POLITECNICO DI MILANO

PhD in MODELLI E METODI MATEMATICI PER L'INGEGNERIA / MATHEMATICAL MODELS AND METHODS IN ENGINEERING - 40th cycle

PNRR 630 Research Field: AN INTEGRATED HPC NUMERICAL PARADIGM TO PRODUCE SEISMIC IMPACT SCENARIOS IN LARGE URBAN AREAS AND INDUSTRIAL PLANTS

Monthly net income of PhDscholarship (max 36 months)
€ 1500.0 In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	The generation of seismic damage scenarios in large urban areas represent a key tool for civil protection to enhance earthquake preparedness, to establish effective prevention policies for seismic risk mitigation and to support decision making in emergency management. Usually, such scenarios are produced using approaches based on segregated algorithms, where the simulation of the ground response is decoupled from that of the buildings, so that the dynamic interaction forces exchanged by the soil and the structure are not taken into account. However, the scientific and technological advances made in recent years have given rise to increasingly flexible, accurate, and scalable numerical methods, and have opened up new perspectives in the numerical modeling of multi-scale seismic phenomena including, in a single model, the seismic source, the propagation in heterogeneous materials, and the dynamic response of civil engineering structures. This integrated approach makes it possible to perform three-dimensional physics-based simulations of seismic risk scenarios at the urban scale, taking into account soil-structure interaction (SSI) and site-city interaction (SCI) effects. In this scenario, the objective of the research subject of the proposed Ph.D. is to update existing methodologies currently employed and develop and implement new methods and physical models for the coupling of three-

	dimensional physics-based ground motion simulations with mathematical models for non-linear structural response at urban scale. The new approach will allow to carry out "source-to-site" seismic analyses, including the regional simulation of earthquake process in heterogeneous soils coupled with structures or cluster of structures modeled as non-linear Multi-Degree-Of-Freedom systems.
Methods and techniques that will be developed and used to carry out the research	The simulation of SSI effects requires efficient numerical strategies to handle the simultaneous, coupled response of the ground and the structure and their interaction.For this reason, it is essential to design new strategies from both a modelling and computational point of view, to provide accurate estimates of structural behavior and, hence, of their potential damage levels, with important implications for seismic risk assessment studies. Different modelling strategies, spanning from "weak coupling" techniques relying on substructuring methods (i.e., the Domain Reduction Method) up to full coupling algorithms (where soil-structure interaction forces are computed and exchanged across the two domains at each time step), will be explored, validated and tested on realistic case studies of industrial interest. Numerical simulations will be performed using the HPC code SPEED (http://speed.mox.polimi.it/) based on Discontinuous Galerkin Spectral Elements. Application case studies will focus mainly on strategic structures of the industrial sector devoted to the production of clean energy, such as wind turbines or hydroelectric power plants. The project will be carried out in collaboration with the company RSE s.p.a. (https://www.rse-web.it/), which is a well-established Italian company whose research activity concerns the energy and sustainability chain, from primary energy sources to all conversion and use systems, from energy carriers to technologies for energy efficiency and storage. In this sense RSE is the most appropriate partner that can provide test cases for validating the new methodologies proposed in this project. A minimum 6-month internship at RSE and a 6-month research period abroad are planned.

Educational objectives	During the PhD, the student will be able to: - develop strong skills in mathematical modeling and numerical analysis - master tools for HPC computing - build 3D physics-based numerical models for seismic wave propagation in complex geophysical domains and for their interaction with the built environment develop seismic risk scenarios of strategic structures for the energy sector (wind farms, hydroelectric power plants). Overall the problem represents a scientific challenge for a young researcher in applied mathematics and scientific computing.
Job opportunities	The research addresses innovative and advanced topics in Computational Modeling, Computational Seismology and Applied Mathematics in general. Thanks to the large-view approach and the versatility of the applied methods, the exiting PhD student will surely be appreciated in the broad ensemble of research activities, both industrial and academic.
Composition of the research group	1 Full Professors 2 Associated Professors 0 Assistant Professors 0 PhD Students
Name of the research directors	Ilario Mazzieri, Chiara Smerzini, Roberto Paolucci

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Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad	
Amount monthly	750.0 €
By number of months	6

National Operational Program for Research and Innovation

Company where the candidate will attend the stage (name and brief description)	RSE
By number of months at the company	6
Institution or company where the candidate will spend the period abroad (name and brief description)	
By number of months abroad	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
Educational activities (purchase of study books and material, funding for participation to courses, summer schools, workshops and conferences): financial aid per PhD student per year 1st year: max 2.038,16 euros 2nd year: max 2.038,16 euros 3rd year: max 2.038,16 euros The PhD students are encouraged to take part in activities related to teaching, within the limits allowed by the regulations.1 individual PC per student +several shared PC. Access to one cluster with 32 processors and 384 GB RAM, and to several multi - processor servers.