UNIVERSITY OF TORONTO

OFFICE OF THE VICE-PROVOST, ACADEMIC PROGRAMS

University of Toronto
New Graduate Program Proposal

Section 1

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Faculty / Academic Division:	Applied Science and Engineering
Graduate Unit (if applicable) where the program will reside:	Civil Engineering
Name of Proposed Program:	Cities Engineering and Management
Degree Name and Short Form:	Master of Engineering in Cities Engineering and Management (M.Eng.C.E.M.)
Professional Program:	Yes
Anticipated start date of new program:	September 2013

Section 2

Table of Contents

1 Executive Summary

Cities are the economic engines of the world. With over 50% of the world's population now living in cities, the health and wealth of nations depend strongly on how well cities function. With global urbanization trends, climate change, limitations of natural resources, and sustainability concerns, urban centres around the world will encounter increasing challenges in managing their infrastructure and in delivering high levels of service to ensure the well-being of their citizens. What is needed are professionals with both technical expertise and a fundamental understanding of the complex and cross-disciplinary issues facing cities. To proactively respond to this growing need, the Department of Civil Engineering of the Faculty of Applied Science and Engineering at the University of Toronto is proposing the creation of a new professional graduate program, the Master of Engineering in Cities Engineering and Management (M.Eng.C.E.M.).

The professional M.Eng.C.E.M. program is founded on the world class expertise of faculty within the Department of Civil Engineering and the Faculty of Applied Science and Engineering, both in traditional areas of infrastructure engineering as well as in emerging areas such as cyber security and innovative technologies in global energy systems. The program is further broadened and enriched by drawing on additional cities-related expertise from the Faculty of Arts and Science and from the School of Public Policy and Governance.

Engineers today are increasingly aware that technical expertise alone is not sufficient to ensure a positive impact of technology on society, and that it is important to understand the context in which technology is used. The University of Toronto's Faculty of Applied Science and Engineering has a number of interdisciplinary centres and institutes with mandates to broaden the research and educational missions of the Faculty, including the Centre for Global Engineering, Centre for Sustainable Energy, and the Institute of Leadership Education and Engineering.

The 16-month full-time M.Eng.C.E.M. program will continue the trend towards broadening engineering education and cross traditional engineering disciplines to focus on the application domain of cities. It will be structured around three themes: Theme A: infrastructure-related courses that focus on quantitative methods to provide a foundation for evidence-based decision making; Theme B: cities as complex systems that influence decision making; and Theme C: an integrative practicum that allows students to apply the technical knowledge they have learned to a complex problem related to cities.

The program is structured to provide both depth and breadth by requiring students within Theme A to take a minimum of two courses on one infrastructure type, and a minimum of one course on a different topic. Samples of concentration areas that provide depth include cyber security, environmental issues for a healthy city, healthcare systems, resilience of critical infrastructure, service provider networks, sustainable energy systems, transportation systems, and urban structures. Students will learn in Theme B about cities as complex systems by studying metrics that describe cities, their limitations, and the data upon which they are based; connections between the way a city is managed and its infrastructure and economic health/wealth; and the impact of policy on a city's ability to manage its assets.

In the practicum component of the M.Eng.C.E.M. program, knowledge will come alive for students as they engage with real city challenges, synthesize and apply their knowledge in an integrated way, and work with multidisciplinary teams. The practicum requirement may be satisfied via placements in companies, governments, NGOs and academic or research

institutions. An exciting option for students is placement at the newly established Centre for Urban Science and Progress (CUSP), a consortium of universities led by New York University (NYU and NYU-Poly), that includes the University of Toronto, Carnegie Mellon University (CMU), City University New York (CUNY), IIT Bombay, and University of Warwick. CUSP also includes major global industry leaders as industry partners, including IBM, Cisco, and Siemens. M.Eng.C.E.M. students will have the opportunity to work with researchers in this innovative and collaborative centre to generate solutions to complex problems.

In developing the program proposal, the Department of Civil Engineering sought input from leading practitioners and researchers from across the University, industry, government, financial and insurance institutions, and global institutions – the very people who are at the forefront of addressing and solving cities-related issues. Based on their feedback, the Department is confident that the type of professionals that this program will produce will be in high demand as employers confront the complex issues associated with urban centres.

The M.Eng.C.E.M. will be an exceptional academic program that will enable the University of Toronto to become a recognized leader in this very important area.

2 Program Rationale

Urbanization may well be the planet's largest systemic change in centuries. In the next seven decades we'll have to build as much urban living space as in all of human history to date. That's equivalent to a new city with a million residents, every week for 70 years. It's a daunting task, but also an amazing opportunity. [1]

Cities are the primary economic engines of the world. Countries that are more than 50% urbanized create five times more wealth than countries that are less than 50% urbanized. The cities that drive economic prosperity must also manage the multifaceted and complex infrastructure and services upon which societies depend, including transportation, water, energy, and waste disposal as well as more abstract functions of civilization, such as healthcare, education, justice, and political discourse.

In Canada, over 80% of the population live and work in cities. Despite their importance, our urban centres often encounter challenges to their successful management of infrastructure due to lack of funding, systemic inertia, or other organizational and political circumstances. As urban populations continue to grow, people continue to migrate inward, and climate change continues to change the way we live our lives, cities can expect even greater challenges to their successful operation.

Out of these challenges emerge great opportunities. Our cyber and physical infrastructure, energy systems, transportation systems and public health and safety structures will need to be revisited, redesigned, expanded and rebuilt, offering us an unprecedented chance to rethink the ways which humans can live in the 21st century.

A new kind of professional is required to meet these challenges in a comprehensive way: professionals who are technically adept, well versed in the complexity of economic,

[1] "Why has TED Given the 2012 TED Prize to the City 2.0?" by Chris Anderson, curator of TED. Available at www.huffingtonpost.com/chris-anderson/city-2-0-ted-prize_b_1314360.html (accessed March 2, 2012)

environmental, and policy issues, and capable of applying evidence-based decision-making to their designs. Twentieth century knowledge silos that provided deep expertise but little contextual breadth are no longer adequate to deal with the rapidly changing urban world. A highly collaborative organization in which knowledge spheres overlap is required to effectively manage the complex systems that are vital to economic prosperity and environmental sustainability in the 21st century.

An exciting new Centre for Urban Science and Progress (CUSP) is being established to address the challenges that an increasingly urbanized planet will face in the coming decades. One of the primary objectives of CUSP is to translate applied science and engineering research into market-ready global solutions to pressing questions, such as how to accommodate more people in cities safely, prosperously and sustainably. CUSP is led by New York University (NYU and NYU-Poly) in partnership with the University of Toronto, Carnegie Mellon (CMU), City University New York (CUNY), IIT Bombay, and University of Warwick. Each of these institutions has a strong track record of education, research, technology transfer, commercialization, and industry collaboration. Included in the founding consortium are global industry leaders IBM, Cisco, Siemens, Con Edison, National Grid, Xerox, Arup, IDEO, and AECOM. Together, CUSP will be an impressive enterprise of world-class universities and technology industry leaders.

As one of the first initiatives in this exciting venture, a new professional Master of Engineering in Cities Engineering and Management (M.Eng.C.E.M.) degree program is proposed as a step toward establishing CUSP Toronto. This program will enable engineers and other technically trained professionals to lead innovation in cities, government, and other infrastructure-supporting organizations, to address the pressing issues that face cities, and to create innovative responses that are environmentally responsible, socially engaging and economically feasible. Students will learn about the complex systems of urban infrastructure and the influential stakeholders who shape decision making while remaining grounded in their own technical disciplines. Program graduates will become thought leaders of global importance, and will bring a new style of management to the cities where they work.

More liveable and sustainable cities require innovative approaches to managing urban services and infrastructure. In addition to studies in the complexity of global cities, the program facilitates learning in the design, operation and management of a broad array of engineering infrastructure that will complement the student's background and core interests. For example, students may choose to gain technical expertise in the newest technologies and social networks to advance the urban environment, or they may wish to improve the resilience of urban infrastructure against assaults, both natural and human-made, to minimize long-term environmental, social, and economic devastation.

Innovative, multidisciplinary engineering approaches may simultaneously contribute to multiple city improvements. For example, an engineering directive to use permeable pavements could result in better storm water management, enhance the appearance of the landscape, improve the habitat for wildlife, and offer recreational spaces for people.

Urban solutions have the potential to address global problems. It is estimated that 70 million hours are spent each year in France[2] searching for parking spaces, thereby unproductively

[2] Eric Gantelet and Amélie Lefauconnier, 2006, "The time looking for a parking space: strategies, associated nuisances and stakes of parking management in France", Association for European Transport and Contributors. Available at:

increasing traffic congestion, greenhouse gas emissions and driver frustration. Consider the broad impacts that reducing traffic congestion could have on urban air quality, economic productivity, and, ultimately, on the demand for oil.

This unique program does not attempt to give students a career path outside their technical background, but instead will enhance their career opportunities by advancing their technical expertise and cultivating a complementary understanding that will allow them to apply their professional skills to one of the greatest challenges to society's well-being – cities! The program includes a significant practicum where students can apply their knowledge and skills to address an urban challenge, interact with the leaders, policy makers, operators and the general public to explore innovative and sustainable solutions.

In summary, this program will give students:

- A comprehensive understanding of the interaction between the systems and services of a city and its ability to generate prosperity and wealth
- Analytical skills to assess the environmental, economic, political, and social risks and the impacts of policy change related to critical infrastructure within a city
- Specialized management skills and evidence-based techniques that can be applied to address the unique challenges inherent in cities around the world.

2.1 Academic Rationale

There are very few city leaders with engineering or scientific backgrounds. This program is the first professional master's degree that will prepare students to approach urban infrastructure innovation and management with a balanced mix of technical expertise and a comprehensive understanding of cities, including their economic, operational, environmental, social and political challenges.

Undergraduate engineering programs produce professionals who can design, analyze and build infrastructure in the traditional domains of construction, manufacturing or power generation. To extend their practice, most engineers learn on the job, or undertake second degrees in areas such as law, medicine or business; however, missing linkages between the engineering and non-engineering degrees can dissociate engineers from their core competencies. The M.Eng.C.E.M. program complements and reinforces students' existing competencies and provides them with the insight into cities needed to drive changes in policy, affect social change, impact urban economic well-being and become world leaders. The proposed curriculum is based on leading edge research that will inform students about advances in this area and provide evidence-based learning. Through a diversity of courses focused on the complexity of the urban management environment, students gain a comprehensive understanding of the processes, challenges and trends in cities related to infrastructure management.

The academic foundation for this program rests on the extensive expertise in urban infrastructure, economics, policy and sustainability currently found within the Faculty of Applied Science and Engineering, and particularly in the Department of Civil Engineering where the program will reside. This expertise ranges from improving the sustainability of individual facilities and operations to an examination of the global impacts of engineering decisions. For example,

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http://stuff.mit.edu/afs/athena/course/11/11.951/oldstuff/albacete/Other_Documents/Europe%20Transport%20Conference/traffic_engineering_an/the_time_looking_f1580.pdf (accessed June 19, 2012)

one research team, focused on the fact that buildings account for 40% of all energy use, creates affordable ways for home owners to reduce energy consumption. Another conducts research and advises on policies for encouraging private sector investment in low carbon, climate resilient infrastructure. On the global scale, one of our professors has authored several books on improving our understanding of the interactions among society, technology, science and the biosphere, and of their implications for human life. Expertise exists in transportation engineering that has implications in every urban centre around the world, including driver behaviour modeling, public transit systems, and efficient movement of freight. Clearly, the diversity of research undertaken in the Department extends well beyond the traditional boundaries of civil engineering.

2.2 Degree Nomenclature and Program Name

The proposed program name is Cities Engineering and Management and the proposed degree is a Master of Engineering in Cities Engineering and Management (M.Eng.C.E.M.). This unique professional degree designation is consistent with the University of Toronto's approved Master of Engineering in Design and Manufacturing (M.Eng.D.M.) program. Both programs are substantive engineering programs focused on a specific domain which is recognized in the distinctive degree name.

The core of the degree name is a Master of Engineering (M.Eng.) reflecting the solid engineering content of the program. The M.Eng. is recognized throughout North America as a degree that focuses on applied research and the application of leading edge engineering technologies.

Like the M.Eng. D.M., however, the proposed M.Eng.C.E.M. program is focused on an application domain in contrast to most existing M.Eng. degrees at the University of Toronto which are focused by discipline. The suffix C.E.M. reflects the fact that the Cities Engineering and Management program crosses all traditional engineering disciplines to focus on one application domain – cities. In contrast, the M. Eng. focuses on disciplines such as chemical engineering, civil engineering or electrical engineering. .

Further, the suffix, C.E.M., references the significant management component within the program designed to provide students with a strong understanding of the drivers, constraints and stakeholders that affect the way cities operate, and which will allow them to engage in the strategic management of city infrastructure. Management-related topics include an investigation of the metrics used to compare cities, the challenges and trends in urban policy, and the connection between infrastructure and urban prosperity. (Another program with a similar management emphasis is the approved Masters of Management and Innovation, M.M.I.)

Like the M.Eng., the M.Eng.C.E.M. does not prepare students for registration as a Professional Engineer (P.Eng). under the Ontario Professional Engineers Act R.S.O. 1990, administered by the Association of Professional Engineers Ontario (PEO). Registration as a P.Eng. typically requires that applicants hold an undergraduate engineering degree.

2.3 Delivery Model

This cohort-based program is founded on three themes or pillars, as shown in Figure 1.

Courses in engineering are half-courses; throughout the rest of this document, a course will refer to a 0.5-weight course.

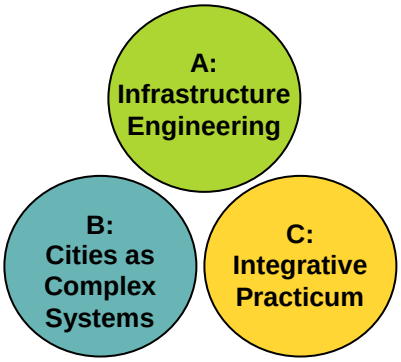

Figure 1: Program Structure

Students will complete 6.0 full course equivalents composed of 10 half-courses, and a double-weighted practicum (1.0 full course equivalent). Of the 10 courses, a minimum of four each must be from Themes A and B.

The remaining two courses may be drawn from Themes A or B, or a list of additional free elective courses, depending on the career goals and professional interests of the student.

Theme A infrastructure-related courses will be selected from the extensive offerings provided by the seven graduate engineering programs at the University of Toronto[3]. Theme B courses are dedicated to this program and will be offered in the fall and winter terms as intense module courses. Each module course will last four weeks, and consist of three hours of lectures per day for two weeks (30 lecture hours total). In the third and fourth weeks, students will complete a course paper or project. Module-based delivery will allow courses to build upon one another sequentially and keep students focused on one topic at a time, allowing them to explore these topics in a concentrated manner through discussion, reading, and analysis.

