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| **Course Title:** | **Performance-Based Earthquake Engineering – 2025/2026** |
| Lecturer: | Gerard J. O'Reilly |
| Dates: | 14/01/2026 – 29/01/2026 |
| Hours: | 48 hours (30 lectures + 18 tutorials) |
| Location: | Palazzo del Broletto, Piazza della Vittoria 15, Pavia, Italy |

## Description

This course covers topics related to performance-based earthquake engineering (PBEE) of new and existing buildings. A quick background on the development of PBEE is first provided, outlining its early beginnings, followed by the notable developments in the past 25 years that have led to the current and avant-garde approaches available in the literature. This relates to the design and assessment of buildings, particularly those commonly found in Italy and Southern Europe. The course focuses on the ingredients necessary for quantifying uncertainties, calculating risk, and estimating economic losses. Advanced topics such as risk- and loss-targeted seismic design methods are presented in addition to both simplified and extensive risk assessment methods available to practitioners. Other issues relating to regional assessment, ground motion and intensity measure selection to characterise seismic response are also covered. The course aims to provide students who are already familiar with current building codes and other standard seismic analysis methods with a better understanding of these advanced topics and state-of-the-art methods available within modern PBEE.

## Grading

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| Coursework | 40% |
| Final exam | 60% |

## Schedule

| Date | Time | Topic |
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| Wed 14/01 | 09:00 – 12:00 | **1. Course Overview**<br>**2. Analysis Methods - Part I**<br>• Non-linear static analysis<br>• Non-linear dynamic analysis<br>• MDOF vs SDOF models<br>• Incremental dynamic analysis (IDA) |
| | 14:00 – 17:00 | **3. Seismic Risk - Part I**<br>• Seismic hazard, logic trees and disaggregation<br>• Fragility functions (FFs)<br>• Derivation of FFs from IDA<br>• Calculation of risk |
| Thur 15/01 | 09:00 – 12:00 | **4. Ground Motion Record Selection**<br>• Code-based selection<br>• Hazard-consistency<br>• Conditional spectrum<br>• Generalised conditional intensity measure (GCIM) |
| | 14:00 – 17:00 | Tutorial: Part 1 - Identification of case study buildings, modal and pushover analysis<br>Part 2 - Get the site hazard |
| Fri 16/01 | 09:00 – 12:00 | **5. Analysis Methods – Part II**<br>• Cloud analysis (CA)<br>• Multiple stripe analysis (MSA)<br>• Derivation of FFs from CA and MSA<br>• Simplified analysis methods |
| | 14:00 – 17:00 | Tutorial: Part 3 - Get the ground motion records for IDA<br>Part 4 - Perform an IDA |

| Mon 19/01 | 09:00 – 12:00 | **6. Intensity Measures (IMs)**<br>• Traditional definitions and novel developments<br>• IM choice – efficiency, sufficiency, practicality<br>• Potential bias in structural response<br>• Ground motion record scaling |
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| | 14:00 – 17:00 | Tutorial: Part 5 - Get the ground motion records for MSA |
| Tue 20/01 | 09:00 – 12:00 | **7. Seismic Risk - Part II**<br>• Demand-intensity models<br>• Sources of uncertainty<br>• Demand-hazard curves |
| | 14:00 – 17:00 | Tutorial: Part 6 - Perform an MSA |
| Wed 21/01 | 09:00 – 12:00 | **8. Loss and Risk Assessment**<br>• Overview of loss assessment<br>• Storey loss function-based assessment<br>• Simplified risk assessment |
| | 14:00 – 17:00 | Tutorial: Part 7 - Create storey loss functions |
| Thur 22/01 | 09:00 – 12:00 | **9. Risk (and Loss)-Targeted Design**<br>• Risk-targeted spectra<br>• Risk-targeted behaviour factors<br>• Yield-frequency spectra<br>• Integrated performance-based seismic design |
| | 14:00 – 17:00 | Tutorial: Part 8 - Economic losses and collapse risk |
| Mon 26/02 | 09:00 – 12:00 | **10. Regional risk assessment**<br>• Scenario-based analysis<br>• Incorporating correlations (spatial, Inter- and intra-structure)<br>• Taxonomies classification and fragility functions<br>• Generating ground shaking and risk maps |
| Tue 27/01 | 09:00 – 12:00 | **11. Future Directions**<br>• Downtime and functional recovery<br>• Indirect losses<br>**12. Typology-Specific Issues**<br>• Infilled frame structures<br>• Unreinforced masonry structures |
| Thur 29/01 | **09:00 – 13:00** | **Final Exam** |