OBJECTIVES:  
The objectives of this course are for the student to become able to:
1. recognise that design criteria in CSA Standard CAN/CSA A23.3 concerning the behaviour and design of reinforced concrete members and structures are simple applications of the fundamentals of statics and applied mechanics;
2. document decisions made during the design process in coherent and legible design calculations;
3. design structural reinforced concrete members and systems that are safe, serviceable, and economical.

TOPICS:  

SPECIFIC LEARNING OBJECTIVES:

1. Behaviour and Strength of Sections in Flexure: At the end of this segment, the student should be able to:
   a) Compute moment-curvature relationships for reinforced concrete sections subjected to bending or combined bending and axial loads using the basic conditions of equilibrium, compatibility, and force-deformation relationships.
   b) Recognise the impact of the response of concrete in uniaxial compression on the stress-strain diagram, and on the response for biaxial and triaxial stress states.
   c) Summarise the additional assumptions necessary to develop a simplified flexural theory for reinforced concrete.
   d) Compute the flexural capacity of T-beams, isolated unsymmetrical beams, and beams with compression reinforcement.
   e) Apply simple truss-based models to determine appropriate transverse reinforcing for T-beam flanges.

2. Serviceability of Concrete Structures: At the end of this segment, the student should be able to:
   a) Distinguish between the different methods used to determine the tensile strength of concrete, and the strengths obtained using the different methods.
b) Distinguish between structural and non-structural cracks, and assess whether the extent of flexural cracking is unserviceable according to current standards.
c) Recognise the potential limit states associated with deflections due to differential settlement, beam or slab bending, prestressing, or column deflections in tall buildings.
d) Compute long-term deflections due to creep and shrinkage of concrete structures.

3. Columns: At the end of this segment, the student should be able to:
a) Classify columns as “short” or “long”, and characterize the column behaviour based on this classification.
b) Distinguish between the axial response of short tied and spiral columns, and determine the geometry of the spiral reinforcement necessary to obtain the desired response.
c) Construct interaction diagrams for columns from first principles.
d) Determine the capacity of a column subjected to biaxial bending.
e) Compute the resistance of a slender column using approximate analyses involving moment magnifiers, or the design criteria presented in A23.3.
f) Distinguish between material failures and stability failures, recognizing the impact of tangent and secant stiffnesses, non-uniform end moments, and sustained loads on stability failures.
g) Analyse columns in sway and non-sway frames.

4. Shear Strength of Reinforced Concrete:
a) Explain from first principles and experimental evidence the behaviour of beams without web reinforcement, and the transfer of forces after inclined cracking in beams with and without web reinforcement.
b) Design beams to resist shear using section design methods or whole member design methods.
c) Distinguish between shear design using Compression Field Theory (A23.3-84), Modified Compression Field Theory (A23.3-94) or Simplified Modified Compression Field Theory (A23.3-04).

5. Bond, Development and Anchorage of Reinforcement:
a) Derive the relationships between bar force and bond, average bond stress in a beam, and an approximate development length equation.
b) Appreciate the basis of, and apply, detailing rules for flexural steel resisting positive and negative moment.

6. Discontinuity Regions, Strut-and-Tie Models:
a) Identify B and D regions in concrete structures and analyse D regions using strut-and-tie methods.
b) Layout plastic trusses, size compression struts and nodal regions, and check the anchorage of tension ties.
c) Correlate the mechanics of bottle-shaped compression regions and strut-and-tie models for opening and closing corners to the observed behaviour of these regions.
7. Two-Way Slabs:
   a) Classify slab systems as one-way or two-way and determine the static equilibrium of either classification.
   b) Carry out preliminary design of two-way slabs, including layout, thickness, flexural reinforcement.
   c) Check shear at interior, edge and corner columns.

**PREREQUISITES:**
CEE 2220a, CEE 2221b, CEE 2202a, CEE 3340a, CEE 3341b, CEE 347a, CEE 358b, or their equivalent, by permission of the Instructor.

**CO-REQUISITES:**
None.

**ANTIREQUISITES:**
None.

**INSTRUCTOR:**
Dr. Aiham Adawi, P. Eng., SEB 20, email: aadawi2@uwo.ca
Office hours: Wednesdays, (4:30pm to 5:30pm)
Administration Support: Kristen Edwards, SEB3009, email: khunt29@uwo.ca

**COURSE DELIVERY:**
Two 3hr lectures per week will be delivered online live using Zoom. Every lecture will be recorded and made available on course OWL after lecture hours until the course is completed. Students will be allowed to communicate with the instructor during lectures through video, audio or chatting tools available within Zoom.

**LECTURE NOTES:**
Will be available to download from the course OWL site.

**TEXT:**
None.

**REFERENCE:**

**ASSIGNMENTS:**
Four or five assignments will be circulated during the course. Assignments should scanned and turned in online as explained on assignment sheet. The penalty for late submission is 10% per working day late. If you need an extension, please indicate this in an email message before the assignment is due.

**COMPUTING:**
Assignments may require the use of structural analysis software.
EVALUATION:

<table>
<thead>
<tr>
<th>Assignment</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Assignments</td>
<td>50%</td>
</tr>
<tr>
<td>Final Exam (written)</td>
<td>35%</td>
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<tr>
<td>Final Exam (oral)</td>
<td>15%</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>100%</strong></td>
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</tbody>
</table>

FINAL EXAM PROCEDURE AND REGULATIONS:

1. Students must pass the final examination (50% in combined written and oral parts) to pass this course. (Students who fail the final examination will be assigned the aggregate course grade or 58%, whichever is smaller).

2. Written final exam will be open book and proctored online via Zoom. Every student will be required to be live on Zoom and within camera frame during exam time.

3. Oral final exam part will be conducted for every student separately via Zoom on a later date following written part.

CHEATING:

University policy states that cheating is a scholastic offence. The commission of a scholastic offence is attended by academic penalties that might include expulsion from the program. If you are caught cheating, there will be no second warning. For further information on scholastic offences, please see: http://grad.uwo.ca/current_students/graduate_regulations/section_10.htm

ENGLISH:

In accordance with Senate and Faculty Policy, students may be penalised up to 10% of the marks on all assignments, tests and examinations for the improper use of English. Additionally, poorly written work with the exception of final examinations may be returned without grading. If resubmission of the work is permitted, it may be graded with marks deducted for poor English and/or late submission.

CONDUCT:

Students are expected to arrive at lectures on time, and to conduct themselves during class in a professional and respectful manner that is not disruptive to others. Late comers may be asked to wait outside the classroom until being invited in by the Instructor. Please turn off your cell phone before coming to a class or exam. On the premises of the University or at a University-sponsored program, students must abide by the Student Code of Conduct: http://www.uwo.ca/univsec/board/code.pdf

CONSULTATION:

Students are encouraged to discuss problems with their instructor at the end of the lecture, or during individual consultations arranged by appointment.

SICKNESS OR OTHER PROBLEMS:

Students should immediately consult with the Department of Civil and Environmental Engineering if they are ill or have any other problems that could affect their performance in the course. Where appropriate, the problems should be documented (see attached). The student should seek advice from the Instructor concerning the recovery of work missed. Failure to notify the Department of illness or any other matter that could affect academic performance immediately (or as soon as possible thereafter) will have a negative effect on any appeal.
NOTICE:
Students are responsible for regularly checking their email and notices posted outside the Civil and Environmental Engineering Department Office.