

Graduate course:
Advanced Composites in Construction
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Course summary:

This course covers the use of advanced composite materials such as fiber reinforced polymers (FRP) and fabric-reinforced cementitious materials (FRCM) in construction. It consists of two major topics namely, 1) the use of FRP bars as internal reinforcement for concrete structures and 2) the use of externally-bonded composites for strengthening concrete structures. The course also covers damage assessment of concrete structures and various repair approaches including conventional and advanced ones.

Course objectives:

- 1- To introduce students to advanced composites and their use in reinforcing and strengthening concrete structures.
- 2- To introduce students to the Canadian and American design codes and design guidelines for composites in construction.
- 3- To introduce students to conventional and modern techniques adopted in reinforcing and repair of concrete structures.

Course contents:

Part 1:

1. Introduction to composite materials:
 - Fibre-reinforced polymer (FRP) sections and rods.
 - FRP manufacturing.
 - Material properties.
 - Design concepts.
 - Quality control.
2. Use of composites as internal reinforcement in concrete structures:
 - Design concepts.
 - Ultimate limit state:
 - o Flexural design with FRP bars.
 - o Shear design with composites.
 - o Additional topics: Bond length, FRP in compression, detailing, applications, etc.
 - Service limit state and code requirements.

Part 2:

1. Introduction to damage aspects in concrete structures, condition assessment, and conventional strengthening techniques.
 - Deterioration of concrete due to environmental attacks (corrosion, chloride attack, sulphate attack, carbonation, etc.)
 - Aspects of structural damage in concrete structures (overloading, impact, earthquake, etc.)
 - Assessment of the structure's integrity (load testing, movement and settlement monitoring, pull off tests, etc.)
 - Monitoring and assessment for corrosion activities (concrete resistivity, half-cell potential, etc.)
 - Conventional strengthening techniques:

2. Use of composites in strengthening applications:
 - Evaluation of the existing condition of the structures (deflections, strains, capacity)
 - Design of externally bonded strengthened structures:
 - o Beams and one-way slabs (flexure and shear strengthening)
 - o Short columns (circular and rectangular sections)
 - o Prestressed elements (*if time allows*)
 - o Installation and quality control
 - o Post-tensioning calculations (*if time allows*)
 - Introduction to near-surface mounted (NSM) method
 - Introduction to mortar-based fibre-reinforced cementitious matrices (FRCM) for strengthening: types, properties, and other considerations.
 - Durability and long-term performance after repair.

Modifications to the course content might take place according to the course progress.

Notes:

- A project consisting of a technical study, an experimental project, or a field application on a subject related to the course contents.

Course references:

Prepared class notes will be made available to students along with other reference materials. There are number of references that cover many aspects of the course materials. These include.

- Concrete Repair Manual - 4th Edition, American Concrete Institute, 2013.
- Composites for construction: Structural design with FRP materials, Wiley publisher, by Bank, L.
- ISIS educational modules.
- Relevant reports of ACI committees, American Concrete Institute.
- Relevant ASTM standards, American Society for Testing and Materials.
- Canadian codes CSA S806, S807, and S16 on fibre-reinforced polymers, Canadian Standards Association.