

# Civil Engineering

This section presents the requirements for programs in:

- M.A.Sc. Civil Engineering
- M.A.Sc. Civil Engineering with Collaborative Specialization in Climate Change
- M. Eng. Civil Engineering
- M.Eng. Civil Engineering with Collaborative Specialization in Climate Change
- Ph.D. Civil Engineering

## Program Requirements

Study at the master's level can be pursued through either a thesis leading to a M.A.Sc., a project option leading to a M.Eng., or a course work option leading to a M.Eng. Requirements are stated in terms of Carleton University credits.

### M.A.Sc. Civil Engineering (5.0 credits)

#### Requirements - Master's degree by thesis (5.0 credits)

- |  |     |
|--|-----|
| 1. 2.5 credits in courses listed below (other courses may be taken with prior departmental approval) | 2.5 |
| 2. 2.5 credits in:   | 2.5 |
| CIVE 5909 [2.5] M.A.Sc. Thesis   |     |
| 3. Participation in the graduate student seminar series:   |     |
| CIVE 5901 [0.0] Master's Seminar   |     |
| 4. Successful oral defence of the thesis   |     |

**Note: per Section 5.3 of the graduate regulations, no more than 1/3 of the coursework credits used towards the program requirements can be obtained from courses cross-listed with a 4000-level course or lower.**

**Total Credits** **5.0**

### M.A.Sc. Civil Engineering with Collaborative Specialization in Climate Change (6.0 credits)

#### Requirements:

- |  |     |
|--|-----|
| 1. 1.0 credit in:  | 1.0 |
| CLIM 5000 [1.0] Climate Collaboration  |     |
| 2. 0.0 credit in:  | 0.0 |
| CLIM 5800 [0.0] Climate Seminar Series   |     |
| 3. 2.5 credits in courses listed below (other courses may be taken with prior departmental approval) | 2.5 |
| 4. 0.0 credit in:  |     |
| CIVE 5901 [0.0] Master's Seminar   |     |
| 5. 2.5 credits in:   | 2.5 |
| CIVE 5909 [2.5] M.A.Sc. Thesis (in the specialization)   |     |

**Note: per Section 5.3 of the graduate regulations, no more than 1/3 of the coursework credits used towards the program requirements can be obtained from courses cross-listed with a 4000-level course or lower.**

**Total Credits** **6.0**

### M. Eng. Civil Engineering (5.0 credits)

#### Requirements - Master's degree by project (5.0 credits)

- |  |     |
|--|-----|
| 1. 4.0 credits in courses listed below (other courses may be taken with prior departmental approval) | 4.0 |
| 2. 1.0 credit in:  | 1.0 |
| CIVE 5900 [1.0] Civil Engineering Project  |     |

**Note: per Section 5.3 of the graduate regulations, no more than 1/3 of the coursework credits used towards the program requirements can be obtained from courses cross-listed with a 4000-level course or lower.**

**Total Credits** **5.0**

#### Requirements - Master's degree by course work (5.0 credits)

- |  |     |
|--|-----|
| 1. 5.0 credits in courses listed below | 5.0 |
|--|-----|

**Note: per Section 5.3 of the graduate regulations, no more than 1/3 of the coursework credits used towards the program requirements can be obtained from courses cross-listed with a 4000-level course or lower.**

### M.Eng. Civil Engineering with Collaborative Specialization in Climate Change (6.0 credits)

#### Requirements - Project pathway:

- |  |     |
|--|-----|
| 1. 1.0 credit in:  | 1.0 |
| CLIM 5000 [1.0] Climate Collaboration  |     |
| 2. 0.0 credit in:  |     |
| CLIM 5800 [0.0] Climate Seminar Series   |     |
| 3. 4.0 credits in courses listed below (other courses may be taken with prior departmental approval) | 4.0 |
| 4. 1.0 credit in:  | 1.0 |
| CIVE 5900 [1.0] Civil Engineering Project (in the specialization)                                    |     |

**Note: per Section 5.3 of the graduate regulations, no more than 1/3 of the coursework credits used towards the program requirements can be obtained from courses cross-listed with a 4000-level course or lower.**

**Total Credits** **6.0**

#### Requirements - Coursework pathway:

- |  |     |
|--|-----|
| 1. 1.0 credit in:  | 1.0 |
| CLIM 5000 [1.0] Climate Collaboration  |     |
| 2. 0.0 credit in:  |     |
| CLIM 5800 [0.0] Climate Seminar Series   |     |
| 3. 4.0 credits in courses listed below (other courses may be taken with prior departmental approval) | 4.0 |
| 4. 1.0 credit from:  | 1.0 |
| ENVE 5105 [0.5] Atmospheric Aerosols   |     |
| ENVE 5200 [0.5] Climate Change and Engineering   |     |
| ENVE 5201 [0.5] Geo-Environmental Engineering  |     |
| ENVE 5205 [0.5] Sludge Treatment and Disposal  |     |
| ENVJ 5908 [0.5] Anaerobic Digestion  |     |
| ENVJ 5212 [0.5] Climate Change Impacts on Water Resources  |     |

or approved Special Topics in the area of climate change

**Total Credits** **6.0**

## Ph.D. Civil Engineering (2.0 credits)

### Requirements:

1. 2.0 credits in courses	2.0
2. Participation in the graduate student seminar series:	0.0
CIVE 6901 [0.0] Ph.D. Seminar	
3. Successful completion of written and oral comprehensive examinations in subject areas determined by the student's advisory committee:	0.0
CIVE 6902 [0.0] Ph.D. Comprehensive Examination	
4. Successful completion of a thesis proposal examination	0.0
CIVE 6903 [0.0] Ph.D. Proposal	
5. 0.0 credits in:	0.0
CIVE 6909 [0.0] Ph.D. Thesis	
6. Successful oral defence of the thesis. The examination board for all theses will include an external examiner, and, when possible, professors from both departments.	0.0

**Note: per Section 5.3 of the graduate regulations, no more than 1/3 of the coursework credits used towards the program requirements can be obtained from courses cross-listed with a 4000-level course or lower.**

**Total Credits 2.0**

### Note

- Subject to approval of their advisory committee and the Associate Chair (Graduate Studies) of the department, a Ph.D. student may take, or be required to take, courses in other disciplines.

