

Western University  
Faculty of Engineering  
*Department of Civil and Environmental Engineering*

**CEE 9549 – Advanced Design and Behavior of Reinforced Concrete**

COURSE OUTLINE Summer 2025

---

---

**DESCRIPTION**

This course sheds light on fundamentals of the analysis and design of reinforced concrete sections and members to resist flexural, shear, and axial loads. It also covers topics on serviceability, durability criteria and slender columns. More complex design techniques such as strut-and-tie methods are also explored. Course content is delivered as per CSA Standard CAN/CSA A23.3.

**ENROLLMENT RESTRICTIONS**

Enrollment in this course is restricted to graduate students in MEng, MEng, and PhD programs, as well as any student that has obtained special permission to enroll in this course from the course instructor as well as the Graduate Chair (or equivalent) from the student's home program.

**INSTRUCTOR CONTACT INFORMATION**

Course instructor: Aiham Adawi, PhD, P.Eng.

Email address: [aadawi2@uwo.ca](mailto:aadawi2@uwo.ca)

Office: SEB20

Office hours: Wednesdays, 4-5pm (in-person)

**COURSE FORMAT**

In-person.

**TOPICS**

Topic #	Description	Learning Activities	Tentative timeline
1	Behavior and Strength of Sections in Flexure		
	Lesson 1: <ul style="list-style-type: none"><li>• 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.</li><li>• Recognize 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.</li></ul>	<ul style="list-style-type: none"><li>• One lecture</li><li>• Practice problems</li><li>• Discussion</li></ul>	Week 1

	<p>Lesson 2:</p> <ul style="list-style-type: none"> <li>• Compute the flexural capacity of T-beams, isolated unsymmetrical beams, and beams with compression reinforcement.</li> <li>• Summarize the additional assumptions necessary to develop a simplified flexural theory for reinforced concrete.</li> <li>• Apply simple truss-based models to determine appropriate transverse reinforcing for T-beam flanges.</li> </ul>	<ul style="list-style-type: none"> <li>• One lecture</li> <li>• Practice problems</li> <li>• Discussion</li> </ul>	Week 1
2	Shear Strength of Reinforced Concrete		
	<p>Lesson 1:</p> <ul style="list-style-type: none"> <li>• Explain from first principles and experimental evidence the behavior of beams without web reinforcement, and the transfer of forces after inclined cracking in beams with and without web reinforcement.</li> <li>• Design beams to resist shear using section design methods or whole member design methods.</li> </ul>	<ul style="list-style-type: none"> <li>• One lecture</li> <li>• Practice problems</li> <li>• Discussion</li> </ul>	Week 2
	<p>Lesson 2:</p> <p>Distinguish between shear design using Compression Field Theory, Modified Compression Field Theory or Simplified Modified Compression Field Theory.</p>	<ul style="list-style-type: none"> <li>• One lecture</li> <li>• Practice problems</li> <li>• Discussion</li> </ul>	Week 2
3	Columns		
	<p>Lesson 1:</p> <ul style="list-style-type: none"> <li>• Classify columns as “short” or “long” and characterize the column behavior based on this classification.</li> <li>• 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.</li> <li>• Construct interaction diagrams for columns from first principles.</li> </ul>	<ul style="list-style-type: none"> <li>• One lecture</li> <li>• Practice problems</li> <li>• Discussion</li> </ul>	Week 3
	<p>Lesson 2:</p> <ul style="list-style-type: none"> <li>• Determine the capacity of a column subjected to biaxial bending.</li> </ul>	<ul style="list-style-type: none"> <li>• One lecture</li> <li>• Practice problems</li> <li>• Discussion</li> </ul>	Week 3

