering	
BLDG 5707 [0.0]	Building Energy Management and Optimization	
ENVE 5104 [0.5]	Indoor Environmental Quality	
MECH 5205 [0.5]	Building Performance Simulation	
3. 0.5 credit in approved electives		0.5
4. 2.5 credits in:		2.5
BLDG 5909 [0.0]	M.A.Sc. Thesis (in the area of the concentration)	
Total Credits		5.0

M.A.Sc. Building Engineering
with Concentration in Fire Safety (5.0 credits)

Requirements:

1. 0.5 credit in:		0.5
BLDG 5701 [0.0]	Introduction to Building Engineering	
2. 1.5 credits in the concentration, from the following list. Other courses may be used, with Supervisor recommendation and Director approval.		1.5
CIVE 5609 [0.5]	Fundamentals of Fire Safety Engineering	
CIVE 5610 [0.5]	Fire Dynamics I	
CIVE 5612 [0.5]	Fire Modeling	
CIVE 5613 [0.5]	Fire Dynamics II	
CIVE 5614 [0.5]	Design for Fire Resistance	
CIVE 5615 [0.5]	Fire Behaviour of Materials	
3. 0.5 credit in approved electives		0.5
4. 2.5 credits in:		2.5
BLDG 5909 [0.0]	M.A.Sc. Thesis (in the area of the concentration)	
Total Credits		5.0

M.A.Sc. Building Engineering
with Concentration in Heritage Conservation (5.0 credits)

Course List		
Requirements:		
1. 0.5 credit in:		0.5
BLDG 5701 [0.0]	Introduction to Building Engineering	
2. 1.5 credits in the concentration, from the following list. Other courses may be used, with Supervisor recommendation and Director approval.		1.5
ARCN 5100 [0.5]	Representation and Documentation in Architectural Conservation	
ARCC 5401 [0.5]	Workshop: Technical Studies in Heritage Conservation	
BLDG 5704 [0.0]	Advanced Research Methods for Building Engineering	
BLDG 5705 [0.0]	Advanced Building Characterization, Conservation and Rehabilitation Heritage	
CDNS 5403 [0.5]	Heritage Conservation and Sustainability	
CIVE 5609 [0.5]	Fundamentals of Fire Safety Engineering	
3. 0.5 credit in approved electives		0.5
4. 2.5 credits in:		2.5
BLDG 5909 [0.0]	M.A.Sc. Thesis (in the area of the concentration)	
Total Credits		5.0

M.Eng. Building Engineering (5.0 credits)

Requirements - Coursework pathway:		
1. 1.0 credit in:		1.0
BLDG 5701 [0.0]	Introduction to Building Engineering	
BLDG 5702 [0.0]	Introduction to Research Methods	
2. 0.5 credit from Building Performance concentration courses:		0.5
BLDG 5107 [0.0]	Building Services Engineering	
BLDG 5704 [0.0]	Advanced Research Methods for Building Engineering	
BLDG 5707 [0.0]	Building Energy Management and Optimization	
ENVE 5104 [0.5]	Indoor Environmental Quality	
MECH 5205 [0.5]	Building Performance Simulation	
3. 0.5 credit from Fire Safety concentration courses:		0.5
CIVE 5609 [0.5]	Fundamentals of Fire Safety Engineering	
CIVE 5610 [0.5]	Fire Dynamics I	
CIVE 5612 [0.5]	Fire Modeling	
CIVE 5613 [0.5]	Fire Dynamics II	
CIVE 5614 [0.5]	Design for Fire Resistance	

CIVE 5615 [0.5]	Fire Behaviour of Materials	
4. 0.5 credit from Heritage Conservation concentration courses:		0.5
ARCN 5100 [0.5]	Representation and Documentation in Architectural Conservation	
ARCC 5401 [0.5]	Workshop: Technical Studies in Heritage Conservation	
BLDG 5704 [0.0]	Advanced Research Methods for Building Engineering	
BLDG 5705 [0.0]	Advanced Building Characterization, Conservation and Rehabilitation Heritage	
CDNS 5403 [0.5]	Heritage Conservation and Sustainability	
CIVE 5609 [0.5]	Fundamentals of Fire Safety Engineering	
5. 1.0 credit in additional concentration courses, not already used to fulfil Items 2-4 above		1.0
6. 1.5 credits in approved electives		1.5
Total Credits		5.0

Requirements - Project pathway:

1. 1.0 credit in:		1.0
BLDG 5701 [0.0]	Introduction to Building Engineering	
BLDG 5702 [0.0]	Introduction to Research Methods	
2. 2.0 credits from the following list. Other courses may be used, with Supervisor recommendation and Director approval.		2.0
ARCN 5100 [0.5]	Representation and Documentation in Architectural Conservation	
ARCC 5401 [0.5]	Workshop: Technical Studies in Heritage Conservation	
BLDG 5107 [0.0]	Building Services Engineering	
BLDG 5704 [0.0]	Advanced Research Methods for Building Engineering	
BLDG 5705 [0.0]	Advanced Building Characterization, Conservation and Rehabilitation Heritage	
CDNS 5403 [0.5]	Heritage Conservation and Sustainability	
CIVE 5609 [0.5]	Fundamentals of Fire Safety Engineering	
CIVE 5610 [0.5]	Fire Dynamics I	
CIVE 5612 [0.5]	Fire Modeling	
CIVE 5613 [0.5]	Fire Dynamics II	
CIVE 5614 [0.5]	Design for Fire Resistance	
CIVE 5609 [0.5]	Fundamentals of Fire Safety Engineering	
ENVE 5104 [0.5]	Indoor Environmental Quality	
MECH 5205 [0.5]	Building Performance Simulation	
3. 1.0 credits in approved electives		1.0
4. 1.0 credit in:		1.0
BLDG 5900 [0.0]	M.Eng. Project	
Total Credits		5.0

M.Eng. Building Engineering
with Concentration in Building Performance (5.0 credits)

Requirements - Coursework pathway:

1. 1.0 credit in:		1.0
BLDG 5701 [0.0]	Introduction to Building Engineering	
BLDG 5702 [0.0]	Introduction to Research Methods	
2. 2.0 credits in the concentration, from the following list. Other courses may be used, with Supervisor recommendation and Director approval.		2.0
BLDG 5107 [0.0]	Building Services Engineering	
BLDG 5704 [0.0]	Advanced Research Methods for Building Engineering	
BLDG 5707 [0.0]	Building Energy Management and Optimization	
ENVE 5104 [0.5]	Indoor Environmental Quality	
MECH 5205 [0.5]	Building Performance Simulation	
3. 2.0 credits in approved electives		2.0
Total Credits		5.0

Requirements - Project pathway:

1. 1.0 credit in:		1.0
BLDG 5701 [0.0]	Introduction to Building Engineering	
BLDG 5702 [0.0]	Introduction to Research Methods	
2. 2.0 credits in the concentration, from the following list. Other courses may be used, with Supervisor recommendation and Director approval.		2.0
BLDG 5107 [0.0]	Building Services Engineering	
BLDG 5704 [0.0]	Advanced Research Methods for Building Engineering	
BLDG 5707 [0.0]	Building Energy Management and Optimization	
ENVE 5104 [0.5]	Indoor Environmental Quality	
MECH 5205 [0.5]	Building Performance Simulation	
3. 1.0 credits in approved electives		1.0
4. 1.0 credit in:		1.0
BLDG 5900 [0.0]	M.Eng. Project	
Total Credits		5.0

M.Eng. Building Engineering
with Concentration in Fire Safety (5.0 credits)

Requirements - Coursework pathway:

1. 1.0 credit in:		1.0
BLDG 5701 [0.0]	Introduction to Building Engineering	
BLDG 5702 [0.0]	Introduction to Research Methods	
2. 2.0 credits in the concentration, from the following list. Other courses may be used, with Supervisor recommendation and Director approval.		2.0
CIVE 5609 [0.5]	Fundamentals of Fire Safety Engineering	

CIVE 5610 [0.5]	Fire Dynamics I	
CIVE 5612 [0.5]	Fire Modeling	
CIVE 5613 [0.5]	Fire Dynamics II	
CIVE 5614 [0.5]	Design for Fire Resistance	
CIVE 5615 [0.5]	Fire Behaviour of Materials	
3. 2.0 credits in approved electives		2.0
Total Credits		5.0

Requirements - Project pathway:

1. 1.0 credit in:		1.0
BLDG 5701 [0.0]	Introduction to Building Engineering	
BLDG 5702 [0.0]	Introduction to Research Methods	
2. 2.0 credits in the concentration, from the following list. Other courses may be used, with Supervisor recommendation and Director approval.		2.0
CIVE 5609 [0.5]	Fundamentals of Fire Safety Engineering	
CIVE 5610 [0.5]	Fire Dynamics I	
CIVE 5612 [0.5]	Fire Modeling	
CIVE 5613 [0.5]	Fire Dynamics II	
CIVE 5614 [0.5]	Design for Fire Resistance	
CIVE 5615 [0.5]	Fire Behaviour of Materials	
3. 1.0 credits in approved electives		1.0
4. 1.0 credit in:		1.0
BLDG 5900 [0.0]	M.Eng. Project	
Total Credits		5.0

M.Eng. Building Engineering
with Concentration in Heritage Conservation (5.0 credits)

Requirements - Coursework pathway:

1. 1.0 credit in:		1.0
BLDG 5701 [0.0]	Introduction to Building Engineering	
BLDG 5702 [0.0]	Introduction to Research Methods	
2. 2.0 credits in the concentration, from the following list. Other courses may be used, with Supervisor recommendation and Director approval.		2.0
ARCN 5100 [0.5]	Representation and Documentation in Architectural Conservation	
ARCC 5401 [0.5]	Workshop: Technical Studies in Heritage Conservation	
BLDG 5704 [0.0]	Advanced Research ~~Research~~ Methods for Building Engineering	
BLDG 5705 [0.0]	Advanced Building Characterization, Conservation and Rehabilitation Heritage	
CDNS 5403 [0.5]	Heritage Conservation and Sustainability	

3. 2.0 credits in approved electives		2.0
Total Credits		5.0

Requirements - Project pathway:

1. 1.0 credit in:		1.0
BLDG 5701 [0.0]	Introduction to Building Engineering	
BLDG 5702 [0.0]	Introduction to Research Methods	
2. 2.0 credits in the concentration, from the following list. Other courses may be used, with Supervisor recommendation and Director approval.		2.0
ARCN 5100 [0.5]	Representation and Documentation in Architectural Conservation	
ARCC 5401 [0.5]	Workshop: Technical Studies in Heritage Conservation	
BLDG 5704 [0.0]	Advanced Research Methods for Building Engineering	
BLDG 5705 [0.0]	Advanced Building Characterization, Conservation and Rehabilitation Heritage	
CDNS 5403 [0.5]	Heritage Conservation and Sustainability	
3. 1.0 credits in approved electives		1.0
4. 1.0 credit in:		1.0
BLDG 5900 [0.0]	M.Eng. Project	
Total Credits		5.0

Ph.D. Building Engineering (10.0 credits)

Requirements:

1. 0.5 credit in:		0.5
BLDG 5701 [0.0]	Introduction to Building Engineering	
2. 1.0 credit from the following list. Other courses may be used, with Supervisor recommendation and Director approval.		1.0
ARCN 5100 [0.5]	Representation and Documentation in Architectural Conservation	
ARCC 5401 [0.5]	Workshop: Technical Studies in Heritage Conservation	
BLDG 5107 [0.0]	Building Services Engineering	
BLDG 5704 [0.0]	Advanced Research Methods for Building Engineering	
BLDG 5705 [0.0]	Advanced Building Characterization, Conservation and Rehabilitation Heritage	
CDNS 5403 [0.5]	Heritage Conservation and Sustainability	
CIVE 5609 [0.5]	Fundamentals of Fire Safety Engineering	
CIVE 5610 [0.5]	Fire Dynamics I	
CIVE 5612 [0.5]	Fire Modeling	
CIVE 5613 [0.5]	Fire Dynamics II	
CIVE 5614 [0.5]	Design for Fire Resistance	
CIVE 5615 [0.5]	Fire Behaviour of Materials	

ENVE 5104 [0.5]	Indoor Environmental Quality	
MECH 5205 [0.5]	Building Performance Simulation	
3. 0.5 credit in:		0.5
BLDG 6901 [0.0]	Thesis Proposal	
4. 8.0 credits in:		8.0
BLDG 6909 [0.0]	Ph.D. Thesis	
Total Credits		10.0

Ph.D. Building Engineering
with Concentration in Building Performance (10.0 credits)

Requirements:		
1. 0.5 credit in:		0.5
BLDG 5701 [0.0]	Introduction to Building Engineering	
2. 1.0 credit in the concentration, from the following list. Other courses may be used, with Supervisor recommendation and Director approval.		1.0
BLDG 5107 [0.0]	Building Services Engineering	
BLDG 5704 [0.0]	Advanced Research Methods for Building Engineering	
BLDG 5707 [0.0]	Building Energy Management and Optimization	
ENVE 5104 [0.5]	Indoor Environmental Quality	
MECH 5205 [0.5]	Building Performance Simulation	
3. 0.5 credit in:		0.5
BLDG 6901 [0.0]	Thesis Proposal (in the area of the concentration)	
4. 8.0 credits in:		8.0
BLDG 6909 [0.0]	Ph.D. Thesis (in the area of the concentration)	
Total Credits		10.0

Ph.D. Building Engineering
with Concentration in Fire Safety (10.0 credits)

Requirements:		
1. 0.5 credit in:		0.5
BLDG 5701 [0.0]	Introduction to Building Engineering	
2. 1.0 credit in the concentration, from the following list. Other courses may be used, with Supervisor recommendation and Director approval.		1.0
CIVE 5609 [0.5]	Fundamentals of Fire Safety Engineering	
CIVE 5610 [0.5]	Fire Dynamics I	
CIVE 5612 [0.5]	Fire Modeling	
CIVE 5613 [0.5]	Fire Dynamics II	
CIVE 5614 [0.5]	Design for Fire Resistance	

CIVE 5615 [0.5]	Fire Behaviour of Materials	
3. 0.5 credit in:		0.5
BLDG 6901 [0.0]	Thesis Proposal (in the area of the concentration)	
4. 8.0 credits in:		8.0
BLDG 6909 [0.0]	Ph.D. Thesis (in the area of the concentration)	
Total Credits		10.0

Ph.D. Building Engineering
with Concentration in Heritage Conservation (10.0 credits)

Requirements:		
1. 0.5 credit in:		0.5
BLDG 5701 [0.0]	Introduction to Building Engineering	
2. 1.0 credit in the concentration, from the following list. Other courses may be used, with Supervisor recommendation and Director approval.		1.0
ARCN 5100 [0.5]	Representation and Documentation in Architectural Conservation	
ARCC 5401 [0.5]	Workshop: Technical Studies in Heritage Conservation	
BLDG 5704 [0.0]	Advanced Research Methods for Building Engineering	
BLDG 5705 [0.0]	Advanced Building Characterization, Conservation and Rehabilitation Heritage	
CDNS 5403 [0.5]	Heritage Conservation and Sustainability	
3. 0.5 credit in:		0.5
BLDG 6901 [0.0]	Thesis Proposal (in the area of the concentration)	
4. 8.0 credits in:		8.0
BLDG 6909 [0.0]	Ph.D. Thesis (in the area of the concentration)	
Total Credits		10.0

Appendix 2. Proposed Calendar Copy – Course Descriptions

Building Engineering (BLDG) Courses

BLDG 5107 [0.5 credit]
Building Services Engineering
This course provides details on how buildings are designed and operated. The materials provide foundational knowledge to understand building services: mechanical, electrical, plumbing systems with associated controls.
Also offered at the undergraduate level, with different requirements, as ENVE 4107, for which additional credit is precluded.

BLDG 5701 [0.5 credit]
Introduction to Building Engineering
Broad introductory and multi-disciplinary coverage of building engineering, with particular emphasis on building performance, heritage conservation, fire safety, and structures. Core competencies including research skills, communication of building engineering topics. Advanced methods for building design and restoration in the architectural, engineering, and construction field.

BLDG 5702 [0.5 credit]
Introduction to Research Methods
Broad introduction to theory and application of research methods in engineering. Key areas include conducting literature reviews; field, laboratory, and computational techniques; and designing, conducting, and presenting research.

BLDG 5704 [0.5 credit]
Advanced Research Methods in Building Engineering
Broad set of technical and non-technical research skills to design, conduct, and publish research focused on building engineering. Key areas: defining research problems; literature reviews; methods to conduct research; inferential statistics; measurement and error analysis; design of experiments; presenting and publishing in scientific venues.

BLDG 5705 [0.5 credit]
Advanced Building Characterization, Conservation and Rehabilitation Heritage
Supporting concepts and techniques for the identification, documentation, and conservation of heritage and existing buildings; advanced workshops by experts from key disciplines and practice areas in heritage conservation.

BLDG 5707 [0.5 credit]
Building Energy Management and Optimization
Fault detection and diagnostics; preventive and predictive maintenance; predictive and adaptive control of indoor climate; advanced sensing technologies for the built environment;

analysis and modelling using data from buildings; data mining; linear and generalized linear models; optimization methods; model selection and validation; inverse modelling.
Also listed as CIVE 5603.

BLDG 5900 [1.0 credit]
M.Eng. Project

BLDG 5909 [2.5 credits]
M.A. Sc. Thesis

BLDG 6901 [0.5 credit]
Thesis Proposal

BLDG 6909 [8.0 credits]
Ph.D. Thesis

Appendix 3. Proposed Calendar Copy – Admission Requirements

M.A.Sc. and M.Eng.

The normal requirement for admission to the M.A.Sc. and M.Eng. in Building Engineering is a bachelor's degree in an engineering or related program, with at least a B+ average. Applicants to the M.A.Sc. are required to include a research proposal statement.

Ph.D.

The normal requirement for admission to the Ph.D. Building Engineering is a master's degree in an engineering or related program, with at least a A- average. Applicants are required to include a research proposal statement.

Students registered in the M.A.Sc. Building Engineering program at Carleton University may be permitted to transfer into the Ph.D. program without completing the master's program, provided they meet the following conditions:

- completion of 2.5 credits of master's-level courses with a minimum average of A-,
- demonstration of exceptional research potential,
- formal application for admission to the PhD program no later than the fourth semester of initial registration in the M.A.Sc. program, and
- permission from the Director of the Building Engineering programs.

Appendix 4. Library Report

Institutional Quality Assurance Process

New Program Not Requiring a Library Report

Date: May 17th, 2018

From: Susan Tudin, Research Support Services

To: Lorraine Dyke, Vice-Provost and Associate Vice-President (Academic)

cc Matthias Neufang, Dean of Graduate Studies and Postdoctoral Affairs
Fred Afagh, Dean of Engineering and Design
Paul van Geel, Chair of Civil and Environmental Engineering
Christina Noja, Manager, Office of the Vice-Provost and Associate Vice-President (Academic)
Sandra Bauer, Program Officer, Graduate Studies and Postdoctoral Affairs
Wayne Jones, University Librarian
George Duimovich, Associate University Librarian (Collections and Technology)
David Sharp, Head of Collection Development and Acquisitions
Laura Newton Miller, Assessment Librarian

Recommendation

After review of Carleton University Library's information resources and services, no additional Library resources are required and so no report from the Library is necessary for the QA process for the new programs:

M.A.Sc, M. Eng, and Ph.D in Building Engineering

This is a formal notification for your records.

Carleton UNIVERSITY
Canada's Capital University

Office of the Vice-Provost and
Associate Vice-President (Academic)

Institutional Quality Assurance Process

Master's and Ph.D. in Building Engineering

Volume 2

Protected when completed

Professor Scott Bucking

Correspondence language: English
Sex: Male
Date of Birth: 4/09
Country of Citizenship: Canada, Netherlands

Contact Information

The primary information is denoted by (*)

Address

Primary Affiliation (*)

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1125 Colonel By Drive
Ottawa Ontario K1S5B6
Canada

Telephone

Work (*)	613-520-2600 extension: 3099

Email

Work (*)	scott.bucking@carleton.ca

Professor Scott Bucking

Language Skills

Language	Read	Write	Speak	Understand	Peer Review
English	Yes	Yes	Yes	Yes	Yes

Degrees

Post-doctorate, Mechanical Engineering, McMaster University

Supervisors: James S. Cotton, 2013/11 - 2015/7

2009/1 - 2013/11 — Doctorate, Building Engineering, Concordia University
Degree Status: Completed

Supervisors: Radu Zmeureanu, 2009/1 - 2013/11; Andreas Athienitis, 2009/1 - 2013/11

2007/5 - 2008/5 — Master's non-Thesis, Building Engineering, Concordia University
Degree Status: Completed

2000/9 - 2004/5 — Bachelor's, Engineering Physics, Carleton University
Degree Status: Completed

Recognitions

2015/6 — 2014 Technical Paper Award for a paper title: "Multi-Objective Optimal Design of a Near Net-Zero Energy Solar House"
ASHRAE
Prize / Award
Best paper presented at an ASHRAE Technical Paper Session

2014/10 — Guest speaker at APEC meeting on Net-Zero Energy Communities
Asia Pacific Economic Cooperation
Honor
Invited as an International expert for Expert Group on Energy Efficiency and Conservation

2014/8 — Governor General’s Academic Gold medal nomination
Concordia University
Distinction
The nomination was based on the highest cumulative GPA, research excellence and contributions to the public domain for the 2014 Graduating class at Concordia University

2013/5 — Best speaker award for a conference paper presented at McMaster University at the NSERC Next Generation Solar - Solar Photovoltaics Canada National Scientific Conference
NSERC Photovoltaic Innovation Network
Prize / Award
First place award in HQP Research Talk Competition

User Profile

Fields of Application: Environment, Economic Policies, Energy

Areas of Research: Solar and Wind Energy, Construction Technologies

Research Specialization Keywords: energy storage, optimization

Research Disciplines: Mechanical Engineering, Computer Engineering and Software Engineering

Employment

2019/5	Associate Professor in Civil Engineering and Architecture Civil and Environmental Engineering, Ottawa, Carleton University Full-time, Associate Professor Tenure Status: Tenure, 2019/1 - Cross appointed between Civil and Architecture, this strategic positions focuses on integration of building information models (BIM) into university curriculum. Teaching responsibilities are 50% between engineering and architecture.
2015/7 - 2019/5	Assistant Professor in Civil Engineering and Architecture Civil and Environmental Engineering, Engineering, Carleton University Full-time, Term, Assistant Professor Tenure Status: Tenure Track Cross appointed between Civil and Architecture, this strategic positions focuses on integration of building information models (BIM) into university curriculum. Teaching responsibilities are 50% between engineering and architecture. Expected to run a world-class engineering research program.
2013/9 - 2015/7	Building Engineering Team Lead S2E Technology Coordinated a team of ten researchers and personnel as the building engineering team lead. Conducted optimization studies of building and district energy systems using energy and cost objective functions. Advised fifteen EnergyPlus modellers exploring over 50 technology options including BIPV/T, cold-climate heat pumps, phase-change materials, advanced fenestration, exterior shading and controls. Emphasis on smart controls around the areas of occupant comfort, healthy environments, energy. Led a CMHC funded Design Charrette for Windmill Developments in Oct. 2014 for a Net-Zero Carbon Community located in Ottawa, ON.
2008/11 - 2013/11	Energy Auditor/Owner Numbered Federal Company Completed over 300 residential energy audits and 30 commercial energy audits throughout Eastern Ontario. Estimated allocation of $1.5 million in government funding; $5.3 million in invested capital into energy related building upgrades; resulting in an estimated annual reduction of 4000 tonnes in equivalent CO2 emissions.
2012/10 - 2013/7	Energy Auditor Efficiency Engineering Incorporated Conducted energy audits on over 3 million square feet of building space. Created energy models to compare mechanical system options for new building design using a life-cycle cost analysis including LEED support. Participated in a team of energy auditors to identify opportunities for campus-wide energy savings at Carleton University. Technical lead on web-based fault detection using BAS data for 18 public works and government service buildings using BACNet and Skyspark software (SkyFoundry). Project management of up to eight simultaneous projects ranging from $5,000 to $80,000.

Research Funding History

Awarded [n=6]

2016/6 - 2021/6
Principal Investigator

Optimization of smart net-zero energy communities, Grant

Funding Sources:

2016/6 - 2021/6 Natural Sciences and Engineering Research Council of Canada (NSERC)
Discovery
Total Funding - 115,000
Portion of Funding Received - 0
Funding Competitive?: Yes

2018/1 - 2021/1
Co-investigator

Integrated Community Energy and Harvesting Systems (ICE-Harvest), Grant

Funding Sources:

2018/1 - 2021/1 Natural Sciences and Engineering Research Council of Canada (NSERC)
Collaborative Research and Development (CRD)
Total Funding - 2,200,000 (Canadian dollar)
Portion of Funding Received - 150,000 (Canadian dollar)
Funding Renewable?: Yes
Funding Competitive?: Yes

2017/6 - 2018/1
Principal Investigator

Engineering Design of a Net-Zero Energy Tiny House, Grant

Funding Sources:

2017/6 - 2018/1 Natural Sciences and Engineering Research Council of Canada (NSERC)
Engage
Total Funding - 25,000 (Canadian dollar)
Portion of Funding Received - 25,000 (Canadian dollar)
Funding Renewable?: No
Funding Competitive?: Yes

2016/8 - 2017/1
Principal Investigator

Micro-grid simulation study for a cold-climate communities, Grant

Funding Sources:

2016/8 - 2017/1 Natural Sciences and Engineering Research Council of Canada (NSERC)
Engage
Total Funding - 25,000
Portion of Funding Received - 25,000
Funding Competitive?: Yes

2014/6 - 2015/7
Principal Applicant

Mitacs Accelerate Post-doctoral Fellowship titled "Optimization methdologies for Net-Zero Energy Communities", Fellowship

Funding Sources:

2014/1 - 2016/1 Mathematics of Information Technology and Complex Systems (MITACS)
Accelerate
Total Funding - 90,000
Portion of Funding Received - 45,000
Funding Competitive?: Yes

2014/8 - 2015/3
Collaborator

Smart community development-city of tomorrow- A strategy for developing the Burlington Innovation District (BID), Grant

Funding Sources:

2014/8 - 2015/3 Natural Sciences and Engineering Research Council of Canada (NSERC)
Engage
Total Funding - 25,000
Portion of Funding Received - 12,500
Funding Competitive?: Yes

Collaborator : Hazem Mahzar;

Principal Applicant : James S. Cotton

Student/Postdoctoral Supervision

Master's Thesis [n=5]

2018/1 - 2020/1
Co-Supervisor

Saptak Dutta (In Progress) , Carleton University
Student Degree Expected Date: 2020/1
Thesis/Project Title: Data mining of building operation logs
Present Position: MASc Student

2017/9 - 2019/9
Principal Supervisor

Seungyeon Hong (In Progress) , Carleton University
Student Degree Expected Date: 2019/9
Thesis/Project Title: Digital work-flow for commissioning studies of net-zero energy buildings
Present Position: MASc Student

2016/7 - 2018/8
Co-Supervisor

Andrew Hicks (In Progress) , Carleton University
Student Degree Expected Date: 2018/8
Thesis/Project Title: Impact of occupant behaviour in multi-residential buildings
Present Position: Student

2016/6 - 2018/8
Co-Supervisor

Maxime St Jacques (In Progress) , Carleton University
Student Degree Expected Date: 2018/8
Thesis/Project Title: District energy analysis of Carleton University Campus
Present Position: Student

2015/1 - 2018/1
Co-Supervisor

Raluca Dobrotescu (In Progress) , Carleton University
Student Degree Expected Date: 2018/1
Thesis/Project Title: Documentation of Historic Buildings
Present Position: Student

Doctorate [n=3]

2017/9 - 2022/1
Co-Supervisor

Haily Fernald (In Progress) , Carleton University
Student Degree Start Date: 2017/9
Student Degree Expected Date: 2022/1
Student Canadian Residency Status: Study Permit
Thesis/Project Title: Energy retrofit of Government building portfolios
Present Position: PhD Student

2017/5 - 2022/1 Co-Supervisor	Michael Gutland (In Progress) , Carleton University Student Degree Expected Date: 2022/1 Thesis/Project Title: Hygrothermal analysis of historical buildings Present Position: Student
2015/8 - 2020/1 Co-Supervisor	Vasken Dermardiros (In Progress) , Concordia University Student Degree Expected Date: 2020/1 Thesis/Project Title: to be determined Present Position: Student

Post-doctorate [n=1]

2018/1 - 2019/1 Co-Supervisor	Saber Mohamed (In Progress) , McMaster University Student Degree Start Date: 2018/1 Student Degree Expected Date: 2019/1 Student Canadian Residency Status: Canadian Citizen Thesis/Project Title: Optimization of community energy systems Present Position: Post Doctoral Fellow

International Collaboration Activities

2014/10 - 2014/10	APEC Expert Group Collaborator on Net-Zero Energy Communities, China Invited guest speaker on Net-Zero energy community research Event was attended by 52 delegates from 12 Asia-Pacific Economic Cooperation (APEC) economies. Second meeting scheduled for August, 2016 in Montreal, QC
2009/5 - 2013/5	IEA Task 40/ECB Annex 52 Participant, Germany Collaborator in IEA Task 40/ECB Annex 52 on Net-Zero Energy Buildings. Collaboration led to a book chapter published by Wiley & Sons.

Presentations

1. Bucking, S. and Athienitis, A. (2015). NSERC Smart Net-zero Energy Buildings strategic Research Network (SNEBRN): Update of Research and Demonstration Projects.Canadian German Conference on Renewable Energies in Buildings Organized by Canadian German Chamber of Industry and Commerce, Toronto, Canada
   Main Audience: Decision Maker
   Invited?: Yes, Keynote?: No
2. Bucking, S. and Athienitis, A. (2014). NSERC Smart Net-zero Energy Buildings strategic Research Network (SNEBRN): Research and Demonstration Projects. 2nd Building Integrated PV Symposium Organized by Canadian German Chamber of Industry and Commerce, Toronto, Canada
   Main Audience: Decision Maker
   Invited?: Yes, Keynote?: No
3. Bucking, S. (2014). Optimization at the Building and Community Level: A Smart Community Design Case Study. 2nd Annual Net-Zero Energy Building Workshop Organized by the Asian Pacific Economic Cooperation, Beijing, China
   Main Audience: Researcher
   Invited?: Yes, Keynote?: No
4. Bucking S. (2014). Optimization of Net-Zero Energy Buildings and Community Design. Research Seminar Organized by the Department of Civil and Environmental Engineering, Waterloo, Canada
   Main Audience: Researcher
   Invited?: Yes, Keynote?: No

5. Bucking S. (2014). Energy Audits and Towards Net-Zero Energy Use. Research Seminar Organized by National Research Council, Ottawa, Canada
   Main Audience: Researcher
   Invited?: Yes, Keynote?: No

6. Bucking, S, Derek, S. (2014). Green Building Programs and Policies: Communicating the Benefits. Green Profit Symposium, Kingston, Canada
   Main Audience: Decision Maker
   Invited?: Yes, Keynote?: No

Publications

Journal Articles

1. Gutland, M., Bucking, S., Santana, M. (2019). Assessing Durability of Historic Masonry Walls with Calibrated Energy Models and Hygrothermal Modelling. International Journal of Architectural Heritage. 13(4)
   Co-Author,

2. Vasken Dermardiros, Andreas Athienitis, and Scott Bucking. (2019). Energy performance, comfort and lessons learned from a net-zero energy library. ASHRAE Transactions. ,

3. Dutta, S., Bucking, S., Gunay, B. (2019). A method for extracting performance metrics using work-order data. Science and Technology for the Built Environment.
   Co-Author,
   Refereed?: Yes

4. Gunay, B., Shen, W., Huchuk, B., Yang, Chunsheng, Bucking, S., O'Brien, W. (2018). On the energy and comfort performance benefits of early detection of building sensor and actuator faults. Building Services Engineering Research and Technology.
   Accepted,
   Refereed?: Yes, Open Access?: No

5. Scott Bucking. (2018). Energy Modelling Methodology for Community Masterplanning. ASHRAE Transactions.
   Accepted,
   Refereed?: Yes

6. Scott Bucking, Vasken Dermardiros. (2018). Distributed evolutionary algorithm for co-optimization of building and district systems for early community energy masterplanning. Applied Soft Computing. 63: 14-22.
   http://dx.doi.org/https://doi.org/10.1016/j.asoc.2017.10.044
   First Listed Author
   Published, Elsevier,
   Refereed?: Yes, Open Access?: No
   Number of Contributors: 2
   Contribution Percentage: 91-100

7. Bucking, S. (2017). Optimization under Economic Uncertainty: A Methodology to Determine the Effects of Solar Variability on Energy and Economic Indicators. ASHRAE Transactions. 123
   Accepted,
   Refereed?: Yes, Open Access?: No

8. Bucking, S. (2016). Optimization under Economic Uncertainty using a Net-Zero Energy Commercial Office Case-Study. ASHRAE Transactions.
   Accepted,
   Refereed?: Yes, Open Access?: No

9. Bucking, S., Cotton, J. (2015). Methodology for energy and economic modelling of net-zero energy communities. ASHRAE Transactions. 212(1): 462-470.
   Published,
   Refereed?: Yes, Open Access?: No

10. Bucking, S., Athienitis, A., Zmeureanu, R. (2014). Multi-objective optimal design of a near net-zero energy solar house. ASHRAE Transactions. 120(1): 224--236.
    Published,
    Refereed?: Yes, Open Access?: No

11. Bucking, S., Zmeureanu, R., Athienitis, A. (2013). A methodology for identifying the influence of design variations on building energy performance.Journal of Building Performance Simulation. 7(6): 411-426.
    Published,
    Refereed?: Yes, Open Access?: No

12. Bucking, S., Zmeureanu, R., Athienitis, A. (2013). An information driven hybrid evolutionary algorithm for optimal design of a Net Zero Energy House. Solar Energy. 96(0): 128-139.
    Published,
    Refereed?: Yes, Open Access?: No

Book Chapters

1. Attia, S., Hamdy, M., Carlucci, S., Pagliano, L. Bucking, S. and Hasan, A. (2015). Building Performance Optimisation of Net Zero-Energy Buildings. Athienitis, A., O'Brien, W.Modelling, Design and Optimization of Net-Zero Energy Buildings. 1st: 175-206.
   Published, Wiley,
   Refereed?: No

Reports

1. Bucking, S., Mazhar, H. and Cotton, J. S. (2015). "Burlington Innovation District: Energy Modelling Methodology" Technical Report: NSERC Engage Grant, Mechanical Engineering Department, McMaster University, Hamilton, January 20, 2015; Submitted to Colliers International, 2015.82. McMaster University

2. Bucking, S., Satnik, D. (2015). "Energy Modelling Report: Zibi Community: Building 13" Submitted to Windmill Developments for the Zibi Community in support of a CMHC funded design Charrette. 86. Canadian Mortgage and Housing Company.

Conference Publications

1. Bucking, S., Dermadiros, V., Athienitis, A. (2016). The Effect of Hourly Primary Energy Factors on Optimal Net-Zero Energy Building Design. 2016. Proceedings of eSim 9th Canadian Conference of the International Building Performance Simulation Association, Hamilton, Canada,
   Conference Date: 2016/5
   Paper
   Published
   Refereed?: Yes, Invited?: No

2. Bucking, S., Cotton, J. (2015). Net Zero Resilient Communities: Three Canadian Case-Studies.CZEBS-iiSBE-APEC Net Zero Built Environment 2015 Symposium, Montreal, Canada,
   Conference Date: 2015/8
   Abstract
   Accepted
   Refereed?: No, Invited?: Yes

3. Bucking, S., Cotton, J. (2014). Simulation approaches for smart communities. eSim 8th Canadian Conference of the International Building Performance Simulation Association, Ottawa, Canada,
   Conference Date: 2014/4
   Paper
   Published
   Refereed?: Yes, Invited?: No

4. Bucking, S., Zmeureanu, R., Athienitis, A. (2013). An optimization methodology to evaluate the effect size of incentives on energy-cost optimal curves. 13th International Conference of the International Building Performance Simulation Association, Chambery, France,
   Conference Date: 2013/9
   Paper
   Published
   Refereed?: Yes, Invited?: No

5. Bucking, S., Athienitis, A., Zmeureanu, R. (2013). Effect of a time-of-use feed-in tariff on optimal net-zero energy home design.NextGenerationSolar Photovoltaics Canada: 2013 National Scientific Conference, Hamilton, Canada,
   Conference Date: 2013/4
   Abstract
   Published
   Refereed?: No, Invited?: No

Dr. Burak Gunay

Correspondence language: English
Sex: Male
Date of Birth: 1/23
Canadian Residency Status: Canadian Citizen
Country of Citizenship: Canada, Turkey

Contact Information

The primary information is denoted by (*)

Address

Primary Affiliation (*)

Dpt. of Civil and Env. Eng.
Room 3432, C.J. Mackenzie Building
1125 Colonel By Drive
Ottawa Ontario K1S 5B6
Canada

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Mobile (*)	1-613-2763798

Email

Personal (*)	burakgunay@cunet.carleton.ca

Website

Corporate	https://carleton.ca/cee/people/gunay-h-burak/
Social Media	https://www.researchgate.net/profile/Burak_Gunay
Social Media	https://scholar.google.ca/citations?user=87iSvawAAAAJ&hl=en

Dr. Burak Gunay

Language Skills

Language	Read	Write	Speak	Understand	Peer Review
English	Yes	Yes	Yes	Yes	Yes
French	Yes	No	No	Yes	No
Turkish	Yes	Yes	Yes	Yes	No

Degrees

2012/9 - 2016/7

Doctorate, Ph.D., Civil Engineering, Carleton University
Degree Status: Completed
Thesis Title: Improving energy efficiency in office buildings through adaptive control of the indoor climate

Supervisors: Ian Beausoleil-Morrison, 2012/9 - 2016/8; Liam O'Brien, 2012/9 - 2016/8

2009/9 - 2011/8

Master's Thesis, M.A.Sc., Civil Engineering, Carleton University
Degree Status: Completed

Supervisors: Burkan Isgor, 2009/9 - 2011/9

2005/9 - 2009/6

Bachelor's, Civil Engineering, Civil Engineering, Bogazici University
Degree Status: Completed

Supervisors: Cem Yalcin, 2005/9 - 2009/6

Credentials

Professional Engineer

Recognitions

2019/8

IEEE Case 2019 Best Paper Award – Finalist
IEEE
Prize / Award
Received one of the six best paper awards among 461 papers at the IEEE CASE 2019 Conference in Vancover.

2019/6

Journal of Science and Technology for the Built Environment Best Paper Award - 500 (United States dollar)
ASHRAE
Prize / Award
Received the best paper award for the Journal of Science and Technology for the Built Environment.

2019/5 Research Achievement Award - 15,000 (Canadian dollar)
Carleton University
Prize / Award
Received Carleton University Research Achievement Award in 2018.

2019/2 Energy and Buildings Journal Best Review Award Paper for 2008-2017 (led by Dr. Yan from Tsinghua University)
Energy and Buildings Journal
Prize / Award
Received the best literature review paper award by the journal of Energy and Buildings for the period between 2008 and 2017.

2018/9 Distinguished Service Award, IEA EBC Annex 66
IEA EBC Annex 66
Prize / Award
Received the IEA EBC Annex 66 Distinguished Service Award for my contributions to this Annex Project during my doctoral years.

2017/5 Early Career Researcher Supplement for Discovery Grant
Natural Sciences and Engineering Research Council of Canada (NSERC)
Distinction
A supplement is added for the Discovery Grant

2016/11 Governor General's Medal
Carleton University
Honor
The Governor General's Medal was awarded based on the academic record and the recommendation of the thesis examination committee for his PhD work. This is the highest level of recognition for the Carleton University Graduates.

2016/7 Carleton University Senate Medal
Carleton University
Honor
The Senate Medal was awarded based on the academic record and the recommendation of the thesis examination committee for his PhD work.

2016/1 NSERC Postdoctoral Fellowship (declined) - 90,000
Natural Sciences and Engineering Research Council of Canada (NSERC)
Prize / Award
An NSERC Postdoctoral Fellowship was awarded based on the research potential and communication/leadership skills. The award was declined because the applicant took a research officer position at National Research Council Canada.

2015/12 W.B. McDermid Holbein Memorial Award - 4,000
Carleton University
Prize / Award
This is an award administrated by Carleton University. The W.B. McDermid Holbein Memorial Award was offered based on academic excellence for the second time during the applicant's PhD.

2015/12 Best paper award at International Building Simulation Conference in India (first author)
International Building Performance Simulation Association
Distinction
First listed author of the best paper award at the International Building Simulation Conference among more than 400 researchers. The decision was based on double-blind reviewer assessments.

2015/9 NSERC Alexander Graham Bell Canada Graduate Scholarships - 35,000
Natural Sciences and Engineering Research Council of Canada (NSERC)
Prize / Award
An NSERC CGS-D award was offered based on academic excellence, research potential, and communication/leadership skills.

2015/8 IBPSA Canada Travel Award - 1,500 (Canadian dollar)
IBPSA Canada
Prize / Award
The award was offered by the International Building Performance Simulation Association of Canada to cover my travel expenses for the International Building Simulation Conference. The decision was based on the academic excellence of the applicant and the review of the conference paper.

2015/5 Green Revolving Fund - 10,500 (Canadian dollar)
Carleton University
Prize / Award
The award was administrated by the Facilities Management and Planning at Carleton University. It was offered based on the research potential of the proposal to upgrade the controls infrastructure in one of the academic buildings.

2015/3 GRIT Awards - 3,000 (Canadian dollar)
Carleton University
Prize / Award
This is an travel award administrated by Carleton University. It was offered based on academic excellence. The award was provided to fund the applicant's travel expenses for IEA Annex 66 meetings and OB-15 Symposium and to meet researchers at Lawrence Berkeley National Laboratories in California for two weeks.

