MASTER OF APPLIED SCIENCE CIVIL ENGINEERING AND CONCENTRATION SUSTAINABLE AND RESILIENT INFRASTRUCTURE

Overview

Civil engineering infrastructure is the backbone upon which society is built. Civil engineers design the infrastructure that forms urban centers, including buildings, bridges, roads and other transportation networks, hydraulic infrastructure such as canals and pipe networks, water and wastewater treatment plants, and waste management facilities. Civil engineers are responsible for ensuring that this infrastructure is resilient to natural and anthropogenic hazards, including floods, earthquakes, and terrorist attacks. Given recent climate change and geopolitics, the risk imposed by such hazards is increasing, resulting in the need for stronger infrastructure with greater capacity. At the same time, construction, operation, and maintenance of this infrastructure consumes vast quantities of natural resources and energy, and industrial expansion of urbanity across the planet has degraded the biosphere and changed the atmosphere. The sustainability of society depends on innovative infrastructure design solutions that minimize resource and energy use. More resilient infrastructure may have longer design life, which improves sustainability, but may also consume more resources. Design of resilient yet sustainable infrastructure is an existential challenge for civil engineers.

There is a need and demand for highly trained civil engineering personnel with the capability of considering both sustainability and resiliency when designing infrastructure. However, conventional civil engineering training fails to consider both sustainability and resiliency simultaneously. This Concentration in Sustainable and Resilient Infrastructure addresses that need.

Summary

- Degree offered: Master of Applied Science (MASc)
- Registration status options: Full-time; Part-time
- Language of instruction: English
- Program option (expected duration of the program):
  - within two years of full-time study
- Academic units: Faculty of Engineering (https://engineering.uottawa.ca/), Department of Civil Engineering (https://engineering.uottawa.ca/civil-dept/), Ottawa-Carleton Institute of Civil Engineering (http://www.ocice.ca/)

Program Description

This program satisfies the requirements of the general Masters of Applied Science Civil Engineering Program, but provides a concentration in Sustainable and Resilient Infrastructure by taking a minimum of 12 units of courses in the area. It is critical that civil engineers understand how to safely and responsibly develop and maintain infrastructure that is sustainable and resilient.

Main Areas of Research

- Construction engineering and management
- Environmental engineering
- Geotechnical engineering
- Structural engineering
- Sustainable Materials and Construction
- Water resources engineering

Other Programs Offered Within the Same Discipline or in a Related Area

- Master of Applied Science Civil Engineering (MASc)
- Master of Applied Science Civil Engineering Specialization in Science, Society and Policy (MASc)
- Master of Applied Science in Environmental Engineering (MASc)
- Master of Applied Science in Environmental Engineering Specialization in Environmental Sustainability (MASc)
- Master of Engineering Civil Engineering (MEng)
- Master of Engineering Environmental Engineering (MEng)
- Doctorate in Philosophy Civil Engineering (PhD)
- Doctorate in Philosophy Environmental Engineering (PhD)

Fees and Funding

- Program fees:
- The estimated amount of university fees (https://www.uottawa.ca/university-fees/) associated with this program are available under the section Finance your Studies (https://www.uottawa.ca/graduate-studies/programs-admission/finance-studies/).
- International students enrolled in a French-language program of study may be eligible for a different tuition fee exemption (https://www.uottawa.ca/university-fees/differential-tuition-fee-exemption/).
- To learn about possibilities for financing your graduate studies, consult the Awards and financial support (https://www.uottawa.ca/graduate-studies/students/awards/) section.

Notes

- Research activities can be conducted either in English, French or both, depending on the language used by the professor and the members of his or her research group.
- Programs are governed by the academic regulations (https://www.uottawa.ca/about-us/leadership-governance/policies-regulations/) in effect for graduate studies at the University of Ottawa.
- In accordance with the University of Ottawa regulation, students have the right to complete their assignments, examinations, research papers, and theses in French or in English.

Program Contact Information

Graduate Studies Office, Faculty of Engineering (https://engineering.uottawa.ca/graduate-studies-office/)
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Ottawa ON Canada
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Twitter | Faculty of Engineering (https://twitter.com/uOttawaGenie/?lang=en)
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Admissions Requirements

For the most accurate and up to date information on application deadlines, language tests and other admission requirements, please visit the specific requirements (https://www.uottawa.ca/graduate-studies/programs-admission/apply/specific-requirements/) webpage.

To be eligible, candidates must:

- Have a bachelor's degree with a specialization or a major (or equivalent) in civil engineering (or equivalent) with a minimum admission average of 75% (B+).

  Note: International candidates must check the admission equivalencies (https://www.uottawa.ca/graduate-studies/international/study-uottawa/admission-equivalencies/) for the diploma they received in their country of origin.

- Demonstrate a good academic performance in previous studies as shown by official transcripts, research reports, abstracts or any other documents demonstrating research skills.
- Applicants holding an honours bachelor's (or major) degree in an engineering discipline other than civil engineering or in science may be considered for admission to a qualifying program with the following conditions:
  - Graduates from honours engineering or science programs with a mathematics content equivalent to that of the civil engineering undergraduate program will have to take a minimum of four undergraduate civil engineering courses in their area of graduate specialty.
  - Graduates from other science programs (i.e. those without the mathematical content covered in a civil engineering undergraduate program) will have to take all the core engineering undergraduate mathematics courses in addition to four qualifying undergraduate civil engineering courses in their area of specialty.
- Identify at least one professor who is willing to supervise your research and thesis.
  - We recommend that you contact potential thesis supervisors as soon as possible.
  - To enroll, you need to have been accepted by a thesis supervisor.
  - The supervisor's name is required at the time of application.

The Accelerated Stream has two additional requirements:

- Complete a CVG 4907 Civil Engineering Design Project and up to three (but not less than 2) master's courses in civil engineering each with 70% (B) or higher grade
- Must be completing or have completed an undergraduate degree in Civil Engineering at the University of Ottawa and ideally have already started research relevant to graduate studies during their final year of civil engineering undergraduate study.

Language Requirements

Courses are delivered in English as the international language for advanced technology in engineering. However, the program will provide an appropriately supportive environment for francophone students to develop professional competence in technical English at their own pace. Students have the right, as stipulated in the University's bilingualism regulations (Academic Regulations I-2), to complete all their work, including their thesis, in the official language of their choice (French or English). There are fully bilingual professors and advisors who can support students in French.

Applicants who first language is neither French or English must provide proof of proficiency in the language of instruction.

Note: Candidates are responsible for any fees associated with the language tests.

Notes

- The admission requirements listed above are minimum requirements and do not guarantee admission to the program.
- Admissions are governed by the academic regulations (https://www.uottawa.ca/about-us/leadership-governance/policies-regulations/) in effect for graduate studies.
- Undergraduate civil engineering courses will not be accepted towards a graduate degree. Graduate students may still be required to take undergraduate courses for credit to fulfill the admission requirements.