	<ul style="list-style-type: none"> <li>• Compute the resistance of a slender column using approximate analyses involving moment magnifiers, or the design criteria presented in A23.3.</li> <li>• 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.</li> </ul>		
4	Lesson 1: Tutorial on using selected commercial software in the design of beams for flexure and shear	<ul style="list-style-type: none"> <li>• One lecture</li> <li>• Practice problems</li> <li>• Discussion</li> </ul>	Week 4
5	Discontinuity Regions, Strut-and-Tie Models		
	Lesson 1: Identify B and D regions in concrete structures and analyze D regions using strut-and-tie methods.	<ul style="list-style-type: none"> <li>• One lecture</li> <li>• Practice problems</li> <li>• Discussion</li> </ul>	Week 5
	Lesson 2: <ul style="list-style-type: none"> <li>• Layout plastic trusses, size compression struts and nodal regions, and check the anchorage of tension ties.</li> <li>• Correlate the mechanics of bottle-shaped compression regions and strut-and-tie models for opening and closing corners to the observed behavior of these regions.</li> </ul>	<ul style="list-style-type: none"> <li>• One lecture</li> <li>• Practice problems</li> <li>• Discussion</li> </ul>	Week 5

### SPECIFIC LEARNING OUTCOMES

Degree Level Expectation	Weight	Assessment Tools	Outcomes
<b>Depth and breadth of knowledge</b>	40%	<ul style="list-style-type: none"> <li>• Assignments</li> <li>• Examinations</li> </ul>	<ul style="list-style-type: none"> <li>• Understanding of advanced concepts and theories</li> <li>• Awareness of important current problems in the field of study</li> <li>• Understanding of computational and/or empirical methodologies to solve related problems</li> </ul>
<b>Research &amp; scholarship</b>	NA	<ul style="list-style-type: none"> <li>• Project</li> </ul>	<ul style="list-style-type: none"> <li>• Ability to conduct critical evaluation of current advancements in the field of specialization</li> </ul>

			<ul style="list-style-type: none"> <li>Ability to conduct coherent and thorough analyses of complex problems using established techniques/principles and judgment</li> </ul>
<b>Application of knowledge</b>	40%	<ul style="list-style-type: none"> <li>Assignments</li> <li>Examinations</li> </ul>	<ul style="list-style-type: none"> <li>Ability to apply knowledge in a rational way to analyze a particular problem</li> <li>Ability to use coherent approach to design a particular engineering system using existing design tools</li> </ul>
<b>Professional capacity / autonomy</b>	NA	<ul style="list-style-type: none"> <li>Project</li> </ul>	<ul style="list-style-type: none"> <li>Awareness of academic integrity</li> <li>Ability to implement established procedures and practices in the coursework</li> <li>Defends own ideas and conclusions</li> <li>Integrates reflection into his/her learning process</li> </ul>
<b>Communication skills</b>	10%	<ul style="list-style-type: none"> <li>Assignments</li> <li>Examinations</li> </ul>	<ul style="list-style-type: none"> <li>Ability to communicate (oral and/or written) ideas, issues, results and conclusions clearly and effectively</li> </ul>
<b>Awareness of limits of knowledge</b>	10%	<ul style="list-style-type: none"> <li>Assignments</li> <li>Examinations</li> </ul>	<ul style="list-style-type: none"> <li>Awareness of the need of assumptions in complex scientific analyses and their consequences</li> <li>Understanding of the difference between theoretical and empirical approaches</li> <li>Ability to acknowledge analytical limitation due to complexity of practical problems</li> </ul>

## ASSESSMENTS

Assessment Type	Material Covered	Tentative Due Date	Weight
Homework Assignments	Topics 1, 2, 3, 4	Three days after each topic is completed	40%
Participation (in class or assignments)	Topics 1, 2, 3, 4,5	Random	10%
Final Exam	Topics 1, 2, 4, 5	End of course	50%

### **Activities in which collaboration is permitted:**

- Students can collaborate in solving assignments, but each student must submit their assignment separately.

### **Activities in which students must work alone (collaboration is not permitted):**

- Final Exam

## REQUIRED TEXTBOOK

None.

## **OPTIONAL COURSE READINGS**

MacGregor, J. G. and Bartlett, F. M. (2000): *Reinforced Concrete: Mechanics and Design (1<sup>st</sup> Canadian Edition)*. Prentice-Hall Canada Inc.

