University of Pavia

IUSS School of Advanced Studies

Civil Engineering for Mitigation of Risk from Natural Hazards

Course: Masonry Structures
a.y.: 2025/2026
Lecturers: Prof. Guido Magenes, Dr. Stylianos Kallioras
Date: 07/01/2026 – 02/02/2026
Classroom: Eucentre, Classroom 1, below the lab

Course schedule

Week	Date	Lecture hours From___To___	Tutorial/lab hours From To___	Tot h	Topic
1	07/01/2026	14: 00 – 16:00 16:15-17:45		3.5	Intro to masonry construction methods. Structural, non structural, unreinforced, reinforced, stone, brick, block, partitions, parapets, infills, veneers. General structural layout and conception of a masonry buildings. Homework #0.
	8/01/2026	11:00 – 12:30 14:00-16:00		3.5	Properties of masonry materials, compressive strength, modulus of elasticity, modulus of rupture, etc. Mechanics of masonry in compression. Homework assignment #1
	9/01/2026	9:00 – 10:45 11:00-12:45		3.5	URM walls in compression (load bearing walls), effects of slenderness. URM in bending part 1
2	12/01/2026	9:00 – 11:00 11:15-12:45		3.5	URM walls in bending (load bearing walls) part 2. Homework assignment #2 URM walls in bending and compression (out-of-plane), 2nd order geometric effects in urm walls (compression, compression and lateral loading).
		14:30-15:15		1	URM walls in bending and compression (continued) Homework assignment #3
			15:15 – 17:00	2	Contact hours – interaction on homeworks
	13/01/2026	9:30 – 11:00 11:15-12:45		3	URM walls under in-plane lateral loads. Failure mechanisms/limit states. Strength formulae. Force-displacement behaviour. Bi-linear idealization Homework #4
			14:30-15:30	1	Contact hours – interaction on homeworks
	15/01/2026	9:30 – 11:00 11:15-12:45		3	Structural analysis of URM buildings. Idealizations under prevailing vertical loads, idealizations under horizontal loads. Rigid diaphragm systems, flexible diaphragm systems.
			14:30-15:30	1	Contact hours – interaction on homeworks
	16/01/2026	9:30 – 11:00 11:15-12:45		3	Seismic response of URM building systems. Global analysis governed by in-plane response. Elastic analysis. Nonlinear analysis.
			14:30 – 16:30	2	Lab session and homework assignment #5
	19/01/2026		11:00-13:00	2	Presentation and discussion of papers (Homework #0)
		14:30-16:30		2	Local out-of-plane seismic assessment/safety check of URM walls.

3	20/01/2026	9:00 – 11:00 11:15-12:15		3	Lateral strength and behaviour of reinforced masonry walls. Flexural strength, shear strength, stiffness, detailing of reinforcement.
	21/01/2026	11:00- 13:00		2	Seismic response of RM buildings. Design and seismic performance assessment. Confined masonry.
		14:30- 16:00		1.5	Behaviour of nonstructural masonry components
			16:00 – 17:30	1.5	Contact hours – interaction on homeworks
	22/01/2025	9:00 – 11:00 11:15-12:45		3.5	Seismic assessment of existing buildings. Homework #7
4	26/01/2025		9:15 – 11:15	2	Lab session on nonlinear software
			11:30-13:00	1.5	Contact hours – interaction on homeworks
	27/01/2026	9:30 – 11:00 11:15-12:45		3	Survey, condition assessment and knowledge base for existing masonry buildings. Strengthening/retrofitting strategies and techniques
			14:30-15:30	1	Contact hours
	28/01/2025	9:30 – 11:00 11:15-12:45		3	Strengthening/retrofitting strategies and techniques part 2.
			14:30-15:30	1	Contact hours
	29/01/2025	9:00-11:30		2.5	Strengthening/retrofitting strategies and techniques part 3. Conclusion of the course.
	02/02/2026	9:30-12:30	**Final Exam**		

Brief Contents Description and Course Syllabus:

The goal of the course is to provide an introduction to materials, construction practices, structural behaviour, analytical methods, and typical code requirements for the design of new masonry buildings and the evaluation and retrofit/rehabilitation of existing ones, with special regard to seismic action. Topics that will be covered are as follows.

Properties of masonry materials: brick, block, mortar, grout and reinforcement. Mechanics of masonry in compression: failure theories, compressive strength, elastic modulus. Behaviour of masonry walls subjected to lateral forces and their role in building structural systems excited by earthquake motions. Unreinforced masonry walls: vertical and transverse loadings, failure mechanisms, capacity models. Building systems: analysis under vertical and under horizontal loading; role of floor diaphragms. Liner vs. nonlinear analysis. Reinforced masonry walls: behaviour, design, detailing of reinforcement. Confined masonry. Assessment and rehabilitation of existing masonry buildings: sources of vulnerability, knowledge and survey of the structure, methods of analysis, performance criteria. Strategies for seismic rehabilitation/retrofitting.

Prerequisites*:* undergraduate course in reinforced concrete structures, fundamentals of structural dynamics and earthquake engineering

Reference Texts:

1. Handouts and scientific papers made available during the course
2. T.Paulay and M.J.N.Priestley, Seismic design and assessment of reinforced concrete and masonry buildings, Chapter 7, John Wiley and Sons, 1992
3. R. Drysdale and A. Hamid, Masonry Structures: Behavior and Design, 3rd ed., The Masonry Society, 2008 (or the 4th edition by A.Hamid, 2018)
4. M. Tomaževič, Earthquake resistant design of masonry buildings, Imperial College Press, London, 1999.
5. A.W. Hendry, Structural Masonry, 2nd ed., Palgrave Macmillan, 1998

Grading:

Problem Assignments: 40%

Final Exam 60%

The final exam is written and consists of a closed books first part (1 h), and an open books second part (2h).

TOPICS OF THE COURSE

Introduction to masonry construction methods. Structural, non-structural, unreinforced, reinforced, stone, brick, block, partitions, parapets, infills, veneer. General structural layout and conception of a masonry buildings

Properties of masonry materials, compressive strength, modulus of elasticity, modulus of rupture, etc.

Mechanics of masonry in compression.

URM walls in compression (load bearing walls), effects of slenderness.

URM walls in bending

URM walls in bending (out-of-plane) and compression, behaviour under lateral out-of-plane load (wind, seismic).

URM walls under in-plane lateral loads. Failure mechanisms/limit states. Strength formulae. Force-displacement behaviour. Bi-linear idealization.

Structural analysis of URM buildings. Idealizations under prevailing vertical loads, idealizations under horizontal loads. Rigid diaphragm systems, flexible diaphragm systems

Review of modern codes approaches to seismic design and methods of analysis (linear static, nonlinear static, linear dynamic, nonlinear dynamic).

Seismic response of URM building systems. Global analysis governed by in-plane response. Elastic analysis. Nonlinear analysis

Local out-of-plane seismic assessment/safety check of URM walls.

Lateral strength and behaviour of reinforced masonry (RM) walls. Flexural strength, shear strength, stiffness, detailing of reinforcement

Seismic response of RM buildings. Design and seismic performance assessment.

Confined masonry.

Behaviour of non-structural masonry components.

Assessment of seismic performance of existing buildings. Overview. Experience from past earthquakes and from experiments. Sources of vulnerability. Response mechanisms.

Assessment of seismic performance of existing buildings. The Eurocode 8 - Italian approach. Survey and knowledge levels, methods for assessment. Local mechanisms. Application of limit analysis to local mechanisms.

Strengthening/retrofitting strategies and techniques for existing masonry buildings.