Program Requirements Master with Thesis

Students must meet the following requirements:

Compulsory Courses:		
CVG 5214	Sustainable and Resilient Infrastructure	3 Units
9 optional course units from the list of optional courses [1]		
3 optional course units in civil engineering (CVG) or environmental engineering (EVG) at the graduate level [1]		
Seminar:		
CVG 5366	Master's Seminar in Civil Engineering	
Thesis:		
THM 7999	Master's Thesis [2]	

Note(s)

1

At least 9 course units from the total 12 optional course units must be approved by the program and must come from at least two following groups: Sustainability, Resiliency, and both Sustainability and Resiliency.

2

Students are responsible for ensuring that have met all of the thesis requirements (http://www.uottawa.ca/graduate-studies/students/theses/). The thesis must be based on original research carried out under the direct supervision of a research faculty member in the Department and must fall within the area of Sustainable and Resilient Infrastructure.

Master's with Thesis, Accelerated Stream

Students must meet the following requirements:

Compulsory Courses:		
CVG 5214	Sustainable and Resilient Infrastructure	3 Units

6 optional course units in civil engineering (CVG) or environmental engineering at the graduate level [1]		6 Units
Seminar:		
CVG 5366	Master's Seminar in Civil Engineering	
Thesis:		
THM 7999	Master's Thesis [2]	

Note(s)

1

If a student completed 9 units of master's courses in civil engineering during their undergraduate degree than only 6 units of optional course units will be required.
Optional course units must be approved by the program and must come from at least two following groups: Sustainability, Resiliency, and both Sustainability and Resiliency.

2

Students are responsible for ensuring that have met all of the thesis requirements (http://www.uottawa.ca/graduate-studies/students/theses/). The thesis must be based on original research carried out under the direct supervision of a research faculty member in the Department and must fall within the area of Sustainable and Resilient Infrastructure.

List of Optional Courses:

Sustainability		
CVG 5150	Advanced Concrete Technology	3 Units
CVG 5181	Decentralized Wastewater Management	3 Units
CVG 5183	Mixing and Transport of Pollutants in Water Bodies	3 Units
CVG 5301	Soil and Water Conservation Engineering	3 Units
EVG 5133	Solid Waste Management	3 Units
EVG 5139	Environmental Assessment of Civil Engineering Projects	3 Units
Resiliency		
CVG 5144	Advanced Reinforced Concrete	3 Units
CVG 5151	Advanced Timber Design	3 Units
CVG 5155	Earthquake Engineering	3 Units
CVG 5188	Loads on Structures	3 Units
CVG 5189	Blast Engineering	3 Units
CVG 5190	Rehabilitation of Concrete Structures	3 Units
Sustainability and Resiliency		
CVG 5182	Water Resources Management	3 Units
CVG 5191	Diagnosis and Prognosis of Concrete Infrastructure	3 Units
CVG 5212	Climate Change Impacts on Water Resources	3 Units
CVG 5216	Climate-Resilient Infrastructures in a Changing Climate	3 Units
CVG 5314	Geotechnical Hazards	3 Units

Minimum Requirements

The passing grade in all courses is B.

A student who has incurred two failures is withdrawn from the program.

Fast-Track from Master's to PhD

Students enrolled in the master's program in civil engineering at the University of Ottawa may be eligible for fast-track directly into the doctoral program without writing a master's thesis. For additional information, please consult the "Admission Requirements" section of the PhD program.

Research

Research at the University of Ottawa

Located in the heart of Canada's capital, a few steps away from Parliament Hill, the University of Ottawa ranks among Canada's top 10 research universities. Our research is founded on excellence, relevance and impact and is conducted in a spirit of equity, diversity and inclusion.

Our research community thrives in four strategic areas:

- Creating a sustainable environment
- Advancing just societies
- Shaping the digital world
- Enabling lifelong health and wellness

From advancing healthcare solutions to tackling global challenges like climate change, the University of Ottawa's researchers are at the forefront of innovation, making significant contributions to society and beyond.

Research at the Faculty of Engineering

Areas of research:

- Chemical and Biological Engineering
- Civil Engineering
- Electrical Engineering and Computer Science
- Mechanical Engineering

For more information, refer to the list of faulty members and their research fields on Uniweb (https://uniweb.uottawa.ca/#!/themes/0/people).

IMPORTANT: Candidates and students looking for professors to supervise their thesis or research project can also consult the website of the faculty or department **(**https://www.uottawa.ca/graduate-studies/students/academic-unit-contact-information/**) of their program of choice. Uniweb does not list all the professors authorized to supervise research projects at the University of Ottawa**

Courses

CVG 5101 Construction Equipment Management (3 units)
The course is designed to provide a thorough understanding of the fundamentals and basis for design and analysis of construction operations. The various types of equipment used in the construction of heavy civil projects is analyzed and evaluated. Methods are developed for selecting, acquiring, maintaining, and replacing equipment. Simulation and optimization techniques are used as well for the optimal selection of equipment.
Course Component: Lecture

CVG 5111 Hydraulic Structures (3 units)
Classification and function of hydraulic structures; analysis and design of hydraulic works for gravity dams, arch dams, earth fill and rock-fill dams; ancillary works including water intakes, various types of spillways, control structures, energy dissipation and stilling basin, bottom outlets. Advanced topic in channel design including transitions; hydraulic transients, free surface and free surge analysis; water towers and compensation basins; penstocks. Navigation locks. Coastal protection works and maritime structures. This course is equivalent to CIVJ 5501 at Carleton University.
Course Component: Lecture

CVG 5112 Numerical modelling in water resources (3 units)
Finite volume methods for advection, diffusion and shallow water equations using structured and unstructured grids, finite volume methods for incompressible Navier-Stokes equations (SIMPLE, SIMPLEC, PISO), error analysis: numerical diffusion and dispersion, truncation errors and Fourier analysis, introduction to turbulence modeling, introduction to methods for tracking free surfaces and moving beds, introduction to other methods in hydrodynamics: finite element, finite difference, Chebyshev and Fourier spectra, semi Lagrangian and vortex methods inhydrodynamics. This course is equivalent to CIVJ 5502 at Carleton University.
Course Component: Lecture

CVG 5124 Coastal Engineering (3 units)
Key concepts in coastal engineering: (1) wave mechanics and coastal hydrodynamics, (2) sediment transport and coastal morphodynamics and (3) coastal structures and coastal zone management. Wave mechanics and coastal hydrodynamics to include small-amplitude wave theory, finite amplitude wave theories (Stokes, Cnoidal and solitary wave), wave generation, wave transformations, development and prediction, hydrodynamics of coastal circulation. Sediment transport and coastal morphodynamics to include: wave and current-induced sediment transport, coastal sediment processes, longshore and cross-shore beach morphologic transformations, etc. Coastal structures and coastal zone management to include: beach erosion control, coastal structures (dikes, breakwaters, groins, seawalls), beach nourishment, coastal pollution and control, nearshore area development. This course is equivalent to CIVJ 5605 at Carleton University.
Course Component: Lecture

