

Beyond Seismic Safety - Sustainable Retrofit Design

Second Semester A.Y. 2025-2026

Lecturers: Martina Caruso, Gianrocco Mucedero
E-mail: martina.caruso@globalquakemodel.org, gianrocco.mucedero@iusspavia.it
Teaching Assistants: Mehmet Firat Aydin, Margherita Buttazzoni
E-mail: firat.aydin@iusspavia.it
margherita.buttazzoni@iusspavia.it

CLASS SCHEDULE

Lectures/Tutorials: February 23th - March 6th, 2026 (7 lectures + 6 tutorials, 36 hours)
Location: Palazzo del Broletto, IUSS, Piazza della Vittoria 15 (Pavia, Italy)

BACKGROUND

Basic knowledge of seismic hazard, seismic analysis, and seismic loss assessment of existing buildings. No specific requirement for energy and environmental assessment procedures.

GENERAL OBJECTIVES

The main objective of the course is to provide an overview of state-of-art methodologies for the integrated seismic/energy assessment and retrofitting of existing buildings, which are crucial in the current climate change emergency. Adopting a multi-disciplinary and holistic perspective in the design approach is essential. The course will also feature seminars and open discussions with invited researchers and practitioners.

COURSE NOTES AND REFERENCES

Slide sets and bibliography posted on Google Drive.

ASSIGNMENTS

Homework assignments will be parts of a project and must be solved in groups, with the same teams remaining intact throughout the course. Each assignment shall be neatly written and submitted on time. The first page of each assignment shall include the course name, the title of the assignment, the date, the student name(s), and signature(s).

GRADING

Evaluation will be based on homework assignments (50%) and an oral presentation of project outcomes (50%).

EXTERNAL STUDENTS

External students interested in attending the course should contact Martina Caruso and Gianrocco Mucedero. The course is available for in-person attendance only.

Lectures

Day 1

INTRODUCTION

- Sustainable development and European policy framework: Sustainable Development Goals, Paris Agreement, European Green Deal, New Bauhaus, Next Generation EU;
- The new concept of sustainability (environmental, economic, social dimensions), including structural/seismic safety;
- Life Cycle Structural Engineering (LCSE): general overview and applications.

SEISMIC RETROFITTING STRATEGIES FOR RC STRUCTURES - Part 1

- Typical deficiencies in RC buildings, relevant terminology, and goals of retrofitting strategies;
- Selective retrofitting techniques: stiffness, strength, ductility.

Tutorial 1: Use of SeismoStruct and structural modelling.

Day 2

SEISMIC RETROFITTING STRATEGIES FOR RC STRUCTURES - Part 2

- Structural-level retrofitting strategies:
 - Conventional methods: RC walls, steel bracing, infill walls added to or integrated into the existing frame;
 - Non-conventional methods: base isolation, viscous dampers;
- Member-level (local) retrofitting techniques: jacketing, metallic haunch, FRP, steel plate.

Tutorial 2: Seismic loss assessment.

Day 3

ENERGY EFFICIENCY RETROFITTING STRATEGIES FOR RC STRUCTURES

- Energy use in buildings, operational energy, primary/secondary energy, CO2 emissions;
- Typical deficiencies in RC buildings, main barriers and challenges in energy upgrades;
- Energy efficiency policies and standards in the European Union;
- Overview of traditional and innovative energy retrofitting solutions: thermal coatings, windows replacement, photovoltaics, system upgrades, etc.

Tutorial 3: Design of seismic retrofitting strategies and numerical implementation in SeismoStruct.

Day 4

DECISION-MAKING APPROACHES FOR THE TRADITIONALLY UNCOUPLED ASSESSMENT AND OPTIMAL RETROFITTING OF BUILDINGS

- Traditional decision-making approaches: expected annual loss, seismic resilience-based assessment, index-based method, seismic risk classification, incremental seismic rehabilitation, cost-benefit analysis.

Tutorial 4: Application of traditional decision-making approaches.

