

Course Title:	Performance-Based Earthquake Engineering – 2026/2027
Lecturers:	Gerard J. O'Reilly, Volkan Ozsarac, Davit Shahnazaryan
Teaching Assistant:	Vitor A. Monteiro
Dates:	16/11/2026 – 03/12/2026
Hours:	55 hours (31 lectures + 24 tutorials)
Location:	Palazzo del Broletto, Piazza della Vittoria 15, Pavia, Italy

Description

This course covers the design and assessment of new and existing buildings within the framework of performance-based earthquake engineering (PBEE), with a focus on structures commonly found in Italy and Southern Europe. A brief background on the development of PBEE is first provided, from its early beginnings to the developments of the past 25 years that underpin current practice. The core of the course addresses the ingredients needed to quantify uncertainty, compute seismic risk, and estimate economic losses: non-linear static and dynamic analysis methods — including incremental dynamic analysis, cloud analysis, and multiple stripe analysis — the derivation of fragility functions, and the propagation of hazard, demand, and damage into risk and loss estimates. Particular attention is paid to characterising seismic response through ground motion record selection and intensity measure choice, including conditional spectrum and generalised conditional intensity measure (GCIM) approaches.

The later part of the course turns to more recent developments in the field: simplified, pushover-based methods for loss and risk estimation alongside the seismic risk classification guidelines now used in practice; regional, large-scale risk assessment — covering scenario-based analysis, spatial and structural correlations, taxonomy-based fragility, and the generation of ground shaking and risk maps; and advanced fragility function methods, including empirical development, updating, and conversion between formats. The course is intended for students already familiar with current building codes and standard seismic analysis methods, and aims to give them a deeper understanding of these advanced and emerging topics within modern PBEE.

Grading

Coursework	40%
Final exam	60%

Schedule

Date	Time	Topic	Room
Mon 16/11	09:00 – 12:00	1. Course Overview 2. Analysis Methods – Part I • Non-linear static analysis • Non-linear dynamic analysis • MDOF vs SDOF models • Incremental dynamic analysis (IDA)	Aula 1-15
Mon 16/11	14:00 – 17:00	Tutorial	Aula 1-16

Date	Time	Topic	Room
Tue 17/11	09:00 – 12:00	3. Seismic Risk - Part I • Seismic hazard, logic trees and disaggregation • Fragility functions (FFs) • Derivation of FFs from IDA • Calculation of risk	Aula 1-17
Tue 17/11	14:00 – 17:00	Tutorial	Aula 1-17
Wed 18/11	09:00 – 12:00	4. Ground Motion Record Selection • Code-based selection • Hazard-consistency • Conditional spectrum • Generalised conditional intensity measure (GCIM)	Aula 1-17
Wed 18/11	14:00 – 17:00	Tutorial	Aula 1-16
Thur 19/11	09:00 – 12:00	5. Analysis Methods – Part II • Cloud analysis (CA) • Multiple stripe analysis (MSA) • Derivation of FFs from CA and MSA • Simplified analysis methods	Aula 1-17
Thur 19/11	14:00 – 17:00	Tutorial	Aula 1-17
Tue 24/11	09:00 – 12:00	6. Intensity Measures • Traditional definitions and novel developments • IM choice – efficiency, sufficiency, practicality • Potential bias in structural response • Ground motion record scaling	Aula 1-17
Tue 24/11	14:00 – 17:00	Tutorial	Aula 1-17
Wed 25/11	09:00 – 12:00	7. Seismic Risk - Part II • Demand-intensity models • Sources of uncertainty • Demand-hazard curves	Aula 1-17
Wed 25/11	14:00 – 17:00	Tutorial	Aula 1-17
Thur 26/11	09:00 – 12:00	8. Loss and Risk Assessment • Overview of loss assessment • Storey loss function-based assessment	Aula 1-17
Thur 26/11	14:00 – 17:00	Tutorial	Aula 1-17
Fri 27/11	09:00 – 12:00	9. Simplified Risk, Loss and Classification • Pushover-based loss and risk methods • Seismic risk classification guidelines	Aula 1-17

Date	Time	Topic	Room
Mon 30/11	09:00 – 12:00	10. Regional Risk Assessment • Scenario-based analysis • Incorporating correlations (spatial, inter- and intra-structure) • Taxonomy-based fragility functions • Generating ground shaking and risk maps	Aula 1-17
Mon 30/11	14:00 – 17:00	Tutorial	Aula 1-17
Tue 01/12	09:00 – 13:00	11. Advanced Fragility Analysis Methods • Empirical fragility function development • Fragility function updating • Fragility function conversion	Aula 1-17
Thur 03/12	09:00 – 13:00	Final Exam	Aula 1-17