**UNIVERSITY OF WATERLOO**
**Civil and Environmental Engineering**

# CIVE 414
# Structural Concrete Design
# Spring 2022

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**Teaching Team:**

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| **Instructor:** | Prof. Maria Anna Polak |
| **Teaching Assistants:** | Graeme Milligan<br>Katherine Liu<br>Leila Miri<br>Patrick Beaulieu |

**Location and time:**

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|---|---|---|---|
| Lectures: Mondays and Wednesdays. | 1:00- 2:20 pm | STC-0020 |
| Tutorials: Mondays | 2:30-3:20 pm | STC-0020 |
| Thursdays | 9:00-10:00 am | CPH 1319 |

**Mark distribution:**

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|---|---|
| Assignments | 15% |
| Laboratory | 10% |
| Mid-Term Exam | 25% |
| Final Exam | 50% |

Note: Students must pass the final examination to pass this course. Students who fail the final examination will be assigned the final examination mark as their course grade.

The Midterm and Final examinations are open book

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**Website:** Waterloo LEARN (learn.uwaterloo.ca)

**Course email:** **mapolak.teaching@gmail.com**

Please use course email for ALL communications regarding the course material with the instructor and the TA. All Teaching Team members have access and can reply to the emails.

**Piazza:** piazza.com/uwaterloo.ca/spring2022/cive414/home password: concreteS22

- All members of the teaching team (the instructor and the TAs) have access to the course email and the Piazza.
- All questions regarding the course should be sent to the course email or to Piazza.
- The questions will be answered by a member of the teaching team. The questions will also be addressed during the tutorials, if appropriate**.**

**References:**
1. **Course Notes (posted on LEARN) (required)**
2. **"Concrete Design Handbook: 4rd Ed.", CAC, 2019.**

**Includes: Part I: CSA Standard A23.3-14 Design of Concrete Structures (required)**

**Part II: Chapters with design information and design aids**

The concrete design handbook can be purchased from CAC direct at the following link (https://www.cement.ca/technical-publications/) or through the Waterloo bookstore https://wstore.uwaterloo.ca/cement-association-of-canada-concrete-design-handbook-4th-edition.html The bookstore will ship textbooks this upcoming term.

You can access the CSA standard A23.3 via UWaterloo library. This does not include Part II of the handbook. A document outlining how to access the standard through the library will be posted to LEARN.

3. MacGregor, J.G. & Bartlett, F.M. "Reinforced Concrete Mechanics and Design: 1st Canadian Ed.", Prentice Hall, 2000
4. Pillai, S.U., Kirk, D.W., Erki, M.A., "Reinforced Concrete Design", McGraw Hill Ryerson 2009, 4th ed.
5. Brzev, S, and Pao, J., "Reinforced Concrete Design – A Practical Approach," Updated Edition, 2009, Pearson Custom Publishing, Toronto, ON

| Topic #: | Topic Description: |
|---|---|
| 1 | Introduction |
| 2 | Flexure in Reinforced Concrete Members |
| 3 | Shear in Reinforced Concrete Members |
| 4 | Bond Between Concrete and Reinforcement |
| 5 | Serviceability |
| 6 | Concrete Columns |
| 7 | Concrete Slabs |

**Course Outline:**

1. **Introduction:**
   - Concrete structures
   - Design process
   - Concrete and reinforcement properties
2. **Flexure in Reinforced Concrete Members**
   - Analysis versus Design
   - Assumptions
   - Singly reinforced beams – review from CivE 310
   - Doubly reinforced beams
   - T-Beams
3. **Shear in Reinforced Concrete Members**
   - Behaviour in shear
   - Modelling for sectional analysis: truss models
   - Design for shear in concrete members
   - Strut and Tie models for deep concrete beams
   - Truss model and design method
4. **Bond between concrete and reinforcement**
   - Mechanics of bond
   - Development length concept
   - Hooks
   - Splicing of reinforcement
   - Detailing
5. **Serviceability**
   - Design for deflections
   - Calculation of deflections
   - Cracking
6. **Concrete Columns:**
   - Short and slender columns
   - Interaction diagrams
   - Design of short columns
   - Design of slender columns
   - Columns in non-sway and sway frames
7. **Concrete Slabs:**
   - Analysis of two-way slabs – overview.
   - Slabs supported on walls
   - Slabs supported on columns
     - direct design method
     - design of two-way slabs for flexure
     - design of two-way slabs for shear: punching shear

## Course Learning Objectives:

This course follows the material introduced in CivE 310. This course is an introduction to design of reinforced concrete members for flexure and shear. The course content is intended to provide practical understanding of nonlinear material behaviour, the process of structural design, and the relationship between structural analysis and design, with a focus on one of the most common and unique civil engineering construction materials – reinforced concrete. Advanced design topics will be introduced, as well as some basic structural systems concepts.