Theme C is the Integrative Practicum. This element is a critical part of the program intended to provide an opportunity for students to apply the concepts learned in their courses to a complex problem related to the city. Students may join one of the CUSP sites (New York, Toronto, Bombay, Warwick) and work as part of an interdisciplinary team to address a pressing issue brought forward to the consortium. Alternatively, the project may be undertaken in partnership with an industry or government sponsor, in a research setting, or as part of an investigative study. Although topics will vary, students will be required to present their findings to an audience of their peers and submit a technical report. The practicum will be completed in the summer term and will be supervised by a faculty member in consultation with a staff member of the host organization.

Courses will be delivered by outstanding faculty whose research programs are at the leading edge of the subject areas. Guest lectures by high profile urban leaders and other researchers will further enhance the learning experience by bringing real examples and current issues to the classroom that might not otherwise be captured.

It is expected that enrolment will be approximately equally distributed between full-time and the extended full-time option.

2.4 Content

The M.Eng.C.E.M. program consists of four Theme A infrastructure engineering courses, four Theme B courses related to complex systems in cities, the Theme C two-course equivalent practicum, and two additional courses that students may select from a combination of Theme A, Theme B or a list of free elective courses. Deviations from this normative program structure must be approved by the Program Director.

Although students will take four courses in each of terms one and two, the modular delivery method for Theme B courses means they will focus on only three courses at any point in time.

[3] Chemical Engineering and Applied Chemistry, Civil Engineering, Electrical and Computer Engineering, Materials Science and Engineering, Mechanical and Industrial Engineering, Aerospace, and Biomaterials and Biomedical Engineering.

Table 1: M.Eng.C.E.M. Curriculum

Term	Course		Description
Term 1: Fall	A: Infrastructure Engineering (2)		▪ 2 Student-selected courses
	B1: Empirical Analysis of Cities		▪ City metrics and what they mean ▪ Analysis methods ▪ Comparing cities around the world
	B2: Infrastructure and Urban Prosperity		▪ Role of infrastructure in stimulating economic growth ▪ Ecology of economies ▪ Evolution of great world cities
Term 2: Winter	A: Infrastructure Engineering (2)		▪ 2 Student-selected courses
	B3: The Challenges Of Urban Policy-Making		▪ Urban planning, citizen participation, and governance ▪ Current legislation affecting asset management ▪ Trends & proposed reforms here & around the world
	B4: Cities as Complex Systems		▪ Complex systems in cities ▪ Sustainability challenges ▪ Decisions under uncertainty
Term 3: Summer	C: Practicum		▪ Project may be evidence or research based ▪ Culminates in a final report due October 1
Term 4: Fall	Choose 2 courses	A: Infrastructure Engineering	▪ Student-selected courses
		B5: Economics & Infrastructure	▪ Macro/micro economics ▪ Asset management & funding projects ▪ Principles of urban finance and taxation
		B6: Integrative Decision Making	▪ Stakeholder viewpoints ▪ Multi objective reasoning and decision making ▪ Communication strategies
		Technology Management Electives	▪ List shown in 2.4.4

2.4.1 Theme A Infrastructure Engineering

Students will select Theme A Infrastructure Engineering courses from a broad range of topics based on their interests and background. Because students will select their courses at the start of their program, they will be well-situated to receive priority in enrolment-limited courses.

A minimum of two courses must focus on one particular infrastructure type to provide students with technical depth, and a minimum of one course must focus on a different topic to provide technical breadth. Breadth can be gained by focusing on a different infrastructure, on related topics such as sustainability, preventive methods, optimization techniques, or project management. Examples of courses that provide technical depth and breadth are listed below to

demonstrate the extensive opportunities available to students at the University of Toronto. This depth/breadth strategy is similar to a traditional civil M. Eng.

Sample topics providing depth:	**Sample of relevant existing courses:**
Cyber security	ECE1518: Seminar in Identity, Privacy and Security ECE1776: Computer Security, Cryptography and Privacy FIS2165: Social Issues in Information and Communication Tech. FIS2305: Surveillance and Identity
Environmental Issues for a Healthy City	CIV549: Groundwater Flow and Contamination CIV1308: Physical and Chemical Water Treatment Processes CIV1309: Biological Water Treatment Processes CHE1433: Air Dispersion Modelling
Healthcare Systems	HAD7001: Tools for Quantitative Health Care Decision Making MIE1616: Healthcare Management
Resilience of Critical Infrastructure	CIV1198: Infrastructure Resilience Planning CIV1199: Infrastructure Protection
Service Provider Networks	ECE1524: Service Provider Networks ECE1548: Advanced Network Architectures
Sustainable Energy Systems	APS510: Innovative Technologies & Origins in Global Energy Systems MIE515: Alternative Energy Systems MIE1240: Wind Power MIE 1000: Current Energy Infrastructure & Resources
Transportation systems	CIV516: Public Transit Operations and Planning CIV1508: Airport Planning and Engineering CIV1532: Fundamentals of Intelligent Transportation Systems AER 1220: Remotely-Piloted Flight Vehicles
Urban structures	CIV1164: Bridge Engineering CIV1167: Structural Dynamics and Earthquake Engineering CIV1169: Advanced Topics in Building Design
Water systems	CIV549: Groundwater Flow and Contamination CIV550: Water Resources Engineering CIV1303: Water Resources Systems Modeling CIV1305: Water Resources Systems Analysis

For breadth, students may select another infrastructure theme. Students will be required to identify their Term 1 and 2 Theme A courses in advance of the start of the program. The courses must be approved by the Program Director to ensure that the courses can be accommodated in the student's schedule and that they meet the program's breadth and depth requirements.

In Term 4, students return to campus after completing their practicum (see 2.4.3). More flexibility is provided to students to customize the final program term program as they complete their 10 course requirement by choosing two courses that best meet their interests. Students have the option of selecting focus entirely on infrastructure engineering or further enhance their understanding of the complexity of cities with courses on integrative decision-making and infrastructure finance (see 2.4.2), or choose from a list of technology management courses to further broaden their professional development (see 2.4.4).

2.4.2 Theme B: Cities as Complex Systems

Theme B courses focus on the application area of cities and the manner in which they operate. Engineering and applied science programs do not generally include courses of this type because they are domain specific and most undergraduate programs attempt to provide students with knowledge that can be applied to any domain. These courses will help students gain the knowledge needed for careers in the management of urban infrastructure by complementing their technical knowledge with an understanding of the complex and multidimensional nature of city systems management.

Four dedicated courses are required by all students. In Term 1, *An Empirical Study of Cities* introduces students to the way in which cities are measured and compared, and discusses the metrics that describe cities, their limitations, and the data upon which they are based. *Infrastructure and Urban Prosperity* explores the evolution of great cities over time, and considers form and function to understand their success. As part of that discussion, the connection between the way in which a city manages its infrastructure and its economic health/wealth will be examined. These two courses provide a global view of how cities perform today and how they evolved and/or devolved over time.

In Term 2, the Theme B courses will focus on a systems-level perspective of cities, giving students the understanding and tools necessary to positively influence the way in which a city manages its physical infrastructure. One important aspect is public policy, how it is changed and how it impacts a city's ability to manage its assets. Finally, these topics will be brought together in a study of the complex systems that comprise a city. The next two courses examine at a more local level the policies and legislation that govern infrastructure and the challenges of urban sustainability

As described in 2.4.1, in Term 4, students have two free electives. The choices available to them include two additional Theme B courses to enhance their understanding of the complexity of cities: courses on integrative decision-making and infrastructure finance.

Because each Theme B course requires them to prepare a research paper, students will also be practicing and improving their self-learning, professional and communication skills.

2.4.3 Theme C: Practicum (1.0 FCE)

The Term 3 practicum is a critical program component. It is analogous to capstone design projects in undergraduate engineering programs that serve as a mechanism to synthesize concepts and methodologies learned in courses focused on narrowly defined subject areas – an essential intellectual stepping stone for learning to apply knowledge. In the practicum, the knowledge that students gained in courses in the first two terms will come alive as they engage with real city problems using cities as living laboratories. In addition, since city problems are multidisciplinary in nature, students will also learn to work across disciplines in collaboration with leading cities practitioners and researchers.

The practicum will be required for all M.Eng.C.E.M. students. A course code will be assigned, and students will be required to register for the course and to complete the required components:

- Project proposal – each student will submit a project proposal to the Program Director along with the name of a faculty advisor, to the Academic Director by February 15 in Term 2; the proposal will be evaluated, and modifications will be made if necessary. Final approval is required by March 15. The Program Director will implement a process

to help students identify potential academic advisors, while the student-advisor matching will be done by mutual agreement similar to current thesis and project supervisory relationships.

- Interim report – each student will submit an interim report to his/her academic advisor by July 15 describing progress in the first half of the summer term.

- Final report and presentation – the practicum will culminate with a report describing the cities-related problem, methods of analysis and solution approach, and the results and conclusions. Students will also present their project to an audience of their advisor, their peers, and relevant industry participants.

Rubrics have been developed to evaluate thesis and project reports that vary significantly in topic and scope. Similar rubrics will be developed to assist faculty advisors and consultants in host organizations to evaluate student practicum performance in a consistent manner, and to provide students with detailed and meaningful feedback. The practicum will provide a strong experiential component to the program, and will help students improve their communication skills through interaction with industry and university advisors, completion of a comprehensive report, and the presentation of their results to an engaged audience.

The Program Director will provide general academic oversight, including the quality of the practicum experience and the consistency of the practicum evaluation process.

There are several possible types of practicum placements that will focus on city-related research projects.

The CUSP initiative will provide an unparalleled opportunity for students to apply their knowledge by becoming an active member of an ongoing city-related research project, undertaken by CUSP. As such, the students would be working in New York or at another CUSP sites such as Bombay, Warwick, or Toronto. In New York City, the CUSP initiative is designed to create a living laboratory, facilitating close relationships with City agencies to develop technologies and solutions to real world urban challenges in the 21st Century. It is anticipated that the partners will establish similar hubs in their own communities that will focus on complementary projects. Depending on the size of the project, this opportunity could involve many other disciplines, providing a unique life experience while working on cutting edge solutions to big city problems.

Students might partner with an industry or governmental organization allowing the student to spend a significant amount of time at the organization interacting with domain experts, accessing data, and validating their findings or conclusions. An example of this might be working with the City of Toronto to examine their financial and planning strategies for the maintenance and repair of infrastructure. Yet another example is working with ministries of health to determine the best ways to manage healthcare service provision in cities and to determine a response to pandemics should they occur.

Placement of students will be facilitated through the Faculty of Applied Science and Engineering's Professional Experience Year (PEY) Office which has over 25 years of experience managing Engineering's undergraduate internship program. The PEY office facilitated the placement of over 550 students last year with companies in Canada, the United States and around the world. In addition to helping match companies and students, the PEY office will assist with maintaining both parties' expectations at levels that are appropriate for this

experience. The PEY Office is actively involved in facilitating graduate level placements. In addition, the program Director will coordinate with the Office closely to ensure that it supports the graduate level expectations of the proposed program.

2.4.4 Technology Management Courses

The Faculty of Applied Science and Engineering offers a large number of courses related to various aspects of technology management. Students will have the option of choosing from this list of courses to fulfill their Term 4 free elective requirements.

Sample topics providing breadth:	APS 1001: Project Management APS 1005: Operations Research for Engineering Management APS 1010: Cognitive and Psychological Foundations of Effective Leadership APS 1012: Management of Innovation in Engineering APS 1015: Social Entrepreneurship APS 1016: Financial Management for Engineers APS 1017: Supply Chain Management and Logistics APS 1088: Entrepreneurship and Business for Engineers APS 1201: Topics in Engineering and Public Policy APS 1202: Engineering and Sustainable Development CHE1435: Six Sigma for Chemical Processes CIV1307: Life Cycle Assessment and Sustainability of Engineering Activities

2.4.5 Full-time (F/T) Program and Extended Full-time (EF/T) Option
The program will normally be completed in 16 months by each cohort of full-time registrants.

There is significant demand from employers to have their employees take this program while still working. Not only will this allow employers to retain exceptional employees, it will encourage innovation within their organizations. As a result, an Extended full-time delivery option will be made available with the expectation that students who are also employees would have four weeks per fall and winter term to complete the Theme B courses. Students may enrol in Theme A courses during any session throughout the program according to the student's schedule, and depending on course availability. To achieve the degree in three years, a significant commitment will be required from the student to take three to four courses per year. Because it is expected that these students will continue working, it may be appropriate to design a practicum linked to their jobs.

Table 2: Extended F/T 3-Year Option*

	Fall	Winter	Summer
Year 1	B1, B2	A1	A2
Year 2	A3	B3, B4	C
Year 3	B6	A4	A5

*The extended full-time option allows students the opportunity of extending their full-time studies over an additional year. Overall tuition remains the same as for the regular full-time program. Students would select this option at the beginning of the program.

2.5 Supporting the University's Mission
The .M.Eng.C.E.M. program contributes strongly toward achieving the University of Toronto's mission "to being an internationally significant research university, with undergraduate and

professional programs of excellent quality."[4] As a unique program that will address some of the most pressing challenges to society over the next century, this program will further heighten international awareness of the University's commitment to research, professional programs and society.

Two of the four mission statements of the Faculty of Applied Science and Engineering are directly related to this proposed program.[5] They refer to sharing knowledge with students by offering professional degree programs of the highest quality, and to equipping students with the leadership skills, communication skills and global awareness required by the engineering profession and by society in general. Along with the overall program objectives, elements within the M.Eng.C.E.M. program that directly apply are the focus on communications, technical excellence, and fact-based decision making.

2.6 Distinctiveness

There are no programs similar to the proposed M.Eng.C.E.M. offered in Canada. In the United States there are a few similar programs including most notably the Master of Science in Urban Systems Engineering and Management at the Polytechnic Institute of New York University and the Master of Infrastructure Engineering and Management at the University of Texas at Arlington. Both share with the proposed M.Eng.C.E.M. program a focus on urban environments and infrastructure The proposed program is unique in extending the engineering expertise of its students to focus on the complex dynamics of the urban environment including policy, organization and decision-making (Theme B). The outcome will be directed not to a specific discipline, but to an area of application that has not yet received the attention that it will need to help cities succeed and prosper around the world. In so doing the program's goal is to create a new type of leader who combines strong technical knowledge with distinctive operational acumen: the ability to understand and manoeuvre through the complexity of city governance and decision making required to manage city infrastructure.

The modular delivery allows the program to be completed in 16 months by full-time students or over three to four years through extended full-time studies.

In the spirit of the CUSP goals, the program intends to include a free open-access lecture series podcast program that will provide the initial or overture lectures from each of the core courses. This would serve to both increase interest in the program and to share the challenges of cities with the public. This is consistent of recent trends where leading academic institutions, including MIT, Harvard and Stanford, are making their lectures and course materials available on the web for the benefit of the global public as well as to their own students.

The program will support tuition fees appropriate to this professional audience and program. See Appendix D for a list of comparator programs.

