# CV4120 ADVANCED REINFORCED CONCRETE DESIGN

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| Academic Year | 2023-24 | Semester | 2 |
| Course Coordinator | | | |
| Course Type | Major Prescribed Elective | | |
| Pre-requisites | CV3011 Reinforced Concrete Design | | |
| AU | 3 | | |
| Grading | Letter Grading | | |
| Contact Hours | 39 (26 hours lecture and 13 hours Tutorial) | | |
| Proposal Date | 10 October 2022 | | |

**Course Aims**

This course aims to:

1. Equip students with advanced mechanics based on fundamental theorems on reinforced and prestressed concrete structures

2. Develop their skills to conduct independent analysis and design of reinforced and prestressed concrete structures.

**Intended Learning Outcomes (ILO)**

By the end of this course, student will be able to:

1. Analyze and design RC frames using Upper Bound methods and applications to seismic loading conditions.

2. Analyze and design disturbed regions of RC structures using Lower Bound method – Strut and Tie Approach.

3. Analyze and design slabs using Upper Bound method – Yield Line Theory.

4. Analyze and design slabs using Lower Bound method – Strip Method.

5. Analyze and design sub-structures with flat slabs using Lower Bound method.

6. Differentiate the two prestressed concrete system - pre-tension and post tension.

7. Calculate prestressed losses for both systems.

8. Select suitable prestressing force and tendon profile using inequality equations.

9. Design based on load-balancing approach.

10. Calculate shear, diagonal tension and web reinforcement and ultimate strength.

11. Calculate deflections and crack widths of prestressed concrete members and apply methods of deflection and crack width control.

12. Design flat slabs with post-tension system

**Course Content**

| No | Topic | Lecture Hours | Tutorial Hours |
|---|---|---|---|
| 1 | Limit analysis of RC frames | 3 | 1 |
| 2 | Strut and tie models | 4 | 2 |
| 3 | Yield line method for slabs | 3 | 2 |
| 4 | Strip method for slabs | 4 | 2 |
| 5 | Analysis of sub-structures and flat slabs | 2 | 1 |
| 6 | Prestressed concrete design | 6 | 3 |
| 7 | Design for serviceability limit state: deflections & cracks | 2 | 1 |
| 8 | Design flat slabs with post tension system | 2 | 1 |
| | **Total:** | **26** | **13** |

**Assessment (Includes both continuous and summative assessment)**

| Component | ILO Tested | EAB Graduate Attributes | Weightage | Team / Individual | Rubrics |
|---|---|---|---|---|---|
| 1. CA1: Quiz 1 | 1,2,3,4,5 | a, b, c | 20% | Individual | N.A. |
| 2. CA2: Quiz 2 | 6,7,8,9 | a, b, c | 20% | Individual | N.A. |
| 3. Final Examination | 1 - 12 | a, b, c | 60% | Individual | N.A. |
| **Total** | | | **100%** | | |

| EAB Graduate Attributes[1] | |
|---|---|
| a) | **Engineering Knowledge**<br>Apply the knowledge of mathematics, natural science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems. |
| b) | **Problem Analysis**<br>Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| c) | **Design / Development of Solutions**<br>Design solutions for complex engineering problems and design systems, components or processes that meet the specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations. |
| d) | **Investigation**<br>Conduct investigations of complex problems using research-based knowledge and research methods including design of experiments, analysis and interpretation of data, |

[1] *Reference: EAB Accreditation Manual*

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| | and synthesis of the information to provide valid conclusions. |
| e) | **Modern Tool Usage**<br>Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations. |
| f) | **The Engineer and Society**<br>Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| g) | **Environment and Sustainability**<br>Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for the sustainable development. |
| h) | **Ethics**<br>Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| i) | **Individual and Team Work**<br>Function effectively as an individual, and as a member or leader in diverse teams and in multidisciplinary settings. |
| j) | **Communication**<br>Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| k) | **Project Management and Finance**<br>Demonstrate knowledge and understanding of the engineering management principles and economic decision-making, and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |
| l) | **Life-long Learning**<br>Recognise the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

**Formative Feedback**

Quiz feedback will be given to students for the common mistakes during lecture class.