At the end of the course you should be able to:

- Analyse and design reinforced concrete elements for flexure using steel reinforcement.
- Analyse and design reinforced concrete elements for shear.
- Design bar curtailment and development length in beams.
- Design beams to avoid excessive deflections
- Design elements subjected to axial compression and bending: columns
- Design flat concrete slabs for flexure and shear (time permitting)

## Assignments:

### Submissions of Assignments:

Submitted in .pdf, .jpg or .png form to Crowdmark. Link is available on LEARN

You need to have a device for scanning the assignments and the tests. A scanner is the best and the easiest. However, you can use a phone for this purpose (many free apps exist such as the scanner app. It allows one to take photos of a max of 10 pages which are then converted to pdf. If you need more than one scan, name the files appropriately 1. 2. 3 etc…, before submitting). Submit the answer for each question individually.

Assignments should be written with **dark pen** or pencil on **plain white paper** to ensure the scanned documents are legible.

Minimum standards of neatness will be expected for all assignments. These standards include neat, legible printing, use of a straight edge for straight lines, and use of an eraser to correct mistakes. Assignments will be returned UNMARKED if these standards are not met.

Due dates will be indicated on the assignment sheets. Late assignments will not be accepted. Assignments are to be submitted to the designated dropbox for the course in Crowdmark. Submit the solutions for each question individually.

Assignment solutions will be made available on the course website.

Assignments are to be individual effort. *Excessive collaboration* on an assignment may constitute a violation of UW Policy 71 “Student Discipline.”

Definition of excessive collaboration:

- Discussing an assignment in significant detail with peers or splitting up work.
- Using a classmate’s assignment as the basis or as a reference for your own, or allowing someone else to do this with your assignment.

- Sharing computer code, spreadsheet file, etc., to be submitted as part of an assignment.

How to avoid excessive collaboration:

- Do not discuss assignment solutions with classmates in step-by-step detail.
- Do not show or give your assignment solution to another student.
- Write up your solution separately from your classmates.
- If you work with someone else or receive assistance, please indicate this and the name(s) of the person(s) involved on your assignment.

**Laboratory:**

- The laboratory component of the course will consist of fabrication, testing and analysis of reinforced concrete beams. Laboratory work is recorded and posted as several videos on LEARN.
- The class will be divided into teams. You will be responsible for signing up into a team (signup sheet will be made available on LEARN).
- Each team will consist of **5 students**.
- The lab videos are posted to LEARN.
- Each team must submit a report analyzing and discussing the results of their beam, and comparing their results to those from the other teams in their group.
- The details of the laboratory portion of the course can be found in the Laboratory handout (to be posted LEARN)

## University of Waterloo Required Statements

Academic Integrity: In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility. [Check www.uwaterloo.ca/academicintegrity/ for more information.]

Grievance: A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70, Student Petitions and Grievances, Section 4, www.adm.uwaterloo.ca/infosec/Policies/policy70.htm. When in doubt please be certain to contact the department's administrative assistant who will provide further assistance.

Discipline: A student is expected to know what constitutes academic integrity [check www.uwaterloo.ca/academicintegrity/] to avoid committing an academic offence, and to take responsibility for his/her actions. A student who is unsure whether an action constitutes an offence, or who needs help in learning how to avoid offences (e.g., plagiarism, cheating) or about "rules" for group work/collaboration should seek guidance from the course instructor, academic advisor, or the undergraduate Associate Dean. For information on categories of offences and types of penalties, students should refer to Policy 71, Student Discipline, www.adm.uwaterloo.ca/infosec/Policies/policy71.htm. For typical penalties check Guidelines for the Assessment of Penalties, www.adm.uwaterloo.ca/infosec/guidelines/penaltyguidelines.htm.

Appeals: A decision made or penalty imposed under Policy 70 (Student Petitions and Grievances) (other than a petition) or Policy 71 (Student Discipline) may be appealed if there is a ground. A student who believes he/she has a ground for an appeal should refer to Policy 72 (Student Appeals) www.adm.uwaterloo.ca/infosec/Policies/policy72.htm.

Note for students with special needs: The AccessAbility Services (https://uwaterloo.ca/disability-services/) located in Needles Hall, Room 1132, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with the AccessAbility Services office at the beginning of each academic term.