2014/4 ASHRAE Grant-in Aid (Life Member Club for top two ranking) - 15,000 (United States dollar)
ASHRAE
Prize / Award
The award was administered by the American Society of Heating, Refrigerating, and Air-Conditioning Society based on academic excellence, research potential, and communication/leadership skills. Nominally it is called the Grant-in Aid Award. However, the applicant had the added distinction of the ASHRAE Life Member Club as he was ranked one of the top two applicants in this international competition.

2014/1 W.B. McDermid Holbein Memorial - 4,000 (Canadian dollar)
Carleton University
Prize / Award
The award was administrated by Carleton University and it was offered based on academic excellence.

2013/9 - 2015/9 NSERC Doctoral Scholarship - 42,000 (Canadian dollar)
Natural Sciences and Engineering Research Council of Canada (NSERC)
Prize / Award
An NSERC Postgraduate Scholarship for Doctoral Studies was awarded for three years based on academic record, research potential, and communication/leadership skills. In the third year, this award was upgraded to an NSERC CGS-D.

2013/9 Ontario Graduate Scholarship (Declined) - 15,000 (Canadian dollar)
Carleton University
Prize / Award
An Ontario Graduate Scholarship was offered based on academic excellence. The award was declined as the applicant was offered an NSERC PGS-D3 concurrently.

2013/1	CUASA Scholarship - 2,000 (Canadian dollar) Carleton University Prize / Award The award was administrated by Carleton University and it was offered based on academic excellence.
2013/1	J. L. Kingston Memorial Scholarship - 4,000 (Canadian dollar) Carleton University Prize / Award The award was administrated by Carleton University and it was offered based on academic excellence.
2012/9	Entrance Scholarship - 3,000 (Canadian dollar) Carleton University Prize / Award The Departmental Entrance Scholarship was an award based on academic excellence.
2012/9 - 2015/9	McGill Engineering Doctoral Award (Declined) - 96,000 (Canadian dollar) McGill University Prize / Award The McGill University Doctoral Award was offered for three years. The award was declined because the applicant started a PhD program at Carleton.
2012/9 - 2016/9	Departmental Scholarship - 28,000 (Canadian dollar) Carleton University Prize / Award The departmental scholarship was awarded for four years based on academic record.
2011/9	Senate Medal for Outstanding Academic Achievement Carleton University Honor The Senate Medal was awarded based on the academic record and the recommendation of the thesis examination committee for his MASc work.
2011/9	Departmental Scholarship - 6,000 (Canadian dollar) Carleton University Prize / Award The departmental scholarship was awarded for two years based on academic excellence.

User Profile

Fields of Application: Construction, Energy, Environment

Areas of Research: Data mining, Energy Conservation, Human Factors in Manufacturing, Stochastic Processes

Research Specialization Keywords: Adaptive indoor climate control in buildings, Fault detection and diagnostics in buildings, Building performance simulation, Occupant comfort and behaviour in buildings, Big data for intelligent buildings, Lighting and daylighting systems

Research Disciplines: Civil Engineering, Mechanical Engineering

Employment

2017/1	Assistant Professor Civil and Environmental Engineering, Carleton University Full-time, Assistant Professor Tenure Status: Tenure Track

2016/8 - 2016/12 Associate Research Officer
National Research Council Canada

2012/9 - 2016/8 Research Assistant
Civil and Environmental Engineering, Carleton University
Part-time
Tenure Status: Non Tenure Track

2014/9 - 2016/4 Teaching Assistant Mentor
Civil and Environmental Engineering, Carleton University
Part-time
Tenure Status: Non Tenure Track

2012/9 - 2014/9 Teaching Assistant
Civil and Environmental Engineering, Carleton University
Part-time
Tenure Status: Non Tenure Track

2011/9 - 2012/9 Research Associate
Civil and Environmental Engineering, Carleton University
Full-time
Tenure Status: Non Tenure Track

2009/9 - 2011/9 Research Assistant
Civil and Environmental Engineering, Carleton University
Part-time
Tenure Status: Non Tenure Track

2009/9 - 2011/9 Teaching Assistant
Civil and Environmental Engineering, Carleton University
Part-time
Tenure Status: Non Tenure Track

Affiliations

The primary affiliation is denoted by (*)

(*) Assistant Professor, Civil and Environmental Engineering, Carleton University

Research Funding History

Awarded [n=22]

2018/9 - 2022/9
Co-investigator

Development and field testing of novel approaches to improve building operations, Grant, Operating
Project Description: In this project, four Carleton professors (Liam O'Brien (PI), Jean Duquette, Scott Bucking) are working with BGIS to investigate retrofit strategies to reduce the carbon emissions from large commercial and institutional buildings. The project is partially sponsored by an industry partner - BGIS.

Funding Sources:

Natural Sciences and Engineering Research Council of Canada (NSERC)
CRD Grants
Total Funding - 480,000 (Canadian dollar)
Portion of Funding Received - 80,000 (Canadian dollar)
Funding Competitive?: Yes

Co-applicant : Jean Duquette; Scott Bucking;

Principal Investigator : Liam O'Brien

2018/5 - 2022/5
Principal Investigator

Data-driven methods for operation and maintenance of commercial buildings, Grant, Operating
Project Description: The project investigates new fault detection and diagnostics methods for the energy systems in large commercial and institutional buildings. The project is partially funded by an industry partner - CopperTree Analytics.

Funding Sources:

Natural Sciences and Engineering Research Council of Canada (NSERC)
CRD Grants
Total Funding - 107,000 (Canadian dollar)
Portion of Funding Received - 80,000 (Canadian dollar)
Funding Competitive?: Yes

Co-applicant : Liam O'Brien

2017/4 - 2022/3
Principal Investigator

Development of datasets, inverse models, and methods for adaptive fault detection and diagnostics in commercial buildings, Grant

Funding Sources:

Natural Sciences and Engineering Research Council of Canada (NSERC)
Discovery Grants Program
Total Funding - 145,000
Portion of Funding Received - 145,000
Funding Competitive?: Yes

2019/6 - 2022/3
Principal Investigator

Next generation actionable building energy performance metrics, data analytics, and visualization: an open-source platform, Contract
Project Description: The project develops and demonstrates a new software tool to conduct analytics on multiple operational data sources - meter, HVAC and lighting controls, CMMS, and WiFi data. Four companies (Delta Controls; Bentall GreenOak; Sensible Building Science; CopperTree Analytics) provide in-kind support for this project.

Funding Sources:

Natural Resources Canada
Green Infrastructure Phase II
Total Funding - 510,000 (Canadian dollar)
Portion of Funding Received - 350,000 (Canadian dollar)
Funding Competitive?: Yes

Co-applicant : Liam O'Brien; Scott Bucking

2019/7 - 2020/6
Co-investigator

Workplace of the future - a Multidisciplinary Research Catalyst Fund, Grant, Operating
Project Description: The project investigates the design and operation of workplaces with regards to their impact on energy efficiency, occupant comfort, satisfaction, health, and workplace productivity.

Funding Sources:

Carleton University
Multidisciplinary Research Catalyst Fund
Total Funding - 50,000 (Canadian dollar)
Portion of Funding Received - 15,000 (Canadian dollar)
Funding Competitive?: Yes

2019/5 - 2020/4

Remote auditing of building energy systems through inverse modelling, Grant, Operating

Principal Investigator

Project Description: The project investigates methods for the remote auditing of building energy systems and envelope through inverse modelling. The project is awarded through an internal grant of Carleton University.

Funding Sources:

Carleton University
Research Achievement Awards
Total Funding - 15,000 (Canadian dollar)
Portion of Funding Received - 15,000 (Canadian dollar)
Funding Competitive?: Yes

2019/10 - 2020/3
Principal Investigator

Energy end-use disaggregation and operation optimization for large commercial buildings, Contract

Project Description: The project investigates new methods for the disaggregation of energy end uses when submetering is not adequate.

Funding Sources:

National Research Council Canada (NRC) (Ottawa, ON)
Total Funding - 14,000 (Canadian dollar)
Portion of Funding Received - 14,000 (Canadian dollar)
Funding Competitive?: Yes

2019/10 - 2020/3
Principal Applicant

Data analysis and modelling for anomaly detection and remote auditing of building energy systems, Contract

Project Description: The project investigates methods for anomaly detection in the airflow and temperature control loops in buildings.

Funding Sources:

National Research Council Canada (NRC) (Ottawa, ON)
Total Funding - 19,000 (Canadian dollar)
Portion of Funding Received - 19,000 (Canadian dollar)
Funding Competitive?: Yes

2017/1 - 2020/1
Principal Investigator

Carleton University start-up fund, Grant

Funding Sources:

2017/1 - 2020/1 Carleton University
Total Funding - 60,000
Portion of Funding Received - 60,000
Funding Competitive?: No

2019/1 - 2019/12
Principal Investigator

Development and testing of innovative lighting automation algorithms to improve energy efficiency, Grant, Operating

Project Description: The project investigates the development and testing of new PoE LED lighting automation strategies together with an industry sponsor (Rimikon).

Funding Sources:

Ontario Center of Excellence (OCE)
VIP 1
Total Funding - 25,000 (Canadian dollar)
Portion of Funding Received - 20,000 (Canadian dollar)
Funding Competitive?: Yes

2017/3 - 2019/3
Co-applicant

Occupant modelling for building codes and standards: roadmap, feasibility study, and illustrative examples, Contract

Funding Sources:

2017/1 - 2019/3 Natural Resources Canada
Total Funding - 300,000
Portion of Funding Received - 50,000
Funding Competitive?: Yes

2017/5 - 2018/5
Principal Investigator

Connected and distributed sensing in buildings: current state and future challenges, Grant

Funding Sources:

Natural Sciences and Engineering Research Council of Canada (NSERC)
Connect Level 3
Total Funding - 25,000
Portion of Funding Received - 25,000
Funding Competitive?: Yes

2015/9 - 2016/9
Principal Applicant

NSERC Alexander Graham Bell Canada Graduate Scholarships, Scholarship

Funding Sources:

2015/9 - 2016/9 Natural Sciences and Engineering Research Council of Canada (NSERC)
Total Funding - 35,000
Portion of Funding Received - 35,000
Funding Competitive?: Yes

2010/1 - 2016/8
Principal Applicant

Departmental and Entrance Scholarships, Scholarship

Funding Sources:

2009/9 - 2016/8 Carleton University
Total Funding - 37,000
Portion of Funding Received - 37,000
Funding Competitive?: Yes

2014/2 - 2016/7
Principal Applicant

Development and implementation of an adaptive lighting and blinds automation algorithm (ASHRAE Grant-in Aid), Grant

Funding Sources:

2014/2 - 2017/7 American Society of Heating, Refrigerating and Air-Conditioning Engineers (The) (ASHRAE)
Total Funding - 15,000
Portion of Funding Received - 15,000
Funding Competitive?: Yes

2015/12 - 2015/12
Principal Applicant

W.B. McDermid Holbein Memorial Award, Scholarship

Funding Sources:

2015/12 - 2015/12 Carleton University
Total Funding - 3,500
Portion of Funding Received - 3,500
Funding Competitive?: Yes

2013/9 - 2015/9
Principal Applicant

NSERC Postgraduate Scholarship, Scholarship

Funding Sources:

2013/9 - 2015/9 Natural Sciences and Engineering Research Council of Canada (NSERC)
Total Funding - 42,000
Portion of Funding Received - 42,000
Funding Competitive?: Yes

2015/8 - 2015/8
Principal Applicant

IBPSA Canada Travel Award, Fellowship

Funding Sources:

2015/8 - 2015/8 International Building Performance Simulation Association of Canada
Total Funding - 1,500
Portion of Funding Received - 1,500
Funding Competitive?: Yes

2015/3 - 2015/3
Principal Applicant

GRIT Travel Awards, Scholarship

Funding Sources:

2015/3 - 2015/3 Carleton University
Total Funding - 3,000
Portion of Funding Received - 3,000
Funding Competitive?: Yes

2014/1 - 2014/1
Principal Applicant

W.B. McDermid Holbein Memorial Award, Scholarship

Funding Sources:

2014/1 - 2014/1 Carleton University
Total Funding - 4,000
Portion of Funding Received - 4,000
Funding Competitive?: Yes

2013/1 - 2013/1
Principal Applicant

J. L. Kingston Memorial Scholarship, Scholarship

Funding Sources:

2013/1 - 2013/1 Carleton University
Total Funding - 3,000
Portion of Funding Received - 3,000
Funding Competitive?: Yes

2013/1 - 2013/1
Principal Applicant

CUASA Scholarship, Scholarship

Funding Sources:

2013/1 - 2013/1 Carleton University
Total Funding - 2,000
Portion of Funding Received - 2,000
Funding Competitive?: Yes

Completed [n=6]

2018/6 - 2018/12
Principal Investigator

Benchmarking operation of commercial buildings through text-mining maintenance work-orders, Grant, Operating
Project Description: The project investigated the viability of employing text mining techniques to extract operational performance benchmarks from operator work order logs. The project is partially sponsored by an industry partner - Bentall GreenOak.

Funding Sources:

Natural Sciences and Engineering Research Council of Canada (NSERC)
Engage Grants
Total Funding - 25,000 (Canadian dollar)
Portion of Funding Received - 25,000 (Canadian dollar)
Funding Competitive?: Yes

2018/1 - 2018/6
Principal Investigator

Occupancy-centric predictive control of building systems, Grant, Operating
Project Description: The project investigated the integration of WiFi-based occupancy information in model-based predictive control of building energy systems. The project is partially funded by an industry partner - Green Power Labs.

Funding Sources:

Natural Sciences and Engineering Research Council of Canada (NSERC)
Engage Grants
Total Funding - 25,000 (Canadian dollar)
Portion of Funding Received - 25,000 (Canadian dollar)
Funding Competitive?: Yes

2017/6 - 2018/3
Principal Investigator

Demonstration of data-driven operation and maintenance strategies to improve the energy efficiency of commercial buildings, Contract
Project Description: The project developed and demonstrated new methods for the use of operational data sources to improve the performance of commercial buildings.

Funding Sources:

National Research Council Canada (NRC) (Ottawa, ON)
Total Funding - 65,000 (Canadian dollar)
Portion of Funding Received - 65,000 (Canadian dollar)
Funding Competitive?: Yes

2017/1 - 2017/3
Principal Investigator

Development of a fault-symptom dataset for automated on-going commissioning in commercial buildings, Contract
Project Description: The project entailed the creation of a new fault-symptom dataset for the development of new fault detection and diagnostics methods for building energy systems.

Funding Sources:

2017/1 - 2017/3 National Research Council Canada (NRC) (Ottawa, ON)
Total Funding - 22,000
Portion of Funding Received - 100
Funding Competitive?: No

2012/12 - 2016/3
Principal Investigator

Implementation of the occupant behaviour and presence models in EnergyPlus and OpenStudio, Contract

Funding Sources:

2012/12 - 2016/8 Natural Resources Canada
Total Funding - 67,000
Portion of Funding Received - 56,000
Funding Competitive?: Yes

2015/5 - 2015/5
Principal Applicant

Implementation of the occupancy learning algorithm in the VAV controllers of Canal Building, Contract

Funding Sources:

2015/5 - 2016/5	Carleton University Total Funding - 10,500 Portion of Funding Received - 10,500 Funding Competitive?: Yes

Declined [n=2]

2016/9 - 2018/9
Principal Applicant

NSERC Postdoctoral Fellowship, Fellowship

Funding Sources:

2016/9 - 2018/9	Natural Sciences and Engineering Research Council of Canada (NSERC) Total Funding - 90,000 Portion of Funding Received - 0 Funding Competitive?: Yes

2012/9 - 2015/9
Principal Applicant

McGill Engineering Doctoral Award, Scholarship

Funding Sources:

2012/9 - 2015/9	McGill University Total Funding - 96,000 Portion of Funding Received - 0 Funding Competitive?: Yes

Courses Taught

2018/01/02 - 2019/10/15
Instructor, Carleton University
Course Title: Building Energy Management and Optimization
Course Code: CIVE 5707
Course Level: Graduate
Number of Students: 25

2017/09/04 - 2019/10/15
Instructor, Carleton University
Course Title: Green Building Design
Course Code: ENVE 4105
Course Level: Undergraduate
Number of Students: 75

2017/01/09 - 2019/10/15
Instructor, Carleton University
Course Title: Building Science
Course Level: Undergraduate
Number of Students: 100

2018/01/02 - 2018/04/26
Instructor, Carleton University
Course Title: Indoor Environmental Quality
Course Code: ENVE 4106
Number of Students: 50

Student/Postdoctoral Supervision

Bachelor's [n=4]

2019/5 - 2019/8 Co-Supervisor	Umar Hafeez (In Progress) , Carleton University Thesis/Project Title: Review of energy and comfort performance monitoring requirements in benchmarking, rating, and labeling, programs Present Position: Undergraduate student, Carleton University
2019/5 - 2019/8 Principal Supervisor	Manav Shah (In Progress) , Carleton University Thesis/Project Title: Creating a new fault-symptom dataset for the development of zone-level sensor and actuator faults Present Position: Undergraduate student, Carleton University
2018/1 - 2018/4 Principal Supervisor	Hirlatu Peruga (In Progress) , Carleton University Thesis/Project Title: Auditing building energy systems to generate a groundtruth fault-symptom dataset Present Position: Graduate Student, Carleton University
2017/5 - 2017/8 Co-Supervisor	Ruth Tamas (In Progress) , Carleton University Thesis/Project Title: Exploratory data analysis on occupants' window use behaviour in condominiums Present Position: Undergraduate student, Carleton University

Master's non-Thesis [n=4]

2019/1 - 2021/12 Principal Supervisor	Jintong Shi (In Progress) , Carleton University Thesis/Project Title: Use of calibrated energy models to investigate retrofit options in heritage buildings Present Position: MEng student, Carleton University
2019/1 - 2020/12 Principal Supervisor	Prathamesh Raut (In Progress) , Carleton University Thesis/Project Title: Using Wi-Fi enabled device counts to optimize the ventilation rates in large commercial buildings Present Position: MEng student, Carleton University
2018/1 - 2018/8 Principal Supervisor	Arshi Mehta (Completed) , Carleton University Thesis/Project Title: Preliminary analysis of window use behaviour in mixed mode ventilation buildings Present Position: Engineer, Environment Canada
2017/5 - 2018/5 Principal Supervisor	Ali Dasmeh (Completed) , Carleton University Thesis/Project Title: Using calibrated building performance simulation models in energy auditing Present Position: Engineer, Environment Canada

Master's Thesis [n=7]

2019/9 - 2021/8 Co-Supervisor	Daniel Lowcay (In Progress) , Carleton University Thesis/Project Title: Development and demonstration of new LED lighting automation strategies for shared perimeter spaces Present Position: MASc student, Carleton University
2019/9 - 2021/8 Principal Supervisor	Ipek Yilmaz (In Progress) , Carleton University Thesis/Project Title: Deriving near-optimal operational policies to improve energy performance in commercial buildings Present Position: MASc student, Carleton University

2019/9 - 2021/8 Principal Supervisor	Zijun Xiong (In Progress) , Carleton University Thesis/Project Title: Inverse modelling the humidity and CO2 concentration in commercial buildings to estimation air infiltration rates Present Position: MASc student, Carleton University
2019/9 - 2021/8 Co-Supervisor	Weihao Liu (In Progress) , Carleton University Thesis/Project Title: Energy efficient operation strategies for mixed-mode ventilation buildings in cold climates Present Position: MASc student, Carleton University
2018/9 - 2020/8 Principal Supervisor	Brodie Hobson (In Progress) , Carleton University Thesis/Project Title: Occupancy-centric control of the indoor climate in commercial buildings Present Position: MASc student, Carleton University
2018/1 - 2019/12 Co-Supervisor	Saptak Dutta (In Progress) , Carleton University Thesis/Project Title: Using computerized maintenance management system data to extract operational performance metrics in large commercial and institutional buildings Present Position: MASc student, Carleton University
2018/1 - 2020/12 Co-Supervisor	Rachel Gullage (In Progress) , Carleton University Thesis/Project Title: Non-destructive testing methods to assess envelope performance in Canadian heritage buildings Present Position: MASc student, Carleton University

Doctorate [n=2]

2018/9 - 2022/8 Co-Supervisor	Darwish Darwazeh (In Progress) , Carleton University Thesis/Project Title: Inverse greybox virtualmetering algorithms for visualizing building energy flows Present Position: PhD student, Carleton University
2017/1 - 2020/8 Co-Supervisor	Tareq Abuimara (In Progress) , Carleton University Thesis/Project Title: Incorporating occupant modelling in building performance simulation-based design Present Position: PhD student, Carleton University

Post-doctorate [n=5]

2019/10 - 2020/9 Co-Supervisor	Zakia Afroz (In Progress) , Carleton University Thesis/Project Title: Investigation of operational data analytics methods to improve building performance Present Position: Postdoctoral researcher, Carleton University
2019/8 - 2020/7 Co-Supervisor	Abdeen Saleem (In Progress) , Carleton University Thesis/Project Title: Effect of building energy model complexity in making retrofit decisions Present Position: Postdoctoral researcher, Carleton University
2019/1 - 2020/2 Principal Supervisor	Long Chen (In Progress) , Carleton University Thesis/Project Title: Development of a metadata inference method for building automation systems Present Position: Postdoctoral researcher, Carleton University
2017/1 - 2018/6 Co-Supervisor	Mohamed Ouf (Completed) , Carleton University Thesis/Project Title: Effect of energy-related occupant behaviour on simulation-based investigation of building performance Present Position: Assistant Professor, Concordia University

2017/1 - 2018/3 Co-Supervisor	Sara Gilani (Completed) , Carleton University Thesis/Project Title: The impact of spatial distribution of occupants on buildings' energy performance Present Position: Postdoctoral researcher, Ryerson University

Event Administration

2019/7 - 2019/10	Scientific Committee, BuildSys 2019, Conference, 2019/10 - 2019/10
2019/6 - 2019/10	Organizer, Designing Future Building Energy Management Tools Workshop, Workshop, 2019/10 - 2019/10
2019/5 - 2019/8	Publicity co-chair, IEEE CASE 2019, Conference, 2019/8 - 2019/8
2018/5 - 2018/10	Organizing and scientific committee, OB 18 Symposium and IEA EBC Annex 79 Meeting in Ottawa, Conference, 2018/10 - 2018/10
2017/5 - 2017/8	Organizer, NSERC Connect 3 Workshop on Big Data in Building Operations, Workshop, 2017/6 - 2017/6
2016/3 - 2016/8	Organizing and scientific committee, IEA EBC Annex 66 Experts Meeting and OB16 Symposium, Association, 2016/8 - 2016/8
2014/9 - 2015/4	Organizing and scientific committee, eSim 2014 Conference, Conference, 2014/5 - 2014/5 Organization of the registration day venue, catering, and live music for over 200 participants
2014/1 - 2014/5	Organizing and scientific committee, SimAUD 2013, Conference, 2013/4 - 2013/4

Editorial Activities

2015/9 - 2017/9	Special issue guest co-editor, Special Issue on the Fundamentals of Occupant Behaviour Research in the Journal of Building Performance Simulation, Journal

Journal Review Activities

Journal peer-review,Energy and Buildings, Building and Environment, Journal of Building Performance Simulation, ASHRAE Transactions, Journal of Building Simulation, Science and Technology for the Built Environment
Number of Works Reviewed / Refereed: 40

Conference Review Activities

Peer-review, Multiple papers for several SimAUD, BuildSys, eSim, Building Simulation, ASHRAE, CISBAT conferences, Double Blind
Number of Works Reviewed / Refereed: 30

International Collaboration Activities

2018/10 - 2023/10 — IEA EBC Annex 79 Subtask 4 Co-leader, France
I am co-leading the IEA EBC Annex 79 Subtask 4 together with Prof. Zoltan Nagy (University of Texas at Austin) and Prof. Clayton Miller (National University of Singapore). The Subtask 4 of IEA EBC Annex 79 is group of over 20 active international expert researchers that develop and test new methods for occupant-centric indoor climate control.

2013/1 - 2018/1 — IEA EBC Annex 66 Member, France
The International Energy Agency (IEA) Energy in Buildings and Communities (EBC) Program Annex 66 is an international collaboration among more than 100 researchers from 14 different countries. I am one of the two members representing Canada. As a result of this collaboration, I authored three journal articles and one conference paper with researchers from China, United States, Austria, and Italy. On topics related to Annex 66, I am a special issue guest co-editor of Journal of Building Performance Simulation. I co-authored two chapters of a book (to be published in 2017) on energy-related occupant behaviour monitoring and data standards with Annex 66 experts. I took an active role during the organization of Annex 66 meetings and OB-16 Symposium in Ottawa.

Other Memberships

2014/4 — Board member and secretary, IBPSA Canada
An elected board member and secretary for the International Building Performance Simulation Association Canada (2016-2018); An elected board member for the International Building Performance Simulation Association Canada (2014-2016); Resposibilities: Communications for Annual General and Board Meetings, participating travel award application review activities, organization of the eSim conferences and delivering technical workshops

2013/1 — Member, ASHRAE Carleton Chapter
A forming member and a former chair of the ASHRAE Carleton Chapter which now has over 100 members and an active member of the ASHRAE Ottawa Valley Chapter

2013/1 - 2016/9 — Student member, NSERC smart Net-zero Energy Buildings strategic Research Network
Participated in annual general meetings in Ottawa, Montreal, and Saskatoon; Attended workshops and panel discussions organized by SNEBRN in Ottawa and Montreal

Presentations

1. (2019). Detection and interpretation of temperature and airflow control anomalies through cluster analysis. Designing Future Building Energy Management Tools Workshop, Ottawa, Canada
   Invited?: Yes, Keynote?: No
2. (2019). Data analytics to improve building performance: case studies, enablers and barriers. Mission Innovation Workshop, Montreal, Canada
   Main Audience: Researcher
   Invited?: Yes, Keynote?: No
3. (2019). Case study implementation of occupant centric controls. ASHRAE Annual Conference, Kansas City, United States
   Main Audience: Researcher
   Invited?: Yes, Keynote?: No, Competitive?: Yes

4. (2019). Detection of energy use anomalies in commercial buildings. ASHRAE Annual Conference, Kansas City, United States
   Main Audience: Researcher
   Invited?: Yes, Keynote?: No, Competitive?: Yes
5. (2018). Estimation of building occupancy count using sensor fusion. NRC-Ottawa Industrial Problem Solving Workshop; Fields Institute and University of Ottawa, Ottawa, Canada
   Main Audience: Researcher
   Invited?: Yes, Keynote?: No, Competitive?: Yes
6. (2018). Case studies on data-driven building operation & maintenance. İzmir Institute of Technology (Invited Talk), Izmir, Turkey
   Main Audience: Researcher
   Invited?: Yes, Keynote?: No
7. (2018). Learning from occupants' thermostat use behaviour. ASHRAE Annual Conference, Research Summit: Optimization for HVAC Systems,, Houston, United States
   Main Audience: Researcher
   Invited?: Yes, Keynote?: No
8. (2018). Using text analytics to benchmark building performance. Energy Profiles Limited (Invited Talk), Toronto, Canada
   Main Audience: Knowledge User
   Invited?: Yes, Keynote?: No
9. (2017). Data mining for residential applications. Ecobee Home Automation (Invited Talk), Toronto, Canada
   Main Audience: Knowledge User
   Invited?: Yes, Keynote?: No
10. (2017). Text-mining operator logbooks for preventive maintenance. Workshop on Big Data in Building Operations, Ottawa, Canada
    Main Audience: Researcher
    Invited?: Yes, Keynote?: No
11. (2017). Data-driven building operation and maintenance. Honeywell (Invited Talk), Minneapolis, United States
    Main Audience: Knowledge User
    Invited?: Yes, Keynote?: No
12. (2017). Visualization for building energy performance from early design to operations. Klipfolio - Data Visualization Event, Ottawa, Canada
    Main Audience: General Public
    Invited?: Yes, Keynote?: No
13. (2017). Occupants in building simulation. Stakeholders' workshop on occupant modelling for energy codes and standards, Ottawa, Canada
    Main Audience: Knowledge User
    Invited?: Yes, Keynote?: No

Publications

Journal Articles

1. Gunay H B, Shen W, Ashouri A. (2019). Load forecasting and near-optimal sequencing of chillers and boilers in a central heating and cooling plant to increase energy efficiency. ASHRAE Transactions. 125 Published,
   Refereed?: Yes

2. Gunay H B, Shen W, Newsham G. (2019). Data analytics to improve building performance: a critical review. Automation in Construction. 97: 96-109.
Published,
Refereed?: Yes

3. O'Brien W, Abdelalim A*, Gunay H B. (2019). Development of an office tenant electricity use model and its application for right-sizing HVAC equipment. Journal of Building Performance Simulation. 12: 37-55.
Published,
Refereed?: Yes

4. O'Brien W, Gunay H B. (2019). Do building energy codes adequately reward buildings that adapt to partial occupancy?. Science and Technology for the Built Environment.
In Press,
Refereed?: Yes

5. Hobson B*, Lowcay D*, Gunay H B, Ashouri A, Newsham G. (2019). Opportunistic occupancy count estimation using sensor fusion: A case study. Building and Environment.
In Press,
Refereed?: Yes

6. Ouf M*, O'Brien W, Gunay H B. (2019). A method to generate design-sensitive occupant-related schedules for building performance simulations. Science and Technology for the Built Environment. 25: 221-232.
Published,
Refereed?: Yes

7. D'Oca S, Gunay H B, Gilani S, O'Brien W. (2019). Critical review and illustrative examples of office occupant modelling formalisms. Building Services Engineering Research and Technology.
In Press,
Refereed?: Yes

8. Abuimara T*, O'Brien W, Gunay, H B. (2019). Quantifying occupants' impact during simulation aided design: a case study. Building Research and Information. 47: 866-882.
Published,
Refereed?: Yes

9. Gunay H B, Ouf M*, Newsham G, O'Brien W. (2019). Sensitivity analysis and optimization of building operations. Energy and Buildings.
In Press,
Refereed?: Yes

10. Gunay H B, Ashouri A, Shen W. (2019). Detection and interpretation of anomalies in building energy use through inverse modelling. Science and Technology for the Built Environment. 25: 488-503.
Published,
Refereed?: Yes

11. Ouf M, O'Brien W, Gunay H B. (2019). Optimization of electricity use in office buildings under occupant uncertainty. Journal of Building Performance Simulation.
In Press,
Refereed?: Yes

12. Gunay H B, Shen W, and Yang C. (2019). Text-mining building maintenance work orders for component fault frequency. Building Research and Information. 47: 518-533.
Published,
Refereed?: Yes

13. Park J Y*, Ouf M, Peng Y, Nagy Z, O'Brien W, Kjærgaard M B. (2019). A critical review of field implementations of occupant-centric building controls. Building and Environment. 165
Published,
Refereed?: Yes

14. Gunay H B, Ashouri A, Shen W, Newsham G, O'Brien W. (2019). Floor level occupancy count estimation: an exploratory data analysis. ASHRAE Transactions. 125
Published,
Refereed?: Yes

15. Ouf M, O'Brien W, Gunay H B. (2019). On quantifying building performance adaptability to variable occupancy. Building and Environment. 155: 257-267.
Published,
Refereed?: Yes

16. Shi Z*, O'Brien W, Gunay H B. (2018). Development of a distributed building fault detection, diagnostic and evaluation system. ASHRAE Transactions. 124: 23-37.
Published,
Refereed?: Yes

17. Gunay H B, Shen W, Newsham G, Ashouri A. (2018). Modelling and analysis of unsolicited temperature setpoint change requests in office buildings. Building and Environment. 133: 203-212.
Published,
Refereed?: Yes

18. Yang C, Shen W, Chen Q, Gunay H B. (2018). A practical solution for HVAC prognostics: Failure mode and effects analysis in building maintenance. Journal of Building Engineering. 15: 26-32.
Published,
Refereed?: Yes

19. Gunay H B, Weiming S, Chunsheng Y, Huchuk B, Zixiao Shi. (2018). A preliminary study on text-mining operator logbooks to develop a fault-frequency model. ASHRAE Transactions. 124: 171-84.
Published, ASHRAE,
Refereed?: Yes

20. Gunay H B, O'Brien W, Beausoleil-Morrison I, Bursill J*. (2018). Development and implementation of a thermostat learning algorithm. Science and Technology for the Built Environment. 24: 43-46.
Published,
Refereed?: Yes

21. Gilani S*, O'Brien W, Gunay H B. (2018). Simulating occupants' impact on building energy performance at different spatial scales. Building and Environment. 132: 327-337.
Published,
Refereed?: Yes

22. Ouf M*, O'Brien W, Gunay H B. (2018). Improving occupant-related features in building performance simulation tools. Building Simulation. 11: 803-817.
Published,
Refereed?: Yes

23. Gunay H B, Shen W, Huchuk B, Yang C, Bucking S, O'Brien W. (2018). Energy and comfort performance benefits of early detection of building sensor and actuator faults. Building Services Engineering Research and Technology. 39: 652-666.
Published,
Refereed?: Yes

24. Gunay H B, Shen W, Yang C. (2017). Characterization of a building's operation using automation data: a review and case study. Building and Environment. 118: 196-210.
Published,
Refereed?: Yes

25. Shen W, Newsham G, Gunay H B. (2017). Leveraging existing occupancy-related data for optimal control of commercial office buildings: A review. Advanced Engineering Informatics. 33: 230-242.
Published,
Refereed?: Yes

26. Gunay H B, Shen W, Newsham G. (2017). Inverse blackbox modelling of the heating and cooling load in office buildings. Energy and Buildings. 142: 200-210.
Published,
Refereed?: Yes

27. O'Brien W, Gunay H B, Tahmasebi F, Mahdavi A. (2017). A preliminary study of representing the inter-occupant diversity in occupant modelling. Journal of Building Performance Simulation. 1: 509-526.
Published,
Refereed?: Yes, Open Access?: No

28. Gunay H B, Shen W, Yang C. (2017). Blackbox modelling of the central heating and cooling plant equipment performance. Science and Technology for the Built Environment. 24: 396-409.
Published, ASHRAE,
Refereed?: Yes

29. Gunay H B, O'Brien W, Beausoleil-Morrison I, Gilani S*. (2017). Development and implementation of an adaptive lighting and blinds control algorithm. Building and Environment. 113: 185-199.
Published,
Refereed?: Yes

30. Gunay H B*, O'Brien W, Beausoleil-Morrison I, Gilani S*. (2016). Modeling plug-in equipment load patterns in private office spaces. Energy and Buildings. 121: 234-249.
Published,
Refereed?: Yes

31. Gunay H B*, O'Brien W, Beausoleil-Morrison I, Bursill J*. (2016). Implementation of an adaptive occupancy and building learning temperature setback algorithm. ASHRAE Transactions. 122(1): 179-192.
First Listed Author
Published,
Refereed?: Yes
Number of Contributors: 4

    Funding Sources: Delta Control Inc.; ASHRAE

32. Gunay H B*, O'Brien W, Beausoleil-Morrison I, Bisaillon P*, Shi Z*. (2016). Development and implementation of a control-oriented model for terminal heating and cooling units. Energy and Buildings. 121: 78-91.
First Listed Author
Published,
Refereed?: Yes
Number of Contributors: 5

    Funding Sources: Delta Control Inc.; Natural Sciences and Engineering Research Council of Canada (NSERC)

33. Gunay H B, O'Brien W and Beausoleil-Morrison I. (2016). Control-oriented inverse modeling of the thermal characteristics in an office. Science and Technology for the Built Environment. 1: 1-20.
Published,
Refereed?: Yes

34. Gunay H B*, O'Brien W, Beausoleil-Morrison I. (2015). Development of an occupancy learning algorithm for terminal heating and cooling units. Building and Environment. 93(2): 71-85.
First Listed Author
Published,
Refereed?: Yes
Number of Contributors: 3

    Funding Sources: Delta Control Inc.; Natural Sciences and Engineering Research Council of Canada (NSERC); Regulvar

35. Yan D, O'Brien W, Hong T, Feng X*, Gunay H B*, Tahmasebi F*, Mahdavi A. (2015). Occupant behavior modeling for building performance simulation: current state and future challenge. Energy and Buildings. 107(2015): 264–278.
Co-Author
Published,
Refereed?: Yes
Number of Contributors: 7

    Funding Sources: Natural Sciences and Engineering Research Council of Canada (NSERC)

36. Gunay H. B., Isgor O.B., Ghods P. (2015). Kinetics of passivation and chloride-induced depassivation of iron in simulated concrete pore solutions using Electrochemical Quartz Crystal Nanobalance (EQCN). Corrosion. 71(5): 615-627.
First Listed Author
Published,
Refereed?: Yes
Number of Contributors: 3

37. Huchuk B*, Gunay H B*, O'Brien W, Cruickshank C. (2015). Model-Based predictive control of office window shades. Building Research & Information. 44(4): 445-455.
Co-Author
Published,
Refereed?: Yes
Number of Contributors: 4

    Funding Sources: Delta Control Inc.; Natural Sciences and Engineering Research Council of Canada (NSERC); Regulvar

38. O'Brien W, Gunay H B*. (2015). Mitigating office performance uncertainty of occupant use of window shades and lighting using robust design. Building Simulation. : 1-16.
Co-Author
Published,
Refereed?: Yes
Number of Contributors: 2

    Funding Sources: Natural Resources Canada

39. Gunay H B*, O'Brien W, Beausoleil-Morrison I. (2015). Implementation and comparison of existing occupant behaviour models in EnergyPlus. Journal of Building Performance Simulation. 1: 1-22.
First Listed Author
Published,
Refereed?: Yes
Number of Contributors: 3

    Funding Sources: Natural Resources Canada

40. Gilani S*, O'Brien W, Gunay H B*, Carrizo J S. (2015). Use of dynamic occupant behavior models in the building design and code compliance processes. Energy and Buildings. 117: 260-271.
Published,
Refereed?: Yes, Open Access?: No

41. Gunay H B*, O'Brien W, Beausoleil-Morrison I, Perna A*. (2014). On the behavioral effects of residential electricity submetering in a heating season. Building and Environment. 81: 396-403.
First Listed Author
Published,
Refereed?: Yes
Number of Contributors: 4

    Funding Sources: Natural Sciences and Engineering Research Council of Canada (NSERC)

42. Gunay H B*, O'Brien W, Beausoleil-Morrison I, Huchuk B*. (2014). On adaptive occupant-learning window blind and lighting controls.Building Research & Information 42, no. 6 (2014): 739-756.42(6): 739-756.
First Listed Author
Published,
Refereed?: Yes
Number of Contributors: 4

Funding Sources: American Society of Heating, Refrigerating and Air-Conditioning Engineers (The) (ASHRAE)

43. Gunay H B*, Bursill J*, Huchuk B*, O'Brien W, Beausoleil-Morrison I. (2014). Shortest-prediction-horizon model-based predictive control for individual offices. Building and Environment. 82: 408-419.
First Listed Author
Published,
Refereed?: Yes
Number of Contributors: 5

Funding Sources: Natural Sciences and Engineering Research Council of Canada (NSERC); Green Power Labs

44. O'Brien W, Gunay H B*. (2014). The contextual factors contributing to occupants' adaptive comfort behaviors in offices – A review and proposed modeling framework. Building and Environment. 77: 77-87.
Co-Author
Published,
Refereed?: Yes
Number of Contributors: 2

Funding Sources: Natural Sciences and Engineering Research Council of Canada (NSERC)

45. Gunay H B*, O'Brien W, Beausoleil-Morrison I, Goldstein R, Breslav S, Khan A. (2014). Coupling stochastic occupant models to building performance simulation using the discrete event system specification formalism. Journal of Building Performance Simulation. 7(6): 457-478.
First Listed Author
Published,
Refereed?: Yes
Number of Contributors: 6

Funding Sources: Natural Sciences and Engineering Research Council of Canada (NSERC); Autodesk Research

46. Bonany J E*, Van Geel P, Gunay H B*,Isgor O B. (2013). Simulating waste temperatures in an operating landfill in Québec, Canada. Waste Management and Research. : 1-8.
Co-Author
Published,
Refereed?: Yes
Number of Contributors: 4

Funding Sources: Golder Associate; Ontario Centres of Excellence; Waste Management of Canada

47. Gunay H B*, Ghods P, Isgor O B, Carpenter G, Wu X. (2013). Characterization of atomic structure of oxide films on carbon steel in simulated concrete solutions using EELS. Applied Surface Science. 274: 195-202.
First Listed Author
Published,
Refereed?: Yes
Number of Contributors: 5

Funding Sources: Natural Sciences and Engineering Research Council of Canada (NSERC)

48. Bonany J E, Van Geel P, Gunay H B, Isgor O B. (2013). Heat budget for a waste lift placed under freezing conditions at a landfill operated in a northern climate. Waste management. 33: 1215-1228.
Co-Author
Published,
Refereed?: Yes
Number of Contributors: 4

Funding Sources: Golder Associate; Ontario Center of Excellence (OCE); Waste Management of Canada

49. Gunay H B*, O'Brien W, Beausoleil-Morrison I. (2013). A critical review of observation studies, modeling, and simulation of adaptive occupant behaviors in offices. Building and Environment. 70: 31-47.
First Listed Author
Published,
Refereed?: Yes
Number of Contributors: 3

Funding Sources: Natural Resources Canada

Book Chapters

1. Dong B, Kjærgaard M B, De Simone M, Gunay H B, O'Brien W, Mora D, Dziedzic J, Zhao J. (2017). Sensing and Data acquisition. Exploring Occupant Behavior in Buildings Methods and Challenges. : 77-105.
Published, Springer,
Refereed?: Yes