CVG 5142 Advanced Structural Dynamics (3 units)
Dynamic behaviour of civil engineering structures under excitations due to earthquakes, wind, waves, etc. Advanced methods in dynamic analysis of structures. Prediction of structural response. Design considerations. This course is equivalent to CIVJ 5201 at Carleton University.
Course Component: Lecture

CVG 5143 Advanced Structural Steel Design (3 units)
Analysis of thin-walled beams; design applications including members under combined forces; analysis and design of beams under non-uniform torsion; limit state design methodology; comparative study of modern structural steel standards; formulating elastic and plastic interaction relations for members under combined forces; designing columns, beams, and beam columns for cross-sectional strengths; local buckling and global stability considerations; design of bracing systems. This course is equivalent to CIVJ 5202 at Carleton University.
Course Component: Lecture

CVG 5144 Advanced Reinforced Concrete (3 units)
Study of the elastic and inelastic response of reinforced concrete structures under monotonic and cyclic loading. Methods for predicting structural behaviour of concrete elements. The relationship between recent research results and building codes. This course is equivalent to CIVJ 5300 at Carleton University.
Course Component: Lecture

CVG 5145 Theory of Elasticity (3 units)
Stress-strain relations. Theories of plane stress and plane strain. Use of stress functions, energy and variational methods in the analysis of elastostatic problems. This course is equivalent to CIVJ 5203 at Carleton University.
Course Component: Lecture

CVG 5146 Numerical Methods of Structural Analysis (3 units)
Numerical procedures and methods of successive approximations for the solution of structural problems. Virtual work, principles of minimum potential and complementary energy. Applications of variation and finite difference techniques to the solutions of complicated problems in beams, plates and shells. This course is equivalent to CIVJ 5302 at Carleton University.
Course Component: Lecture

CVG 5147 Theory of Plates and Shells (3 units)
Stress distribution in flat plates of various shapes. Large deflection theory, numerical methods. Membrane theory, bending theory for cylindrical shells, bending theory for shells of revolution. This course is equivalent to CIVJ 5204 at Carleton University.
Course Component: Lecture

CVG 5148 Prestressed Concrete Design (3 units)
Materials, methods of prestressing, prestress losses, and anchorage zone stresses. Elastic analysis, design and behaviour of simple and continuous prestressed concrete beams, frames and slabs. Discussion of current design specifications. Ultimate strength of members. This course is equivalent to CIVJ 5305 at Carleton University.
Course Component: Lecture

CVG 5149 Structural Stability (3 units)
Elastic, inelastic, and torsional buckling of columns, beam column behaviour, plane and space frame stability, lateral torsional buckling of beams, global buckling of truss systems, plate and shell buckling, local buckling in tubulars, use of energy methods, matrix analysis, and finite element analysis in modeling stability problems, bracing requirements, standard provisions and design considerations in structural stability. This course is equivalent to CIVJ 5304 at Carleton University.
Course Component: Lecture

CVG 5150 Advanced Concrete Technology (3 units)
Cement: types, hydration, physical properties; aggregate: classification, grading, properties; fresh concrete: influence of basis constituents and admixtures on workability, mixing, placing; strength of hardened concrete; nature of strength, influence of constituents, curing methods; durability; chemical attack, frost action, thermal effects; elasticity, shrinkage and creep; special concrete; lightweight, high density; mix design; approaches, weigh batching, volume proportioning, special mixes; field and laboratory test methods. This course is equivalent to CIVJ 5206 at Carleton University.
Course Component: Lecture

CVG 5151 Advanced Timber Design (3 units)
Characteristic values for timber and engineered wood products , modification factors used in design; design of members subjected to combined bending axial loading; design for bi-axial bending; design of curved glued laminated beams, Timber-Concrete Composite (TCC) floor systems; lateral design (wind and seismic loading) for light-frame, CLT and hybrid structures; advanced connection design including design of proprietary connections. This course is equivalent to CIVJ 5151 at Carleton University.
Course Component: Lecture

CVG 5153 Wind Engineering (3 units)
The structure and climate of wind; wind loading on structures; wind induced dynamic problems of structures; environmental aerodynamics; dispersion of pollutant; analysis of wind data; experimental investigations. This course is equivalent to CIVJ 5209 at Carleton University.
Course Component: Lecture

CVG 5154 Random Vibration (3 units)
Descriptions of random data. Frequency domain analysis and time domain analysis. Stochastic response of structures; wind and earthquake excitation, etc. Data analysis techniques. Prediction for design purposes. Simulation of random processes. Special topics. This course is equivalent to CIVJ 5308 at Carleton University.
Course Component: Lecture

CVG 5155 Earthquake Engineering (3 units)
Nature and characteristics of earthquake motions. Non-linear response of single and multi-degree-of-freedom structures to seismic excitations. Modal superposition technique. Simplified procedures for dynamic structural analysis. Principles of earthquake resistant design. Strength, stiffness, ductility and energy absorption requirements of structures for seismic forces. Response spectra analysis. Current design procedures for aseismic design. Recent research on earthquake engineering. This course is equivalent to CIVJ 5306 at Carleton University.
Course Component: Lecture

CVG 5156 Finite Element Methods I (3 units)
Review of basic matrix methods. Structural idealizations. The displacement versus the force method. Stiffness properties of structural elements. Finite elements in beam bending, plane stress and plate bending. This course is equivalent to CIVJ 5301 at Carleton University.
Course Component: Lecture

CVG 5157 Finite Element Methods II (3 units)
Application of finite elements to folded plates, shells and continua. Convergence criteria and order of accuracy. Inertial and initial stress properties. Dynamic and buckling problems. Non-linear deflections and plasticity. This course is equivalent to CIVJ 5303 at Carleton University.
Course Component: Lecture

CVG 5158 Elements of Bridge Engineering (3 units)
Introduction; limit state design; highway bridge design loads; analysis and design of concrete decks; impact and dynamics; load capacity rating of existing bridges and construction in cold climate. This course is equivalent to CIVJ 5307 at Carleton University.
Course Component: Lecture

CVG 5159 Long Span Structures (3 units)
Mechanics of cables. Suspension bridges and cable-stayed bridges. Space structures. Design and construction of long span structures. Dynamics of long span bridges. Case studies. Future of long span structures. This course is equivalent to CIVJ 5309 at Carleton University.
Course Component: Lecture

