University of Pavia

IUSS School of Advanced Studies

# Civil Engineering for Mitigation of Risk from Natural Hazards

**Course:** **Reinforced Concrete Structures**
a.y.: 2019-2020
Lecturer: Professor Guney Ozcebe
Date: 28/10/2019 – 22/11/2019
Classroom: TBA

**Course schedule:**
Lectures (L): From 09:00 to 12:00, Tutorials (T): From 13:30 to 15:30

| Week | Date | L | T | Subject | Total hrs |
|---|---|---|---|---|---|
| 1 | 28/10 | × | | **Introduction:** History of Prestressed Concrete (PC); Limitations of Reinforced Concrete; Reason for Prestressing; Basic Concepts of Prestressing; Prestressing Methods-Post Tensioned Concrete & Prestressed Concrete; Efficiency of Prestressing; Types of Prestress; PC vs RC; Prestressing Applications and Examples | 3 |
| | | | × | **Prestressing and Post Tensioning Technology:** Classification; Pre-Post Comparison; Ways of Applying Force; Prestressing Tendons - Where to Use; Prestressing Operations; Standard Precast Sections; Post Tensioning; Bonding of Tendons; Post Tensioning Systems; Post Tensioning Operations Pre-Tension vs Post-Tension | 2 |
| | 29/10 | × | | **Response of RC and PC Members Subjected to Axial Load:** Modelling of Uniaxial $\sigma$–$\varepsilon$ Properties: Concrete, Mild Steel Reinforcement and Prestressing Steel Tendon; Response Prediction of Axially Loaded Members;<br>**Losses:** Immediate Losses – Elastic Shortening, Anchorage Losses, Friction Losses; Time-Dependent Losses: Creep of Concrete, Shrinkage of Concrete; Relaxation of Steel; Approximate Loss Amounts. | 3 |
| | | | × | **Response of RC and PC Members Subjected to Axial Load (cont'd):** Accounting for Losses and Thermal Effects; Tensile Stresses in Concrete after Cracking – Tension Stiffening; Crack Widths and Crack Spacings. | 2 |
| | 30/10 | × | | **Examples on RC and PC Axial Response Calculations**<br>"Assignment #1: Axial Load" out<br>**Analysis of RC and PC Sections for Flexure:** Introduction to Flexural Behavior; Linear Modelling Approach for Flexural Response Analysis; Equilibrium Conditions; Compatibility Conditions for Bonded and Unbonded Tendons | 2<br>1 |
| | | | × | **Analysis of RC and PC Sections for Flexure:** Procedure to Obtain Nonlinear M–K Response of RC and PC Sections | 2 |
| | 31/10 | × | | **Analysis of RC and PC Sections for Flexure (cont'd):** Ultimate Moment Calculation – I Sections; Estimation of Camber and Deflections; Analysis of Composite Sections | 3 |
| | | | × | An Example on M-K Calculation. | 2 |
| | 01/11 | - | - | All Saints' Day | 0 |
| | | | | **Week #1 Total** | **20** |

