

**Course Title: Performance-Based Earthquake Engineering**

Lecturer: Gerard J. O'Reilly  
 Dates: 23<sup>rd</sup> January – 3<sup>rd</sup> February 2023  
 Hours: 24 lectures + 10 tutorials  
 Location: Palazzo del Broletto, Aula 1-17

**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-targeted seismic design methods are presented in addition to both simplified and extensive risk assessment methods available to practitioners. Other issues relating to 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**

Course project 40%  
 Final exam 60%

**Schedule**

	Date	Time	Topic
Week 1	Mon	09:00 – 12:00	<b>1. Course Overview</b> <b>2. Analysis Methods - Part I</b> <ul style="list-style-type: none"> <li>Non-linear static analysis</li> <li>Non-linear dynamic analysis</li> <li>MDOF vs SDOF models</li> <li>Incremental dynamic analysis (IDA)</li> </ul>
		14:00 – 17:00	<b>3. Seismic Risk - Part I</b> <ul style="list-style-type: none"> <li>Seismic hazard</li> <li>Fragility functions (FFs)</li> <li>Derivation of FFs from IDA</li> <li>Computation of risk</li> </ul>
	Wed	09:00 – 12:00	<b>4. Intensity Measures (IMs)</b> <ul style="list-style-type: none"> <li>IM choice – efficiency, sufficiency, practicality</li> <li>Record scaling and potential bias</li> <li>Possible future directions for different typologies</li> </ul>
		15:00 – 17:00	Presentation of project assignment
	Thur	09:00 – 12:00	<b>5. Ground Motion Record Selection</b> <ul style="list-style-type: none"> <li>Scenario-based selection</li> <li>Code-based selection</li> <li>Conditional spectrum</li> </ul>



			<ul style="list-style-type: none"> <li>• Hazard-consistency</li> <li>• Spatial variability and correlation</li> <li>• Considering tectonic environment in selection</li> </ul>
		15:00 – 17:00	Tutorial
	Fri	09:00 – 12:00	<b>6. Analysis Methods – Part II</b> <ul style="list-style-type: none"> <li>• Cloud analysis (CA)</li> <li>• Multiple stripe analysis (MSA)</li> <li>• Derivation FFs from CA and MSA</li> <li>• Simplified Analysis Methods</li> </ul> <b>7. Seismic Risk - Part II</b> <ul style="list-style-type: none"> <li>• Demand-intensity models</li> <li>• Sources of uncertainty</li> <li>• Demand-hazard curves</li> </ul>
		15:00 – 17:00	Tutorial
	Mon	09:00 – 12:00	<b>8. Loss and Risk Assessment</b> <ul style="list-style-type: none"> <li>• Component-based loss assessment</li> <li>• Storey loss function-based assessment</li> <li>• Simplified risk assessment</li> <li>• Loss assessment for (re)insurance industries</li> </ul>
Week 2		15:00 – 17:00	Tutorial
	Tue	09:00 – 12:00	<b>9. Risk-Targeted Design</b> <ul style="list-style-type: none"> <li>• Risk-targeted behaviour factors</li> <li>• Risk-targeted spectra</li> <li>• Yield-frequency spectra</li> <li>• Integrated performance-based seismic design</li> </ul>
		15:00 – 17:00	Tutorial
	Wed	09:00 – 12:00	<b>10. Typology-Specific Issues</b> <ul style="list-style-type: none"> <li>• Infilled frame structures</li> <li>• Unreinforced masonry structures</li> </ul> <b>11. Future Directions</b> <ul style="list-style-type: none"> <li>• Downtime</li> <li>• Indirect losses</li> </ul>
	Thur	09:00 – 12:00	<b>Project presentations</b>
	Fri	09:00 – 12:00	<b>Final Exam</b>