Day 5

ENVIRONMENTAL IMPACT ASSESSMENT

- Life Cycle Assessment (LCA): scope, boundaries, types;
- Relevant legislation, standards, available tools and databases;
- Life Cycle Cost Assessment (LCCA) and Social Life Cycle Assessment (S-LCA) procedures;
- Environmental impact assessment and seismic loss estimation: damage-to-impact conversion.

INTEGRATED ASSESSMENT AND RETROFITTING OF BUILDINGS

- Life Cycle Structural Engineering (LCSE) approach;
- Life Cycle Thinking (LCT): design principles, choices and objectives.

INTEGRATED RETROFITTING STRATEGIES

- Coupled/integrated retrofitting techniques: incremental strategies, seismic thermal coatings, exoskeletons, etc.;
- Integrated strategies for new buildings: lightweight structures, XLAM, etc.

Tutorial 5: Quantification of environmental impacts of retrofits' components.

Day 6

DECISION-MAKING TOOLS FOR THE INTEGRATED ASSESSMENT AND OPTIMAL RETROFITTING OF BUILDINGS

- Multi-criteria decision-making approaches, including simplified methods.

Tutorial 6: Application of integrated decision-making approaches.

Day 7

NEW RESEARCH FRONTIERS - Invited researchers/practitioners



IUSS

Scuola Universitaria Superiore Pavia

Palazzo del Broletto
Piazza della Vittoria, 15 - 27100, Pavia (PV)
C.F. 96049740184 - P.IVA 02202080186
www.iusspavia.it/en

Course Schedule

Week	Date	Lecture hours	Tutorial hours	Subject	Total
1	23/02/2026	09.00 am to 1.00 pm Aula 1-15, IUSS	2.30 pm to 4.30 pm Aula 1-15, IUSS	Lecture 1: Introduction + Seismic retrofitting strategies for RC structures (Part 1)	6
	24/02/2026	10.00 am to 1.00 pm Aula 1-15, IUSS	2.30 pm to 4.30 pm Aula 1-15, IUSS	Tutorial 1: Use of SeismoStruct and structural modelling, Q&A, Assignment No. 1 Lecture 2: Seismic retrofitting strategies for RC structures (Part 2)	5
	25/02/2026	9.00 am to 1.00 pm Aula 1-15, IUSS	2.30 pm to 4.30 pm Aula 1-15, IUSS	Tutorial 2: Seismic loss assessment, Q&A Lecture 3: Energy efficiency retrofitting strategies for RC structures	6
	26/02/2026	10.00 am to 1.00 pm Aula 1-15, IUSS	2.30 pm to 4.30 pm Aula 1-15, IUSS	Tutorial 3: Design of seismic retrofitting strategies and implementation in SeismoStruct, Q&A Lecture 4: Decision-making approaches for the traditionally uncoupled assessment and optimal retrofitting of buildings	5
2	02/03/2026	9.00 am to 1.00 pm Aula 1-15, IUSS	2.30 pm to 4.30 pm Aula 1-15, IUSS	Tutorial 4: Application of traditional decision-making approaches, Q&A Lecture 5: Environmental impact assessment + Integrated assessment and retrofitting of buildings + Integrated retrofitting strategies	6
	03/03/2026	10.00 am to 12.00 pm Aula 1-15, IUSS	2.30 pm to 4.30 pm Aula 1-15, IUSS	Tutorial 5: Quantification of environmental impacts of retrofits' components, Q&A, Assignment No. 2 Lecture 6: Decision-making tools for the integrated assessment and optimal retrofitting of buildings	4
	06/03/2026	9.00 am to 1.00 pm Sala del Camino		Tutorial 6: Application of integrated decision-making approaches, Q&A Lecture 7: New research frontiers	4
				Exam: Project presentation	4
				Total hours	36
				Exam	4



IUSS

Scuola Universitaria Superiore Pavia

Palazzo del Broletto
Piazza della Vittoria, 15 - 27100, Pavia (PV)
C.F. 96049740184 - P.IVA 02202080186
www.iusspavia.it/en