CVG 5160 Sediment Transport (3 units)
An introduction to particle transport, with special emphasis on river engineering applications, including natural channel design. Sediment properties, initiation of motion, bed load, suspended load, fluvial dunes, alluvial channels, bank erosion and protection, natural channel design. Special topics include contaminated sediments, local scour, morphodynamic modelling, fluvial habitat. This course is equivalent to CIVJ 5503 at Carleton University.
Course Component: Lecture

CVG 5161 Mechanics of Unsaturated Soils (3 units)
Introduction to unsaturated soils, phases of an unsaturated soil, phase properties and relations, stress state variables for saturated and unsaturated soils. Measurement of soil suction: theory of soil suction, capillarity, measurements of total suction and matric suction. Flow Laws: flow of water and measurement of permeability, shear strength theory: history, failure envelope for unsaturated soils, triaxial and direct shear tests, typical results, simple testing procedures, volume change behavior including expansive soils behavior. Soil-water characteristic curve: its behavior and use in predicting the engineering properties of unsaturated soils, practical applications of the principles of unsaturated soils. This course is equivalent to CIVJ 5106 at Carleton University.
Course Component: Lecture

CVG 5162 River Hydraulics (3 units)
Advanced concepts of river hydraulics, with an emphasis on field measurement techniques and application of numerical models. Navier-Stokes equations, turbulence, flow resistance, numerical modelling of simplified momentum and continuity equations, field-based measurement and statistical analysis of velocity fields. Special topics include contaminant transport, morphodynamic modelling. This course is equivalent to CIVJ 5504 at Carleton University.
Course Component: Lecture

CVG 5175 Numerical Methods for Geotechnical Engineers (3 units)
Non-linear analysis of stresses and deformations using the effective stress concept; analysis of consolidation using the excess pore water pressure concept; flow through porous media; finite element, discrete element and finite difference methods; applications to foundations of structures, retaining walls, dams, tunnels, pipelines, human-made and natural slopes in rock and soil. This course is equivalent to CIVJ 5105 at Carleton University.
Course Component: Lecture

CVG 5181 Decentralized Wastewater Management (3 units)
Fundamental principles and practical design applications of decentralized wastewater treatment for domestic and industrial sources. Management of decentralized wastewater systems; Pre-treatment systems; Soil infiltration systems; Advanced onsite technologies, constructed wetlands; Alternative collection systems; Wastewater reuse and septage management. This course is equivalent to CIVJ 5181 at Carleton University.
Course Component: Lecture

CVG 5182 Water Resources Management (3 units)
Global water supply and demand; Integrated water resources management; Modeling and optimization of water resources systems; Reservoir Management; Uncertainty modeling; Climate Change and water; Decision under uncertainty. This course is equivalent to CIVJ 5182 at Carleton University.
Course Component: Lecture
Courses CVG 5182, EVG 5182 cannot be combined for units.

CVG 5183 Mixing and Transport of Pollutants in Water Bodies (3 units)
Typical models for selected water resources systems : Rivers, lakes, estuaries; Water quality parameters; Conservative parameters; Non conservative parameters; Laminar and turbulent flows; Dispersion; Pollution sources; Modeling; Simplified (integral) models; Dilution models; Three Dimensional models; Advection-Diffusion Equation; Analytical solution; Numerical solution; Non-conservative transport and Multi-component systems; Modeling approaches based on conservative and non-conservative transport and kinetics; Certain water quality parameters (Temperature, Salinity, etc.). This course is equivalent to CIVJ 5183 at Carleton University.
Course Component: Lecture
Courses CVG 5183, EVG 5183 cannot be combined for units.

CVG 5184 Construction Cost Estimating (3 units)
General overview of construction cost estimating. Techniques and construction cost estimating process; Elements of project cost; Conceptual and detailed cost estimation methods; Risk assessment and range estimating; Work breakdown structure applied in building projects. Computer applications in building construction cost estimating and infrastructure projects. This course is equivalent to CIVJ 5184 at Carleton University.
Course Component: Lecture

CVG 5185 Construction Life Cycle Analysis (3 units)
General overview of analyzing the economics of construction projects by applying the concept of time value of money. Financing strategies for construction projects and profitability analysis; Correlation between Value Engineering, Life cycle cost analysis and assessment for construction projects. Break Even, Sensitivity and Risk analysis and their application to project life cycle analysis. This course is equivalent to CIVJ 5185 at Carleton University.
Course Component: Lecture

CVG 5186 Project Information Management (3 units)
Topics in contractual relationships between construction project teams. Different type of construction contracts and their application. Preparation of project documents. Evaluation of different types of project organization structure and associated project delivery systems. Bidding strategies. Network analysis using deterministic and stochastic methods for construction time and cost management. This course is equivalent to CIVJ 5186 at Carleton University.
Course Component: Lecture

CVG 5187 Rock Mechanics (3 units)
Rock exploration, laboratory and in-situ testing; rock mass classification; deformation and strength; failure criteria; stresses in rock; foundations on rock. This course is equivalent to CIVJ 5110 at Carleton University.
Course Component: Lecture

CVG 5188 Loads on Structures (3 units)
Overview of loads on buildings according to Canadian codes and standards. Dead and live loads; Snow loads; Wind loads; Earthquake loads; Loads on non-structural components; Vibrations. Selected topics in the practical design of building structures. This course is equivalent to CIVJ 5188 at Carleton University.
Course Component: Lecture

CVG 5189 Blast Engineering (3 units)
Overview of explosives and blast loads on structural and non-structural infrastructure components; dynamic analysis of elements under blast-induced shock waves and dynamic pressures; elastic and inelastic response; incremental equation of motion and nonlinear analysis; development of resistance functions; pressure-impulse (P-I) diagrams; design of blast-resistant buildings and building components, including glazed windows, curtain walls, and blast-resistant doors as per codes and standards; progressive collapse analysis; blast retrofits and blast-risk mitigation strategies. This course is equivalent to CIVJ 5189 at Carleton University.
Course Component: Lecture

CVG 5190 Rehabilitation of Concrete Structures (3 units)
Durability of concrete bridges and building structures in Canada; assessment and evaluation of damaged concrete structures; repair, rehabilitation, and strengthening techniques; applicable design codes and guidelines; monitoring technologies for structures; implications for infrastructure management. This course is equivalent to CIVJ 5190 at Carleton University
Course Component: Lecture

CVG 5191 Diagnosis and Prognosis of Concrete Infrastructure (3 units)
Condition assessment of concrete infrastructure using experimental (i.e. visual, non-destructive, microscopic and mechanical) and analytical approaches; Overview of repair and maintenance techniques according to damage type and extent; “Serviceability performance” and “appraisal guides” for aging infrastructure; Design for durability through performance based design (PBD) approaches. This course is equivalent to CIVJ 5191 at Carleton University.
Course Component: Lecture

