B[UILD] SMART!

comfort, sicurezza, sostenibilità, innovazione

Francesca TITTARELLI

EnDurCrete - New **En**vironmental friendly and **Dur**able con**Crete**, integrating industrial by-products and hybrid systems, for civil, industrial and offshore applications

SPECIFIC CHALLENGE OF THE TOPIC NMBP - 06 - 2017

- **Durability** is a **key criterion** for materials in many applications and environments.
- **Longer performing** materials can strongly **reduce overall life time costs**, such as lower usage costs through reduced maintenance and shorter service interruptions.
- **Durability problems** in concrete are often related to **external causes**: chemical attack, cracking, scaling via freeze/thaw, spalling, carbonation and steel corrosion. These impact on the durability of concrete buildings and infrastructures.
- Typical **applications requiring excellent long term durability** and high reliability are buildings, **marine** applications and infrastructures including **offshore**.
- In many applications, operational **durability** needs to be better understood, particularly for **innovative products** which have not demonstrated long term performance.
- **Durability** has to be evaluated both **theoretically** and in **real installation conditions** (including challenging environments) as these may influence final product performance.

NEED

- **Costs** may also be **reduced** in the **production phase** (raw materials, energy, transport, formability), in the installation phase, and the materials may be more appropriate for end of life reuse/recycling.
- **Concrete** is the world's **most consumed** man-made **material**.
- **Portland cement** is a cost-effective **standard material** for the manufacture of **concrete** building components. However, its manufacture consumes significant mineral resources (good-quality limestone and clay), energy and fuel, and creates greenhouse gas emissions. Ordinary Portland cement has essentially reached its technical limit in terms of CO_2 reduction.

There is need for innovative, durable & sustainable concrete especially in harsh environment, where the cost-effectiveness, easy installation and durability of concrete is a real added value.