**Learning & Teaching Approach**

| **Approach** | **How does this approach support students in achieving the learning outcomes?** |
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| Lectures | Weekly lectures to provide students with the necessary knowledge to achieve the learning outcomes |
| Tutorials | Weekly tutorials to enable the students to apply the knowledge into practice and hone their skills to achieve the learning outcomes |
| Quizzes | Continual assessments to enhance students understanding and ability to apply |

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| | principles learned during lectures and tutorials |

**Readings & References**


1. Wight, J.K., “Reinforced Concrete: Mechanics and Design”, 7th edition, Pearson/Prentice-Hall, 2015.

2. Darwin, D., Dolan, C.W. and Nilson, A.H., "Design of Concrete Structures", 15th edition, McGraw-Hill, New York, 2016.

3. O'Brien, E., Dixon, A. and Sheils, E., “Reinforced and Prestressed Concrete Design to EC2: The Complete Process” 2nd Edition (2013), Spon Press.

4. Gilbert, I.P., Mickleborough, N.C. and Ranzi, G, "Prestressed Concrete Design to Eurocode 2", 2nd Ed. CRC Press, Boca Raton, 2017

5. Hurst, M.K. , "Prestressed Concrete Design", 2nd edition, E & FN SPON, London, 1998.


**Course Policy & Student Responsibility**

***(1) General***

Students are expected to complete all assigned pre-class readings and activities, attend all classes punctually and take all scheduled assignments and tests by due dates. Students are expected to take responsibility to follow up with course notes, assignments, and course-related announcements for sessions they have missed. Students are expected to participate in all discussions and activities.

***(2) Absenteeism***

The quizzes make up a significant portion of your course grade. Absence from quizzes without a valid reason will affect your overall course grade. Valid reasons include falling sick supported by a medical certificate and participation in NTU’s approved activities supported by an excuse letter from the relevant bodies. There will be no make-up opportunities for quizzes.

**Academic Integrity**

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU’s shared values.

As a student, it is important that you recognise your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. On the use of technological tools (such as

Generative AI tools), different courses / assignments have different intended learning outcomes. Students should refer to the specific assignment instructions on their use and requirements and/or consult your instructors on how you can use these tools to help your learning. If you are uncertain about the definitions of any of these terms, you should refer to the Academic Integrity Handbook for more information. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

**Course Instructors**

| Instructor | Office | Phone | Email |
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## Planned Weekly Schedule

| Week | Topics | Course ILO | Reading /Activities |
|---|---|---|---|
| 1 | Frame models | 1 | Tutorial and lectures |
| 1 | Strut and Tie models | 2 | Tutorial and lectures |
| 2 | Strut and Tie models | 2 | Tutorial and lectures |
| 3 | Yield Line Method for slabs | 3 | Tutorial and lectures |
| 4 | Yield Line Method for slabs | 3 | Tutorial and lectures |
| 5 | Strip Method for slabs | 4 | Tutorial and lectures |
| 6 | Strip Method for slabs | 4 | Tutorial and lectures |
| 7 | Sub-structure and flat slab model | 1,5 | Tutorial and lectures |
| 9 | Prestressed Concrete Design – concept, pretension/post-tension system, material properties, losses of prestressing forces | 6,7 | Tutorial and lectures |
| 10 | Prestressed Concrete Design – Service Limit State, design equations, Magnel diagram, allowable stresses & prestressing forces | 8,9 | Tutorial and lectures |
| 11 | Prestressed Concrete Design – load balancing, tendon profile, shear, anchorage zone design and Ultimate Shear Resistance and Ultimate Flexural Resistance | 8,9,10 | Tutorial and lectures |
| 12 | Design for Serviceability Limit State: Deflection & Crack | 11 | Tutorial and lectures |

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| 13 | Prestressed Concrete Flat Slab example and compare with RC Flat Slab example | 6-12 | Tutorial and lectures |