CVG 5192 Characterization Methods for Materials (3 units)
Modern materials characterization techniques especially with respect to civil engineering materials. Choosing the right characterization methods in order to determine the properties of materials such as chemical composition, atomic structure, and surface properties used in their research. Interpreting the results of each method as well as the insight into the interrelationships between characterization methods and their interdependency. This course is equivalent to CIVJ 5192 at Carleton University.
Course Component: Lecture

CVG 5193 Instrumentation and Experimental Design for Civil Engineering (3 units)
Introduction to instrumentation in civil engineering applications; Instrument types and performance; Strain gauges; Transducers; Measurement of position, velocity, acceleration, force, pressure, temperature and flow; Data collection and data acquisition systems; Diagnostics and calibration; Control (Closed versus Open-loop); Servomotor types and servo-valves. This course is equivalent to CIVJ 5193 at Carleton University.
Course Component: Lecture

CVG 5212 Climate Change Impacts on Water Resources (3 units)
Spatiotemporal distribution of water and its impact on human activities, including domestic and municipal consumption, hydropower generation, rain-fed and irrigated agriculture, design and operation of sewer systems, floodplain zoning, navigation, etc. Critical assessment of methodologies for climate change impacts estimation. Theoretical knowledge and hands-on applications experience needed to perform climate change analysis on a water resources system. This course is equivalent to CIVJ 5212 at Carleton University.
Course Component: Lecture

CVG 5214 Sustainable and Resilient Infrastructure (3 units)
Concepts of sustainability and resiliency as applied to civil engineering infrastructure. Discussion of evolving infrastructure needs and infrastructure risk profiles due to climate and societal change. Introduction to sustainability and resiliency assessment tools including non-stationary risk assessment, triple bottom line accounting, life cycle costs, and carbon accounting. Development of infrastructure design strategies to meet objectives for both sustainability and resiliency.
Course Component: Lecture

CVG 5216 Climate-Resilient Infrastructures in a Changing Climate (3 units)
Development of a class of infrastructure with long-term sustainability and resiliency under various extreme events, particularly, the events introduced by changing climate. Climate change drivers, climate modelling and climate change impact studies. The concepts of sustainability, resiliency, and reliability. Climatic and flooding hazards. Uncertainty and non-stationarity processes as extreme events become more severe. Benefits of building sustainable and resilient infrastructures in terms of efficient capital and operational costs while providing society with healthier and more convenient infrastructure. This course is equivalent to CIVJ 5207 at Carleton University.
Course Component: Lecture

CVG 5301 Soil and Water Conservation Engineering (3 units)
The design, water quality and climate change impacts of soil and water conservation systems. Topics include: urban storm water management (including LID) erosion control practices, subsurface and surface drainage systems and irrigation technologies.
Course Component: Lecture

CVG 5308 Wastewater Treatment Principles and Design (3 units)
Theoretical aspects of unit operations and processes for wastewater treatment with design applications. Topics include wastewater characteristics, flow rates, primary treatment, chemical unit processes, biological treatment processes, advanced wastewater treatment, disinfection, biosolids treatment and disposal. Laboratory procedures: activated sludge, anaerobic growth, chemical precipitation, disinfection. Includes: Experiential Learning Activity. This course is equivalent to ENVE 5008 at Carleton University.
Course Component: Lecture

CVG 5309 Estimation and Identification in Dynamics using Data (3 units)
Dynamical systems and their computational models, probability and stochastic processes, stochastic dynamical systems, state estimation in linear dynamics using Kalman filtering, state estimation of nonlinear dynamical systems, system identification using combined state and parameter estimation, application to engineering. Includes: Experiential Learning Activity. This course is equivalent to CIVE 5109 at Carleton University.
Course Component: Lecture

CVG 5310 Advanced Computational Modeling Strategies of Historic Buildings (3 units)
Introduction to conservation engineering; commonly used construction materials in historic buildings and their constitutive laws; Graphical and numerical methods to analyze masonry arches; Theory and application of discrete element method and its applications to assess masonry buildings. This course is equivalent to CIVE 5210 at Carleton University.
Course Component: Lecture

CVG 5311 Bridge Design (3 units)
Design of highway bridges according to the Canadian Highway Bridge Design Code (CHBDC). Comparisons with other bridge codes (e.g., the American Code - AASHTO, the European, the New Zealand, and the British bridge codes). The topics covered include the following: main structural components of highway bridges; types of highway bridges; serviceability and ultimate limit state design requirements; design loads (dead loads, traffic loads, seismic loads, and wind loads); load combinations; code specifications for loading due to traffic (design lane, characteristics of design truck, positions of design truck on bridge, etc.); dynamic effects due to traffic loads; practical approaches specified in CHBDC for determining forces and deflections in structural embers; principles of capacity design in highway bridges. This course is equivalent to CIVJ 5310 at Carleton University.
Course Component: Lecture

CVG 5312 Durability of Concrete Structures (3 units)
i) Properties of cementitious materials (constituents of concrete; hydration of cement; structure of hardened concrete; transport processes in concrete); ii) deterioration of concrete (built-in problems; construction defects; cracking; dimensional stability; alkali-aggregate reaction; sulphate attack; corrosion of reinforcing steel; freezing-thawing cycles); (iii) evaluation of concrete structures (inspection; in-situ testing; laboratory testing); (iv) repair and maintenance of concrete (repair materials; repair procedures and techniques; prevention, protection and maintenance); and, (v) durability design (philosophy; modelling of deterioration processes; service life prediction; life-cycle cost analysis.) This course is equivalent to CIVJ 5311 at Carleton University.
Course Component: Lecture

CVG 5313 Seismic Analysis and Design of Concrete Structures (3 units)
Review of seismic hazards in Canada, building code provisions for earthquake loads, uniform hazard spectra, linear elastic modal response spectrum analysis, linear elastic time history analysis, equivalent static force procedure, advanced state-of-the-art nonlinear modeling techniques including the finite element method and fiber modeling, emerging methods such as performance-based earthquake engineering and displacement-based design, ductility concepts, plastic hinge formulations, capacity design philosophy for seismic resistance, seismic analysis and design of common seismic force resisting systems including slender and squat shear walls, moment resisting frames, coupled shear walls, and coupling beams, shear wallmoment resisting frame interaction, and lessons learned from recent earthquakes. This course is equivalent to CIVJ 5312 at Carleton University.
Course Component: Lecture

CVG 5314 Geotechnical Hazards (3 units)
Understanding of assessment, prevention, and mitigation of geotechnical hazards, overview of natural and man-made geo-hazards; concepts of hazards, disasters, vulnerability and risks; geotechnical hazards induced by problem soils: fundamentals, assessment, and mitigation; landslide hazards and risk assessment: fundamentals, solutions (prevention, stabilization) for landslides and slope instability; monitoring of landslides and slope; mining geotechnical hazards: hazards related to surface mining geotechnical facilities; hazards related to underground mining geotechnical facilities. This course is equivalent to CIVJ 5109 at Carleton University.
Course Component: Lecture

