University of Macau

Undergraduate Civil Engineering Programme

Coordinating Unit:	Department of Civil and Environmental Engineering, Faculty of Science and Technology		
Supporting Unit(s):	Nil		
Course Code:	CEEB321	Year of Study:	3
Course Title:	Reinforced Concrete Design		
Compulsory/Elective:	Compulsory		
Course Prerequisites:	CEEB224 Structural Analysis		
Prerequisite Knowledge:	Load estimation skills and structural analysis capability, particularly shear and moment diagrams obtained from static analysis under the appropriate loads.		
Duration:	One semester	Credit Units:	3
Class/Laboratory Schedule:	Three hours of lecture and one hour of tutorial per week.		
Laboratory/Software Usage:	The design software SAP2000 is adopted.		
Course Description:	This course covers the following topics: reinforced concrete material properties; limit state design concepts; introduction to European design standards (i.e. Eurocodes 1 and 2); analysis of frames and shear wall structures; analysis of sections in bending and/or axial loads; yield line and strip methods for slabs; behavior and design of reinforced concrete beams, one-way slabs and two-way slabs considering flexure, shear, anchorage, curtailment and serviceability requirements; behavior and design of short and slender columns under combined bending and axial loads.		
Course Objectives:	1. To introduce to students the theory and application of analysis and design of reinforced concrete structures. 2. To develop students with an understanding of the behavior and design of reinforced concrete members and systems. 3. To prepare students for the effective use of the latest industry standard formulas, tables, design aids and computer software in the design of reinforced concrete members.		
Learning Outcomes (LO):	Upon completion of this course, students should be able to: 1. recognize the design philosophy of reinforced concrete structures [POs: a,c]; 2. apply techniques and computer software to analyze reinforced concrete structural systems under gravity and lateral loads [POs: a,e,l]; 3. identify the typical failure modes of reinforced concrete members, and determine appropriate approaches to calculate the design strength for each typical failure mode [POs: a,c,e]; 4. apply the principles, procedures and current code requirements to the analysis and design of reinforced concrete beams, slabs and columns [POs: a,c,e]. 5. work in groups in the solution of analysis and/or design problems and adequately present technical information of engineering solutions [POs: d,g]		
Texts & References: *(* recommended textbook(s))*	1. Mosley, W.H., Bungey, J.H., and Hulse, R. (2012)*, *Reinforced Concrete Design to Eurocode 2*, 7th ed., Palgrave Macmillan, U.K. 2. BSI (2004), *BS EN1992-1-1:2004, Eurocode 2: Design of Concrete Structures – Part 1-1 General rules and rules for buildings*, British Standard Institution, U.K. 3. Jacobs, J.P. (2008a), *Eurocode 2 – Commentary*, European Concrete Platform ASBL, Belgium. 4. Jacobs, J.P. (2008b), *Eurocode 2 – Worked Examples*, European Concrete Platform ASBL, Belgium. 5. Narayanan, R.S., and Beeby A. (2005), *Designers' Guide to EN1992-1-1 and EN1992-1-2 Eurocode 2: Design of Concrete Structures. General Rules and Rules for Buildings and Structural Fire Design*, Thomas Telford Ltd, London.		

	6. Betonvereniging, The Concrete Society and Deutscher Beton-Verein (2005), *Design Aids for EC2 – Design of Concrete Structures*, 2005 edition, E & FN Spon, London.
Student Assessment:	• One test/mid-term examination: 30%; • One project (teamwork): 35%; • One final examination: 35%
Learning Outcome Assessment:	• Tests, project, and final examination. • Course evaluation
Pedagogical Methods:	☑ Lecture ☐ Service learning ☐ Guest speakers ☐ Internship ☐ Case study ☐ Field study ☐ Role playing ☐ Company visits ☑ Student presentation ☐ e-learning ☑ Project ☑ Independent study ☐ Simulation game ☑ Others: Computer software lab ☑ Exercises and problems