3 Need and Demand

Over the next decades, the need for cities to effectively manage their infrastructure will become increasingly important as the impacts of population growth, increased urbanization, and climate change are fully realized. Leadership enhanced by technical and organizational skills is needed

[4] University of Toronto Statement of Institutional Purpose. Available from http://www.governingcouncil.utoronto.ca/policies/mission.htm (accessed June 15, 2012)

[5] Academic Plan, Faculty of Applied Science and Engineering, University of Toronto, 2011-2016. Available from: http://www.engineering.utoronto.ca/Assets/AppSci+Digital+Assets/pdf/Publications/academicplan.pdf (accessed June 15, 2012)

to ensure the long term vitality of cities around the world. These leaders need to be resilient and adept at communicating data, analysis, and assessment of benefits vs. risks to inform and influence policy decisions.

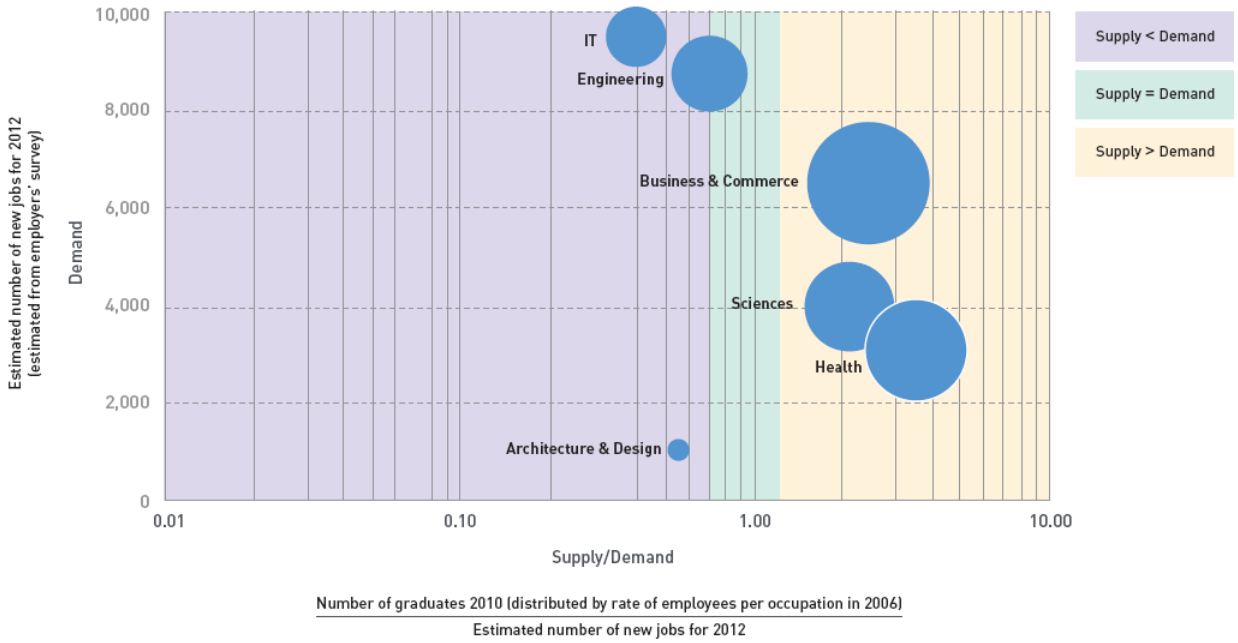

Figure 2: Supply/Demand for occupational groups (Martinez Fonte et al. 2012)

In the Toronto area, the demand for infrastructure expertise is not being met through the supply of IT or engineering graduates (Figure 2). Providing engineers and applied scientists the exciting opportunity to enhance their technical skills and business acumen through the proposed M.Eng.C.E.M. program will help fill this infrastructure void.

This program is envisioned for applicants with work experience in an engineering related field who wish to better equip themselves to lead progressive change in the urban environment. This includes both recent graduates and mid-career managers who wish to participate in higher level strategic planning within their organizations. This skill set will be valuable to a variety of employers[6] such as:

- Public sector, governments, and public agencies (City of Toronto, City of Oshawa, TTC)
- Financial and insurance institutions (CIBC)
- Consulting industry
- Global organizations and NGOs (World Bank, Canadian Urban Institute)
- Security and police organizations
- Environmental and political advocacy groups

Industry has identified a strong need for a program of this type, and discussions to date have been very positive. The following comments are based on feedback received during the proposal development process, both through email and in person.

[6] Brackets indicate those organizations from which individuals have provided consultation and feedback on this proposal.

“I believe that you are really being forward thinking. I would say that there is indeed a current and future need for individuals with this degree.”

Director, Business Management, CIBC

“I'm very excited with the potential of this program, and (will) support in any way I can. I'm keen to champion it with the international community as soon as you're close. I think you can get a lot of applicants from the cities and national governments we work with.”

Lead Urban Advisor, World Bank

This sounds like a fantastic program. I've spoken to a few people about it already.

Senior Project Engineer, City of Toronto

"I found this very exciting, interesting and timely. I think this program would be very helpful and valuable to the TTC and all other municipal (mostly), provincial, federal and, NGO’s."

Head, Civil Design, Engineering, TTC

The program aims for international student enrolments of at least 25%. Overall enrolment is expected to reach steady state of 60 FTE’s in 2016-17, the program’s fourth year.

Table 1: Graduate Enrolment Projections

Year in program	2013-14	2014-15	2015-16	2016-17	2017-18
Full time (Term 1)	15	20	30	30	30
Full time (Term 4)		15	20	30	30
Extended full time (new)	5	10	10	10	10
Extended full time (cont.)	0	5	15	20	20
Headcounts	20	50	75	90	90
FTE	20	50	75	90	90

4 Admission Requirements

Students entering the M.Eng.C.E.M. program at the University of Toronto will register in the Department of Civil Engineering.

To be considered for admission into this professional master’s degree, applicants must have a bachelor's degree with grades equivalent to a mid-B or better from a recognized university in engineering or a related applied science. Examples of related applied science fields include, but are not limited to, applied chemistry, environmental science and technology, nuclear science, forestry, urban planning, and computer science. This is consistent with existing M.Eng. program where students from related programs (who do not have a B.A.Sc. degree) are routinely accepted and encounter no difficulty completing the graduate program requirements.

Applicants are also required to have at least one year of work experience before applying. The work experience, gained through full-time employment after graduation, through summer employment during their undergraduate studies, or during a PEY term, will give students practical understanding of the ways in which the infrastructure industry functions. Like experience requirements for MBAs, the knowledge, practice, and maturity gained from industry experience provide significant benefits to the program in that attendees better appreciate world challenges and the complexities involved. Students will be encouraged to use their work experiences as a basis for class discussions rather than basing them on theoretical situations.

5 Program Requirements

Faculty Affiliation
Department of Civil Engineering
Faculty of Applied Science and Engineering

Degree Program Offered
Master of Engineering in Cities Engineering and Management - M.Eng.C.E.M.

Overview
The Master of Engineering in Cities Engineering and Management (M.Eng.C.E.M.) program focuses on the governance and leadership of global cities by considering the long term impacts of decisions on society, the environment, and the economy, using a fact-based approach. This perspective explores the complex systems of urban infrastructure and influential stakeholders that shape decision making while enhancing a technical discipline.

The program has three learning themes: A) infrastructure engineering that extends technical knowledge; B) complex systems that influence decision making in cities, and C) an integrative practicum that provides the opportunity to apply the learned techniques and tools to a complex problem related to cities.

This program is appropriate for students with backgrounds in engineering or applied sciences that relate to urban infrastructure. Students are required to have at least one year of work experience before applying to this program. The program welcomes applications from international students.

Contact and Address
Web: www.civ.utoronto.ca
Email: gradciv@ecf.utoronto.ca
Telephone: TBD
Fax: TBD

Department of Civil Engineering
University of Toronto
Room 105, Galbraith Building
35 St. George St.
Toronto, ON M5S 1A4
Canada

Minimum Admission Requirements

Program Requirements

Normal Program Length: 16 months (full-time); 3 years (extended full-time option)
Time Limit: 3 years

Course List

Theme A: Infrastructure Engineering
Theme B: Cities as Complex Systems
Theme C: Practicum

See Appendix A for course descriptions.
See Appendix E for SGS Calendar entry.

6 Program Description

As noted in Section 2.5, in addition to full-time studies, extended full-time studies will be accommodated with the modular delivery facilitating both strategies. In full-time studies, the program can be completed in sixteen months, as outlined in Section 2.3. In the extended full-time option, students can complete the program in three years.

Whereas the Province's Quality Assurance Framework requires that students complete a minimum of 2/3 courses at the graduate level, the University of Toronto requires graduate students to complete all of their course requirements from amongst graduate level courses. This proposed program complies with this requirement.

7 Fields

This proposed program will not have any fields.

8 Degree Level Expectations, Program Learning Outcomes and Program Structure

As a professional master's program, the informed research component is demonstrated through the practicum, which facilitates the exploration of knowledge and creative solutions through analysis of relevant problems.

Master's Degree Level Expectations (based on the Ontario Council of Academic Vice Presidents [OCAV] DLEs)	**Master's Program Learning Objectives and Outcomes**	**How the Program Design and Requirement Elements Support the Attainment of Student Learning Outcomes**
EXPECTATIONS: The Master of Engineering in Cities Engineering and Management (M.Eng.C.E.M.) is awarded to students who have demonstrated:		
1. Depth and Breadth of Knowledge A systematic understanding of knowledge, and a critical awareness of current problems and/or new insights, much of which is at, or informed by, the forefront of the academic discipline, field of study, or area of professional practice.	Depth and breadth of knowledge is defined in M.Eng.C.E.M. as a systematic understanding of current problems and/or new insights, much of which is at the forefront of professional practice. This is reflected in students who are able to: ▪ Display expertise in at least one area of infrastructure	The program design and requirement elements that ensure these student outcomes for depth and breadth of knowledge are: ▪ Embedded in the three themes that comprise the program ▪ The requirement for depth and breadth in the four infrastructure engineering Theme A courses, where at least two courses are focused on one

Master's Degree Level Expectations (based on the Ontario Council of Academic Vice Presidents [OCAV] DLEs)	Master's Program Learning Objectives and Outcomes	How the Program Design and Requirement Elements Support the Attainment of Student Learning Outcomes
	▪ Critically assess a complex problem with opposite and conflicting perspectives ▪ Understand the political process and how it works	infrastructure type and at least one must be in a different but complementary area ▪ Inherent in the complex systems Theme B courses where students explore city economic, political, and operational systems that relate to infrastructure ▪ Captured in the Theme C practicum as students complete a comprehensive project and report
2. Research and Scholarship A conceptual understanding and methodological competence that i) Enables a working comprehension of how established techniques of research and inquiry are used to create and interpret knowledge in the discipline; ii) Enables a critical evaluation of current research and advanced research and scholarship in the discipline or area of professional competence; and iii) Enables a treatment of complex issues and judgments based on established principles and techniques; **and,** on the basis of that competence, has shown at least one of the following: i) The development and support of a sustained argument in written form; or ii) Originality in the application of knowledge.	Research and Scholarship is defined in M.Eng.C.E.M. as a conceptual understanding and methodological competence that enables: ▪ A working knowledge of how established techniques of research and inquiry are used to create and interpret knowledge in the discipline ▪ A critical evaluation of current research and scholarship in the area of professional competence ▪ A treatment of complex issues and judgments based on established principles and technique This is reflected in students who are able to: ▪ Critically assess a complex problem with opposite and conflicting perspectives ▪ Condense complex topics and analyses into simple and easily communicated	The program design and requirement elements that ensure these student outcomes for scholarship are: ▪ Outstanding instructors whose expertise will bring both theory and practice to the classroom ▪ Course papers for Theme B courses where students will have the opportunity to explore in-depth topics ▪ The assessment for their practicum report

Master's Degree Level Expectations (based on the Ontario Council of Academic Vice Presidents [OCAV] DLEs)	**Master's Program Learning Objectives and Outcomes**	**How the Program Design and Requirement Elements Support the Attainment of Student Learning Outcomes**
	messages for a diverse set of stakeholders	
3. Level of Application of Knowledge Competence in the research process by applying an existing body of knowledge in the critical analysis of a new question or of a specific problem or issue in a new setting.	Application of knowledge is defined in M.Eng.C.E.M. as competence in applying an existing body of knowledge in the critical analysis of a new question or of a specific problem or issue in a new setting. This is reflected in students who are able to: ▪ Demonstrate expertise in an infrastructure type ▪ Critically and comprehensively assess a complex problem from the viewpoints of stakeholders	The program design and requirement elements that ensure these student outcomes for level and application of knowledge are: ▪ Exams and projects in the Theme A courses ▪ Captured in the practicum experience ▪ Demonstrated in the practicum report

Master's Degree Level Expectations (based on the Ontario Council of Academic Vice Presidents [OCAV] DLEs)	**Master's Program Learning Objectives and Outcomes**	**How the Program Design and Requirement Elements Support the Attainment of Student Learning Outcomes**
4. Professional Capacity/Autonomy a. The qualities and transferable skills necessary for employment requiring i) The exercise of initiative and of personal responsibility and accountability; and ii) Decision-making in complex situations; b. The intellectual independence required for continuing professional development; c. The ethical behavior consistent with academic integrity and the use of appropriate guidelines and procedures for responsible conduct of research; and d. The ability to appreciate the broader implications of applying knowledge to particular contexts.	Professional capacity/autonomy is defined in M.Eng.C.E.M. as the qualities and transferable skills necessary for employment requiring the exercise of initiative and of personal responsibility and accountability; and decision-making in complex situations; the intellectual independence required for continuing professional development; the ethical behaviour consistent with academic integrity; and, the ability to appreciate the broader implications of applying knowledge to particular contexts. This is reflected in students who are able to: ▪ Prepare research papers ▪ Integrate professional, social, and environmental considerations into their decision analyses	The program design and requirement elements that ensure these student outcomes for professional capacity/autonomy are: ▪ Individual exams in the Theme A courses ▪ Course papers required in the Theme B courses ▪ Independent work in the practicum
5. Level of Communications Skills The ability to communicate ideas, issues and conclusions clearly.	Communications Skills are defined in M.Eng.C.E.M. as the ability to communicate ideas, issues and conclusions clearly. This is reflected in students who are able to: ▪ Construct a credible argument and present it in appropriate formats ▪ Generate research and position papers ▪ Make professional presentations	The program design and requirement elements that ensure these student outcomes for level of communication skills are: ▪ Theme B course papers ▪ Practicum report ▪ Practicum presentation

9 Assessment of Learning

Student performance in the program will be assessed through a variety of methods including reports, presentations, assignments and exams. Students will receive marks for their performance in each course.

Learning Outcomes	Assignments	Projects	Exams	Presentations
1. Depth and Breadth of Knowledge				
▪ Display expertise in at least one area of infrastructure	✓		✓	
▪ Critically assess a problem that is complex and has conflicting objectives	✓	✓		
▪ Adjust communications to address different audiences		✓		✓
▪ Identify key debates that result from conflicting stakeholder views	✓	✓	✓	
2. Scholarship				
▪ Conceptualize, design, implement infrastructure management strategies	✓	✓		
▪ Make informed judgements on complex issues in the context of cities	✓	✓		
▪ Communicate those strategies and judgements	✓	✓		✓
3. Application of Knowledge				
▪ Assess a complex problem from the viewpoints of stakeholders	✓	✓	✓	
4. Professional Capacity				
▪ Complete the degree requirements in a timely manner	✓	✓	✓	
5. Communication Skills				
▪ Prepare data for presentation purposes	✓	✓		
▪ Prepare reports that outline the problem, options, and solutions		✓		✓

10 Consultation

This M.Eng.C.E.M. program is not expected to have a significant impact on the nature or quality of the current MASc and PhD engineering graduate programs. Graduate level courses may experience increased enrolment due to the M.Eng.C.E.M., but the impact is not expected to be major due to the small size of the proposed program and the large number of courses available to students. Few graduate courses in engineering have limited enrolment.

