University of Pavia IUSS School of Advanced Studies

Civil Engineering for Mitigation of Risk from Natural Hazards

SEISMIC ISOLATION AND DISSIPATION

FIRST SEMESTER 2023-2024

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Course Dropbox : https://www.dropbox.com/sh/nkvriydjk58amtd/AADtCXEzWrZ3RsGIS2DvG8OBa?dl=0
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GENERAL OBJECTIVES

The basic principle of conventional earthquake-resistant design is to ensure an acceptable safety level while avoiding catastrophic failures and loss of life. When a structure does not collapse during a major earthquake, and the occupants can evacuate safely, it is considered that this structure has fulfilled its function even though it may never be functional again. This approach can be considered adequate for most types of structures. However, for important structures, safer methods are required, while keeping economic factors in mind. For example, avoiding collapse is not sufficient for facilities that must remain functional immediately after an earthquake: hospitals, police stations, communication centers, and so on.

Over the last 30 years, a large amount of research has been conducted into developing innovative earthquake-resistant systems in order to raise the safety level while keeping construction costs reasonable. Most of these systems are intended to dissipate the seismic energy introduced into the structure by supplemental damping mechanisms and/or to isolate the main structural elements from receiving this energy through isolation systems.

The main objective of the course is to familiarize Structural Engineers with the various innovative systems that have demonstrated considerable potential through analytical studies, experimental testing, and actual structural implementation. The discussion will focus on passive energy dissipation systems and base isolation systems.

At the end of the course, Structural Engineers should be able to:

- Provide a critical comparison of various systems.
- Model and design various systems with general structural engineering software.
- Recommend optimum systems for particular seismic design or retrofit projects.

ONLINE CLASS SCHEDULE

The lectures and project tutorials will be delivered online in real time and recorded. The lectures are offered online via Zoom and the project tutorials are offered online via Google Meet with no in-person requirements. The students are encouraged to participate in live online lectures at specific times. All the live online lectures and project tutorials will be recorded and will be available online on the course Dropbox for viewing at any time for the remainder of the semester.

Online Lectures on Zoom: Mondays, Wednesdays, and Fridays 14:00 to 18:00 (Italy Time).
Zoom Link: https://us02web.zoom.us/j/87807999067?pwd=czJrcVVlcUh6aDJwVjFHK0tVWFl4dz09
Meeting ID: 878 0799 9067
Passcode: 327348

Online Project Tutorials on Google Meet: Tuesdays and Thursdays 11:00 to 14:00 (Italy Time)
Google Meet Link: https://meet.google.com/mwd-tsdu-wkr

GRADING

Evaluation	% of Final Mark	Documentation
Project Report	50%	Open
Project Oral Presentation and Examination*	25%	Open
Final Written Examination**	25%	1-A4 Sheet

* The oral examination will consist of an oral presentation of the project followed by an individual oral examination with the instructor.

** Attendance to the final examination is mandatory. A missed final examination will be assigned a grade of zero unless an acceptable excuse is provided to the instructor prior to the exam. In cases of emergency, the instructor should be notified as soon as possible. Students with a legitimate absence will be given an oral make-up final examination. The written final examination will be three hours long.

REQUIRED TEXT

- Christopoulos, C., and Filiatrault, A. 2022. "Principles of Supplemental Damping and Seismic Isolation – Second Edition," European Centre for Training and Research in Earthquake Engineering - EUCENTRE, Pavia, Italy, 660 p. Order at EUCENTRE head office or online at:
  https://bookstore.eucentre.it/prodotto/principles-of-passive-supplemental-damping-and-seismic-isolation-2nd-edition/?lang=en
  or
  https://www.amazon.com/Principles-Passive-Supplemental-Damping-Isolation/dp/8885701183

- Slide sets available on the course Dropbox

PROJECT

The objective of the project is to evaluate the effect and recommend an optimum innovative system for the seismic retrofit of a particular building structure. Students are divided into teams of four or five during the first lecture. Each team will be working on the same building structure but will have to consider different specified earthquake design ground motions. Each assignment will represent a phase of the project and will be related to a particular innovative system discussed in the class. For each system, an optimum retrofit strategy will be sought.

Each team will hand in only one project report at the last lecture. The project report must reflect the various phases of the project and must include the optimum solution for each system. A final recommendation among the various systems studied must be given at the end of the report.

A Peer Reviewer Panel (PRP) will monitor the progress of each team. Each team must meet privately online with the PRP at least twice during the semester. It is the responsibility of each team to contact the PRP to schedule each online meeting. During each meeting, the team must present an update of its progress in the project and seek "big picture" advice from the PRP if required. After each meeting, the PRP will prepare a letter to the team that provides its opinion on the progress of the team and concerns if any. Each team must include the two letters from the PRP in its final project report and describe how the comments from the PRP were addressed in the execution of the project. If comments from the PRP were not addressed, justifications must be provided.

The PRP for the project will be composed of:
Roberto Merino, Chair (robertojavier.merinovela@iusspavia.it);
Bryan Chalarca (bryan.chalarca@iusspavia.it); and
Alessandra Miliziano (alessandra.miliziano@iusspavia.it).

