SEISMIC FRAGILITY OF NON LINEAR STRUCTURES USING ADVANCED INTENSITY MEASURES

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During this course the students will learn about the evolution of ground motion intensity measures and their importance for structural engineering, seismology and earthquake engineering. In addition, they will be able to quantitatively evaluate the most common intensity measures such as peak ground acceleration, peak ground velocity, pseudoacceleration and pseudovelocity at the fundamental period of vibration of the structure, as well as more advanced intensity measures inspired in the spectral shape parameter N_p such as I_{Np} and I_{Bg}. Then, the correlation between various intensity measures will be evaluated and the students will learn how to scale each of them to perform incremental dynamic analysis of nonlinear structures. From the incremental dynamic analyses via various traditional and advanced scalar ground motion intensity measures, the structural fragility curves will be obtained. Additionally, the students will learn how to obtain the efficiency in terms of structural response and probability of failure of nonlinear systems from vector-valued ground motion intensity measures by means of multinomial logistic regression. On the other hand, the students will understand the importance of an adequate intensity measure for ground motion record selection and a vision toward the optimization of modern intensity measures will be given. Finally, the course will be evaluated with a written report which will be discussed in the last lecture.

Number of hours: 18-24

Period: 8 - 16 October 03 (2025)

Course Program

Lecture 1. Introduction to ground motion intensity measures IMs

- Introduction and course schedule.
- History of the assessment of the ground motion potential of an earthquake.
- Definition of magnitude and intensity.
- Evolution of ground motion intensity measures.
- Computing traditional intensity measures based on amplitude and ground motion duration.
- Evaluating the correlation among intensity measures.
- Homework 1.

Lecture 2. Definition and scaling intensity measures in terms of spectral ordinate

- Computing traditional spectral ordinate IMs.
- Developing a computer program to scale records in terms of peak ground acceleration PGA.
- Exercise and discussion: Comparing the seismic response of nonlinear structures with the PGA.

- Scaling spectral acceleration at first mode of vibration of the structure $Sa(T_1)$.
- Introduction to incremental dynamic analysis in terms of $Sa(T_1)$.
- Homework 2.

Lecture 3. Incremental Dynamic Analysis and seismic fragility assessment for traditional scalar intensity measures

- Calculate the seismic response of nonlinear structures under ground motions records.
- Compute for several earthquakes the seismic response in terms of traditional IMs.
- Comparing Incremental Dynamic Analysis in terms of PGA, $Sa(T_1)$ and other spectral ordinate IMs.
- Seismic fragility assessment of nonlinear structures in terms of PGA.
- Seismic fragility assessment of nonlinear structures in terms of $Sa(T_1)$.
- Comparing the seismic fragility of PGA vs $Sa(T_1)$.
- Homework 3.

Lecture 4. IDA and fragility curves for advanced spectral shape IMs

- Compute for several earthquakes the seismic response in terms of advanced IMs.
- Incremental Dynamic Analysis in terms of advanced intensity measures.
- Example of IDA curves for Sa, IR, INp, IB, etc.
- Fragility curves of nonlinear structures in terms of advanced spectral shape proxies.
- Homework 4.

Lecture 5. Introduction to vector-valued ground motion intensity measures and computing fragility surfaces

- Definition of vector-valued IMs.
- Advantages of vector-valued IMs.
- Introduction to logistic regression.
- Computing fragility surfaces for vector-valued ground motion intensity measures.
- A new vision toward the optimal ground motion intensity measure (efficiency, scaling robustness, record selection, etc.)
- Homework 5 (written report).

Lecture 6. Conclusion and evaluation of the course