UNICUSANO
ROME

Italian code: ICAR/09 (old) – CEAR-07/A (new) **Credits: 12**
Course: Structural Engineering
Main language of instruction: Italian
Other language of instruction: English

Head instructor
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Objectives

The course aims to deepen the understanding of the statics of reinforced concrete structures, providing the tools and methods necessary for designing and evaluating the safety level of structures of primary interest to civil engineers. The course is divided into macro-modules addressing the theory and techniques of reinforced concrete and the structural analysis and design of reinforced concrete buildings.
The e-tivities associated with the course are designed to enhance understanding of specific and fundamental topics. Specifically, two e-tivities are offered to achieve a comprehensive understanding of the Theory and Techniques of Reinforced Concrete Structures and Structural Analysis. Additionally, one e-tivity focuses on the structural design of a building, where students will be guided in drafting a fully detailed project (executive level) for the main and secondary structural elements.
Students who successfully complete the final exam will acquire specialized knowledge of the principles, methodologies, and tools for modelling and analysing newly constructed reinforced concrete structures. They will also be able to interpret structural modelling results and apply the acquired knowledge to design and characterize the structural behavior of components and civil structural systems for building construction.

Course structure

The course has the following educational objectives:

- Evaluate the stress state in simple structural models.
- Define a reinforced concrete section and understand its behavioral models.
- Select the most appropriate structural models to describe a reinforced concrete structure.

- Identify the loads acting on a building.
- Define the functioning models of the main structural elements and select simplified structural models for individual components.
- Design the individual structural elements of a reinforced concrete building for static loads.
- Assess the static behavior of a reinforced concrete structure concerning ultimate and serviceability limit states.

Competencies

A. Knowledge and understanding:

At the end of the course, the student will have demonstrated the ability to identify the loads acting on a building, understand the behavioural models of a reinforced concrete section under various stress states, and define the functional models of the main structural elements.

B. Applying knowledge and understanding:

By the end of the course, the student will be able to use the acquired knowledge to evaluate the stress state in simple structural models, define a reinforced concrete section and characterize its structural behavior, and select simplified structural models for individual structural elements.

C. Making judgements:

At the end of the course, the student will be capable of selecting the most appropriate structural models to define a reinforced concrete structure, statically design its individual structural elements, and evaluate the static behavior of the structure.

D. Communication skills:

By the end of the course, the student will have developed a scientifically accurate and comprehensible language that allows for clear and unambiguous communication of acquired scientific and technical knowledge. These communication skills will be assessed through e-tivities and the written exam.

E. Learning skills:

Thanks to the methodological tools acquired during the course, the student will have developed the ability to learn new knowledge for solving unfamiliar problems related to reinforced concrete construction systems.

Syllabus

Subject 1. Structural Analysis

Proposed topics: Analysis of Isostatic and Hyperstatic Structures; Grinter Frames; Stress Diagrams. *E-tivity 1:* Solving Structural Analysis exercises.

Subject 2. Theory and Techniques of Reinforced Concrete Construction

Proposed topics: Structural Safety; Materials; Modelling of Reinforced Concrete; Stress States (Axial Force, Simple Bending, Combined Bending, Shear, Torsion). *E-tivity 2:* Exercises in Reinforced Concrete Theory.

Subject 3. Theory of Reinforced Concrete Buildings

Proposed topics include the static behavior of reinforced concrete buildings: The building as a spatial structural system; Schematic representation of actions on buildings (static loads, wind, thermal variations, and exceptional actions); Slabs (design against ultimate limit states, serviceability limit state checks); Overhangs (side cantilevers and corner cantilevers); Openings in slabs; Specific issues related to decks; Beams (design with band criteria, ultimate limit state checks, reinforcement placement, and geometric limitations); Columns (design with band criteria, reinforcement placement, geometric limitations, confinement effects); Stairs (ramp-slab stairs and knee-beam stairs); Foundations (design criteria, isolated footings, foundation beams, introduction to pile foundations). *E-tivity 3* – Design Project: Slab Design and SLU Calculation for a Strip (numerical report with extended explanation of performed calculations); SLE Checks for the Strip (numerical report with extended explanation of performed calculations); Deck Formwork Plan (graphic report at 1:50 scale); Design of a Typical Frame (numerical report with extended explanation of performed calculations; graphic reports for beams and columns at 1:50 scale); Foundation Design (numerical report with extended explanation of performed calculations; graphic report at 1:50 scale); Stair Design (numerical report with extended explanation of performed calculations; graphic report at 1:50 scale); Design of a Secondary Deck Element (numerical report with extended explanation of performed calculations; graphic report at 1:50 scale).

Evaluation system and criteria

The examination consists of a written test designed to assess the ability to analyse and apply acquired concepts, along with a series of activities (E-tivities) completed during the course in virtual classrooms. E-tivities are assessed continuously throughout the course. The written test includes:

- Two exercises and open-ended questions.
- A dedicated section for evaluating asynchronous exercises (E-tivities 1 and 2).

The exercises aim to verify the student's ability to solve problems related to reinforced concrete calculations and structural analysis. Open-ended questions assess the understanding of theoretical aspects underpinning reinforced concrete and building theory, as well as challenges encountered in design. Specifically, five design-related questions are included, during which the quality of the submitted design project (E-tivity 3) will also be evaluated. The completion of the exam is contingent upon the submission of all required E-tivities. The written exam evaluates

knowledge of the subject and the ability to apply it. Communication skills, ability to draw conclusions, and self-learning skills are assessed through mandatory E-tivities. Students must complete at least 50% of each E-tivity to be eligible for the exam.

Exam Weightage

- **Exercises**: 37% of the total grade (approximately 11 out of 30 points).
- **Open-ended Questions**: 50% (approximately 2 points per question, totaling 17 out of 30 points).
- **E-tivities (excluding E-tivity 3, which is evaluated in open-ended questions)**: 13% (2 points each, totaling 4 out of 30 points).

The total duration of the exam is 180 minutes.

Bibliography and resources

1. *Materials to consult*

Notes written by the instructor are available in Italian.

2. *Recommended bibliography*

Suggested readings are:

- Choo B.S., MacGinley T.J. (2018) Reinforced Concrete: Design Theory and Examples . Third Edition. CRC Press.
- Toniolo G.D., Di Prisco M. (2017). Reinforced Concrete Design to Eurocode 2. Springer International Publishing.
- Park R., Paulay T. (2000) Reinforced concrete structures. John Wiley & Sons.