CVG 5320 Fire Behaviour of Materials (3 units)
Fundamentals and scientific aspects of the behaviour of materials during fires and the fire hazards of materials. Topics to be covered include material specifications, thermal and mechanical properties, structural fire response, residual strength, failure criteria, mechanisms of flame retardancy, and standards and testing protocols. This course is equivalent to CIVE 5615 at Carleton University.
Course Component: Lecture

CVG 5333 Research Methodology (3 units)
Key components and strategies required to build a robust scientific research program in civil engineering including research questions, literature review, experiment design, data interpretation, scientific manuscripts, public speaking, ethics, and plagiarism. This course is equivalent to CIVJ 5333 at Carleton University.
Course Component: Lecture

CVG 5366 Master's Seminar in Civil Engineering
Attendance and participation in the monthly seminar. All students must make one presentation and continue to attend throughout the program. Graded S (Satisfactory) / NS (Not satisfactory).
Course Component: Seminar

CVG 6000 Projet en génie civil / Civil Engineering Report (6 crédits / 6 units)
Volet / Course Component: Recherche / Research

CVG 6108 Directed Studies I (3 units)
Special courses set up for one student on an exceptional basis. Limited to one in the Master's level and to two total Master's plus PhD. This course is equivalent to CIVE 5906 at Carleton University.
Course Component: Research
Permission of the Department is required.

CVG 6109 Directed Studies II (3 units)
Special courses set up for one student on an exceptional basis. Limited to one in the Master's level and to two total Master's plus PhD. This course is equivalent to CIVE 6906 at Carleton University.
Course Component: Research
This course is reserved for students in the PhD Civil Engineering program.

CVG 6301 Special Topics in Structures (3 units)
This course is equivalent to CIVJ 6001 at Carleton University.
Course Component: Lecture

CVG 6303 Special Topics in Structures (3 units)
This course is equivalent to CIVJ 6003 at Carleton University.
Course Component: Lecture

CVG 6304 Special Topics in Geotechnical Engineering (3 units)
This course is equivalent to CIVJ 6004 at Carleton University.
Course Component: Lecture

CVG 6305 Special Topics in Geotechnical Engineering (3 units)
This course is equivalent to CIVJ 6005 at Carleton University.
Course Component: Lecture

CVG 6306 Special Topics in Water Resources (3 units)
This course is equivalent to CIVJ 6006 at Carleton University.
Course Component: Lecture

CVG 6307 Special Topics in Water Resources (3 units)
This course is equivalent to CIVJ 6007 at Carleton University.
Course Component: Lecture

CVG 6308 Special Topics in Environmental Engineering (3 units)
This course is equivalent to CIVJ 6008 at Carleton University.
Course Component: Lecture

CVG 6309 Special Topics in Environmental Engineering (3 units)
This course is equivalent to CIVJ 6009 at Carleton University.
Course Component: Lecture

CVG 6310 Special Topics in Materials & Construction Management (3 units)
This course is equivalent to CIVJ 6010 at Carleton University.
Course Component: Lecture

CVG 6311 Special Topics in Materials & Construction Management (3 units)
This course is equivalent to CIVJ 6011 at Carleton University.
Course Component: Lecture

CVG 6508 Études dirigées I (3 crédits)
Cours individuels créés seulement pour les cas exceptionnels. Un étudiant peut en suivre un au niveau de la maîtrise ou un total de deux pour les études de maîtrise et de doctorat.
Volet : Cours magistral

CVG 6509 Études dirigées II (3 crédits)
Cours individuels créés seulement pour les cas exceptionnels. Un étudiant peut en suivre un au niveau de la maîtrise ou un total de deux pour les études de maîtrise et de doctorat.
Volet : Cours magistral

CVG 7100 Geotechnical Case Studies (3 units)
The critical study of case histories relating to current procedures of design and construction in geotechnical engineering. The importance of instrumentation and monitoring field behavior will be stressed. In-situ testing. Includes: Experiential Learning Activity. This course is equivalent to CIVE 5209 at Carleton University.
Course Component: Lecture, Seminar

CVG 7101 Advanced Soil Mechanics (3 units)
Effective stress, pore pressure parameters, saturated and partially saturated soils; seepage; permeability tensor, solutions of the Laplace equation; elastic equilibrium; anisotropy, non-homogeneity, consolidation theories; shear strength of cohesive and cohesionless soils; failure and yield criteria. This course is equivalent to CIVE 5300 at Carleton University.
Course Component: Lecture

CVG 7103 Pavement and Materials (3 units)
An analysis of the interaction of materials, traffic, and climate in the planning, design construction, evaluation, maintenance, and rehabilitation of highway and airport pavements. This course is equivalent to CIVE 5303 at Carleton University.
Course Component: Lecture

CVG 7104 Earth Retaining Structures (3 units)
Approaches to the theoretical and semi-empirical analysis of earth retaining structures. Review of the earth pressure theories. Analysis and design methods for rigid and flexible retaining walls, braced excavations, and tunnels. Instrumentation and performance studies. This course is equivalent to CIVE 5500 at Carleton University.
Course Component: Lecture

CVG 7105 advanced Foundation Engineering (3 units)
Review of methods of estimating compression and shear strength of soils. Bearing capacity of shallow and deep foundations. Foundations in slopes. Pile groups. Use of in-situ testing for design purposes. This course is equivalent to CIVE 5501 at Carleton University.
Course Component: Lecture

CVG 7107 Numerical Methods in Geomechanics (3 units)
Advanced theories of soil and rock behavior. Plasticity models. Generalized failure criteria. Critical state and cap models. Dilatancy effects. Associative and non-associative flow rules. Hardening rules. Consolidation, visco-elasticity, creep behavior. Finite element formulation. Iterative schemes. Time marching schemes. Solution of typical boundary value problems. This course is equivalent to CIVE 5503 at Carleton University.
Course Component: Lecture
Prerequisites: CVG 7120, CVG 7122.

