McGill University
Department of Civil Engineering

CIVE 463 – Sustainable Design of Concrete Structures

Winter 2024

Course handbook

Prof. D.Malomo
daniele.malomo@mcgill.ca

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Course Outline

CIVE 463

Course Title:	**Sustainable Design of Concrete Structures**
Credits:	3
Contact Hours:	(3-3-3)
Course Prerequisite(s):	CIVE 318
Course Corequisite(s):	N/A
Course Description:	**Design of reinforced concrete members (e.g., beams, one-way slabs, columns, disturbed regions, two-way slabs, shear walls, footings, retaining wall) with considerations for sustainability, structural resiliency, and ethical impacts. Aspects of seismic design of columns and shear walls. Introduction to design software, the design of prestressed concrete members, sustainable material selection, and green building design.**

Canadian Engineering Accreditation Board (CEAB) Curriculum Content

CEAB curriculum category content	Number of AU's	Description
Math	0	Mathematics include appropriate elements of linear algebra, differential and integral calculus, differential equations, probability, statistics, numerical analysis, and discrete mathematics.
Natural science	0	Natural science includes elements of physics and chemistry, as well as life sciences and earth sciences. The subjects are intended to impart an understanding of natural phenomena and relationships through the use of analytical and/or experimental techniques.
Complementary studies	0	Complementary studies include the following areas of study to complement the technical content of the curriculum: engineering economics and project management; the impact of technology on society; subject matter that deals with the arts, humanities and social sciences; management; oral and written communications; health and safety; professionalism, ethics, equity and law; and sustainable development and environmental stewardship.
Engineering science	29.3	Engineering science involves the application of mathematics and natural science to practical problems. They may involve the development of mathematical or numerical techniques, modeling, simulation, and experimental procedures. Such subjects include, among others, applied aspects of strength of materials, fluid mechanics, thermodynamics, electrical and electronic circuits, soil mechanics, automatic control, aerodynamics, transport phenomena, elements of materials science, geoscience, computer science, and environmental science.
Engineering design	29.3	Engineering design integrates mathematics, natural sciences, engineering sciences, and complementary studies in order to develop elements, systems, and processes to meet specific needs. It is a creative, iterative, and open-ended process, subject to constraints which may be governed by standards or legislation to varying degrees depending upon the discipline. These constraints may also relate to economic, health, safety, environmental, societal or other interdisciplinary factors.

Accreditation units (AU's) are defined on an hourly basis for an activity which is granted academic credit and for which the associated number of hours corresponds to the actual contact time: one hour of lecture (corresponding to 50 minutes of activity) = 1 AU; one hour of laboratory or scheduled tutorial = 0.5 AU. Classes of other than the nominal 50-minute duration are treated proportionally. In assessing the time assigned to determine the AU's of various components of the curriculum, the actual instruction time exclusive of final examinations is used.

Graduate Attributes

This course contributes to the acquisition of graduate attributes as follows:

Graduate attribute	KB	PA	IN	DE	ET	IT	CS	PR	IE	EE	EP	LL
Level descriptor		A		D	D							

I = Introduced; D = Developed; A = Applied

KB - Knowledge Base for Engineering: Demonstrated competence in university level mathematics, natural sciences, engineering fundamentals, and specialized engineering knowledge appropriate to the program.

PA - Problem Analysis: An ability to use appropriate knowledge and skills to identify, formulate, analyze, and solve complex engineering problems in order to reach substantiated conclusions.

IN - Investigation: An ability to conduct investigations of complex problems by methods that include appropriate experiments, analysis and interpretation of data, and synthesis of information in order to reach valid conclusions.

DE - Design: An ability to design solutions for complex, open-ended engineering problems and to design systems, components or processes that meet specified needs with appropriate attention to health and safety risks, applicable standards, economic, environmental, cultural and societal considerations.

ET - Use of Engineering Tools: An ability to create, select, adapt, and extend appropriate techniques, resources, and modern engineering tools to a range of engineering activities, from simple to complex, with an understanding of the associated limitations.

IT - Individual and Team Work: An ability to work effectively as a member and leader in teams, preferably in a multi-disciplinary setting.

CS - Communication Skills: An ability to communicate complex engineering concepts within the profession and with society at large. Such abilities include reading, writing, speaking and listening, and the ability to comprehend and write effective reports and design documentation, and to give and effectively respond to clear instructions.