## **CHEATING, PLAGIARISM/ACADEMIC OFFENCES**

Academic integrity is an essential component of learning activities. Students must have a clear understanding of the course activities in which they are expected to work alone (and what working alone implies) and the activities in which they can collaborate or seek help; see information above and ask instructor for clarification if needed. Any unauthorized forms of help-seeking or collaboration will be considered an academic offense. University policy states that cheating is an academic offence. If you are caught cheating, there will be no second warning. Students must write their essays and assignments in their own words. Whenever students take an idea or a passage of text from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing such as footnotes or citations. Plagiarism is a major academic offence. Academic offences are taken seriously and attended by academic penalties which may include expulsion from the program. Students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence at the following website: [https://www.uwo.ca/univsec/pdf/academic\\_policies/appeals/scholastic\\_discipline\\_grad.pdf](https://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_grad.pdf)

## **CONDUCT**

Students are expected to follow proper etiquette to maintain an appropriate and respectful academic environment. Any student who, in the opinion of the instructor, is not appropriately participating in course activities and/or is not following the rules and responsibilities associated with the course activities, will be reported to the Associate Dean (Graduate) (after due warning has been given). On the recommendation of the Department concerned, and with the permission of the Associate Dean (Graduate), the student could be debarred from completing the assessment activities in the course as appropriate.

## **HEALTH/WELLNESS SERVICES**

As part of a successful graduate student experience at Western, we encourage students to make their health and wellness a priority. Western provides several health and wellness related services to help you achieve optimum health and engage in healthy living while pursuing your graduate degree. Information regarding health- and wellness-related services available to students may be found at <http://www.health.uwo.ca/>.

Students seeking help regarding mental health concerns are advised to speak to someone they feel comfortable confiding in, such as their faculty supervisor, their program director (graduate chair), or other relevant administrators in their unit. Faculty of Engineering has a Student Wellness Counsellor. Information on how to schedule an appointment with the counsellor is available at: <https://www.eng.uwo.ca/undergraduate/academic-support-and-accommodations/Student-Wellness-Counselling.html>.

Students who are in emotional/mental distress should refer to Mental Health@Western: <http://www.uwo.ca/uwocom/mentalhealth/> for a complete list of options about how to obtain help.

## **STATEMENT ON GENDER-BASED AND SEXUAL VIOLENCE**

Western is committed to reducing incidents of gender-based and sexual violence (GBSV) and providing compassionate support to anyone who is going through or has gone through these traumatic events. If you are experiencing or have experienced GBSV (either recently or in the past), you will find information about support services for survivors, including emergency contacts at the following website: [https://www.uwo.ca/health/student\\_support/survivor\\_support/get-help.html](https://www.uwo.ca/health/student_support/survivor_support/get-help.html). To connect with a case manager or set up an appointment, please contact [support@uwo.ca](mailto:support@uwo.ca).

## **SICKNESS**

Students should immediately consult with the Instructor (for a particular course) or Associate Chair (Graduate) (for a range of courses) if they have problems that could affect their performance. The student should seek advice from the Instructor or Associate Chair (Graduate) regarding how best to deal with the problem. Failure to notify the Instructor or the Associate Chair (Graduate) immediately (or as soon as possible thereafter) will have a negative effect on any appeal. Obtaining appropriate documentation (e.g., a note from the doctor) is valuable when asking for accommodation due to illness.

Students who are not able to meet certain academic responsibilities due to medical, compassionate or other legitimate reason(s), could request for academic consideration. The Graduate Academic Accommodation Policy and Procedure details are available at:

<https://www.eng.uwo.ca/graduate/current-students/academic-support-and-accommodations/index.html>

## **ACCESSIBLE EDUCATION WESTERN (AEW)**

Western is committed to achieving barrier-free accessibility for all its members, including graduate students. As part of this commitment, Western provides a variety of services devoted to promoting, advocating, and accommodating persons with disabilities in their respective graduate program. Graduate students with disabilities (for example, chronic illnesses, mental health conditions, mobility impairments) are strongly encouraged to register with Accessible Education Western (AEW): [http://academicsupport.uwo.ca/accessible\\_education/index.html](http://academicsupport.uwo.ca/accessible_education/index.html)

AEW is a confidential service designed to support graduate and undergraduate students through their academic program. With the appropriate documentation, the student will work with both AEW and their graduate programs (normally their Graduate Chair and/or Course instructor) to ensure that appropriate academic accommodations to program requirements are arranged. These accommodations include individual counselling, alternative formatted literature, accessible campus transportation, learning strategy instruction, writing exams and assistive technology instruction.