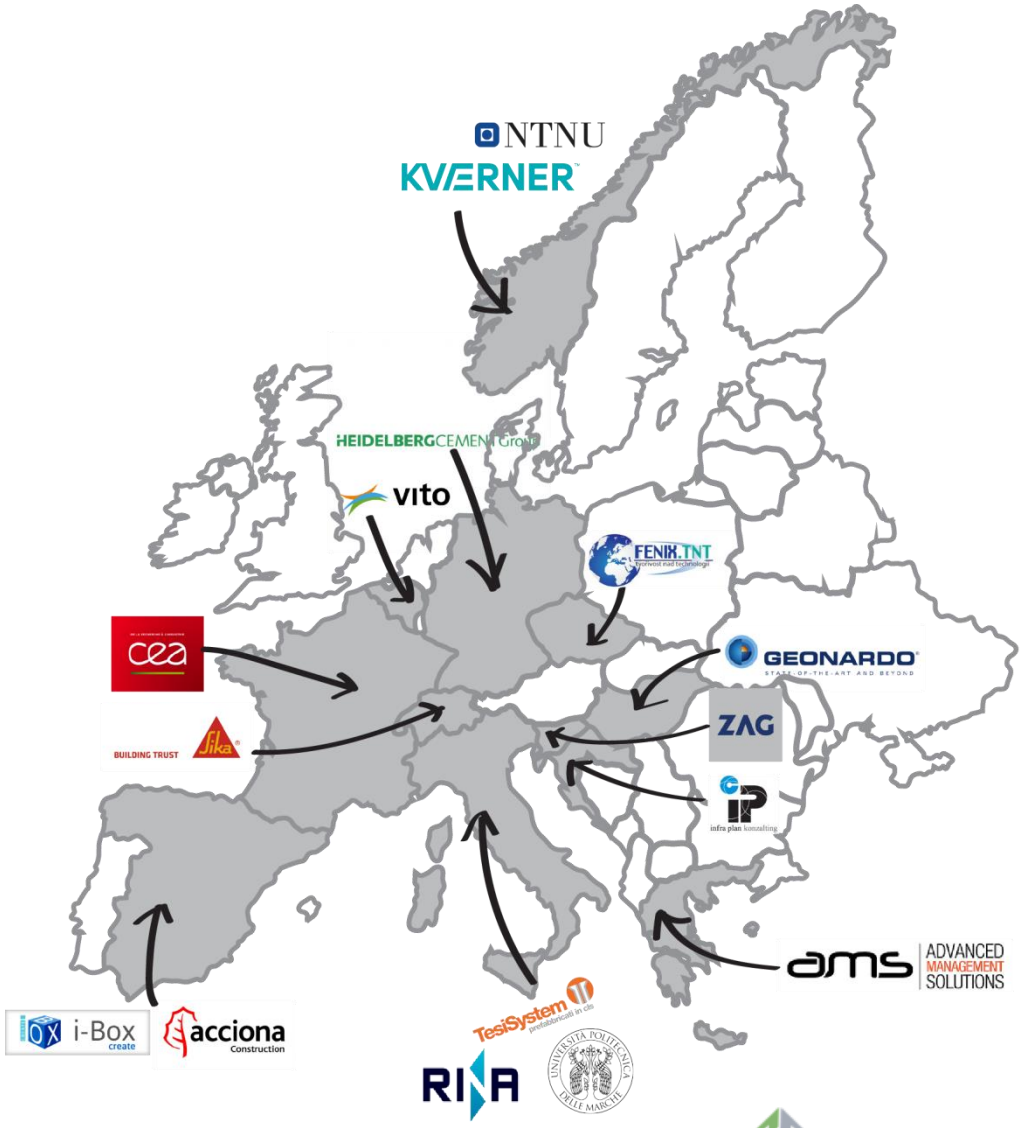
ENDURCRETE PROJECT

New Environmental friendly and Durable conCrete, integrating industrial by-products and hybrid systems, for civil, industrial and offshore application

The main goal of EnDurCrete Project is to develop **a new cost-effective sustainable reinforced concrete** for long lasting and added value applications.

PARTNERS

16 partners
from
12 countries



PROJECT OBJECTIVE

- The **concept** is based on the **integration of novel low-clinker cement** including high-value industrial by-products, **new nano and micro technologies and hybrid systems** ensuring enhanced durability of sustainable concrete structures with high mechanical properties, self-healing and self-monitoring capacities.

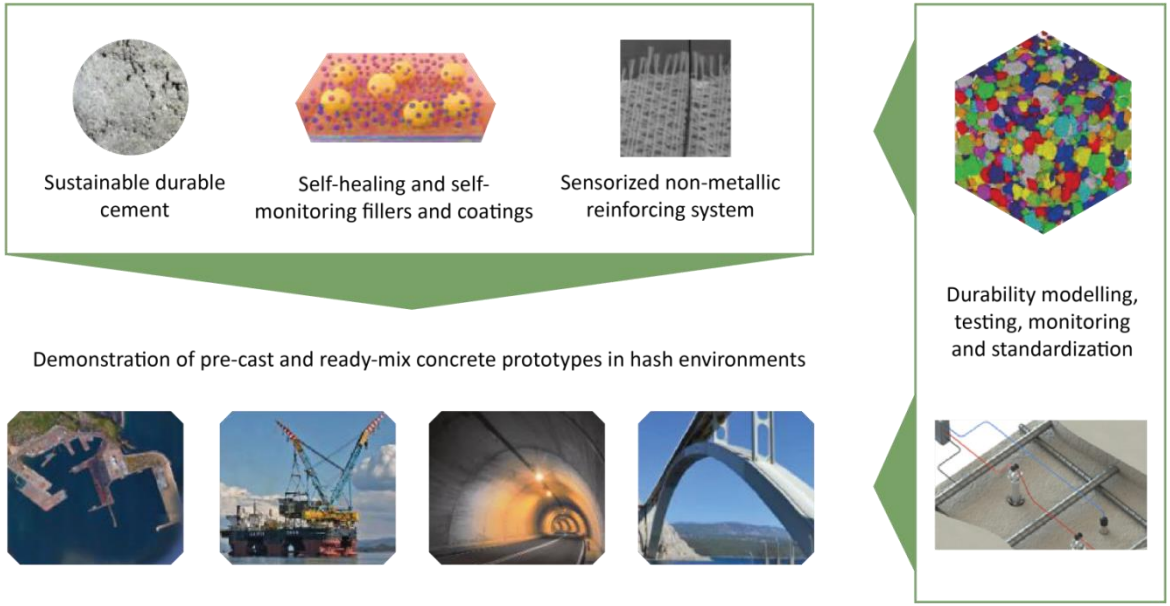
The key EnDurCrete technologies:

