Building better, for longer, with less: "holistic" lessons learned from a lustrum long research on Ultra High Performance Concrete @Politecnico-DICA

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ABSTRACT

The recently concluded Horizon 2020 ReSHEALience project has developed a new conceptual design approach for concrete structures exposed to challenging structural scenarios, including extremely aggressive environmental conditions. Ultrahigh Durability Concretes (UHDC), based on Ultra High Performance Fibre Reinforced Concretes (UHPFRC) and Textile Reinforced Concretes (TRC) incorporating nano additives to enhance functionalities, have been developed and validated, under mechanical and aggressive scenarios in lab and on-site. The approach combines, in a holistic life cycle thinking framework, higher and longer lasting performance with enhanced structural functionality and high value aesthetic requirements. The signature of high resilience material concept developed and validated in the project - "branded" as UHDC - also features the possibility of engineering the structural performance over time through its self-healing capacity, i.e. the ability of the material to self-repair without external intervention but thanks to its suitably designed composition cracks and defects. Thanks to this innovative conceptual design approach for structural engineering, concretes are no longer regarded as providers of passive protection only, whose degradation over time has to be delayed as much as possible, but become active players in shaping their own performance as a function of the requirement in the operating scenario while retaining functionality and aesthetics. The conceptual design approach, suitably "nestled" into a life cycle thinking framework, represents a key driver for advanced materials innovation uptake in concrete construction industry. The overall performance assessment must no longer rely on the merely misleading concepts of material unit volume cost and environmental impact at its time of generation. Contrarily, it has to be framed appropriately into a structural functional unit context all along its service life. The project results have demonstrated that up to 70% less amount of material can be used to achieve the same or higher structural and durability performance, with maintenance from five to ten times less frequent all along the reference service life period.

This represents a breakthrough innovation in the approach of concrete construction industry to the use of advanced cement based materials, overcoming the current situation where Ultra High Performance Concretes are very often promoted only through their extremely high compressive strength, whereas their higher durability is simply accepted as a bonus but has hardly been quantified as true benefit in design, construction, maintenance and use stage of buildings and structures.

This new concept has been demonstrated by the project consortium in six full-scale pilot applications serving a broad portfolio of challenging societal needs, also implementing a synergic contribution towards the EU decarbonisation objectives. They include: two tanks, for water (TRL6) and mud (TRL7) collection, in a geothermal power plant in Italy; a floating raft for mussel farming (TRL7) and a floater of an offshore wind tower in Spain (TRL6) (Mediterranean sea); a floating pontoon in Ireland (TRL6) (Atlantic west coast) and the retrofitting of a reinforced concrete heritage structure in Malta (TRL7). The paper will summarize the main findings of the project with a specific focus on the real scale applications and their design validation.

Liberato Ferrara is associate professor of Structural Analysis and Design at Politecnioco di Milano, Italy and holds the Italian National qualification to full professor. He has been Fulbright visiting scholar at the Center for Advanced Cement Based Materials, Northwestern University, IL, USA. His research interests include material concept and development of advanced cement based materials and development of structural design methodologies for applications in aggressive scenarios and for automated and additive manufacturing/construction technologies.

He is the PI in a project funded by the Italian Government for development of automated technolofy for tunnel retrofitting, together with company Hinfra and has coordinated/is coordinating several EU grant projects including the H2020 project ReSHEALience (GA 760824): Rethinking coastal defence and green energy service infrastructures through enhanced durability high-performance fiber reinforced cement based materials. He is also deputy coordinator MSCA ITN SMARTINCS (GA 86006): Self-healing multifunctional advanced repair technologies in cementitious systems and is involved in the RFCS project MINRESCUE (GA 899518): From mining waste to valuable resource: new concepts for a circular economy.
Author of more than 80 peer-reviewed journal papers, he is Past chair of the American Concrete Institute (ACI) TC 544-Fiber Reinforced Concrete and is member of several international research and standardization committees in organizations such as ACI, RILEM and *fib*.