Enrolment in the existing professional M.Eng. program may decrease if students who initially were drawn to the M.Eng. program choose M.Eng.C.E.M. instead. However, even a moderate shift in enrolment from one program to the other can be accommodated as the Department of Civil Engineering has managed a large M.Eng. program for several decades.

The Department has initiated discussions with individuals within the University from the Munk School of Global Affairs, Rotman School of Management, Department of Geography, and School of Public Policy and Governance. Members of the decanal teams of the Faculty of Arts and Science, Faculty of Architecture, Landscape and Design, and the School of Graduate Studies have all responded positively to CUSP generally, and the M.Eng.C.E.M. in particular. More broadly, the Provost has galvanized the University community around the establishment of CUSP Toronto, and with it, this proposed master's program by holding collaborative discussions with Deans and faculty members from a large number of the University's Faculties.

Consultations have also taken place with groups external to the University, including the City of Toronto, Toronto Transit Commission, World Bank, Greater Toronto Airports Authority, City of Oshawa, City of Mississauga, City of St. Catharines, ARUP Canada, Hatch Mott MacDonald, and the Canadian Urban Institute. Without exception, the feedback was enthusiastic, with several organizations asking to be involved in the practicum.

11 Resources

11.1 Faculty Complement

A number of professors and industry experts who will be core participants in this program are highlighted in this section to illustrate the depth and breadth of research conducted at the University. These experts are listed because (a) they offer existing Theme A courses, (b) they will develop new Theme B courses, or (c) they are likely academic advisors for practicum placements. In addition, a large community of faculty engaged in cities-related scholarship has agreed to support the program by serving as guest lecturers, providing guidance on practicum projects and generally engage in intellectual discourse on cities-related topics (see 11.1.3). The reader is encouraged to refer to the complete list of graduate faculty in Appendix B, and the corresponding curricula vitae for a fuller picture of their tremendous and collective expertise.

Professor Eric Miller will serve as the inaugural Program Director and will provide academic oversight and leadership on all aspects of program quality and delivery, particularly with respect to admissions, teaching, and course content. As Program Director, he will also coordinate the practicum placements, ensuring that evaluation practices are consistently applied. Professor Miller was the inaugural director of the University of Toronto's acclaimed Cities Centre, and his leading-edge research and positioning in transportation-related public policy is sought by urban leaders and media alike. He has authored or co-authored over 100 peer-reviewed journal papers, 114 research reports, two books and seven book chapters in his area of expertise.

In Theme A, the Faculty of Applied Science and Engineering has over 200 FTE academic faculty, over half of whom could be considered as having research interests in infrastructure-related areas. For Theme B components, an outstanding team of cities-specific researchers and industry experts has been assembled.

11.1.1 Theme A

The Faculty of Applied Science and Engineering has world-class expertise in the infrastructure systems that comprise a city including water, energy, transportation, healthcare, structural resilience, communications and emergency response. The following is just a sample of the resources available to support and enhance the Theme A component of the proposed program.

Baher Abdulhai is a world leader in intelligent transportation systems, applying emerging technologies to advance traffic management to reduce congestion and improve urban air quality.

Dionne Aleman is modeling the spread of a pandemic disease during an outbreak and optimizing operating room scheduling under deadlines and emergency surgery disruptions.

Robert Andrews, holder of the NSERC Industrial Research Chair in drinking water, is working with public agencies to minimize the threats to public water systems and to enhance water quality.

Constantin Christopoulos, holder of a Canada Research Chair in seismic resilience of

infrastructure, is developing a new generation of earthquake resistant buildings to not only save lives, but to minimize damage to buildings and therefore the disruption to essential services in a city.

Yuri Lawryshyn focuses on the optimization of business processes and municipal asset management.

Alberto Leon-Garcia, a Canada Research Chair, is developing data management systems for all types of infrastructure including transportation, communication networks and computing clouds.

Ted Sargent holds a Canada Research Chair in nanotechnology and is developing solar cells that are cost effective and have the potential to revolutionize the way in which we are able to capture and use solar energy.

Brent Sleep is developing economic contaminated groundwater remediation strategies to convert brownfields into usable public lands and to improve urban waterways.

11.1.2 Theme B

The Theme B program components will be supported by an outstanding team of professors and renowned industry leaders to create a powerhouse of cities expertise. The courses offered in this Theme are drawn from their research and current teaching areas.

Bryan Karney is an expert in urban water and energy systems, developing economic and performance metrics to find ways to improve them while meeting the demands of users and maintaining a healthy natural environment. From district cooling systems to water pumping systems in Africa, his expertise is respected worldwide by governmental policy makers, urban leaders, and other public agencies.

Chris Kennedy looks at cities differently than most engineers, viewing them as organisms that convert energy such as food into product and waste, i.e. greenhouse gasses. His research extends this theme to the creation of policy frameworks that incentivizes private investment in green infrastructure. In his recently published *The Evolution of Great World Cities: Urban Wealth and Economic Growth*, Dr. Kennedy describes the connection between infrastructure and economic development and prosperity using examples from around the world.

Heather MacLean is an expert in the evaluation of conventional and alternative energy systems, including the techno-economic and environmental performance of bioenergy systems (for transportation and electricity generation), unconventional fossil resources (oil sands-derived fuels) and alternative fuels/propulsion systems for light-duty vehicles. Much of her research has taken a life cycle approach for a more comprehensive and environmentally focused assessment. Her interdisciplinary research incorporates environmental, chemical and mechanical engineering, economics and public policy components. She works closely with both the public and private sectors.

Patricia McCarney is the creator of the Global City Indicators Facility, a database of comparable statistics that allow cities from every part of the world to track their effectiveness through 100+ indicators. These indicators include planning and economic growth, to transportation and education. By exchanging knowledge about best practices, cities can improve their quality of life and attractiveness to international investors. Dr. McCarney's expertise in the metrics upon which cities can be measured and compared is recognized by the over 125 cities that participate in this program.

Eric Miller: See section 11.1.

Richard Stren is Professor Emeritus of Political Science and Director of the University of Toronto Urban International at the Centre for Urban and Community Studies. He is a scholar in urban and community studies and has focused on the state and public policy issues in Canada, and the developing world, including Tanzania, Kenya, Nigeria, and Cote d'Ivoire. Dr. Stren has written or edited 18 books and more than 50 journal articles and book chapters. He teaches courses on comparative urban politics, politics and the environment and third world politics.

11.1.3 Supporting Community of Cities Scholars at the University of Toronto

The program focuses on a subject that is of enormous interest and as such will be able to draw periodically on a wide range of scholars not actively teaching in the program but who will add their perspective, provide advice, guest lecture in key courses, identify cities-related problems for practicum projects, and form part of a stimulating intellectual campus wide discussion concerning cities.

A sample of practitioners is included to emphasize the remarkable quality of individuals who will participate.

Paul Cadario recently retired from The World Bank as a Senior Manager and is joining the University of Toronto as a Distinguished Senior Fellow. His integrity and organizational skills have been dedicated to fighting poverty and improving the living standards of people in the developing world. A Rhodes Scholar, Mr. Cadario was determined to help the Bank eliminate barriers to the effective use of its funds and reduce poverty. He influenced economic reforms in China and countries of the former Soviet Union, to name a few. Throughout his career, he has had significant impact on the results and ethics of international economic development.

Dan Hoornweg is a Lead Urban Specialist in Cities and Climate Change at The World Bank. He has more than 20 years' experience working with 200 cities in Sub-Saharan Africa, East Asia and the Pacific Islands, South Asia and Latin America, and Caribbean regions. He led the Bank's urban program on cities and climate change, including numerous studies related to climate change impacts in cities - mitigation and adaptation.

Lloyd McCoomb recently retired as the president and CEO of the Greater Toronto Airports Authority at Toronto's Pearson Airport. His career in the public transportation sector has given him a unique perspective on the issues related to the diverse stakeholders that influence policy and decision-making. Before becoming president, he was singly responsible for the highly visible $4.4 billion megaproject for the revitalization at Pearson Airport. This unique and much scrutinized project served the public both locally and internationally throughout its development, and was the largest infrastructure project in Canada. He continues to teach graduate courses in airport planning and traffic management, as he has through most of his career.

11.2 Administrative Support

One administrative support person will be hired to look after admissions, finances, graduation reviews, industry liaison, marketing, program coordination and student counseling.

11.3 Financial Support for Graduate Students

Financial support is not anticipated other than scholarships typically available to graduate students. Professional engineering master's programs are not funded, although some students may be sponsored by their employer.

11.4 Space/Infrastructure

In steady state, it is expected that there will be up to 60 students (full-time plus extended full-time) enrolled in each of the core courses. Room GB217, which has a capacity of 58, will be dedicated for core course lectures during the fall and winter terms. Currently part of the Department's space inventory, this room is appropriately configured for medium sized groups with large tables and chairs that can be rearranged for lectures, group discussions and small team projects. It also has a built-in projection system, speakers, blackboards and plenty of natural light. Wireless internet access is available for students as needed. No laboratory space is needed for the core courses. Labs associated with the infrastructure engineering courses will be provided through those courses.

Space in the anticipated new engineering building will be sought combining the M.Eng.C.E.M. administration office, a lecture room, and a workspace/common room.

Students will supply their own laptops.

In the short term, the proposed program will not require additional space or renovation of existing space. In the longer term, as space pressures on the Faculty mount, additional space in a proposed new building will be required.

12 Quality and Other Indicators

Faculty expertise ranges from improving the sustainability of individual facilities and operations to an examination of the global impacts of engineering decisions. Focused on the fact that buildings account for 40% of all energy use, one research team creates affordable ways for home and other building owners to reduce energy consumption. Another produces research and advises on policies for encouraging private sector investment in low carbon, climate resilient infrastructure. On the global scale, one of our professors has authored several books on improving our understanding of the interactions between society, technology, science and the biosphere and of their implications for human life.

Faculty members involved with the M.Eng.C.E.M., and truly faculty throughout the Faculty, go beyond the typical stereotype of an engineer. Through their research and teaching they are developing solutions to problems encountered throughout the world. Students will have the opportunity to learn from these world-class researchers and bring that knowledge to bear when working in urban centres.

13 Governance Process

	Levels of Approval Required
Consultation with Provost	
Decanal and Provostial Sign Off	
	Graduate unit approval
	Faculty/Divisional Governance
Submission to Provost's Office	
	AP&P
	Academic Board
	Executive Committee of Governing Council
Program may begin advertising as "Pending Approval"	
	Ontario Quality Council

	Submitted to MTCU (in case of new graduate degrees and programs, new diplomas)

14 References

Martinez Fonte, L., Draper P., Chau, P.K., Norman, K., Yoo, N., Chan, J. Research & Innovation Jobs -Opportunities and challenges in the Toronto Region Labour Market. Report sponsored by Employment Ontario, the Government of Canada, University of Toronto and TD Bank Group. Toronto Region Research Alliance. February 2012, 72 pages. (http://www.trra.ca/RIjobs)

Appendix A – Course Descriptions

The following are new, dedicated courses for this program:

B1: An Empirical Study of Cities
B2: Infrastructure and Urban Prosperity
B3: The Challenges of Urban Policy-Making
B4: Cities as Complex Systems
B5: Economics & Infrastructure
B6: Integrative Decision Making
D: Practicum

The technical electives in engineering infrastructure will come from a broad and dynamic list of hundreds of existing graduate level courses currently available in engineering with Post Codes AER, APS, BME, CHE, CIV, ECE, MIE, MSE and others. These will be approved by the Program Director of the M.Eng.C.E.M. program in advance of the start of the program.

B1: An Empirical Study of Cities

Rationale:
This course is part of the core requirements for the proposed Master of Engineering in Cities Engineering and Management program.

Course Description:
This course provides students with an introduction to the topic of cities, how they are measured, and the methods used to measure them. The strengths and limitations of various measures are examined including issues related the cost of collecting data and the challenges in ensuring its integrity. After reviewing the most commonly used statistical analysis methods, student will calculate and use metrics to compare cities in Canada, North America, and around the world. Metrics of interest include, but are not limited to, those related to city services, public health and well-being, environmental sustainability, and economic vitality.

Delivery and Contact Hours:
30 hours of lecture contact hours in a modular format

Evaluation Components, Percentage Value and Timing:
30% Assignments
70% Course Project Report

Prerequisite:
None

B2: Infrastructure and Urban Prosperity

Rationale:
This course is part of the core requirements for the proposed Master of Engineering in Cities Engineering and Management program.

Course Description:
The course explores the evolution of great cities over time, looking at form and function to understand urban economic growth and accumulation of wealth. Drawing from various strands of economic thought, topics include: value theory; quantification of urban wealth; microeconomics of real estate markets; infrastructure for competitive financial centres; macroeconomics of urban form; growth theory; and evolutionary economics applied to urban systems. Using current and historical examples of urban development, the implications of infrastructure planning and management on the health/wealth of cities is examined.

Delivery and Contact Hours:
2 lecture hours per week, or equivalent

Evaluation Components, Percentage Value and Timing:
20% Problem Sets (throughout the course)
30% Course paper (due end of course)
50% Final Exam

Prerequisite:
None

B3: The Challenges of Urban Policy-Making

Rationale:
This course is part of the core requirements for the proposed Master of Engineering in Cities Engineering and Management program.

Course Description:
Cities and associated urban policies are fundamental features of contemporary life. Policy themes such as citizen participation and governance, urban planning, environment and sustainability, and urban competitiveness are central issues to public managers, and to a growing and influential group of professionals and civic activists who are attempting to improve our lives at the local level. This course will consider these themes, as well as current legislation affecting asset management, trends and proposed reforms here and around the world, and our emerging understanding of multilevel governance.

Delivery and Contact Hours:
Modular course:

- 2 weeks of 3-hour lectures (or lectures as part of a seminar) per day; 30 total hours. Each student will complete a short bibliographic paper based on the readings.
- 2 week intensive research project – a research paper on an important public policy issue with special reference to a local municipality.

Evaluation Components:
30% Short bibliographic paper
70% Research paper.

Prerequisite:
TBD

B4: Cities as Complex Systems

Rationale:
This course is part of the core requirements for the proposed Master of Engineering in Cities Engineering and Management program.

Course Description:
Cities are “problems in organized complexity” (Jacobs, 1961). This course will explore this theme and its implications for city engineering and management in terms of: introduction to complex systems theory; exploration of cities as systems (physical, economic, social, etc.); holistic and reductionist approaches to “a science of cities”; approaches to city planning and design in the face of complexity; challenges to sustainable design; and decision-making under uncertainty.

