University of Pavia

IUSS School of Advanced Studies

Civil Engineering for Mitigation of Risk from Natural Hazards

Course: **Fundamentals of Seismic Design**
Lecturers: Ricardo Monteiro, Gianrocco Mucedero
Teaching Assistant: Besim Yukselen
Date: 15/05/2024 – 07/06/2023
Classroom:

Brief Contents Description and Course Syllabus

The course will start with a brief review on the main aspects of the dynamic behaviour of linear and nonlinear single-degree-of-freedom systems, which represents the basis to understand seismic design. Afterwards, the conceptual seismic design of structures will be addressed. The core of the course will be the discussion of (largely enforced) force-based and (developing) displacement-based seismic design philosophies, focusing on the tools and steps required for their employment and verification. Capacity design principles, necessary to ensure a target hierarchy of ductile inelastic deformations will be explained with emphasis on the design and detailing of reinforced concrete structures with the adoption of Eurocode 8, amongst other codes and guidelines. Further attention will also be paid to the characterisation of the force-deformation behaviour of reinforced concrete structural elements as well as the modelling and analysis of reinforced concrete structures with nonlinear finite element approaches. Four homework assignments are foreseen, which will address the characterization of the seismic input and the seismic design and detailing of a reinforced concrete structural wall building.

Suggested reading material

In addition to specific papers and handouts indicated/delivered during classes, the following general textbooks are recommended.

[STRUCTURAL DYNAMICS]

- Chopra A., “Dynamics of Structures”, Prentice Hall, Third Edition, 2007
- Clough R.W., Penzien J., "Dynamics of structures", Computers & Structures Inc, 2003

[SEISMIC RESPONSE AND DESIGN]

- Priestley, M.J.N., “Myths and Fallacies in Earthquake Engineering, Revisited”, Rose School, Pavia, 2003
- Paulay, T. and Priestley, M.J.N., “Seismic Design of Reinforced Concrete and Masonry Buildings”, Wiley, 1992
- Priestley, M.J.N., Calvi G.M. and Kowalsky, M.J., “Displacement-Based Seismic Design of Structures”, IUSS Press, 2007

Software

At least two specific types of software will be necessary:

[SECTION ANALYSIS]

- Bentz E.: “Response 2000”. User Manual. Department of Civil Engineering, University of Toronto, Canada. Toronto, March 2001. (http://www.ecf.utoronto.ca/~bentz/r2k.htm)

[STRUCTURAL ANALYSIS]

- Seismosoft: “SeismoStruct - A computer program for static and dynamic nonlinear analysis of framed structures”. 2018. (http://www.seismosoft.com/seismostruct)
- Mazzoni et al.: “OpenSEES - The open system for earthquake engineering simulation”, PEER, UC Berkeley, 2006. (http://opensees.berkeley.edu)

Grading

Homework assignments:	50% (12.5% each)
Final exam:	50%

Course schedule

Date	Lecture	Tutorial	Subject	Homework	Classroom
13/05					
14/05					
15/05	9:30 – 12:30		1. Introduction (R. Monteiro) 2. Force-deformation characteristics of RC elements (R. Monteiro) - Material properties of concrete and steel - Section analysis		Broletto
16/05	9:30 – 12:30		3. Elastic and inelastic response spectra (R. Monteiro) - Elastic response spectra - Strength and ductility		Broletto
17/05	9:30 – 12:30	14:30 – 17:30	3. Elastic and inelastic response spectra (R. Monteiro) - Inelastic response spectra - Linear equivalent SDOF systems; overdamped spectra **Introduction to HW1**	HW1 set	Broletto
20/05	9:30 – 12:30	14:30 - 17:30	4. Seismic design methods (R. Monteiro) - Possible force-based design methods - Equivalent lateral force method **Tutorial** **Introduction to HW2**	HW2 set	Broletto
21/05	9:30 – 12:30	14:30 - 17:30	4. Seismic design methods (R. Monteiro) - Response spectrum method - Considerations on force-based seismic design **Introduction to HW3**	HW3 set	Marelli
22/05	9:30 – 12:30		5. Capacity design (R. Monteiro) - Introduction and principles - Code-based capacity design steps - Section detailing		Broletto
23/05					
24/05				(HW1 due)	
27/05	9:30 – 12:30	14:30 - 17:30	6. Seismic design methods (G. Mucedero, R. Monteiro) - Performance-based seismic design - Direct displacement-based seismic design (DDBD) **Tutorial** **Introduction to HW4**	HW4 set	Broletto
28/05	9:30 – 12:30	14:30 - 17:30	7. Seismic design methods (G. Mucedero, R. Monteiro) - Direct displacement-based seismic design (DDBD) - Modelling of RC buildings and linear analysis **Tutorial**	(HW2 due)	Broletto
29/05	9:30 – 12:30	14:30 - 17:30	9. Design verification and introduction to retrofitting (G. Mucedero, R. Monteiro)		Marelli
30/05					
31/05				(HW3 due)	

Date	Lecture	Tutorial	Subject	Homework	Classroom
03/06	9:30 – 12:30		8. Conceptual seismic design (R. Monteiro)		Broletto
04/06	9:30 – 12:30	14:30 - 17:30	9. Inelastic analysis and seismic assessment methods (R. Monteiro) - Pushover analysis - Nonlinear static procedures - Nonlinear dynamic analysis **Tutorial**		Broletto
05/06	9:30 – 12:30		10. Seismic retrofitting strategies for RC structures (G. Mucedero, R. Monteiro) - Selective intervention techniques: stiffness, strength, ductility - Member level approach or local retrofitting - Structural-level approach of retrofitting		Broletto
06/06				(HW4 due)	
07/06	9:30 – 12:30		Final Exam		Broletto