After the last lecture, each team will make an online oral presentation to the class on the main findings of their project. This online session will be open to the public.

Note: At the end of the project, each team member will be asked to grade anonymously the performance of all teammates (including him or herself) during the project. This informal grading will help the instructor to grade the project report for each student in the class.

COURSE CONTENT

Chapter 1	Introduction
Chapter 2	Review of Seismic Design Philosophies and Analysis Methods
Chapter 3	Energy Concepts in Earthquake Engineering
Chapter 4	Basic Concepts of Structures with Passive Energy Dissipating Systems
Chapter 5	Metallic and Friction (Hysteretic) Dampers
Chapter 6	Viscous and Viscoelastic Dampers
Chapter 7	The ASCE 7-22 Design Provisions for Structures with Passive Energy Dissipating Systems
Chapter 8	Theory of Linear Seismically Isolated Systems
Chapter 9	Seismic Isolation Systems
Chapter 10	The ASCE 7-22 Design Provisions for Seismically Isolated Buildings
Chapter 11	The AASHTO Design Guide Specifications for Seismically Isolated Bridges
Chapter 12	Tuned-Mass Dampers
Chapter 13	Self-Centering Systems

COURSE SCHEDULE

Week	Date	Online Lectures / Project Tutorials Hours and Topics on Zoom (Italy Time)	Total hrs
1	5/2/24	14:00 to 18:00 Lecture 1: Course Presentation, Chapters 1-2: Introduction, Review of Seismic Design Methods. Project Phase 1.	4
	6/2/24	11:00 to 14:00 Tutorial 1a: Introduction to RUAUMOKO. Tutorial 1b: Introduction to OpenSeesPy. Tutorial 1c: Introduction to SeismoStruct. Tutorial 2: Producing Response Spectra with SeismoSpect, Q&A	3
	7/2/24	14:00 to 18:00 Lecture 2: Chapters 3-4: Energy and Basic Concepts. Project Phase 2.	4
	8/2/24	11:00 to 14:00 Tutorial 3a: Energy Computation in RUAUMOKO. Tutorial 3b: Introduction to Dynamic Analyses in OpenSeesPy. Tutorial 3c: Introduction to Dynamic Analyses in SeismoStruct. Tutorial 4a: Running RUAUMOKO and Dynaplot in Batch Mode and Linking with Matlab. Tutorial 4b: Running OpenSeesPy in Batch Mode. Tutorial 4c: Using the SeismoStruct Batch Facility, Q&A.	3
	9/2/24	14:00 to 18:00 Lecture 3: Chapter 5: Hysteretic Dampers. Project Phase 3.	4
2	12/2/24	14:00 to 18:00 Lecture 4: Chapter 6: Viscous and Viscoelastic Dampers. Project Phase 4.	4
	13/2/24	11:00 to 14:00 Tutorials 5a: Modelling of Hysteretic Dampers in RUAUMOKO. Tutorial 5b: Modelling Hysteretic Dampers in OpenSeesPy. Tutorial 5c: Modelling Hysteretic Dampers in SeismoStruct, Q&A.	3
	14/2/24	14:00 to 18:00 Lecture 5: Chapter 7: ASCE7-22 Provisions for Buildings with Passive Supplemental Damping Systems.	3
	15/2/24	11:00 to 14:00 Tutorial 6a: Modelling of Viscous Dampers in RUAUMOKO. Tutorial 6b: Modelling of Viscous Dampers in OpenSeesPy. Tutorial 6c: Modelling of Viscous Dampers in SeismoStuct. Review Problem No. 1, Q&A.	3
	16/2/24	14:00 to 18:00 Lecture 6: Chapter 8: Theory of Linear Seismic Isolation. Project Phase 5.	4
3	19/2/24	14:00 to 18:00 Lecture 7: Chapter 9: Seismic Isolation Systems.	4
	20/2/24	11:00 to 14:00 Review Problem No. 2, Q&A.	5
	21/2/24	14:00 to 18:00 Lecture 8: Chapter 10: ASCE 7-22 Isolation Provisions. Project Phase 6.	4
	22/2/24	11:00 to 14:00 Tutorial 7a: Modelling of Lead-Rubber Bearings in RUAUMOKO. Tutorial 7b: Modelling of Lead-Rubber Bearings in OpenSeesPy. Tutorial 7c: Modelling of Lead-Rubber Bearings in SeismoStruct. Review Problem No. 3. Q&A.	3
	23/2/24	14:00 to 18:00 Lecture 9: Chapter 11: AASHTO Guide for Isolated Bridges. Oral Project Presentation Instructions.	4
4	26/2/24	14:00 to 18:00 Lecture 10: Chapter 12: Tuned-mass Dampers; Chapter 13: Self-Centering Systems.	4
	27/2/24	11:00 to 14:00 Review Problem No. 4, Q&A.	3
	28/2/24	15:00 to 18:00 Project Online Oral Presentations.	3
	29/2/24	15:00 to 18:00 Project Online Oral Examinations.	3
	1/3/24	15:00 to 18:00 Final Online Written Examination.	3
		Total	**70**