Delivery and Contact Hours:
Modular course:

- 2 weeks of 3-hour lectures per day; 30 total lecture hours.
- 2 week intensive project.

Evaluation Components:
15% Assignments
20% Project Proposal
20% Interim Report
15% final Presentation
30% Final Report

Prerequisite:
TBD

Jacobs, Jane, 1961, The Death and Life of Great American Cities, Random House Inc. New York

Appendix B – Faculty Complement

Name	Home Department / Unit	Rank	Graduate Faculty Membership Status **	Commitment to other programs (please list)	Nature of contribution to program*
Tenured					
Abdulhai, Baher	Civil Eng	Professor	Full	None	CI & C/PS
Andrews, Robert	Civil Eng	Professor	Full	None	CI & C/PS
Carter, Michael	Mechanical & Industrial Eng	Professor	Full	None	CI & C/PS
Christopoulos, Constantin	Civil Eng	Professor	Full	None	CI & C/PS
Hatzinakos, Dimitrios	Electrical & Computer Eng	Professor	Full	None	CI & C/PS
Hess, Paul	Geography	Associate Professor	Full	100%	CI & C/PS
Karney, Bryan	Civil Eng	Professor	Full	None	CI & C/PS
Kennedy, Christopher	Civil Eng	Professor	Full	None	CI & C/PS
Leon-Garcia, Alberto	Electrical & Computer Eng	Professor	Full	None	CI & C/PS
MacLean, Heather	Civil Eng	Professor	Full		CI & C/PS
McCarney, Patricia	Architecture	Professor	Full	100%	CI & C/PS
Miller, Eric	Civil Eng	Professor	Full	None	CI & C/PS
Sargent, Edward	Electrical & Computer Eng	Professor	Full	None	CI & C/PS
Sinton, David	Mechanical & Industrial Eng	Associate Professor	Full	None	CI & C/PS
Sleep, Brent	Civil Eng	Professor	Full	None	CI & C/PS
Sorensen, Andre	Social Science, UTSC	Professor	Full		CI & C/PS
Stren, Richard	Political Science	Professor Emeritus	Full	100%	CI & C/PS
Turner, Matthew	Economics	Professor	Full	100%	CI & C/PS
Wolfe, David	Political Science	Professor	Full	100%	CI & C/PS
Tenure-Stream					
Aleman, Dionne	Mechanical & Industrial Eng	Assistant Professor	Full	None	CI & C/PS
Chan, Timothy	Mechanical & Industrial Eng	Assistant Professor	Full	None	CI & C/PS

Lawryshyn, Yuri	Chemical Eng	Associate Professor	Full	None	CI & C/PS
Siemiatycki, Matti	Geography	Assistant Professor	Full	100%	CI & C/PS
Non-Tenure Stream (i.e. CLTA)					
Teaching Stream					
Sessional Lecturer					
Cadario, Paul	Civil Engineering	Adjunct	No status at this time	None	CI & C/PS
Hoornweg, Dan	Civil Engineering (The World Bank)	Adjunct	No status at this time	None	CI & C/PS
Others					
McCoomb, Lloyd Former Pres. & CEO of Greater Toronto Airports Authority	Civil Eng	Adjunct	Associate	None	CI & C/PS
Slack, Enid	Munk School of Global Affairs	Adjunct	No status at this time	100%	CI & C/PS

** CI: course instructor; TS: thesis supervisor; C/PS: clinical or practice supervisor*

**** Associate or Full privileges)**

Appendix C – Library Statement

UNIVERSITY OF TORONTO
LIBRARIES

University of Toronto Libraries Statement in Support of the Proposed Program for a Master of Engineering in Cities Engineering and Management

Context: The University of Toronto Library (UTL) system is the largest academic library in Canada and is currently ranked fourth among academic research libraries in North America, behind Harvard, Yale and Columbia.[1] The research and special collections, together with the undergraduate libraries comprise almost 11.5 million print volumes, nearly 5.5 million microform volumes, more than 17,000 journal subscriptions, in addition to a rich collection of manuscripts, films, and cartographic materials. The system also provides access to approximately 900,000 electronic resources in various forms including e-books, e-journals, and online indices and increasingly supports access via personal handheld devices.[2] There are numerous collection strengths in a wide range of disciplines reflecting the breadth of research and instructional programs at the University. The strong collections, facilities and staff expertise attract unique donations of books and manuscripts from around the world, which in turn draw scholars for research and graduate work.

Major North American Research Libraries[3]					
	1998-1999	2005-06	2006-07	2007-08	2008-09
ARL RANK	UNIVERSITY	UNIVERSITY	UNIVERSITY	UNIVERSITY	UNIVERSITY
1	Harvard	Harvard	Harvard	Harvard	Harvard
2	Yale	Yale	Yale	Yale	Yale
3	Stanford	Columbia	Columbia	**Toronto (3rd)**	Columbia
4	**Toronto (4th)**	**Toronto (4th)**	**Toronto (4th)**	Columbia	**Toronto (4th)**
5	California, Berkeley	California, Berkeley	California, Berkeley	California, Berkeley	Michigan

Top 5 Canadian Universities in the ARL Ranking of Major North American Research Libraries					
	1998-1999	2005-06	2006-07	2007-08	2008-09
	RANK/ UNIVERSITY	RANK/ UNIVERSITY	RANK/ UNIVERSITY	RANK/ UNIVERSITY	RANK/ UNIVERSITY
	4/ Toronto	**4/Toronto**	**4/Toronto**	**3/Toronto**	**4/Toronto**
	30/Alberta	27/Alberta	19/Alberta	12/Alberta	16/Alberta
	31/British Columbia	29/British Columbia	25/British Columbia	25/British Columbia	26/British Columbia
	57/McGill	34/Montreal	33/Montreal	26/McGill	34/Montreal
	76/York	39/McGill	36/McGill	33/Montreal	40/McGill

Space and Access Services: The Library system provides a variety of individual and group study spaces for both undergraduates and graduates in the 10 central and 23 divisional libraries on the St. George, Mississauga, Scarborough and Downsview campuses. The Engineering and Computer Science Library, on the St. George campus, is open 78.5 hours per week from September to May and 59.50 hours per week from May to August. At this site, 36 networked public computer terminals are available within the Engineering and Computer Science Library and these provide access to the Library catalogue and online resources. The Engineering and Computer Science has recently installed 4 scanners and appropriate software for use by Engineering students to help with their assignments, and it is anticipated that a laptop loan program will be introduced in the fall of 2012. This

[1] Chronicle of Higher Education, "Library Investment Index at University Research Libraries, 2008 – 2009." In the Almanac of Higher Education, 2010.
[2] Figures as of 2010 taken from UTL's "What's new in E-Resources" page
http://main.library.utoronto.ca/eir/EIRwhatsnew.cfm and UTL's annual statistics
http://discover.library.utoronto.ca/general-information/about-the-library/annual-statistics
[3] Association of Research Libraries Statistics.

Library provides 267 seats for study and research in addition to the 1330 study spaces available in the nearby Gerstein Science Information Centre. Study space and computer facilities are available twenty four hours, five days per week at one location, Robarts Library, also on the St. George campus. Web-based services and electronic materials are accessible at all times from campus or remote locations, through the U of T based Scholars Portal and other leading edge digital services.

Instruction & Research Support: The Library plays an important role in the linking of teaching and research in the University. To this end, the Library offers information literacy instruction to assist in meeting graduate degree level expectations in the ability to gather, evaluate and interpret information. These services are aligned with the Association of College and Research Libraries (ACRL) Information Literacy Competency Standards for Higher Education.[4] Research groups, student teams and individuals can request customized workshops, seminars or one-to-one consultations, and customized seminars have been presented in past years for research groups such as Intelligent Transportation systems. Advanced Engineering Research workshops are offered four times per year to graduate students in all engineering disciplines, and drop in sessions have also been offered in past years on topics such as RefWorks bibliographic management system and citation searching.

Program Specific Instruction: Instruction occurs at a variety of levels for engineering students and is provided by librarians of Engineering & Computer Science Library. The Library makes available to any interested faculty instruction integrated into class schedules. The Library, through its liaison librarians, also customizes feeds of library resources which appear prominently in Portal/Blackboard course pages, and creates online research guides in support of specific courses or areas of study, as well as online research guides for general disciplines such as Civil Engineering and Environmental Studies.

Collections: Almost all of the relevant material that will support the proposed Master's of Urban Engineering program is housed in the Engineering and Computer Science Library in the Sandford Fleming Building or is available online through the Library's licensed subscriptions. Related literature is housed in other libraries, primarily Gerstein Science Information Centre, Robarts Library & Map and Data Library, Rotman Business Information Centre and, to a lesser extent, the Noranda Earth Sciences Library. Students and faculty may borrow material from any library at the University. Collections are purchased in all formats to meet the variety of preferences and styles of our current students and faculty. The University of Toronto Library is committed to collecting both print and electronic materials in support of a Master's of Urban Engineering program at the University of Toronto.

Journals: The Library's journal collections are well equipped to support the proposed program. The Library subscribes to all of the top 25 journals listed in Journal Citation Reports (JCR)[5] in subject category *Engineering, Civil*, the top 24 of 25 in subject category *Transportation Science & Technology*, and all of the top 25 in other relevant JCR subject categories: *Engineering, Environmental; Urban Studies; Public Administration*; and *Planning & Development.*

Monographs: The University of Toronto Library maintains comprehensive book approval plans with 53 book dealers and vendors worldwide. These plans ensure that the Library receives academic monographs from publishers all over the world in an efficient manner. For Engineering, monographs are purchased in electronic form where possible. The Library currently receives all current e-books directly from Springer, Wiley, Elsevier and Oxford University Press publishers, and subscribes to the Knovel engineering ebooks multi-publisher platform.

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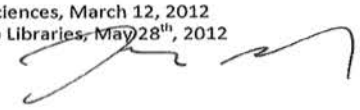
[4] Association of College & Research Libraries. *Information Literacy Standards*. ACRL, 2006.

[5] 2009 Journal Citation Reports® (Thomson Reuters, 2010)

Preservation, Digitization, and Open Access: The University of Toronto Library supports open access to scholarly communication through its institutional research repository (known as T-Space), its open journal and open conference services, and subscriptions to open access publications. In addition to acquiring materials in support of Engineering programs, the Library is also, in cooperation with the Internet Archive, digitizing its monograph holdings published before 1923. These books are available without charge to anyone with access to the Internet through the Scholar's Portal e-Book platform.

Key Databases: Subscriptions are maintained to major Engineering discipline-specific online indexes such as *Compendex, Transport Database and Engineering Research Database*, which includes *ASCE Civil Engineering Abstracts, Environmental Engineering Abstracts, Mechanical & Transportation Engineering Abstracts* and *Transport Database*. The Library also has active subscriptions to key databases in sustainable development and urban studies research including *Web of Science, Scopus, Environmental Sciences & Pollution Management database, GreenFILE, GEOBASE, PolicyFile, International Bibliography of the Social Sciences, Muniscope, EconLit and Canadian Periodical Index (CPI.Q)*. In the areas of business, the Library maintains subscriptions to all key databases including *Business Source Premier, ABI Inform, Factiva, CBCA Business, ProQuest Asian Business, ProQuest European Business, and Management & Organization Studies: a SAGE Full-Text Collection*.

Prepared by: Cristina Sewerin, Selector for Physical & Applied Sciences, March 12, 2012
Submitted by: Larry Alford, Chief Librarian, University of Toronto Libraries, May 28th, 2012



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Appendix D – Comparator Programs

The M.Eng.C.E.M. program is unique to programs offered at other institutions, but is most closely aligned with:

Institution and Unit	Degree and Program	Program Description	Curriculum	Comments	Tuition
NYU-Poly Brooklyn, NY	**Master of Science in Urban Systems Engineering and Management** http://www.poly.edu/academics/programs/urban-systems-engineering-and-management-ms	The program will help engineering and non-engineering professionals alike understand and manage major urban infrastructure systems. Developed as part of the Institute for Civil Infrastructure Systems (ICIS), a consortium effort led by New York University, and supported by the National Science Foundation, our program shows how the technical aspects of infrastructure management are informed by their sociopolitical contexts. Issues of public policy, finance, monitoring, and maintenance are studied and brought to bear on urban infrastructures. This gives our students a holistic look at the development of cities and how they function. The program aims to give students: – A broad understanding of infrastructure management and policy issues; – Analytical and decision-making skills for reviewing the political, economic, and social impacts of infrastructure technologies; – A wide overview of a spectrum of urban infrastructure systems, as well as an	Students must complete: 1. a program core, 2. a minor area of concentration, and/or approved technical electives, and 3. a capstone or thesis. Required Program Core Courses: – CE 7813 Infrastructure Planning, Engineering and Economics – CE 7843 Introduction to Urban SysteMS Engineering – CE 7853 Concepts and Implementation of Infrastructure Management SysteMS – CE 7673 Environmental Impact Assessment – CE 8733 Infrastructure Financing: Structuring of A Deal Minor Areas of Concentration: To complete a minor, students	The program is open to professionals with BS or BA degrees and backgrounds in engineering, science, public policy, management, economics, and/or finance. Necessary mathematics background, usually including undergraduate calculus, is required, as is an undergraduate GPA of 3.0 or better. All applicants for the program must also show evidence of general quantitative analytic ability, including a minimum of 2 years of college mathematics and a college-level course in statistics.	$43,032-$46,944 USD in 2012-13 $44,036-$48,039 CAD[7] 33-36 credits required to complete program @ $1,304 per credit

[7] XE Currency Converter – http://www.xe.com/ (June 14, 2012)

Institution and Unit	Degree and Program	Program Description	Curriculum	Comments	Tuition
		integrated knowledge of the interactions and interdependencies of those systems; and – Specialized management skills and techniques that you can apply to the unique challenges introduced by the infrastructure sector.	must take 3 required courses and 2-3 technical electives that are available to all program students. An adviser may approve additional electives. Minor areas of concentration are: 1. Transportation Systems Management 2. Construction Management 3. Environment Systems Management 4. Civil Infrastructure Systems Management Students may decide not to take a specified minor area. Instead, they may take 5 or 6 technical electives from an approved list in any specified area. The number of technical electives is influenced by what students choose for their capstone experience: a 3-credit case study report or a 6-credit MS thesis.		
Wageningen University Environmental Sciences Wageningen, The Netherlands	**Master of Urban Environmental Management** http://www.mue.wur.nl/UK/	International and interactive program providing a balanced curriculum of theory, tools and application. Emphasizes the development of cross-disciplinary outlook, critical thinking, analytical, problem-solving and practical decision-making skills through a combination of teamwork, simulation exercises, field trips and an individual research project. The 1-year program is comprised of 120 European Credit points (EC), equivalent to 2 academic years. The first year entirely consists of 40 weeks of coursework; the second year	Coursework consists of foundation course (common across all majors), at least 2 out of 4 program-specific urban courses, and 2-3 courses that are unique to the major of one's choice. The coursework concludes with the European Workshop, an extensive fieldwork assignment carried out in (and commissioned by) a local authority in a selected EU country.	Graduates from the program are well-equipped with the skills and knowledge to continue academic training (PhD) or to enter or continue careers in city management, environmental research, urban planning and environmental consulting, water, waste management and	€ 1,771 – 2012/13 statutory tuition fee for students who meet nationality, address, degree requirement, and study duration requirements $2,289 CAN €12,020 – 2012/13 institutional fee 3 for students who do not