PR - Professionalism: An understanding of the roles and responsibilities of the professional engineer in society, especially the primary role of protection of the public and the public interest.

IE - Impact of Engineering on Society and the Environment: An ability to analyse social and environmental aspects of engineering activities. Such abilities include an understanding of the interactions that engineering has with the economic, social, health, safety, legal, and cultural aspects of society; the uncertainties in the prediction of such interactions; and the concepts of sustainable design and development and environmental stewardship.

EE - Ethics and Equity: An ability to apply professional ethics, accountability, and equity.

EP - Economics and Project Management: An ability to appropriately incorporate economics and business practices including project, risk and change management into the practice of engineering, and to understand their limitations.

LL - Life-Long Learning: An ability to identify and to address their own educational needs in a changing world, sufficiently to maintain their competence and contribute to the advancement of knowledge.

Policies

Academic Integrity

McGill University values academic integrity. Therefore, all students must understand the meaning and consequences of cheating, plagiarism and other academic offences under the Code of Student Conduct and Disciplinary Procedures.
(see www.mcgill.ca/students/srr/honest/ for more information).
(approved by Senate on 29 January 2003)

In accord with McGill University's Charter of Students' Rights, students in this course have the right to submit in English or in French any written work that is to be graded.
(approved by Senate on 21 January 2009)

Grading Policy

In the Faculty of Engineering, letter grades are assigned according to the grading scheme adopted by the professor in charge of a particular course. This may not correspond to practices in other Faculty and Schools in the University.

In the event of extraordinary circumstances beyond the University's control, the content and/or evaluation scheme in this course is subject to change.

COURSE DETAILS

Instructor: Prof. D. Malomo; office hours: Mon/Wed (11.35 AM – 12.35 PM – booking in advance only)

Lecture hours: Tue/Thu (10.05 AM – 11.25 AM),

Lecture delivery mode: in-person – Macdonald Engineering Building, room 276.

TAs: Tutorial leader: L. Davis (lucy.davis@mail.mcgill.ca; office hours: Tue 3 PM – 4 PM, room MD292
Assignments: M. Hosny (mohamed.hosny@mail.mcgill.ca; office hours: Wed 1 PM – 2 PM, room MD292
Grading support for exams (moustafa.el-assaly@mail.mcgill.ca); office hours: TBD

Tutorial hours: Fri (8.35 AM – 11.25 AM). First tutorial session on 12 January 2024.

Tutorial delivery mode: in-person – Macdonald Engineering Building, room 279.

Office hours appointments: instructor/TAs office hours (in-person only) must be booked via this link.

Required course material: course slides and notes will be uploaded on MyCourses.

Suggested readings: 1) J. Pao, S. Brzev, *Reinforced Concrete Design: A Practical Approach*, 3rd Ed. (Pearson); 2) Concrete Design Handbook, 4th Ed., Cement Association of Canada; 3) CSA A23.3-19, Design of Concrete Structures, Canadian Standards Association; 4) National Building Code of Canada 2020.

Instructor-students communication: As the instructor of this course it is my goal to provide an inclusive, productive and stimulating learning environment. However, if you experience barriers or any other sort of difficulty in learning in this course, do not hesitate to reach out via email or after class.

Note: all important course communications will be transmitted via MyCourses, *announcements* tab.

EVALUATION

Marking scheme and grading policy:

Assignments	(group)	25% (5 bi-weekly assignments submitted by group leaders via MyCourses)
Midterm	(individual)	25% (in-person)
Final Exam	(individual)	50% (in-person)

Midterm: open book/notes, 2 hours.
Final exam: open book/notes, 3 hours

NO late submissions accepted. Assessments are evaluated based on worked solution (not necessarily correct answer). Solutions and marked assignments will be made available through MyCourses.

A sign-up form will be sent out early in the semester asking students to create groups of 3/4 people, which must be the same for the whole duration of the course (if you do not have a group, we will form it for you). Students should indicate on the form the name of the group leader in charge of MyCourses ‘submissions.

Numerical (percentage) to letter grade conversion: Assignments will be graded in this course using percentages. Please refer to the table reported here for converting to letter grade system.

INFO ON SUBMISSIONS

1 - Neat, legible and logically presented design calculations are expected. Figures or graphs should be used when they help to clarify the work. Marks will be deducted if these requirements are unsatisfactory.