2. O'Brien W, Gilani S, Gunay H B. (2017). In Situ Approaches to Studying Occupants. Exploring Occupant Behavior in Buildings Methods and Challenges. : 129-167.
Published, Springer,
Refereed?: Yes

Thesis/Dissertation

1. Improving energy efficiency in office buildings through adaptive control of the indoor climate. (2016). Carleton University. Doctorate.
Number of Pages: 290 Supervisor: O'Brien Liam; Beausoleil-Morrison Ian

2. Electrochemical and microscopic investigation of the passivation and depassivation processes of iron and steel in simulated concrete pore solutions. (2011). Carleton University. Master's Thesis.
Number of Pages: 199 Supervisor: Burkan Isgor

Magazine Entries

1. Gunay H B, Shen W. (2017). Connected and Distributed Sensing in Buildings: Improving Operation and Maintenance. IEEE SMC Magazine. 3: 27-34.
Published, IEEE,

Conference Publications

1. Hobson B*, Gunay H B, Ashouri A, Newsham G. (2020). Wi-Fi based occupancy clustering and motif identification: a case study. ASHRAE Winter Conference, Orlando, United States. ASHRAE,
Paper
Accepted
Refereed?: Yes, Invited?: No

2. Darwazeh D*, Gunay H B, Duquette J. (2019). Development of a virtual metering method for characterizing energy flows in air handling units. IEEE CASE, Vancouver, Canada. IEEE,
   Paper
   Published
   Refereed?: Yes, Invited?: No

3. Shi Z, Newsham G, Chen L*, Gunay H B. (2019). Evaluation of clustering and time series features for point type inference in smart building retrofit. ACM BuildSys, New York City, United States. ACM,
   Paper
   Published
   Refereed?: Yes, Invited?: No

4. Dutta S*, Gunay H B, Bucking S. (2019). Using text analytics on operator logbooks for performance benchmarking: a case study. ASHRAE Annual Conference, Kansas City, United States. ASHRAE,
   Paper
   Published
   Refereed?: Yes, Invited?: No

5. Shi Z, Newsham G, Pardasani A, Gunay H B. (2019). Development of an adaptive online grey-box thermal model for residential houses. Building Simulation, Rome, Italy. IBPSA,
   Paper
   Published
   Refereed?: Yes, Invited?: No

6. Gunay H B, Salehi M, Papavinasam S, Isgor O B. (2019). Investigation of corrosion inhibitor persistency using electrochemical quartz crystal nanobalance. ASTM Symposium on Advances in Electrochemical Techniques for Corrosion Monitoring and Laboratory Corrosion Measurements, Atlanta, United States,
   Paper
   Published
   Refereed?: Yes, Invited?: No

7. Abuimara T*, O'Brien W, Gunay H B. (2019). Simulating the impact of occupants on office building design process: a case study. Building Simulation, Rome, Italy. IBPSA,
   Paper
   Published
   Refereed?: Yes, Invited?: No

8. Gunay H B, Ouf M*, Newsham G*, O'Brien W. (2019). Building performance optimization for operational rule extraction. Building Simulation, Rome, Italy. IBPSA,
   Paper
   Published
   Refereed?: Yes, Invited?: No

9. Ouf M*, O'Brien W, Gunay H B, Azzouz A, Richard P, Todesco G. (2019). Quantifying occupancy-adaptive building operations. Building Simulation, Rome, Italy. IBPSA,
   Paper
   Published
   Refereed?: Yes, Invited?: No

10. O'Brien W, Gunay H B, Ouf M*. (2019). Simulation-based approach to assess occupant adaptability of buildings. Building Simulation, Rome, Italy. IBPSA,
    Paper
    Published
    Refereed?: Yes, Invited?: No

11. Schweiker M, O'Brien W, Gunay H B. (2019). Characterization of occupant behaviour models for simulation engineers and architects. Schweiker M, O'Brien W, Gunay H B, Rome, Italy. IBPSA,
    Paper
    Published
    Refereed?: Yes, Invited?: No

12. Gunay H B, Shi Z, Yang C, Shen W. (2019). An inquiry into the predictability of failure events in chillers and boilers. IEEE CASE, Vancouver, Canada. IEEE,
    Paper
    Published
    Refereed?: Yes, Invited?: No

13. Ashouri A, Hu Y, Gunay H B, Newsham G, Shen W. (2019). Model-based and data-driven anomaly detection for heating and cooling demands in office buildings. ASHRAE Winter Conference, Atlanta, United States. ASHRAE,
    Paper
    Published
    Refereed?: Yes, Invited?: No

14. Ouf M*, O'Brien W, Gunay H B. (2019). Optimizing building performance using stochastic occupant models. ASHRAE Winter Conference, Atlanta, United States. ASHRAE,
    Paper
    Published
    Refereed?: Yes, Invited?: No

15. Yang C, Shen W, Gunay H B. (2019). Toward machine learning-based prognostics for heating ventilation and air-conditioning systems. ASHRAE Winter Conference, Atlanta, United States. ASHRAE,
    Paper
    Published
    Refereed?: Yes, Invited?: No

16. Ashouri A, Newsham G, Shi Z, Gunay H B. (2019). Day-ahead prediction of building occupancy using WiFi signals. IEEE CASE, Vancouver, Canada. IEEE,
    Paper
    Published
    Refereed?: Yes, Invited?: No

17. Ashouri A, Shi Z, Gunay H B. (2019). Data-driven short-term load forecasting for heating and cooling demand in office buildings. CISBAT, Lausanne, Switzerland,
    Paper
    Published
    Refereed?: Yes, Invited?: No

18. Gunay H B, Shi Z, Ashouri A, Newsham G. (2019). Development of a clustering-based morning start time estimation algorithm for space heating and cooling. ACM BuildSys, New York City, United States. ACM,
    Paper
    Published
    Refereed?: Yes, Invited?: No

19. Abuimara T*, O'Brien W, Gunay H B. (2018). Modelling occupants in buildings: stakeholders' workshop on current barriers, challenges and needs. eSim, Montreal, Canada. IBPSA Canada,
    Paper
    Published
    Refereed?: Yes, Invited?: No

20. Gunay H B, O'Brien W. (2018). Implementation of occupant models in EnergyPlus through an OpenStudio measure. eSim, Montreal, Canada. IBPSA Canada,
    Paper
    Published
    Refereed?: Yes, Invited?: No

21. Abuimara T*, O'Brien W, Gunay H B, Carrizo S. (2018). Assessing the impact of occupants on building design decision making. eSim, Montreal, Canada. IBPSA Canada,
    Paper
    Published
    Refereed?: Yes, Invited?: No

22. Tamas R*, Gunay H B, O'Brien W. (2018). Summer window use behaviour in air-conditioned condominiums. eSim, Montreal, Canada. IBPSA Canada,
    Paper
    Published
    Refereed?: Yes, Invited?: No

23. Dasmeh A*, Gunay H B. (2018). Use of calibrated building performance simulation models in energy auditing. eSim, Montreal, Canada. IBPSA Canada,
    Paper
    Published
    Refereed?: Yes, Invited?: No

24. Abuimara T, O'Brien W, Gunay H B, Burpee H, Day J. (2018). Designing for occupants: a review of the integrated design practice. ACEEE Summer Study on Energy Efficiency in Buildings, Pacific Grove, United States. ACEEE,
    Paper
    Published
    Refereed?: Yes, Invited?: No

25. Ouf M*, O'Brien W, Gunay H B. (2018). A Framework to Improve Occupant Modeling Capabilities in Building Simulation Tools. eSim, Montreal, Canada. IBPSA Canada,
    Paper
    Published
    Refereed?: Yes, Invited?: No

26. Ouf M, O'Brien W, Gunay H B. (2018). Generating design sensitive occupant related schedules for building performance simulations. International Building Physics Conference, Syracuse, United States,
    Paper
    Published
    Refereed?: Yes, Invited?: No

27. O'Brien W, Abdelalim A, Beausoleil-Morrison, I, Carrizo S, Danks R, Gunay H B, Kesik T, Ouf M*. (2018). Occupant modelling for building codes and standards – technology roadmap. eSim, Montreal, Canada. IBPSA Canada,
    Paper
    Published
    Refereed?: Yes, Invited?: No

28. Gilani S*, O'Brien W, Gunay H B. (2018). Exploring occupants' impact at different spatial scales. International Building Physics Conference, Syracuse, United States,
    Paper
    Published
    Refereed?: Yes, Invited?: No

29. Yang C, Shen W, Chen Q, Gunay H B. (2017). Toward failure mode and effect analysis for heating, ventilation and air-conditioning. IEEE CSCWD, Wellington, New Zealand,
Paper
Published
Refereed?: Yes, Invited?: No

30. Gunay H B, O'Brien W, Beausoleil-Morrison I, Shen W, Newsham G, Macdonald I. (2017). The effect of zone level occupancy characteristics on adaptive controls. Building Simulation, San Francisco, United States,
Conference Date: 2017/8
Paper
Published
Refereed?: Yes, Invited?: No

31. Gunay H B*, Fuller A*, O'Brien W, Beausoleil-Morrison I. (2016). Detecting occupants' presence in office spaces: a case study. eSim, Hamilton, Canada,
Conference Date: 2016/5
Paper
Published
Refereed?: Yes, Invited?: No

32. Shi Z*, O'Brien W, Gunay H B*. (2016). Building zone fault detection with Kalman Filter-based methods. eSim, Hamilton, Canada,
Conference Date: 2016/5
Paper
Published
Refereed?: Yes, Invited?: No

33. O'Brien W, Gunay H B. (2016). Occupant behaviour diversity modelling and its applications. eSim, Hamilton, Canada,
Conference Date: 2016/5
Paper
Published
Refereed?: Yes, Invited?: No

34. Gunay H B*, O'Brien W, Beausoleil-Morrison I. (2016). A toolkit for developing data-driven occupant behaviour and presence models. eSim, Hamilton, Canada,
Conference Date: 2016/4
Paper
Published
Refereed?: Yes, Invited?: No

35. Gunay H B*, O'Brien W, Beausoleil-Morrison I, D'Oca S, Corgnati S. (2015). On modelling and simulation of occupant models (Best paper award). Building Simulation 2015, Hyderabad, India,
Conference Date: 2015/12
Paper
First Listed Author
Published
Refereed?: Yes, Invited?: No
Number of Contributors: 5

Funding Sources: Natural Resources Canada; Natural Sciences and Engineering Research Council of Canada (NSERC)

36. Ghods P, Isgor O B, Gunay H B*. (2015). Nano-scale investigation of interactions of chlorides with oxides that form on carbon steel in concrete pore solutions. Nanotechnology in Construction. International Symposium on Nanotechnology in Construction, Chicago, United States,
Conference Date: 2015/5
Paper
Published
Refereed?: Yes, Invited?: No

37. Megalla D*, Geel P V, Gladish A*, Gunay H B*. (2014). Impacts of aerobic and anaerobic biodegradation on the heat budget for landfills operating in northern climates. EuroWaste, Venice, Italy,
Conference Date: 2014/9
Paper
Published
Refereed?: Yes, Invited?: No

38. Huchuk B*, Cruickshank C A, O'Brien W, Gunay H B*. (2014). Recursive thermal building model training using Ensemble Kalman Filters. eSim, Ottawa, Canada,
Conference Date: 2014/4
Paper
Published
Refereed?: Yes, Invited?: No

39. Gunay H B*, O'Brien W, Beausoleil-Morrison I, Huchuk B*, Palmer M, Fletcher J, Pavlovski A. (2014). The effect of input uncertainty in model-based predictive control. eSim, Ottawa, Canada,
Conference Date: 2014/4
Paper
First Listed Author
Published
Refereed?: Yes, Invited?: No
Number of Contributors: 7

Funding Sources: Natural Sciences and Engineering Research Council of Canada (NSERC)

40. Bennet I*, O'Brien W, Gunay H B*. (2014). Effect of window blind use in residential buildings: observation and simulation study. eSim, Ottawa, Canada,
Conference Date: 2014/4
Paper
Published
Refereed?: Yes, Invited?: No

41. Gunay H B*, O'Brien W, Goldstein R, Breslav S, Khan A. (2013). Development of discrete event system specification (DEVS) building performance models for building energy design. Symposium on Simulation for Architecture & Urban Design, San Diego, United States,
Conference Date: 2013/4
Paper
Published
Refereed?: Yes, Invited?: No

42. Bonany J*, Geel P V, Gunay H B*. (2012). Process optimization at the Sainte-Sophie anaerobic bioreactor landfill, Quebec, Canada. CSCE Annual General Meeting and Conference, Edmonton, Canada,
Conference Date: 2012/6
Paper
Published
Refereed?: Yes, Invited?: No

43. Bonany J*, Geel P V, Gunay H B*, Isgor O B. (2012). Heat budget for the Sainte-Sophie anaerobic bio-reactor landfill, Quebec, Canada. AWMA 105th annual meeting, San Antonio, United States,
Conference Date: 2012/6
Paper
Published
Refereed?: Yes, Invited?: No

44. Gunay H B*, Isgor O B, Razaqpur A G, Foo S. (2011). Improving the energy efficiency of buildings with hollow core slabs: a numerical investigation. CSCE Annual General Meeting and Conference, Ottawa, Canada,
Conference Date: 2011/6
Paper
Published
Refereed?: Yes, Invited?: No

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Dissertation: Numerical Modelling of LPG Horizontal Cylindrical Tanks Subjected to Heating Environments

M.Sc. Mechanical Engineering, University of New Brunswick, Canada, 1985
Thesis: Numerical Studies of Free Convective Flows

B.Sc. Mechanical Engineering, University of New Brunswick, Canada, 1983

3 EMPLOYMENT HISTORY:

2017- Professor, Fire Safety Engineering, Department of Civil and Environmental Engineering, Carleton University

2001- 2017 Professor, Department of Civil and Environmental Engineering, Carleton University, Holder of Industrial Research Chair in Fire Safety Engineering.

1989 – 2001 Senior Research Officer and Group Leader,
Fire Risk Management Program
Institute for Research in Construction,
National Research Council Canada, Ottawa, Ontario.

1990 – 2001 Adjunct Professor
Mechanical Engineering Department, University of New Brunswick

1987 – 1988 Lecturer and Research Engineer
Mechanical Engineering Department, University of New Brunswick

1985 – 1986 Research Assistant
Mechanical Engineering Department, University of New Brunswick

1980 -1981 Site Engineer, A&P Paraskevaides Ltd., Abu-Dhabi, UAE

4 HONOURS:

- Outstanding paper award, 6th International Conference on Applications of Structural Fire Engineering, Singapore, 2019
- Carleton University Research Achievement Award, 2013
- Best paper award, International Symposium on Tunnel Safety and Security, New York, USA, March 2012
- NSERC Industrial Research Chair in Fire Safety Engineering, 2012-2017
- Best poster award, International Conference of Action Integrated Fire Engineering and Response, Prague, Czech Republic, April 2011.
- Best poster award, 6th International Conference on Structures in Fire, Michigan USA, June 2010
- NSERC Industrial Research Chair in Fire Safety Engineering, 2006-2011
- Elected fellow of Society of Fire Protection Engineers (SFPE), 2004
- Canada Foundation for Innovation grant for new Fire Research Facility, January 2002
- Ontario Innovation Trust grant for new Fire Research Facility, May 2002
- NSERC Industrial Research Chair in Fire Safety Engineering, 2001-2005
- ASHRAE, Best Symposium Paper Award, 1998
- SFPE Honor Lecturer, 1998
- SFPE Invited Speaker, 1994
- IRC Outstanding Achievement Award, given to the NFL's Risk-Cost Assessment Team, 1994

5 SCHOLARLY AND PROFESSIONAL ACTIVITIES:

- 2019 Organised 3rd International Fire Safety Symposium, IFireSS 2019, Chair of Organising Committe.
- 2017 Chair of Scientific Committee, 2nd International Fire Safety Symposium, IFireSS 2017
- 2015 Chair of Scientific Committee, 1st International Fire Safety Symposium, IFireSS 2015
- 2015- present Member of editorial board of Fire Technology
- 2014 – present Visiting Professor European University of Cyprus
- 2009 – 2017 Member IAFSS Executive Committee

- 2008 – 2016 Member of Departmental Review panel, Hong Kong Polytechnic University
- 2010 Member of Program Committee 8th International Conference on Performance-Based Codes and Fire Safety Design Methods
- 2009 Member of Scientific Advisory Board of Advanced Research Workshop Smoke Control in Buildings and Tunnels, Santander,
- 2008 – 2019 Coordinator of CIB W-14 Fire Safety
- 2005 – present Member of ULC Fire Test Committee

6 GRADUATE SUPERVISIONS:

	Completed	In Progress
Master's total	34	1
Master's thesis	24	0
Master's project	10	1
Doctoral	12	3
Postdoctoral	2	0

7 GRADUATE COURSES:

Fall 2019, Fundamentals of Fire Safety Engineering, CIVE 5609 (0.5 credit)
Winter 2019, Fundamentals of Fire Safety Engineering, CIVE 5609 (0.5 credit)
Winter 2018, Fundamentals of Fire Safety Engineering, CIVE 5609 (0.5 credit)
Winter 2017, Fundamentals of Fire Safety Engineering, CIVE 5609 (0.5 credit).
Winter 2016, Fundamentals of Fire Safety Engineering, CIVE 5609 (0.5 credit).
Winter 2014, Fundamentals of Fire Safety Engineering, CIVE 5609 (0.5 credit).
Winter 2013, Fire Modelling, CIVE 5612 (0.5 credit).
Winter 2012, Fundamentals of Fire Safety Engineering, CIVE 5609 (0.5 credit).
Winter 2011, Fire Modelling, CIVE 5612 (0.5 credit).
Winter 2010, Fundamentals of Fire Safety Engineering, CIVE 5609 (0.5 credit).

8 1. EXTERNAL RESEARCH FUNDING:

Source	**Type**	**Duration**	**Total (/yr)**	**Share (%)**	**Role**	**Purpose**
NSERC	grant	2019-24	32,000	100	PI	research
Bombardier	contract	2014-16	112,000	100	PI	testing
CHM Fire	contract	2015	12,955	100	PI	testing

CHM Fire	contract	2014	19,000	100	PI	testing
FII	contract	2015	52,800	100	PI	research
NSERC	grant	2012-16	38,000	100	PI	research
NSERC	grant	2012-16	40,000	100	PI	research
FPInnovations	grant	2012-16	25,000	100	PI	research
CIVELEC Consultants	grant	2012-16	15,000	100	PI	research
NSERC	grant	2010-14	1,060,000	18%	Co-PI	research
NSERC	grant	2007-11	24,000	100	PI	research

2. INTERNAL RESEARCH FUNDING:

Source	Type	Duration	Total (/yr)	Share (%)	Role	Purpose
CU	award	2013	10,000	100	PI	research

9 PUBLICATIONS:

a) Life-time summary:

- Papers in refereed journals 66
- Papers in refereed conference proceedings. 99
- Book Chapters……2
- Technical reports 52
- Others (workshops presented) 65

b) Journal Papers

1. Amir Rafinazari and George Hadjisophocleous, An investigation of the effect of make-up air velocity on smoke layer height with asymmetric openings and rotational air flow in atrium fires, Journal of Building Engineering, 27, https://doi.org/10.1016/j.jobe.2019.100933, 2020
2. Amir Rafinazari and George Hadjisophocleous, A study of the effect of make-up air velocity on the smoke layer height with symmetric openings in atrium fires, Fire Technology, 54, 229–253, 2018
3. Rafinazari A., Hadjisophocleous G. Full-Scale Tests and CFD Modeling to Investigate the Effect of Opening Arrangement on Smoke Layer Height in Atrium Fires, Fire Science and Technology 2017. Springer, Singapore
4. Xiao Li, Xiaoqian Sun, Chin-Fai Wong, George Hadjisophocleous, Effects of Fire Barriers on Building Fire Risk - A Case Study Using CUrisk, Procedia Engineering 135 (2016) 445 – 454
5. Duck Hee Lee, Won Hee Park, Uiwang, Jungho Hwang, George Hadjisophocleous, Full-Scale Fire Test of an Intercity Train, Fire Technology, in press DOI: 10.1007/s10694-015-0482-1
6. Li, X., Zhang X., Hadjisophocleous, G., McGregor, C. Experimental Study of Combustible and Non-combustible Construction in a Natural Fire. Fire Technology, in press. DOI: 10.1007/s10694-014-0407-4

7. Xia Zhang, Xiao Li and George Hadjisophocleous, A probabilistic occupant response model for fire emergencies, Fire Safety Journal, Volume 68, pp 41-51, 2014
8. Li, X., Zhang X., Hadjisophocleous, G. Fire Risk Analysis of a 6-Storey Residential Building Using CUrisk. Procedia Engineering, 2013. 62: 609-617. DOI: 10.1016/j.proeng.2013.08.106
9. Xia Zhang, Xiao Li and George Hadjisophocleous, A probabilistic occupant evacuation model for fire emergencies using Monte Carlo methods, Fire Safety Journal, Volume 58, pp 15-24, 2013
10. Yoon Ko and George Hadjisophocleous, Study of smoke backlayering during suppression in tunnels, Fire Safety Journal, Volume, pp 240-247, 2013
11. Yan Wang, George Hadjisophocleous and Ehab Zalok. Smoke movement in multi-storey buildings using CUsmoke. Safety Science, 52, pp.13-27, 2013
12. Duckhee Lee, Wonhee Park, Woosung Jung, Sungjin Yang, Hagbum Kim, George Hadjishophocleous4and Jungho Hwang, Estimations of heat release rate curve in case of railcar fire, Journal of Mechanical Science and Technology, (Accepted), (2012)
13. Wang, Y., Hadjisophocleous, G., Zalok, E., Smoke movement in multi-storey buildings using CUsmoke, Safety Science, Article in Press (2012)
14. Osama Salem, George Hadjisophocleous and Ehab Zalok, Experimental Examination of the Structural Performance of Restrained HSS Steel Beams and their End Connections in Fire, Journal of Structural Engineering, Volume 3, No 3, (2012)
15. Xia Zhang, George Hadjisophocleous, An improved two-layer zone model applicable to both pre- and post-flashover fires, Fire Safety Journal Volume 53, pp 63–71, 2012
16. Zhigang Liu, George Hadjisophocleous, Guofeng Ding and Siong Lim, Study of a Video Image Fire Detection System for Protection of Large Industrial Applications and Atria, Fire Technology, Volume 48, No 2, pp. 459-492, 2012
17. Hao Cheng and George Hadjisophocleous, Experimental Study and Modeling of Radiation from Compartment Fires to Adjacent Buildings, Fire Safety Journal, Volume 53 pp. 43–62, 2012
18. Lei Peng, George Hadjisophocleous, Jim Mehaffey and Mohammad Mohammad, Fire Performance of Timber Connections, Part 1: Fire Resistance Tests of Bolted Wood-Steel-Wood and Steel-Wood-Steel Connections, Journal of Structural Fire Engineering, Vol 3, Number 2 pp. 107 -132 (2012)
19. Lei Peng, George Hadjisophocleous, Jim Mehaffey and Mohammad Mohammad, Fire Performance of Timber Connections, Part 2: Thermal and Structural Modelling, Journal of Structural Fire Engineering, Vol 3, Number 2 pp. 133 -154 (2012)
20. Hao Cheng, George Hadjisophocleous, Dynamic modeling of fire spread in buildings, Fire Safety Journal, Volume 46, pp 211–224, 2011
21. Yoon J. Ko, Richard Michels, and George V. Hadjisophocleous, Instrumentation Design for HRR Measurements in a Large-Scale Fire Facility, Fire Technology, 47, 1047-1061, 2011
22. E. Zalok, G. V. Hadjisophocleous, Assessment of the Use of Fire Dynamics Simulator in Performance-Based Design, Fire Technology, 47, 1081-1100, 2011
23. Lei Peng, George Hadjisophocleous, Jim Mehaffey and Mohammad Mohammad, Predicting the Fire Resistance of Wood-Steel-Wood Timber Connections, Fire Technology, 47, 1101-1119, 2011
24. Y. Wang, E. Zalok, and G. V. Hadjisophocleous, An Experimental Study of Smoke Movement in Multi Storey Buildings, Fire Technology, 47, 1141-1169, 2011
25. Lei Peng, George Hadjisophocleous, Jim Mehaffey and Mohammad Mohammad, Performance of Unprotected Wood-Wood-Wood and Wood-Steel-Wood Connections: A Literature Review and New Data Correlations, Fire Safety Journal, Volume 45, Issue 6-8, 2010, Pages 392-399.

26. G. V. Hadjisophocleous and Z. Chen, Survey of Fire Loads in Elementary Schools and High Schools, Journal of Fire Protection Engineering, Vol. 20, pp. 55-71, 2010

27. E. Zalok, G. V. Hadjisophocleous, and G.D. Lougheed, Design Fire Experiments for Commercial Premises, Journal of Fire Sciences, 27, 4, pp 369 - 403*, 2009*

28. Hao Cheng and George Hadjisophocleous, The modelling of Fire Spread in Buildings by Bayesian Network, Fire Safety Journal, 44, 901 – 908, 2009

29. E. Zalok, G. V. Hadjisophocleous, and J. R. Mehaffey, Fire Loads in Commercial Premises, *Fire and Material.,33, 63-78, 2009*

30. Hadjisophocleous, G.V., Jia, Q, Comparison of FDS Prediction of Smoke Movement in a 10-storey Building with Experimental Data, Fire Technology, Vol. 45, No. 2, pp. 163-177, 2009

31. Hadjisophocleous, G., Ko Y, Impact of Various Parameters on the CFD Predictions of Atrium Smoke Management Systems. ASHRAE Transactions, CH-09-028, 2009

32. Kashef, Z.G. Liu, G. Lougheed, G. Crampton, K. Yoon, G. Hadjisophocleous and K.H. Almand, Findings of the International Road Tunnel Fire Detection Research Project, Fire Technology, Vol. 45, No. 2, pp. 221-237, 2009

33. Craft, S.T.; Isgor, B.; Hadjisophocleous, G.V. and Mehaffey, J.R. 2008. Predicting the Thermal Response of Gypsum Board Subjected to a Constant Heat Flux. Fire and Materials, 32, 333-355, 2008.

34. Klote, J, and Hadjisophocleous G.V., An Overview of Evacuation Analysis with Application to Smoke Control Systems, ASHRAE Transactions, SL-08-014, pp. 143150, 2008

35. Hadjisophocleous G.V. and Zhou J., Evaluation of Atrium Smoke Exhaust Make-up Air Velocity, ASHRAE Transactions, Volume 114, Part 1, pp 147-155, 2008

36. Zhou J. and Hadjisophocleous G.V., Parameters Affecting Fire Plumes, ASHRAE Transactions, Volume 114, Part 1, pp. 140-146, 2008

37. Ko Y, Hadjisophocleous, G., Lougheed, G., "CFD Study of the Air Entrainment of Balcony-Spill Plumes at the Balcony Edge", ASHRAE Transactions, Volume 114, Part 1, pp. 344-354, 2008.

38. Kang, Y., Hadjisophocleous, G.V., Khoo, H.A, Effect of Partial loss of Spray-on Protection on the Load Capacity of Steel Beams during a Standard Fire, Journal of Fire Protection Engineering, 2008; vol. 18: pp. 5 - 27

39. Hadjisophocleous, G.V., Fu, Z., Foo, S., and Dutcher, C., "Prediction of Fire Growth for Compartments of Office Buildings as Part of a Fire Risk/Cost Assessment Model", SFPE Journal of Fire Protection Engineering, pp 185-209, 2007

40. Hadjisophocleous, G, Zalok, E., "Experiments for the Characterization of Design Fires for Commercial Buildings", ASHRAE Transactions, CH-06-3-3, pp 394-400, 2006.

41. Hadjisophocleous, G.V., and McCartney, "Guidelines for the Use of CFD Simulations for Fire and Smoke Modelling", ASHRAE Transactions, DE-05-7-3 pp. 583-594, 2005 (Presented at the ASHRAE Annual Meeting in Denver in June 2005)

42. Hadjisophocleous, G.V., Richardson, J.K., Water Flow Demands for Firefighting, Fire Technology, 41, 173-191, 2005

43. Bénichou, N., Kashef, A.H., Reid, I., Hadjisophocleous, G.V., Torvi, D.A., and Morinville, G., "FIERASYSTEM: A fire risk assessment tool to evaluate fire safety in industrial building and large spaces, Journal of Fire Protection Engineering, Journal of Fire Protection Engineering, Aug 2005; 15: 145 - 172

44. Hadjisophocleous, G.V., Fu, "Literature Review of Fire Risk Assessment Methodologies", International Journal on Engineering Performance-Based Fire Codes Volume 6, Number 1, pp 28-

45, 2004

45. Hadjisophocleous, G.V., Fu, Z., and Lougheed, G.D., “Experimental Study and Zone Modelling of Smoke Movement in a Model Atrium”, ASHRAE Transactions, 108, (2), pp. 865-871, 2002.
46. Torvi, D.A.; Hadjisophocleous, G.V.; Guenther, M.B.; Thomas, G., "Estimating water requirements for firefighting operations using FIERAsystem," Fire Technology, 37, (3), July, pp. 235-262, 2001.
47. Hadjisophocleous, G.V., Bénichou, N., "Development of performance-based codes, performance criteria and fire safety engineering methods," International Journal on Engineering Performance-Based Fire Codes, Vol. 2 Number 4, pp. 127-142, 2000.
48. Fu, Z., Hadjisophocleous, G.V., "Two-zone fire growth and smoke movement model for multi-compartment buildings," Fire Safety Journal, 34, pp. 257-285, 2000.
49. Hadjisophocleous, G.V., Lougheed, G.D., "Experimental and numerical study of smoke conditions in an atrium with mechanical exhaust," International Journal on Engineering Performance-Based Fire Codes, 1, (3), pp. 183-187, 2000.
50. Torvi, D.A., Hadjisophocleous, G.V., "Research in protective clothing for fire fighters - state of the art and future directions," Fire Technology, 35, (2), May pp. 111-130, 1999
51. Hadjisophocleous, G.V., Bénichou, N., "Performance criteria used in fire safety design," Automation in Construction, 8, (4), pp. 489-501, 1999
52. Hadjisophocleous, G.V., Fu, Z., "Modeling smoke conditions in large compartments equipped with mechanical smoke exhaust using a two-zone model," International Journal on Engineering Performance-Based Fire Codes, 1, (3), pp. 162-167, 1999.
53. Yung, D.T., Hadjisophocleous, G.V., "Cost-effective fire-safety retrofits for Canadian government office buildings," International Journal on Engineering Performance-Based Fire Codes, 1, (3), pp. 123-128, 1999.
54. Lougheed, G.D., Hadjisophocleous, G.V., McCartney, C., Taber, B.C., "Large-scale physical model studies for an atrium smoke exhaust system," ASHRAE Transactions, 105, (1), pp. 676-698, 1999
55. Hadjisophocleous, G.V., Lougheed, G.D., Cao, S., "Numerical study of the effectiveness of atrium smoke exhaust systems," ASHRAE Transactions, 105, (1), pp. 699-715, 1999
56. Yung, D.T., Hadjisophocleous, G.V., Proulx, G., "A Description of the probabilistic and deterministic modelling used in FiRECAM," International Journal on Engineering Performance-Based Fire Codes, 1, (1), pp. 18-26, 1999
57. Hadjisophocleous, G.V., Bénichou, N., Tamim, A.S., "Literature review of performance-based fire codes and design environment," Journal of Fire Protection Engineering, 9, (1), pp. 12-40, 1998
58. Lougheed, G.D., Hadjisophocleous, G.V., "Investigation of atrium smoke exhaust effectiveness," ASHRAE Transactions, 103, (2), pp. 519-533, 1997 (Presented at the ASHRAE Annual Meeting in Boston in June 1997)
59. Karagiozis, A.N., Hadjisophocleous, G.V., Cao, S., "Wind-driven rain distributions on two buildings," Journal of Wind Engineering and Industrial Aerodynamics, 67-68, pp. 559-572, 1997
60. Hadjisophocleous, G.V., Cacambouras, M., "Computer modeling of compartment fires," Journal of Fire Protection Engineering, 5, (2), pp. 39-52, 1993
61. Hadjisophocleous, G.V., Yung, D.T., "Model for calculating the probabilities of smoke hazard from fires in multi-storey buildings," Journal of Fire Protection Engineering, 4, (2), pp. 67-80, 1992 (Reprinted in NRCC-39021)
62. Hadjisophocleous, G.V., Sousa, A.C.M., Venart, J.E.S., "Mathematical modelling of LPG tanks subjected to full and partial fire engulfment," International Journal for Numerical Methods in Engineering, 30, pp. 629-646, 1990

63. Hadjisophocleous, G.V., Sousa, A.C.M., Venart, J.E.S., "A Study of the effect of the tank diameter on the thermal stratification in LPG tanks subjected to fire engulfment," Journal of Hazardous Materials, 25, pp. 19-31, 1990
64. Hadjisophocleous, G.V., Sousa, A.C.M., Venart, J.E.S., "Prediction of transient natural convection in enclosures of arbitrary geometry using a nonorthogonal numerical model," Numerical Heat Transfer: An International Journal of Computation and Methodology, 13, (3), pp. 373-392, 1988
65. Hadjisophocleous, G.V., Sousa, A.C.M., "Three dimensional numerical predictions of internally heated free convective flows," Warme- und Stoffubertragung, 21, pp. 283-290, 1987
66. Sousa, A.C.M., Hadjisophocleous, G.V., Venart, J.E.S., "Numerical simulation of 3-D laminar free convection in tanks with localized heat sources," Heat and Technology, 3, (1), pp. 49-60, 1985

c) Papers in Refereed Conference Proceedings

1. Aba Owusu, Osama (Sam) Salem and George Hadjisophocleous, Fire performance of concealed timber connections with varying bolt patterns, Applications of Structural Fire Engineering, Singapore, P39, 2019
2. Oluwadamilola Okunrounmu, Paul Lhotsky and George Hadjisophocleous, Drainage characteristics of compressed air foam subjected to thermal radiation, Third International Fire Safety Symposium, IFireSS 2019, Ottawa, Canada, 593-599, 2019
3. Kyriacos A. Kyriakides and George Hadjisophocleous, Evaluation of structural behaviour of a Franco-byzantine Basilica in Cyprus after a fire attack, Third International Fire Safety Symposium, IFireSS 2019, Ottawa, Canada, 389-398, 2019
4. Paul Lhotsky, Carlo Mastroberardino and George Hadjisophocleous, Fire protection design for automated storage and retrieval systems (ASRS) warehouses, Third International Fire Safety Symposium, IFireSS 2019, Ottawa, Canada, 559-564, 2019
5. Hossam Shalabi and George Hadjisophocleous, High energy arc faults (HEAF) in Canadian nuclear plants, Third International Fire Safety Symposium, IFireSS 2019, Ottawa, Canada, 559-564, 2019
6. Aba Owusu, Osama (Sam) Salem and George Hadjisophocleous, Fire performance of protected and unprotected concealed timber connections, Third International Fire Safety Symposium, IFireSS 2019, Ottawa, Canada, 370-378, 2019
7. Amir Rafinazari, George Hadjisophocleous, Make-up Air Effects on the Smoke Interface Height in Atrium Fires, Proceedings, 14th International Interflam Conference 2016, London, UK, 1277-1287, 2016
8. Xia Zhang, Jim Mehaffey, George Hadjisophocleous, Effects of Performance of Active Fire Protection Systems o
9. n Life Risks due to Fire in a Mid-rise Residential Building, Proceedings, 14th International Interflam Conference 2016, London, UK, 1217-1228, 2016
10. Hailey Quiquero, John Gales, George Hadjisophocleous, Behaviour of Char Layer in Fire-damaged box Section Timber Beams, Proceedings, 14th International Interflam Conference 2016, London, UK, 1063-1074, 2016
11. Amir Rafinazari, George Hadjisophocleous. Full-scale Tests and CFD Modelling to Investigate the Effect of Different Make-up Air Velocities on Smoke Layer Height in Atrium Fires, International Fire Safety Symposium 2015, Coimbra, Portugal, April 20-22, 2015
12. Xia Zhang, Xiao Li, George Hadjisophocleous. A design Fire Model for the Full Process of Fire, International Fire Safety Symposium 2015, Coimbra, Portugal, April 20-22, 2015.
13. Li, X., Zhang X., Hadjisophocleous, G. The Effects of Construction Type and Active Fire Protection

Option on the Overall Building Fire Risk. International Fire Safety Symposium 2015, Coimbra, Portugal, April 20-22, 2015.

14. Li, X., Rao, P., Zhang X., Hadjisophocleous, G. A case study on the effect of building construction type, height and area on the building fire risk using the fire risk assessment model CUrisk. 14th International Conference on Fire and Materials, San Francisco, USA, February 2-4, 2015
15. Sabah G. Ali, Aaron O. Akotuah, Jeffrey Erochko and George Hadjisophocleous, Fire Performance of Hybrid Timber Connections with Full-Scale Tests and Finite Element Modelling, 8th International Conference on Structures in Fire, Shanghai, China, June 11-13, 2014
16. George Hadjisophocleous, Duck Hee Lee and Won Hee Park, Development of a Full-Scale Intercity Traincar Fire, Sixth International Symposium on Tunnel Safety and Security, Marseille, France, March 12-14, 2014, pp 123-132
17. George Hadjisophocleous, Duck Hee Lee and Won Hee Park, Development of a Full-Scale Intercity Traincar Fire, Sixth International Symposium on Tunnel Safety and Security, Marseille, France, March 12-14, 2014, pp 123-132
18. Cameron McGregor, George Hadjisophocleous and Steven Craft, Contribution of Cross Laminated Timber Panels to Room Fires, Conference Proceedings of the Thirteenth International Interflam Conference, London UK, June 24-26, 2013, pp 1453-1464.
19. Sabah Ali and George Hadjisophocleous, Full-Scale Tests to Study the Influence of Various Parameters on the Fire Performance of Hybrid Timber Connections, Conference Proceedings of the Thirteenth International Interflam Conference, London UK, June 24-26, 2013, pp. 1169-1179.
20. Xia Zhang, Xiao Li and George Hadjisophocleous, Modelling the Response of Occupants to Warnings from Different Fire Safety Systems, Conference Proceedings of the Thirteenth International Interflam Conference, London UK, June 24-26, 2013, pp 577-582.
21. Marc Aguanno, George Hadjisophocleous and Steven Craft, Fire Resistance Tests on Cross Laminated Timber Floor Panels, Fire and Materials 2013, 13th International Conference, January 28-30, 2013, San Francisco, California, USA, pp. 197-208
22. Amir Rafinazari and George Hadjisophocleous, Full Scale Tests and CFD Modeling of a Compartment Fire in an Atrium with Smoke Exhaust, Advanced Research Workshop, Fire Protection and Life Safety in Buildings and Transportation Systems, Santander, Spain, pp 87-102, 2012
23. Xiao Li, Xia Zhang, George Hadjisophocleous Fire Risk Analysis of a 6-Storey Residential Building by CUrisk, 9th Asia-Oceania Symposium on Fire Science and Technology, Hefei, China, October 2012, Procedia Engineering 00 (2012) 000–000.
24. Salem, O., Hadjisophocleous, G., and Zalok, E., "FE Modelling of Bolted Steel End-Plate Moment Connections Subjected to a Standard Fire", 14th Int. Symposium on Tubular Structures (ISTS14), London, UK, Sept. 12 to 14, Editor Leroy Gartner, pp. 2012.
25. George Hadjisophocleous, Duck Hee Lee and Won Hee Park, Full-scale Experiments for Heat Release Rate Measurements of Railcar Fires, Fifth International Symposium on Tunnel Safety and Security, New York, USA, March 14-16, 2012, pp 457-466. Best paper award.
26. Osama Salem, George Hadjisophocleous and Ehab Zalok, Fire Modelling of Axially-restrained tubular Steel Beams, Proceedings, Application of Structural Fire Engineering, 29 April 2011, Prague, Czech Republic, pp 49-54. (Best Poster Award)
27. Lei Peng, George Hadjisophocleous, Jim Mehaffey and Mohammad Mohammad, On the Fire Performance of Double-Shear Timber Connections, 10th International IAFSS Symposium, 2011, Maryland, USA, pp 1207-1218
28. Ling Lu, Jim Mehaffey, George V. Hadjisophocleous and Xin Mou, Fire Risk Analysis for Single Family Houses – Validation of CUrisk, Fire and Materials - 12th International Conference, 31st Jan -

2nd Feb 2011, San Francisco, California, USA, pp195-207.

