UNICUSANO
ROME

Italian code: ICAR/09 (old) – CEAR-07/A (new) **Credits: 9**
Course: Structural Strengthening of Masonry Structures
Main language of instruction: Italian
Other language of instruction: English

Head instructor
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Objectives

The course aims to provide the tools and knowledge necessary to evaluate vulnerability and design structural strengthening interventions for existing buildings, with a specific focus on historic masonry structures of artistic value. During the course, students will develop the skills required to identify and address seismic vulnerability issues in existing historic masonry structures while adhering to current regulatory requirements.
By the end of the course, students will have a solid understanding of the principles and methodologies for structural analysis of existing masonry structures, including the application of nonlinear analysis techniques. They will be able to interpret structural modelling results, assess structural safety levels, and identify critical issues and/or vulnerability factors in historic masonry buildings of artistic value.
Students who successfully complete the final exam will also acquire advanced knowledge of both traditional and innovative strengthening systems to mitigate structural vulnerabilities in existing masonry buildings and evaluate the effectiveness of the proposed interventions.
Students are expected to have a good understanding of structural analysis and design principles covered in previous structural engineering courses, particularly *Earthquake Engineering*.

Course structure

The course has the following educational objectives:

- To understand the fundamentals of the statics of masonry structures.
- To comprehend the seismic behavior of masonry structures, distinguishing between global and local behavior.

- To define modeling methods for existing buildings, tailored to each type of behavior.
- To analyze and evaluate the behavior of masonry solids.
- To characterize an existing building.
- To assess the seismic safety level of an existing structure, referencing modern performance-based regulations.
- To understand the functioning and design of the main strengthening techniques.

Competencies

A. Knowledge and understanding:

At the end of the course, students will have demonstrated their knowledge of the statics and kinematics of masonry structures and will be able to identify the seismic behavior of existing structures. Students will also be able to list and define different types of existing masonry, select modeling methods appropriate for the seismic behavior of existing buildings, apply modern performance-based regulations to assess the seismic safety of existing buildings, and describe the functioning of major strengthening techniques.

B. Applying knowledge and understanding:

By the end of the course, students will be able to identify the most appropriate models to determine the seismic vulnerability of existing masonry buildings, select the optimal strengthening system to mitigate identified vulnerabilities, and assess the effectiveness and quality of the proposed intervention.

C. Making judgements:

At the end of the course, students will be capable of selecting the most suitable structural models to define a reinforced concrete structure, statically designing its individual structural elements, and evaluating the static behavior of the structure as a whole.

D. Communication skills:

By the end of the course, students will have developed accurate and comprehensible scientific language skills, enabling them to clearly and unambiguously express the scientific and technical knowledge acquired. These communication skills will be assessed through e-tivities and a written examination.

E. Learning skills:

Thanks to the methodological tools acquired during the course, students will have developed the ability to learn new concepts to solve unfamiliar problems concerning existing masonry buildings. Additionally, they will have the opportunity to pursue further studies (Ph.D.) in the field of structural civil engineering.

Syllabus

Subject 1. The Masonry as a material
Proposed topics: characterization of the material (compliance with the rule of art, definition of the quality index masonry, characterization of the masonry material).
Subject 2. Static Behavior of Historical Masonry Structures
Proposed topics: behavior of linear elements (walls and columns) and curved elements (arches and vaults)
Subject 3. Seismic Behavior of Historical Masonry Structures
Proposed topics: survey and investigation of masonry structures, definition of the structural vulnerabilities, detailed analysis of all the kinematic mechanisms responsible for seismic vulnerability of Existing Historical Masonry Structures; seismic behavior and methods for the structural modelling.
Subject 4. Seismic Retrofitting Techniques
Proposed topics: Traditional retrofitting techniques for masonry structures; outgrowths of traditional techniques by mean the introduction of innovative materials.

Evaluation system and criteria

The examination consists of a written test aimed at assessing the student's analytical and conceptual understanding, as well as a series of activities (e-tivities) completed during the course in virtual classrooms. The e-tivities involve essays assigned upon the student's request on the main topics covered in the course. The evaluation of the e-tivities, graded on a scale of 0 to 4 points, is conducted during the correction of the written test. The exam accounts for the remaining 26 points and is conducted in written form. It includes two exercises and two open-ended questions. The exercises are designed to assess the student's ability to solve problems related to evaluating the vulnerability of existing masonry buildings and designing strengthening interventions to mitigate such vulnerabilities. The open-ended questions evaluate the student's understanding of the theoretical aspects underlying the statics of masonry buildings and the various topics addressed in the course.
Exercise represent 47% of the total exam score (approximately 7 points each, for a total of 14 out of 30), while the open-ended questions account for 40% (approximately 6 points each, for a total of 12 out of 30). The remaining 13% is attributed to the e-tivities. The exam duration is 90 minutes in total.
The learning outcomes related to knowledge of the subject and its application are evaluated through the exam, while communication skills, the ability to draw conclusions, and self-learning abilities are assessed during the course through the e-tivities.

Bibliography and resources

1. *Materials to consult*

Notes written by the instructor are available in Italian.

2. *Recommended bibliography*

Suggested readings are:

- Como M. (2018) Statics of Historic Masonry Constructions. Third Edition. Springer.
- Hamid A. A., Schuller M. (2019). Assessment and Retrofit of Masonry Structures. The Masonry Society. Fourth Edition. Wiley.