Institution and Unit	Degree and Program	Program Description	Curriculum	Comments	Tuition
		comprises a 16-week academic internship and 24-week thesis program as the core components of the program Students enrolling in program must have: – At least a BSc degree (or equivalent) in a field of science relevant to the specific programme selected; – A GPA (Grade Point Average) for the BSc study of at least 7 (or 70% of the maximum of the scale); – Fluency in English, both written and spoken (see English language proficiency); – Good skills in mathematics and/or statistics; – Basic computer skills. Due to increasing demand for the courses offered within the program, applicants must demonstrate that they not only meet the general admission requirements, but also have the relevant skills, experience and motivation to excel within the program. Students enrolled in this program will be expected to perform consistently at a high standard.	The 16-week internship program provides a valuable opportunity to gain practical experience in a country and organization of your choice. The 24-week thesis program is the individual research project that forms the core component of the program. Within the program, students can major in one of 7 disciplines: 1. Environmental Policy 2. Environmental Economics 3. Environmental Systems Analysis 4. Urban Environmental Technology and Management 5. Geo-Information Science and Remote Sensing 6. Land Use Planning 7. Management Studies	transport, and construction and building stock management.	meet the nationality requirement $15,537 CAN
University of Texas at Arlington Dept. of Civil Engineering	**Master of Infrastructure Engineering & Management** http://www.uta.edu/ce/infrastructures.php	This online and in-class program focuses on the planning, design, construction, operation and maintenance of lifeline infrastructures that include roads and highways, railroads, airports, and pipelines/tubes for transportation of freight, water, sewer, waste, oil and gas, and information. The program is specifically delineated for public works and transportation officials, municipalities, government agencies, utility and pipeline owners, design and consulting engineers and professionals involved in	24 hours of course work must be in Civil Engineering. Core Courses: 12 semester hours are required from the Core Courses list. Elective Courses: 21 semester hours of elective course work must be taken from Civil Engineering Elective Courses (i.e., 1 x 3-hr course from each of environmental, geotechnical,		$8,892 USD – 2012-2013 average tuition and fees for a full time graduate student paying the in-state rate. $9,101 CAN $14,526 USD – 2012-2013 average tuition and fees for a full time graduate student paying the

Institution and Unit	Degree and Program	Program Description	Curriculum	Comments	Tuition
		operation and maintenance and asset management of pipelines and utilities, railroads, roads and bridges, airports, pavements, water and wastewater treatment plants, hydraulic structures, and culverts and drainage structures. The Infrastructure Engineering includes service life estimation, asset management, life cycle cost analysis, deterioration theories, inspection and assessment methods, and renewal and maintenance of infrastructure with utilization of innovative methods, sustainability considerations, environmental protection, and trenchless technologies. Each student's program of study is customized towards the student's interest and is developed with the supervising committee before completing 12 graduate credit hours.	structures, transportation, and water resources). 3 additional semester hours of electives must be taken from the department or selected courses outside the department. 3 semester hours of elective course work must be taken as a research tool or supporting courses to the program of work. Course selection must result in a cohesive program that supports the degree plan and must receive the approval of the student's supervising committee. Project Course: Students must complete a 3-hr project on Infrastructure Design Engineering (CE5395 Master Project). Final Exam: Enrollment in CE 5193, Master's Comprehensive Examination is required in the semester of graduation.		non-resident rate. $14,867 CAN http://wweb.uta.edu/ses/fao/content/financialaid/cost_of_attendance.aspx
Monash University Faculty of Engineering Victoria, Australia	**Master of Infrastructure Engineering and Management** http://www.monash.edu/study/coursefinder/course/3262/	The program is a response to the growing need for engineers with broad awareness of the characteristics and significance of infrastructure, including its technological, economic and social impact. The program outlines the state-of-the-art of infrastructure engineering and management as it may be applied to the solution of real problems in the planning, design, management and operation of facilities. It gives students a thorough understanding of	Entry based on a 4-year degree requires completion of a total of 48 credit points (8 units) study in addition to 24 credit points of credit: – 4 core units – up to 3 units from the list of engineering electives – up to 3 units from the list of business and economics electives	Also offers graduate diploma and graduate certificate in Infrastructure Engineering and Management Program duration is 1.5 years full-time or 3 years part-time (domestic students) or 1.5 years full-time (international students)	$19,590 AUD – domestic fee per 48 credit points (representing a standard full-time course load for a year), for 2012/13 $20,089 CAN $20,850 AUD – international fee per 48 credit points

Institution and Unit	Degree and Program	Program Description	Curriculum	Comments	Tuition
		the nature of infrastructure and its operation and management by stressing the development of appropriate analytical skills and practical knowledge together with recognition of the role of other disciplines in tackling infrastructure-related issues. It is primarily aimed at applicants with a few years' postgraduate experience who wish to have formal education in this field, such as engineers working with public transport authorities, or in local government, as well as those with an interest in infrastructure planning or research. The program is designed and administered with the assistance of professionals in the field, such as representatives of government departments, local government, research institutions and private firms with an interest in infrastructure, who help keep the department abreast of needs and opportunities related to infrastructure education. Graduates will understand the need to plan, develop and maintain infrastructure at a high level; evaluate alternative projects and policies in a rigorous manner; plan and execute the development of infrastructure projects; communicate their arguments effectively to teams and clients and critically evaluate their work and the work of others; and be able to recognize the importance of whole of life considerations in achieving the best operation of infrastructure.	Entry based on a 3-year degree requires completion of a total of 72 credit points (12 units): – 4 core units – up to 6 units from the list of engineering electives – up to 5 units from the list of business and economics electives – up to 5 units from the list of business and economics electives Requirements - core units: – CIV5310 Infrastructure project and policy evaluation – CIV5311 Infrastructure project management – CIV5312 Asset management I – CIV5313 Asset management II	*14.1.1*	(representing a standard full-time course load for a year), for 2012/13 $21,381 CAN http://www.monash.edu/study/coursefinder/course/3262
Kyoto University Dept. of Civil	**International Course in**	Two-year program leading to a Master of Engineering degree, cultivating human		All lectures and research guidance provided in	535,800 yen tuition – 2012/13 $6,910 CAN

Institution and Unit	Degree and Program	Program Description	Curriculum	Comments	Tuition
and Earth Resources Engineering Graduate School of Engineering Kyoto, Japan	**Management of Civil Infrastructure** (Master's program) http://www.ce.t.kyoto-u.ac.jp/mci/en	resources capable of managing civil infrastructures and addressing environmental issues in various countries, particularly in the developing countries of the Asian and African regions. Addresses how to achieve a stable supply of natural resources and harmonize human activities with the global environment; the development of fundamental key technologies that support public infrastructure and energy development; the creation and development of new versatile technologies and design methods concerning the constructions, improvement, operation, and maintenance of public infrastructure and disaster mitigation measures, as well as technologies related to the exploration, development, and utilization of the natural environment, natural resources and energy. Such issues are approached by the framework of applied mechanics and computational mechanics with the integration of theoretical and experimental works.		English.	
University of Illinois at Urbana-Champaign Dept. of Civil and Environmental Engineering	**Master of Sustainable & Resilient Infrastructure Systems Program (SRIS)** http://cee.illinois.edu/SRIS and http://cee.illinois.edu/SRIS/MS-PhD	The cross-cutting and inter-disciplinary program in SRIS is intended to foster collaborations and leadership in holistically planning, designing, and managing sustainable and resilient infrastructure systems and their interactions. It focuses on fundamental sciences and engineering principles associated with planning, designing, and managing sustainable and resilient CEE infrastructure systems and their interactions. Application domains are interdisciplinary in nature, which include, but are not limited to: construction management, geotechnical and structural systems engineering, transportation systems analysis,	A. Required and Recommended Courses *Core courses* – CEE 498 Infrastructure Sustainability and Systems Analysis – CEE 491 Decision and Risk Analysis – CEE 595 SRS Sustainable and Resilient Infrastructure Systems seminar (all semesters enrolled in the program)	Also offers PhD program	$15,732 - USD new and continuing resident graduate students - 2011-12 $16,099 CAN $28,998 - USD new and continuing non-resident graduate students – 2011-12 $29,672 CAN

Institution and Unit	Degree and Program	Program Description	Curriculum	Comments	Tuition
		logistics systems design, water system design and operation, natural resource and energy management, environmental engineering, and sustainability-related policies. The student in this program not only acquires a broad range of domain knowledge from the traditional civil and environmental engineering areas, but also learns holistic systems analysis tools such as optimization and decision support, probability and statistics, and environmental and natural resources economics, often by taking advanced courses outside of CEE. Our graduates are especially well-suited for work in government agencies and laboratories, consulting engineering firms and other industry, sustainability advocacy organizations, as well as academic institutions.	M.S. students are encouraged and Ph.D. students are required to select at least one additional core course related to systems theory and methods [from preselected list]. *Advanced Courses (highly recommended):* Students are encouraged to take at least one advanced course that synthesizes sustainability, resilience, and/or systems methods into CEE infrastructure planning, design, construction, and/or management. This objective can be met through independent study or research (CEE 597 or 599) with an SRIS faculty member or through courses such as the following [pre-selected list]. B. Elective Courses A variety of courses are available within CEE and across campus that are related to infrastructure systems and sustainability and can be used to fulfill the remaining required credit hours for the MS or PhD degrees. Some of these are listed below [in pre-selected list]. Students may select more or other courses in agreement with their advisor. Civil and Environmental Infrastructure [see pre-selected list]		

Institution and Unit	Degree and Program	Program Description	Curriculum	Comments	Tuition
			Systems Theory and Methods [see pre-selected list] Sustainability Knowledge and Skills [see pre-selected list]		
University of Cambridge Architecture & Engineering Cambridge, UK	**Master of Interdisciplinary Design for the Built Environment (IDBE)** http://www.idbe.org/	The program gives its graduates a broad strategic understanding of the social, economic and environmental context of design, and of the current challenges and opportunities facing the production of the built environment. The course brings together individuals already competent in their specialism and encourages them to see the bigger picture, and how best they can help to develop an integrated product and then deliver it. It emphasizes strategic decision making, inventive problem solving, team leadership, and interdisciplinary collaboration, and equips its students with the skills needed to create buildings, spaces and neighbourhoods that are visually attractive, supportive of social activities, ecologically friendly and economically viable. The program has proved valuable to a wide variety of disciplines including: – Architecture and Landscape Architecture – Engineering (Civil, Structural, Building Services & Transportation) – Design Management, and Project and Construction Management – Cost Planning and Building Economics – Facility Procurement and Management – Urban Design and Policymaking	Students spend a total of 7 residential weeks in Cambridge during the 2 years; 4 weeks in the first year and 3 in the second. Each week comprises an intensive program of: – Formal lectures from leading practitioners and academics – Workshops and seminars – A studio design project undertaken in small interdisciplinary teams of students supported by design tutors – Meetings with Director of Studies and Supervisors. The course, and its program of lectures, seminars and workshops, is centred on the linked topics of buildings, cities, infrastructure, sustainability, technology, teams and clients. The themes of the residential weeks are: – Interdisciplinary understanding – The client, the user and the design team – Teamwork, leadership and	Part-time, two-year master's degree at the University of Cambridge offered jointly by the Departments of Architecture and Engineering	£10,100 for 2012-2014 $16,076 CAN

Institution and Unit	Degree and Program	Program Description	Curriculum	Comments	Tuition
		– Clients and other stakeholders	collaboration – Sustainable construction – Infrastructure and landscape – The structure of the industry – Urban design and sustainable communities Between residential sessions students conduct research and prepare the written work needed to achieve the degree. This comprises case study, 2 essays and thesis.		
Lund University Faculty of Engineering Lund, Sweden	**Master of Sustainable Urban Design** http://www.lth.se/english/education/master/sustainable_urban_design	For urban design to be a sustainable and responsible practice, a dynamic education for architects and designers is necessary. Learning from culture and history, and searching together for new ways of designing, the program provides a leading education in this critical, architectural discipline. The objectives of the program are to: – offer a broad education, covering the most important aspects of sustainability related to urban design – provide students with the skills to manifest specific social, economic and environmental intentions in physical form through urban design – prepare students for professional practice and continued life-long intellectual development – take advantage of the possibilities created by a multinational student group	Year 1 – mandatory courses: – Sustainable urban recycling – Urban recycling – theory and methods – Urban quality and urban form – Sustainable urban landscape – Sustainable urban landscape - theory and methods – Landscape architecture and gardens Year 2 – mandatory courses: – Sustainable urban dynamics – Urban dynamics – theories and tendencies – Urban process Elective courses: – Climate Smart Architecture and Urban Design	2-year, full-time program	

Institution and Unit	Degree and Program	Program Description	Curriculum	Comments	Tuition
			Master thesis: – Degree Project in Sustainable Urban Design		
École des Ingénieurs de la Ville de Paris	**Master of Urban Engineering** http://www.eivp-paris.fr/	Traditionally the development and management of urban areas were organized vertically by areas: roads, buildings, water supply, sanitation, greenery, cleanliness, etc. and specialists were assigned to each of these areas. This program applies to the development and management of urban and peri-urban in all their dimensions, and breaks down the barriers that positions specialists around each of their areas. Engineers in Urban Engineering operate in the following areas: – Urban planning – development of public spaces and urban development projects; – Infrastructure and support; – Buildings; and – The environment – water treatment, air quality, noise, waste and discards. They are active in public or private sector and contribute to public service. This specificity is enhanced by close contacts with the network of alumni who hold positions of responsibility within local communities and in more than 100 companies involved in the Cities (in all sectors: environment, travel, buildings, public works, etc.).			Unknown
NED University of Engineering Technology Faculty of Civil Engineering and Architecture Department of	**Master of Transportation Infrastructure Management** http://www.neduet.edu.pk/UE/masters.html	The Department aims to provide students background of planning, design and management of the urban infrastructure. Its objective is to deliver capacity building and value addition to the youths of the society in the form of Urban & Infrastructure Engineers.			450,000 PKR for local applicants $4,882 CAN 850,000 PKR for overseas applicants $9,221 CAN

Institution and Unit	Degree and Program	Program Description	Curriculum	Comments	Tuition
Urban & Infrastructure Engineering Karachi, Pakistan	and http://www.neduet.edu.pk/Registrar/prospectus/pg_prospectus.pdf	This program will link the concepts of management with the deriving engineering fields to produce professionals that are better capable of managing the engineering projects than the conventional business managers. Considering the wide scope of the field, this master's program is focused toward the management of transportation systems and their sustainable operation. Current relevant research fields include: – ITS-based Urban Traffic Management Model – Traffic Incident Management system – Transportation Assets Management Model – Integrated Control of Urban Arterial Under Saturated Conditions – Capacity Improvements of Major Urban and Rural Routes – Road Condition Monitoring and Development of Remedial Strategies – Use of Expert Systems in Geometric Design of Highways – Analysis and Design of Urban Road Drainage Systems – Mechanistic and Finite Element Analysis of Major National Highways in Pakistan – Pavement Condition Monitoring and Evaluation of Roads and Airport Airside – Development of Computerized Travel Demand Forecasting Model for Urban Areas – Application of Geographic Information System (GIS) for Facility Management – Accessibility based Analysis of Household Travel			

Institution and Unit	Degree and Program	Program Description	Curriculum	Comments	Tuition
		– Transportation Network Modelling using EMME2			

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Appendix E – Calendar Copy

2012/2013 SGS Calendar entry

Civil Engineering

Faculty Affiliation

Applied Science and Engineering

Degree Programs Offered

Civil Engineering – MASc, MEng, PhD
Cities Engineering and Management - MEngCEM

Collaborative Programs

The following collaborative program is available to students in participating degree programs as listed below:

Environmental Engineering

- Civil Engineering, MASc, MEng, PhD

Overview

The Department of Civil Engineering offers a graduate program in Civil Engineering leading to the **Master of Applied Science (MASc)**, the **Master of Engineering (MEng)**, and the **Doctor of Philosophy (PhD)**. Qualified applicants are accepted for advanced studies in one of the following fields: Building Engineering, Environmental Engineering, Structural Engineering, Transportation Engineering, and Geomechanics. Students registered in MASc or PhD are required to participate in the non-credit seminar course JDE 1000H *Ethics in Research* during their first or second session of registration.