- Novel cement (CEM II/C and CEM VI)
- Self-sensing carbon-based micro fillers/fibers
- Multifunctional coatings with self-healing properties
- Sensorised non-metallic reinforcement systems

OVERALL CONCEPT AT A GLANCE

EnDurCrete concept is based on the following novel technologies and tools

- Novel CEM II/C and CEM VI **cements**
- Novel low cost smart **fillers**
- Nano-enabled smart corrosion **inhibitors**
- New multifunctional **coatings**
- Concrete non-metallic multifunctional **reinforcing systems**
- Advanced **non-destructive continuous** and testing tools and procedures
- **Coupled experimental and computational approach** for theoretical and experimental understanding of factors affecting **durability**



OBJECTIVES

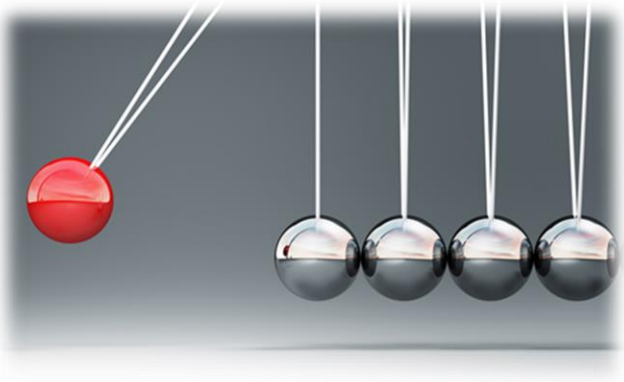
- To develop **new more durable** reinforced concrete systems.
- To develop **experimental tools to measure the durability** of concrete, by using different techniques including structuring health monitoring and other non-destructive inspection procedures and tools.
- To develop **numerical tools** to theoretical understand and model (at macro, meso, micro level) the factors affecting the durability of concrete and to capture the multiscale evolution of damage.
- To develop **models for service life prediction**.
- To promote **novel standards** in the field of durability **monitoring** and testing as well as new sustainable concrete **materials** and systems.
- To obtain **safe and sustainable products** by addressing **social, environmental and safety aspects**.
- To perform **market assessment** and **business modelling** in order to promote future market uptake of the developed technologies, products and services.
- To test the functionality of new concrete technologies under severe operating conditions in **4 demo-sites**.

DEMOSITE

- **Demonstrators** will be tested in working sites of **tunnels, ports, and offshore structures**, in order to prove the enhanced durability and the decreased cost of the new concrete systems in such critical applications. Innovation aspects such as standardization, life cycle assessments, health and safety and training activities will be addressed.

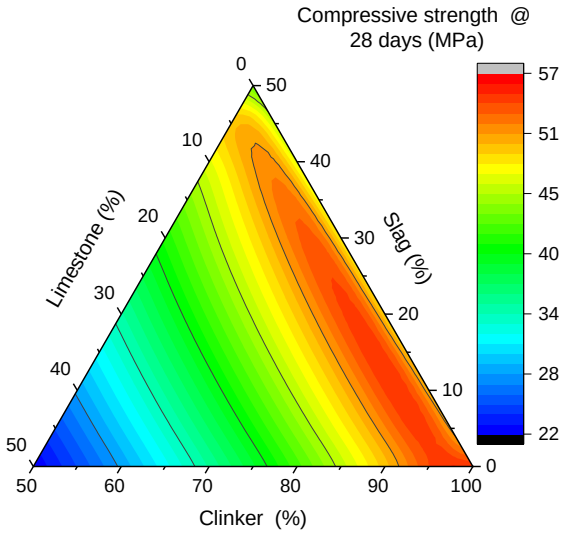
1. Port of Gijón “El Musel” in Spain
2. Mining tunnel facility in Leon, Spain
3. Ship Yard in Norway
4. Krk Bridge in Croatia