29. Lei Peng, George Hadjisophocleous, Jim Mehaffey and Mohammad Mohammad, Calculating Fire Resistance of Timber Connections, Fire and Materials – 12th International Conference, 2011, San Francisco, USA.
30. Yoon Ko, George Hadjisophocleous, Modelling the Interaction Between Suppression and Ventilation Systems in Tunnel Fires, Proceedings of the Twelfth International Conference INTERFLAM, 2010, Nottingham UK, pp. 1103-1113
31. Yoon Ko, George Hadjisophocleous, An Experimental Study of the Impact of Tunnel Suppression on Tunnel Ventilation, Proceedings of the Fourth International Symposium on Tunnel Safety and Security, 2010, Frankfurt am Main, Germany pp. 232-240
32. Lei Peng, George Hadjisophocleous, Jim Mehaffey and Mohammad Mohammad, On the Fire Performance of Wood-Wood-Wood and Wood-Steel-Wood Connections Using Bolts and Dowels, Proceedings of the Twelfth International Conference INTERFLAM, 2010, Nottingham UK.
33. Lei Peng, George Hadjisophocleous, Jim Mehaffey and Mohammad Mohammad, Fire Resistance of Wood-Steel-Wood Bolted Timber Connections, Structures in Fire – Proceedings of the Sixth International Conference, 2010, Pages 552-559. (Best poster award)
34. Cheng, H., Hadjisophocleous, G.V., Experiments to Investigate Radiant Heat Flux on Adjacent Buildings, Advanced Research Workshop, Fire Protection and Life Safety in Buildings and Transportation Systems, Santander, Spain, pp 87-102, 2009
35. 66. Craft, S.T., Isgor, B., Mehaffey, J.R. and Hadjisophocleous, G.V., 2008. Modelling Heat and Mass Transfer in Wood-frame Floor Assemblies Exposed to Fire. Proceedings of the Ninth International Symposium – Fire Safety Science, September 21st – 26th, Karlsruhe, Germany.
36. Yoon, K., Hadjisophocleous, G.V., Kashef, A., Modelling Smoke Movement during the Early Stage of Tunnel Fires under Different Ventilation Conditions, Proceedings of International Congress Smoke Control in Buildings and Tunnels, Santander, Spain, pp 305-332, 2008
37. Kashef, A, Liu, Z.G., Lougheed, G, Crampton G., Yoon, K., Hadjisophocleous, G.V., Almand, K.H., Findings of the International Road Tunnel Fire Detection Research Project, Proceedings of International Congress Smoke Control in Buildings and Tunnels, Santander, Spain, pp 247-261, 2008
38. Hadjisophocleous, G.V., Jia, Q, Comparison of FDS Prediction of Smoke Movement in a 10-storey Building with Experimental Data, Proceedings of International Congress Smoke Control in Buildings and Tunnels, Santander, Spain, pp19-28, 2008
39. Hadjisophocleous, G.V., Zalok, E., Development of Design Fires for Performance-Based Designs, Keynote Paper, Proceedings of the Ninth International Symposium – Fire Safety Science, September 21st – 26th, Karlsruhe, Germany.
40. Chen, Z., Hadjisophocleous, G. and Zalok, E., A Survey of Fire Loads in Motels and Hotels, 3rd International Symposium, "Centre of Excellence" of Research and Education for Fire Safety Science, and Developing a Global Network, pp 235-247, March 10-11, 2008
41. Lei Peng, George Hadjisophocleous, Jim Mehaffey and Mohammad Mohammad, "An Investigation on Heavy Timber Connections Exposed to Fire", CSCE 2008 Annual Conference, June 10-13, 2008, Quebec City, QC, Canada.
42. Lu, L., Isgor, B, Hadjisophocleous, G.V., A Numerical Study of the Modulus of Elasticity for Wood Floor Joists during a Fire, CSCE 2008 Annual Conference, June 10-13, 2008, Quebec City, QC, Canada.
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54. George Hadjisophocleous and Zhuman Fu, "Development and Case Study of a Risk Assessment Model CUrisk for Building Fire" Fourth International Symposium on Fire Safety Science, Beijing, China, pp. 877-887, 2005.
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57. Hadjisophocleous G.V, Fu, Z., "A Fire Risk Computer Model for Commercial Timber-Frame Buildings", Fire and Explosion Hazards", Londonderry, Northern Ireland, pp 481-492, 2003
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Smoke Flow in the Stair Shaft of a 10-Storey Tower Using CONTAMW and FIERAsmoke", Submitted to: ASHRAE Winter Meeting, Atlanta, GA., U.S.A., 2001.

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81. Hadjisophocleous, G.V., Yung, D.T., "Parametric study of the NRCC fire risk-cost assessment model for apartment and office buildings," Fourth International Symposium on Fire Safety Science (Ottawa, Ont., Canada, 1994), pp. 829-840, 1994
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94. Hadjisophocleous, G.V., Sousa, A.C.M., Venart, J.E.S., "Natural convection heat transfer in partially filled horizontal cylinders," Numerical Methods in Thermal Problems: Proceedings of the 6th International Conference (Swansea, U.K., 1989), pp. 611-621, 1989 (ISBN: 0906674697) (Main QC320.2 I61)
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96. Sollows, K.F., Aydemir, N.U., Hadjisophocleous, G.V., Dutcher, C.R., Venart, J.E.S., Sousa, A.C.M., "Full field flow visualization and analysis: convection in partly filled horizontal cylinders," Proceedings of the First World Conference on Experimental Heat Transfer, Fluid Mechanics, and Thermodynamics (Dubrovnik, Yugoslavia, 1988), pp. 730-736, 1988 (ISBN: 0444013377) (Main QC319.8 W927)
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d) Book Chapters

- Hadjisophocleous G., Johnson, R., Proceedings, 3rd International Fire safety Symposium, IFireSS 2019, ISBN 9781488400100
- Hadjisophocleous G, Mehaffey, J. SFPE Handbook of Fire Protection Engineering, 5th Edition, Chapter 5.11 Fire Scenarios, Society of Fire Protection Engineers, 2015.

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Summary:

Self-motivated, practical, and capable of developing novel and comprehensive research plans with existing resources. While a great team-player, can succeed working independently. Equipped with numerical and analytical modelling skills.

Awards:

Best PhD Thesis Award by IIFC
NSERC PDF 2019 Scholarship

Software skills:

- ABAQUS
- MATLAB
- VBA (MS-Office)
- AutoCAD
- SAP
- ETABS

References:

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Structural Safety Researcher & Structural Engineer

2017–10 Present **Postdoctoral Fellow**
Queen's University

- Contributing significantly to the development the new ACI-216 Guideline
- Developing design guidelines for efficient design of GFRP reinforced concrete slabs in fire
- Studying the fire and the collapse of Plasco Tower in collaboration with Hong Kong Polytechnic University
- Drafting technical reports for Ontario Ministry of Transportation
- Co-supervising two graduate students
- Collaborating with Cergy University to study the behavior of high strength concrete at high temperatures
- Studying the shear and bond strength of Recycled Aggregate Concrete (RAC)

2018–11 2018–12 **Visiting Researcher**
Hong Kong Polytechnic University

- Modelling the collapse of Plasco Tower in fire using OpenSees program

Experiences: Research & Teaching

2012-09 2017-09 **Research & Teaching Assistant (PhD Candidate)**
Queen's University

- Enhanced the knowledge on the tensile and bond behavior of GFRP bars at high temperatures
- Identified and quantified the most dominant material properties of FRP at high temperatures
- Designed GFRP reinforced concrete slabs using CSA S806, CSA A23.3 ACI 440.1R
- Performed standard fire tests on GFRP reinforced concrete slabs at the National Research Council of Canada (NRC) according to ASTM E119 and ULC S101
- Implemented non-contact optical methods such as Digital Image Correlation (DIC) in measuring the strains on GFRP bars and concrete at high temperatures
- Modelled the multiphysics heat transfer and mechanical behavior of reinforced concrete slabs in fire using ABAQUS

Teaching Fellow
Queen's University

2014-01 2014-05
- Taught course CIVL-215 (Materials for Civil Engineers) in winter 2016 semester

HAMZEH HAJILOO

Structural Safety Researcher & Structural Engineer

Engineering Work Experiences

2014-03
2014-06

Internship (Mitacs Canada)
Pultrall Company, Canada

- Involved in Quality Assurance tests and requirements for FRP production
- Involved in daily Research & Development activities in the plant such as improving the GFRP bond strength to concrete

2009
2010

Structural Engineer & Engineering Team leader
Radyab Consulting Engineer Company, Partner of DRM Swiss

- Involved in the Bam Earthquake Emergency Reconstruction Project (BEER) to restore the living conditions of the communities affected by the earthquake
- Led the local engineering team responsible of the inspection and evaluation of key structures
- Modelled buildings in ETABS using the collected information from the inspection phase and the available as-built documents
- Determined the level of deficiency of buildings and developed strengthening plans

2010
2012

Structural Engineer
Miragar Tajhiz Consulting company
Tehran, Iran

- Conducted the inspection, evaluation, and modelling of three school buildings

Education

2017 **Queen's University**
Doctor of Philosophy (PhD) / Structural Engineering

- Thesis: Glass Fibre Reinforced Polymer (GFRP) Internally Reinforced Concrete Slabs in Fire

2009 **University of Tehran**
Master's degree / Structural Engineering

- Thesis: efficiency of FRP confinement around square columns

2006 **Urmia University**
Bachelor / Civil Engineering

HAMZEH HAJILOO Structural Safety Researcher & Structural Engineer

PUBLICATIONS & CONTRIBUTIONS

Journal Papers

1. **Hajiloo**, H., & Green, M. F. (2019). GFRP reinforced concrete slabs in fire: Finite element modelling. *Engineering Structures,* 183, 1109-1120.

2. **Hajiloo**, H., Green, M. F., Noël, M., Bénichou, N., & Sultan, M. (2019). GFRP-Reinforced Concrete Slabs: Fire Resistance and Design Efficiency. *Journal of Composites for Construction,* 23(2), 04019009.

3. **Hajiloo**, H., and Green, M. (2018) Bond Strength of GFRP Reinforcing Bars at High Temperatures with Implications for Performance in Fire. *Journal of Composites for Construction,* 22(6): 04018055.

4. **Hajiloo**, H., and Green, M. (2018) Post-Fire Residual Properties of GFRP Reinforced Concrete Slabs: A Holistic Investigation. *Composite Structures*, 201: 398-413.

5. **Hajiloo**, H., Green, M., and Gales, J. (2018) Mechanical Properties of GFRP Reinforcing Bars at High Temperatures. *Construction and Building Materials*, 162: 142-154.

6. **Hajiloo**, H., Green, M., Noël, M., Bénichou, N., and Sultan, M. (2017) Fire Tests on Full-Scale FRP Reinforced Concrete Slabs. *Composite Structures*, 179: 705-719.

7. Pliya, P., Cree, D., **Hajiloo**, H., Beaucourm, A.-L., Green, M. F., Noumowé, A. (2019). High-Strength Concrete Containing Recycled Coarse Aggregate Subjected to Elevated Temperatures. *Fire Technolgy,* https://doi.org/10.1007/s10694-019-00820-0

8. Yarlagadda, T., **Hajiloo**, H., Jiang, L., Green, M., & Usmani, A. (2018). Preliminary Modelling of Plasco Tower Collapse. *International Journal of High-Rise Buildings*, 7(4), 397-408.

9. Tomlinson, D., Moradi, F., **Hajiloo**, H., Ghods, P., Alizadeh, A., and Green, M. (2017) Early Age Electrical Resistivity Behaviour of Various Concrete Mixtures Subject to Low Temperature Cycling. *Cement and Concrete Composites*, 83: 323-334.

10. Adelzadeh, M., **Hajiloo**, H., and Green, M. (2014) Numerical Study of FRP Reinforced Concrete Slabs at Elevated Temperature. *Polymers,* 6(2): 408-422.

Selected refereed conference

1. **Hajiloo**, H., Jiang, L., Yarlagadda, T., Usmani, A., and Green, M. (2018) Collapse Analysis of the Plasco Tower Using Opensees. The 10th Int. Conference on Structures in Fire (SiF'18), Ulster University, Belfast, UK, 41-48. (Other work)

2. **Hajiloo,** H., Adelzadeh, M., and Green, M. (2017) Collapse of the Plasco Tower in Fire. The 1st Int. Conference on Structural Safety under Fire & Blast, London, UK. (Other work)

3. **Hajiloo,** H., and Green, M. (2017) Rational Fire Scenarios on FRP Reinforced Concrete Slabs. The 5th Int. Conference on Durability of FRP Composites for Construction and Rehabilitation of Structures, Sherbrooke, Canada. (PhD work)

4. **Hajiloo,** H., and Green, M. (2016) Post-Fire Residual Strength of GFRP Bars. The 5th Int. Structural Specialty Conference, London, ON. (PhD work)

5. **Hajiloo,** H., and Green, M. (2016) Numerical Analysis of the Post-Fire Strength of FRP Reinforced Bridge Decks. The 8th Int. Conference on Fibre-Reinforced Polymer (FRP) Composites in Civil Engineering (CICE 2016), Hong Kong, China. (PhD work)

6. **Hajiloo,** H., Green, M., Bénichou, N., and Sultan, M. (2016) Fire Performance of FRP reinforced concrete slabs. The 7th Int. Conference on Advanced Composite Materials in Bridges and Structures, Vancouver, Canada. (PhD work)

7. **Hajiloo,** H., Green, M., Bénichou, N., and Sultan, M. (2016) GFRP Reinforced Concrete Slabs with Low Cover in Fire. The 9th Int. Conference on Structures in Fire, Princeton, NJ, 3-11. (PhD work)

8. **Hajiloo,** H., Gales, J., Noël, M., and Green, M. F. (2015) Material Characteristics of GFRP Bars at High Temperature. 5th Int. Workshop on Performance, Protection & Strengthening of Structures under Extreme Loading, East Lansing, MI, 94-104. (PhD work)

9. **Hajiloo,** H., Motavalli, M., Hosseini, A. (2009) Improvement in Axial Stress-Strain Behavior of Columns Using Pre-Stressed Non-Laminated FRP. The 3rd Int. Conference on Concrete and Development, Tehran, Iran (MSc work)

WILLIAM (LIAM) O'BRIEN, Ph.D., P.Eng.

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Citizenship: Canadian and American (dual)

CAREER OBJECTIVES:

- Engage the public, industry, and students about high-performance building and city design and operation
- Develop new knowledge and research methods on building occupants through multidisciplinary collaboration
- Inspire and train students through creative teaching techniques, real applications, and challenging projects
- Maintain and build close ties with government agencies and laboratories, industry, and international researchers to disseminate research findings and demonstrate technologies

EDUCATION

- 2007 to 2011 — Ph.D., Concordia University, Building Engineering. Supervisors: A. Athienitis and T. Kesik (Toronto) *The development and methodology of a conceptual solar house design tool*
- 2005 to 2007 — M.A.Sc.,UTIAS (University of Toronto Institute for Aerospace Studies). *Development of fully functional nanosatellites deployers*. All five deployers were successful after launch from India on April 28, 2008.
- 2001 to 2005 — B. Eng. Honours, Ryerson University, Aerospace Engineering. *A study of the economic feasibility of generating wind power in an urban environment*.

RECENT CAREER HIGHLIGHTS

- **Editor for two books: on net-zero energy buildings and on occupant research methods; 78 published or submitted journal articles, and 80 conference papers; 6 best paper awards & 1 data viz. award**.
- Approx. **$3.4-million in research funding ($2.4-million as PI)** from NSERC, OCE, the Ontario and Canadian Governments, ASHRAE, and 12 industry and government laboratory partners in the past six years.
- NSERC Discovery Accelerator Supplement ($40k/year, 2019-2022)
- Founder and PI of Human Building Interaction Laboratory, an interdisciplinary team (civil, environmental, mechanical, and electrical engineering; architecture; psychology) of approx. 12 graduate students and staff
- Numerous Canadian and international keynote and plenary talks, such as a TEDxTalk and eSim 2018
- Elected President of IBPSA-Canada for two terms 2014-2018; chaired 2 conferences and 3 industry workshops
- My first supervised PhD student, **Burak Gunay won the Governor General's Medal and Senate Medal and received a tenure-track assistant professor position at Carleton**; **my second PhD student also received an assistant professor position**; former post-doc **Mohamed Ouf is an assistant professor at Concordia**
- Extensive national and international interdisciplinary collaboration (e.g., **Operating Agent for new IEA EBC Annex 79 Occupant-centric building design and operation**; subtask co-leader of International Energy Agency Energy in Buildings and Communities Programme Annex 66: Definition and Simulation of Occupant Behaviour in Buildings; researcher of NSERC Smart Net-zero Energy Buildings Strategic Network)
- Author of five of the top 25 cited articles in Building and Environment and Building and Energy since 2013; Best review paper in Energy in Buildings from 2008-2017
- Development of novel occupant models covering occupancy, lighting, thermostats, and window blinds; implementation and public release of about 20 occupant models into EnergyPlus and training exercises.
- Construction of a living lab, whereby we have complete access to develop and test novel building control schemes. We have **reduced heating and cooling energy by 75% from the original controls.**
- Recipient of the **Ontario Building Envelope Council Rising Star Award**, **IBPSA Outstanding Young Contributor Award**, **Ontario Early Researcher Award** ($150K), **Carleton Research Achievement Award** ($15K), **Carleton Research Excellence Fund** ($60K), Carleton **Teaching Excellence Award** ($1.5k)
- Consulting for energy and sustainability of 12 different building projects using building simulation.

TECHNICAL SKILLS

- Occupant behaviour monitoring and modelling to support building performance simulation
- Multi-scale energy modelling from renewable energy and building systems to the urban scale
- Dynamic energy modelling, design, and visualization of the design space of buildings and renewable energy systems; working knowledge of building energy codes: ASHRAE Standards. 90.1, 55, and 62.1, Ontario Building Code, Canadian Building Code
- Strong MATLAB programming skills: scripting, file I/O, graphical user interface design, image recognition and processing
- Software: MS Office, EnergyPlus, OpenStudio, ESP-r, TRNSYS, EE4 (DOE-2.1), LBNL WINDOW 6, RETScreen, SketchUP, CATIA, SolidEdge, AutoCAD, IDEAS, Daysim, IA-QUEST, CONTAM, HOT3000, AGI 32
- Life cycle analysis: energy, cost, and emissions
- Lab and experimental experience: analysis of monitored buildings, vibration testing, thermal shocking and thermal vacuum testing, aerodynamics/wind tunnels, fluids, heat transfer, materials science, green roof monitoring

PROFESSIONAL ACADEMIC EXPERIENCE

July 2011- **Associate Professor (tenured as of Dec. 2014; promoted to Associate Professor July 2016) and Program Advisor, Architectural Conservation and Sustainability Engineering, Department of Civil and Environmental Engineering (cross-appointment with Mechanical and Aerospace Engineering), Carleton University, Ottawa, Canada**

- Principal Investigator of the Human Building Interaction Lab (2012-)
- Founding member of the Carleton Building Performance Research Centre (with five other professors)
- Developed new curriculum for and taught the following courses:
    - ENVE 4105: Green Building Design (undergraduate); enrolled by engineering and architecture students
    - ENVE 4106/5104: Indoor Air Quality (undergrad/grad)
    - ENVE 4106/5104: Indoor Environmental Quality (undergrad/grad)
    - ENVE 5704: Research Methods for Building Engineering (grad)
- Taught/coordinated the following courses:
    - ECOR 4995: Professional Practice (for engineering)
    - ENVE 4918: 4th Year Engineering Design Project
- Innovative use of educational technology:
    - Module developer for University of Toronto-led online buildings science course
    - Introduced ePortfolios as a method for students to reflect on their work in the context of learning outcomes of their fourth-year design project
    - Co-developed, co-taught, and administered Carleton's largest online course (Professional Practice) with about 500-600 students/year
    - Developed online resource to provide students with understanding of building design and construction process using a new Carleton building as a case study (resource includes online repository of recorded interviews, guest lectures, technical tours, building energy data, drawings, and contract documents)
    - Developed many classroom experiments (e.g., Heliodon daylight testing device, 3D printed solar shading devices, kit of indoor environmental quality measurement devices)
- Completed 12-week Certificate in University Teaching at Carleton
- Thesis defense committees: 8 MASc, 5 PhD (3 external)

- Faculty Advisor, ASHRAE Carleton University Student Chapter (2012-)
- Faculty Advisor, Team Ontario: Solar Decathlon (2011-2013)
    - Advised on simulation-based design methodologies and modelling approaches for advanced building systems
- Committees:
    - Chair of an assistant professor hiring committee; member of several others
    - NSERC PGS committee (2018)
    - Graduate Attributes (development of system for assessing engineering graduates based on Canadian Engineering Accreditation Board)
    - Green Revolving Fund committee: a $1-million fund that was established to identify and select proposals for Carleton campus retrofits that are both economically and environmentally sustainable
    - Carleton Sustainability Committee
    - Outreach committee (attend numerous recruitment events and give presentations and technical tours, and lead hands-on activities for potential new students)

OTHER RESEARCH AND RELATED WORK EXPERIENCE

2011 **Researcher, Natural Resources Canada (3-month contract)**

- Worked on joint research project with Lawrence Berkeley National Labs (LBNL) to optimize the controls of commercial buildings to reduce peak loads and ultimately energy costs.

2007 to 2011 **Research Assistant, NSERC Solar Buildings Research Network (SBRN)**

- Facilitated 6-day PhD Workshop on net-zero energy buildings for 35 international students taught by 15 professors and industry professionals.
- Coordinated three-day meeting for 90 national and international solar energy and building researchers and industry experts. Organized four expert panel sessions on net-zero energy housing, commercial buildings, building-integrated solar systems, and communities.
- Assisted in applying for $7.6-million federal grant for an NSERC research network ("Smart Net-zero Energy Buildings Research Network"), which was granted in 2011.
- Participated in International Energy Agency Solar Heating and Cooling Task 40: "Towards net-zero solar energy buildings". I have produced several technical reports as a result of my participation. I chaired monthly experts' meetings, including creating agendas, facilitating research efforts, keeping minutes, and managing the online workspace.
- Organized building-integrated solar photovoltaics workshop for architects and researchers. Gave one-hour lecture with theory and case studies.
- Organized public speaking workshop at Ryerson University
- Developed technical reports and website promotional material for solar energy demonstration projects

2006-2007 **Research Assistant, Space Flight Lab**

- Designed, manufactured, and qualified spacecraft systems through rigorous thermal-vacuum and vibration testing.
- Assembled spacecraft systems in clean room according to military standards.

OTHER TEACHING EXPERIENCE

2008-2012 **Miscellaneous teaching/lecturing**

- Facilitated, prepared material for, and taught EnergyPlus introductory workshop to 15 graduate students, after having seen a gap in knowledge among peers
- Guest lecture for sustainable buildings course in Faculty of Architecture, University of Toronto
- Guest lecture for Daylight and Illumination course at Concordia University
- Two guest lectures to computational arts class, Concordia: "Sustainable building design"
- Private tutoring for daylighting and illumination course

2008 **Teaching Fellow: Building Systems Engineering, Concordia University**

- Prepared for and delivered five lectures to a class of 70 students
- Prepared teaching material and exams, and evaluated students

2008 **Teaching Assistant and Lecturer: Acoustics and Illumination, Concordia University**

- Prepared for and gave lectures to 45 senior building engineering students
- Wrote final exam, and graded assignments and presentations
- Gave course for specialized illumination software (AGI32)

2005-2007 **Teaching Assistant: Engineering Strategies and Practice, U. of Toronto**

- Led tutorials of 30-35 engineering students through the design process for real client projects
- Authored Project Manager Manual to teach future professors the course principles and guidelines

OTHER EXPERIENCE

2008-present **Consultant: building energy modelling and design and sustainability assessments**

- Design charrette participant and consultant for three large Carleton University buildings (2014-2017)
- Preliminary energy performance assessment for Yellowknife EcoHome.
- Thermal comfort assessment of advanced dynamic window systems for EcoTay Inc.
- Performed whole-building modeling for a large Toronto high school project using eQUEST. Wrote all documentation to demonstrate compliance with building energy codes (Ontario Building Code and ASHRAE Std. 90.1).
- Performed optimization of temperature controls to reduce peak loads using DRQAT software for NRCan CanmetENERGY.
- Performed retrofit analysis of off-grid Interpretive Centre at Misery Bay, Manitoulin Island, Ontario. Modelled building in EnergyPlus and sized solar collectors to achieve independence from diesel generator.
- Organized design charrette and led eight-person engineering team to design a low-energy office and housing facility in Uganda for Concordia Volunteer Abroad Program. Led the writing of an engineering report for delivery to a local (Ugandan) engineer and builder.
- Worked with Concordia University building managers to optimize window shade control in new 16-storey John Molson School of Business building to enhance passive solar performance and reduce energy costs.
- Contracted by NRCan to create energy model for NRCan Varennes facility using EnergyPlus.
- Developed toolkit for Tremco Inc. to assess cost reduction measures and payback periods, using Excel and VBA.
- Performed feasibility study for a community-scale solar domestic hot water system for Toronto Community Housing Corporation (TCHC) Block 21 and 23. Consulted for Baird Sampson Neuert Architects.
- Performed energy systems design for off-grid luxury cottage (5000 sq. ft.) in Montebello for private client. Provided a simulated-based feasibility for multiple heating system options.
- Parametric optimization of louver geometry to minimize heating and cooling loads for Unicel Inc. for a commercial building in Toronto using EnergyPlus.

- Acted as an energy consultant for the new Mission 2050 building at the University of Guelph, a $150-million planned net-zero energy agri-science facility. Attended a three-day design charrette to discuss design concepts with other experts.
- Created building energy model for the University of Toronto Mining Engineering building upgrade project; worked with architects (Baird Sampson Neuert Architects) to explore different strategies to minimize energy and resource use; wrote 15-page report outlining results.
- Modelled large number of possible high-rise apartment building upgrades using ESP-r to determine energy savings potential. Created script to automatically generate input files and perform batch runs. The outcome was included in the Toronto Mayor's Tower Renewal Guidelines – a comprehensive study of performance upgrades to Toronto's 5000 high-rise residential buildings.
- Ad-hoc consultant for Roll A Shade on advanced window shade controls for a new product

Summer 2004 **Bombardier Aerospace/DeHavilland**

- Facilitated the mechanical design of Control Cable Tension Regulators for the Q400 Aircraft
- Wrote a MATLAB program to optimize the mechanism to maintain near-constant tension
- Used CATIA and AutoCAD to model the design
- Stress analysis (FEM) using CATIA
- Was selected as the presenter to showcase my design to a large group of government officials, senior managers, and academics

CERTIFICATES AND AWARDS (OTHER THAN RESEARCH GRANTS)

- Faculty of Engineering and Design (Carleton) Teaching Excellence Award (2019)
- Six best paper awards (see papers section) (2009-2018)
- People's Choice and Honorable Mention Awards – IBPSA STASIO (data visualization competition) (2018)
- Ontario Building Envelope Council - Rising Star Award (2017)
- IEA EBC Annex 66 – Distinguished Service Award (2017)
- IBPSA (International Building Performance Simulation Association) Outstanding Young Contributor Award (US$500) (2017)
- Ontario Early Researcher Award ($150,000 over 5 years) (2015)
- Carleton Research Achievement Award ($15,000) (2015)
- Nominated for Carleton Graduate Supervision Award (2014 and 2016)
- Certificate in University Teaching (12-week course) (2012)
- ASHRAE Grant-in-Aid Award ($10,000) (2009-2010)
- SimBuild 2010 Student Travel Award (2010)
- Graduate Student Association Conference Travel Award (Concordia) (2010)
- IBPSA-Canada Student Travel Award (2009)
- Modular Building Institute Green Building design competition winner (2008)
    - The design was since built for a Virginia school board
    - Details here: http://modular.org/HtmlPage.aspx?name=arch_student
- Health & Safety on construction sites course (2008)
- Ontario Graduate Scholarship (OGS) $15,000 (2006-2007)
- MASc Fellowship, University of Toronto (2005-2007)
- Pratt & Whitney Canada Scholarship ($3,000) (2004)
- NSERC USRA Award ($4,500) (2004)
- Dean's List, Ryerson ($2,000/year) (2002-2004)
- Standard First Aid/CPR (2002)
- 1st place in Ryerson Engineering Design Competition (2001)
- Entrance Scholarship, Ryerson Aerospace Engineering (2001)
- 1st Place in age division in Waterloo-Kitchener Marathon (42km) (1999)

PROFESSIONAL MEMBERSHIPS AND LEADERSHIP

- Past President and board member, International Building Performance Simulation Association (IBPSA)–Canada (2018-2020)
- President (elected), International Building Performance Simulation Association (IBPSA)–Canada (2014-2016; 2016-2018)
- Member, International Building Physics Association (2018-present)
- Member, Ontario Building Envelope Council (2017-present)
- Affiliate Director (Canada), IBPSA (2014-2018)
- Vice President, International Building Performance Simulation Association – Canada (2012-2014)
- Member and Professional Engineer, Professional Engineers of Ontario (PEO) (2016-present)
- Member/Engineer in training, Professional Engineers of Ontario (PEO) (2001-2016)
- Member, International Building Performance Simulation Association (IBPSA) (2007-present)
- Member, Illuminating Engineering Society of North America (2015-2016)
- Associate Member, American Society for Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) (2008-present)
- Canadian Green Building Council, Ottawa Chapter (CaGBC) (2011-2014)

SELECT PRESENTATIONS AND INVITED TALKS

- Keynote: Design of buildings for occupants. Zero Energy Mass Custom Home Network Conference, UAE (2020)
- Invited webinar: Modeling Occupants for Better Buildings. IBPSA-USA webinar (2020)
- Invited presentation: *Design of comfortable, low-energy, resilient MURBs*. CaGBC workshop on Innovation in MURBs, Ottawa, Ontario (2019)
- Invited presentation: *Data-driven methods for building design and operations*. 2019 RPIC Real Property National Workshop, Ottawa, Ontario (2019)
- Invited presentation: *Key challenges in building operations*. ASHRAE President Elect Advisory Committee (PEAC), Ottawa, Ontario (2018)
- Invited presentation and panelist: *Designing buildings for people*. National Energy Efficiency Conference, Sydney Australia (2018)
- Keynote: *Designing buildings for people*. ASHRAE Ottawa Valley Chapter (industry dinner with ~100 audience members) (2018)
- Keynote: *Humanizing building simulation: Current state and future outlook of modelling occupants*. eSim 2018 conference, Montreal, QC (2018)
- Panelist: *The Role of Occupant Behaviour in Reducing GHG Emissions*. Reshaping Energy 2018, The Conference Board of Canada, Ottawa, Ontario (2018)
- Invited speaker: *Humans in buildings: From the room to campus scale*. International Facilities Management Association. Ottawa, Ontario (2018)
- Keynote: *Data visualization for building and campus performance* (co-presented with Burak Gunay and Zixiao Shi). Data Viz Meetup. Ottawa, Ontario (2017)
- Panelist for two panels: *Daylight metrics* and *Occupant modelling and simulation*. Building Simulation conference, San Francisco (2017)
- Plenary talk: *Occupant behaviour and comfort in the workplace.* 2017 Real Property Institute of Canada - Forum on the Workplace. Ottawa, Ontario (2017)
- Plenary talk: *Applying lessons learned from occupants to new and existing buildings.* Sustainable Labs Conference. Edmonton, Alberta (2016)
- Keynote: *Acting on lessons learned from building occupants*. Ottawa Better Buildings Breakfast (2016)
- Keynote: *Carleton University campus as a living laboratory and educational opportunity*. ASHRAE Ottawa Valley Chapter (industry dinner with ~100 audience members) (2016)
- *Simulating passive buildings*. Ontario Association of Architects Challenge 2030 Continuing Education Lecture Series. Toronto and Ottawa (2014, 2015, 2016)
- *Introduction to occupant modelling*. Half-day educational workshop at eSim 2016 Conference. Hamilton (2016)
- *Considering occupant behaviour in new building design*. Selected seminar presenter at IIDEX (Canada's largest interior design show). Toronto (2015)
- *Design of resilient, low-energy condominiums*. Panelist in CZEBS-iiBSE-APEC Symposium. Montreal (2015)

- *High-performance buildings: The human factor*. FED Talks - Carleton's community lecture series. Ottawa (2014)
- *Occupant behaviour in next generation green buildings*. Next Generation Green Buildings Workshop. Vancouver, Canada (2014)
- Panelist: *A three-tiered approach to addressing occupant behaviour in new building design*. Open Forum on Occupant Behaviour. Hong Kong (2014)
- *Incorporating occupant behaviour into new building design*. Canada Green Building Council Seminar Series, Ottawa, Canada (2014)
- *Approaches to addressing occupant behaviour in Net-Zero Energy Buildings.* Asia-Pacific Economic Cooperation Workshop on Net-Zero Energy Buildings, Beijing, China (2013)
- *Lessons learned from Net*-zero *energy buildings*. Net-zero energy building workshop. Montreal (2013)
- *EcoTerra Net-zero energy house: design, performance, and recommendations*. NZEB Workshop, Chambery, France (2013)
- *Occupant-conscious building design*. TEDxRideau Canal (2012) (http://www.youtube.com/watch?v=mwOzFrt2J70)
- *Applied Building Performance Simulation*. Seminar for Department of Mechanical and Aerospace Engineering, Carleton University (2012)
- *Applied Building Performance Simulation*. Seminar for Department of Civil and Environmental Engineering, Carleton University (2012)
- *Sustainable Buildings: Design, Technology, and Energy Sources*, Professional Engineers of Ontario (PEO), Ottawa Chapter (2011)
- *Successes and Failures in Sustainable Buildings*, Association for Canadian Studies in the Netherlands (ACSN), Rotterdam, The Netherlands (2011)
- *Conceptual Design of Solar Houses*, PhD Workshop on Net-zero Energy Buildings, Concordia University, Montreal (2011)
- *Design of Solar Buildings*. Building Ecology, Science, and Technology (BEST) Lecture Series, University of Toronto; audience of over 200 researchers, consultants, and architects (2011)
- *Thermal Comfort and Related Modelling Issues in the EcoTerra House*. Canada Housing and Mortgage Corporation EQuilibrium™ Housing Forum (2010)
- *Applications of Building Performance Simulation.* Computer Graphics Department, Cornell University (2010)
- *Design of a control cable tension regulator for Bombardier aircraft*. Ryerson University (2004)
- About 15 conference presentations (listed under conference papers)

MEDIA APPEARANCES (SELECT)

- *If your high performance building isn't performing, try talking to the people inside. Daily Commerce Journal (2017)*
- *The things people do to foil energy-saving buildings.* Smithsonian Magazine (2017)
- *Architecture's UX problem.* Co.Design website *(2017)*
- *High-efficiency building bloopers revealed.* Science Daily *(2017)*
- *Massive new energy use data resource coming this January.* Forbes (2016)
- *Residential energy submetering*. CBC Radio interview *(2014)*
- *Design process of Uganda building and facility design.* CBC Radio interview (2011)
- *Featured several times in Carleton's online Research Stories magazine*

ADDITIONAL OUTREACH AND MENTORSHIP (SELECT)

- Outreach leader for Architectural Conservation and Sustainability Engineering program (developed presentations, developed and led hands-on activities, gave technical tours, discuss educational and career prospects with high school students and their families)
- Science day camp guest instructor – day-long daylighting design activity
- Led numerous technical tours for public (Toronto Exhibition Place wind turbine, mechanical rooms of Carleton buildings, walking tour of green buildings)

- Regular blogger (e.g., on LinkedIn) about topics of occupant behaviour, green buildings, energy, and indoor environmental quality
- Panelist for several educational sessions aimed at graduate students (e.g., How to get an academic job, How to publish a journal article)

STUDENT AND RESEARCH ASSISTANT SUPERVISION

	Undergraduate research assistant	MASc/MArch	PhD	Post-doctoral fellow	Research assistant
In progress	**3**	**4**	**6**	**1**	**3**
Completed	**15**	**5**	**4**	**2**	**3**

Duration	Student name	Title of thesis/project; notes	Current position
Graduate students/post-doctoral fellows			
2019-2020	Post-doc: Vinu Subashini (co-supervised with Gabriel Wainer)	Generative design to improve office energy and comfort performance	
2019-2020	Post-doc: Abdeen Saleem (co-supervised with Burak Gunay)	Workplace of the future and related research	
2019-2020	Post-doc: Zakia Afroz (co-supervised with Burak Gunay)	Energy data analytics to support building operations	
2019-	MASc: Dan Lowcay (co-supervised by Burak Gunay)	Field and simulation study of LED lighting with high special resolution control	
2019-	MASc: Fereshteh Yazdani	Measurement of energy impact of teleworking: pilot study	
2019-	PhD: Pedram Nodejehi (co-supervised by Burak Gunay)	Text-mining of computerized maintenance records for predictive building maintenance	
2019-	PhD: Arefeh Fathi	Generative design and data-driven design to optimize offices performance	
2019-	PhD: Mohammed Derahkti	Rapid building model calibration for retrofit optimization	
2018-	MASc: Adrian Soble	Application of generative design to evaluate the energy and indoor environmental quality of office retrofits	
2018-	MASc: Connor Brackley (co-supervised by Chantal Trudel, Industrial Design)	Use of model predictions to provide thermal trajectories to office occupants	
2018-	PhD: Maedot Andargie (co-supervised by Marianne Touchie, Toronto)	Field study of comfort, behaviour, and resilience of condominiums	
2018-	MASc: Shengbo	Simulation-based design methodology to	

	Zhang (co-supervised by Marianne Touchie, Toronto)	improve condominium energy performance and resilience	
2017-	M.Arch: Noor Alkhalili (co-supervised by Ted Kesik, Architecture, Toronto)	Methodology and metrics to assess visual privacy in buildings in urban environments	
2017-2019	Post-doc: Mohamed Ouf (co-supervised by Burak Gunay)	Project 1: development of a program to engage occupants in a sustainable community Project 2: Occupant modelling for building design and energy codes: roadmap, feasibility study, best practices guidebook, and tested case study	Assistant professor, Building Engineering, Concordia University
2017-	PhD: Tareq Abuimara (co-supervised by Burak Gunay)	Statistical design applications in occupant modelling for building performance simulation; NSERC PGS D award	
2016-	PhD: Jayson Bursill (co-supervised by Ian Beausoleil-Morrison)	Development, implementation, and field testing of innovative adaptive building controls	Engineer, PSPC
2016-2018 (MASc) 2018- (PhD)	MASc/PhD: Maxime St-Jacques (co-supervised by Scott Bucking)	Modelling greenhouse gas emissions of electrical grids in Canada	
2016-2018	MASc: Andrew Hicks (co-supervised with Scott Bucking)	Development of occupant-in-the-loop controls for Zibi	Engineer, Brookfield Global Integrated Solutions
2015-2018	PhD: Aylin Ozkan (U. of Toronto; co-supervised by Ted Kesik, U of Toronto)	Methodology for assessing the comfort and resilience of condominiums	Researcher at University of Toronto
2015-2017	MASc: Justin Berquist	Energy-related faults analysis in existing offices	Research Officer, National Research Council and part-time researcher for HBI Lab
2015- 2016 (stopped due to illness)	BEng and MASc: Anthony Fuller	Development of an algorithm to count occupants in photos of indoor spaces	Research assistant for HBI Lab
2014-2017; 2017-2018	PhD; post-doc (half-time): Aly Abdelalim	Methodology for using building information models and energy models to advise building operators	Assistant Professor, Arab Academy for Science, Technology & Maritime Transport
2014-2017; 2017-2019	PhD; post-doc: Sara Gilani	Monitoring, modelling, and simulation of occupants in offices; Occupant modelling for building design and energy codes: roadmap, feasibility study, best practices guidebook, and tested case study	Researcher, Natural Resources Canada
2014-2015	Research Assistant: Vera Hu	Development of occupant engagement strategies for a major residential property manager.	Researcher, National Research Council
2014-2018	PhD: Shawn Shi	Novel building zone-level fault detection and diagnostics (two best paper awards)	Associate Research Officer, National Research Council
2013-2017	BEng (2013-2015) and MASc (2015-2017): Isis Bennet	Development of methods to reduce energy use in an office tower (Ontario Graduate Scholarship)	Engineer, WSP
2013-2015	MASc: Austin Selvig	Optimization of mass-produced net-zero	Building energy modeller, Arborus

	(co-supervised with Craig Merrett)	energy houses.	Consulting
2013-2014	Research Assistant: Laura Scrimgeour	Consultant for a variety of survey development projects	Private consultant
2012-2016	PhD: Burak Gunay (co-supervised with Ian Beausoleil-Morrison)	Development of adaptive building controls that learn individualized occupant comfort expectations, habits, and behaviours. Burak is the recipient of numerous awards (e.g., Governor General's Medal, Senate Medal, NSERC PGS, OGS, ASHRAE Grant in aid, BS2015 conference best paper award, and many internal awards). Dr. Gunay was hired as an assistant professor at Carleton.	Assistant professor, Carleton University
2012-2014; 2017-	MASc (co-supervised with Cynthia Cruickshank); PhD (co-supervised with Scott Sanner, Toronto): Brent Huchuk	MASc: Development of predictive controls of window shades for energy and comfort performance optimization. (nominated for Senate Medal) PhD: Machine Learning for Residential Building HVAC Analytics Platform	Ecobee/PhD student
Undergraduate research students			
2019	BEng: Ava Bebbington	building system audits to assess performance and faults	
2019	BEng: Manav Shah	building system audits to assess performance and faults	
2019	BEng: Hannah Villeneuve	Text-mining of indoor environmental quality-related aspects of Airbnb reviews	
2016/2017	BEng: Saptak Dutta	Development of building zone-level virtual sensors	M.A.Sc. student, Carleton
2016/2017	BEng: Noor Alkhalili	Development and testing of occupant view and privacy metrics for residential buildings	M.Arch. student and research assistant, Toronto
2016/2017	BEng: John Thomson	Methodology for determining optimal thermostat location to avoid solar exposure	Project Coordinator, Demathieu Bard
2016-2018 (summers)	BEng: Ruth Tamas (co-supervised with Burak Gunay in 2017)	Field study of LEED condos and occupant behaviour	(undergrad student)
2016	BEng: Ninoshka Rodrigues (Memorial University, Newfoundland)	Datamining of smart thermostat data	Project coordinator, Wired Synergy
2015/2016	BEng: Joel Becker	Design and construction of a micro-heliodon	Morrison Hershfield
2015/2016	BEng: Krista McWilliam	3D printing of innovative daylight shading devices	(unknown)
2015/2016	BEng: Abhijit Dhanda	Systematic assessment energy-saving potential in an existing building	Researcher, CIMS Lab
2014/2015	BEng: Kristen Jorgensen	Measurement and statistical analysis of daylight distribution and plug loads in offices	Engineer, Windmill Developments
2014	BEng: Nicholas Dumoulin	Assessment of thermal and visual comfort in perimeter zones of buildings	Engineer, Regulvar
2013	BEng: Christopher Henningsen	Development of correlations between indoor illuminance and advanced daylight glare metrics (funded by ASHRAE Senior	Engineering design technologist, telecommunications

