POLITECNICO
MILANO 1863

Supervisor Expression of Interest
MSCA - Marie Sklodowska Curie Action - (PF) Postdoctoral Fellowship 2022

Supervisor name:	Liberato Ferrara
Email address:	liberato.ferrara@polimi.it
Link *"Pagina docente"*:	LIBERATO FERRARA
Department Name:	Dipartimento di Ingegneria Civile e Ambientale
Research topic:	• PE8_11 Sustainable design (for recycling, for environment, eco-design) • PE8_3 Civil engineering, architecture, maritime/hydraulic engineering, geotechnics, waste treatment • PE8_8 Materials engineering (biomaterials, metals, ceramics, polymers, composites, etc.) Self-healing concrete Concrete technologies Construction materials Structural design
MSCA-PF Research Area Panels:	☐ CHE_Chemistry ☐ ECO_Economic Sciences **X ENG_Information Science and Engineering** ☐ ENV_Environmental and Geosciences ☐ LIF_Life Sciences ☐ MAT_Mathematics ☐ PHY_Physics ☐ SOC_Social Sciences and Humanities
Politecnico di Milano Areas:	**x Cultural Heritage** ☐ Smart Cities ☐ Horizon Europe Missions ☐ Health ☐ Industry 4.0

Brief description of the Department and Research Group (including URL if applicable):	***Department of Civil and Environmental Engineering*** The supervisor belongs to the Department of Civil and Environmental Engineering, which employs 104 faculty members, 96 post-doctoral research fellows, 89 PhD students under 2PhD programs, (Structural, Earthquake and Geotechnical Engineering and Environmental Engineering and Infrastructures), and 42 staff people. The Department *performs* interdisciplinary research in the fields of theoretical, computational and experimental mechanics of materials and structures, with

POLITECNICO
MILANO 1863

	main focus on concrete and masonry structures, including architectural heritage; engineering seismology and earthquake engineering; geology, soil mechanics and geotechnical engineering; structural diagnosis and retrofitting; hydrology, hydraulic engineering and water science; environmental engineering; geodesy and geomatics; transportation and infrastructure engineering. The **research group** led by the supervisor (prof. L. Ferrara) is composed by two assistant professors (dr. E. Cuenca and dr. F. Lo Monte) and currently eight PhD students (two are joint PhD students with University of Gent, with either institution as a host), jointly supervised by the supervisor together with two associate professors (prof. G. di Luzio and prof. P. Bamonte). The group is active in research, teaching and service in the broad fields of concrete and advanced cement based materials, with documented activities and experience covering several aspects of the proposal. The group has performed top-notch research in the fields of: advanced cement-based materials concept and technology; experimental characterization of mechanical properties, also under extreme conditions, including, e.g., earthquake, fire or extreme environmental exposure; material durability, with analysis of degradation processes and of self-healing autogenous and engineered mechanisms; interaction with steel and polymer reinforcement, including corrosion; structural applications and design methods; multi-scale and multi-physics modelling including hydration, fracture, damage and degradation processes; advanced multi-scale characterization of cementitious materials, e.g. computer tomography, also for the identification of self-healing outcomes, and non-destructive characterization of fibre reinforced concrete meso-structures, including fibre dispersion/orientation with electrical resistivity and magnetic inductance based methods. The supervisor has documented coordination and leadership experience in international projects and consortia. He is: - coordinator of the H2020 project ReSHEALience (2018-2021- GA 760824), with 14 partners and 3 LTPs (5.5 M€), focusing on the development and applications of nano-engineered cementitious composites with self-healing functionalities in aggressive environment structural applications; - deputy coordinator of the ITN SMARTINCS (GA 860006) on the use of self-healing multifunctional advanced repair technologies in cementitious systems; - WP leader of the RFCS project MINRESCUE (GA 899518) on the use of mine waste as recycled constituents in construction materials. - WP leader and responsible of round-robin testing activity in the COST Action CA 15202 SARCOS: Self-healing As prevention Repair of COncrete Structures . The group is also active in fundraising and healthy cooperation with major industrial players in the field of concrete construction industry, including, e.g. CEMEX (a multinational partner in the field of cementitious composites) and Hinfra (a BuzziUnicem group start-up in the field of additive manufacturing with mineral based construction materials).

Title	Biomimetic technologies for Built Heritage Conservation in the Age of Climate Change

Brief project description:

Existing un-reinforced masonry buildings constitute a significant portion of construction heritage in the UK. The Intergovernmental Panel on Climate Change (IPCC) recently reported that non-negligible climate change events are increasingly stressing already existing pathologies of historic buildings. A range of traditional interventions are available to address damage in masonry structures. However, several examples of unsuccessful interventions have been documented, even when they have followed established best practice. **In fact, traditional repair technology is inadequate to provide optimal performance over time with respect to current weathering circumstances and future climate change scenarios.**

The proposed project aims to introduce transformative technology in restoration systems for historic masonry constructions, to create materials that develop immunity to harmful external stresses, to self-diagnose deterioration, and to self-heal at the onset of damage. The project is based on biomimetic technology that combines monitoring, detection and repair that will improve the service life of historic structures and dramatically reduce on-going maintenance costs. This technology is based on an integrated system of vascular network and discrete conductive tubular sensors that have a dual sensing-activation capability. This system includes 4D printed hollow interconnected channels housing healing agents that are released when a threshold value of mechanical stress (damage) is exceeded, thus repairing local cracks and diffusing further to permeate the whole mortar. Tubular sensors provide real-time monitoring and recording of the electrical conductivity in relation to stress variations. They also provide a series of storage vessels from which a repair cargo may be released similarly to a vascular network. If the repair cargo is itself conductive, then the electrical conductance of the channel may also provide an indication of the degree of cargo release and self-repair efficacy.
The synergistic effect of self-healing (SH) and self-sensing (SS) technologies will enhance the durability of historic constructions through prevention of crack development and premature aging/degradation of the mortar joint, thus reducing the amount of natural resources used to maintain structures. The overall goal is to provide long-term, sustainable, durable, and resilient restorations that lower the cost of maintenance, are minimally invasive, and rely on novel and unexploited intervention techniques and materials.

The project encompasses a multidisciplinary approach that draws together expertise in materials/heritage science, chemistry of materials, civil engineering, and architecture in a fully integrated research programme.