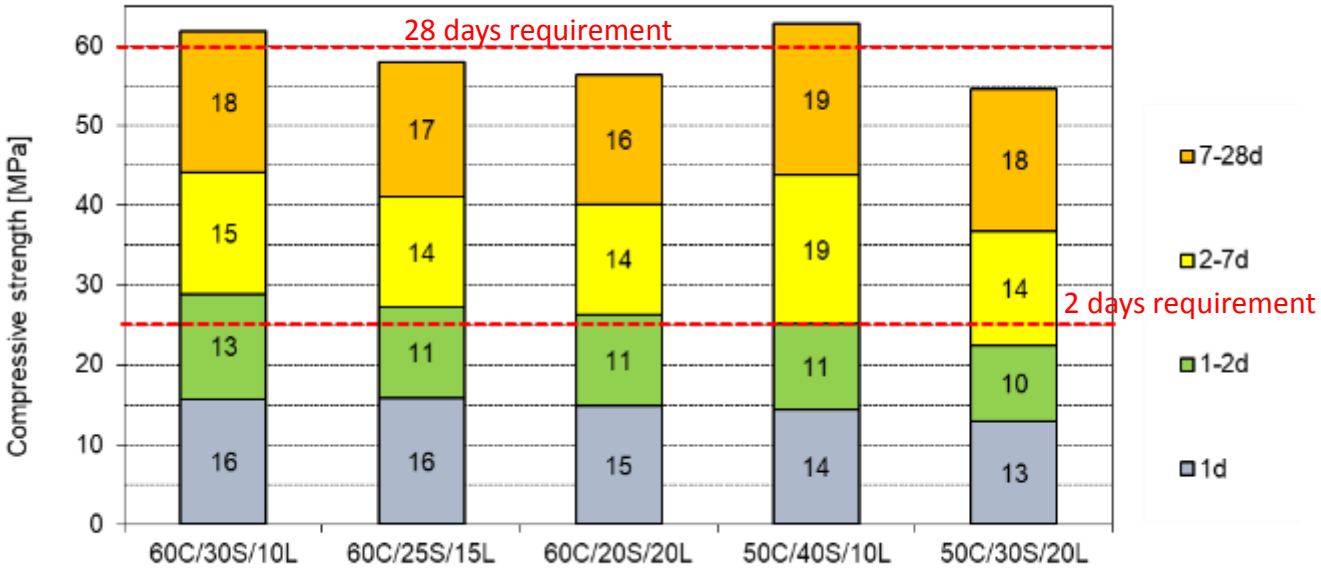
EXPECTED IMPACT



- Strengthening the **competitiveness of the European industry**, including in the field of “green” technologies
- At least **30% lower cost**
- At least **30% improved durability**
- Positive contribute to **LCA balance**