The Department also offers a graduate program in Cities Engineering and Management leading to the Master of Engineering in Cities Engineering and Management (MEngCEM).

Contact and Address

Admission

Web: www.civil.engineering.utoronto.ca
E-mail: graduateadmissions@civ.utoronto.ca
Telephone: (416) 946-8028
Fax: (416) 978-6813

Program

Web: www.civil.engineering.utoronto.ca
Fax: (416) 978-6813

M.Eng

E-mail: shayni@civ.utoronto.ca
Telephone: (416) 978-5905

M.A.Sc/Ph.D

E-mail: colin@civ.utoronto.ca
Telephone: (416) 978-0945

M.Eng.CEM

E-mail: TBA
Telephone: TBA

Department of Civil Engineering
University of Toronto
Galbraith Building
35 St. George Street
Toronto, Ontario M5S 1A4
Canada

Degree Programs

Civil Engineering

Master of Applied Science

Minimum Admission Requirements

- Applicants are admitted under the General Regulations of the School of Graduate Studies.
- Students who do not possess an undergraduate degree in civil engineering may be required to take more than the usual time and number of courses.

Program Requirements

- Each student, in consultation with a staff member at the beginning of the program, will establish the distribution of time between coursework and thesis or design project.
- Normally, a minimum of 2.5 full-course equivalents (FCEs) (five half courses) and a thesis. Some sections may require 3.0 FCEs (six half courses) and a thesis. Consult the supervisor and/or refer to the departmental graduate student handbook for further details.

Normal Program Length: 5 sessions full-time

Time Limit: 3 years full-time

Master of Engineering

Minimum Admission Requirements

- Applicants are admitted under the General Regulations of the School of Graduate Studies.
- Students who do not possess an undergraduate degree in civil engineering may be required to take more than the usual time and number of courses.

Program Requirements

- Each student, in consultation with a staff member at the beginning of the program, will establish the distribution of time between coursework andthesis or design project.
- Normally, 5.0 full-course equivalents (FCEs) (10 half courses) for the coursework-only program. Up to two half-courses may be replaced by a research/design project.
- There is no formal residence requirement for MEng students; therefore, the program may be completed through part-time studies.

Normal Program Length: 3 sessions full-time; 5 sessions part-time

Time Limit: 3 years full-time; 6 years part-time

Doctor of Philosophy

Minimum Admission Requirements

- Students are admitted under the following departmental regulations, in addition to the SGS General Regulations and Degree Regulations for the PhD:
  - Satisfy the department of the ability to undertake advanced research.
  - Admission directly from a bachelor's degree is not normally permitted.
  - If a student transfers from a master's degree program to a PhD program, courses taken during the master's program may be applied to the PhD program.

Program Requirements

- A major and two minor fields of study, normally consisting of a minimum of 4.5 full-course equivalents (FCEs) (nine half courses) in total beyond the bachelor’s degree. More FCEs may be required depending on the student’s background preparation. It is normally expected that at least one of the minor fields will be taken outside of the department.
- PhD students with an MASc degree (or equivalent in the same field) must take a minimum of 2.0 FCEs (four half courses) beyond the MASc degree.

- Students enrolled in the MASc degree program who transfer to the PhD program without submitting an MASc thesis must complete a total of 4.5 FCEs (nine half courses) beyond the bachelor's degree program.
- Students with an MEng degree may use up to 3.0 FCEs (six graduate half courses) from the MEng program towards the PhD course requirements.
- Comprehensive examination after completing most of the coursework and preferably within one year after first enrolment in the PhD program. This examination consists of a four- to five-day take-home written examination, followed approximately a week later by an oral examination. The examination is administered by a Comprehensive Examination Committee created and supervised by the department's Examination and Degree Committee.

Students normally must spend at least two academic years of their program on campus on a full-time basis.

The academic program must be approved by the department's Examination and Degree Committee during the student's first session.

Students must have a supervisory committee by the end of the second year of the program. This committee must include the supervisor and at least two graduate faculty members.

Normal Program Length: 4 years full-time; 5 years direct-entry

Time Limit: 6 years full-time; 7 years direct-entry

Course List

Not all courses are given every year. Some courses may require a prerequisite. Please consult the department.

General Interest

CIV 1001H M.Eng. Project I
CIV 1002Y M.Eng. Project II
CIV 1099H Special Studies in Civil Engineering
CIV 1307H Life Cycle Assessment of Engineering Activities
CIV 1310H Infrastructure Economics
CIV 1311H Advanced and Sustainable Drinking Water Treatment
CIV 1337H Simulation in Civil Engineering
CIV 1422H Dynamic Response of Engineering Materials
CIV 1429H Advanced Rock Engineering: Rock Engineering in Fractured Rock Masses
CIV 1504H Applied Probability and Statistics for Civil Engineering
CIV 1539H Evaluation of Civil Engineering Systems
CIV 1600H Readings in Technology and Modern Society I
CIV 1601H Readings in Technology and Modern Society II

Building Engineering

CIV 514H Concrete Technology
CIV 575H Building Science
CIV 1201H Concrete Technology and Non-Destructive Testing Principles
CIV 1250H Instrumentation Techniques in Concrete Technology
CIV 1252H Repair and Maintenance of Concrete Structures
CIV 1277H Construction Estimating and Finance
CIV 1278H Pre-Project Planning and Constructability Analysis
CIV 1279H Construction Contract Documents
CIV 1280H Building Envelope Design
CIV 1281H Asset Management
CIV 1282H Case Studies in Building Science
CIV 1283H Civil Informatics
CIV 1299H Special Studies in Civil Engineering

Environmental Engineering

CIV 540H Treatment Processes
CIV 549H Groundwater Flow and Contamination
CIV 550H Water Resources Engineering
CIV 1303H Water Resources Systems Modelling
CIV 1305H Water Resources Systems Analysis
CIV 1308H Physical and Chemical Treatment Processes
CIV 1309H Biological Treatment Processes

CIV 1319H Chemistry and Analysis of Water and Wastes
CIV 1335H Advanced Hydrogeology
CIV 1399H Special Studies in Civil Engineering

Geomechanics

CIV 523H Geotechnical Design
CIV 529H Rock Engineering
CIV 1404H Material Fracture Dynamics: Experimental Methods
CIV1410H Satellite Positioning and Remote Sensing
CIV 1419H Rock Dynamics
CIV 1420H Soil Properties and Behaviour
CIV 1421H Continuum Mechanics of Fluids and Solids
CIV 1446H Slopes and Earthworks
CIV 1499H Special Studies in Civil Engineering

Structural Engineering

CIV 510H Solid Mechanics II
CIV 513H Collaborative Engineering and Architectural Design Studio
CIV 517H Prestressed Concrete Structures
CIV 518H Behaviour and Design of Steel Structures
CIV 519H Structural Analysis II
CIV 1163H Mechanics of Reinforced Concrete
CIV 1164H Bridge Engineering
CIV 1169H Advanced Topics in Building Design
CIV 1167H Advanced Structural Dynamics
CIV 1171H Earthquake Engineering and Seismic Design
CIV 1174H Finite Element Methods in Structural Mechanics
CIV 1175H Design of Tubular Steel Structures
CIV 1180H Advanced Modeling Methods for Seismic Performance Assessment of Structures
CIV 1185H Seismic Design with Supplemental Damping and Isolation Systems
CIV 1199H Special Studies in Civil Engineering
CIV 1361H Reinforced and Prestressed Concrete Structures

Transportation Engineering and Planning

CIV 531H Transport III—Planning
CIV 533H Transport Operations
CIV 1505H Transportation Research Seminar
CIV 1506H Freight Transportation and ITS Applications
CIV 1507H Public Transport
CIV 1508H Airport Planning and Engineering
CIV 1520H Travel Survey Methods
CIV 1535H Transportation and Development
CIV 1532H Fundamentals of ITS and Traffic Management
CIV 1538H Transportation Demand Analysis
CIV 1540H Urban Transportation Networks
CIV 1599H Special Studies in Civil Engineering

Cities Engineering and Management

Master of Engineering in Cities Engineering and Management

Minimum Admission Requirements

- Applicants are admitted under the General Regulations of the School of Graduate Studies.
- Students with backgrounds in an applied science other than engineering may be admitted.
- Students are required to have one year of work experience before admission to the program

Program Requirements

- The MEngCEM program can be completed through full-time studies over two years or through an extended full-time option over three years.

- The program requires completion of 6.0 full-course equivalents (FCEs), composed of 10 half courses (5.0 FCE's) and a 1.0 FCE Practicum typically completed during the summer of the first academic year (full-time) or summer of the second year (extended full-time option)
- The program consists of three required themes (see course list below):
    - Theme A Infrastructure Engineering: minimum of four half-courses chosen from Theme A course list (2.0. FCE); each student's course selection requires approval by the Program Director prior to enrolment
    - Theme B Cities as Complex Systems: four required half-courses (2.0 FCE)
    - Theme C Practicum: includes presentation and technical report (1.0 FCE)
- Two half course electives (1.0 FCE) chosen from either Theme A or B list of courses or from the list of Technology Management courses below.

Normal Program Length: 4 sessions full-time; 9 sessions extended full-time option
Time Limit: 3 years

COURSE LIST

Cities Engineering and Management

Courses must be approved by the Program Director.

Theme A

Eligible courses include graduate courses with course prefixes as follows: AER, BME, CHE, CIV, ECE, MIE, and MSE, including courses at the 500 level.

Theme B

Required Courses:

CIV XXXXH An Empirical Study of Cities (Core)

CIV XXXXH Infrastructure and Urban Prosperity (Core)

CIV XXXXH The Challenges of Urban Policy-Making (Core)

CIV XXXXH Cities as Complex Systems (Core)

Electives:

CIV XXXXH Economics and Infrastructure

CIV XXXXH Integrative Decision Making

Theme C

CIV XXXXY Cities Engineering and Management Practicum (required)

Technology Management Course Electives (list of courses is subject to change)

APS 1001: Project Management
APS 1005: Operations Research for Engineering Management
APS 1010: Cognitive and Psychological Foundations of Effective Leadership
APS 1012: Management of Innovation in Engineering
APS 1015: Social Entrepreneurship
APS 1016: Financial Management for Engineers
APS 1017: Supply Chain Management and Logistics
APS 1088: Entrepreneurship and Business for Engineers
APS 1201: Topics in Engineering and Public Policy
APS 1202: Engineering and Sustainable Development
CHE1435: Six Sigma for Chemical Processes
CIV1307: Life Cycle Assessment and Sustainability of Engineering Activities

UNIVERSITY OF TORONTO

New Master of Engineering in Cities Engineering and Management Program Proposal
Civil Engineering

Appraisal Report
July 29, 2012

From roads and housing to policing and green innovation, municipalities contribute greatly to the quality of life in Canada and abroad. (Federation of Canadian Municipalities, http://www.fcm.ca)

Engineers have traditionally relied upon historical data to design long-lasting, safe and reliable municipal infrastructure, but now they must develop new design and operational practices to withstand new weather conditions - both extremes and gradual changes. They must accommodate increased uncertainties because the data about future climate will never be as precise as the historical data. (Public Infrastructure Engineering Vulnerability Committee, http://pievc.ca)

The three reviewers, Dr. Amr Elnashai (University of Illinois at Urbana-Champaign), Dr. Slobodan Simonovic (Western University) and Dr. Reza Vaziri (The University of British Columbia) visited University of Toronto campus for the review on July 24, 2012. They initially met Prof. Cristina Amon (Dean, Faculty of Applied Science and Engineering), Prof. Brenda McCabe (Chair, Department of Civil Engineering), Prof. Eric Miller (MEngCEM Program Director), and Prof. Shamim Sheikh (Associate Chair Academic, Department of Civil Engineering). In the course of the day, they met the faculty that will be offering courses under: (a) Theme A – Infrastructure Engineering (Profs. Andrews, Chan, Hatzinakos, Leon-Gracia, and Sinton), (b) Theme B – Cities as Complex Systems (Profs. Kennedy, Karney, McCarney, McCoomb, Miller, and Stren), and (c) Practicum (Profs. Cheng, Miller and Mr. Pereira). During the remaining time they met Prof. Gertler (Dean of Arts & Science), and representatives of the University Governance: Dr. Corman (Vice-Provost, Graduate Education, and Dr. Regehr (Vice-Provost, Academic Programs).

As outlined below, the reviewers conclude that the MEngCEM degree is a timely and well conceived proposal, a natural complement to existing City-related programs at the University of Toronto. The proposed program demonstrates a visionary leadership with a clear opportunity to fill in the needs of Canadian and international municipalities. ***The reviewers are offering a strong support to the establishment of the Master of Engineering in Cities Engineering and Management program at the University of Toronto.***

Comments and suggestions of the review panel are provided below for possible consideration.

Program evaluation

1. Objectives

a) Consistency of the program with the institution's mission and unit's academic plans.

The proposed program is well aligned with the academic plan of the Faculty and will help with accomplishing several of its goals including: heightening excellence in student experience; enhancing its global reputation and visibility; increasing internal and external collaboration; and developing a culture of outreach and influence. Moreover the proposed program meets the professional training needs in the area of municipal infrastructure engineering and management. The major strength of the proposed program is in its interdisciplinary content and explicit implementation of the systems view of municipal infrastructure engineering and management. There are very few, if any, professional programs at Canadian universities that integrate engineering rigour and technical depth with the much needed understanding and appreciation of the social and natural sciences necessary for decision making in building, maintaining, and managing urban communities. The proposed program is unique in Canada and its introduction enhances the current reputation that University of Toronto enjoys as one of the leading academic institutions in the world.

b) Clarity and appropriateness of the program's requirements and associated learning outcomes in addressing the academic division's graduate Degree Level Expectations.