CVG 7109 Geotechnical Earthquake Engineering (3 units)
Seismic hazards, earthquakes and ground motion, wave propagation, ground response analysis, soil properties for dynamic analysis: laboratory tests, in-situ tests, modulus and damping curves, liquefaction susceptibility, post liquefaction response, seismic effects on slope stability, retaining structures. This course is equivalent to CIVE 5505 at Carleton University.
Course Component: Lecture

CVG 7110 Road Safety Analysis (3 units)
Fundamental analytical techniques for road safety analysis, background of traffic safety analysis, network screening, before and after analysis, and surrogate measures of safety. This course is equivalent to CIVE 5310 at Carleton University.
Course Component: Lecture

CVG 7111 Advanced Building Characterization, Conservation and Rehabilitation (3 units)
Supporting concepts and techniques for the identification, documentation, and conservation of heritage and existing buildings; advanced workshops by experts from key disciplines and practice areas in heritage conservation. Includes: Experiential Learning Activity. This course is equivalent to CIVE 5603 at Carleton University
Course Component: Laboratory, Lecture

CVG 7112 Wood structures and fire (3 units)
Introduction to fire-safe design of wood buildings, brief review of wood products and wood design, prescriptive code requirements, determination of fire-resistance of wood structures through different methods. Includes: Experiential Learning Activity. This course is equivalent to CIVE 5616 at Carleton University.
Course Component: Laboratory, Lecture

CVG 7113 Practical applications of fire protection (3 units)
Introduction to the practical application of fire protection engineering from a consulting and a regulatory perspective. Main highlights include performance-based design, fire forensics, emergency preparedness and firefighting. This course is equivalent to CIVE 5617 at Carleton University.
Course Component: Lecture

CVG 7114 Probability, Statistics, Stochastic Processes and Statistical Inference in Engineering (3 units)
Fundamental of probability and statistics, (robust and ridge) regression, generalized linear models, sparse models, mixture models, stochastic processes, statistical inference and applications. Includes: Experiential Learning Activity. This course is equivalent to CIVE 5604 at Carleton University.
Course Component: Laboratory, Lecture

CVG 7115 Structural Assessment of Historic Buildings (3 units)
General concepts related to conservation of heritage structures; materials, construction techniques and structural components; classical structural analysis approaches; seismic behaviour, damage and collapse mechanisms of historic buildings; modern conservation criteria and practical implementation of repair or strengthening strategies. This course is equivalent to CIVE 5202 at Carleton University.
Course Component: Lecture

CVG 7116 Fundamentals of Geomechanics (3 units)
Tensor calculus, Cauchy stress, kinematics of continuum deformation (strain), elasticity for geomaterials, plasticity for geomaterials, constitutive models for soils, Cam-clay model. This course is equivalent to CIVE 5506 at Carleton University.
Course Component: Lecture

CVG 7120 Solid Mechanics (3 units)
Cartesian tensor notation; stresses and strains in a continuum; transformations, invariants; equations of motion; constitutive relations; generalized Hooke's Law, bounds for elastic constant: strain energy, superposition, uniqueness; formulation of plane stress and plane strain problems; energy principles, variational methods; plasticity. This course is equivalent to CIVE 5101 at Carleton University
Course Component: Lecture

CVG 7122 Finite Element Analysis 1 (3 units)
Advanced finite element methods for linear systems. The relationship with variational and Galerkin formulations, system of linear equations, polynomial interpolation, numerical integration, and theory of elasticity is explored. Isoparametric formulations for structural and continuum elements are examined. Introduction to linear dynamics and nonlinear problems. This course is equivalent to CIVE 5103 at Carleton University.
Course Component: Lecture

CVG 7123 Earthquake Analysis and Design of Structures (3 units)
Advanced vibration analysis techniques; Rayleigh-Ritz procedure; subspace iteration; derived Ritz coordinates; proportional and non-proportional damping; introduction to seismology; earthquake response analysis via time and frequency domain; response spectrum approach; multiple input excitations; design considerations and code requirements; other advanced topics in earthquake engineering. This course is equivalent to CIVE 5104 at Carleton University.
Course Component: Lecture

CVG 7124 Finite Element Analysis 2 (3 units)
Variational and Galerkin formulations: assumed displacement, assumed stress and hybrid elements; plate bending: convergence, completeness and conformity, patch test, Kirchhoff and Mindlin plate theories, nonlinear elasticity and plasticity; geometric non-linearity, Eulerian and Lagrangian formulations; incremental and iterative schemes, finite elements in dynamics. This course is equivalent to CIVE 5105 at Carleton University.
Course Component: Lecture

CVG 7126 Advanced Steel Structures (3 units)
Limit states design philosophy; material behavior; tension members; plate buckling; torsion; lateral torsional buckling; beams, axially loaded columns and beam-column behavior; brittle fracture and fatigue; frame stability and second order effects. This course is equivalent to CIVE 5204 at Carleton University.
Course Component: Lecture

CVG 7128 Prestressed Concrete (3 units)
Behavior and analysis of prestressed concrete elements subjected to axial loads, flexure and shear: material properties; prestressing systems; linear and non-linear behavior; deflections; compression-field approaches; disturbed regions; restraint of deformations; design requirements; applications to pressure vessels, bridges and frames. This course is equivalent to CIVE 5206 at Carleton University.
Course Component: Lecture

CVG 7130 Advanced Mechanics of Reinforced Concrete (3 units)
Review of various analytical methods, constitutive models, and failure criteria for reinforced concrete structures; performance assessment and forensic analysis; nonlinear finite element analysis of concrete structures. This course is equivalent to CIVE 5208 at Carleton University.
Course Component: Lecture

CVG 7137 Dynamics of Structures (3 units)
Structural dynamics, single and multi-degree-of-freedom systems, formulation of equations of motion, methods of analytical mechanics, free and forced vibrations, normal mode analysis, numerical methods for the response analyses of single and multiple-degree-of-freedom systems. This course is equivalent to CIVE 5106 at Carleton University.
Course Component: Lecture

CVG 7138 Masonry Behavior and Design (3 units)
Properties of masonry materials and assemblages. Behavior and design of walls, columns and lintels. Treatment of specialized design and construction topics. Design of low rise and high rise structures. Discussion of masonry problems. Emphasis on a practice-oriented approach. This course is equivalent to CIVE 5200 at Carleton University.
Course Component: Laboratory, Lecture

CVG 7151 Traffic Engineering (3 units)
Introduction to principles of traffic engineering. Traffic operation concepts. Travel modes and modal characteristics. Traffic stream characteristics and queuing theory. Capacity and level of service analysis of roads and intersections. Includes: Experiential Learning Activity. This course is equivalent to CIVE 5305 at Carleton University.
Course Component: Lecture

CVG 7153 Urban Transportation (3 units)
Urban transportation systems, planning and management. Introduction to models of urban travel demand. Overview of modern transportation planning issues and policies. The role of transportation planning within the wider context of transportation decision-making. Transportation land use interaction. This course is equivalent to CIVE 5307 at Carleton University.
Course Component: Lecture

CVG 7154 Highway Geometric Design (3 units)
Principles of highway geometric design. Safety and human factors, and their interaction with the road elements. Multimodal considerations. Road design elements. New and evolving concepts. This course is equivalent to CIVE 5308 at Carleton University.
Course Component: Lecture