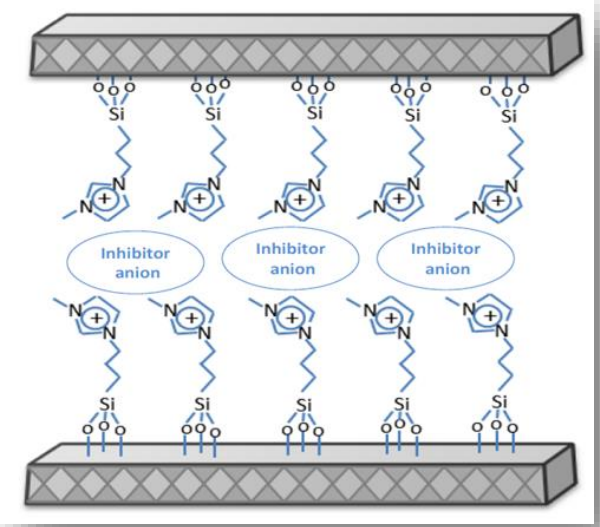
FIRST RESULTS (1) _ CEMENT DEVELOPMENT





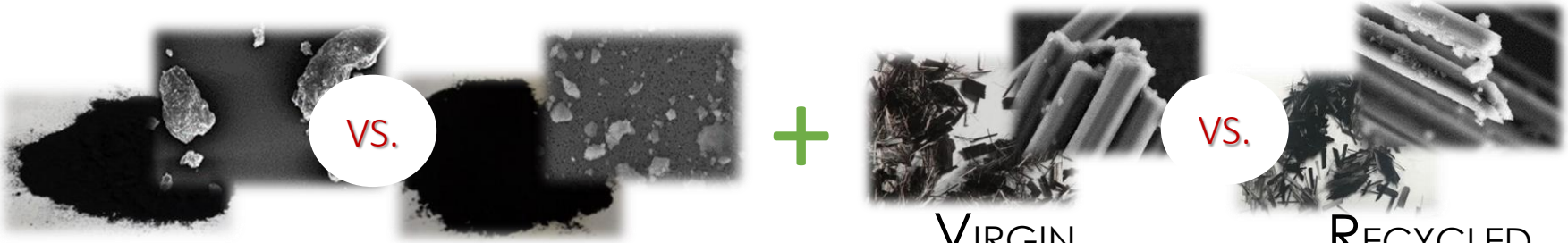
wt.%	60C/30S/10L	60C/25S/15L	60C/20S/20L	50C/40S/10L	50C/30S/20L
CEM I 52.5R	60%	60%	60%	50%	50%
GGBFS	30%	25%	25%	40%	30%
Limestone filler	10%	15%	15%	10%	20%

FIRST RESULTS (2) _ DEVELOPMENT AND OPTIMIZATION OF SMART CORROSION INHIBITORS, BASED ON NANO-MODIFIED CLAYS



- The **synthesis** of nano-modified clays has been optimized
- The effectiveness of the synthesized nano-modified clays in terms of **corrosion inhibition** and **controlled release** of the inhibitor in cement based materials has been tested.

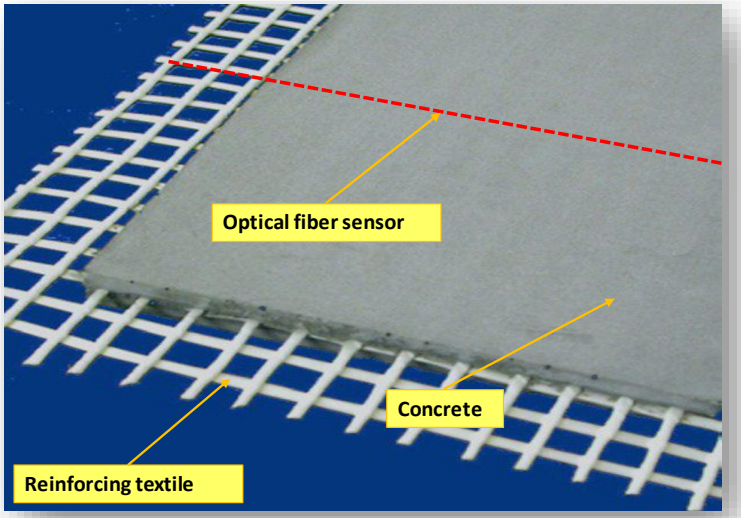
FIRST RESULTS (3) _ DEVELOPMENT AND OPTIMIZATION OF NOVEL SELF-SENSING CARBON-BASED ADDITIONS



BY-PRODUCT #1 | BY-PRODUCT #2 | VIRGIN CARBON FIBERS | RECYCLED CARBON FIBERS

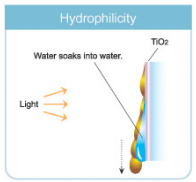
- The **best by-product** to improve the electrical behaviour of mixtures has been chosen.
- The similar behaviour of **Recycled Carbon Fibres** with respect to **Virgin** Carbon Fibers in mixtures has been tested.
- The **optimum dosage** of Recycled Carbon Fibers and the selected By-product to reach the best mechanical and electrical performances in mixtures has been selected.

