**Integrated Assessment and Retrofitting of Existing Buildings**

**Second Semester A.Y. 2024-2025**

**Lecturers**: Martina Caruso, Gianrocco Mucedero

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**Teaching Assistants**: Besim Yükselen, Margherita Buttazzoni

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**CLASS SCHEDULE**

**Lectures/Tutorials**: February 24th - March 6th, 2025 (7 lectures + 6 tutorials, 40 hours)

**Location**: Palazzo del Broletto, IUSS, Piazza della Vittoria 15 (Pavia, Italy)

**BACKGROUND**

Basic knowledge of seismic hazard, seismic analysis, and 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 an open discussion with invited researchers and practitioners.

**COURSE NOTES AND REFERENCES**

Slide sets and bibliography posted on Google Drive.

**ASSIGNMENTS**

Homework assignments will be part 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**

Assignments 50% + Project final presentation 50%

**EXTERNAL STUDENTS**

External students interested in attending the course should contact postlaurea@iusspavia.it. The course is available for in-person attendance. Evaluation will be based on homework assignments and a final presentation of project outcomes.

**LECTURES**

**Lecture 1**

*INTRODUCTION* (1 h) – Martina Caruso

* General overview of the course (topics, tutorials, project);
* European targets and objectives: Paris Agreement, European Green Deal, New Bauhaus, Next Generation EU, Sustainable Development Goals;
* Definition of a new concept of sustainability (environment, economy, and society), including structural/seismic safety;
* Existing buildings: main structural and energy issues and deficiencies, common uncoupled/sectorial approach to their assessment and retrofitting;
* Introduction to the integrated (multi-performance) assessment and retrofitting of buildings.

*SEISMIC RETROFITTING STRATEGIES FOR R.C. STRUCTURES - (Part 1) (3h) –* Gianrocco Mucedero

* Overview of typical deficiencies in R.C. buildings, review of relevant terminology, goals of retrofit strategy;
* Selective intervention techniques: stiffness, strength, ductility.

*Tutorial 1:* Use of SeismoStruct and seismic loss assessment methodologies - Besim Yükselen/Margherita Buttazzoni

**Lecture 2**

*SEISMIC RETROFITTING STRATEGIES FOR R.C. STRUCTURES* *- (Part 2)* (3h) – Gianrocco Mucedero

* Structural-level approach of retrofitting:
	+ Conventional methods: R.C. walls, steel bracing or infill walls into/onto the existing frame;
	+ Non-conventional methods: base isolation, viscous dampers;
* Member-level approach or local retrofitting: jacketing, metallic haunch, FRP, steel plate, and others.

*Tutorial 2:* Design of seismic retrofitting strategies and implementation in SeismoStruct – Besim Yükselen/Margherita Buttazzoni

**Lecture 3**

*ENERGY EFFICIENCY RETROFITTING STRATEGIES FOR R.C. STRUCTURES* (4h) – Martina Caruso

* Energy use in buildings, operational energy, primary/secondary energy, CO2 emissions;
* Main challenges of energy efficiency retrofitting;
* Traditional and innovative energy retrofitting solutions (thermal coatings, replacement of windows, photovoltaics, thermal insulation, replacement of existing heating, cooling, and lighting systems, etc).

*Tutorial 3:* Design of energy retrofitting strategies and implementation in Edilclima – Besim Yükselen/Margherita Buttazzoni

**Lecture 4**

*DECISION-MAKING APPROACHES FOR THE TRADITIONALLY UNCOUPLED ASSESSMENT AND OPTIMAL RETROFITTING OF BUILDINGS* (3h) – Gianrocco Mucedero

* Traditional uncoupled (seismic or energy) decision-making approaches: expected annual loss, seismic resilience-based assessment, index-based method, seismic risk classification, incremental seismic rehabilitation, energy classification, cost-benefit analysis, green resilience indicator.

*Tutorial 4:* Application of one of the above decision-making approaches – Besim Yükselen/Margherita Buttazzoni

**Lecture 5**

*INTEGRATED ASSESSMENT AND RETROFITTING OF BUILDINGS* (1h) – Martina Caruso

* Life Cycle Structural Engineering (LCSE) approach;
* Life Cycle Thinking (LCT) performance objectives.