		Undergraduate Project Grant)	
2012/2013	BEng: Peter Hutchins	Web interface development for the Carleton green roof	Engineering consultant
2012/2013	BEng: Erqin Zeng	Measurement and occupant survey of thermal comfort in Carleton's academic buildings (funded by ASHRAE Senior Undergraduate Project Grant)	MASc student
2012/2013	BEng: Lindsay Cook	Study of window blind use in high-rise office buildings	EIT, City of Winnipeg
2011/2012	BEng: Robyn Chatwin-Davies	Instrumentation of the Carleton University green roof	MASc student

RESEARCH FUNDING

Total research funding (2012-present)	~$3.5M; ~$2.7M awarded as PI

Year funding was awarded	**Funding source/name**	**Amount (100% to Liam O'Brien unless otherwise noted)**
2011	Start-up grant, Carleton University	$30,000
2012	ASHRAE undergraduate project award grant: Indoor air quality measuring equipment	US$5,000
2012	NSERC Engage Grant: Development of occupant behaviour models for use in building simulation (partnered with Autodesk Inc.)	$25,000 cash; $20,000 in-kind
2013	NSERC Engage Grant: Development of predictive shades control with experimental mock-up (partnered with Regulvar Inc.)	$25,000 cash; $9,000 in-kind
2013	Natural Resources Canada research contract: Literature review of occupant behaviour modelling	$14,080
2013	NSERC Interaction Grant: Travel funding to visit and initiate research with Delta Controls, Vancouver, BC	$5,000
2013	Natural Resources Canada sub-contract: OpenStudio software training	$20,500
2013	ASHRAE undergraduate project award grant: Toolkit for measuring comfort in perimeter zones of buildings	US$5,000
2013	Cooke Trust Grant: Passive Solar Design Guidebook (co-applicant with Ted Kesik)	$47,500 total (40%)
2013	NSERC Engage Grant: Development of predictive building control strategies using high-resolution weather data	$25,000 cash; $5,000 in-kind
2013-2019	NSERC Discovery Grant: Robust design of solar homes: methodology and technology	$150,000 ($25,000/year for 6 years)
2013-2016	Carleton Research Excellence Fund: Digital Campus Innovation – Creation of a Building Information Modelling (BIM) model to assessment of Carleton building sustainability (with Autodesk)	$60,000 cash; $150,000 in-kind
2013-2014	Internal Carleton University award (I-CUREUS) Measurement of apartment temperatures in the heating season	$1,125
2013 and 2014	Carleton USRA with Isis Bennet (undergrad B.Eng. student): various observational studies to support occupant behaviour research	$8,500
2011-2016	NSERC Smart Net-Zero Energy Buildings Research Network (SNEBRN)	$70,000 total for 2014-

	– Strategic Network (PI: Andreas Athienitis)	2016 (of $7.6-million awarded from NSERC)
2014	Ontario Centres of Excellence (OCE)/Natural Sciences and Engineering Research Council (NSERC)/Connect Canada with s2e Technologies Inc.: Development of a robust design methodology for net-zero energy residential buildings	$55,000 cash + $15,000 in-kind
2014	Natural Resources Canada (NRCan) research contract: Implementation of occupant behaviour models into EnergyPlus Simulation software	$24,960
2014-2015	ASHRAE Undergrad Senior Project Grant: Toolkit to develop learning lighting and blind controls	US$5,000
2014	Networks of Centres of Excellence - Graphics, Animation, and New Media (GRAND) Phase 1: New Media for Sustainable Living (co-applicant)	$10,700 (of $23-million)
2014-2017	NSERC Collaborative Research & Development Grant (with Delta Controls Inc.): Development of occupant-learning controls (co-applicant: Ian Beausoleil-Morrison)	$90,000 cash + $130,000 in-kind total for 3 years
2014-2017	NSERC Collaborative Research & Development Grant (with Autodesk Research): Methodology for using BIM for campus energy management and operations	$108,000 cash + $140,000 in-kind for 3 years
2014	Research contract with Ottawa Community Housing to quantify measured benefit of advanced heating in high-rise apartment buildings	$10,000
2014	NSERC Engage Grant with Morrison Hershfield Ltd.: Simulation-based investigation of residential building envelope systems	$25,000 cash; $6,600 in-kind
2015-2020	Ontario Early Researcher Award: Methodology for high-performance condominium design	$150,000
2015	Research contract to develop a green behaviour report card for Centretown Citizens Ottawa Corporation	$25,000
2015	NSERC Engage Grant with Hidi Rae: Use of occupant behaviour models in the design process for offices	$25,000 cash; $7,500 in-kind
2015	Natural Resources Canada research contract: Guidelines for developing and using occupant behaviour models	$17,100
2015-2016	Carleton University Research Achievement Award – Demonstration of occupant behaviour models in the building design process	$15,000
2015-2016	ASHRAE Undergrad Senior Project Grant: Equipment to build heliodon and test performance of 3D-printed solar shading systems	US$5,000
2015-2021	NSERC CREATE: Heritage Engineering (PI: Mario Santana)	~$165,000 (10% of $1.65M), co-PI
2015	NSERC Engage with Bentall Kennedy (Canada): Leveraging electricity submetering data for high-rise office buildings to reduce energy use	$25,000 (+ $13,000 in kind)
2015	NSERC Connect Level 3: Digital tools for sustainability management of campuses and building clusters	$25,000
2015	BC Housing Research & Education Grants: Design guidelines and buyer guide for resilient and comfortable condominiums in British Columbia (co-PI with Ted Kesik)	$40,000 (50%)
2016	Natural Resources Canada research contract: Implementation of existing occupant models into OpenStudio	$16,500
2016	NSERC Engage with RWDI: Field monitoring of occupants' energy-	$25,000 (+ $8,000 in kind)

	related actions and presence in offices	
2016-2017	ASHRAE Undergrad Senior Project Grant: Equipment to estimate zone level energy and mass flows	US$5,000
2016-2019	NSERC CRD with Delta Controls: Development and implementation of adaptive building controls (co-applicant: Ian Beausoleil-Morrison)	$180,000
2016	CFI-JELF/ORF: Advanced building controls hardware and software for the Health Sciences Building: Use of 25 offices as an in-situ research and student training facility. (This proposal was also submitted as part of a $20M Sustainable Infrastructure Fund (SIF), under which it was ultimately funded)	$400,000 cash and $167,000 in-kind
2017	OCE VIP I with QuadReal (Canada): Development of a program to engage office building occupants on energy use	$25,000 (+ $16,000 in kind)
2017-2019	NRCan Energy Innovation Program: Occupant modelling for building design and energy codes: roadmap, feasibility study, best practices guidebook, and tested case study (with Burak Gunay and Ian Beausoleil-Morrison)	$350,000 + $148,000 in-kind (80%)
2017	Ontario Centres of Excellence (OCE)/Natural Sciences and Engineering Research Council (NSERC) with Windmill Developments Inc.: Occupant-in-the-loop controls for a sustainable community	$50,000 cash + $15,000 in-kind
2017	Ontario-Baden-Wurttemberg Faculty Exchange: two-month visit to Karlsruhe Institute of Technology (Germany)	$5,250
2017	Natural Resources Canada research contract: Development of dynamic Sankey diagrams to represent energy flows	$12,500
2017	NSERC Connect 2 Grant: Workshop on Modelling and Simulation of Occupants	$8,200
2017-2022	NSERC CRD with ecobee: Machine Learning for Residential Building HVAC Analytics Platform (PI: Scott Sanner, Toronto)	$160,000 (50%)
2017	NSERC Engage with Homesol Building Solutions: Methodology and case study to assess occupant comfort, mechanical equipment, and energy use for an athletic facility	$25,000
2018-2022	NSERC CRD with CopperTree: Data-driven methods for operation and maintenance of commercial buildings (PI: Burak Gunay)	$100,000 (33%)
2018-2020	Borealis Foundation: Study of usability of residential building interfaces (co-PI, Chantal Trudel, Industrial Design, Carleton)	$20,000 (50%)
2018-2022	NSERC CRD/OCE VIP II with Brookfield Global Integrated Solutions: Development and field testing of novel approaches to improve building operations	$480,000 (37.5%)
2018	NSERC Engage Grant with Stantec: Development of a tool to quantify the occupant-adaptability of buildings	$25,000
2019-2022	Natural Resources Canada Green Infrastructure Fund Phase II: Next Generation actionable building energy performance metrics, data analytics, and visualization: an open-source platform (PI: Burak Gunay)	$510,000 (33%)
2019-2022	NSERC Strategic Project Grant: SUSTAIN - Sensor-based Unified Simulation Techniques for Advanced In-building Networks (PI: Gabriel Wainer, Systems Engineering, Carleton)	$610,000 (25%)
2019-2024	NSERC Discovery Grant and Discovery Accelerator Supplement: Quantitative holistic assessment of environmental impacts of teleworking	$230,000 ($46,000/year) + $120,000 ($40,000/year

		for first three years)
2019-2020	Carleton Multidisciplinary Catalyst Fund: Workplace of the Future (PI with 15 others)	$50,000
2019-2020	NRCan contract: Assessment of Canadian building performance simulationist/modeller knowledge and skills gaps and provide recommendations for professional certification	$25,000
2019-2021	NRC contract: Investigation on the enhancement of Canadian building codes based on new data and information about occupants	$114,000
2019-2020 (applied for)	NSERC Research Tools and Instruments: Instrumentation to measure the whole energy use impact of teleworking and related building performance topics (co-PIs: Cynthia Cruickshank, Burak Gunay)	$150,000

INTERNATIONAL SCHOLARLY COMMITTEES

- Operating Agent for International Energy Agency (IEA) in Energy in Buildings and Communities (EBC) Annex 79: Occupant-centric building design and operation. (2018-2023)
    - Coordination of about 100 researchers from 20 countries to conduct state-of-the-art research on occupant comfort, occupant behaviour, and occupant-centric building design and operations
    - Chairing biannual three-day meetings
    - Reporting to International Energy Agency Executive Committee biannually
    - Outreach via website, newsletters, panel discussions, invited presentations, etc.
- Member of IBPSA Awards Committee (2018-present)
- Subtask co-leader for International Energy Agency Energy (IEA) in Energy in Buildings and Communities (EBC) Annex 66: Definition and simulation of occupant behaviour in buildings. (2014-2017)
    - Co-led group of 10 international researchers, focusing on office occupant modelling and simulation
    - Co-edited a textbook on occupant research (with six authored chapters) with 36 authors from 14 countries
    - Published six journal articles and four conference papers
    - Regular contributor or editor of newsletter
    - Organized, led and contributed to panel discussions
- Subtask co-leader for International Energy Agency (IEA) Solar Heating and Cooling Task 40/ECB Annex 52 – Towards Net-zero Energy Solar Buildings (2009-2013)
    - Co-edited a textbook on net-zero energy buildings
    - Led initiative to compile and document building case studies
    - Facilitated PhD summer school on net-zero energy buildings for 20 international PhD students

CONFERENCE LEADERSHIP AND COMMITTEES

- Chair, OB-18 (Occupant Behaviour Symposium 2018), Ottawa, ON
- Scientific Committee, eSim 2018, Montreal, QC
- Scientific Committee, Building Simulation 2017, San Francisco
- Chair, Workshop on Occupant Modelling and Simulation, May 2017, Carleton University
- Scientific Committee Co-chair, SimAUD 2017, Toronto, ON,
- Chair, OB-16 (Occupant Behaviour Symposium 2016), Ottawa, ON
- Scientific and Organizing Committees, SimAUD 2011-2016
- Program Committee, NSERC Workshop on Big Data and the Built Environment, June 2016, Toronto, ON
- Chair, NSERC Workshop on Sustainable Campus Management, January 2016, Ottawa, ON
- Scientific Committee, ACEEE 2014-2015, Pacific Grove, CA
- Chair, eSim 2014, Ottawa, ON
- Chair, SimAUD 2013, San Diego, CA
- Scientific Committee, Climate Change Technology Conference 2013

- Organizing and Scientific Committees, Net-Zero Energy Customized Home Conference, 2012
- Scientific Committee, Solar Heating and Cooling Conference 2012
- Scientific Committee and workshop facilitator, eSim 2012
- Scientific Committee, International Solar Energy Society 2011
- Scientific Committee, Canadian Solar Buildings Conference 2009

JOURNAL REVIEWS AND EDITORSHIP

- Guest editor, Special Issue titled "State-of-the-art in occupant-centric building design and operation: a collection of reviews" in Building and Environment (in progress)
- Guest editor, Special Issue on Occupant Behaviour Fundamentals, Journal of Building Performance Simulation (2017)
- Guest editor, Special Issue on Architecture and Urban Design, Simulation Journal (2014)
- Reviewer for: Journal of Building Performance Simulation; Building Simulation; Building Research and Information
- Environment and Planning: B; Energy and Buildings; Applied Energy; Journal of Landscape Architecture; Journal of Energy Efficiency

EDITED BOOKS AND PROCEEDINGS

[1] Wagner, A., **O'Brien, W**., Dong., B. (2018). Exploring occupant behaviour in buildings: Methods and challenges. Cham, Switzerland: Springer Nature.
[2] Turrin, M., Peters, B., **O'Brien, W**., Stouffs, R., Dogan, T. Proceedings for Symposium on Simulation of Architecture and Urban Design 2017. Toronto, ON.
[3] Athienitis, A., **O'Brien, W**. 2015. Modelling, design, and optimization of net-zero energy buildings. Berlin, Germany: Wiley and Sons. (translated to Chinese in 2017)
[4] **O'Brien, W**., Gunay, HB., Khan, A. Proceedings for Symposium on Simulation of Architecture and Urban Design 2013. San Diego, CA.

AUTHORED BOOK CHAPTERS

[1] Wagner, A., **O'Brien, W**., Dong., B. (2018). Introduction In A. Wagner, A., W. O'Brien. & B. Dong. *Exploring occupant behaviour in buildings: methods and challenges*. (1-5) Springer Nature.
[2] Schweiker, M., Carlucci, S., Andersen, R., Dong, B. **O'Brien, W**. (2018) Occupancy and occupants' actions. In A. Wagner, W. O'Brien. & B. Dong. *Exploring occupant behaviour in buildings: methods and challenges*. (pp. 7-38). Cham, Switzerland: Springer Nature.
[3] Dong, B., Kjoergaard, M., De Simone, M., Gunay, HB., **O'Brien., W**., Dziedzic, J., Novakovic, V., Zhao, J. (2018). Sensing and data acquisition In A. Wagner, W. O'Brien. & B. Dong. *Exploring occupant behaviour in buildings: methods and challenges*. (pp. 77-105). Cham, Switzerland: Springer Nature.
[4] **O'Brien, W**., Wagner, A., Day, J. (2018) Introduction to occupant measurement methods In A. Wagner, W. O'Brien. & B. Dong. *Exploring occupant behaviour in buildings: methods and challenges*. (pp. 107-127). Cham, Switzerland: Springer Nature.
[5] **O'Brien, W**., Gilani, S., Gunay, HB. (2018) In-situ methods to study occupants In A. Wagner, W. O'Brien. & Dong. *Exploring occupant behaviour in buildings: methods and challenges*. (pp. 129-167). Cham, Switzerland: Springer Nature.
[6] **O'Brien, W**., Wagner, A., Dong., B. (2018). Conclusion and future outlook. In A. Wagner, W. O'Brien. & B. Dong. *Exploring occupant behaviour in buildings: methods and challenges*. (pp. 307-310). Cham, Switzerland: Springer Nature.
[7] Carlucci, S., Pagliano, L., **O'Brien, W**., Kapsis, K. (2015). Comfort for Net ZEBs: Theory and design. In Athienitis, A., O'Brien W. *Modelling, Design, and Optimization of Net-Zero Energy Buildings*. (75-101) Berlin, Germany: Wiley and Sons.
[8] **O'Brien, W**., Bourdoukan, P., Delisle, V., Yip, S. (2015). Net ZEB design processes and tools. In Athienitis, A., O'Brien W. *Modelling, Design, and Optimization of Net-Zero Energy Buildings*. (107-166) Berlin, Germany: Wiley and Sons.
[9] Athienitis, A., **O'Brien, W**., (2015). Net ZEB case studies. In Athienitis, A., O'Brien W. *Modelling, Design, and Optimization of Net-Zero Energy Buildings*. (107-166) Berlin, Germany: Wiley and Sons.

MAGAZINE ARTICLES

[1] Berquist, J, Ouf, M., **O'Brien, W**. (2020) Automatic long-term thermal comfort monitoring in buildings. ASHRAE Journal. February.
[2] Abuimara, T., **O'Brien, W.**, Gunay, B. (2020) How can assumptions about occupants misinform building design? ASHRAE Journal. January.
[3] **O'Brien, W.**, Gilani, S., Ouf, M. (2019) Occupant modeling for building design and code compliance – Part 1. ASHRAE Journal. February.
[4] Ouf, M., Gilani, S., **O'Brien, W.** (2019) Occupant modeling for building design and code compliance – Part 2. ASHRAE Journal. March.
[5] Gilani, S., **O'Brien, W.**, Ouf, M. (2019) Occupant modeling for building design and code compliance – Part 3. ASHRAE Journal. April.
[6] Ouf, M., **O'Brien, W.** (2018). Can we game code compliance through occupant modeling? ASHRAE Journal. February.
[7] **O'Brien, W.**, Kesik, T. (2016) Condominiums & Resilience. Canadian Consulting Engineer Magazine. Pg. 16-18. URL: http://www.canadianconsultingengineer.com/wp-content/uploads/sites/21/2016/12/CCE_2016_Dec_DE.pdf
[8] **O'Brien, W.** (2014) The occupant factor in high-performance building design. Sustainable Architecture and Buildings Magazine. URL: http://www.sabmagazine.com/blog/2014/09/23/the-occupant-factor-in-low-energy-building-design/

BLOG POSTS (SELECT)

[1] **O'Brien, W.** (2019). Cost-effective measurement of long-term thermal sensation in public areas. LinkedIn post.
[2] **O'Brien, W.** (2018). From natural ventilation to building forensics. LinkedIn post.
[3] **O'Brien, W.** (2017). Usability of building interfaces: a report from two months of sabbatical travel. LinkedIn post.

JOURNAL PUBLICATIONS

[1] Huchuk, B., **O'Brien, W.,** Sanner, S., (submitted) Hold on: Maybe smart thermostat overrides are not so bad after all. Energy and Buildings.
[2] Day, J., McIlvennie, C., Tarantini, M., Brackley, C., Piselli, C., Hahn, J., **O'Brien, W.**, and 6 others (submitted) A comprehensive review of human-building interfaces: Behavior, energy use impacts and occupant comfort. Building and Environment.
[3] **O'Brien, W.**, Tahmasebi, F., and 20 others (submitted) An international review of occupant-related aspects of building energy codes and standards. Building and Environment.
[4] Bursill, J., **O'Brien, W.**, Beausoleil-Morrison, I. (submitted) Development and widescale field implementation of in-situ rule-extraction control to reduce building energy use. Energy and Buildings.
[5] Bursill, J., **O'Brien, W.**, Beausoleil-Morrison, I. (submitted) Additional sensors for energy use estimation in commercial buildings – sense or nonsense? Building and Environment.
[6] St-Jacques, M., Bucking, S., **O'Brien, W.**, (submitted) Spatially and temporally sensitive consumption-based emission factors for mixed-use electrical grids. Energy.
[7] **O'Brien, W.**, Wagner, A., and 11 others (in press) Introducing IEA EBC Annex 79: Key challenges and opportunities in the field of occupant-centric building design and operation. Building and Environment.
[8] Villeneuve, H., **O'Brien, W.** (in press). Listen to the guests: Text-mining Airbnb reviews to explore indoor environmental quality. Building and Environment.
[9] Park, J., Ouf, M., Gunay, B., Peng, Y., **O'Brien, W.**, Nagy, Z. (in press) A critical review of field implementations of occupant-centric building controls. Building and Environment.
[10] Abuimara, T., **O'Brien, W.**, Gunay, B. (in press) Quantifying the Impact of Occupants During the Simulation-Aided Design Process: A Case Study. Building Research and Information. 47(8):866-882
[11] Ouf, M., **O'Brien. W.**, Gunay, B. (in press) Optimization of electricity use in office buildings under occupant uncertainty. Journal of Building Performance Simulation.
[12] Day, J., Ruiz, S., **O'Brien, W.**, Schweiker, M. (in press) Seeing is believing: An innovative approach to post occupancy evaluation. Energy Efficiency (Invited paper)
[13] Tamas, R., Ouf., M., **O'Brien, W.** (in press) A field study on the effect of building automation on perceived comfort and control in institutional buildings. Architectural Science Review.
[14] Gunay, HB., Ouf, M., **O'Brien, W.**, Newsham, G., (2019) Sensitivity Analysis and Optimization of Building Operations. Energy and Buildings. 199(Sept):164-175
[15] **O'Brien, W.**, Schweiker, M., Day, J., (2019) Get the picture? Lessons learned from a smartphone-based post-occupancy evaluation. Energy Research and Social Science. 56
[16] Huchuk, B., Sanner, S., **O'Brien, W.** (in press) Comparison of machine learning models for occupancy prediction in residential buildings using connected thermostat data. Building and Environment.

[17] Andargie, M., Touchie, M., **O'Brien, W.** (2019) A review of factors affecting occupant comfort in multi-unit residential buildings. Building and Environment. 160(August)
[18] Gunay, HB., Ashouri, A., Shen, W., Newsham, G., **O'Brien, W.** (2019) Floor level occupancy count estimation: an exploratory data analysis. ASHRAE Transactions.
[19] Shi, Z., **O'Brien, W.** (2019) Development and implementation of automated fault detection and diagnostics for building systems: A review. Automation in Construction. 104(August):215-229
[20] Gilani, S., **O'Brien, W.** (2019) Exploring the impact of office building occupant modeling approaches on energy use across Canadian climates. Energy and Buildings. 132:327-337
[21] Ouf, M., **O'Brien. W.**, Gunay, B. (2019) On quantifying building performance adaptability to variable occupancy. Building and Environment. 155:257-267
[22] **O'Brien, W.**, Gunay, B. (2019) Do building energy codes adequately reward buildings that adapt to partial occupancy? Science and Technology for the Built Environment. 25(6):678-691
[23] Abdelalim, A., **O'Brien, W**., Gilani, S. (2019) A probabilistic approach towards achieving net-zero energy buildings using stochastic tenant models. Science and Technology for the Built Environment. 25(6):743-752
[24] Ouf, M., **O'Brien. W.**, Gunay, B. (2019) A method to derive design-sensitive schedules for light use in buildings. Building and Environment. 25(2):221-232
[25] Bursill, J. **O'Brien, W.**, Beausoleil-Morrison, I. (2019) Experimental application of classification learning to generate simplified model predictive controls for a shared office heating system. Science and Technology for the Built Environment. 25(5):615-628
[26] Berquist, J., Ouf, M., **O'Brien, W.** (2019) A Longitudinal Study of Indoor Environmental Quality and Perceived Occupant Comfort in a Sports Facility. Building and Environment. 150(2019):88-98
[27] **O'Brien, W.**, Abdelalim, A., Gunay, B. (2019) Development of an office tenant electricity use model and its application for right-sizing HVAC equipment. Journal of Building Performance Simulation. 12(1):37-55
[28] D'Oca, S., Gunay H.B., Gilani S., **O'Brien W.** (2019) A review of the occupant modeling approaches in offices with illustrative examples. Building Services Engineering Research and Technology.
[29] Shi, Z, **O'Brien, W.** (2019) Sequential state prediction and parameter estimation with Dual Constrained Extended Kalman Filter for Building Zone Thermal Responses. Energy and Buildings. 183(January):538-546
[30] Ozkan, A., Kesik, T., Yilmaz, A., **O'Brien, W**. (2019) Development and application of time-based building energy performance metrics. Building Research and Information. 47(5):493-517
[31] Ouf, M., **O'Brien. W.**, Gunay, B. (2018) Improving occupant-related features in building performance simulation tools. Building Simulation. 11(4):803–817
[32] Huchuk, B., **O'Brien, W.**, Sanner, S. (2018) A longitudinal study of thermostat behaviors based on climate, seasonal, and price considerations using connected thermostat data. Building and Environment. 139:199-210
[33] Berquist, J., **O'Brien. W.** (2018) A Quantitative Model-Based Fault Detection and Diagnostics (FDD) System for Zone-Level Inefficiencies. ASHRAE Transactions. (**Best student paper award)**
[34] Gunay, HB., Shen, W., Huchuk, B, Yang, C., Bucking, S., **O'Brien, W.** (2018) On the energy and comfort performance benefits of early detection of building sensor and actuator faults. Building Services Engineering Research and Technology. 39(6):652-666
[35] Shi, Z, **O'Brien, W,** Gunay, B. (2018) Development of a distributed building fault detection, diagnostic and evaluation system. ASHRAE Transactions. 124:23-37
[36] Gilani, S., **O'Brien, W.**, Gunay, B. (2018) Simulation of occupants' impact at different spatial scales. Building and Environment. 132:327-337
[37] Shi, Z., **O'Brien, W.** (2018) Building energy model reduction using the Model-Cluster-Reduce Pipeline. Journal of Building Performance Simulation. 11(5):553-567
[38] Gilani, S., **O'Brien, W.** (2018) A preliminary study of occupants' use of manual lighting controls in private offices: A case study. Energy and Buildings. 159(1):572-586
[39] Gunay, HB., **O'Brien, W.**, Beausoleil-Morrison, I. (2018) Development and implementation of a thermostat learning algorithm. Science and Technology for the Built Environment. 24(1):43-56
[40] Bursill, J., **O'Brien, W.**, Beausoleil-Morrison, I. (2018) Software-based fault detection for multi-circuit building lighting systems. ASHRAE Transactions.
[41] Bennet, I., **O'Brien, W.** (2017) Office building plug and light loads: Comparison of a multi-tenant office tower to conventional assumptions. Energy and Buildings. 153:461-475
[42] Abdelalim, A., **O'Brien, W.,** Shi, Z. (2017) Data visualization and analysis of energy flow on a multi-zonal building scale. Automation in Construction. 84:258-273
[43] **O'Brien, W.**, Gaetani, I., Carlucci, S., Hoes, P., Hensen. J. (2017) On occupant-centric building performance metrics. Building and Environment. 122:373-385
[44] Abdelalim, A., **O'Brien, W.,** Shi, Z. (2017) Development of Sankey diagrams to visualize real HVAC performance. Energy and Buildings. 149:282-297

[45] Day, J., **O'Brien, W.** (2017) Oh behave! Survey stories and lessons learned from building occupants in high-performance buildings. Energy Research and Social Science. 31:11-20
[46] Gilani, S., **O'Brien, W.** (2017) Monitoring occupant behavior in an office building in Canada. ASHRAE Transactions. 123(1)
[47] **O'Brien, W.**, Gunay, HB., Tahmasebi, F. Mahdavi, A. (2017) A preliminary study of representing the inter-occupant diversity in occupant modelling. Journal of Building Performance Simulation. 10(5-6):509-526
[48] Bennet, I., **O'Brien, W.** (2017). Field study of thermal comfort and occupant satisfaction in Canadian condominiums. Architectural Science Review. 60(1):27-39
[49] Gilani, S., **O'Brien, W.** (2017) Review of current methods, opportunities, and challenges in in-situ monitoring for occupant modeling in office spaces. Journal of Building Performance Simulation. 10(5-6):444-470
[50] **O'Brien, W.**, Gaetani, I., Gilani, S., Carlucci, S., Hoes, P., Hensen. J. (2017) International survey on current occupant modelling approaches in building performance simulation. Journal of Building Performance Simulation. 10(5-6):653-671
[51] Shi, Z., **O'Brien, W.**, Dicaire, D., Hu, V. (2017) Wireless heating management system and tenant usage behavior in bulk-metered apartment buildings: A Case Study. ASHRAE Transactions. 123(1)
[52] Gunay, HB., **O'Brien, W.**; Beausoleil-Morrison, I., Gilani, S. (2016) Development and implementation of an adaptive lighting and blinds control algorithm. Building and Environment. 113: 185-199
[53] Gunay, HB., **O'Brien, W.**; Beausoleil-Morrison, I., Bisaillon, P., Shi, Z. (2016). Development and implementation of a control-oriented model for terminal heating and cooling units. Energy and Buildings. 121: 78-91
[54] Gunay, HB, **O'Brien, W.**, Beausoleil-Morrison, I., (2016) Control-oriented inverse modelling of the thermal characteristics in an office. Science and Technology for the Built Environment. 22(5): 586-605
[55] Gunay, HB, **O'Brien, W.**, Beausoleil-Morrison, I., Gilani, S., (2016) Modelling plug-in equipment load patterns in private office spaces. Energy and Buildings: Invited Special Issue on Occupant Behaviour. 121(1): 234-249
[56] Gilani, S., **O'Brien, W.**, Gunay, HB., Carrizo, SJ (2016). Use of dynamic occupant behavior models in the building design and LEED certification processes. Energy and Buildings. 117(1):260-271
[57] **O'Brien, W**., Bennet, I. (2016). Simulation-based evaluation of high-rise residential building thermal resilience. ASHRAE Transactions. 122(1)
[58] Gunay, HB., **O'Brien, W.**; Beausoleil-Morrison, I., Bursill, J., (2016) Implementation of an adaptive occupancy and building learning temperature setback algorithm. ASHRAE Transactions. 122(1):179-192
[59] Huchuk, B., Gunay, HB., **O'Brien, W.**, Cruickshank, C. (2016) Model-based predictive control of office window shades. Building Research and Information. 44(4):445-455
[60] Abdelalim, A., **O'Brien, W.**, Shi, Z. (2015) Visualization of energy and water consumption and GHG emissions: a case study of a university campus. Energy and Buildings. 109: 334-352
[61] Gunay, HB., **O'Brien, W.**, Beausoleil-Morrison, I. (2015). Implementation and comparison of existing office occupant behaviour models in EnergyPlus. Journal of Building Performance Simulation. 9(6):567-588
[62] Yan, D., **O'Brien, W.**, Hong, T., Feng, X., Gunay, B., Tahmasebi, F., Mahdavi, A. (2015) Occupant behavior modeling for building performance simulation: current state and future challenges. Energy and Buildings. 107(15): 264-278. **(Best Review Paper Award 2008-2017)**
[63] **O'Brien, W.**, Gunay, HB. (2015) Mitigating office performance uncertainty of occupant use of window blinds and lighting using robust design. Building Simulation: An International Journal. 8(6): 621-636.
[64] Gunay, HB., **O'Brien, W.**, Beausoleil-Morrison, I. (2015). Development of an occupancy learning algorithm for terminal heating and cooling units. Building and Environment. 93(2):71-85
[65] Gunay, HB., Bursill, J., Huchuk, B., **O'Brien, W.**, Beausoleil-Morrison, I. (2014) Shortest-prediction-horizon model-based predictive control for individual offices. Building & Environment. 82(1) 408-419
[66] Gunay, HB., **O'Brien, W.**, Beausoleil-Morrison, Perna, A. (2014) On behavioral effects of residential electricity submetering. Building & Environment. 81(1) 396-403
[67] **O'Brien, W.**, Gunay, HB. (2014) The contextual factors contributing to occupants' adaptive comfort behaviors in offices — a review and proposed modeling framework. Building and Environment 77 (7): 77-87
[68] Gunay, HB., **O'Brien, W.**, Beausoleil-Morrison, Huchuk, B. (2014) On adaptive occupant-learning window blind and lighting controls. Building Research & Information. 42(6): 739-756
[69] Gunay, HB., **O'Brien, W.**, Beausoleil-Morrison, I., Goldstein, R., Breslav, S., Khan., A. (2014) Coupling stochastic occupant models to building performance simulation using the Discrete Event System Specification (DEVS) formalism. Journal of Building Performance Simulation. 70(6): 457-478.
[70] **O'Brien, W**. Kesik, T., Athienitis, A. (2014) Solar Design Days: A tool for passive solar house design. ASHRAE Transactions. 120 (1).
[71] Gunay, HB, **O'Brien, W.**, Beausoleil-Morrison, I. (2013) A Critical review of state-of-the-art energy and comfort related occupant behavior in office buildings. Building and Environment. 70. 31-47.
[72] **O'Brien, W**., Kapsis, K., Athienitis, A. (2013) Manually-operated window shade patterns in office buildings: a critical review. Building and Environment 60(2): 319-338.

[73] Attia, S., Hamdy, M., **O'Brien, W.**, Carlucci, S. (2013) Assessing the Gaps and Needs for Integrating Building Performance Optimization Tools in Net Zero Energy Buildings Design, Energy and Buildings Journal. 60(5): 110-124

[74] **O'Brien, W.**, Athienitis, A., Kesik, T. (2011). Parametric analysis to support the integrated design and performance modelling of net-zero energy houses. ASHRAE Transactions. 117(1).

[75] Doiron, M., **O'Brien, W.**, Athienitis, A. (2011). Energy performance, thermal comfort, and lessons learned from a near net-zero energy house. ASHRAE Transactions 117(2).

[76] Candanedo, L.M., Athienitis, A.K., Candanedo, J.A., **O'Brien, W.**, and Chen, Y. (2011) Transient and steady state models for open loop air based BIPV/T Systems. ASHRAE Transactions, 116(1).

[77] **O'Brien, W.**, Athienitis, A. Kesik, T. (2011). Thermal zoning and interzonal airflow in the design and simulation of solar houses: a sensitivity analysis. Journal of Building Performance Simulation. 4(3): 239-256.

[78] **O'Brien, W**., Kennedy, C., Athienitis, A. Kesik, T. (2010). The relationship between personal net energy use and the urban density of solar buildings. Environment and Planning: B. 37(6): 1002-1021.

REFEREED CONFERENCE PROCEEDINGS (*PRESENTED BY LIAM O'BRIEN)

[1] Peters, T., Alkhalili, N., Kesik, T. **O'Brien, W.** (2020). Metrics and Methods for Climate-based Daylight Simulations Of Multi-Unit Residential Buildings. SimBuild. Chicago, IL. Aug. 12-14.

[2] Kesik, T. **O'Brien, W.**, Ozkan, A. (2020). Towards A Standardized Framework for Thermal Resilience. SimBuild. Chicago, IL. Aug. 12-14.

[3] Ouf, M., Tamas, R., **O'Brien, W.** (2019). Usability and comfort in Canadian offices: Interview of 170 university employees. AIQVEC, Bari, Italy, Sept. 5-7.

[4] Zhang, S., Fine, J., Touchie, M., **O'Brien, W.** (submitted). A Novel Simulation Framework for Comfort-based Assessments of Window Designs. ASHRAE Conference.

[5] Gilani, S., Goldstein, R., Breslav, S., Tessier, A., **O'Brien, W.** (2019) Building Performance Implications of Occupant Mobility. Building Simulation 2019. Sept. 2-4. Rome, Italy.

[6] **O'Brien, W.,** Gunay, B., Ouf, M. (2019) Simulation-based Approach To Assess Occupant-adaptability Of Buildings. Building Simulation 2019. Sept. 2-4. Rome, Italy.*

[7] Abuimara., T., **O'Brien, W.**, O'Brien, W. (2019) Simulating the Impact of Occupants on Office Building Design Process: A Case Study. Building Simulation 2019. Sept. 2-4. Rome, Italy.

[8] Schweiker, M., O'Brien, W., Gunay, B. (2019) Characterization of Occupant Behaviour Models for Simulation Engineers and Architects. Building Simulation 2019. Sept. 2-4. Rome, Italy.

[9] Huchuk, B. Sanner, S., **O'Brien, W.** (2019) Short-Horizon Probabilistic Models For Whole Home Motion Prediction Using Connected Thermostat Data. Building Simulation 2019. Sept. 2-4. Rome, Italy.

[10] Ouf, M., **O'Brien, W.,** Gunay, B. (2019) Quantifying Occupancy-adaptive Building Operations. Building Simulation 2019. Sept. 2-4. Rome, Italy.

[11] Bursill, J., **O'Brien, W.**, Beausoleil-Morrison, I. (2019) Development and Analysis of Simplified Control-oriented Models for a Group of Institutional Offices. Building Simulation 2019. Sept. 2-4. Rome, Italy.

[12] Gunay, B., Ouf, M., Newsham, G., **O'Brien, W.** (2019) Building Performance Optimization for Operational Rule Extraction. Building Simulation 2019. Sept. 2-4. Rome, Italy.

[13] Tahmasebi, F., **O'Brien, W.**, Wang, Y., Mumovic, D., Mahdavi, A. (2019) Inter-Occupant Diversity in Occupant Behaviour Models: Exploring Potential Benefits for Predicting Light Switch-on Actions. Building Simulation 2019. Sept. 2-4. Rome, Italy.

[14] Ouf, M., **O'Brien, W.**, Gunay, B. (2019) Optimizing Building Performance using Stochastic Occupant Models. ASHRAE Winter Conference. Jan. 12-16. Atlanta, GA

[15] Shi, Z., **O'Brien, W.** Bucking, S. (2018) Achieving faster building energy model optimization through selective zone elimination. International Building Physics Conference 2018. Sept. 24-26 Syracuse, NY*

[16] Alkhalili, N., Kesik, T., **O'Brien, W.**, Peters, T. (2018) Developing and Testing Visual Privacy Metrics. International Building Physics Conference 2018. Sept. 24-26 Syracuse, NY

[17] **O'Brien, W.** Fuller, A., Schweiker, M., Day, J. (2018) A picture is worth a thousand words: Smart phone photo-surveys for collecting data on office occupant adaptive opportunities. International Building Physics Conference 2018. Sept. 24-26 Syracuse, NY*

[18] Gilani, S., **O'Brien, W.,** Gunay, B. (2018) Exploring occupants' impact at different spatial scales. International Building Physics Conference 2018. Sept. 24-26 Syracuse, NY*

[19] Gilani, S., **O'Brien, W.** (2018) Quantification of building energy performance uncertainty associated with building occupants and operators. International Building Physics Conference 2018. Sept. 24-26 Syracuse, NY*

[20] Ouf, M., **O'Brien, W.**, Gunay, B. (2018) Generating design-sensitive occupant-related schedules for building performance simulations. International Building Physics Conference 2018. Sept. 24-26 Syracuse, NY **(Best paper award)**

[21] Day, J., Ruiz, S., **O'Brien, W**., Schweiker, M. (2018) Seeing is believing: A mixed methods approach to understanding the human-building interface. ACEEE Summer Study. Aug. 12-17, 2018 Pacific Grove, California
[22] Abuimara, T., **O'Brien, W.**, Gunay, B., Burpee, H., Day, J. (2018) Designing for Occupants: A Review of the Integrated Design Practice. ACEEE Summer Study. Aug. 12-17, 2018 Pacific Grove, California
[23] Gilani, S., **O'Brien, W**. On the appropriateness of occupancy models for various temporal and spatial scales. eSim 2018. May 9-10, Montreal, QC
[24] Fernald, H., Hong, S., Bucking, S., **O'Brien, W**. BIM to BEM translation workflows and their challenges: A case study using a detailed BIM model. eSim 2018. May 9-10, Montreal, QC
[25] Hicks, A., Ouf, M., **O'Brien, W.** Bucking, S. The effect of occupant behaviour on energy consumption in conventional vs. high-performance residential buildings. eSim 2018. May 9-10, Montreal, QC
[26] Shi, Z., **O'Brien, W**. Using Building Performance Simulation for Fault Impact Evaluation. eSim 2018. May 9-10, Montreal, QC
[27] Abdelalim, A., **O'Brien, W**. An approach towards achieving net-zero energy buildings based on a stochastic tenant model. eSim 2018. May 9-10, Montreal, QC
[28] Gunay, B., **O'Brien, W.** An OpenStudio measure to incorporate data-driven occupant models in EnergyPlus. eSim 2018. May 9-10, Montreal, QC
[29] Ouf, M., **O'Brien, W.**, Gunay, B. A Framework to Improve Occupant Modeling Capabilities in Building Simulation Tools. eSim 2018. May 9-10, Montreal, QC
[30] Bursill, J, **O'Brien, W.**, Beausoleil-Morrison, I. An approach to virtual sensing of cooling systems using state-space inverse modelling and gradient descent. eSim 2018. May 9-10, Montreal, QC
[31] Abuimara, T., **O'Brien, W.**, Gunay, B., Carrizo, S. Assessing the impact of occupants on building design decision making. eSim 2018. May 9-10, Montreal, QC
[32] Abuimara, T., **O'Brien, W.**, Gunay, B., Abdelalim, A., Ouf, M., Gilani, S. Modelling occupants in buildings: Stakeholders' workshop on current barriers, challenges, and needs. eSim 2018. May 9-10, Montreal, QC
[33] Tamas, R., **O'Brien, W.**, Gunay, B. Summer window use behaviour in air-conditioned condominiums. eSim 2018. May 9-10, Montreal, QC
[34] **O'Brien, W.**, Gunay, B., Beausoleil-Morrison, I., Kesik, T. Carrizo, S., Danks, R., Ouf, M., Gilani, S., Abdelalim, A., Roadmap for Occupant Modelling for Building Codes and Standards. eSim 2018. May 9-10, Montreal, QC
[35] Mahdavi, A., Tahmasebi, F., Gunay, B., **O'Brien, W.**, The diversity challenge in models of occupants' presence in buildings, Proceedings of Building Simulation Conference 2017
[36] Abdelalim, A., **O'Brien, W.** Visualization of building performance using Sankey diagrams to enhance the decision-making process. SimAUD 2017. Toronto, ON
[37] Berquist, J., Tessier, A., **O'Brien, W.,** Attar, R. Generative design for heating, ventilation, and air-conditioning. SimAUD 2017. Toronto, ON
[38] Ozkan, A., Kesik, T., **O'Brien, W.** Visualization of passive performance parameters through time-based metrics and discussion of a survey for validation of the approach. Building Simulation Conference 2017. Aug 5-7. San Francisco, CA.*
[39] Gunay, HB., **O'Brien, W.**, Beausoleil-Morrison, I., Newsham, G., Macdonald, I. The effect of zone level occupancy characteristics on adaptive controls. Building Simulation Conference 2017. Aug 5-7. San Francisco, CA.
[40] Gilani, S., **O'Brien, W.** Modelling and simulation of lighting use patterns in office spaces. Building Simulation Conference 2017. Aug 5-7. San Francisco, CA.
[41] Shi. Z., **O'Brien, W.** Building energy model reduction using principal component analysis and affinity propagation clustering of thermal zones. ASim 2016. Nov 27-29, Korea. (**Best paper award**)
[42] Ozkan, A., Kesik, T., **O'Brien, W**. Correlating the time-based metrics of thermal autonomy and passive survivability to the energy performance of multi-unit residential buildings. ICBEST 2017. May 15-18. Istanbul, Turkey.
[43] Ozkan, A., Kesik, T., **O'Brien, W**. The influence of passive measures on building energy demands for space heating and cooling in multi-unit residential buildings. eSim 2016. May 3-5, Hamilton, ON.
[44] Gilani, S., **O'Brien, W.** Potential for virtual daylight sensors using daylight simulation and high-resolution measurement of solar radiation. eSim 2016. May 3-5, Hamilton, ON.*
[45] Gunay, HB., Fuller, A., **O'Brien, W.**, Beausoleil-Morrison, I. Detecting occupants' presence in office spaces: a case study. eSim 2016. May 3-5, Hamilton, ON.
[46] Gunay, HB., **O'Brien, W.**, Beausoleil-Morrison, I. A starter toolkit for developing data-driven occupant behaviour and presence models. eSim 2016. May 3-5, Hamilton, ON.
[47] **O'Brien, W.**, Gunay, HB. Modelling occupant diversity and its applications. eSim 2016. May 3-5, Hamilton, ON.*
[48] Abdelalim, A., Shi. Z., **O'Brien, W.** Energy flow analysis on a multi-zonal building scale using Sankey diagrams. eSim 2016. May 3-5, Hamilton, ON.
[49] Shi. Z., O'Brien, W. A web-based interactive 3D visualization tool for building data. eSim 2016. May 3-5, Hamilton, ON.

