Course: Seismic Response and Analysis of Structures
Lecturer: Enrico Spacone
TA : Alexander Kagermanov
Date: 27/11/2017 – 22/12/2017
Classroom: Sala del Camino (IUSS)

Course schedule

Week	Date	Lecture hours	Tutorial hours	Classroom	Tot h
1	27/11/2017	8:30 - 11:30	14:00 -16:00		5
	28/11/2017	9:00 - 12:00	14:00 -16:00		5
	29/11/2017	9:00 - 12:00	15:00 -17:00	Lect: 1-14/ Tut: Library room	5
	30/11/2017	9:00 - 12:00	13:00 -15:00	Lect: 1-14/ Tut: Library room	5
	1/12/2017	9:00 - 12:00		Lect: 1-14	3
2	4/12/2017	9:00 - 12:00		Lect: 1-14	5
	5/12/2017	9:00 - 12:00	14:00 -16:00	Lect/Tut: 1-14	3
	6/12/2017	9:00 - 12:00		Lect: 1-14	3
	7/12/2017	9:00 - 12:00		Lect: 1-14	3
3	11/12/2017	9:00 - 12:00	14:00 -16:00	Lect/Tut: 1-17	5
	12/12/2017	9:00 - 12:00		Lect: 1-14	3
	13/12/2017		9:00 – 11:00	Tut: 1-14	
	14/12/2017	9:00 - 12:00		Lect: 1-14	3
	15/12/2017	9:00 - 12:00		Lect: 1-17	3
4	18/11/2017	9:00 - 12:00	14:00 -16:00	Lect: 1-17	5
	19/11/2017		9:00 – 11:00	Tut: 1-14	2
	20/11/2017		9:00 – 11:00	Tut: 1-14	2
	21/11/2017				
	22/11/2017	9:00 – 12:00		Exam: 1-14	3

COURSE OBJECTIVES

Structures respond elastically for minor earthquakes and start experiencing damage, and thus behave nonlinearly, for earthquakes of increasing intensity. Structural design of new structures is currently based on linear elastic analysis. Nonlinear analyses are becoming increasingly attractive for seismic assessment of existing structures, as modern building codes encourage designers to use more advanced tools.

The course will consider different modeling assumptions (mostly frame vs continuum modeling) for structures, and will discuss pros and cons of different approaches and how different models describe the actual behavior of structures.

The main goal of the course is to provide students with skills that can be applied to both research and practice for analyzing structures. The class will focus on the theory of linear nonlinear structural analysis, with particular emphasis on available computational models, their characteristics and limitations. Modeling alternatives and their effect on the model output will be discussed. The course will also present the nonlinear methods of analysis prescribed by the seismic design codes and available in the published literature

The final goal is to leave attendees with a firm idea of the importance of the modeling assumptions and the methods of analyses that are used to analyze a structure mainly with respect to the actual behaviors of structures under seismic loads.

COURSE TOPICS

1. Review of basic structural analysis formulations (Beam Theory – Strong Form).
2. Formulation of linear elements
3. Review of basic Energy theorems
4. Seismic response of structures: linear vs. nonlinear behavior. Sources and types of nonlinearities
5. Material Nonlinearities: Lumped vs. Distributed inelasticity
   a) Section models and Hinge element formulations
   b) Frame element formulations (Weak form)
   c) Section models
   d) Material modeling
6. Structure solution strategies: event-to-event, Newton type solution strategies. Advanced procedures
7. Modeling for computer analysis: use of computer programs.
8. Nonlinear methods of analysis: static vs dynamic
9. Geometric nonlinearities: P-Δ theory and applications. Structural stability. Large displacement theory.

TEXTBOOK: *No textbook is required for the class*. Handouts and selected papers will be distributed during the class.

Earthquake Engineering – From Engineering Seismology to Performance-Based Engineering, edited by Yousef Bozorgnia and Vitelmo V. Bertero, 2004

Bathe, K.-J. (1996). *Finite Element Procedures*. Prentice-Hall, Englewood Cliffs, New Jersey.

Crisfield, M.A. (1991). *Non-linear Finite Element Analysis of Solids and Structures*. John Wiley & Sons, Chichester, England.

Yang, Y.-B., and Kuo, S.-R. (1994). *Theory and Analysis of Nonlinear Framed Structures*. Prentice Hall, Englewood Cliffs, New Jersey.

Zienkiewicz, O.C. and Taylor, R.L (1989). *The Finite Element Method. Volume 1. Basic Formulation and Linear Problems*. Fourth Edition. McGraw Hill, London.

Zienkiewicz, O. C., and Taylor, R. L. (1991). *The Finite Element Method. Volume 2. Solid and Fluid Mechanics, Dynamics and Non-Linearity*. Fourth Edition. McGraw Hill, London.

ASSIGNMENTS: There will be regular reading and homework assignments. Homework assignments will involve both hand derivations and computer analyses.

EXAMINATION: There will be a three-hour final written examination December 22, 2017, 9 to 12.

GRADING: 50% Homerwork, 50% Final Examination.