The proposed program is clear and contains the components necessary to satisfy degree level expectations. Courses under Theme A provide for technical depth and courses under Theme B provide for breadth of knowledge necessary for building, maintaining, and managing urban systems. All the proposed courses provide the knowledge of methodologies that will enable a working comprehension of established techniques, critical thinking, and interdisciplinary treatment of municipal building, maintenance and management issues. The proposed practicum will provide competence in the application of knowledge to the critical analysis of advanced municipal problems and issues. Most of the proposed courses will be delivered by Professional Engineers that will assist in building professional capacity of the program participants. Delivery format for the Themes A and B courses and practicum requirements will increase the level of communications skills required from the professional engineers working in Cities Engineering and Management.

Comment 1: The proposed program requires continuous adjustments in order to maintain and increase its consistency with the degree level expectations.

c) Appropriateness of the degree or diploma nomenclature.

The professional master's degree (M.Eng.) is an appropriate degree type for this program and the nomenclature, MEngCEM, distinguishes it from other discipline specific MEng programs and helps make the program distinctive and marketable.

2. Admission requirements

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

The program's admission requirements are consistent with other existing MEng programs at the University of Toronto which require a minimum GPA of mid-B level in engineering or a related applied science bachelor's degree from a recognized university. In addition, given the prerequisite maturity and real world experience that is expected from the students entering this program it is quite appropriate to require at least one year of work experience from applicants. The prior knowledge and experience gained from practical experience provides the students with a better appreciation of the complexities and challenges facing large urban communities and enriches class discussions. It is expected that at least 50% of the program participants will come from the pool of candidates currently expressing interest in MEng programs at the University of Toronto.

b) Appropriateness of any alternative requirements for admission into the program such as minimum grade point average or additional languages or portfolios, along with how the program recognizes prior work or learning experience.

The proposed program will be attractive to applicants with social or natural science backgrounds without an engineering degree. From the review of Theme A courses (discipline specific) it is clear that the pre-requisites for many of the courses in this category involve at least basic mathematics and statistics.

Recommendation 1: It is our recommendation that the pre-requisite knowledge for basic discipline-specific courses be provided to the potential students in various forms (for example, as on line courses or similar).

Granting a Master of Engineering degree to those who do not have a basic engineering (or at least science) undergraduate degree will result in dissimilarities between the program graduates with and without an undergraduate engineering degree.

Comment 2: The program proponent should assess the possibility of a dual degree: (i) MEngCEM for the candidates with an engineering undergraduate degree, and (ii) Master's of CEM for the graduates without an engineering undergraduate degree.

3. Structure

a) Appropriateness of the program's structure and regulations to meet specified program learning outcomes and Degree Level Expectations.

The proposed program is very well structured to meet the specified learning outcomes. There is a challenge in that there are elements that are missing in the curriculum (further elaborated below). Adding these critical elements will have to coincide with removing other elements.

Comment 3: The structure of the proposed program should be reviewed to (a) include some of the missing topics (risk management and water infrastructure, in particular); (b) insure that all Theme A courses include relevant links to city engineering and management; and (c) provide better cohesiveness between Theme A and B courses.

Comment 4: The Program Director should play an active role in assisting program candidates in choosing a cluster of courses designed to provide a certain depth/breadth in a range of subject matters that fit together with the students background education, rather than giving them the option of taking any 4 courses from a list 20 or so courses on wide ranging topics.

Recommendation 2: If the proposed program is revised according to the comments and recommendations from this review we are recommending that the revised structure should be reviewed by the faculty members involved in the proposed program.

b) Rationale for program length in order to ensure that the program requirements can be reasonably completed within the proposed time period.

There are many course-based or taught Master's programs around the world that are of a calendar year duration, and others that are designed for a 16 month timeline. Taking into account the broad nature of this MEngCEM program, and the need to insure sufficient depth combined with the practical experience gained through the 4-month practicum module, the proposed program duration of 16 months is appropriate.

4. Program content

a) Ways in which the curriculum address the current state of the discipline or area of study.

The topics that exist already, mainly Theme A topics, are rigorous and modern. The reviewers have noticed only two main deficiencies: (i) missing course(s) on risk management; and (ii) missing course(s)

on water infrastructure. There is an underlying challenge with all Theme A courses and that is how to make them more relevant to the Cities flavor of the new MEngCEM program. Theme B courses are all new and the discussion with their instructors confirms that they will be of an international caliber.

Comment 5: The Program Director should take on the challenge of leading such a distinguished group of program instructors and develop a coherent set of courses that are linked to one another.

b) Identification of any identified unique curriculum or program innovations or creative components and their appropriateness.

There are some nearly unique features of the program ('nearly' is used because there are current and ongoing developments in academe to increase the integration of engineering education and to use system-level project-based learning as the primary environment in undergraduate and graduate degrees (for a rather unique example, refer to Franklin Olin College in Boston, USA). The integration of a rigorous program of fundamentals, enabling technologies and the practicum is a very powerful framework for the new MEngCEM program. It is not just utterly appropriate, it is necessary for such an interdisciplinary subject.

c) For research-focused graduate programs: Clarity of the nature and suitability of the major research requirements for degree completion.

This is not a research-focused program.

d) Evidence that each graduate student in the program is required to take all of the course requirements from among graduate level courses.

We did not verify this aspect of the program. It seems that there are only a few courses listed in Theme A that are not graduate courses (i.e. not 1000 level).

5. Mode of delivery

a) Appropriateness of the proposed mode(s) of delivery (distance learning, compressed part-time, online, mixed-mode or non-standard forms of delivery, flex-time options) to meet the intended program learning outcomes and Degree Level Expectations.

The program courses are proposed to be delivered in two different formats: (i) full term format (Theme A) and (ii) intense module format (Theme B).

Comment 6: Taking courses presented in two different formats at the same time may result in students focusing all of their attention on the intense module courses and not devoting the necessary time to the full term Theme A courses that they will be taking concurrently.

Comment 7: Extended full-time option designed for employees may conflict with the requirement to spend almost 8 weeks solid to do two Theme B courses in a given term (B1 & B2 in the Fall of Year 1 and B3 & B4 in the winter of Year 2).

There is an opportunity, especially with the University of Toronto joining Coursera, to perhaps redeploy the courses in an inverted format through a MOOCs model. This, however, can be undertaken at a later stage when the program is launched and fully established.

6. Assessment of teaching and learning

a) Appropriateness of the proposed methods for the assessment of student achievement of the intended program learning outcomes and Degree Level Expectations.

The assessment of the Practicum reports (Theme C) provided to us follows a well structured and appropriate set of rubrics. Theme A courses are largely assessed through conventional exams, homework assignments and projects while the assessment of Theme B courses are based on course papers where the students are provided with the opportunity to explore a given topic in-depth. The assessment of the latter will benefit from an appropriately customized rubric guide which may resemble those used to assess the practicum reports.

b) Completeness of plans for documenting and demonstrating the level of performance of students, consistent with the academic division's statement of its Degree Level Expectations.

We did not investigate this aspect of the new program.

7. Resources

a) 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 resources of the departments in the Faculty involved with the delivery of the proposed program are not just adequate, they are superior. With the addition of the committed new building for engineering and the planned faculty hiring in the Faculty of Applied Science and Engineering including three new faculty positions in Civil Engineering alone, the unit is poised to have more than adequate resources to successfully deliver a high caliber program.

b) Participation of a sufficient number and quality of faculty who are competent to teach and/or supervise in the program.

The faculty members involved are adequate in number and of world-class quality.

c) Adequacy of resources to sustain the quality of scholarship and research activities of graduate students, including library support, information technology support, and laboratory access.

All available resources are of high quality, comparable to top international academic institutions.

d) Faculty have recent the research or professional/clinical expertise needed to sustain the program, promote innovation and foster an appropriate intellectual climate.

Most of the faculty, or all of them, are involved in high quality research on topics close or identical to the subjects that they are intended to share with the students of the new MEngCEM program.

e) Where appropriate to the program, financial assistance for students will be sufficient to ensure adequate quality and numbers of students.

We have not assessed this issue, but know that the existing framework of Government support is adequate for this program as it is for existing ones. While students in professional engineering master's programs are not funded it is anticipated that some students may be sponsored by their employer.

8. Quality and other indicators

a) Quality of the faculty (e.g., qualifications, research, innovation and scholarly record; appropriateness of collective faculty expertise to contribute substantively to the proposed program).

b) Program structure and faculty research that will ensure the intellectual quality of the student experience.

Both of these questions are answered above. To reiterate, the quality of the faculty is very high (the review team was provided with the detailed CVs of all Faculty of Applied Science and Engineering faculty involved in this program, and they are all found to possess high academic standards), the

resources for the delivery of the proposed program are sufficient and of high quality, and they will together ensure a high level of the scientific and practical student experience.

UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE & ENGINEERING

August 9, 2012

Cheryl Regehr
Vice-Provost, Academic Programs
University of Toronto
27 King's College Circle, Room 224
Toronto, ON M5S 1A1

Dear Cheryl

The proposed Master of Engineering in Cities Engineering and Management program, to be offered through the Department of Civil Engineering, underwent an external appraisal visit on July 24, 2012 under UTQAP. This appraisal has allowed us to critically reflect on the proposed program's strengths and opportunities.

As you will see in the report that:

> "the appraisers conclude that the MEngCEM degree is a timely and well conceived proposal, a natural complement to existing City-related programs at the University of Toronto. The proposed program demonstrates a visionary leadership with a clear opportunity to fill in the needs of Canadian and international municipalities. ***The appraisers are offering a strong support to the establishment of the Master of Engineering in Cities Engineering and Management program at the University of Toronto.***"

I write in response to the appraisers' comments and recommendations outlined in five areas and clarify one point in the report.

1. ***Program Objectives - Clarity and appropriateness of the program's requirements and associated learning outcomes in addressing the academic division's graduate Degree Level Expectations***
   - *Comment1 - The appraisers note that "the proposed program requires continuous adjustments in order to maintain and increase its consistency with the degree level expectations."*

Administrative response:
We are pleased to note that the appraisers state:

> "The proposed program is very well structured to meet the specified learning outcomes."

We agree, as per normal practice, the program will be periodically reviewed and adjusted to incorporate feedback, learn from experiences, and ensure consistency with degree level expectations.

2. ***Admission requirements - Appropriateness of any alternative requirements for admission into the program such as minimum grade point average or***

additional languages or portfolios, along with how the program recognizes prior work or learning experience

- *Recommendation 1: The appraisers recommend that "the pre-requisite knowledge for basic discipline-specific courses be provided to the potential students in various forms (for example, as on line courses or similar)."*
- *Comment 2: The appraisers suggest that "the program proponent should assess the possibility of a dual degree: (i) MEngCEM for the candidates with an engineering undergraduate degree, and (ii) Master of CEM for the graduates without an engineering undergraduate degree."*

Administrative response:
As stated in the proposal:

> "To be considered for admission into this professional master's degree, applicants must have a bachelor's degree with grades equivalent to a mid-B or better from a recognized university in engineering or a related applied science. Examples of related applied science fields include, but are not limited to, applied chemistry, environmental science and technology, nuclear science, forestry, urban planning, and computer science. This is consistent with existing M.Eng. program where students from related programs (who do not have a B.A.Sc. degree) are routinely accepted and encounter no difficulty completing the graduate program requirements."

Starting a second CEM degree for non-applied science backgrounds is under consideration by other groups within the University.

3. Structure - Appropriateness of the program's structure and regulations to meet specified program learning outcomes and Degree Level Expectations

- *Comment 3: The appraisers commented that "the structure of the proposed program should be reviewed to (a) include some of the missing topics (risk management and water infrastructure, in particular); (b) insure that all Theme A courses include relevant links to city engineering and management; and (c) provide better cohesiveness between Theme A and B courses."*
- *Comment 4: The appraisers commented that "the Program Director should play an active role in assisting program candidates in choosing a cluster of courses designed to provide a certain depth/breadth in a range of subject matters that fit together with the students background education, rather than giving them the option of taking any 4 courses from a list 20 or so courses on wide ranging topics."*
- *Recommendation 2: The appraisers recommended that "if the proposed program is revised according to the comments and recommendations from this appraisal they are recommending that the revised structure should be reviewed by the faculty members involved in the proposed program."*

Administrative response:
Many graduate level infrastructure courses currently exist. They were not all highlighted in the proposal but are available to students as Theme A options. We have added four water courses to the table in section 2.4.1 of the proposal to highlight a water theme.

The Director will ensure that program candidates receive assistance in selecting courses that fit together in a coherent manner. With respect to Recommendation 2, the appraisers are emphasizing the best practice of good communication amongst participants in a program with which we agree.

4. ***Program Content - Ways in which the curriculum address the current state of the discipline or area of study; evidence that each graduate student in the program is required to take all of the course requirements from among graduate level courses.***
    - *Appraisers state that "it seems that there are only a few courses listed in Theme A that are not graduate courses (i.e. not 1000 level)."*

Administrative response:
As stated in the proposal:

> "Whereas the Province's Quality Assurance Framework requires that students complete a minimum of 2/3 courses at the graduate level, the University of Toronto requires graduate students to complete all of their course requirements from amongst graduate level courses. This proposed program complies with this requirement."

5. ***Mode of delivery - Appropriateness of the proposed mode(s) of delivery (distance learning, compressed part-time, online, mixed-mode or non-standard forms of delivery, flex-time options) to meet the intended program learning outcomes and Degree Level Expectations***
    - *Comment 6: The appraisers commented that "taking courses presented in two different formats at the same time may result in students focusing all of their attention on the intense module courses and not devoting the necessary time to the full term Theme A courses that they will be taking concurrently."*

Administrative response:
The Department and the Director will closely monitor the program delivery mode; however, this format has been successful in our and other institutions including MIT.

Thank you for your participation in the appraisal visit. We look forward to implementing this new program in the Department of Civil Engineering.

Sincerely

Cristina Amon

cc: Professor Brenda McCabe
Chair, Department of Civil Engineering

Jane Harrison
Director, Planning and Policy, Office of the Vice-President & Provost

UNIVERSITY OF TORONTO

OFFICE OF THE VICE-PROVOST,
ACADEMIC PROGRAMS

August 10, 2012

Cristina Amon
Dean
Faculty of Applied Science and Engineering

Re: Appraisal Report, Proposed new Master of Engineering in Cities Engineering and Management (M.Eng.C.E.M.)

Dear Cristina,

Thank you for forwarding external appraisal report of the proposed Master of Engineering in Cities Engineering and Management. I note that the report explicitly states "***The reviewers are offering strong support to the establishment of the Master of Engineering in Cities Engineering and Management program at the University of Toronto.***" The reviewers further described this program as unique and commented repeatedly on the strong reputation of the faculty supporting it. Your administrative response to the appraisal nicely summarizes the report and highlights the specific suggestions made by the reviewers for consideration. I note that you have added four additional courses to the Theme A courses focusing on water infrastructure in response to the suggestion by the reviewers.

I will be very pleased to recommend this new professional Master's program to governance for approval, following approval at the Divisional level.

Sincerely,

Cheryl Regehr
Vice-Provost, Academic Programs

cc. Brenda McCabe, Jane Harrison, Christina da Rocha-Feeley

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