[50] Shi. Z., **O'Brien, W.** Building zone fault detection with Kalman filter Based methods. eSim 2016. May 3-5, Hamilton, ON. (**Best paper award)**
[51] Abdelalim, A., Shi. Z., **O'Brien, W.** An approach towards developing methods to analyze and visualize energy flow of HVAC systems. SimAUD 2016
[52] Gunay, HB., **O'Brien, W.**, Beausoleil-Morrison, I., D'Oca, S., Corgnati, S. On modelling and simulation of occupant models. Building Simulation Conference 2015. (**Best paper award**)
[53] Shi, Z., Abdelalim, A., **O'Brien, W**., Attar, R., Akiki, P., Graham, K., Waarden, B. V., Fai, S., Tessier, A., Khan, A. (2015). Digital Campus Innovation Project : Integration of building information modelling with building performance simulation and building diagnostics. *SimAUD 2015*.
[54] Bennet, I., **O'Brien, W.**, Gunay, HB. Effect of window blind use in residential buildings: Observation and simulation study. eSim 2014. Ottawa, Canada. May 8-9.
[55] Huchuk, B., Cruickshank, C., **O'Brien, W.**, Gunay, HB. Recursive thermal building model training using Ensemble Kalman Filters. eSim 2014. Ottawa, Canada. May 8-9.
[56] Selvig, A., **O'Brien, W.**, Merrett, C. 2013 Solar Decathlon: Technologies, modelling tools, and Canadian applications. eSim 2014. Ottawa, Canada. May 8-9.
[57] Carrizo, JS, **O'Brien, W.**, Santana, M. Lasers, Light, and God: 3-D scanning assisted lighting analysis of a house of worship. eSim 2014. Ottawa, Canada. May 8-9.
[58] Kesik, K., **O'Brien, W.** Feasible upper boundaries of passive solar space heating fraction potentials by climate zone. eSim 2014. Ottawa, Canada. May 8-9.
[59] Gunay, HB., **O'Brien, W.**, Beausoleil-Morrison, I., Huchuk, B., Palmer, M., Fletcher, J., Pavlovski, A. The effect of input uncertainty in model-based predictive control. eSim 2014. Ottawa, Canada. May 8-9.
[60] Kapsis, K., **O'Brien, W.,** Athienitis, A. (2013) time-lapse photography and image recognition to monitor occupant-controlled shade patterns: analysis and results. Building Simulation Conference. August 26-29.
[61] Attia, S., Hamdy, M., **O'Brien, W.**, Carlucci, S. (2013) Computational optimisation for zero energy buildings design: interviews results with twenty-eight international experts. IBPSA Building Simulation Conference. August 26-29.
[62] **O'Brien, W**. (2013) Evaluating the performance robustness of fixed and movable shading devices against diverse occupant behaviors. SimAUD. San Diego, CA. April 7-10.*
[63] Huchuk, B., **O'Brien, W**., Cruickshank, C. (2013) Preliminary Results of Model Predictive Control of Shading Systems. SimAUD. San Diego, CA. April 7-10.*
[64] Gunay, H., **O'Brien, W**., Goldstein, R., Breslav, S., Khan, A. (2013) Development of Discrete Event System Specification (DEVS) building performance models for building energy design. SimAUD. San Diego, CA. April 7-10.
[65] **O'Brien, W**. (2013) Occupant-proof buildings: can we design buildings that are robust against occupant behaviour? Building Simulation. Chambery, France. August 26-29.*
[66] **O'Brien, W**. (2012) Use of Sankey Diagrams to Enhance Building Performance Simulation-Supported Design. SimAUD. Orlando, FL. March 26-29.*
[67] Kesik, T., **O'Brien, W**. (2012) Design Methodology Embodying the Energy and Economic Performance of Solar Houses. eSim 2012. Halifax, NS. May 2-4.*
[68] **O'Brien, W.**, A. K. Athienitis, S. Bucking, M. Doiron, and T. Kesik (2010). A Study of Design Tools and Processes Through a Near Net-Zero Energy House Redesign. EuroSun 2010. Graz, Austria.
[69] S. Bucking, A. K. Athienitis, R. Zmeureanu, **W. O'Brien**, and M. Doiron (2010). Design Optimization Methodology for a Near Net Zero Energy Demonstration Home. EuroSun 2010. Graz, Austria.
[70] Athienitis, A., Torcellini, P., Hirsch, A., **O'Brien, W.**, Cellura, M., Klein, R., Delisle, V., Attia, S., Bourdoukan, P., Carlucci, S. (2010). Design, Optimization, and Modelling Issues of Net-Zero Energy Solar Buildings. EuroSun 2010. Graz, Austria.
[71] **O'Brien, W.**, K. Kapsis, A. K. Athienitis and T. Kesik (2010). Methodology for quantifying the performance implications of intelligent shade control in existing buildings in an urban context. SimBuild 2010. New York City.*
[72] **O'Brien, W.**, A. K. Athienitis and T. Kesik (2010). Implementation of a management system for multiple design concepts and their performance in a solar house design tool. eSim 2010. Winnipeg, MB.*
[73] **O'Brien, W.**, Athienitis, A., Kesik, T. The development of a solar house design tool. 11th International Building Performance Simulation Association Conference, Glasgow, Scotland. July 27-30, 2009. *
[74] Candanedo, L., Athienitis, A., **O'Brien, W**. Development of an air-based open loop building-integrated photovoltaic/thermal systems. 11th International Building Performance Simulation Association Conference, Glasgow, Scotland. July 27-30, 2009.
[75] **O'Brien, W**., Athienitis, A. Kesik, T. The methodology and development of a solar house design tool. 4th Canadian Solar Buildings Conference, Toronto, ON. June 25-27, 2009. *

[76] **O'Brien, W**., Kennedy, C., Athienitis, A. Kesik, T. The relationship between personal net energy use and the urban density of solar buildings. 4th Canadian Solar Buildings Conference, Toronto, June 25-27, 2009. *
[77] Hachem, C., Athienitis, A. Fazio, P, **O'Brien, W**. Evaluation of low energy, low cost housing: case study. 4th Canadian Solar Buildings Conference, Toronto, ON. June 25-27, 2009.
[78] Candanedo, L., Athienitis, A., Candanedo, J., **O'Brien, W**., Chen, Y., Simplified model for open-loop air-based BIPV/T systems. 4th Canadian Solar Buildings Conference, Toronto, ON. June 25-27, 2009. **(Best paper award)**
[79] **O'Brien, W.**, Athienitis, A. Kesik, T. Roofs as extended solar collectors: practical issues and design methodology. 12th Canadian Conference on Building Science and Technology, Montreal, QC. May 6-8, 2009.*
[80] **O'Brien, W**., Athienitis, A., Kesik, T. Sensitivity analysis for a passive solar house energy model. International Solar Energy Society – Asia Pacific Conference, Sydney, Australia. November 25-28, 2008.
[81] **O'Brien, W**., Kesik, T., Athienitis, A. The use of solar design days in a passive solar house conceptual design tool. 3rd Canadian Solar Buildings Conference, Fredericton, NB, August 20-22, 2008. *

CURRICULUM VITAE: MARIO SANTANA QUINTERO

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Tel: +1 (613) 520-2600 x 3093 - Fax +1 (613) 520-3951 Email: Mario.santana@carleton.ca, http://www1.carleton.ca/cee/people/santana-quintero-mario
Citation index: http://scholar.google.com/citations?user=9FIFN40AAAAJ&hl=en
Orcid: 0000-0002-3836-9714
Professional Ontario Engineers (limited license for Faculty): 100199000
Doctorate Honoris Causa, University of Liege (2018)
Co-Editor, Journal of Cultural Heritage Management and Sustainable Development:

Education

University of Leuven (KU Leuven), Leuven, Belgium: **Ph.D. in engineering** (Built heritage Conservation) (1997- 2003) and **Master in Conservation of Historic Towns and Buildings** (1995-1997)
Universidad Central de Venezuela, Caracas, Venezuela: **Architect** (1988-1994)

Relevant experience

Getty Conservation Institute:
- Scholar - 2019 (3 months)

Carleton University:
- Associate professor (tenured), Architectural Conservation and Sustainability and faculty member of the Carleton Immersive Media Studio (CIMS) – crossed appointed Department of Civil and Environmental Engineering / Azrieli School of Architecture and Urbanism. Faculty member of the Carleton Immersive Media Studio (CIMS) -2012/01 to present
- Director NSERC Create Program Heritage Engineering -2015/05 to present

University College St-Lieven, Ghent, Belgium
- Professor (40%) - 2007 to 2011/12
- Guest professor - 2005 – 2007
- Coordinator of the 3D Risk Mapping European Leonardo Project (www.3driskmapping.org) – 2006 – 2008

University of Leuven (KU Leuven): Raymond Lemaire International Centre for Conservation, Leuven, Belgium:
- Guest professor -2012/01 to present
- Assistant professor (40%) -2007 to 2011/12
- Post-doctoral researcher: Silk Road Cultural Heritage Information System project -2010 - 2011
- Post doctoral researcher (20%) www.mace-project.eu -2007 to 2009
- Post doctoral researcher (20%) -2003 - 2007

University of Pennsylvania (Graduate program in Historic Preservation)
- Lecturer (http://www.design.upenn.edu/) - 2009 - 2012
- Associate Faculty - Spring 2008
- Guest lecturer - Spring 2006, 2007

European agencies:
- Evaluation of Education, Audiovisual and Culture Executive Agency: cooperation funds - 2011
- European Research Executive Agency: Evaluation of IIF, IOF and IEF Marie Curie People Grant Schema - 2012, 2011, 2010

Other teaching experiences:
- Guest Professor, University of Ibague (Ibague, Colombia) - 2017
- Guest lecture, Stanford University (Palo Alto, USA) - 2011
- Guest lecturer, University of Columbia (New York, USA) - 2009 and 2017
- Guest professor, University of Aachen RWTH (Germany) - 2007 to present
- Visiting professor, Sophia University (Tokyo, Japan) (Funded by the Japanese Society for the Promotion of Sciences) - Fall 2004

UNESCO World Heritage Centre
- Coordinator, Information management Systems workgroup - 2003-2005

International Society on Virtual Systems and MultiMedia
- Executive officer - 2005 to present

International Scientific Committee for Heritage Documentation (CIPA-ICOMOS)
- Vice-president - 2015 to present
- President - 2011 – 2014
- Vice-president - 2006 to 2011

Selected consultancy work (Architectural heritage documentation and conservation)
- The Getty Conservation Institute - 2006 to present

- UNESCO Beirut Heritage Conservation project in Baalbek - 2011, 2010, 2009
- Euromed - 2008
- World Monuments Fund - 2004 thru 2008
- UNESCO World Heritage Centre - 2005 to present
- Abu Dhabi Tourism and Culture Authority - 2006 to present
- United Nations Development programme - 2006
- ICCROM's ATHAR, ARIS and the Built Heritage programs - 2005 - 2010
- Petra National Trust (Jordan) - 2006

Keywords

Conservation of built heritage; world heritage; civil engineering surveying; preventive conservation; risk assessment; civil engineering: surveying; three-dimensional surveying and modeling; architecture; archaeology; international cooperation; capacity building.

Relevant skills

- Relevant experience in the development of capacity building programmes and research for built heritage documentation and conservation by supporting education at universities, government institutions, and other educational institutions;
- Expertise in providing timely information for the conservation of built heritage places;
- Development of strategies for improving the quality and sustainability of the built environment by promoting the protection of architectural heritage;
- Experience in the development of risk assessment approaches for the protection of built heritage;
- Development of preventive maintenance tools for monitoring of cultural heritage;
- Work in cooperation with academic institutions, inter and governmental organizations, and the industry in promoting the conservation of heritage;
- Advanced knowledge of 3D digital tools for heritage documentation (Computer-Aided Design programmes; 3D modelling modules; active and passive web –design; surveying instruments; photogrammetry; image processing; 3D laser scanning; word processing; presentation);
- Evaluation of scientific applications for funding in heritage documentation and conservation;
- Organization of scientific gatherings (conferences, workshops, and expert groups).

Geographic experience

- Consultancy and teaching experience in the following countries: Afghanistan, Algeria, Australia, Bahrain, Belgium, Canada, Cambodia, China, Colombia, Cuba, Ecuador, Egypt, France, Germany, India, Italy, Japan, Jordan, Jerusalem, Kazakhstan, Korea, Lebanon, Mexico, Morocco, Myanmar, Nepal, Spain, Syria, Peru, Tunisia, Sudan, Sultanate of Oman, United Arab Emirates, United Kingdom, United States of America and Venezuela.

Additional skills

- Proficient in English, Spanish (mother tongue), French, and Dutch / Basic knowledge of German and Italian;
- Advanced knowledge: Computer-Aided Design packages (AutoCAD, AutoCAD Civil, AutoCAD Raster Design, Sketch Up, and Microstation), Raster image processing (Adobe Photoshop, Fireworks, PtGui, Autodesk Stitcher, IPhoto), surveying software (Agisoft MetaShape, Faro Scene, Bentley Point Tools, Photoplan, Trextify, Theolt, Photomodeler, Leica Cyclone, Orbit, Strabo, Leica Geo-office, Robogeo), word processing (Ms Word, In-Design), vector proceesing (Illustrator and Freehand), web development and databases (Dreamweaver, PhP, MySQL, Joomla, Moodle, Navicat).
- Advanced knowledge in operating surveying instruments: REDM Total Station, 3D laser scanner (mid-range), and GNSS mapping devices.
- Photographic skills with a selected number of pictures published in books and relevant websites (UNESCO and UNESCO World Heritage Portal).

Activities

Awards:

- Faculty teaching Award, Carleton University (2020)
- Doctorate Honoris Causa, University of Liege (2018)
- Tartessos Award for his leadership as president of CIPA. Spanish Society of Virtual Archaeology (SEAV) (2012)

Publications

Articles in internationally reviewed scientific journals	18
Peer-reviewed conferences and symposia, published in full in proceedings	61
Papers at local conferences and symposia, published in full in proceedings	2
Meeting abstracts, presented at international conferences and symposia, published or not published in proceedings or journals	14
Meeting abstracts, presented at local conferences and symposia, published or not published in proceedings or journals	8
Internationally reviewed scientific journals: as guest editor	4
Other published books; as author	2
Books, internationally recognized scientific publisher; as editor	7
Book chapters, internationally recognized scientific publisher	16

Selected examples:

- Costamagna, E., Santana Quintero, M., Bianchini, N., Mendes, N., Lourenço, P. B., Su, S., Min, A. (2019). Advanced non-destructive techniques for the diagnosis of historic buildings: The Loka-Hteik-pan temple in Bagan. Journal of Cultural Heritage, doi:10.1016/j.culher.2019.09.006
- Shepperd, J. Gray, C. Santana Quintero, M. Guest Editors' Note. APT Bulletin: The Journal of Preservation Technology: Special Issue on Documentation, vol. 68, no. 4/4, 2017, pp. 4.
- Santana Quintero, M. Georgopoulos, A. Stylianide, E. Lerma, J. CIPA's Mission: Digitally Documenting Cultural Heritage. APT Bulletin: The Journal of Preservation Technology: Special Issue on Documentation, vol. 68, no. 4/4, 2017, pp. Shepperd, J. Gray, C. Santana Quintero, M. Guest Editors' Note ." APT Bulletin: The Journal of Preservation Technology, vol. 68, no. 4/4, 2017, pp. 4.
- Myers, D. Santana Quintero, M. Introduction, Special Issue: Cultural heritage inventory systems for posterity and conservation, Journal of Cultural Heritage Management and Sustainable Development, Vol 6 No 2, 2016, Emerald, ISSN: 2044-1266
- Santana Quintero, M. Percy, K. Ward, S. Morrison, T. Digitizing Alexander Grahan Bell's Beinn Bhreagh for its conservation. SCIRES-IT Vol 4/1 (2014). E-ISSN 2239-4303. Pp. 141-147
- Ntregkaa, A. Georgopoulos, A. Santana Quintero, M. Investigation on the use of HDR images for Cultural Heritage Documentation, International Journal of Heritage in the Digital Era, Vol 3/1, 2014, pp. 2 -18.
- Heras, V. Wijffels, A. Santana Quintero, M. Cardoso, F. Della Torre, S. Van Orshoven, J. Steenberghen, T. Van Balen, K. A value based monitoring system to support heritage conservation planning Journal of Cultural Heritage Management and Sustainable Development, Vol. 3 No. 2, 2013, pp. 130-147.
- Ioannides, M. Santana Quintero, M. Akashesh, T. Preface. Ioannides, International Journal of Heritage in the Digital Era Vol 1 No 2, 2012, iii - iv. Multi Science Publishing, Essex (UK), ISSN 2047-4970.
- Cesaro, G. Vadafari, A. Paolini, A. Santana Quintero, M. Van Balen, K. Vileikis, O. Petra Archaeological Park: defining boundaries and mapping risk, American Journal of Archaeology, The Archaeological Institute of America, Vol 116 No 4, October 2012, pp. 733-734.
- Cesaro, G. Santana Quintero, M. Preliminary Risk Assessment at the Petra Archaeological Park: Recording Strategy. Ioannides, International Journal of Heritage in the Digital Era Vol 1 No 2, 2012, 295-312. Multi Science Publishing, Essex (UK) , ISSN 2047-4970.
- Heras, V. Steenberghe, T. Zuñiga, M. Cardoso, F. Santana Quintero, M. Van Balen, K. "An Information System for heritage documentation management of Cuenca city, Ecuador" MASKANA Scientific Journal of the University of Cuenca, Vol. 3 / N° 1/ Jun 2012, 05 (51 - 61), Cuenca, Ecuador, ISSN No. 1390-6143 http://diuc.ucuenca.edu.ec/index.php?option=com_jdownloads&Itemid=149&view=viewdownload&catid=72&cid=165
- Santana Quintero, M. Eppich, R. Introduction – Current Trends in Cultural Heritage and Documentation (2016), in Stylianidis, E. Remondino, F. (Eds.) 3D Recording, Documentation and Management of Cultural Heritage, Whittles Publishing, pp. 1-13. ISBN 978-184995-168-5.
- Mezzino, D. Pei, W. Santana Quintero, M. Interpretation of reality-based 3D documentation, in Münster, S. Pfarr-Harfst, M. et al ed. 3D Research Challenges in Cultural heritage II: How to manage data and knowledge related to interpretative digital 3D reconstructions of Cultural Heritage, Springer, Lectures Notes in Computer Sciences 10025. pp. 119-135. ISSN 0302-9743
- (2012). Risk Management at Heritage Sites: a case study of the Petra World Heritage Site (Cesaro, G. Fakhoury, L. Paolini, A. Santana Quintero, M. Vadafari, A. Van Balen, K. Vileikis, O.), Paris, France: United Nations Educational, Scientific and Cultural Organization (UNESCO), Katholieke Universiteit Leuven & UNESCO Amman Office, ISBN 978-92-3-001073-7.
- (2011). CIPA Heritage Documentation. (Santana Quintero, M., Ed., Stylianidis, E., Ed., Patias, P., Ed.). Athens, Greece: ICOMOS & ISPRS Committee for Documentation of Cultural Heritage. ISBNc16821750

- (2011). Protecting BAALBEK's Integrity. (Santana Quintero, M., Ed., Seif, A., Ed.). Leuven, Belgium: Raymond Leimare International Centre for Conservation (KU Leuven) - University College St. Lieven.

CURRICULUM VITAE

Ehab Zalok, Ph.D., P.Eng.

Associate Professor
Department of Civil and Environmental Engineering, Carleton University

Education

- Ph.D. Civil Engineering (Structural Fire Safety Engineering), 2006, Carleton University, Canada.
- Ph.D. Structural Engineering (incomplete, moved to Canada), 2001, Ain Shams University, Egypt.
- M.A.Sc. Structural Engineering, 1997, Ain Shams University, Egypt.
- B.Sc. Civil Engineering, 1992, Military Technical College, Egypt.

Awards

- Carleton University Teaching Achievement Award for demonstrating excellence in teaching, 2010.
- Society of Fire Protection Engineers, National Capital Region Chapter Scholarship in Fire Safety Engineering for excellent research in the field of Fire Safety, 2007.

Employment Experience

Academic

- Associate Professor, Department of Civil and Environmental Engineering, Carleton University (2015-present)
- Assistant Professor (Tenured), Department of Civil and Environmental Engineering, Carleton University (2010-2015)
- Assistant Professor (Tenure Track), Department Civil and Environmental Engineering, Carleton University
  (2008-2010)
- Assistant Professor (two, one-year term), Department Civil and Environmental Engineering, Carleton University (2006-2008)
- Sessional Lecturer, Department Civil and Environmental Engineering, Carleton University (2005-2006)
- Teaching / Research Assistant, Department Civil and Environmental Engineering, Carleton University (2001-06)

Other

- Visiting Researcher, National Research Council of Canada (NRCC) (2007-present)

- Research Assistant, National Research Council of Canada (NRCC) (2003-2006)
- Technical Officer, National Research Council of Canada (NRCC) (2001)

Membership in Professional Societies

- (*Associate Member, 2019*) American Concrete institute
- (*Member 2010-present*) Int. Society of Fire Protection Engineers (SFPE)
    - (*President, 2010-2012*) SFPE – National Capital Region Chapter (NCR)
- Int. Council for Research and Innovation in Building and Construction (CIB), CIB W014 fire
    - (*Group Leader, 2009-presesnt*) WG1 - design fires
    - (*Member, 2009-present*) WG3 - structural performance in fire
- (*Member, 2008-present*) Canadian Society for Civil Engineering, Engineering Mechanics and Materials Division
- (*Professional Engineer, 2010-present*) Professional Engineers Ontario (PEO)
- (*Chair, 2008-2016*) CSA committee on Fire-performance and antistatic requirements for conveyor belting (CAN/CSA-M422-12)
- (*Member, 2013*) Fire Protection Research Foundation, Fire Safety of Tall Wood Buildings project committee

Teaching

Mechanics I - Mechanics of Solids I - Engineering Economics - Construction Management - Building Fire Safety - Structural Design for Fire Safety - Behaviour of Materials in Fire

Graduate & Undergraduate Supervision

Summary of the number of students supervised:

	Current		Completed		Total
	Supervised	Co-supervised	Supervised	Co-supervised	
Postdoctoral			1	2	3
Doctoral	2	1		1	2
M.A.Sc.			3	8	11
M.Eng. Project			2	2	4
M.Eng. Coursework			10		10
Undergraduate			1	2	3
4th year project			150		150
Total	2	1	167	15	184

Students' Awards

- Hannah Keelson: Outstanding Master's Thesis Award by The American Masonry Society's (TMS) Research Committee, 2019.
- Hannah Keelson: Society of Fire Protection Engineering National Capital Region Chapter Scholarship for Fire Safety Engineering, 2018.
- Hamish Pope: Ontario Graduate Scholarship (OGS) 2016, 2017, 2018).
- Hamish Pope: Society of Fire Protection Engineering National Capital Region Chapter Scholarship for Fire Safety Engineering, 2016.
- Nawar Al-Akhras: Senate Medal for Outstanding Academic Achievement, 2014
- Osama Salem: Senate Medal for Outstanding Academic Achievement, 2014
- Osama Salem: Best Poster Award (2011), "Fire Modelling of Axially-Restrained Tubular Steel Beams" Int. Conference on Application of Structural Fire Engineering (ASFE), Prague, Czech Republic.

Research Activities

Current Research in the Areas of Fire-Structure Interaction and Fire Safety Engineering

- Improving the Fire Endurance of Concrete Block Masonry Walls towards Next-Generation Performance-Based Fire Standards
- Fire Induced Progressive Collapse of Steel Structures
- Impact of fire and smoke control techniques on road tunnels
- Fire safety of combustible vs. non-combustible construction

- Structural Fire Performance of Beam-to-Column Moment Connections Joining Tubular Steel Members
- Flexural Response of Corroded Reinforced Concrete Beams at Elevated Temperatures
- Hygrothermal properties of wood, wood frames, cross laminated timber, and thermal insulations for durability design
- Development of design fires for mid-rise buildings, offices, computer server rooms, motels and hotels and the burning impact of fuel packages on life safety
- Improving the residual strength and spalling of reinforced concrete slabs exposed to fire and impact using hybrid steel/polypropylene fibre
- Development of a sensing device to reduce the risk from kitchen fires

Publications

- Articles in refereed publications = 17
- Articles Submitted to refereed publications = 2
- Papers in refereed conference proceedings = 16
- Scholarly reports and non-refereed contributions = 12

Collaborations (Academic + Industry)

1. Dr. Alex Bwalya, Research Officer (NRCC). Publications: 2 report.
2. Mr. Curt Copeland (Council of Forest Industries, Canada). Publications: 1 Journal + 2 conference.
3. Professor George Hadjisophocleous (Carleton University). Co-supervision: 1 PDF + 1 Ph.D. + 5 M.A.Sc. + 1 M.Eng. Publications: 7 Journal + 8 conference + 6 report publications.
4. Professor Burkan Isgor (Carleton University). Co-supervision: 1 M.A.Sc. Publications: 1 Journal + 1 Journal (submitted).
5. Dr. Kanwal Kumaran, P.Eng, Research Officer (NRCC). Publications: 1 Journal + 2 conference.
6. Dr. Gary Lougheed, Research Officer (NRCC). Publications: 1 Journal.
7. Dr. Jim Mehaffy, Adjunct Research Professor (Carleton University). Publications: 1 Journal.
8. Dr. Waleed Mekky, P.Eng, Adjunct Research Professor (McMaster University), (AMEC Nuclear Safety Solutions, NSS). Publications: 1 Journal + 1 conference.
9. Dr. Phalguni Mukhopadhyaya, P.Eng, Adjunct Research Professor (Carleton University), Research Officer (NRCC). Co-supervision: 2 M.A.Sc. Publications: 2 Journal + 2 conference + 1 report.
10. Mr. Paul Newman (Canada Wood). Publications: 1 Journal + 2 conference.
11. Ms. Naki Ocran, M.A.Sc. Civil Engineer (GHL Consultants Ltd). Publications: 4 reports.

12. Professor Abd El Halim Omar (Carleton University). Co-supervision: 2 UG. Publications: 1 Journal + 1 conference.
13. David Van Reenen, Technical Officer (NRCC). Publications: 2 Journal + 2 conference + 1 report.
14. Professor Ahmed Tolba (Military Technical College, Egypt). Co-supervision: 2 UG. Publications: 1 Journal + 1 conference.
15. Dr. Jungyong Wang, P.Eng, Research Officer (NRCC). Publications: 1 Journal.

Research Grants and Contracts

Amount (CAD$)	Granting Agency	Project Title	Years Held	PI / CO-PI*
833,340	NSERC – Collaborative Research and Development Grants	Improving the Fire Endurance of Concrete Block Masonry Walls towards Next-Generation Performance-Based Fire Standards [$625,005 (cash) + 263,320 (in-kind)].	2015-21	PI
105,000	NSERC Discovery	Thermal and Structural Performance of Hollow Steel Connections at Fire Temperatures	2013-18	PI
164,000	NSERC Network	Rationalization of Life Safety - Code Requirements – part of NSERC Strategic Network on Innovative Wood Products and Building Systems	2010-15	CO-PI
10,000	Canadian Nuclear Safety Commission	Validation of Fire Models on the PRISME Integral Tests	2013	PI
20,000	National Research Council (NRC – IRC)	Engineering Performance Assessment of Bio-Based Construction Materials	2011-12	PI
12,000	National Research Council (NRC – IRC)	Hygrothermal Properties Characterization of Wood and Cross-Laminated Timber (CLT) for Durability Design	2010-12	PI
30,000 (US$)	National Fire Protection Association (USA) Fire Protection Research Foundation	Validation of Methodologies to Determine Fire Loads for Use in Structural Fire Protection Design	2010-12	PI
25,000	Canada Mortgage and Housing Corporation (CMHC)	Simple Design Tools For The Assessment Of Upholstered Furniture Burning In Home Fires	2009-11	PI
8,000	National Research Council (NRC – IRC)	Moisture and Thermal Performance of Building Materials and Envelopes	2009-10	PI
5,000	National Research Council (NRC – IRC)	Use of Hygrothermal Simulation Tool to Develop Design Guidelines for Canadian Style Wood Frame Building Envelope Construction in Taiwan	2007-08	PI
25,000	Carleton University	Start-Up Grant	2006	PI

SQAPC Discussant Report: Graduate Programs in Building Engineering
Julie Garlen
2 Feb 2021

Programs Overview
The primary rationale for launching these new graduate programs in Building Engineering is the need to address the lack of specialized graduate options for students who complete the current undergraduate degree in Architectural Conservation and Sustainability Engineering (ACSE), which has been housed in the Department of Civil and Environmental Engineering since 2011. The existing programs in Civil and Environmental Engineering do not address the specialized skills needed to pursue careers in building performance, heritage conservation, and fire safety.

There are three proposed programs, for which students may opt to specialize in one of three optional concentrations (Performance, Heritage Conservation, and Fire Safety Engineering) or generalize:

- MEng in Building Engineering (coursework or project pathways)
- MASc in Building Engineering
- PhD in Building Engineering

Reviewer Issues and Concerns
The primary concerns identified by the reviewers involve the proposed curriculum. The reviewers found the Degree Level Expectations to be poorly aligned with the Program Learning Outcomes, resulting in a lack of breadth. Further, they found the integration between the three proposed concentrations to be weak. They saw the curriculum as lacking elements of green building design that align with university sustainability goals. Additionally, some courses are labeled as "core" but are not required. The lack of mandatory courses and the assignment of multiple instructors across courses are not conducive to a cohesive, consistent curriculum. High teaching loads in comparison to engineering faculty at research intensive institutions is also mentioned, although new faculty hires could contribute to workload distribution. There is currently a lack of gender diversity that should be addressed in order to respond to Carleton's EDI commitments.

Reviewer Recommendations
I find **six** recommendations in the reviewers' report, but only five are listed in the Unit Response and Implementation Plan. Those five are summarized here as potential actions:

1. Improve curriculum alignment/ mapping.
2. Improve integration of concentrations and coordination of mandatory course sections.
3. Address high teaching loads.
4. Add courses to address green building design and include additional offerings from the School of Architecture & Urbanism.
5. Address lack of gender diversity.

Unit's Response

Agreed to unconditionally (and adequately addressed): In the unit's response and implementation plan, curriculum alignment is explicitly and thoughtfully addressed. The perceived faculty load issue was explained as an issue with the table presentation and work assignment descriptions, illustrating that current faculty loads are actually consistent with those cited by the reviewers.

Agreed to in principle (and adequately addressed): The unit addressed the coordination of the mandatory course and added a research methods course to the M.Eng program. However, the unit resists the further addition of required courses because it would dilute critical course offerings in each concentration. They note that already one-third of course requirements for PhD students are specified (and shared across concentrations).

Agreed to in principle (and <u>incorrectly categorized</u>): Responding to the reviewers' request to add more courses, the unit disagrees, expressing the concern that for thesis-based students, "more generalized course requirements would displace courses that are related to student theses." However, it stated that "we agree to add more courses for M.Eng. students when resources become available." This does not appear to be consistent with the categorization provided.

Agreed to in principle (and <u>inadequately addressed</u>): The unit failed to respond to the need to address gender diversity with a specific goal related to hiring, instead citing gender diversity among students. The response raises the question of why this is not agreed to unconditionally.

Internal Reviewer's comments:
IR notes that diversity is not explicitly mentioned (especially with regards to gender ratio and steps taken to increase gender balance if this is a problem in the faculty) but states that "This topic was discussed and clarified fairly well during the program faculty meeting." However, there is nothing added to the report to indicate such an outcome. IR gave another general comment about providing an organizational chart in order to facilitate the review.

Dean's response:
Approved with little comment.

Discussant's Response:
The proposed programs respond to an important need for specialized graduate education. The programs are designed to maximize current resources, including existing courses, faculty, and physical space. However, based on my evaluation of the reviewers' recommendations and the unit's response, there are a number of concerns that should be addressed before the proposal can be recommended to commence.

Curriculum design:

1. For each concentration, all three programs are drawing from the same set of courses, with the exception of theses and dissertation. It is unclear how advanced learning outcomes for the Phd cab be addressed when the same courses are serving students at both levels. Clarification is need on how learning outcomes are aligned with specific courses.
2. The purpose of the "core" course designations remains unclear in relation to the essential knowledge and skills that are to be obtained. For example, in the proposed M.ASc Building Engineering (p. 49), students are to choose **two** "core" courses from a list of **14** courses. It is unclear how curricular consistency can be maintained with such a model. Clarification is needed to demonstrate how learning outcomes can be addressed and/or evaluated with so many options and so few consistent requirements.

Impact on Human Resources:

1. The proposed initiative formally creates twelve new degree programs (p. 4). This refers to the three proposed programs, each with three concentrations options and a generalized option. The unit reports that the department has sufficient administrative staff resources to handle the increase in students. However, it is unclear whether sufficient consideration has been given to the administrative load required for the management of such a large number of new program options, even with the moderate enrolment projections.
2. The unit's report states on p. 41 that "Only one new course is to be added to the program from existing faculty." This is inconsistent with the courses listed in Appendix 2: Proposed Calendar Copy. Here **10** new courses with new BLDG designation are proposed. It is unclear how this large number of new courses can be integrated into the program with only the proposed addition of one faculty member to be hired in the third year of the program pending enrolment targets.

Lack of gender diversity

In my opinion, the lack of gender diversity noted by the reviewers must be adequately addressed by the unit before this program can commence. The unit should commit to a specific plan for addressing this issue.

Recommendation to SQAPC:

Recommend to discuss concerns and whether additional action items should be requested prior to recommendation to commence.

Site Visit for the Graduate Programs in Building Engineering
July 29-31

External Reviewers: Dr. Burcu Akinci, Carnegie Mellon University
Dr. Christopher Kennedy, University of Victoria

Internal Reviewer: Dr. Jean Duquette, Mechanical and Aerospace Engineering
Moderator: Dr. Dwight Deugo, Office of the Vice-Provost and Associate Vice-President (Academic)

All meetings can be accessed at:
https://us02web.zoom.us/j/82548183549

***Please note that there is a 15 minute buffer between meetings to allow for breaks and/or resolution of technical difficulties.**

EST Time	July 29, 2020	Location	PST Time
12:30 – 1:00	Meet and greet with Dr. Dwight Deugo, Vice-Provost and Associate Vice-President (Academic)	Zoom ID: 82548183549	9:30 – 10:00
1:15 – 1:45	Meeting with Dr. Jerry Tomberlin, Provost and Vice- President (Academic)	Zoom ID: 82548183549	10:15 – 10:45
1:45 – 2:15	BREAK		10:45 – 11:15
2:15 – 2:45	Meeting with Dr. Amir Hakami, Associate Dean, Faculty of Engineering, Research and Graduate Studies	Zoom ID: 82548183549	11:15 – 11:45
3:00 – 3:30	Meeting with Dr. Patrice Smith, Dean of the Faculty of Graduate and Postdoctoral Affairs	Zoom ID: 82548183549	12:00 – 12:30
3:45-4:15	Wrap-up and question period (Dr. Akinci, Dr. Kennedy & Dr. Duquette)	Zoom ID: 82548183549	12:45 - 1:15
Time	**July 30, 2020**	**Location**	
12:30 – 12:45	Day 2 Opening Meeting (Dr. Akinci, Dr. Kennedy & Dr. Duquette)	Zoom ID: 82548183549	9:30 – 9:45
12:45 – 1:45	Meeting with Dr. Yasser Hassan, Department Chair	Zoom ID: 82548183549	9:45 – 10:45
2:00 – 2:30	Meeting with Negin Alikhani Graduate Administrator	Zoom ID: 82548183549	11:00 – 11:30
2:30 – 3:00	BREAK		11:30 – 12:00
3:00 – 4:00	Meeting with Faculty Dr. Liam O'Brien, Dr. Burak Gunay, Dr. Scott Bucking, Dr. Mario Santana, Dr George Hadjisophocleous, Dr. Ehab Zalok, Dr. Hamzeh Hajiloo	Zoom ID: 82548183549	12:00 – 1:00
4:00 – 4:15	Virtual Tour of Department: Presenting in the following order: Dr. Liam O'Brien Dr. Mario Santana Dr. Ehab Zalok	Zoom ID: 82548183549	1:00 – 1:15
Time	**July 31, 2020**	**Location**	
12:30 – 1:15	Closing Meeting with Dr. Dwight Deugo, Vice-Provost and Associate Vice-President (Academic)	Zoom ID: 82548183549	9:30 – 10:15

1:30 – 2:30	External Reviewers' Report Preparation Meeting	Zoom ID: 82548183549	10:30 – 11:30
2:30 - 3:00	Additional time (to be used only if technical issues require the rescheduling of a meeting)	Zoom ID: 82548183549	11:30 – 12:00

Email Addresses for Attendees

Position/Role	Name	Email
External Reviewer	Dr. Burcu Akinci	bakinci@cmu.edu
External Reviewer	Dr. Christopher Kennedy	cakenned@uvic.ca
Internal Reviewer	Dr. Jean Duquette	Jean.Duquette@carleton.ca
Associate Dean -FED	Dr. Amir Hakami	Amir.Hakami@carleton.ca
Dean of the Faculty of Graduate and Postdoctoral Affairs	Dr. Patrice Smith	Patrice.Smith@carleton.ca
Department Chair	Dr. Yasser Hassan	Yasser.hassan@carleton.ca
Graduate Administrator	Negin Alikhani	Negin.Alikhani@carleton.ca
Faculty Member	Dr. Liam O'Brien,	Liam.Obrien@carleton.ca
Faculty Member	Dr. Burak Gunay	Burak.Gunay@carleton.ca
Faculty Member	Dr. Scott Bucking	Scott.Bucking@carleton.ca
Faculty Member	Dr. Mario Santana	Mario.Santana@carleton.ca
Faculty Member	Dr George Hadjisophocleous	George.Hadjisophocleous@carleton.ca
Faculty Member	Dr. Ehab Zalok	Ehab.Zalok@carleton.ca
Faculty Member	Dr. Hamzeh Hajiloo	Hamzeh.Hajiloo@carleton.ca

External Reviewers' Biographies

Dr. Chris Kennedy is Chair of the new 'green' Civil Engineering Department at the **University of Victoria**. He conducts research on sustainable cities, urban metabolism, and the industrial ecology of sustainable global infrastructure systems. Holding qualifications in civil engineering, economics and business, Chris has conducted consulting work on sustainable infrastructure & cities for several national governments, as well as the World Bank, Ontario Ministry of Finance and others. In 2011-12, he was seconded to the OECD in Paris, to work on Cities, Green Growth and Policies for Encouraging Investment in Low Carbon Infrastructure. Chris has been a visiting professor at Oxford University and ETH Zürich. He is a former President of the International Society for Industrial Ecology; and author of *The Evolution of Great World Cities: Urban Wealth and Economic Growth*.

Dr. Burcu Akinci is the Paul Christiano Professor of Civil & Environmental Engineering, Associate Dean for Research for the College of Engineering, Director of the Engineering Research Accelerator and co-director of Pennsylvania Smarter Infrastructure Incubator at **Carnegie Mellon University.**
She earned her BS in Civil Engineering (1991) from Middle East Technical University and her MBA (1993) from Bilkent University at Ankara, Turkey. After that, she earned her MS (1995) and her Ph.D. (2000) in Civil and Environmental Engineering with a specialization in Construction Engineering and Management from Stanford University.