2 - When numerical information is obtained from a text or design standard and used in design calculations, reference should be given to the Table, Clause, page number, etc.

3 - The essential component of any design course is the working out of design problems. It is of great importance that every student participates fully in the tutorial periods. Many assignment questions will be representative of questions in the class test and final exam.

4 – Tutorials will involve work sessions with the TA to help you with the assignments. Attempt assignment questions covered in lectures before the tutorial. Please ask any questions on course material or assignments.

COURSE CONTENT

1. Design and sustainability principles
2. Design of members under flexure
3. Design of columns
4. Design of members under shear
5. Design of disturbed regions
6. Design of two-way slabs
7. Design of footings
8. Design of retaining walls
9. Design of shear walls
10. Intro to prestressed concrete design
11. Sustainable and holistic design methods and examples

Learning outcomes (LO):

1. To describe the principles underlying mechanics of materials necessary for evaluating and designing reinforced concrete structures and their impact on carbon emissions (topics from course content 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11), **2**. To describe the design process of reinforced concrete structures (topics from course content 1, 2, 3, 4, 5, 6, 7, 8, 9, 10), **3**. To examine and define the final design of reinforced concrete structures and holistically evaluate for sustainability metrics (topics from course content 2, 3, 4, 6, 7, 8, 9, 11).

Graduate attributes (GA):

– *Problem Analysis* **- PA.3:** analyzes and solves complex engineering problems
– *Design* - **DE.4:** implements and evaluates a final design
– *Use of Engineering Tools* - **ET.1:** Selects and uses tools

Table 1. Correlation between LO, AU's, GA indicators and evaluation methods

LO #	AU	GA indicators	Evaluations
1	Engineering Science: 27.3 Engineering Design: 27.3	Problem Analysis.3 (A) Design.4 (D)	Assignments 1, 2, 3, 4, 5 Midterm, Final exam
2	Engineering Science: 2 Engineering Design: 2	Engineering Tools.1 (D)	Assignments 1, 2, 3, 4, 5
TOTAL	29.3 (ES) + 29.3 (ED) = 58.6	-	-

LO#: learning outcome number, **AU**: CEAB accreditation units
GA: graduate attributes – (I) introduced, (D) developed, (A) applied
ES: Engineering Science, **ED**: Engineering Design

ADDITIONAL POLICY STATEMENTS

Confidential materials: instructor-generated course materials are protected by law and may not be copied or distributed in any form without the written permission of the instructor. Infringements of copyright can be subject to follow up by the University under the Code of Student Conduct and Disciplinary Procedures.

Recorded lectures on Zoom: if required by the University health protocols, lectures and tutorials will be held online. Please read the Guidelines for teaching and learning and this document. You will be notified through a "pop-up" box in Zoom if part of a class is being recorded. By remaining in sessions that are recorded, you agree to the recording, and you understand that your image, voice, and name may be disclosed to classmates. You also understand that recordings will be made available in MyCourses to students registered in the course.

Changes due to extraordinary circumstances: In the event of extraordinary circumstances beyond the University's control, the content and/or evaluation scheme in this course is subject to change.

LINKING TEACHING ACTIVITIES AND AU:

Lectures: #26 × 1.5 hours = 39 AU
Tutorials: #14 × 3 hours = 42 AU/2 = 21 AU

Total: (39 + 21) AU = 60 AU (this edition of the course) > 58.6 AU (Faculty outline)