### Graduate Courses

In all programs, the student may choose graduate courses from either university with the approval of the adviser or the advisory committee. Graduate courses are listed below, grouped by subject area. Course descriptions may be found in the departmental section of the calendar concerned. All courses are of one term duration. The codes given in parentheses are those used by the University of Ottawa. Courses beginning with "CIVE" and "ENVE" are offered at Carleton University and those beginning with "CIVJ" and "ENVJ" are offered at the University of Ottawa. Not all courses listed are necessarily given during one academic year. Courses taken outside the Institute (i.e., course codes other than CIVE, ENVE, CIVJ, or ENVJ) will not count towards the degree requirements. However, thesis students may take courses outside the Institute if prior approval is obtained from the thesis supervisor or the advisory committee, and the program's Associate Chair (Graduate studies). In all programs, at least one-half of the course work must be taken from the Institute regardless of the number of courses completed at another University (applicable to transfer students). Advanced standing (i.e., credit for courses taken elsewhere) is only granted at the time of admission.

### Geotechnical Engineering

CIVE 5209 (CVG 7100)	Geotechnical Case Studies
CIVE 5300 (CVG 7101)	Advanced Soil Mechanics
CIVE 5500 (CVG 7104)	Earth Retaining Structures

CIVE 5501 (CVG 7105)	Advanced Foundation Engineering
CIVE 5503 (CVG 7107)	Numerical Methods in Geomechanics
CIVE 5505 (CVG 7109)	Geotechnical Earthquake Engineering
CIVE 5506	Fundamentals of Geomechanics
CIVE 5800 (CVG 7305)	Topics in Geotechnique
CIVE 5801 (CVG 7306)	Topics in Geotechnique
CIVE 5802 (CVG 7307)	Topics in Geotechnique
CIVE 5803 (CVG 7308)	Topics in Geotechnique
CIVE 5804 (CVG 7309)	Topics in Geotechnique
CIVJ 5105 (CVG 5175)	Numerical Methods for Geotechnical Engineering
CIVJ 5106 (CVG 5161)	Mechanics of Unsaturated Soils
CIVJ 5109 (CVG 5314)	Geotechnical Hazards

### Structural Engineering

CIVE 5101 (CVG 7120)	Solid Mechanics
CIVE 5103 (CVG 7122)	Finite Element Analysis 1
CIVE 5104 (CVG 7123)	Earthquake Engineering and Analysis
CIVE 5105 (CVG 7124)	Finite Element Analysis 2
CIVE 5106 (CVG 7137)	Dynamics of Structures
CIVE 5108 (CVG 7181)	Performance-Based Earthquake Engineering
CIVE 5109	Estimation and Identification in Dynamics using Data
CIVE 5200 (CVG 7138)	Masonry Behaviour and Design
CIVE 5202	Structural Assessment of Historic Buildings
CIVE 5204 (CVG 7126)	Advanced Steel Structures
CIVE 5206 (CVG 7128)	Prestressed Concrete
CIVE 5208 (CVG 7130)	Advanced Mechanics of Reinforced Concrete
CIVE 5210	Advanced Computational Modeling Strategies of Historic Buildings
CIVE 5507 (CVG 7184)	Blast Load Effects on Structures
CIVE 5603	Advanced Building Characterization, Conservation and Rehabilitation
CIVE 5604	Probability, Statistics, Stochastic Processes and Statistical Inference in Engineering
CIVE 5705 (CVG 7300)	Topics in Structures

CIVE 5706 (CVG 7301)	Topics in Structures
CIVE 5707 (CVG 7302)	Topics in Structures
CIVE 5708 (CVG 7303)	Topics in Structures
CIVE 5709 (CVG 7304)	Topics in Structures
CIVJ 5101 (CVG 5101)	Construction Equipment Management
CIVJ 5151 (CVG 5151)	Advanced Timber Design
CIVJ 5201 (CVG 5142)	Advanced Structural Dynamics
CIVJ 5202 (CVG 5143)	Advanced Structural Steel Design
CIVJ 5203 (CVG 5145)	Theory of Elasticity
CIVJ 5204 (CVG 5147)	Theory of Plates and Shells
CIVJ 5206 (CVG 5150)	Advanced Concrete Technology
CIVJ 5209 (CVG 5153)	Wind Engineering
CIVJ 5300 (CVG 5144)	Advanced Reinforced Concrete
CIVJ 5302 (CVG 5146)	Numerical Methods of Structural Analysis
CIVJ 5305 (CVG 5148)	Prestressed Concrete Design
CIVJ 5304 (CVG 5149)	Structural Stability
CIVJ 5306 (CVG 5155)	Earthquake Engineering
CIVJ 5301 (CVG 5156)	Finite Element Methods I
CIVJ 5303 (CVG 5157)	Finite Element Methods II
CIVJ 5307 (CVG 5158)	Elements of Bridge Engineering
CIVJ 5308 (CVG 5154)	Random Vibrations
CIVJ 5309 (CVG 5159)	Long Span Structures
CIVJ 5310 (CVG 5311)	Bridge Design
CIVJ 5311 (CVG 5312)	Durability of Concrete Structures
CIVJ 5312 (CVG 5313)	Seismic Analysis and Design of Concrete Structures