Major Assessment Methods: For each Major Assessment Method below, please indicate the specific pedagogical methods involved (by putting a ✓ in the relevant box(es) on the right-hand side).	Case Study	Role Playing	Student Presentation	Individual project/paper	Group project/paper	Simulation Game	Exercises & problems	Service learning	Internship	Field Study	Company visits	Written examination	Oral examination	Others (please specify)
Class Participation/ Discussion														
Assignment(s)														
Test(s)												✓		
Examination												✓		
Others *(please specify)* Team Project			✓		✓									
Course Web: (if any)	Course materials are available in UMMoodle (http://webcourse.umac.mo/).													

Course Content: (topic outline)

Week no.	Topics	LO no.
1	**Properties of Concrete & Reinforcing steel** Stress-strain relations; composite action; creep; shrinkage and thermal movement; specification of materials	1
2,3	**Limit State Design Concepts** Limit states; partial factors of safety; load combinations; introduction to Eurocode 1	1, 5
3,4	**Analysis of Structures** Shear and moment envelopes; analysis of frames and sub-frames; simplified analysis for lateral loads, analysis of shear walled structures	2, 5
5,6	**Section Analysis** Introduction to Eurocode 2; distribution of stress and strain across a section in bending and/or axial loads, equivalent stress blocks; singly reinforced rectangular section in bending at the ultimate limit state (ULS); doubly reinforced rectangular section in bending at ULS; analysis of flanged sections in bending; section analysis for combined bending and axial loads	3, 4
7	**Analysis and Design for Shear in Beam** Strut inclination method; vertical shear links and bent-up bars; longitudinal shear in flanged sections.	3
8	**Anchorage bond and Laps in reinforcement** Anchorage length design; lap length; Hooks and loops	3, 4
8	**Serviceability and Durability** Detailing requirement for serviceability and durability; deflection controls; crack controls	4
9,10	**Design of Reinforced Concrete Beam** Preliminary sizing; simply supported beam; continuous beams; design procedures for bending and shear; curtailment and anchorage of reinforcement	3, 4
11,12	**Analysis and Design of Solid Slabs** Shear and bending in slabs; one-way slabs; two-way slabs (simply supported and restrained); deflection controls for slabs; curtailment and anchorage of reinforcement; simplified analysis using moment and shear coefficients; yield line method; Hilleborg strip method	3, 4
13,14	**Design of columns** Preliminary sizing; slenderness; short columns under uni-axial bending and axial loads; short columns under biaxial bending and axial loads; design of slender columns	3, 4

Percentage Content of:

Mathematics and Basic Sciences	Engineering Subjects	Complementary Studies	Total
10	90	---	100

Timetabled work in hours per week:

Lecture	Tutorial	Laboratory	Other	Total
3	1	---	---	4

Contribution to Programme Outcomes:	

Programme Outcomes	Contribution to POs#	
	Primary	Secondary
(a) an ability to apply knowledge of mathematics, science, and engineering appropriate to the degree discipline	✓	
(b) an ability to design and conduct experiments, as well as to analyse and interpret data		
(c) an ability to design a system, component or process to meet desired needs within realistic constraints, such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability	✓	
(d) an ability to function on multi-disciplinary teams	✓	
(e) an ability to identify, formulate and solve engineering problems	✓	
(f) an ability to understand professional and ethical responsibility		
(g) an ability to communicate effectively		✓
(h) an ability to understand the impact of engineering solutions in a global and societal context, especially the importance of health, safety and environmental considerations to both workers and the general public		
(i) an ability to stay abreast of contemporary issues		
(j) an ability to recognise the need for, and to engage in life-long learning		
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice appropriate to the degree discipline		
(l) an ability to use the computer/IT tools relevant to the discipline along with an understanding of their processes and limitations		✓

Course Instructor(s):	Prof. Wai-Meng QUACH (Please refer to the following link for the consultation hours of the course instructor: http://www.fst.umac.mo/cee/contacthour.html)