CVG 7158 Airport Planning (3 units)
Framework for airport planning and design. Aircraft characteristics; demand forecasting; airport site selection; noise, airside capacity; geometric design; the passenger terminal complex; cargo area; general aviation; ground transportation; land use planning. This course is equivalent to CIVE 5403 at Carleton University.
Course Component: Lecture

CVG 7170 Fundamentals of Fire Safety Engineering (3 units)
The fire safety system, including social, economic and environmental issues; description of the fire safety regulatory system and the governing building codes and standards. This includes the global fire safety system in a facility and active fire protection systems; detection, suppression, smoke management. This course is equivalent to CIVE 5609 at Carleton University.
Course Component: Lecture

CVG 7171 Fire Dynamics I (3 units)
Fundamentals of combustion including material and energy balances, chemical thermodynamics, kinetics, premixed and diffusive burning. Advanced topics in the theory of combustion, flame propagation, efficiency of combustion, and the physico-chemical properties of combustible material. This course is equivalent to CIVE 5610 at Carleton University.
Course Component: Lecture

CVG 7172 Fire Dynamics II (3 units)
Fire dynamics from ignition through heat transfer to growth and spread of fires and their suppression. Factors such as containment and its role in the dynamics of fires and explosions are covered. This course is equivalent to CIVE 5613 at Carleton University.
Course Component: Lecture
Prerequisite: CVG 7171.

CVG 7173 People in Fires (3 units)
Review of the work presented by the founders in the field of human behavior in fire. Introduction to the basic notions of perception, cognition, information processing, decision-making and problem solving. Behavioral concepts such as panic, commitment, affiliation, familiarity and role are discussed. This course is equivalent to CIVE 5611 at Carleton University.
Course Component: Lecture

CVG 7174 Fire Modelling (3 units)
Fire modeling and its role in fire safety engineering. Review of the main modeling techniques used in Fire Safety Engineering: network, zone and Computational Fluid Dynamics (CFD). This course is equivalent to CIVE 5612 at Carleton University.
Course Component: Lecture

CVG 7175 Design for Fire Resistance (3 units)
Behavior of materials and structures at elevated temperatures; fire-resistance tests; fire-resistance ratings; building code requirements; real-world fires; assessing the fire resistance of steel, concrete and wood building assemblies. This course is equivalent to CIVE 5614 at Carleton University.
Course Component: Lecture

CVG 7181 Performance-Based Earthquake Engineering (3 units)
Seismic performance assessment of new and existing buildings using modelling. Design and construction of nonlinear structural models. Accounting for mass, material behavior, damping, and nonlinear geometry. Use of pushover and time history analysis methods to determine seismic performance. Consideration of nonstructural elements in determining performance. This course is equivalent to CIVE 5108 at Carleton University.
Course Component: Lecture

CVG 7184 Blast Load Effects on Structures (3 units)
Threats, risk analysis, vulnerability assessment; explosives: types and mechanisms; load determination; response of structural elements under blast loads, analysis and design for blast loads; blast mitigation, retrofit of structures; post-event assessment. This course is equivalent to CIVE 5507 at Carleton University.
Course Component: Lecture

CVG 7185 Topics in Fire Safety (3 units)
Courses in special topics related to fire safety, not covered by other graduate courses. This course is equivalent to CIVE 5810 at Carleton University.
Course Component: Lecture

CVG 7300 Topics in Structures (3 units)
This course is equivalent to CIVE 5705 at Carleton University.
Course Component: Lecture

CVG 7301 Topics in Structures (3 units)
This course is equivalent to CIVE 5706 at Carleton University.
Course Component: Lecture

CVG 7302 Topics in Structures (3 units)
This course is equivalent to CIVE 5707 at Carleton University.
Course Component: Lecture

CVG 7303 Topics in Structures (3 units)
This course is equivalent to CIVE 5708 at Carleton University.
Course Component: Lecture

CVG 7304 Topics in Structures (3 units)
This course is equivalent to CIVE 5709 at Carleton University.
Course Component: Lecture

CVG 7305 Topics in Geotechnique (3 units)
This course is equivalent to CIVE 5800 at Carleton University.
Course Component: Lecture

CVG 7306 Topics in Geotechnique (3 units)
This course is equivalent to CIVE 5801 at Carleton University.
Course Component: Lecture

CVG 7307 Topics in Geotechnique (3 units)
This course is equivalent to CIVE 5802 at Carleton University.
Course Component: Lecture

CVG 7308 Topics in Geotechnique (3 units)
This course is equivalent to CIVE 5803 at Carleton University.
Course Component: Lecture

CVG 7309 Topics in Geotechnique (3 units)
This course is equivalent to CIVE 5804 at Carleton University.
Course Component: Lecture

CVG 7310 Topics in Transportation (3 units)
This course is equivalent to CIVE 5805 at Carleton University.
Course Component: Lecture

CVG 7311 Topics in Transportation (3 units)
This course is equivalent to CIVE 5806 at Carleton University.
Course Component: Lecture

CVG 7312 Topics in Transportation (3 units)
This course is equivalent to CIVE 5807 at Carleton University.
Course Component: Lecture

CVG 7313 Topics in Transportation (3 units)
This course is equivalent to CIVE 5808 at Carleton University.
Course Component: Lecture

CVG 7314 Topics in Transportation (3 units)
This course is equivalent to CIVE 5809 at Carleton University.
Course Component: Lecture

CVG 7315 Topics in Fire Safety (3 units)
This course is equivalent to CIVE 5811 at Carleton University.
Course Component: Lecture

CVG 7316 Topics in Fire Safety (3 units)
This course is equivalent to CIVE 5812 at Carleton University.
Course Component: Lecture

CVG 7317 Topics in Fire Safety (3 units)
This course is equivalent to CIVE 5813 at Carleton University.
Course Component: Lecture

CVG 7318 Topics in Fire Safety (3 units)
This course is equivalent to CIVE 5814 at Carleton University.
Course Component: Lecture

CVG 7337 Energy and the Critical Zone (3 units)
Survey of environmental impacts of energy development including groundwater and soil contamination and greenhouse gas emissions. Application of relevant theory (multiphase flow, mass transfer, fate and transport) to describe key environmental processes, detection, monitoring, and mitigation. Previous contaminant hydrogeology related course knowledge expected. Includes: Experiential Learning Activity. This course is equivalent to ENVE 5207 at Carleton University.
Course Component: Lecture

CVG 8366 Doctoral Seminar in Civil Engineering
Attendance and participation in the monthly seminar. All students must make one presentation and continue to attend throughout the program. Graded S (Satisfactory) / NS (Not satisfactory).
Course Component: Seminar

CVG 9998 Examen général de doctorat / Comprehensive Examination (Phd)
Volet / Course Component: Recherche / Research