POLITECNICO DI MILANO

PhD in INGEGNERIA STRUTTURALE, SISMICA, GEOTECNICA / STRUCTURAL SEISMIC AND GEOTECHNICAL ENGINEERING - 37th cycle

PON - GREEN Research Field: AUTOMATION IN CONCRETE CONSTRUCTION FOR ZERO-WASTE REFURBISHMENT OF TUNNELS AND INFRASTRUCTURES

Monthly net income of PhDscholarship (max 36 months)
€ 1180.0 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 project aims at developing and validating a large-scale extrusion project for the refurbishment of urban (utilities) and highway tunnels, with total reclaim and recycling of the existing structure (zero-waste/sustainable development) and using reduced clinker content cement (decarbonisation), also achieving enhanced durability (reduction of environmental impact) in the intended scenarios.
Methods and techniques that will be developed and used to carry out the research	The project will be structured according to the following WPs: - Physical, chemical and mechanical characterization of materials currently employed in tunnel construction and their use as recycled constituents in extrudable cement-based mixes; - Development of a mix design concept employing the materials as above and binders with reduced clinker content, and hence reduced CO2 emissions; - Characterization of rheological properties of the developed mixes, also with the aim of identifying parameters relevant to the manufacturing process and with the support of suitable numerical modelling tools, targeted to the design of the manufacturing project and to the structural design of intended manufacts for the whole service life cycle; - Correlation between rheological properties and non-

	destructively measured parameters, measured through sensors which can be installed onto the additive manufacturing machines for a real time adaption of the mix composition and of the time-parameters of the manufacturing process; - Real scale (at field lab of the company) verification through prototyping; - Structural optimization and LCA/LCC evaluation considering: - 1. Job execution time (and reduced traffic interruption; no use of moulds); - 2. Integral recovery of pre-existing materials; - 3. Achievement of enhanced structural and durability performance and their outcomes on planned maintenance.
Educational objectives	The candidate will be trained in advanced topics related to the structural design and applications of advanced cement based materials, additive manufacturing and life-cycle analysis.
Job opportunities	The topics of additive manufacturing and advanced cement based materials are crucial in the development of the construction sector. The candidate, once graduated, can spend his skills into a broad portfolio of engineering firms and construction companies and the training in the Hinfra company as well as the collaboration with the international institutions partner of the research group will surely open broad possibilities.
Composition of the research group	0 Full Professors 1 Associated Professors 2 Assistant Professors 7 PhD Students
Name of the research directors	Prof. Liberato Ferrara

Contacts
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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	566.36 €
By number of months	6

National Operational Program for Research and Innovation	
Company where the candidate will attend the stage (name and brief description)	Hinfra (https://www.hinfra.it/)
By number of months at the company	6
Institution or company where the candidate will spend the period abroad (name and brief description)	ETH Zurich
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): 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 second year.

Teaching assistanship (availability of funding in recognition of support to teaching activities by the PhD student): Ph.D. students are encouraged to apply, upon prior authorization, to the calls to support teaching activities at the undegraduate and Master levels at Politecnico, being paid for that. The teaching assistantship will be limited up to about 80 hours, maximum half of them devoted to teaching and classroom activities and the rest to support classworks and exams.

Computer availability and desk availability: Each Ph.D. student has his/her own computer for individual use.Each Ph.D. student has his/her own desk, cabinet and locker.