IUSS Scuola Universitaria Superiore Pavia

Course: Seismic Design, Assessment and Strengthening of Masonry Structures
Lecturer: Prof. M. Griffith ; Prof. G. Magenes
Date: 06/06/2017-23/06/2017
Classroom: Classroom 1 @ Eucentre Foundation

Course schedule

Week	Date	Lecture hours From____ To____	Tutorial hours From____ To_____	Subject	Tot h
1	05/06	9:00-12:00		Intro 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. Homework #0	3
		12:00-13:00		Properties of masonry materials,	1
	06/06	9:00-13:00		Compressive strength, modulus of elasticity, modulus of rupture, etc. Mechanics of masonry in compression. URM walls in compression (load bearing walls), effects of slenderness. Homework assignment #1	4
	07/06	9:00-12:00		URM walls in bending (load bearing walls) Homework assignment #2	3
	08/06	9:00-12:00		URM walls in bending and compression (out-of-plane), 2nd order geometric effects in urm walls (compression, compression and lateral loading). Homework assignment #3	3
	09/06	9:00-13:00		URM walls under in-plane lateral loads. Failure mechanisms/limit states. Strength formulae. Force-displacement behaviour. Bi-linear idealization Homework #4	4
2	12/06	9:00-13:00		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.	4
	13/06	9:00-13:00		Global analysis governed by in-plane response. Elastic analysis. Nonlinear analysis. lab session and homework assignment #5	4
	14/06	9:00-12:00		Local out-of-plane seismic assessment/safety check of URM walls.	3
	15/06	9:00-13:00		Presentations of papers (Hmwk #0)	4
	16/06	9:00-13:00		Lateral strength and behaviour of reinforced masonry walls. Flexural strength, shear strength, stiffness, detailing of reinforcement. Seismic response of RM buildings. Design and seismic performance assessment. Homework assignment #6.	4
3	19/06	9:00-10:00		Confined masonry	1
		10:00-13:00		Lab session on nonlinear software. Behaviour of nonstructural masonry components 2 h + Seismic assessment of existing buildings.	3
	20/06	09:00-12:00*		Seismic assessment continued. Limit analysis, local mechanisms. Homework #7. Discussion of previous Homeworks	3
	21/06	09:00-11:00		Survey, condition assessment and knowledge base for existing masonry buildings.	2

		11:00-13:00	15:00-17:00	Strengthening/retrofitting strategies and techniques. cont'd if necessary. Performance based assessment (ASCE-41)	2 2
	23/06	09:30-12:30	14:30-17:30	Final exam Recent and relevant topics lecture	3 3

*(to be confirmed)

Brief Contents Description and Course Syllabus:

Synopsis: The goal of the course is to provide an introduction to materials, construction practices, structural behavior, analytical methods, and typical code requirements for the seismic design of new masonry buildings and the seismic evaluation and retrofit/rehabilitation of existing ones.
Properties of masonry materials: brick, block, mortar, grout and reinforcement; Mechanics of masonry in compression: failure theories, compressive strength, elastic modulus; Behavior 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, shear walls; Reinforced masonry walls: axial force, flexure and shear design, detailing of reinforcement; Building systems: floor diaphragms, lateral-force distribution to shear walls; 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.

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 (load bearing walls)

URM walls in bending and compression (out-of-plane), 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 nonstructural 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 eartquakes and from experiments. Sources of vulnerability. Response mechanisms (reprise).

Performance-based criteria for seismic assessment and reference according to recent codes (discussion of ASCE-SEI 41)

Assessment of seismic performance of existing buildings. The EC8 - Italian approach. Survey and knowledge levels, methods for assessment. Local mechanisms. Application of limit analysis.

Strengthening/retrofitting strategies and techniques.

Office Hours: to be announced on a weekly basis

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

Grading:

Problem Assignments:	40%
Final Exam	60%

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.
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