POLITECNICO DI MILANO

PhD in INGEGNERIA STRUTTURALE, SISMICA, GEOTECNICA / STRUCTURAL SEISMIC AND GEOTECHNICAL ENGINEERING - 41st cycle

THEMATIC Research Field: CONCRETE BASED ENERGY STORAGE

Monthly net income of PhDscholarship (max 36 months)
1800.0 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 surging electrification and reliance on intermittent sources of renewable energy, plus the need to reduce CO2 footprint, create perfect conditions for market penetration of innovative solutions for energy storage. Concrete-based thermal energy storage (C-TES) is the most mature and promising of such technologies. In C-TES, molten salts flow through channels within a large mass of concrete, storing and extracting heat in typically daily cycles. High storage temperatures (T) improve efficiency and performance, but commercial C-TES today is bound to 400°C max. Higher temperatures and concrete-salt interactions cause thermo-chemical degradation and fatigue, which may drastically compromise performance and safety. The objectives of this project are to: (O1) Obtain missing experimental data on high-T cyclic behaviour and damage of promising high-performance concrete for C-TES; (O2) Develop the first multiscale model of concrete for high-T TES, to link micro-processes of degradation with full-scale performance and integrity; (O3) Synergise the new models and additional model-oriented experiments to develop a robust concrete mix design for high-T TES.
Methods and techniques that will be developed and used to carry out the research	The pursuit of O1 will involve screening promising concrete formulations for high-T exposure, through

	classical mechanical testing of strength, modulus, toughness, etc, both at room T and residual after cooling from high T. Shortlisted mixes will be tested for cyclic thermo-chemical degradation and fatigue, combining mechanical tests with microstructural characterisation to quantify chemical evolution and damage progression. The experimental data will inform model development towards O2. The models will involve coarse-grained kinetic Monte Carlo simulations of microstructural degradation (chemo-thermo-mechanical) and constitutive modelling towards mesoscale simulations of concrete damage at sample scale and at full battery scale (e.g. by adapting the concrete damage plasticity model in ABAQUS). The pursuit of O3 will leverage all the aforementioned experimental and modelling results and tools.
Educational objectives	To educate a researcher able to understand the high-temperature degradation processes of concrete in TES batteries, along with their dependence on concrete formulation, as a way to optimize the mix design. This will entail specific skill development in targeted experimental and modelling techniques at multiple length-scales, which will equip the student with a valuable skillset to conduct research in multi-scale modelling and characterization of complex engineering materials and their degradation.
Job opportunities	Employment in advanced materials modelling or advanced energy/oil research centres or universities; companies designing the implementation of innovative energy storage systems as part of new and existing businesses; companies developing and selling new energy storage devices and solutions.
Composition of the research group	1 Full Professors 2 Associated Professors 5 Assistant Professors 13 PhD Students
Name of the research directors	L. Ferrara, E. Masoero, F. Lo Monte

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Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents	--

Scholarship Increase for a period abroad	
Amount monthly	900.0 €
By number of months	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 Ph.D. student per year. The Ph.D. course supports the educational activities of its Ph.D. students with an additional funding equal to 10% of the scholarship, starting from the first year. Teaching assistantship: availability of funding in recognition of support to teaching activities by the Ph.D. student. There are various forms of financial aid for activities of support to the teaching practice. The Ph.D. is encouraged to take part in these activities, within the limits allowed by the regulations. Computer availability: each Ph.D. student has his/her own computer for individual use. Desk availability: each Ph.D. student has his/her own desk, cabinet and locker.