

# CIVIL ENGINEERING

---

## Departmental Facilities

The laboratories at Ellis Hall and the West Campus are well equipped for research studies in structures and rehabilitation, concrete, soils, geotechnical and geoenvironmental engineering, groundwater and hydrology, environmental engineering, water distribution systems and rivers, lakes and coastal engineering. A state of the art server room facilitates software modeling in all areas. In addition, researchers and students have access to the University's High Performance Computing Virtual Laboratory and to facilities located in other University departments and at the Royal Military College of Canada. There are 2 workshops and an instrumentation shop to service all areas of research.

A 380m<sup>2</sup> high bay structures laboratory with strong floor, a 380m<sup>2</sup> low bay testing laboratory, a concrete laboratory and a state-of-the-art materials testing laboratory are equipped with various loading systems for testing structures, structural components and materials. Two closed-loop servo-hydraulic power supplies drive 7 dynamic actuators ranging from 100kN to 2000kN for static and dynamic load testing. In addition, a 2000kN concrete cylinder tester, a 100kN and a 1000kN universal testing machine and a 600kN universal testing machine equipped with a muffle furnace for high temperature materials testing are available. Five programmable environmental chambers ranging in size from 10m<sup>2</sup> to 38m<sup>2</sup> are equipped for freeze-thaw, wet-conditioning/curing and cold temperature testing.

Laboratory facilities totaling 1900m<sup>2</sup> are available for research into rivers, lakes and coastal engineering and fluid mechanics. The water research laboratory is equipped with 3 wave flumes with programmable wave generators, sediment transfer flume, and a laser laboratory and a 20m internal wave flume and a 1m diameter rotating table, for research on environmental and geophysical fluid dynamics. Extensive use is made of state-of-the-art measuring equipment, including ADV's, LIF and PIV used in hydrodynamics studies. The laboratory is equipped with an 8-inch pump which supplies a constant head water distribution pipe network for experimental testing in a 175m<sup>2</sup> model river basin (used in research on river morphology and river morphodynamics), a 10m-long tilting flume for open-channel flow studies, and a 2m-long recirculating sediment transport flume.

A 420m<sup>2</sup> geoenvironmental laboratory and a 435m<sup>2</sup> geotechnical/geoenvironmental laboratory complex are well equipped to carry out unique physical model testing. Facilities include a world class Geosynthetic Landfill Liner Simulator laboratory, an analytical laboratory, geosynthetic aging equipment and a geotechnical materials laboratory. The

test pit located at West Campus is the only facility in North America capable of testing a range of buried infrastructure systems as well as conventional and trenchless construction processes at scale. A 20m<sup>3</sup> landslide testing facility located in the water research laboratory is available and is capable of modeling tsunami/landslide interactions.

The environmental laboratory complex is equipped to carry out studies in water quality, water treatment, groundwater, hydrology of fractured rock, bioreactor systems, water distribution systems and human health studies. A 360m<sup>2</sup> laboratory complex includes two Level-2 biosafety laboratories, a field staging laboratory, environmental chambers, pilot plant laboratory, analytical laboratory, a clean water testing laboratory and general wet lab facilities. There are 3 fully equipped field research trailers available for hydrology field testing and various field equipment for water treatment and biological systems field studies. A 70 m<sup>2</sup> drinking water discolouration laboratory consisting of two 200m long, 4-inch diameter pipe loops and wet laboratory is a stand-alone facility housed at the West Campus water research laboratory.

## Financial Assistance

Qualified first class students are recommended for university scholarships and bursaries, although the number of scholarships which can be awarded is limited. Research students are generally supported through Research Assistantships administered under the regulations of the awarding agency. Qualified students will also be considered for Teaching Assistantships. Specific details of funding arrangements are agreed upon by students and their supervisor(s).

## Admission Requirements

Applicants are accepted into a Master's or Doctoral Program under the general regulations of the School of Graduate Studies providing they also satisfy the requirements of the Department. Normally, the minimum Departmental requirements are a four-year Bachelor's degree with a standing in the mid B range (70% graduating average or a ranking in the top third of the graduating class where number grades are not available).

Applicants with a Bachelors degree in a cognate science may be admitted, at the discretion of the department, to the Master's degree program.