### Fire Safety Engineering

CIVE 5609 (CVG 7170)	Fundamentals of Fire Safety Engineering
CIVE 5610 (CVG 7171)	Fire Dynamics I
CIVE 5611 (CVG 7173)	People in Fires
CIVE 5612 (CVG 7174)	Fire Modeling
CIVE 5613 (CVG 7172)	Fire Dynamics II

CIVE 5614 (CVG 7175)	Design for Fire Resistance
CIVE 5615 (CVG 5320)	Fire Behaviour of Materials
CIVE 5616	Wood Structures and Fire
CIVE 5617	Practical Applications of Fire Protection
CIVE 5810 (CVG 7185)	Topics in Fire Safety
CIVE 5811	Topics in Fire Safety
CIVE 5812	Topics in Fire Safety
CIVE 5813	Topics in Fire Safety
CIVE 5814	Topics in Fire Safety

### Transportation Engineering

CIVE 5303 (CVG 7103)	Pavements and Materials
CIVE 5305 (CVG 7151)	Traffic Engineering
CIVE 5307 (CVG 7153)	Urban Transportation
CIVE 5308 (CVG 7154)	Highway Geometric Design
CIVE 5310	Road Safety Analysis
CIVE 5311	Advanced Pavement Engineering and Management
CIVE 5403 (CVG 7158)	Airport Planning
CIVE 5805 (CVG 7310)	Topics in Transportation
CIVE 5806 (CVG 7311)	Topics in Transportation
CIVE 5807 (CVG 7312)	Topics in Transportation
CIVE 5808 (CVG 7313)	Topics in Transportation
CIVE 5809 (CVG 7314)	Topics in Transportation

### Water Resources Engineering

CIVJ 5501 (CVG 5111)	Hydraulic Structures
CIVJ 5502 (CVG 5112)	Numerical Modelling in Water Resources
CIVJ 5605 (CVG 5124)	Coastal Engineering
CIVJ 5182 (CVG 5182)	Water Resources Management
CIVJ 5212 (CVG 5212)	Climate Change Impacts on Water Resources
CIVJ 5183 (CVG 5183)	Mixing and Transport in Water Bodies
CIVJ 5503 (CVG 5160)	Sediment Transport
CIVJ 5504 (CVG 5162)	River Hydraulics

### Environmental Engineering

ENVE 5004 (EVG 7144)	Advanced Wastewater Treatment
ENVE 5007 (EVG 7101)	Filtration and Membranes in Water Treatment

ENVE 5101 (EVG 7101)	Air Pollution Control
ENVE 5105 (EVG 7105)	Atmospheric Aerosols
ENVE 5106 (EVG 7106)	Atmospheric Chemical Transport Modelling
ENVE 5107 (EVG 7107)	Radiative Transfer and Remote Sensing
ENVE 5200 (EVG 7200)	Climate Change and Engineering
ENVE 5201 (EVG 7201)	Geo-Environmental Engineering
ENVE 5204 (EVG 7134)	Resource Industry Waste Management
ENVE 5205 (EVG 7132)	Sludge Treatment and Disposal
ENVE 5206 (EVG 7206)	Energy and Resource Recovery from Waste
ENVE 5207 (EVG 7207)	Energy and the Critical Zone
ENVE 5301 (EVG 7301)	Contaminant Hydrogeology
ENVE 5303 (EVG 7303)	Multiphase Flow in Soils
ENVE 5305	Stormwater Management and Low Impact Development
ENVE 5701 (EVG 7001)	Topics in Environmental Engineering
ENVE 5702 (EVG 7002)	Topics in Environmental Engineering
ENVE 5703 (EVG 7003)	Topics in Environmental Engineering
ENVE 5704 (EVG 7004)	Topics in Environmental Engineering
ENVE 5705 (EVG 7005)	Topics in Environmental Engineering
ENVJ 5001 (EVG 5001)	Biofilm Processes in Wastewater Treatment
ENVJ 5182 (EVG 5182)	Water Resources Management
ENVJ 5301 (EVG 5301)	Soil and Water Conservation Engineering
ENVJ 5302 (EVG 5302)	Decentralized Wastewater Management
ENVJ 5333 (EVG 5333)	Research Methodology
ENVJ 5700 (EVG 5139)	Environmental Assessment of Civil Engineering Projects
ENVJ 5900 (EVG 5130)	Wastewater Treatment Process Design
ENVJ 5901 (EVG 5132)	Unit Operations of Water Treatment
ENVJ 5902 (EVG 5138)	Advanced Water Treatment
ENVJ 5905 (EVG 5137)	Water and Wastewater Treatment Process Analysis
ENVJ 5906 (EVG 5133)	Solid Waste Management
ENVJ 5907 (EVG 5134)	Chemistry for Environmental Engineering
ENVJ 5908 (EVG 5179)	Anaerobic Digestion

ENVJ 6300 (EVG 6300)	Special Topics in Environmental Engineering
ENVJ 6301 (EVG 6301)	Special Topics in Environmental Engineering
ENVJ 6302 (EVG 6302)	Special Topics in Environmental Engineering
ENVJ 6303 (EVG 6303)	Special Topics in Environmental Engineering
ENVJ 6304 (EVG 6304)	Special Topics in Environmental Engineering
CIVJ 5181 (CVG 5181)	Decentralized Wastewater Management

