

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	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	
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 technical engineering courses	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)	
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	4.0
2. 1.0 credit in:	1.0
CIVE 5900 [1.0] Civil Engineering Project	
Total Credits	5.0

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

1. 5.0 credits in courses	5.0
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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 technical engineering courses	4.0
4. 1.0 credit in:	1.0
CIVE 5900 [1.0] Civil Engineering Project (in the specialization)	
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 technical engineering courses	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 are stated in terms of Carleton University 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
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
Total Credits	2.0

Note

- Subject to approval of his/her advisory committee, 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 will not count towards the degree requirements unless approved by the adviser or the advisory committee and the program's Associate Chair (graduate affairs). In all programs, at least one half of the course work must be taken from the Institute.

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)	Nonlinear Analysis and Design of Advanced Earthquake-Resistant Structures
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 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 5201 (CVG 5142)	Advanced Structural Dynamics
CIVJ 5202 (CVG 5143)	Advanced Structural Steel Design
CIVJ 5300 (CVG 5144)	Advanced Reinforced Concrete
CIVJ 5203 (CVG 5145)	Theory of Elasticity
CIVJ 5302 (CVG 5146)	Numerical Methods of Structural Analysis
CIVJ 5204 (CVG 5147)	Theory of Plates and Shells
CIVJ 5305 (CVG 5148)	Prestressed Concrete Design
CIVJ 5304 (CVG 5149)	Structural Stability
CIVJ 5206 (CVG 5150)	Advanced Concrete Technology
CIVJ 5209 (CVG 5153)	Wind Engineering
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

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 5403 (CVG 7158) Airport Planning

CIVE 5404 (CVG 7182) Introduction to Infrastructure Management

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) Computational Hydrodynamics

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 of Pollutants 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 5104 (EVG 7104) Indoor Environmental Quality

ENVE 5105 (EVG 7105) Atmospheric Aerosols

ENVE 5106 (EVG 7106) Atmospheric Chemical Transport Modelling

ENVE 5107 (EVG 7003) 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 Energy and Resource Recovery from Waste

ENVE 5301 (EVG 7301) Contaminant Hydrogeology

ENVE 5303 (EVG 7303) Multiphase Flow in Soils

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 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 5903 (EVG 5331) Sludge Utilization and Disposal

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

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 6906 (CVG 6109)	Directed Studies 2
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
CIVE 6901	Ph.D. Seminar

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 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 is considered a regularly scheduled break approved by the University. Students should resume full-time studies in September.

Civil Engineering - Joint (CIVJ) Courses

CIVJ 5105 [0.5 credit] (CVG 5175)

Numerical Methods for Geotechnical Engineering

CIVJ 5106 [0.5 credit] (CVG 5161)

Mechanics of Unsaturated Soils

CIVJ 5109 [0.5 credit] (CVG 5314)

Geotechnical Hazards

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 5182 [0.5 credit] (CVG 5182)

Water Resources Management

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.

Also listed as ENVJ 5182.

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****CIVJ 5202 [0.5 credit] (CVG 5143)****Advanced Structural Steel Design****CIVJ 5203 [0.5 credit] (CVG 5145)****Theory of Elasticity****CIVJ 5204 [0.5 credit] (CVG 5147)****Theory of Plates and Shells****CIVJ 5206 [0.5 credit] (CVG 5150)****Advanced Concrete Technology****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****CIVJ 5300 [0.5 credit] (CVG 5144)****Advanced Reinforced Concrete Design****CIVJ 5301 [0.5 credit] (CVG 5156)****Finite Element Methods I****CIVJ 5302 [0.5 credit] (CVG 5146)****Numerical Methods of Structural Analysis****CIVJ 5303 [0.5 credit] (CVG 5157)****Finite Element Methods II****CIVJ 5304 [0.5 credit] (CVG 5149)****Structural Stability****CIVJ 5305 [0.5 credit] (CVG 5148)****Prestressed Concrete Design****CIVJ 5306 [0.5 credit] (CVG 5155)****Earthquake Engineering****CIVJ 5307 [0.5 credit] (CVG 5158)****Elements of Bridge Engineering****CIVJ 5308 [0.5 credit] (CVG 5154)****Random Vibrations****CIVJ 5309 [0.5 credit] (CVG 5159)****Long Span Structures**

Includes: Experiential Learning Activity

CIVJ 5310 [0.5 credit] (CVG 5311)**Bridge Design****CIVJ 5311 [0.5 credit] (CVG 5312)****Durability of Concrete Structures****CIVJ 5312 [0.5 credit] (CVG 5313)****Seismic Analysis and Design of Concrete Structures**

Includes: Experiential Learning Activity

CIVJ 5501 [0.5 credit] (CVG 5111)**Hydraulic Structures****CIVJ 5502 [0.5 credit] (CVG 5112)****Computational Hydrodynamics****CIVJ 5503 [0.5 credit] (CVG 5160)****Sediment Transport****CIVJ 5504 [0.5 credit] (CVG 5162)****River Hydraulics****CIVJ 5605 [0.5 credit] (CVG 5124)****Coastal Engineering****CIVJ 5906 [0.5 credit]****Solid Waste Disposal****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.

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.

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)
Nonlinear Analysis and Design of Advanced Earthquake-Resistant Structures

Design and construction of nonlinear structural models. Accounting for mass, material behaviour, damping, and nonlinear geometry. Use of pushover and time history analysis methods. Design and modelling of structural systems using passive damping devices and isolation systems.

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 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. Basic characteristics of drivers, vehicles, and traffic. Volume, speed, and delay studies. Traffic stream characteristics and queuing theory. Capacity analysis of roads and intersections. Safety.

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

Urban transportation systems, planning and management. Urban development models, an introduction. Urban transportation policy.

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

Principles of highway geometric design. Components of the highway system, their interrelationships, abilities, limitations, and their relations with the design elements. Safety and human factors, and their interaction with the highway 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 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 5404 [0.5 credit] (CVG 7182)**Introduction to Infrastructure Management**

Infrastructure management and its relationship to facility and asset management; challenges facing infrastructure managers; tools for effective IM; concept of total quality management; economic analysis of maintenance, rehabilitation and reconstruction; use of life cycle cost analysis in decision making, development and use of IM systems.

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.

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.

Precludes additional credit for CIVE 5708 (2001-2003).

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 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 6906 [0.5 credit] (CVG 6109)

Directed Studies 2

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

CIVE 6909 [8.0 credits] (CVG 9999)

Ph.D. Thesis

Includes: Experiential Learning Activity