FIRST RESULTS (4) _ DESIGN AND INTEGRATION OF THE MULTIFUNCTIONAL SELF-MONITORING REINFORCING SYSTEM

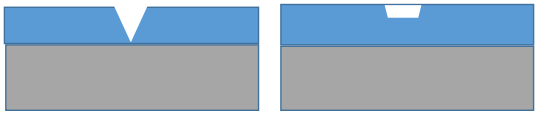


- **Textile** specifications and procurement
- **Sensor** specifications and procurement
- Definition of the **integration procedure** of the sensor in the textile
- Definition of the technology and procedure **to embed** the **sensorized textile inside the concrete** component

FIRST RESULTS (5) _ DEVELOPMENT & OPTIMIZATION OF NOVEL, ENVIRONMENTAL FRIENDLY, MULTIFUNCTIONAL COATINGS WITH IMPROVED RESISTANCE TO AGGRESSIVE AGENTS



- Self cleaning



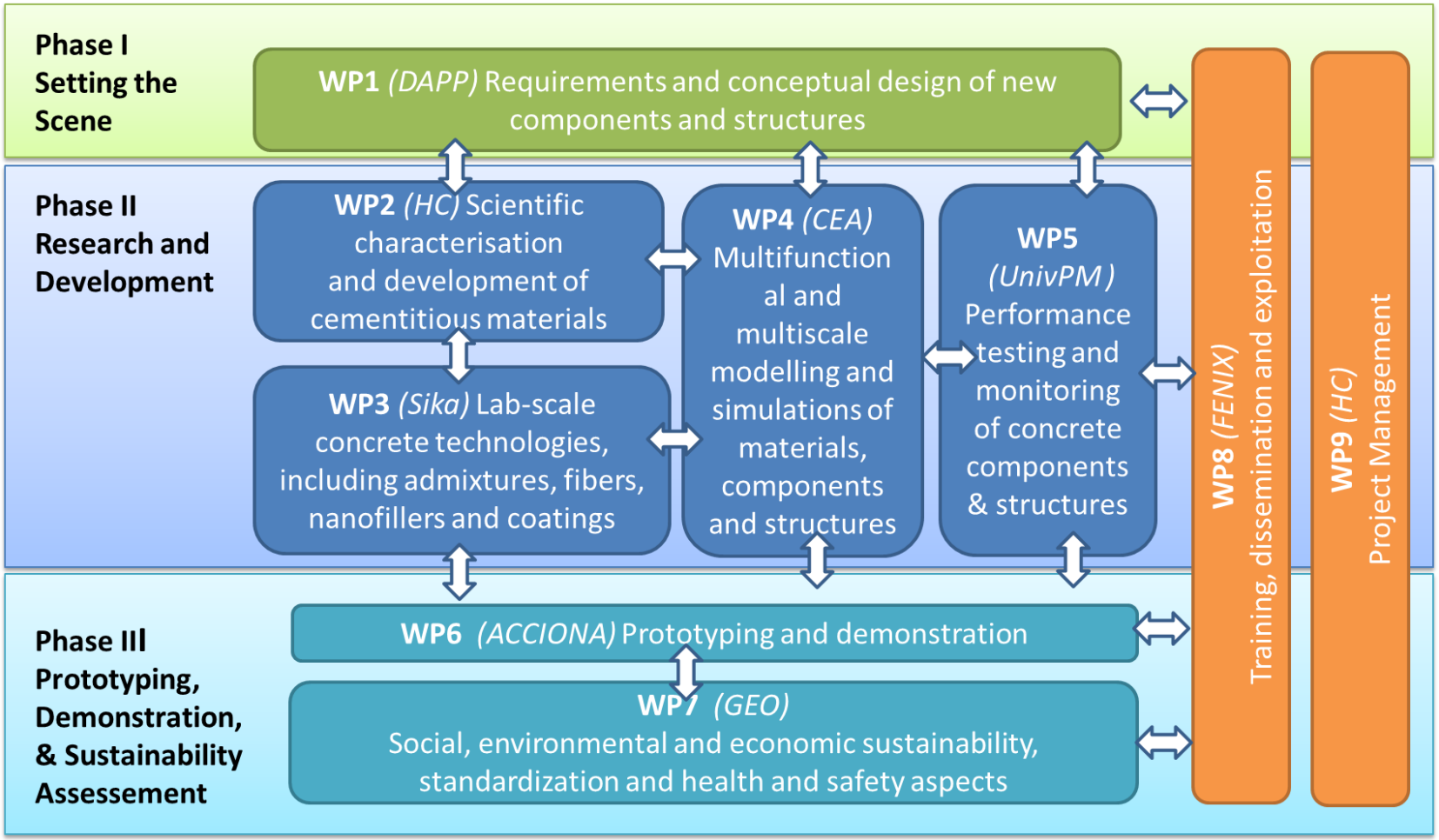
- **Self healing**

- Anti moulding
- Light reflective

- **Coating** formulation
- Self healing – development of **microcapsules**
- Self healing – **incorporation** of microcapsules in coating formulation
- **Application** of coating on concrete specimens