### Studies and Seminars

CIVE 5901 (CVG 7314)	Master's Seminar
CIVE 5906 (CVG 6108)	Directed Studies 1
CIVE 6901	Ph.D. Seminar
CIVE 6906 (CVG 6109)	Directed Studies 2
CIVJ 5333 (CVG 5333)	Research Methodology
CIVJ 6000 (CVG 6300)	Special Topics in Civil Engineering
CIVJ 6001 (CVG 6301)	Special Topics in Civil Engineering
CIVJ 6002 (CVG 6302)	Special Topics in Civil Engineering
CIVJ 6003 (CVG 6303)	Special Topics in Civil Engineering
CIVJ 6004 (CVG 6304)	Special Topics in Civil Engineering
CIVJ 6005 (CVG 6305)	Special Topics in Civil Engineering
CIVJ 6006 (CVG 6306)	Special Topics in Civil Engineering
CIVJ 6007 (CVG 6307)	Special Topics in Civil Engineering
CIVJ 6008 (CVG 6308)	Special Topics in Civil Engineering
CIVJ 6009 (CVG 6309)	Special Topics in Civil Engineering
CIVJ 6010 (CVG 6310)	Special Topics in Civil Engineering
CIVJ 6011 (CVG 6311)	Special Topics in Civil Engineering
CIVJ 6012 (CVG 6312)	Special Topics in Civil Engineering
CIVJ 6013 (CVG 6313)	Special Topics in Civil Engineering
CIVJ 6014 (CVG 6314)	Special Topics in Civil Engineering
CIVJ 6015 (CVG 6315)	Special Topics in Civil Engineering
CIVJ 6016 (CVG 6316)	Special Topics in Civil Engineering
CIVJ 6017 (CVG 6317)	Special Topics in Civil Engineering
CIVJ 6018 (CVG 6318)	Special Topics in Civil Engineering

CIVJ 6019 (CVG 6019)	Special Topics in Civil Engineering
CIVJ 6020 (CVG 6320)	Special Topics in Civil Engineering

### Projects and Theses

CIVE 5900 (CVG 6000)	Civil Engineering Project
CIVE 5909 (CVG 5909)	M.A.Sc. Thesis
CIVE 6902 (CVG 9998)	Ph.D. Comprehensive Examination
CIVE 6903	Ph.D. Proposal
CIVE 6909 (CVG 9999)	Ph.D. Thesis

### Admission

The normal requirement for admission to a master's program is a bachelor's degree with at least high honours standing in civil engineering.

1. Graduates from engineering programs other than civil engineering, or Honours science programs with a mathematics content equivalent to the civil engineering program will have to take a minimum of four qualifying undergraduate civil engineering courses in their area of graduate specialty.
2. Graduates from other science programs will have to take all the core engineering undergraduate mathematics courses in addition to the requirements specified in (1) above.

The undergraduate courses required will be specified in the Certificate of Admission.

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 fulfil the admission requirements.

No more than one half of the program credit requirements or that stipulated in the regulations of the university in which the student is registered, whichever is less, can be transferred at admission.

### Accelerated Pathway

The accelerated pathway in Civil Engineering is a flexible and individualized plan of graduate study. Students in the final year of Bachelor of Engineering in Civil, Environmental, or Architectural Conservation and Sustainability Engineering with demonstrated excellent aptitude for graduate studies and research may qualify for this option.

Students with a CGPA of 10.0 or higher, going into their final year of undergraduate study, and intending to apply to a Master's degree in Civil Engineering in the following academic year should consult with both the Undergraduate and Graduate Associate Chairs to determine if the accelerated pathway is appropriate for them and to confirm their selection of courses.

Upon approval for the accelerated pathway, students will replace a maximum of 1.0 credit of their engineering electives with 5000 level CIVE or ENVE courses. Students

will receive advanced standing for the approved 5000 level courses in which they receive a grade of A- or higher.

### Admission

The normal requirement for admission into the Ph.D. program is a master's degree with thesis in civil engineering. Students who have been admitted to a master's program may be permitted to transfer into the Ph.D. program if they demonstrate:

1. outstanding academic performance by completing at least 2.5 credits of course work with a CGPA of A- or higher, and
2. significant promise for advanced research and the ability to defend their Ph.D. proposal [in the first year of their Ph.D. program.](#)

### Regulations

See the General Regulations section of this Calendar.

### Regularly Scheduled Break

For immigration purposes, the summer term (May to August) for the M.Eng. Civil Engineering (coursework and project pathways) is considered a regularly scheduled break approved by the University. Students should resume full-time studies in September.

**Note:** a Regularly Scheduled Break as described for immigration purposes does not supersede the requirement for continuous registration in Thesis, Research Essay, or Independent Research Project as described in Section 8.2 of the Graduate General Regulations.

### Civil Engineering - Joint (CIVJ) Courses

#### CIVJ 5101 [0.5 credit] (CVG 5101)

##### Construction Equipment Management

Fundamentals and basis for design and analysis of construction operations. Equipment used in the construction of heavy civil projects is analyzed and evaluated. Methods for selecting, acquiring, maintaining, and replacing equipment. Simulation and optimization techniques for the optimal selection of equipment.

#### CIVJ 5105 [0.5 credit] (CVG 5175)

##### Numerical Methods for Geotechnical Engineering

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.

#### CIVJ 5106 [0.5 credit] (CVG 5161)

##### Mechanics of Unsaturated Soils

Introduction to unsaturated soils, phase properties and relations, stress state variables. Measurement & theory of soil suction, capillarity, permeability, shear strength, failure envelope for unsaturated soils, triaxial and direct shear tests, volume change behaviour.

**CIVJ 5109 [0.5 credit] (CVG 5314)****Geotechnical Hazards**

Assessment, prevention, and mitigation of geotechnical hazards, Natural and man-made geohazards; 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.

