



## Civil Engineering for Mitigation of Risk from Natural Hazards

### Course: Masonry Structures

a.y.: 2020/2021

Lecturer: Prof. Guido Magenes

Date: 11/01/2021 – 05/02/2021

Classroom: Online

### Course schedule

Week	Date	Lecture hours From__ To__	Tutorial hours From__ To__	Tot h	Topic
1	11/01/2021	13:30 – 15:00 15:15-16:45		3	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.
	12/01/2021	13:30 – 15:00 15:15-16:45		3	Properties of masonry materials, compressive strength, modulus of elasticity, modulus of rupture, etc. Mechanics of masonry in compression. Homework assignment #1
	13/01/2021	13:30 – 15:00 15:15-16:45		3	URM walls in compression (load bearing walls), effects of slenderness.
	14/01/2021	13:30 – 15:30		2	URM walls in bending (load bearing walls) Homework assignment #2
		15:30-17:45		2.5	URM walls in bending and compression (out-of-plane), 2nd order geometric effects in urm walls (compression, compression and lateral loading). Homework assignment #3
	15/01/2021		9:00 – 11:00	2	Contact hours – interaction on homeworks
2	18/01/2021	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
	19/01/2021	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.
			14:15 – 16:00	2	Contact hours – interaction on homeworks
	20/01/2021	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.
			14.00 – 16.00	2	Lab session and homework assignment #5
	21/01/2021	09:15 – 11:30		2	Local out-of-plane seismic assessment/safety check of URM walls.

3	25/01/2021	9:15– 12:45		3	Presentation and discussion of papers (Homework #0)
		14.30 – 17:30		3	Lateral strength and behaviour of reinforced masonry walls. Flexural strength, shear strength, stiffness, detailing of reinforcement.
	26/01/2021	09.15 – 12.30		3	Seismic response of RM buildings. Design and seismic performance assessment. Confined masonry.
			14.00 – 16.00	2	Contact hours – interaction on homeworks
	27/01/2021	14:30 – 16:00 16:15-17:45		3	Behaviour of nonstructural masonry components + Seismic assessment of existing buildings.
	28/01/2021	9:30 – 11:00 11:15-12:45		2	Seismic assessment of existing buildings continued + Contact hours discussion of previous homeworks. Homework #7
			14:30-16:30	2	Lab session on nonlinear software + contact.
4	01/02/2021	9:30 – 11:00 11:15-12:45		3	Survey, condition assessment and knowledge base for existing masonry buildings. Strengthening/retrofitting strategies and techniques part 1.
	02/02/2021	9:30 – 11:00 11:15-12:45		3	Strengthening/retrofitting strategies and techniques part 2.
	03/02/2021	09.15 – 11.00		2	Strengthening/retrofitting strategies and techniques part 3. Conclusion of the course.
			11.00 – 12.30	1.5	Contact hours
	05/02/2021	09:30-13:00	<b>Final Exam</b>		

#### 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. Linear 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, 1997

3. R. Drysdale and A. Hamid, Masonry Structures: Behavior and Design, 3rd ed., The Masonry Society, 2008 (or the 4<sup>th</sup> 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%

**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
- 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.
- Review of modern codes approaches to seismic design and methods of analysis (linear static, nonlinear static, linear dynamic, nonlinear dynamic).
- Assessment of seismic performance of existing buildings. Overview. Experience from past earthquakes and from experiments. Sources of vulnerability. Response mechanisms.
- Performance-based criteria for seismic assessment with reference to recent codes
- 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.
- Strengthening/retrofitting strategies and techniques for existing masonry buildings.