Her research interests include the development of approaches to model and reason about information-rich histories of facilities, to streamline construction and facility management processes. She specifically focuses on investigating utilization and integration of building information models with data capture and tracking technologies, such as 3D imaging, embedded sensors and radio-frequency identification systems to capture semantically-rich as-built histories of construction projects and facility operations.

Dr. Akinci has one patent, two patent applications, over 60 refereed journal publications, and 80 refereed conference publications. She co-edited a book on CAD/GIS Integration and another book on Embedded Commissioning. She has graduated more than 16 PhD students and 15 MS thesis students and is currently advising/co-advising 4 PhD students.

Carleton University New Program Review

M.Eng, MASc and PhD Programs in Building Engineering

Reviewers report prepared by:

Dr. Burcu Akinci and Dr. Chris Kennedy,

August 30, 2020

Executive Summary with Recommendations:

The proposed new program in Building Engineering is strongly aligned with the strengths of the Faculty of Engineering and Design; and is consistent with Carleton's priority areas in the Strategic Mandate Agreement (2017-2020), The university has excellent research in the areas of building performance, heritage conservation, and fire safety engineering, around which the new program will be built. That said, there is potential to develop a broader curriculum including topics beyond these three areas of strength.

Weaknesses

The mapping from Degree Level Expectations (DLEs) to Program Learning Outcomes (LOs) to program elements is weak and has resulted in a program that lacks breath, especially with respect to the MEng degree. Some courses are labelled as 'core,' but are not mandatory.

Concerns

The relatively weak integration between the three Concentrations in the program is a potential risk to the breadth and cohesion of student learning. The only mandatory course in the programs BLDG 5701 (Introduction to Building Engineering) has many objectives - and being co-taught by at least three instructors there is a danger that the contents become disparate.

Faculty members teaching in the program already have high teaching loads. Most are teaching four courses per year, when three per year is more common for research intensive engineering programs. Some faculty are teaching more than four courses per year (Table D4). These high teaching loads do not preclude launch of the program since some new faculty hires are expected.

Opportunities

There is potential to broaden the learning content of the building engineering programs, for example bringing in elements of building economics and construction management and adding elements of green building design beyond energy related impacts. Such enhancements could help the program better align with the University goals of sustainability Further existing courses from the School of Architecture & Urbanism (beyond those already listed for the program) could be considered in broadening the curriculum.

Hiring of additional new faculty members to teach in the program could be an opportunity to address the lack of gender diversity amongst current instructors.

Strengths

In addition to having faculty doing great research in building engineering, the laboratory facilities (viewed virtually) seem to be excellent. There is already some research which integrates across the three areas of concentration - which is a great strength for the program.

1) The Visit

The ‘site visit’ was conducted on-line via Zoom from July 29-31 due to the COVID-19 pandemic.

2) The program

Consistency of the program with the institution’s mission and academic plans.

The program is potentially strongly aligned with Carleton’s priority areas in the Strategic Mandate Agreement (2017-2020), specifically areas of strength in Environment and Sustainability; and Advanced Technology and Design. The design of high performance buildings is an important strategy for addressing global environmental and sustainability challenges.

Do the program’s intellectual profile and learning outcomes match the teaching and research strengths of the academic unit(s)?

The Department of Civil and Environmental Engineering (CEE) offers a B.Eng in Architectural Conservation and Sustainability Engineering at the undergraduate level that is synergistic with the new graduate program in Building Engineering. The Faculty of Engineering and Design also hosts the Azrieli School of Architecture & Urbanism. Hence, the new program fits very well with the strengths of the Department and the Faculty.

Ways in which the curriculum addresses the current state of the discipline or area of study. Identification of any unique curriculum or program innovations or creative components

The program is built upon the Faculty’s strengths in i) Building Performance; ii) Heritage Conservation; and iii) Fire Safety Engineering. Strengths ii) and iii) are perhaps unique within engineering schools in Canada. Strength i) is broader, but still only seen at a few Canadian engineering schools.
All three of these strengths are ‘current’, but there are elements of building engineering that arguably lie beyond the three strengths, for example: indoor air quality; aspects of building economics and construction management; and environment and sustainability aspects that go beyond energy. The new programs, and especially the MEng program, might benefit from greater breadth. There are, for example, some existing courses in the School of Architecture & Urbanism that could partially help with a broadening of the programs, such as:

- ARCC 5100 Advanced Building Systems
- ARCC 5500 Advanced Design Economics
- ARCH 5001 Architecture Seminar 1

Clarity and appropriateness of the program's Degree nomenclature

This initiative formally creates twelve new degree programs as listed on p. 39. The nomenclature is clear. We did question whether formal recognition of the “Concentrations” is necessary - especially at the PhD. level. There are perhaps some trade-offs between market appeal and additional administrative complexity.

For graduate programs, a clear rationale for program length that ensures that the program requirements can be reasonable completed within the proposed time period

We may have missed an explicit statement of the program length, but based on section E3, we infer that the Masters programs are two years and the PhD programs are four years. If these are correct, then the program requirements (as per Table B2.1) can be achieved within the time periods.

For research-focused graduate programs, clear indication for the nature and suitability of the major research requirements for degree completion

Table B2.1 shows suitable major research requirements for the MASc and PhD degrees.

Evidence that each graduate student in the program is required to take a minimum of two-thirds of the course requirements from among graduate level courses

Table B2.2 and the text below it demonstrates that all course requirements are from the graduate level.

Appropriateness of the proposed mode(s) of delivery to meet the intended program learning outcomes and Degree Level Expectations

The modes of delivery, plus activities and artifacts (Table B2.1 & Table B.2 a-c) are appropriate, but see further comments on learning outcomes and degree level expectations below.

Is there a clear indication of essential requirements?

The first bullet under “Program essential requirements” (p.23) describes attributes that students should possess on entrance to the program; whereas the definition of essential requirements quoted on p.24 described them as “knowledge or skills that must be acquired or demonstrated.” The rest of the bullets in section B.4 describe generic requirements that would be applicable to most programs; we wonder whether program specific knowledge and skills should be listed here (such as described by the program goals on p.10).

Does the program have an appropriate governance and administrative structure?

The program will be governed and administered in a similar way to the other graduate programs in the Department - with a director for the program and a full time graduate administrator. Having a director responsible for championing the program is good.

Appropriateness of the program's admission requirements for the learning outcomes established for the completion of the program

The admission requirements are appropriate, other than English language requirements for overseas students (not mentioned in Section E).

Sufficient explanation of alternative requirements, if any, for admission into a graduate program, such as minimum grade point average, additional languages or portfolios, along with how the program recognizes prior work or learning experience.

A list of technical courses to support alternative entry into the program is provided on p.32 and seems appropriate.

3) Learning outcomes assessment

Clarity and appropriateness of the program's

- **Requirements and associated learning outcomes in addressing the institution's own graduate Degree Level Expectations**
- **Proposed methods for the assessment of student achievement of the intended program learning outcomes and Degree Level Expectations**

The mapping from Degree Level Expectations (DLEs) to Program Learning Outcomes (LOs) to Program design could be done with more rigor - potentially resulting in an enriched curriculum. There are some challenges with the current mapping. For example DLE 1 'Depth and breadth of knowledge' is mapped onto LO1 'Be able to create, collect and/or analyze data related to the built environment' (Table B1a). Use of the term 'built environment' is appropriate here - providing 'breadth', although the LO more generally is somewhat focussed on 'data' and arguably misses 'theory.' More challenging is the subsequent mapping from LO1 to the components of the three programs (Tables B.2 a-c). LO1 maps on to the "Core courses listed in Table B2.2", plus the project or thesis. The definition of a 'core course' causes some confusion. The only mandatory course in the programs is BLDG 5701 (Introduction to Building Engineering). The other so-called core courses are electives and are quite different depending on the Concentration. (The footnote on p.20 also indicates that these elective core courses can be substituted with other outside courses - which is good - but confusing). Moreover, with the exception of the Research Methods course (in two of three Concentrations), the elective core courses are narrow specialized technical courses - and so do not provide much breadth. It could be argued that the student projects or thesis provide some breadth, but that may be highly

dependent on the topic. So the bottom-line here is that the programs are weak on the 'breadth' part of DLE1.

Another of the DLEs is 'Experiential Learning.' Given the topic of the Program and the fabulous applied research activities that the faculty are pursuing, there is no doubt that opportunities for experiential learning abound. The mapping from DLE7 through the learning outcomes to 'core courses' again, however, fails to rigorously show how experiential learning is achieved in the new programs.

Similar arguments can be made for the other DLEs. We are confident that the DLEs can be achieved by the program(s), but the mapping through LOs to 'core courses' and project/thesis lacks clarity.

We also had a comment specifically on the one proposed mandatory course BLDG 5701: Introduction to Building Engineering. There are several goals for this course - broad multidisciplinary coverage of building engineering, development of research skills, communication, and advanced methods in architecture, engineering & construction (from course description on p.52). With so many objectives - and being co-taught by at least three instructors - there is a danger that the course contents could become somewhat disparate.

4) Resources

Participation of a sufficient number and quality of faculty who are competent to teach and/or supervise in the program.

Faculty members associated with this program are of high quality and represent the necessary disciplines for the curriculum. They are definitely competent to teach and supervise in the program. They seem to have a large load of courses to teach and hence would benefit from additional hiring.

Adequacy of the administrative unit's planned utilization of existing human, physical and financial resources, and any institutional commitment to supplement those resources, to support the program.

The proposed program builds on utilization of existing faculty in Civil, Mechanical and Architecture departments. It is a highly energetic group of faculty members who are enthusiastic about the program and ready to launch it with existing resources. The faculty has access to great state-of-the art labs/facilities (based on what we could deduct from the virtual lab tour).

Evidence that there are adequate resources to sustain the quality of scholarship produced by undergraduate students as well as graduate students' scholarship and research activities, including library support, information technology support, and laboratory access.

Based on the provided description, the students will have access to scholarships as well as laboratory and library resources to successfully complete their programs.

Is the program's curriculum expected to achieve the program's learning outcomes in an effective manner?

The proposed program has an innovative curriculum that allows concentration on building performance, heritage conservation and fire safety engineering. The program goals fall under three categories: (1) Interdisciplinarity; (2) Research and (3) Communication. It also includes several learning outcomes. The way that the curriculum is designed around three fields/concentrations enable achieving the stated learning outcomes in the document. Having said that, we have suggestions to enable further achievement of program learning outcomes (e.g., having more required courses, further enhancing experiential learning, etc.) These are discussed in Section 3 of this report.

Are there redundancies in curriculum offerings in terms of achieving program-level learning outcomes?

The committee has not found any redundancies in curriculum offerings. On the contrary, the committee thinks that the curriculum can be enhanced further by bringing in additional aspects. For example, it would be valuable to include more building systems, such as building envelopes, into the planned curriculum. Similarly, courses that provide deeper understanding on building physics, construction and sustainability management approaches, and data science and analytics techniques would greatly enhance the proposed curriculum.

Are there efficiencies that can be effected in program delivery that will offset the perceived need for additional faculty

There can be potential efficiencies that might be achieved by having closer connection with other units in the university, such as Azrieli School of Architecture & Urbanism and potentially the Computer Science department.

Can there be any other innovations that can offset the need for additional faculty resources at the same time as improving the student experience?

It seems like the faculty has already employed possible ways to stretch out existing resources (mainly the faculty time). They seem to have large course loads teaching a variety of topics, and meeting the needs of both undergraduate and graduate curriculums. They have implemented innovative approaches to offer their courses to both undergraduates and graduates (referred to as "piggy backing").

5) Students

The proposed program was formulated based on the students' strong interest in building engineering. Given the uniqueness of the program together with already existing interests from students, it is expected that the program will attract a large number of students. While this would be welcoming in terms of robustness of the program, it can also result in challenging the student-faculty ratios in courses. During the visit, we heard about hiring plans within the department and we believe that it is important that to have focused hiring targeting this program so as to eliminate any potential negative impact to student-faculty ratio.

The home unit of the students will be the Department of Civil and Environmental Engineering. The planned graduate student orientation will be done by FGPA together with a department-specific orientation to be done under the direction of Associate Chair of Graduate Studies. Each graduate student will have a supervisor and the students enrolled in the PhD program will have Graduate Advisory Committee. All of the students will benefit from an interdisciplinary community that is already existing and that brings complementary perspectives to the curriculum. All of this create a great support ecosystem for students to thrive in and benefit from.

There is an increasing demand for building engineering and its related fields in Canada and many parts of the world. It is expected that the students will be able to pick a path from several career choices, such as sustainability engineers, energy managers, building automation and control engineers and fire safety engineers.

The external review team did not have an opportunity to meet with students during the virtual site visit. So, all of the comments stated above are based on the documents that were provided and interviews with faculty and staff.

6) Assessing faculty competence

One of the biggest assets of this program is the excellent group of faculty, the diversity of their background and the enthusiasm and passion that they have for building engineering. This group of faculty have great research track record and are well-known in their respective fields of heritage conservation, energy management, building science and control, and fire dynamics. They have collectively raised significant amount of funding over the last seven year and have a good track record of student supervision.

This group of faculty already formed an interdisciplinary community under the umbrella of building performance research center and have been collaborating and working together for a while. Within that center, they are organizing seminars and invite guest speakers. They also stated that they have been co-advising students in their research projects.

All of these show a great group of faculty who have complementary expertise, are already working together and will collectively contribute substantively to the proposed program. This is one of the most important ingredients of a successful program.

Building Engineering
Unit Response to External Reviewers' Report & Implementation Plan
Programs Being Reviewed: Graduate Programs

Note: This document (excluding the categorization and unit response column) is forwarded to Senate, the Quality Council and posted on the Vice- Provost's external website.

Introduction & General Comments

Please include any general comments regarding the External Reviewers' Report.

The Department of Civil Engineering was pleased to receive the Reviewers' positive External Reviewers' report on September 21, 2020. This report was shared with our faculty and staff, and we are committed to the continual improvement of our programs to enhance the student, staff, and faculty experience. This document contains both a response to the External Reviewers' Report and a revised Volume 1/proposal which have been created in consultation with the Dean(s).

For each recommendation one of the following responses must be selected:

Agreed to unconditionally: used when the unit agrees to and is able to take action on the recommendation without further consultation with any other parties internal or external to the unit.
Agreed to **if additional resources permit:** used when the unit agrees with the recommendation, however action can only be taken if additional resources are made available. Units must describe the resources needed to implement the recommendation and provide an explanation demonstrating how they plan to obtain those resources. In these cases, discussions with the Deans will normally be required and therefore identified as an action item.
Agreed to in principle: used when the unit agrees with the recommendation, however action is dependent on something other than resources. Units must describe these dependencies and determine what actions, if any, will be taken.
Not agreed to: used when the unit does not agree with the recommendation and therefore will not be taking further action. A rationale must be provided to indicate why the unit does not agree (no action should be associated with this response).

Calendar Changes

If any of the action items you intend to implement will result in calendar changes, please describe what those changes will be. To submit a formal calendar change, please do so using the Courseleaf system.

- Addition of mandatory BLDG 5702 Introduction to Research Methods – for M.Eng. students only
- Above addition changes Core courses to 3.0 credits for MEng students

- Change of name for BLDG 5704 to Advanced Research Methods for Building Engineering to distinguish from above M.Eng course.

UNIT RESPONSE AND IMPLEMENTATION PLAN

Programs Being Reviewed: Building Engineering

Prepared by (name/position/unit): Liam O'Brien, Associate Professor, Civil and Environmental Engineering

External Reviewer Recommendation & Categorization	Unit Response: 1- Agreed to unconditionally 2- Agreed to if additional resources permit (describe resources) 3- Agreed to in principle 4- Not agreed to Rationales are required for categories 2, 3 & 4	Action Item	Owner	Timeline	Will the action described require calendar changes? (Y or N)
1. The mapping from Degree Level Expectations (DLEs) to Program Learning Outcomes (LOs) to program elements is weak and has resulted in a program that lacks breath, especially with respect to the MEng degree. Some courses are labelled as 'core,' but are not mandatory. (Weakness)	*1 – agreed to unconditionally* We have improved the DLE to LO mapping. However, we believe the reviewers may not be familiar with the Ontario-specific terminology regarding core and elective courses.	We met with Andy Thompson and significantly revised the mapping of DLEs to LOs. Refer to Tables B.2.a – B.2.c.	*Liam*	*C*omplete	No
2. The relatively weak integration between the three Concentrations in the program is a potential risk to the breadth and cohesion of student learning. The only mandatory course in the programs BLDG 5701 (Introduction to Building Engineering) has many objectives - and being co-taught by at least three instructors there is a	3 – agreed in principle We have further elaborated in Vol 1 that BLDG5701 will be centrally coordinated to improve cohesiveness between the major concentration areas. For the thesis-based programs, there is a	Vol 1 has been updated regarding role of introductory courses to improve integration	*Liam*	Complete	Yes (for M.Eng. research methods course and related implications)

danger that the contents become disparate. (Concern)	concern among the faculty members that if we were to add additional course requirements, it would dilute critical course offerings in each concentration. For example, already one-third of course requirements for PhD students are specified (and shared across concentrations). For the M.Eng. program, a mandatory research methods course has been added to further blend concentrations, while formalize research methods training (it will be taught by a contract instructor). Finally, we note that details on the shared graduate student offices are now clearer; we expect proximity of graduate students from all concentrations to enhance multi-disciplinary collaboration. This has been noted in Section G.2.				

3. Faculty members teaching in the program already have high teaching loads. Most are teaching four courses per year, when three per year is more common for research intensive engineering programs. Some faculty are teaching more than four courses per year (Table D4). These high teaching loads do not preclude launch of the program since some new faculty hires are expected. (Concern)	*1 – agreed unconditionally*	There were several minor errors in Table D4 for Scott Bucking and Liam O'Brien. Also, there may be some confusion for the reviewers about which courses involve lecturing vs. admin/management. A note has been added to Table D4. None of the professors teach more than 4 lecture-based courses; most teach 3 + a fourth year project supervision.	*Liam*	Complete	No
4. There is potential to broaden the learning content of the building engineering programs, for example bringing in elements of building economics and construction management and adding elements of green building design beyond energy related impacts. Such enhancements could help the program better align with the University goals of sustainability Further existing courses from the School of Architecture & Urbanism (beyond those already listed for the program) could be considered in broadening the curriculum. (Concern)	3 – agreed in principle We <u>agree</u> that M.Eng. students should receive a broader education, since the purpose of M.Eng. degrees is to provide greater specialization than B.Eng. degrees, while maintaining some breadth in courses. However, we <u>do not agree</u> to increase breadth of thesis-based degrees because this would reduce the number of specialized courses they take. We note that the Introduction	No changes to Vol 1.	*All professors*	Several years (dependent on new FED-wide M.Eng. program that is in planning)	Not until changes are made in the future.

	to Building Engineering course is already unique compared to other programs in the Department, with regards to providing breadth.				
5. Hiring of additional new faculty members to teach in the program could be an opportunity to address the lack of gender diversity amongst current instructors. (Concern)	3 – agreed in principle This is consistent with the overall objective in engineering to improve gender diversity. We note that the B.Eng. in Architectural Conservation and Sustainability Engineering and current grad student group has a much higher proportion of female students – approximately 50% - than most engineering programs. The new graduate programs will help in training potential future professors.	Several new hires are underway or expected in the Department; gender diversity is a consideration in the selection process.	Chair and Hiring committees		No

Carleton UNIVERSITY
Canada's Capital University

Office of the Vice-Provost and
Associate Vice-President (Academic)

memorandum

Date: April 22, 2021

To: Dr. Liam O'Brien, Associate Professor, Civil & Environmental Engineering
Dr. Yasser Hassan, Chair, Civil & Environmental Engineering

From: Dr. Dwight Deugo, Vice-Provost and Associate Vice-President (Academic);
Chair, Senate Quality Assurance and Planning Committee

Cc: Dr. Larry Kostiuk, Dean, Faculty of Engineering and Design
Dr. Patrice Smith, Dean, Faculty of Graduate and Postdoctoral Affairs
Dr. James Opp, Associate Dean, Programs, Faculty of Graduate and Postdoctoral Affairs
Sandra Bauer, Program Officer, Faculty of Graduate and Postdoctoral Affairs
Christina Noja, Manager, Office of the Vice-Provost and Associate Vice-President (Academic) Tiffany Douglas, Program Officer, Office of the Vice-Provost and Associate Vice- President (Academic)
Dr. Andrea Thompson, Program Assessment Specialist, Office of the Vice-Provost and Associate Vice-President (Academic)

RE: Outcome of New Program Proposal

The Senate Quality Assurance and Planning Committee (SQAPC) met on April 22, 2021 to consider the unit's response to the External Reviewers' report for the following new program proposal:

- Masters in Building Engineering
- PhD in Building Engineering

In accordance with article 3.5.8 of Carleton's Institutional Quality Assurance Process, SQAPC has determined the has determined the outcome of the programs as "**Recommended to commence**".

The External Reviewers' Report made a number of recommendations, which the committee felt were appropriately addressed.

The Committee wishes to thank the unit for their submission and congratulate the unit on a successful new program proposal. The next stage in the new program approval process is the submission of the new program brief to Carleton University Senate (April 30, 2021). Before the program can be advertised and officially commence, approval from both the Ontario Universities' Council on Quality Assurance and the Ministry of Advanced Education and Skills Development is required.

Please do not hesitate to contact me should you have any questions or concerns.

Dwight Deugo

Dr. Dwight Deugo
Vice-Provost & Associate Vice-President (Academic)

Program Change Request

New Program Proposal

Date Submitted: 01/28/20 12:31 pm

Viewing: **TBD-1969 : Building Engineering M.A.Sc.**

Last edit: 04/09/21 10:35 am

Last modified by: sandrabauer

Changes proposed by: sandrabauer

In Workflow

1. **CIVE ChairDir GR**
2. **ENG Dean**
3. **GRAD Dean**
4. **PRE GRAD FCC**
5. **GRAD FCC**
6. **GRAD FBoard**
7. **Future Cycle**
8. PRE SCCASP
9. SCCASP
10. SQAPC
11. Senate
12. CalEditor

Approval Path

1. 01/28/20 2:19 pm Yasser Hassan (yasserhassan): Approved for CIVE ChairDir GR
2. 01/29/20 5:09 pm Jerome Talim (jerometalim): Approved for ENG Dean
3. 01/30/20 10:46 am Sandra Bauer (sandrabauer): Approved for GRAD Dean
4. 02/10/20 3:09 pm Sandra Bauer (sandrabauer): Approved for PRE GRAD FCC
5. 02/10/20 3:10 pm Sandra Bauer (sandrabauer): Approved for GRAD FCC
6. 02/19/20 2:09 pm Sandra Bauer (sandrabauer): Approved for GRAD FBoard
7. 10/27/20 9:55 am Sarah Cleary (sarahcleary): Rollback to GRAD FBoard for PRE

SCCASP
8. 11/16/20 6:29 pm Sandra Bauer (sandrabauer): Approved for GRAD FBoard

Effective Date	2022-23
Workflow	majormod
Program Code	TBD-1969
Level	Graduate
Faculty	Faculty of Engineering and Design
Academic Unit	Department of Civil and Environmental Engineering
Degree	
Title	Building Engineering M.A.Sc.

Program Requirements

M.A.Sc. Building Engineering (5.0 credits)

Requirements:

1. 0.5 credit in: **0.5**

BLDG 5701 [0.0] Introduction to Building Engineering

2. 1.0 credit from the following list. Other courses may be used, with Supervisor recommendation and Director approval. **1.0**

ARCN 5100 [0.5] Representation and Documentation in Architectural Conservation
ARCC 5401 [0.5] Workshop: Technical Studies in Heritage Conservation
BLDG 5107 [0.0] Building Services Engineering
BLDG 5704 [0.0] Advanced Research Methods for Building Engineering
BLDG 5705 [0.0] Advanced Building Characterization, Conservation and Rehabilitation Heritage
CDNS 5403 [0.5] Heritage Conservation and Sustainability
CIVE 5609 [0.5] Fundamentals of Fire Safety Engineering
CIVE 5610 [0.5] Fire Dynamics I
CIVE 5612 [0.5] Fire Modeling
CIVE 5613 [0.5] Fire Dynamics II
CIVE 5614 [0.5] Design for Fire Resistance
CIVE 5615 [0.5] Fire Behaviour of Materials
ENVE 5104 [0.5] Indoor Environmental Quality
MECH 5205 [0.5] Building Performance Simulation

3. 1.0 credit in approved electives **1.0**

4. 2.5 credits in:		**2.5**
BLDG 5909 [0.0]	**M.A.Sc. Thesis (in the area of the concentration)**	
Total Credits		5.0

M.A.Sc. Building Engineering with Concentration in Building Performance (5.0 credits)

Requirements:		
1. 0.5 credit in:		**0.5**
BLDG 5701 [0.0]	**Introduction to Building Engineering**	
2. 1.5 credits in the concentration, from the following list. Other courses may be used, with Supervisor recommendation and Director approval.		**1.5**
BLDG 5107 [0.0]	**Building Services Engineering**	
BLDG 5704 [0.0]	**Advanced Research Methods for Building Engineering**	
BLDG 5707 [0.0]	**Building Energy Management and Optimization**	
ENVE 5104 [0.5]	**Indoor Environmental Quality**	
MECH 5205 [0.5]	**Building Performance Simulation**	
3. 0.5 credit in approved electives		**0.5**
4. 2.5 credits in:		**2.5**
BLDG 5909 [0.0]	**M.A.Sc. Thesis (in the area of the concentration)**	
Total Credits		5.0

M.A.Sc. Building Engineering with Concentration in Fire Safety (5.0 credits)

Requirements:		
1. 0.5 credit in:		**0.5**
BLDG 5701 [0.0]	**Introduction to Building Engineering**	
2. 1.5 credits in the concentration, from the following list. Other courses may be used, with Supervisor recommendation and Director approval.		**1.5**
CIVE 5609 [0.5]	**Fundamentals of Fire Safety Engineering**	
CIVE 5610 [0.5]	**Fire Dynamics I**	
CIVE 5612 [0.5]	**Fire Modeling**	
CIVE 5613 [0.5]	**Fire Dynamics II**	
CIVE 5614 [0.5]	**Design for Fire Resistance**	
CIVE 5615 [0.5]	**Fire Behaviour of Materials**	
3. 0.5 credit in approved electives		**0.5**
4. 2.5 credits in:		**2.5**
BLDG 5909 [0.0]	**M.A.Sc. Thesis (in the area of the concentration)**	
Total Credits		5.0

M.A.Sc. Building Engineering with Concentration in Heritage Conservation (5.0 credits)

Requirements:		
1. 0.5 credit in:		**0.5**
BLDG 5701 [0.0]	**Introduction to Building Engineering**	
2. 1.5 credits in the concentration, from the following list. Other courses may be used, with Supervisor recommendation and Director approval.		**1.5**
ARCN 5100 [0.5]	**Representation and Documentation in Architectural Conservation**	
ARCC 5401 [0.5]	**Workshop: Technical Studies in Heritage Conservation**	
BLDG 5704 [0.0]	**Advanced Research Methods for Building Engineering**	
BLDG 5705 [0.0]	**Advanced Building Characterization, Conservation and Rehabilitation Heritage**	
CDNS 5403 [0.5]	**Heritage Conservation and Sustainability**	
CIVE 5609 [0.5]	**Fundamentals of Fire Safety Engineering**	
3. 0.5 credit in approved electives		**0.5**
4. 2.5 credits in:		**2.5**
BLDG 5909 [0.0]	**M.A.Sc. Thesis (in the area of the concentration)**	
Total Credits		5.0

New Resources	No New Resources
Summary	Add Building Engineering M.A.Sc.
Rationale	New program
Transition/Implementation	New program
Program reviewer comments	**sarahcleary (10/27/20 9:55 am):** Rollback: Rollback as requested. **sandrabauer (11/16/20 5:49 pm):** Creating individual entries for BLDG programs/concentrations previously bundled. Approvals: 01/28/20 2:19 pm Yasser Hassan (yasserhassan): Approved for CIVE ChairDir GR 01/29/20 5:09 pm Jerome Talim (jerometalim): Approved for ENG Dean 01/30/20 10:46 am Sandra Bauer (sandrabauer): Approved for GRAD Dean 02/10/20 3:09 pm Sandra Bauer (sandrabauer): Approved for PRE GRAD FCC 02/10/20 3:10 pm Sandra Bauer (sandrabauer): Approved for GRAD FCC 02/19/20 2:09 pm Sandra Bauer (sandrabauer): Approved for GRAD FBoard 10/27/20 9:55 am Sarah Cleary (sarahcleary): Rollback to GRAD FBoard for PRE SCCASP **sarahcleary (02/23/21 4:44 pm):** Changed effective year to 2022-2023 as per email with FGPA and OVPAVPA. Moved to Future Cycle. **sandrabauer (04/09/21 10:35 am):** Minor edit to wording of item 2.

Key: 1969

Program Change Request

New Program Proposal

Date Submitted: 01/28/20 12:32 pm

Viewing: **TBD-1970 : Building Engineering M.Eng.**

Last edit: 04/09/21 10:37 am

Last modified by: sandrabauer

Changes proposed by: sandrabauer

In Workflow

1. **CIVE ChairDir GR**
2. **ENG Dean**
3. **GRAD Dean**
4. **PRE GRAD FCC**
5. **GRAD FCC**
6. **GRAD FBoard**
7. **Future Cycle**
8. PRE SCCASP
9. SCCASP
10. SQAPC
11. Senate
12. CalEditor

Approval Path

1. 01/28/20 2:19 pm Yasser Hassan (yasserhassan): Approved for CIVE ChairDir GR
2. 01/29/20 5:09 pm Jerome Talim (jerometalim): Approved for ENG Dean
3. 01/30/20 10:46 am Sandra Bauer (sandrabauer): Approved for GRAD Dean
4. 02/10/20 3:09 pm Sandra Bauer (sandrabauer): Approved for PRE GRAD FCC
5. 02/10/20 3:10 pm Sandra Bauer (sandrabauer): Approved for GRAD FCC
6. 02/19/20 2:09 pm Sandra Bauer (sandrabauer): Approved for GRAD FBoard
7. 10/26/20 11:27 am Sarah Cleary (sarahcleary): Rollback to GRAD FBoard for PRE

SCCASP
8. 11/16/20 6:30 pm
Sandra Bauer
(sandrabauer): Approved
for GRAD FBoard

Effective Date	2022-23
Workflow	majormod
Program Code	TBD-1970
Level	Graduate
Faculty	Faculty of Engineering and Design
Academic Unit	Department of Civil and Environmental Engineering
Degree	Master of Engineering
Title	Building Engineering M.Eng.

Program Requirements

M.Eng. Building Engineering (5.0 credits)

Requirements - Coursework pathway:

1. 1.0 credit in:			**1.0**
	BLDG 5701 [0.0]	**Introduction to Building Engineering**	
	BLDG 5702 [0.0]	**Introduction to Research Methods**	
2. 0.5 credit from Building Performance concentration courses:			**0.5**
	BLDG 5107 [0.0]	**Building Services Engineering**	
	BLDG 5704 [0.0]	**Advanced Research Methods for Building Engineering**	
	BLDG 5707 [0.0]	**Building Energy Management and Optimization**	
	ENVE 5104 [0.5]	**Indoor Environmental Quality**	
	MECH 5205 [0.5]	**Building Performance Simulation**	
3. 0.5 credit from Fire Safety concentration courses:			**0.5**
	CIVE 5609 [0.5]	**Fundamentals of Fire Safety Engineering**	
	CIVE 5610 [0.5]	**Fire Dynamics I**	
	CIVE 5612 [0.5]	**Fire Modeling**	
	CIVE 5613 [0.5]	**Fire Dynamics II**	
	CIVE 5614 [0.5]	**Design for Fire Resistance**	
	CIVE 5615 [0.5]	**Fire Behaviour of Materials**	
4. 0.5 credit from Heritage Conservation concentration courses:			**0.5**
	ARCN 5100 [0.5]	**Representation and Documentation in Architectural Conservation**	
	ARCC 5401 [0.5]	**Workshop: Technical Studies in Heritage Conservation**	

BLDG 5704 [0.0]	Advanced Research Methods for Building Engineering	
BLDG 5705 [0.0]	Advanced Building Characterization, Conservation and Rehabilitation Heritage	
CDNS 5403 [0.5]	Heritage Conservation and Sustainability	
CIVE 5609 [0.5]	Fundamentals of Fire Safety Engineering	
5. 1.0 credit in additional concentration courses, not already used to fulfil Items 2-4 above		**1.0**
6. 1.5 credits in approved electives		**1.5**
Total Credits		5.0

Requirements - Project pathway:

1. 1.0 credit in:		**1.0**
BLDG 5701 [0.0]	Introduction to Building Engineering	
BLDG 5702 [0.0]	Introduction to Research Methods	
2. 2.0 credits from the following list. Other courses may be used, with Supervisor recommendation and Director approval.		**2.0**
ARCN 5100 [0.5]	Representation and Documentation in Architectural Conservation	
ARCC 5401 [0.5]	Workshop: Technical Studies in Heritage Conservation	
BLDG 5107 [0.0]	Building Services Engineering	
BLDG 5704 [0.0]	Advanced Research Methods for Building Engineering	
BLDG 5705 [0.0]	Advanced Building Characterization, Conservation and Rehabilitation Heritage	
CDNS 5403 [0.5]	Heritage Conservation and Sustainability	
CIVE 5609 [0.5]	Fundamentals of Fire Safety Engineering	
CIVE 5610 [0.5]	Fire Dynamics I	
CIVE 5612 [0.5]	Fire Modeling	
CIVE 5613 [0.5]	Fire Dynamics II	
CIVE 5614 [0.5]	Design for Fire Resistance	
CIVE 5609 [0.5]	Fundamentals of Fire Safety Engineering	
ENVE 5104 [0.5]	Indoor Environmental Quality	
MECH 5205 [0.5]	Building Performance Simulation	
3. 1.0 credits in approved electives		**1.0**
4. 1.0 credit in:		**1.0**
BLDG 5900 [0.0]	M.Eng. Project	
Total Credits		5.0

New Resources	No New Resources
Summary	Add MEng Building Engineering
Rationale	new program
Transition/Implementation	new program

Program reviewer comments	**sarahcleary (08/25/20 8:56 am):** M.Eng concentration in building performance, project pathway - corrected credit values. M.Eng concentration in building performance, course pathway - corrected section numbering. **sarahcleary (10/26/20 11:27 am):** Rollback: Rollback as requested. **sandrabauer (11/16/20 6:28 pm):** Creating individual entry - previously bundled. Approval Path 01/28/20 2:19 pm Yasser Hassan (yasserhassan): Approved for CIVE ChairDir GR 01/29/20 5:09 pm Jerome Talim (jerometalim): Approved for ENG Dean 01/30/20 10:46 am Sandra Bauer (sandrabauer): Approved for GRAD Dean 02/10/20 3:09 pm Sandra Bauer

(sandrabauer): Approved for PRE GRAD FCC 02/10/20 3:10 pm Sandra Bauer (sandrabauer): Approved for GRAD FCC 02/19/20 2:09 pm Sandra Bauer (sandrabauer): Approved for GRAD FBoard 10/26/20 11:27 am Sarah Cleary (sarahcleary): Rollback to GRAD FBoard for PRE SCCASP

sarahcleary (02/23/21 4:46 pm): Changed effective year to 2022-2023 as per email with FGPA and OVPAVPA. Moved to Future Cycle.

sandrabauer (04/09/21 10:37 am): Minor edit to wording of item 2.

Key: 1970

Program Change Request

New Program Proposal

Date Submitted: 01/28/20 12:32 pm

Viewing: **TBD-1971 : Building Engineering Ph.D.**

Last edit: 04/09/21 10:43 am

Last modified by: sandrabauer

Changes proposed by: sandrabauer

In Workflow

1. **CIVE ChairDir GR**
2. **ENG Dean**
3. **GRAD Dean**
4. **PRE GRAD FCC**
5. **GRAD FCC**
6. **GRAD FBoard**
7. **Future Cycle**
8. PRE SCCASP
9. SCCASP
10. SQAPC
11. Senate
12. CalEditor

Approval Path

1. 01/28/20 2:19 pm Yasser Hassan (yasserhassan): Approved for CIVE ChairDir GR
2. 01/29/20 5:09 pm Jerome Talim (jerometalim): Approved for ENG Dean
3. 01/30/20 10:46 am Sandra Bauer (sandrabauer): Approved for GRAD Dean
4. 02/10/20 3:09 pm Sandra Bauer (sandrabauer): Approved for PRE GRAD FCC
5. 02/10/20 3:10 pm Sandra Bauer (sandrabauer): Approved for GRAD FCC
6. 02/19/20 2:09 pm Sandra Bauer (sandrabauer): Approved for GRAD FBoard
7. 10/27/20 9:55 am Sarah Cleary (sarahcleary): Rollback to GRAD FBoard for PRE

SCCASP
8. 11/16/20 6:30 pm Sandra Bauer (sandrabauer): Approved for GRAD FBoard

Effective Date	2022-23
Workflow	majormod
Program Code	TBD-1971
Level	Graduate
Faculty	Faculty of Engineering and Design
Academic Unit	Department of Civil and Environmental Engineering
Degree	Doctor of Philosophy
Title	Building Engineering Ph.D.

Program Requirements

Ph.D. Building Engineering (10.0 credits)

Requirements:

1. 0.5 credit in: **0.5**

BLDG 5701 [0.0] Introduction to Building Engineering

2. 1.0 credit from the following list. Other courses may be used, with Supervisor recommendation and Director approval. **1.0**

ARCN 5100 [0.5] Representation and Documentation in Architectural Conservation
ARCC 5401 [0.5] Workshop: Technical Studies in Heritage Conservation
BLDG 5107 [0.0] Building Services Engineering
BLDG 5704 [0.0] Advanced Research Methods for Building Engineering
BLDG 5705 [0.0] Advanced Building Characterization, Conservation and Rehabilitation Heritage
CDNS 5403 [0.5] Heritage Conservation and Sustainability
CIVE 5609 [0.5] Fundamentals of Fire Safety Engineering
CIVE 5610 [0.5] Fire Dynamics I
CIVE 5612 [0.5] Fire Modeling
CIVE 5613 [0.5] Fire Dynamics II
CIVE 5614 [0.5] Design for Fire Resistance
CIVE 5615 [0.5] Fire Behaviour of Materials
ENVE 5104 [0.5] Indoor Environmental Quality
MECH 5205 [0.5] Building Performance Simulation

3. 0.5 credit in: **0.5**

BLDG 6901 [0.0]	Thesis Proposal	
4. 8.0 credits in:		**8.0**
BLDG 6909 [0.0]	Ph.D. Thesis	
Total Credits		10.0

Ph.D. Building Engineering with Concentration in Building Performance (10.0 credits)

Requirements:

1. 0.5 credit in:		**0.5**
BLDG 5701 [0.0]	Introduction to Building Engineering	
2. 1.0 credit in the concentration, from the following list. Other courses may be used, with Supervisor recommendation and Director approval.		**1.0**
BLDG 5107 [0.0]	Building Services Engineering	
BLDG 5704 [0.0]	Advanced Research Methods for Building Engineering	
BLDG 5707 [0.0]	Building Energy Management and Optimization	
ENVE 5104 [0.5]	Indoor Environmental Quality	
MECH 5205 [0.5]	Building Performance Simulation	
3. 0.5 credit in:		**0.5**
BLDG 6901 [0.0]	Thesis Proposal (in the area of the concentration)	
4. 8.0 credits in:		**8.0**
BLDG 6909 [0.0]	Ph.D. Thesis (in the area of the concentration)	
Total Credits		10.0

Ph.D. Building Engineering with Concentration in Fire Safety (10.0 credits)

Requirements:

1. 0.5 credit in:		**0.5**
BLDG 5701 [0.0]	Introduction to Building Engineering	
2. 1.0 credit in the concentration, from the following list. Other courses may be used, with Supervisor recommendation and Director approval.		**1.0**
CIVE 5609 [0.5]	Fundamentals of Fire Safety Engineering	
CIVE 5610 [0.5]	Fire Dynamics I	
CIVE 5612 [0.5]	Fire Modeling	
CIVE 5613 [0.5]	Fire Dynamics II	
CIVE 5614 [0.5]	Design for Fire Resistance	
CIVE 5615 [0.5]	Fire Behaviour of Materials	
3. 0.5 credit in:		**0.5**
BLDG 6901 [0.0]	Thesis Proposal (in the area of the concentration)	
4. 8.0 credits in:		**8.0**
BLDG 6909 [0.0]	Ph.D. Thesis (in the area of the concentration)	
Total Credits		10.0

Ph.D. Building Engineering
with Concentration in Heritage Conservation (10.0 credits)

Requirements:		
1. 0.5 credit in:		**0.5**
BLDG 5701 [0.0]	**Introduction to Building Engineering**	
2. 1.0 credit in the concentration, from the following list. Other courses may be used, with Supervisor recommendation and Director approval.		**1.0**
ARCN 5100 [0.5]	**Representation and Documentation in Architectural Conservation**	
ARCC 5401 [0.5]	**Workshop: Technical Studies in Heritage Conservation**	
BLDG 5704 [0.0]	**Advanced Research Methods for Building Engineering**	
BLDG 5705 [0.0]	**Advanced Building Characterization, Conservation and Rehabilitation Heritage**	
CDNS 5403 [0.5]	**Heritage Conservation and Sustainability**	
3. 0.5 credit in:		**0.5**
BLDG 6901 [0.0]	**Thesis Proposal (in the area of the concentration)**	
4. 8.0 credits in:		**8.0**
BLDG 6909 [0.0]	**Ph.D. Thesis (in the area of the concentration)**	
Total Credits		10.0

New Resources	No New Resources
Summary	Add new program in Building Engineering PhD incl. conc. Building Performance, Fire Safety, Heritage Conservation.
Rationale	new program
Transition/Implementation	new program

Program reviewer comments	**sarahcleary (10/27/20 9:55 am):** Rollback: Rollback as requested. **sarahcleary (02/23/21 4:47 pm):** Changed effective year to 2022-2023 as per email with FGPA and OVPAVPA. Moved to Future Cycle. **sandrabauer (04/09/21 10:43 am):** Minor edit to wording of item 2.