**CIVJ 5110 [0.5 credit] (CVG 5187)****Rock Mechanics**

Rock exploration, laboratory and in-situ testing, rock mass classification, deformation and strength, failure criteria, stresses in rock, foundations on rock.

**CIVJ 5151 [0.5 credit] (CVG 5151)****Advanced Timber Design**

Characteristic values for timber and engineered wood products, modification factors used in design; combined bending axial loading; design for bi-axial bending; design of curved glued laminated beams, Timber-Concrete Composite (TCC) floor systems; lateral design (light frame, CLT, hybrid structures); advanced connection design.

**CIVJ 5181 [0.5 credit] (CVG 5181)****Decentralized Wastewater Management**

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. Also listed as ENVJ 5302.

**CIVJ 5182 [0.5 credit] (CVG 5182)****Water Resources Management**

Global water supply and demand, integrated water resources management, modelling and optimization of water resources systems, reservoir management, uncertainty modelling, climate change and water, decision under uncertainty.

Also listed as ENVJ 5182.

**CIVJ 5183 [0.5 credit] (CVG 5183)****Mixing and Transport in Water Bodies**

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 models, dilution models, three-dimensional models, advection-diffusion equation, analytical/numerical solution, non-conservative transport and multi-component systems.

Also listed as ENVJ 5183.

**CIVJ 5184 [0.5 credit] (CVG 5184)****Construction Cost Estimating**

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.

**CIVJ 5185 [0.5 credit] (CVG 5185)****Construction Life Cycle Analysis**

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. Breakeven, sensitivity and risk analysis.

**CIVJ 5186 [0.5 credit] (CVG 5186)****Project Information Management**

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.

**CIVJ 5188 [0.5 credit] (CVG 5188)****Loads on structures**

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.

**CIVJ 5189 [0.5 credit] (CVG5189)****Blast Engineering**

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; blast-resistant building design.

**CIVJ 5190 [0.5 credit] (CVG 5190)****Rehabilitation of Concrete Structures**

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.

Lecture three hours a week

**CIVJ 5191 [0.5 credit] (CVG 5191)****Diagnosis and Prognosis of Concrete Infrastructure**

Condition assessment of concrete infrastructure using experimental (i.e. visual, nondestructive, 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 approaches.

Lecture three hours a week

**CIVJ 5192 [0.5 credit] (CVG 5192)****Characterization Methods for Materials**

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.

**CIVJ 5193 [0.5 credit] (CVG 5193)****Instrumentation and Experimental Design for Civil Engineering**

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, closed versus open-loop control; servomotor types and servo-valves.

**CIVJ 5201 [0.5 credit] (CVG 5142)****Advanced Structural Dynamics**

Dynamic behaviour of civil engineering structures under excitations due to earthquakes, wind, waves. Advanced methods in dynamic analysis of structures. Prediction of structural response. Design considerations.

**CIVJ 5202 [0.5 credit] (CVG 5143)****Advanced Structural Steel Design**

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.

**CIVJ 5203 [0.5 credit] (CVG 5145)****Theory of Elasticity**

Stress-strain relations. Theories of plane stress and plane strain. Use of stress functions, energy and variational methods in the analysis of elastostatic problems.

**CIVJ 5204 [0.5 credit] (CVG 5147)****Theory of Plates and Shells**

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.

**CIVJ 5206 [0.5 credit] (CVG 5150)****Advanced Concrete Technology**

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.

**CIVJ 5207 [0.5 credit] (CVG 5216)****Sustainable and Resilient Infrastructure in Changing Climate**

Development of infrastructure with long-term sustainability and resiliency under various extreme events; 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.

**CIVJ 5209 [0.5 credit] (CVG 5153)****Wind Engineering**

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.

**CIVJ 5212 [0.5 credit] (CVG 5212)****Climate Change Impacts on Water Resources**

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.

Also listed as ENVJ 5212.

**CIVJ 5300 [0.5 credit] (CVG 5144)****Advanced Reinforced Concrete**

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.

**CIVJ 5301 [0.5 credit] (CVG 5156)****Finite Element Methods I**

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. Precludes additional credit for CIVE 5103.

**CIVJ 5302 [0.5 credit] (CVG 5146)****Numerical Methods of Structural Analysis**

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.

**CIVJ 5303 [0.5 credit] (CVG 5157)****Finite Element Methods II**

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. Precludes additional credit for CIVE 5105.

**CIVJ 5304 [0.5 credit] (CVG 5149)****Structural Stability**

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.

**CIVJ 5305 [0.5 credit] (CVG 5148)****Prestressed Concrete Design**

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.

**CIVJ 5306 [0.5 credit] (CVG 5155)****Earthquake Engineering**

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.

**CIVJ 5307 [0.5 credit] (CVG 5158)****Elements of Bridge Engineering**

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.

**CIVJ 5308 [0.5 credit] (CVG 5154)****Random Vibrations**

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.

**CIVJ 5309 [0.5 credit] (CVG 5159)****Long Span Structures**

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. Includes: Experiential Learning Activity

**CIVJ 5310 [0.5 credit] (CVG 5311)****Bridge Design**

Design of highway bridges, Canadian Highway Bridge Design Code (CHBDC). Comparisons with other bridge codes (AASHTO, the European, the New Zealand, and the British). Structural components of highway bridges, types of highway bridges, serviceability and ultimate limit state design requirements, design loads.

**CIVJ 5311 [0.5 credit] (CVG 5312)****Durability of Concrete Structures**

Properties of cementitious materials (constituents of concrete, hydration of cement, structure of hardened concrete, transport processes in concrete); deterioration of concrete (built-in problems, construction defects, cracking, dimensional stability, alkali-aggregate reaction, sulphate attack, corrosion of reinforcing steel, freezing-thawing cycles); evaluation of concrete structures.