## Fields of Research

Research activity in the Department of Civil Engineering is generally classified under two fields: Civil Engineering Environment and Civil Engineering Infrastructure. Environment encompasses the areas of Environmental, Geotechnical, Geoenvironmental and Hydrotechnical Engineering, while Infrastructure comprises the areas of Structural Engineering and Geotechnical Infrastructure. These two fields reflect the growing inter-relationships and collaborations among the areas within the Department, and with other research programs both within and outside the University.

### Civil Engineering Environment

Environment research is directed toward surface water quality, source water protection, groundwater quality, and subsurface remediation.

In the areas of surface water quality, source water protection and biotechnological processes, current topics of investigation include use of natural/engineered biological systems for water quality control in traditional and innovative on-site applications, and the use of integrated environmental management techniques for the control of surface water degradation resulting from urban storm runoff. Research projects are carried out in collaboration with faculty in Civil Engineering and other Queen's departments, and with local and regional consulting firms and government agencies. Many projects are conducted at regional field and demonstration facilities.

Geoenvironmental engineering research involves the development of design concepts, computer modelling, laboratory testing and field monitoring relating to the design of landfills. This includes the examination of clay and geomembrane liners, primary and secondary leachate collection system (both granular and geosynthetic) aging and contaminant migration through berm systems.

In the area of subsurface water quality, research is being directed at the development of numerical models to simulate multiphase/multi-component flow and transport in both porous and fractured media, as well as the investigation of remedial technologies for the clean-up of chemical spill sites contaminated by hazardous industrial liquids such as PCB oils, jet fuel, and chlorinated solvents. Research is also conducted on the development of new site characterization techniques including new hydraulic and tracer testing methods. Collaborative research is carried out within Queen's with the Biology, Chemistry and Chemical Engineering Departments, School of Urban and Regional Planning and outside of Queen's with International Consortiums.

Geotechnical research is involved in studies of the stress-strain behaviour of soils, the influence of repeated loadings on soils, the influence of frost heaving on natural and stabilized soils, the performance of railroad track ballasts and fills, slope stability and earth dams. State-of-the-art computer facilities are used in modelling the behaviour of geosynthetics, reinforced walls, slopes and embankments. Modelling also plays a key role in work on soft ground tunnelling. The existence of coastal engineering, mining engineering and engineering geology at Queen's provides opportunities for interdisciplinary research. Waste management and contaminant control are areas of growing research needs and are areas of current expansion of the geotechnical research carried out at Queen's.

Hydrotechnical research includes the areas of lake dynamics, fluvial hydraulics, river engineering and pipelinecoastal engineering. A common theme in many of these areas is sediment motion, which requires the application of fluid mechanics, physical modelling and mathematical modelling to both steady and oscillating conditions. Research is also underway into the evaluation and mitigation of short and long term anthropogenic impacts on rivers, lakes and estuaries, including physical impacts such as channel incision, increased bank erosion, etc., and environmental impacts such as hypoxia, harmful algae blooms and loss of quality of the aquatic environment for animal species. Further research topics include river and coastal hydrodynamics and power generation, and long term coastal erosion and protection. Both physical modeling and advanced numerical modeling are used, and often conducted in collaboration with faculty in other areas of civil engineering (environmental, geotechnical and structural), other departments at Queen's ( Mechanical Engineering, Biology, Chemistry and Mathematics and Statistics) and other research institutes (National Water Research Institute and National Research Council).

### Civil Engineering Infrastructure

The Structures Group currently undertakes research in the areas of (i) using novel and sustainable materials for new construction, (ii) retrofitting of existing structures, (iii) the performance of structures in extreme temperatures and (iv) structural health monitoring. Research projects in the area of novel materials include the use of FRPs for stay-in place formwork for reinforced concrete construction. The use of straw bales as both an energy efficient and environmentally friendly alternative to traditional construction techniques is also an on-going topic of interest. The group has conducted pioneering research into the use of FRPs for strengthening of structures, including the use of prestressed FRPs for efficient flexural strengthening. Current research projects in this area seek to investigate if FRP can enhance the buckling and flexural strength of steel members. The group also has



a long standing research collaboration with the National Research Council of Canada that seeks to better understand the performance of both reinforced and retrofitted concrete structures in fire. Research projects in the area of structural health monitoring aim to investigate the link between deterioration and structural capacity through the application of advanced measurement systems for both above ground and buried infrastructure. The structures group conducts a number of these research projects in co-operation with both industrial and government partners including the Ministry of Transportation Ontario and Transport Canada.