Key: 1971

New Program Proposal

Date Submitted: 11/16/20 5:54 pm

Viewing: TBD-2062 : Building Engineering M.Eng. with Concentration in Building Performance

Last edit: 02/23/21 4:46 pm

Last modified by: sarahcleary

Changes proposed by: sandrabauer

In Workflow

1. **GRAD FBoard**
2. **Future Cycle**
3. PRE SCCASP
4. SCCASP
5. SQAPC
6. Senate
7. CalEditor

Approval Path

1. 11/16/20 6:30 pm Sandra Bauer (sandrabauer): Approved for GRAD FBoard

Effective Date	2022-23
Workflow	majormod
Program Code	TBD-2062
Level	Graduate
Faculty	Faculty of Engineering and Design
Academic Unit	Department of Civil and Environmental Engineering
Degree	Master of Engineering
Title	Building Engineering M.Eng. with Concentration in Building Performance

Program Requirements

M.Eng. Building Engineering
with Concentration in Building Performance (5.0 credits)

Requirements - Coursework pathway:

1. 1.0 credit in: **1.0**

BLDG 5701 [0.0]	**Introduction to Building Engineering**
BLDG 5702 [0.0]	**Introduction to Research Methods**

2. 2.0 credits in the concentration, from the following list. Other courses may be used, with Supervisor recommendation and Director approval. **2.0**

BLDG 5107 [0.0]	Building Services Engineering	
BLDG 5704 [0.0]	Advanced Research Research Methods for Building Engineering	
BLDG 5707 [0.0]	Building Energy Management and Optimization	
ENVE 5104 [0.5]	Indoor Environmental Quality	
MECH 5205 [0.5]	Building Performance Simulation	
3. 2.0 credits in approved electives		**2.0**
Total Credits		5.0

Requirements - Project pathway:

1. 1.0 credit in:		**1.0**
BLDG 5701 [0.0]	Introduction to Building Engineering	
BLDG 5702 [0.0]	Introduction to Research Methods	
2. 2.0 credits in the concentration, from the following list. Other courses may be used, with Supervisor recommendation and Director approval.		**2.0**
BLDG 5107 [0.0]	Building Services Engineering	
BLDG 5704 [0.0]	Advanced Research Research Methods for Building Engineering	
BLDG 5707 [0.0]	Building Energy Management and Optimization	
ENVE 5104 [0.5]	Indoor Environmental Quality	
MECH 5205 [0.5]	Building Performance Simulation	
3. 1.0 credits in approved electives		**1.0**
4. 1.0 credit in:		**1.0**
BLDG 5900 [0.0]	M.Eng. Project	
Total Credits		5.0

New Resources	No New Resources
Summary	Add Building Engineering M.Eng. with Concentration in Building Performance
Rationale	np
Transition/Implementation	np

Program reviewer comments	**sandrabauer (11/16/20 6:29 pm):** Creating individual entry - previously bundled. Approval Path 01/28/20 2:19 pm Yasser Hassan (yasserhassan): Approved for CIVE ChairDir GR 01/29/20 5:09 pm Jerome Talim (jerometalim): Approved for ENG Dean 01/30/20 10:46 am Sandra Bauer (sandrabauer): Approved for GRAD Dean 02/10/20 3:09 pm Sandra Bauer (sandrabauer): Approved for PRE GRAD FCC 02/10/20 3:10 pm Sandra Bauer (sandrabauer): Approved for GRAD FCC 02/19/20 2:09 pm Sandra Bauer (sandrabauer): Approved for GRAD FBoard 10/26/20 11:27 am Sarah Cleary (sarahcleary): Rollback to GRAD FBoard for PRE SCCASP **sarahcleary (02/23/21 4:46 pm):** Changed effective year to 2022-2023 as per email with FGPA and OVPAVPA. Moved to Future Cycle.

Key: 2062

New Program Proposal

Date Submitted: 11/16/20 6:01 pm

Viewing: TBD-2063 : Building Engineering M.Eng. with Concentration in Fire Safety

Last edit: 02/23/21 4:47 pm

Last modified by: sarahcleary

Changes proposed by: sandrabauer

In Workflow

1. **GRAD FBoard**
2. **Future Cycle**
3. PRE SCCASP
4. SCCASP
5. SQAPC
6. Senate
7. CalEditor

Approval Path

1. 11/16/20 6:30 pm
   Sandra Bauer
   (sandrabauer): Approved
   for GRAD FBoard

Effective Date	2022-23
Workflow	majormod
Program Code	TBD-2063
Level	Graduate
Faculty	Faculty of Engineering and Design
Academic Unit	Department of Civil and Environmental Engineering
Degree	Master of Engineering
Title	Building Engineering M.Eng. with Concentration in Fire Safety

Program Requirements

M.Eng. Building Engineering
with Concentration in Fire Safety (5.0 credits)

Requirements - Coursework pathway:

1. 1.0 credit in: **1.0**

BLDG 5701 [0.0]	**Introduction to Building Engineering**
BLDG 5702 [0.0]	**Introduction to Research Methods**

2. 2.0 credits in the concentration, from the following list. Other courses may be used, with Supervisor recommendation and Director approval. **2.0**

CIVE 5609 [0.5]	Fundamentals of Fire Safety Engineering	
CIVE 5610 [0.5]	Fire Dynamics I	
CIVE 5612 [0.5]	Fire Modeling	
CIVE 5613 [0.5]	Fire Dynamics II	
CIVE 5614 [0.5]	Design for Fire Resistance	
CIVE 5615 [0.5]	Fire Behaviour of Materials	
3. 2.0 credits in approved electives		**2.0**
Total Credits		5.0

Requirements - Project pathway:

1. 1.0 credit in:		**1.0**
BLDG 5701 [0.0]	Introduction to Building Engineering	
BLDG 5702 [0.0]	Introduction to Research Methods	
2. 2.0 credits in the concentration, from the following list. Other courses may be used, with Supervisor recommendation and Director approval.		**2.0**
CIVE 5609 [0.5]	Fundamentals of Fire Safety Engineering	
CIVE 5610 [0.5]	Fire Dynamics I	
CIVE 5612 [0.5]	Fire Modeling	
CIVE 5613 [0.5]	Fire Dynamics II	
CIVE 5614 [0.5]	Design for Fire Resistance	
CIVE 5615 [0.5]	Fire Behaviour of Materials	
3. 1.0 credits in approved electives		**1.0**
4. 1.0 credit in:		**1.0**
BLDG 5900 [0.0]	M.Eng. Project	
Total Credits		5.0

New Resources	No New Resources
Summary	Add M.Eng. Building Engineering with Concentration in Fire Safety
Rationale	new program
Transition/Implementation	new program

Program reviewer comments	**sandrabauer (11/16/20 6:04 pm):** Creating individual entry - previously bundled. Approval Path 01/28/20 2:19 pm Yasser Hassan (yasserhassan): Approved for CIVE ChairDir GR 01/29/20 5:09 pm Jerome Talim (jerometalim): Approved for ENG Dean 01/30/20 10:46 am Sandra Bauer (sandrabauer): Approved for GRAD Dean 02/10/20 3:09 pm Sandra Bauer (sandrabauer): Approved for PRE GRAD FCC 02/10/20 3:10 pm Sandra Bauer (sandrabauer): Approved for GRAD FCC 02/19/20 2:09 pm Sandra Bauer (sandrabauer): Approved for GRAD FBoard 10/26/20 11:27 am Sarah Cleary (sarahcleary): Rollback to GRAD FBoard for PRE SCCASP **sarahcleary (02/23/21 4:47 pm):** Changed effective year to 2022-2023 as per email with FGPA and OVPAVPA. Moved to Future Cycle.

Key: 2063

New Program Proposal

Date Submitted: 11/16/20 6:07 pm

Viewing: TBD-2064 : Building Engineering M.Eng. with Concentration in Heritage Conservation

Last edit: 02/23/21 4:47 pm

Last modified by: sarahcleary

Changes proposed by: sandrabauer

In Workflow

1. **GRAD FBoard**
2. **Future Cycle**
3. PRE SCCASP
4. SCCASP
5. SQAPC
6. Senate
7. CalEditor

Approval Path

1. 11/16/20 6:30 pm Sandra Bauer (sandrabauer): Approved for GRAD FBoard

Effective Date	2022-23
Workflow	majormod
Program Code	TBD-2064
Level	Graduate
Faculty	Faculty of Engineering and Design
Academic Unit	Department of Civil and Environmental Engineering
Degree	Master of Engineering
Title	Building Engineering M.Eng. with Concentration in Heritage Conservation

Program Requirements

M.Eng. Building Engineering
with Concentration in Heritage Conservation (5.0 credits)

Requirements - Project pathway:

1. 1.0 credit in: **1.0**

BLDG 5701 [0.0] Introduction to Building Engineering

BLDG 5702 [0.0] Introduction to Research Methods

2. 2.0 credits in the concentration, from the following list. Other courses may be used, with Supervisor recommendation and Director approval. **2.0**

ARCN 5100 [0.5]	Representation and Documentation in Architectural Conservation	
ARCC 5401 [0.5]	Workshop: Technical Studies in Heritage Conservation	
BLDG 5704 [0.0]	Advanced Research Research Methods for Building Engineering	
BLDG 5705 [0.0]	Advanced Building Characterization, Conservation and Rehabilitation Heritage	
CDNS 5403 [0.5]	Heritage Conservation and Sustainability	
3. 1.0 credits in approved electives		**1.0**
4. 1.0 credit in:		**1.0**
BLDG 5900 [0.0]	M.Eng. Project	
Total Credits		5.0

New Resources	No New Resources
Summary	Add M.Eng. Building Engineering with Concentration in Heritage Conservation
Rationale	new program
Transition/Implementation	new program
Program reviewer comments	**sandrabauer (11/16/20 6:10 pm):** Creating individual entry - previously bundled. Approval Path 01/28/20 2:19 pm Yasser Hassan (yasserhassan): Approved for CIVE ChairDir GR 01/29/20 5:09 pm Jerome Talim (jerometalim): Approved for ENG Dean 01/30/20 10:46 am Sandra Bauer (sandrabauer): Approved for GRAD Dean 02/10/20 3:09 pm Sandra Bauer (sandrabauer): Approved for PRE GRAD FCC 02/10/20 3:10 pm Sandra Bauer (sandrabauer): Approved for GRAD FCC 02/19/20 2:09 pm Sandra Bauer (sandrabauer): Approved for GRAD FBoard 10/26/20 11:27 am Sarah Cleary (sarahcleary): Rollback to GRAD FBoard for PRE SCCASP **sarahcleary (02/23/21 4:47 pm):** Changed effective year to 2022-2023 as per email with FGPA and OVPAVPA. Moved to Future Cycle.

Key: 2064

New Program Proposal

Date Submitted: 11/16/20 5:28 pm

Viewing: TBD-2059 : Building Engineering M.A.Sc. with Concentration in Building Performance

Last edit: 02/23/21 4:44 pm

Last modified by: sarahcleary

Changes proposed by: sandrabauer

In Workflow

1. **GRAD FBoard**
2. **Future Cycle**
3. PRE SCCASP
4. SCCASP
5. SQAPC
6. Senate
7. CalEditor

Approval Path

1. 11/16/20 6:30 pm Sandra Bauer (sandrabauer): Approved for GRAD FBoard

Effective Date	2022-23
Workflow	majormod
Program Code	TBD-2059
Level	Graduate
Faculty	Faculty of Engineering and Design
Academic Unit	Department of Civil and Environmental Engineering
Degree	Master of Applied Science
Title	Building Engineering M.A.Sc. with Concentration in Building Performance

Program Requirements

M.A.Sc. Building Engineering with Concentration in Building Performance (5.0 credits)

Requirements:

1. 0.5 credit in: **0.5**

BLDG 5701 [0.0] Introduction to Building Engineering

2. 1.5 credits in the concentration, from the following list. Other courses may be used, with Supervisor recommendation and Director approval. **1.5**

BLDG 5107 [0.0] Building Services Engineering

BLDG 5704 [0.0]	Advanced Research Research Methods for Building Engineering	
BLDG 5707 [0.0]	Building Energy Management and Optimization	
ENVE 5104 [0.5]	Indoor Environmental Quality	
MECH 5205 [0.5]	Building Performance Simulation	
3. 0.5 credit in approved electives		**0.5**
4. 2.5 credits in:		**2.5**
BLDG 5909 [0.0]	M.A.Sc. Thesis (in the area of the concentration)	
Total Credits		5.0

New Resources	No New Resources
Summary	Creating individual entry for Building Engineering programs/concentrations
Rationale	n/a
Transition/Implementation	np

Program reviewer comments	**sandrabauer (11/16/20 5:33 pm):** Creating individual entry - previously bundled. Approvals: 01/28/20 2:19 pm Yasser Hassan (yasserhassan): Approved for CIVE ChairDir GR 01/29/20 5:09 pm Jerome Talim (jerometalim): Approved for ENG Dean 01/30/20 10:46 am Sandra Bauer (sandrabauer): Approved for GRAD Dean 02/10/20 3:09 pm Sandra Bauer (sandrabauer): Approved for PRE GRAD FCC 02/10/20 3:10 pm Sandra Bauer (sandrabauer): Approved for GRAD FCC 02/19/20 2:09 pm Sandra Bauer (sandrabauer): Approved for GRAD FBoard 10/27/20 9:55 am Sarah Cleary (sarahcleary): Rollback to GRAD FBoard for PRE SCCASP **sarahcleary (02/23/21 4:44 pm):** Changed effective year to 2022-2023 as per email with FGPA and OVPAVPA. Moved to Future Cycle.

Key: 2059

New Program Proposal

Date Submitted: 11/16/20 5:37 pm

Viewing: TBD-2060 : Building Engineering M.A.Sc. with Concentration in Fire Safety

Last edit: 02/23/21 4:45 pm

Last modified by: sarahcleary

Changes proposed by: sandrabauer

In Workflow

1. **GRAD FBoard**
2. **Future Cycle**
3. PRE SCCASP
4. SCCASP
5. SQAPC
6. Senate
7. CalEditor

Approval Path

1. 11/16/20 6:30 pm Sandra Bauer (sandrabauer): Approved for GRAD FBoard

Effective Date	2022-23
Workflow	majormod
Program Code	TBD-2060
Level	Graduate
Faculty	Faculty of Engineering and Design
Academic Unit	Department of Civil and Environmental Engineering
Degree	Master of Applied Science
Title	Building Engineering M.A.Sc. with Concentration in Fire Safety

Program Requirements

M.A.Sc. Building Engineering with Concentration in Fire Safety (5.0 credits)

Requirements:

1. 0.5 credit in: **0.5**

BLDG 5701 [0.0] **Introduction to Building Engineering**

2. 1.5 credits in the concentration, from the following list. Other courses may be used, with Supervisor recommendation and Director approval. **1.5**

CIVE 5609 [0.5] **Fundamentals of Fire Safety Engineering**

CIVE 5610 [0.5]	Fire Dynamics I	
CIVE 5612 [0.5]	Fire Modeling	
CIVE 5613 [0.5]	Fire Dynamics II	
CIVE 5614 [0.5]	Design for Fire Resistance	
CIVE 5615 [0.5]	Fire Behaviour of Materials	
3. 0.5 credit in approved electives		**0.5**
4. 2.5 credits in:		**2.5**
BLDG 5909 [0.0]	M.A.Sc. Thesis (in the area of the concentration)	
Total Credits		5.0

New Resources	No New Resources
Summary	Add new program M.A.Sc. Building Engineering with Concentration in Fire Safety
Rationale	n/a
Transition/Implementation	np
Program reviewer comments	**sandrabauer (11/16/20 5:38 pm):** Creating individual entry - previously bundled. Approvals: 01/28/20 2:19 pm Yasser Hassan (yasserhassan): Approved for CIVE ChairDir GR 01/29/20 5:09 pm Jerome Talim (jerometalim): Approved for ENG Dean 01/30/20 10:46 am Sandra Bauer (sandrabauer): Approved for GRAD Dean 02/10/20 3:09 pm Sandra Bauer (sandrabauer): Approved for PRE GRAD FCC 02/10/20 3:10 pm Sandra Bauer (sandrabauer): Approved for GRAD FCC 02/19/20 2:09 pm Sandra Bauer (sandrabauer): Approved for GRAD FBoard 10/27/20 9:55 am Sarah Cleary (sarahcleary): Rollback to GRAD FBoard for PRE SCCASP **sarahcleary (02/23/21 4:45 pm):** Changed effective year to 2022-2023 as per email with FGPA and OVPAVPA. Moved to Future Cycle.

Key: 2060

New Program Proposal

Date Submitted: 11/16/20 5:43 pm

Viewing: TBD-2061 : Building Engineering M.A.Sc. with Concentration in Heritage Conservation

Last edit: 02/23/21 4:45 pm

Last modified by: sarahcleary

Changes proposed by: sandrabauer

In Workflow

1. **GRAD FBoard**
2. **Future Cycle**
3. PRE SCCASP
4. SCCASP
5. SQAPC
6. Senate
7. CalEditor

Approval Path

1. 11/16/20 6:30 pm Sandra Bauer (sandrabauer): Approved for GRAD FBoard

Effective Date	2022-23
Workflow	majormod
Program Code	TBD-2061
Level	Graduate
Faculty	Faculty of Engineering and Design
Academic Unit	Department of Civil and Environmental Engineering
Degree	Master of Applied Science
Title	Building Engineering M.A.Sc. with Concentration in Heritage Conservation

Program Requirements

M.A.Sc. Building Engineering with Concentration in Heritage Conservation (5.0 credits)

Requirements:

1. 0.5 credit in: **0.5**

BLDG 5701 [0.0] Introduction to Building Engineering

2. 1.5 credits in the concentration, from the following list. Other courses may be used, with Supervisor recommendation and Director approval. **1.5**

ARCN 5100 [0.5] Representation and Documentation in Architectural Conservation

ARCC 5401 [0.5]	Workshop: Technical Studies in Heritage Conservation	
BLDG 5704 [0.0]	Advanced Research Research Methods for Building Engineering	
BLDG 5705 [0.0]	Advanced Building Characterization, Conservation and Rehabilitation Heritage	
CDNS 5403 [0.5]	Heritage Conservation and Sustainability	
CIVE 5609 [0.5]	Fundamentals of Fire Safety Engineering	
3. 0.5 credit in approved electives		**0.5**
4. 2.5 credits in:		**2.5**
BLDG 5909 [0.0]	M.A.Sc. Thesis (in the area of the concentration)	
Total Credits		5.0

New Resources	No New Resources
Summary	New program M.A.Sc. Building Engineering with Concentration in Heritage Conservation
Rationale	np
Transition/Implementation	np

Program reviewer comments	**sarahcleary (02/23/21 4:45 pm):** Changed effective year to 2022-2023 as per email with FGPA and OVPAVPA. Moved to Future Cycle.

Key: 2061

New Program Proposal

Date Submitted: 11/16/20 6:13 pm

Viewing: TBD-2065 : Building Engineering PhD with Concentration in Building Performance

Last edit: 02/23/21 4:48 pm

Last modified by: sarahcleary

Changes proposed by: sandrabauer

In Workflow

1. **GRAD FBoard**
2. **Future Cycle**
3. PRE SCCASP
4. SCCASP
5. SQAPC
6. Senate
7. CalEditor

Approval Path

1. 11/16/20 6:30 pm
   Sandra Bauer
   (sandrabauer): Approved
   for GRAD FBoard

Effective Date	2022-23
Workflow	majormod
Program Code	TBD-2065
Level	Graduate
Faculty	Faculty of Engineering and Design
Academic Unit	Department of Civil and Environmental Engineering
Degree	
Title	Building Engineering PhD with Concentration in Building Performance

Program Requirements

Ph.D. Building Engineering
with Concentration in Building Performance (10.0 credits)

Requirements:

1. 0.5 credit in: **0.5**

BLDG 5701 [0.0] Introduction to Building Engineering

2. 1.0 credit in the concentration, from the following list. Other courses may be used, with Supervisor recommendation and Director approval. **1.0**

BLDG 5107 [0.0] Building Services Engineering

BLDG 5704 [0.0]	**Advanced Research Research Methods for Building Engineering**	
BLDG 5707 [0.0]	**Building Energy Management and Optimization**	
ENVE 5104 [0.5]	**Indoor Environmental Quality**	
MECH 5205 [0.5]	**Building Performance Simulation**	
3. 0.5 credit in:		**0.5**
BLDG 6901 [0.0]	**Thesis Proposal (in the area of the concentration)**	
4. 8.0 credits in:		**8.0**
BLDG 6909 [0.0]	**Ph.D. Thesis (in the area of the concentration)**	
Total Credits		10.0

New Resources	No New Resources
Summary	Add PhD Building Engineering with Concentration in Building Performance
Rationale	new program
Transition/Implementation	new program
Program reviewer comments	**sandrabauer (11/16/20 6:27 pm):** Creating individual entry - previously bundled. Approval Path 01/28/20 2:19 pm Yasser Hassan (yasserhassan): Approved for CIVE ChairDir GR 01/29/20 5:09 pm Jerome Talim (jerometalim): Approved for ENG Dean 01/30/20 10:46 am Sandra Bauer (sandrabauer): Approved for GRAD Dean 02/10/20 3:09 pm Sandra Bauer (sandrabauer): Approved for PRE GRAD FCC 02/10/20 3:10 pm Sandra Bauer (sandrabauer): Approved for GRAD FCC 02/19/20 2:09 pm Sandra Bauer (sandrabauer): Approved for GRAD FBoard 10/27/20 9:55 am Sarah Cleary (sarahcleary): Rollback to GRAD FBoard for PRE SCCASP **sarahcleary (02/23/21 4:48 pm):** Changed effective year to 2022-2023 as per email with FGPA and OVPAVPA. Moved to Future Cycle.

Key: 2065

New Program Proposal

Date Submitted: 11/16/20 6:17 pm

Viewing: TBD-2066 : Building Engineering PhD with Concentration in Fire Safety

Last edit: 02/23/21 4:48 pm

Last modified by: sarahcleary

Changes proposed by: sandrabauer

In Workflow

1. **GRAD FBoard**
2. **Future Cycle**
3. PRE SCCASP
4. SCCASP
5. SQAPC
6. Senate
7. CalEditor

Approval Path

1. 11/16/20 6:30 pm
   Sandra Bauer
   (sandrabauer): Approved
   for GRAD FBoard

Effective Date	2022-23
Workflow	majormod
Program Code	TBD-2066
Level	Graduate
Faculty	Faculty of Engineering and Design
Academic Unit	Department of Civil and Environmental Engineering
Degree	Doctor of Philosophy
Title	Building Engineering PhD with Concentration in Fire Safety

Program Requirements

Ph.D. Building Engineering
with Concentration in Fire Safety (10.0 credits)

Requirements:

1. 0.5 credit in: **0.5**

BLDG 5701 [0.0] Introduction to Building Engineering

2. 1.0 credit in the concentration, from the following list. Other courses may be used, with Supervisor recommendation and Director approval. **1.0**

CIVE 5609 [0.5] Fundamentals of Fire Safety Engineering

CIVE 5610 [0.5]	**Fire Dynamics I**	
CIVE 5612 [0.5]	**Fire Modeling**	
CIVE 5613 [0.5]	**Fire Dynamics II**	
CIVE 5614 [0.5]	**Design for Fire Resistance**	
CIVE 5615 [0.5]	**Fire Behaviour of Materials**	
3. 0.5 credit in:		**0.5**
BLDG 6901 [0.0]	**Thesis Proposal (in the area of the concentration)**	
4. 8.0 credits in:		**8.0**
BLDG 6909 [0.0]	**Ph.D. Thesis (in the area of the concentration)**	
Total Credits		10.0

Ph.D. Building Engineering

New Resources	No New Resources
Summary	Add PhD Building Engineering with concentration in Fire Safety
Rationale	new program
Transition/Implementation	new program
Program reviewer comments	**sandrabauer (11/16/20 6:27 pm):** Creating individual entry - previously bundled. Approval Path 01/28/20 2:19 pm Yasser Hassan (yasserhassan): Approved for CIVE ChairDir GR 01/29/20 5:09 pm Jerome Talim (jerometalim): Approved for ENG Dean 01/30/20 10:46 am Sandra Bauer (sandrabauer): Approved for GRAD Dean 02/10/20 3:09 pm Sandra Bauer (sandrabauer): Approved for PRE GRAD FCC 02/10/20 3:10 pm Sandra Bauer (sandrabauer): Approved for GRAD FCC 02/19/20 2:09 pm Sandra Bauer (sandrabauer): Approved for GRAD FBoard 10/27/20 9:55 am Sarah Cleary (sarahcleary): Rollback to GRAD FBoard for PRE SCCASP **sarahcleary (02/23/21 4:48 pm):** Changed effective year to 2022-2023 as per email with FGPA and OVPAVPA. Moved to Future Cycle.

Key: 2066

New Program Proposal

Date Submitted: 11/16/20 6:21 pm

Viewing: TBD-2067 : Building Engineering PhD with Concentration in Heritage Conservation

Last edit: 02/23/21 4:49 pm

Last modified by: sarahcleary

Changes proposed by: sandrabauer

In Workflow

1. **GRAD FBoard**
2. **Future Cycle**
3. PRE SCCASP
4. SCCASP
5. SQAPC
6. Senate
7. CalEditor

Approval Path

1. 11/16/20 6:30 pm Sandra Bauer (sandrabauer): Approved for GRAD FBoard

Effective Date	2022-23
Workflow	majormod
Program Code	TBD-2067
Level	Graduate
Faculty	Faculty of Engineering and Design
Academic Unit	Department of Civil and Environmental Engineering
Degree	Doctor of Philosophy
Title	Building Engineering PhD with Concentration in Heritage Conservation

Program Requirements

Ph.D. Building Engineering with Concentration in Heritage Conservation (10.0 credits)

Requirements:

1. 0.5 credit in: **0.5**

BLDG 5701 [0.0] Introduction to Building Engineering

2. 1.0 credit in the concentration, from the following list. Other courses may be used, with Supervisor recommendation and Director approval. **1.0**

ARCN 5100 [0.5] Representation and Documentation in Architectural Conservation

ARCC 5401 [0.5]	Workshop: Technical Studies in Heritage Conservation	
BLDG 5704 [0.0]	Advanced Research Research Methods for Building Engineering	
BLDG 5705 [0.0]	Advanced Building Characterization, Conservation and Rehabilitation Heritage	
CDNS 5403 [0.5]	Heritage Conservation and Sustainability	
3. 0.5 credit in:		**0.5**
BLDG 6901 [0.0]	Thesis Proposal (in the area of the concentration)	
4. 8.0 credits in:		**8.0**
BLDG 6909 [0.0]	Ph.D. Thesis (in the area of the concentration)	
Total Credits		10.0

New Resources	No New Resources
Summary	Add PhD Building Engineering with Concentration in Heritage Conservation
Rationale	New program
Transition/Implementation	new program

Program reviewer comments	**sandrabauer (11/16/20 6:27 pm):** Creating individual entry - previously bundled. Approval Path 01/28/20 2:19 pm Yasser Hassan (yasserhassan): Approved for CIVE ChairDir GR 01/29/20 5:09 pm Jerome Talim (jerometalim): Approved for ENG Dean 01/30/20 10:46 am Sandra Bauer (sandrabauer): Approved for GRAD Dean 02/10/20 3:09 pm Sandra Bauer (sandrabauer): Approved for PRE GRAD FCC 02/10/20 3:10 pm Sandra Bauer (sandrabauer): Approved for GRAD FCC 02/19/20 2:09 pm Sandra Bauer (sandrabauer): Approved for GRAD FBoard 10/27/20 9:55 am Sarah Cleary (sarahcleary): Rollback to GRAD FBoard for PRE SCCASP **sarahcleary (02/23/21 4:49 pm):** Changed effective year to 2022-2023 as per email with FGPA and OVPAVPA. Moved to Future Cycle.

Key: 2067

New Course Proposal

Date Submitted: 11/25/19 3:15 pm

Viewing: BLDG 5909 : M.A.Sc. Thesis

Last edit: 02/23/21 4:23 pm

Changes proposed by: sandrabauer

Programs referencing this course	Building Engineering M.A.Sc. Building Engineering M.A.Sc. with Concentration in Building Performance Building Engineering M.A.Sc. with Concentration in Fire Safety Building Engineering M.A.Sc. with Concentration in Heritage Conservation

In Workflow

1. **CIVE ChairDir GR**
2. **ENG Dean**
3. **GRAD Dean**
4. **GRAD FCC**
5. **GRAD FBoard**
6. **Future Cycle**
7. PRE SCCASP
8. SCCASP
9. SQAPC
10. Senate
11. Banner

Approval Path

1. 01/28/20 2:18 pm Yasser Hassan (yasserhassan): Approved for CIVE ChairDir GR
2. 01/29/20 5:09 pm Jerome Talim (jerometalim): Approved for ENG Dean
3. 01/30/20 11:16 am Sandra Bauer (sandrabauer): Approved for GRAD Dean
4. 01/30/20 11:25 am Sandra Bauer (sandrabauer): Approved for GRAD FCC
5. 02/19/20 2:08 pm Sandra Bauer (sandrabauer): Approved for GRAD FBoard

Effective Date	2022-23
Workflow	majormod
New Resources	
Level	Graduate
Course Code	BLDG
Course Number	5909

Title	M.A.Sc. Thesis
Title (short)	M.A.Sc. Thesis
Faculty	Faculty of Engineering and Design
Academic Unit	Department of Civil and Environmental Engineering
Credit Value	2.50
Significant Experiential Learning	None
Course Description	
Prerequisite(s)	
Class Format	
Precluded Courses	
Also listed as	
Piggybacked Courses	
U Ottawa Code	
Grade Mode	Thesis/Dissertation
Schedule Type	*Masters Thesis *May constitute a major modification under Carleton's IQAP. Please consult https://carleton.ca/viceprovost/major-minor-modifications/ for more details.
Unpaid Placement	No
Summary	Add new course
Rationale for new course	To support new Building Engineering programs proposal.
Course reviewer comments	**sandrabauer (01/30/20 10:46 am):** Changed year to 21-22 **sarahcleary (02/23/21 4:23 pm):** Changed effective year to 2022-2023 as per email with FGPA and OVPAVPA. Moved to Future Cycle.

Key: 9788
Preview Bridge
Why Did This Not Sync?

Preview Bridge

New Course Proposal

Date Submitted: 11/25/19 3:13 pm

Viewing: BLDG 5900 : M.Eng. Project

Last edit: 02/23/21 4:22 pm

Changes proposed by: sandrabauer

Programs referencing this course	Building Engineering M.Eng. Building Engineering M.Eng. with Concentration in Building Performance Building Engineering M.Eng. with Concentration in Fire Safety Building Engineering M.Eng. with Concentration in Heritage Conservation

In Workflow

1. **CIVE ChairDir GR**
2. **ENG Dean**
3. **GRAD Dean**
4. **GRAD FCC**
5. **GRAD FBoard**
6. **Future Cycle**
7. PRE SCCASP
8. SCCASP
9. SQAPC
10. Senate
11. Banner

Approval Path

1. 01/28/20 2:18 pm Yasser Hassan (yasserhassan): Approved for CIVE ChairDir GR
2. 01/29/20 5:09 pm Jerome Talim (jerometalim): Approved for ENG Dean
3. 01/30/20 10:46 am Sandra Bauer (sandrabauer): Approved for GRAD Dean
4. 01/30/20 11:25 am Sandra Bauer (sandrabauer): Approved for GRAD FCC
5. 02/19/20 2:08 pm Sandra Bauer (sandrabauer): Approved for GRAD FBoard

Effective Date	2022-23
Workflow	majormod
New Resources	
Level	Graduate
Course Code	BLDG
Course Number	5900

Title	M.Eng. Project
Title (short)	M.Eng. Project
Faculty	Faculty of Engineering and Design
Academic Unit	Department of Civil and Environmental Engineering
Credit Value	1.0
Significant Experiential Learning	Applied Research Project
Course Description	
Prerequisite(s)	
Class Format	
Precluded Courses	
Also listed as	
Piggybacked Courses	
U Ottawa Code	
Grade Mode	Standard Letter Grade
Schedule Type	*Research Project *May constitute a major modification under Carleton's IQAP. Please consult https://carleton.ca/viceprovost/major-minor-modifications/ for more details.
Unpaid Placement	No
Summary	Add M.Eng. Project
Rationale for new course	To support new Building Engineering programs proposal.
Course reviewer comments	**sandrabauer (01/30/20 10:46 am):** Changed year to 21-22 **sarahcleary (02/23/21 4:22 pm):** Changed effective year to 2022-2023 as per email with FGPA and OVPAVPA. Moved to Future Cycle.

Key: 9789
Preview Bridge
Why Did This Not Sync?

Preview Bridge

New Course Proposal

Date Submitted: 02/26/20 10:44 am

Viewing: BLDG 6909 : Ph.D. Thesis

Last edit: 02/23/21 4:24 pm

Changes proposed by: sandrabauer

Programs referencing this course	Building Engineering Ph.D. Building Engineering PhD with Concentration in Building Performance Building Engineering PhD with Concentration in Fire Safety Building Engineering PhD with Concentration in Heritage Conservation

In Workflow

1. **CIVE ChairDir GR**
2. **ENG Dean**
3. **GRAD Dean**
4. **GRAD FCC**
5. **GRAD FBoard**
6. **Future Cycle**
7. PRE SCCASP
8. SCCASP
9. SQAPC
10. Senate
11. Banner

Approval Path

1. 01/29/20 3:54 pm Sandra Bauer (sandrabauer): Approved for CIVE ChairDir GR
2. 01/30/20 10:43 am Sandra Bauer (sandrabauer): Approved for GRAD FCC
3. 02/19/20 2:08 pm Sandra Bauer (sandrabauer): Approved for GRAD FBoard
4. 02/26/20 10:41 am Sarah Cleary (sarahcleary): Rollback to Initiator
5. 02/26/20 10:45 am Sandra Bauer (sandrabauer): Approved for CIVE ChairDir GR
6. 02/26/20 10:45 am Sandra Bauer (sandrabauer): Approved for ENG Dean
7. 02/26/20 10:46 am Sandra Bauer (sandrabauer): Approved for GRAD Dean
8. 02/26/20 10:48 am Sandra Bauer (sandrabauer): Approved for GRAD FCC
9. 02/26/20 10:49 am Sandra Bauer

(sandrabauer): Approved for GRAD FBoard

Effective Date	2022-23
Workflow	majormod
New Resources	
Level	Graduate
Course Code	BLDG
Course Number	6909
Title	Ph.D. Thesis
Title (short)	Ph.D. Thesis
Faculty	Faculty of Engineering and Design
Academic Unit	Department of Civil and Environmental Engineering
Credit Value	8.0
Significant Experiential Learning	None
Course Description	
Prerequisite(s)	
Class Format	
Precluded Courses	
Also listed as	
Piggybacked Courses	
U Ottawa Code	
Grade Mode	Thesis/Dissertation
Schedule Type	*PhD Thesis *May constitute a major modification under Carleton's IQAP. Please consult https://carleton.ca/viceprovost/major-minor-modifications/ for more details.
Unpaid Placement	No
Summary	Add PhD Thesis
Rationale for new course	For new program proposal in Building Engineering

Course reviewer comments	**sandrabauer (01/30/20 10:40 am):** Year changed to 21-22. **sarahcleary (02/26/20 10:41 am):** Rollback: Rollback to change workflow to major mod. **sandrabauer (02/26/20 10:49 am):** Re-approved on behalf of unit/eng dean as item was re-streamed through major mod workflow. **sarahcleary (02/23/21 4:24 pm):** Changed effective year to 2022-2023 as per email with FGPA and OVPAVPA. Moved to Future Cycle.

Key: 9790
Preview Bridge
Why Did This Not Sync?

Preview Bridge

New Program Proposal

Date Submitted: 01/28/20 12:33 pm

Viewing: TBD-1995 : R-GR-ADMREQT-Building Engineering PhD

Last edit: 02/23/21 4:53 pm

Last modified by: sarahcleary

Changes proposed by: sandrabauer

In Workflow

1. **CIVE ChairDir GR**
2. **ENG Dean**
3. **GRAD Dean**
4. **PRE GRAD FCC**
5. **GRAD FCC**
6. **GRAD FBoard**
7. **Future Cycle**
8. PRE SCCASP
9. SCCASP
10. SQAPC
11. Senate
12. CalEditor

Approval Path

1. 01/28/20 2:20 pm Yasser Hassan (yasserhassan): Approved for CIVE ChairDir GR
2. 01/29/20 5:10 pm Jerome Talim (jerometalim): Approved for ENG Dean
3. 01/30/20 11:16 am Sandra Bauer (sandrabauer): Approved for GRAD Dean
4. 02/10/20 3:09 pm Sandra Bauer (sandrabauer): Approved for PRE GRAD FCC
5. 02/10/20 3:10 pm Sandra Bauer (sandrabauer): Approved for GRAD FCC
6. 02/19/20 2:11 pm Sandra Bauer (sandrabauer): Approved for GRAD FBoard

Effective Date	2022-23
Workflow	majormod
Program Code	TBD-1995

Level	Graduate
Faculty	Faculty of Engineering and Design
Academic Unit	Department of Civil and Environmental Engineering
Degree	Doctor of Philosophy
Title	R-GR-ADMREQT-Building Engineering PhD

Program Requirements

Admission

The normal requirement for admission to the Ph.D. Building Engineering is a master's degree in an engineering or related program, with at least a A- average. Applicants are required to include a research proposal statement.

Students registered in the M.A.Sc. Building Engineering program at Carleton University may be permitted to transfer into the Ph.D. program without completing the master's program, provided they meet the following conditions:

- completion of 2.5 credits of master's-level courses with a minimum average of A-,
- demonstration of exceptional research potential,
- formal application for admission to the PhD program no later than the fourth semester of initial registration in the M.A.Sc. program, and
- permission from the Director of the Building Engineering programs.

New Resources	No New Resources
Summary	Add new program
Rationale	
Transition/Implementation	
Program reviewer comments	**sandrabauer (01/30/20 10:47 am):** Changed year to 21-22. **sarahcleary (02/23/21 4:53 pm):** Changed effective year to 2022-2023 as per email with FGPA and OVPAVPA. Moved to Future Cycle.

Key: 1995

New Program Proposal

Date Submitted: 01/28/20 12:33 pm

Viewing: TBD-1994 : R-GR-ADMREQT-Building Engineering MASc and MEng

Last edit: 02/23/21 4:52 pm

Last modified by: sarahcleary

Changes proposed by: sandrabauer

In Workflow

1. **CIVE ChairDir GR**
2. **ENG Dean**
3. **GRAD Dean**
4. **PRE GRAD FCC**
5. **GRAD FCC**
6. **GRAD FBoard**
7. **Future Cycle**
8. PRE SCCASP
9. SCCASP
10. SQAPC
11. Senate
12. CalEditor

Approval Path

1. 01/28/20 2:20 pm Yasser Hassan (yasserhassan): Approved for CIVE ChairDir GR
2. 01/29/20 5:10 pm Jerome Talim (jerometalim): Approved for ENG Dean
3. 01/30/20 10:47 am Sandra Bauer (sandrabauer): Approved for GRAD Dean
4. 02/10/20 3:09 pm Sandra Bauer (sandrabauer): Approved for PRE GRAD FCC
5. 02/10/20 3:10 pm Sandra Bauer (sandrabauer): Approved for GRAD FCC
6. 02/19/20 2:11 pm Sandra Bauer (sandrabauer): Approved for GRAD FBoard

Effective Date	2022-23
Workflow	majormod
Program Code	TBD-1994

Level	Graduate
Faculty	Faculty of Engineering and Design
Academic Unit	Department of Civil and Environmental Engineering
Degree	
Title	R-GR-ADMREQT-Building Engineering MASc and MEng

Program Requirements

Admission

The normal requirement for admission to the M.A.Sc. and M.Eng. in Building Engineering is a bachelor's degree in an engineering or related program, with at least a B+ average. Applicants to the M.A.Sc. are required to include a research proposal statement.

New Resources	No New Resources
Summary	Add new program
Rationale	
Transition/Implementation	
Program reviewer comments	**sandrabauer (01/30/20 10:47 am):** Changed year to 21-22. **sarahcleary (02/23/21 4:52 pm):** Changed effective year to 2022-2023 as per email with FGPA and OVPAVPA. Moved to Future Cycle.

Key: 1994

Associated Minor Modifications- Building Engineering

Future Cycle (28)				
Code	**Title**	**Status**	**Initiator**	**Received**
BLDG 5702	BLDG 5702: Introduction to Research Methods	Added	liamobrien	11/10/2020
BLDG 5701	BLDG 5701: Introduction to Building Engineering	Added	sandrabauer	2/19/2020
BLDG 5707	BLDG 5707: Building Energy Management and Optimization	Added	sandrabauer	2/19/2020
BLDG 5705	BLDG 5705: Advanced Building Characterization, Conservation and Rehabilitation Heritage	Added	sandrabauer	2/19/2020
BLDG 5107	BLDG 5107: Building Services Engineering	Added	sandrabauer	2/19/2020
BLDG 5704	BLDG 5704: Advanced Research Research Methods for Building Engineering	Added	sandrabauer	11/10/2020
BLDG 6901	BLDG 6901: Thesis Proposal	Added	sandrabauer	10/1/2020