**CIVJ 5312 [0.5 credit] (CVG 5313)****Seismic Analysis and Design of Concrete Structures**

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 (FEM and fiber modeling), performance-based earthquake engineering and displacement-based design. Includes: Experiential Learning Activity

**CIVJ 5333 [0.5 credit] (CVG 5333)****Research Methodology**

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. Also listed as ENVJ 5333.

**CIVJ 5501 [0.5 credit] (CVG 5111)****Hydraulic Structures**

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. channel design.

**CIVJ 5502 [0.5 credit] (CVG 5112)****Numerical Modelling in Water Resources**

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, methods for tracking free surfaces.

**CIVJ 5503 [0.5 credit] (CVG 5160)****Sediment Transport**

Introduction to particle transport with 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.

**CIVJ 5504 [0.5 credit] (CVG 5162)****River Hydraulics**

Advanced concepts of river hydraulics, with an emphasis on field measurement techniques and application of numerical models. Navier-Stokes equations, turbulence, flow resistance, numerical modeling of simplified momentum and continuity equations, field-based measurement and statistical analysis of velocity fields. Special topics include contaminant transport, morphodynamic modeling.

**CIVJ 5605 [0.5 credit] (CVG 5124)****Coastal Engineering**

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).

**CIVJ 6000 [0.5 credit] (CVG 6300)****Special Topics in Civil Engineering****CIVJ 6001 [0.5 credit] (CVG 6301)****Special Topics in Civil Engineering****CIVJ 6002 [0.5 credit] (CVG 6302)****Special Topics in Civil Engineering****CIVJ 6003 [0.5 credit] (CVG 6303)****Special Topics in Civil Engineering****CIVJ 6004 [0.5 credit] (CVG 6304)****Special Topics in Civil Engineering****CIVJ 6005 [0.5 credit] (CVG 6305)****Special Topics in Civil Engineering****CIVJ 6006 [0.5 credit] (CVG 6306)****Special Topics in Civil Engineering**

**CIVJ 6007 [0.5 credit] (CVG 6307)**  
**Special Topics in Civil Engineering**

**CIVJ 6008 [0.5 credit] (CVG 6308)**  
**Special Topics in Civil Engineering**

**CIVJ 6009 [0.5 credit] (CVG 6309)**  
**Special Topics in Civil Engineering**

**CIVJ 6010 [0.5 credit] (CVG 6310)**  
**Special Topics in Civil Engineering**

**CIVJ 6011 [0.5 credit] (CVG 6311)**  
**Special Topics in Civil Engineering**

**CIVJ 6012 [0.5 credit] (CVG 6312)**  
**Special Topics in Civil Engineering**

**CIVJ 6013 [0.5 credit] (CVG 6313)**  
**Special Topics in Civil Engineering**

**CIVJ 6014 [0.5 credit] (CVG 6314)**  
**Special Topics in Civil Engineering**

**CIVJ 6015 [0.5 credit] (CVG 6315)**  
**Special Topics in Civil Engineering**

**CIVJ 6016 [0.5 credit] (CVG 6316)**  
**Special Topics in Civil Engineering**

**CIVJ 6017 [0.5 credit] (CVG 6317)**  
**Special Topics in Civil Engineering**

**CIVJ 6018 [0.5 credit] (CVG 6318)**  
**Special Topics in Civil Engineering**

**CIVJ 6019 [0.5 credit] (CVG 6019)**  
**Special Topics in Civil Engineering**

**CIVJ 6020 [0.5 credit] (CVG 6320)**  
**Special Topics in Civil Engineering**

## **Civil Engineering (CIVE) Courses**

### **CIVE 5101 [0.5 credit] (CVG 7120)**

#### **Solid Mechanics**

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.

### **CIVE 5103 [0.5 credit] (CVG 7122)**

#### **Finite Element Analysis 1**

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.

Precludes additional credit for CIVJ 5301.

Also offered at the undergraduate level, with different requirements, as CIVE 4201, for which additional credit is precluded.

### **CIVE 5104 [0.5 credit] (CVG 7123)**

#### **Earthquake Engineering and Analysis**

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.

Prerequisite(s): CIVE 5106 or permission of the Department.

### **CIVE 5105 [0.5 credit] (CVG 7124)**

#### **Finite Element Analysis 2**

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.

Precludes additional credit for CIVJ 5303.

Prerequisite(s): CIVE 5103 or permission of the Department.

**CIVE 5106 [0.5 credit] (CVG 7137)****Dynamics of Structures**

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.

**CIVE 5108 [0.5 credit] (CVG 7181)****Performance-Based Earthquake Engineering**

Seismic performance assessment of new and existing buildings using modelling. Design and construction of nonlinear structural models. Accounting for mass, material behaviour, damping, and nonlinear geometry. Use of pushover and time history analysis methods to determine seismic performance. Consideration of nonstructural elements in determining performance.

**CIVE 5109 [0.5 credit]****Estimation and Identification in Dynamics using Data**

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

**CIVE 5200 [0.5 credit] (CVG 7138)****Masonry Behaviour and Design**

Properties of masonry materials and assemblages. Behaviour and design of walls, columns and lintels. Treatment of specialized design and construction topics. Design of lowrise and highrise structures. Discussion of masonry problems. Emphasis on a practice-oriented approach.

Also offered at the undergraduate level, with different requirements, as CIVE 4403, for which additional credit is precluded.

**CIVE 5202 [0.5 credit]****Structural Assessment of Historic Buildings**

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.

Also listed as BLDG 5202.

