University of Florence
Department of Civil and Environmental Engineering

Georisk Engineering S.r.l.

International Ph.D. Scholarship

NON-DETERMINISTIC NUMERICAL GEOTECHNICAL SEISMIC SITE RESPONSE ANALYSIS

Main tutor: Prof. Marco Uzielli, Ph.D.

Seismic site response analysis is a fundamental phase of seismic risk assessment and management as it allows enhanced estimation of seismic hazard due to the propagation and modification of seismic waves and their interaction with the built environment. From a geotechnical earthquake engineering perspective, seismic site response analysis entails the quantitative investigation of stratigraphic, topographic, and basin effects as parameterized by geometric, geotechnical, and seismic attributes of a geotechnical system. Quantitative values of such attributes are always pervaded by uncertainties stemming from the real spatial variability of the geologic environment, indetermination in future seismic actions which will occur at a given site, imperfections in measurements from geotechnical testing outputs, scatter in models and correlations used to derive geotechnical parameters from testing data, and approximations in the approaches used to conduct site response analysis, which include analytical and numerical methods. Numerical approaches most often provide higher-quality estimates of site response and allow the modeling of two- or three-dimensional scenarios.

The geotechnical discipline is experiencing a momentous shift in paradigm from deterministic approaches to uncertainty-based and data-driven approaches, which entail the explicit modeling, processing, and reporting of uncertainties. The adoption of the non-deterministic paradigm in geotechnical design codes attests to the convenience of embracing the awareness of uncertainties to pursue cost-performance optimization in geotechnical earthquake engineering analysis and design.

This Ph.D. project focuses on non-deterministic numerical geotechnical site response analysis. The aims of the project are: (1) development of best-practice approaches to non-deterministic geotechnical seismic site response analysis; and (2) provision of design-format methods implementing the outputs of the analyses.

Activities will tentatively include: (a) uncertainty-based geotechnical earthquake site characterization using advanced (e.g., Bayesian) approaches; (b) definition and generation of spectrum-compatible strong ground motions; (c) non-deterministic deconvolution of seismic motions; (d) non-deterministic linear, linear equivalent, and non-linear 1D site response analysis; (e) pre-processing and post-processing of 2D site response analyses to be conducted using the OpenSees free software (note: graphical pre- and post-processing will be conducted using available free softwares such as Paraview); (f) machine learning-based metamodeling of numerical analysis outputs; (g) non-deterministic analysis of numerical and metamodeling output data for the quantification of amplification and aggravation phenomena; (h) formulation and calibration of design-format methods; (i) application of the developed tools to case-studies; and (j) validation of case-study outputs against literature results and/or empirical data. An integrated suite of software routines in the Python language will be compiled to achieve the above objectives.