| Week | Date | L | T | Subject | Total hrs |
|---|---|---|---|---|---|
| 2 | 04/11 (Mon) | × | | **Design for Flexure:** Types of Standard Precast Cross-Sections; Choice of Proper Cross-Section; Stress Limits; Tendon Layouts; Prestressing Strategies (ULS and SLS); Design stages; Deflection Checks. | 3 |
| | | | × | Examples on RC and PC Flexural Response Calculations<br>Assignment #1 in<br>"Assignment #2: Flexural Analysis" out | 2 |
| | 05/11 (Tue) | × | | **Design of Post Tensioned Members:** Design Process; Tendon Layouts – Main Principles; Estimating the Optimal Eccentricity; Duct Diameter; Recommended Minimum Radii of Curvature. Closed-form Expressions for Parabolic Tendons at External and Internal Spans. | 3 |
| | | | × | Design Examples<br>Assignment #2 in<br>"Assignment #3: Design" out | 2 |
| | 06/11 (Wed) | - | - | | 0 |
| | 07/11 (Thu) | × | | **Analysis and Design of Floor Systems:** Types of Floor Systems; Analysis and Design of One-Way Slabs; Yield Line Analysis of Two-Way Slabs. | 3 |
| | | | × | Example of YL Analyses and Design of Two-Way Slabs<br>Assignment #3 in<br>"Assignment #4: Design of 1-Way Slabs & YLA of 2-Way Slabs" out | 2 |
| | 08/11 (Fri) | × | | **Analysis and Design of Floor Systems (cont'd):** Flat Slabs. Torsion in Flat Slabs, Design for Punching. (EFM will be given as reading assignment.) | 3 |
| | | | × | Design Examples | 2 |
| | | | | **Week #2 Total** | **20** |
| 3 | 11/11 (Mon) | × | | **Footings:** Types of Footings; Soil Pressure under Footings, Structural Action of Spread and Strip Footings; Transfer of Load from Column to Footing; Design of Spread Footings. | 3 |
| | | | × | An Example of Spread Footing Design.<br>Assignment #4 in<br>"Assignment #5: 2-Way Slab Design & Punching" out | 2 |
| | 12/11 (Tue) | × | | **Footings (cont'd):** Design of Strip or Wall Footings; Design of Combined Footings; Pile Caps | 3 |
| | | | × | Example Designs on strip and combined footings. | 2 |
| | 13/11 (Wed) | - | - | | 0 |
| | 14/11 (Thu) | × | | **Torsion:** Pure Torsion; Torsional Stiffness; Combined Torsion, Flexure and Shear; Torsion in Structural Systems; Design for Equilibrium Torsion and Compatibility Torsion. | 3 |
| | | | × | Design Example(s)<br>Assignment #5 in<br>"Assignment #6: Torsion Design" out | 2 |
| | 15/11 (Fri) | - | - | | 0 |
| | | | | **Week #3 Total** | **15** |

| Week | Date | L | T | Subject | Total hrs |
|---|---|---|---|---|---|
| 4 | 18/11 (Mon) | × | | **Design of Disturbed Regions:** Strut-and-Tie Modelling. | 3 |
| | | | × | Sample Calculations using S&T Models – Deep Beams; Joints and Connections<br>Assignment #6 in<br>"Assignment #7: STM Applications" out | 2 |
| | 19/11 (Tue) | - | - | | |
| | 20/11 (Wed) | | × | Q&A Session<br>Assignment #7 in | |
| | 21/11 (Thu) | × | | Final Exam | 3 |
| | 22/11 (Fri) | | × | Announcement of Final Grades | - |
| | | | | **Week #4 Total** | **10** |
| | | | | **TOTAL LECTURE HOURS** | **65** |

**Brief Contents Description and Course Syllabus:**

The main objective of the course is to develop knowledge and skills necessary for the design of a variety of important reinforced and prestressed concrete members and structures as listed in the course content. The focus is placed on using fundamental principles (flow of forces, compatibility of deformations, stress-strain relationships, equilibrium) to solve different design problems from 1D (beams and girders) to 3D members and structures (single foundations, pile caps and wall systems). In this manner, the course develops a fundamental understanding of structural design which the students can apply to any other type of concrete structures not covered in the syllabus.

To maximize the learning outcome, the course will use a variety of different learning methods. The classes will include a combination of slide presentations, occasional blackboard lectures, solved demonstration problems, individual and group work of the students for solving challenging problems, video materials, reading and critically analyzing materials in the classroom. The students will participate actively by using first principles to solve analysis and design problems which are aimed at providing an important insight into the behavior of concrete structures. They will be guided towards the final solution by solving intermediate problems with increasing complexity.

**Student Workload:**

Estimated as 168-173 hrs. Please note: 1 ECTS Credits = 25-30 hrs. 6 ECTS = 150 – 180 hrs.
Lectures & Tutorials..... 65 hrs
Resource Review & Course Readings..... 80 hrs
Assignment Reports ..... 20-25 hrs
Final Exam..... 3 hrs

**Final Grade:**

max [(60 percent of Final Exam Mark + 40 percent of Average Assignment Mark), Final Exam Mark]
The exam will consist of two parts: exercises (open book) and theory (closed book)

**Office hours:** by appointment