**CIVE 5204 [0.5 credit] (CVG 7126)****Advanced Steel Structures**

Limit states design philosophy; material behaviour; tension members; plate buckling; torsion; lateral torsional buckling; beams, axially loaded columns and beam-column behaviour; brittle fracture and fatigue; frame stability and second order effects.

**CIVE 5206 [0.5 credit] (CVG 7128)****Prestressed Concrete**

Behaviour and analysis of prestressed concrete elements subjected to axial loads, flexure and shear: material properties; prestressing systems; linear and non-linear behaviour; deflections; compression-field approaches; disturbed regions; restraint of deformations; design requirements; applications to pressure vessels, bridges and frames.

**CIVE 5208 [0.5 credit] (CVG 7130)****Advanced Mechanics of Reinforced Concrete**

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.

**CIVE 5209 [0.5 credit] (CVG 7100)****Geotechnical Case Studies**

The critical study of case histories relating to current procedures of design and construction in geotechnical engineering. The importance of instrumentation and monitoring field behaviour will be stressed. In-situ testing. Includes: Experiential Learning Activity

**CIVE 5210 [0.5 credit]****Advanced Computational Modeling Strategies of Historic Buildings**

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.

Also listed as BLDG 5203.

**CIVE 5300 [0.5 credit] (CVG 7101)****Advanced Soil Mechanics**

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.

**CIVE 5303 [0.5 credit] (CVG 7103)****Pavements and Materials**

An analysis of the interaction of materials, traffic, and climate in the planning, design construction, evaluation, maintenance, and rehabilitation of highway and airport pavements.

**CIVE 5305 [0.5 credit] (CVG 7151)****Traffic Engineering**

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

Also offered at the undergraduate level, with different requirements, as CIVE 4205, for which additional credit is precluded.

**CIVE 5307 [0.5 credit] (CVG 7153)****Urban Transportation**

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.

**CIVE 5308 [0.5 credit] (CVG 7154)****Highway Geometric Design**

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.

**CIVE 5310 [0.5 credit]****Road Safety Analysis**

Fundamental analytical techniques for road safety analysis, background of traffic safety analysis, network screening, before and after analysis, and surrogate measures of safety.

**CIVE 5311 [0.5 credit]****Advanced Pavement Engineering and Management**

Civil infrastructure system, pavement network analysis, pavement structural designs, PMED, pavement management systems, life cycle assessment (LCA) methodologies, life cycle cost analysis (LCCA) procedures.

**CIVE 5403 [0.5 credit] (CVG 7158)****Airport Planning**

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.

**CIVE 5500 [0.5 credit] (CVG 7104)****Earth Retaining Structures**

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.

**CIVE 5501 [0.5 credit] (CVG 7105)****Advanced Foundation Engineering**

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.

**CIVE 5503 [0.5 credit] (CVG 7107)****Numerical Methods in Geomechanics**

Advanced theories of soil and rock behaviour. Plasticity models. Generalized failure criteria. Critical state and cap models. Dilatancy effects. Associative and non-associative flow rules. Hardening rules. Consolidation, visco-elasticity, creep behaviour. Finite element formulation. Iterative schemes. Time marching schemes. Solution of typical boundary value problems.

Prerequisite(s): CIVE 5101, CIVE 5103, or permission of the Department.

**CIVE 5505 [0.5 credit] (CVG 7109)****Geotechnical Earthquake Engineering**

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.

Precludes additional credit for CIVE 5801 (2001-2003).

**CIVE 5506 [0.5 credit]****Fundamentals of Geomechanics**

Tensor calculus, Cauchy stress, kinematics of continuum deformation (strain), elasticity for geomaterials, plasticity for geomaterials, constitutive models for soils, Cam-clay model.

**CIVE 5507 [0.5 credit] (CVG 7184)****Blast Load Effects on Structures**

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.

Also listed as IPIS 5507.

Prerequisite(s): those enrolled in the M.IPIS program must have prior knowledge of structural steel and reinforced concrete design, typically obtained through the completion of an undergraduate engineering degree.

**CIVE 5603 [0.5 credit]****Advanced Building Characterization, Conservation and Rehabilitation**

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

Also listed as BLDG 5201.

**CIVE 5604 [0.5 credit]****Probability, Statistics, Stochastic Processes and Statistical Inference in Engineering**

Fundamental of probability and statistics, (robust and ridge) regression, generalised linear models, sparse models, mixture models, stochastic processes, statistical inference and applications.

Includes: Experiential Learning Activity

**CIVE 5609 [0.5 credit] (CVG 7170)****Fundamentals of Fire Safety Engineering**

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.

Precludes additional credit for CIVE 5707 (2001-2002).

**CIVE 5610 [0.5 credit] (CVG 7171)****Fire Dynamics I**

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.

Precludes additional credit for CIVE 5705 (2001-2003).

**CIVE 5611 [0.5 credit] (CVG 7173)****People in Fires**

Review of the work presented by the founders in the field of human behaviour in fire. Introduction to the basic notions of perception, cognition, information processing, decision-making and problem solving. Behavioural concepts such as panic, commitment, affiliation, familiarity and role are discussed.

**CIVE 5612 [0.5 credit] (CVG 7174)****Fire Modeling**

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).

Precludes additional credit for CIVE 5802 (2002-2003).

**CIVE 5613 [0.5 credit] (CVG 7172)****Fire Dynamics II**

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.

Precludes additional credit for CIVE 5803 (2002-2003).

Prerequisite(s): CIVE 5610 Fire Dynamics I.

**CIVE 5614 [0.5 credit] (CVG 7175)****Design for Fire Resistance**

Behaviour 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.