Date	Week	L/T/A	Sections covered in the slides/notes	LO
Jan 4	1	L0	*Course organization* + Chapter 1 – 1.1 to 1.11 – *Introduction I*	1
Jan 9	2	L1	Discussion – *Sustainable and holistic design methods*	1, 2
Jan 11		L2	Chapter 2 – 1.1 to 2.11 – *Review of flexural behaviour*	1, 2
Jan 12		T1	Tutorial # 1 on L1, L2 – work session on A1	1, 2, 3
		A1	Assignment #1 (beams) – L1 to L4 – due by the end of **Jan 26**	1, 2, 3
Jan 16	3	L3	Chapter 3 – 3.1 to 3.13 – *Design of members under flexure 1*	1, 2, 3
Jan 18		L4	Chapter 3 – 3.14 to 3.25 – *Design of members under flexure 2*	2, 3
Jan 19		T2	Tutorial # 2 – L3, L4 – work session on A1	1, 2, 3
Jan 23	4	L5	Chapter 4 – 4.1 to 4.13 – *Design of columns 1*	1, 2, 3
Jan 25		L6	Chapter 4 – 4.14 to 4.23 – *Design of columns 2*	2, 3
Jan 26		T3	Tutorial # 3 – L5, L6 – work session on A2	1, 2, 3
		A2	Assignment #2 (columns) – L5 to L7 – due by the end of **Feb 9**	1, 2, 3
Jan 30	5	L7	Chapter 4 – 4.24 to 4.42 – *Design of columns 3*	2, 3
Feb 1		L8	Chapter 5 – 5.1 to 5.18 – *Shear behaviour design 1*	1, 2, 3
Feb 2		T4	Tutorial # 4 – L5 to L7 – work session on A2	1, 2, 3
Feb 6	6	L9	Chapter 5 – 5.19 to 5.30 – *Shear behaviour design 2*	2, 3
Feb 8		L10	Chapter 5 – 5.31 to 5.45 – *Shear behaviour design 3*	2, 3
Feb 9		T5	Tutorial # 5 – L8, L9, L10 – work session on A3	1, 2, 3
		A3	Assignment #3 (slabs) – L8 to L12 – due by end of **Mar 1**	1, 2, 3
Feb 13	7	L11	Chapter 6 – 6.1 to 6.12 – *Shear behaviour design 4*	2, 3
Feb 15		L12	Chapter 6 – 6.13 to 6.31 – *Design of disturbed regions*	1, 2
Feb 16		T6	Tutorial # 6 – L11, L12 – work session on A3	1, 2, 3
Feb 20	8	L13	Review for Midterm exam (L1 to L12)	1, 2, 3
Feb 22			**Midterm** (L1 to L12)	1, 2, 3
Feb 23		T7	Tutorial # 7 – Midterm solutions	1, 2, 3
Feb 27	9	L14	Chapter 7 – 7.1 to 7.17 – *Design of two-way slabs 1*	1, 2, 3
Feb 29		L15	Chapter 7 – 7.18 to 7.34 – *Design of two-way slabs 2*	2, 3
Mar 1		T8	Tutorial # 8 – L14, L15 – work session on A4	1, 2, 3
		A4	Assignment #4 (footings) – L14 to L17 – due by end of **Mar 22**	1, 2, 3
Mar 4 – Mar 8			**Winter Reading Break**	

Date	Week	L/T/A	Sections covered in the slides/notes	LO
Mar 12	10	L16	Chapter 8 – 8.1 to 8.11 – *Design of two-way slabs 3*	2, 3
Mar 14		L17	Chapter 8 – 8.12 to 8.22 – *Design of footings*	1, 2, 3
Mar 15		T9	Tutorial # 9 – L16, L17 – work session on A4	1, 2, 3
Mar 19	11	L18	Chapter 9 – 9.1 to 9.11 – *Design of walls 1*	1, 2, 3
Mar 21		L19	Chapter 9 – 9.12 to 9.22 – *Design of walls 2*	2, 3
Mar 22		T10	Tutorial # 10 – L18, L19 – work session on A5	1, 2, 3
		A5	Assignment #5 (walls) – L20 to L21 – due by the end of **Apr 6**	1, 2, 3
Mar 26	12	L20	Chapter 10 – 10.1 to 10.11 – *Design of walls 3*	2, 3
Mar 28		L21	Chapter 11 – 11.1 to 11.52 – *Intro to prestressed concrete*	1, 2
Mar 29		T11	Tutorial # 11 – L20 – work session on A5	1, 2, 3
Apr 2	13	L22	Discussion – *Sustainable and holistic design examples*	1, 2
Apr 4		L23	Preparation for the final exam – discussion on made-up solutions	1, 2, 3
Apr 5		T12	Tutorial # 12 – Preparation for the final exam – solving exercises	1, 2, 3
Apr 9	14	L24	Preparation for the final exam – solving exercises	1, 2, 3
Apr 11		L25	Preparation for the final exam – Q&A session	1, 2, 3
Apr 12		T13	Tutorial # 13 – Preparation for the final exam – solving exercises	1, 2, 3
Apr 19			**Final Exam** (L1 to L22)	1, 2, 3