*ENVIRONMENTAL IMPACT ASSESSMENT* (2h) – Martina Caruso

* Life Cycle Assessment (LCA): contents, boundaries, types;
* 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 RETROFITTING STRATEGIES* (1h) – Martina Caruso

* Examples of coupled/integrated retrofitting techniques: incremental strategies for coupled/integrated retrofitting, seismic thermal coating, exoskeletons, etc.;
* Examples of new buildings designed based on an integrated strategy (lightweight structures, etc), EPS, mixed wood-R.C. (XLAM).

*Tutorial 5:* Example calculation of environmental impacts – Besim Yükselen/Margherita Buttazzoni

**Lecture 6**

*DECISION-MAKING TOOLS FOR THE INTEGRATED ASSESSMENT AND OPTIMAL RETROFITTING OF BUILDINGS - PART 1* (2h) – Martina Caruso/Gianrocco Mucedero

* Multi-criteria decision-making approaches (including simplified ones).

*Tutorial 6:* Application of one of the decision-making approaches – Besim Yükselen/Margherita Buttazzoni

**Lecture 7**

*DECISION-MAKING TOOLS FOR THE INTEGRATED ASSESSMENT AND OPTIMAL RETROFITTING OF BUILDINGS - PART 2* (4h) – Martina Caruso/Gianrocco Mucedero/Invited researchers and practitioners

* Real case-study applications;
* Open discussion with invited researchers and practitioners.

**COURSE SCHEDULE**

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| **Week** | **Date** | **Lecture hours** | **Tutorial hours** | **Subject** | **Total** |
| 1 | 24/02/2025 | 09.00 am to 1.00 pmAula 1-16, IUSS | 2.30 pm to 4.30 pmAula 1-16, IUSS | **Lecture 1**: Introduction + Seismic retrofitting strategies for R.C. structures (Part 1)**Tutorial 1**: Use of SeismoStruct and seismic loss assessment methodologies, Q&A, Assignment No. 1 | 6 |
| 25/02/2025 | 10.00 am to 1.00 pmAula 1-16, IUSS | 2.30 pm to 4.30 pmAula 1-16, IUSS | **Lecture 2**: Seismic retrofitting strategies for R.C. structures (Part 2)**Tutorial 2**: Design of seismic retrofitting strategies and implementation in SeismoStruct, Q&A | 5 |
| 26/02/2025 | 9.00 am to 1.00 pmAula 1-16, IUSS | 2.30 pm to 4.30 pmAula 1-16, IUSS | **Lecture 3**: Energy efficiency retrofitting strategies for R.C. structures**Tutorial 3**: Design of energy retrofitting strategies and implementation in Edilclima, Q&A | 6 |
| 27/02/2025 | 10.00 am to 1.00 pmAula 1-16, IUSS | 2.30 pm to 4.30 pmAula 1-16, IUSS | **Lecture 4**: Decision-making approaches for the traditionally uncoupled assessment and optimal retrofitting of buildings**Tutorial 4**: Application of one of the decision-making approaches, Q&A, Assignment No. 2 | 5 |
| 2 | 03/03/2025 | 9.00 am to 1.00 pmAula 1-16, IUSS | 2.30 pm to 4.30 pmAula 1-16, IUSS | **Lecture 5**: Integrated assessment and retrofitting of buildings + Environmental impact assessment + Integrated retrofitting strategies**Tutorial 5**: Example calculation of environmental impacts, Q&A, Assignment No. 3 | 6 |
| 04/03/2025 | 10.00 am to 12.00 pmAula 1-16, IUSS | 2.30 pm to 4.30 pmAula 1-16, IUSS | **Lecture 6**: Decision-making tools for the integrated assessment and optimal retrofitting of buildings (Part 1) **Tutorial 6**: Application of one of the decision-making approaches, Q&A | 4 |
| 05/03/2025 | 9.00 am to 1.00 pmSala del Camino |  | **Lecture 7**: Decision-making tools for the integrated assessment and optimal retrofitting of buildings (Part 2) | 4 |
| 06/03/2025 | 9.00 am to 1.00 pmSala del Camino |  | **Exam**: Project presentation | 4 |
|  |  |  |  | Total hours | 40 |