Precludes additional credit for CIVE 5709 (2001-2003).

**CIVE 5615 [0.5 credit] (CVG 5320)****Fire Behaviour of Materials**

Fundamentals and scientific aspects of materials behaviour during fires, material specifications, thermal and mechanical properties, fire hazards of materials, structural fire response, residual strength, failure criteria, mechanisms of flame retardancy, and standards and testing protocols.

**CIVE 5616 [0.5 credit]****Wood Structures and Fire**

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

**CIVE 5617 [0.5 credit]****Practical Applications of Fire Protection**

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.

Includes: Experiential Learning Activity

**CIVE 5705 [0.5 credit] (CVG 7300)****Topics in Structures**

Courses in special topics related to building design and construction, not covered by other graduate courses.

**CIVE 5706 [0.5 credit] (CVG 7301)****Topics in Structures**

Courses in special topics related to building design and construction, not covered by other graduate courses.

**CIVE 5707 [0.5 credit] (CVG 7302)****Topics in Structures**

Courses in special topics related to building design and construction, not covered by other graduate courses.

**CIVE 5708 [0.5 credit] (CVG 7303)****Topics in Structures**

Courses in special topics related to building design and construction, not covered by other graduate courses.

**CIVE 5709 [0.5 credit] (CVG 7304)****Topics in Structures**

Courses in special topics related to building design and construction, not covered by other graduate courses.

**CIVE 5800 [0.5 credit] (CVG 7305)****Topics in Geotechnique**

Courses in special topics in geotechnical engineering, not covered by other graduate courses.

**CIVE 5801 [0.5 credit] (CVG 7306)****Topics in Geotechnique**

Courses in special topics in geotechnical engineering, not covered by other graduate courses.

**CIVE 5802 [0.5 credit] (CVG 7307)****Topics in Geotechnique**

Courses in special topics in geotechnical engineering, not covered by other graduate courses.

**CIVE 5803 [0.5 credit] (CVG 7308)****Topics in Geotechnique**

Courses in special topics in geotechnical engineering, not covered by other graduate courses.

**CIVE 5804 [0.5 credit] (CVG 7309)****Topics in Geotechnique**

Courses in special topics in geotechnical engineering, not covered by other graduate courses.

**CIVE 5805 [0.5 credit] (CVG 7310)****Topics in Transportation**

Courses in special topics in transportation engineering, not covered by other graduate courses.

**CIVE 5806 [0.5 credit] (CVG 7311)****Topics in Transportation**

Courses in special topics in transportation engineering, not covered by other graduate courses.

**CIVE 5807 [0.5 credit] (CVG 7312)****Topics in Transportation**

Courses in special topics in transportation engineering, not covered by other graduate courses.

**CIVE 5808 [0.5 credit] (CVG 7313)****Topics in Transportation**

Courses in special topics in transportation engineering, not covered by other graduate courses.

**CIVE 5809 [0.5 credit] (CVG 7314)****Topics in Transportation**

Courses in special topics in transportation engineering, not covered by other graduate courses.

**CIVE 5810 [0.5 credit] (CVG 7185)****Topics in Fire Safety**

Courses in special topics related to fire safety, not covered by other graduate courses.

**CIVE 5811 [0.5 credit]****Topics in Fire Safety**

Courses in special topics related to fire safety, not covered by other graduate courses.

**CIVE 5812 [0.5 credit]****Topics in Fire Safety**

Courses in special topics related to fire safety, not covered by other graduate courses.

**CIVE 5813 [0.5 credit]****Topics in Fire Safety**

Courses in special topics related to fire safety, not covered by other graduate courses.

**CIVE 5814 [0.5 credit]****Topics in Fire Safety**

Courses in special topics related to fire safety, not covered by other graduate courses.

**CIVE 5900 [1.0 credit] (CVG 6000)****Civil Engineering Project**

Students enrolled in the program M.Eng. by project will conduct an engineering study, analysis, or design project under the general supervision of a member of the Department.

Includes: Experiential Learning Activity

**CIVE 5901 [0.0 credit] (CVG 7314)****Master's Seminar**

The series consists of presentations by graduate students or external speakers. Graduate students in the Civil Engineering program are required to participate in these seminar series by attending all seminars and making at least one presentation during their graduate studies.

**CIVE 5906 [0.5 credit] (CVG 6108)****Directed Studies 1**

Prerequisite(s): open only to students in a Civil Engineering Master's program.

**CIVE 5909 [2.5 credits] (CVG 5909)****M.A.Sc. Thesis**

Includes: Experiential Learning Activity

**CIVE 6901 [0.0 credit]****Ph.D. Seminar**

The series consists of presentations by graduate students or external speakers. Graduate students in the Civil Engineering program are required to participate in these seminar series by attending all seminars and making at least one presentation during their graduate studies.

**CIVE 6902 [0.0 credit] (CVG 9998)****Ph.D. Comprehensive Examination**

Graduate students at the Doctoral level in the Civil Engineering program are required to successfully complete written and oral comprehensive examinations in subject areas determined by the student's advisory committee.

**CIVE 6903 [0.0 credit]****Ph.D. Proposal**

Graduate students at the Doctoral level in the Civil Engineering program are required to successfully complete a PhD Thesis Proposal which consists of a written proposal and a successful defence of the proposal. Students should register in term they will defend their proposal.

Prerequisite(s): CIVE 6909 (taken concurrently).

**CIVE 6906 [0.5 credit] (CVG 6109)****Directed Studies 2**

Prerequisite(s): open only to students in the Civil Engineering Ph.D. program.

**CIVE 6909 [0.0 credit] (CVG 9999)****Ph.D. Thesis**

Includes: Experiential Learning Activity