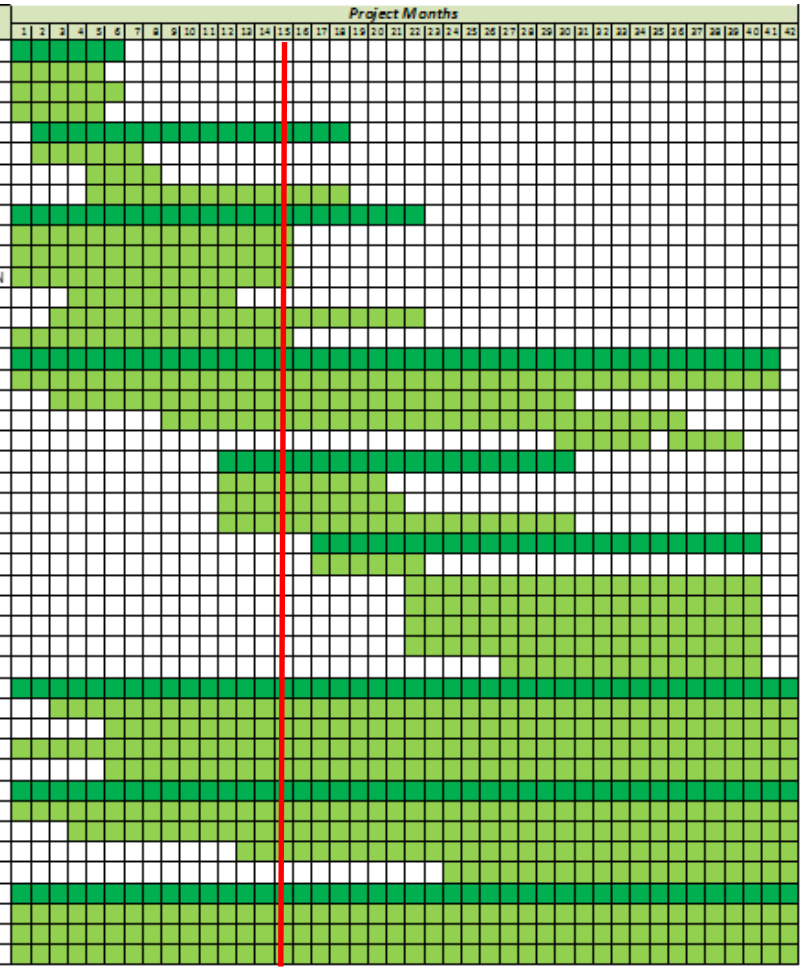
- **Scratch** test
- **Impact** test
- **Anti-moulding** test
- **Self cleaning** test
- **Light reflectance** test

WORK PACKAGES OVERVIEW



GANTT CHART

WP and Tasks	WP/T Lead
WP1 – Design requirements for structures exposed to aggressive environment	**RINA-C**
T1.1: Requirements and design process for marine environment	RINA-C
T1.2: Requirements and design process for continental environment (road infrastructures)	RINA-C
T1.3: Requirements and design process for offshore platforms	KVAER
WP2 – Development and characterisation of new green and low-cost cementitious materials	**HC**
T2.1: Optimisation of a novel Portland Composite Cement, including sustainable supplementary cementitious materials	HC
T2.2: Development of customised separate grinding technology for each PCC component	HC
T2.3: Characterization of the novel cementitious materials	NTNU
WP3 –Innovative concrete technologies, including nano/microfillers, coatings and reinforcement	**SIKA**
T3.1: Development and optimization of smart corrosion inhibitors, based on nano-modified clays	IBOX
T3.2 Development and optimization of novel self-sensing carbon-based green microfillers	UNIVPM
T3.3: Development and optimisaiton of new multi-functional protective coatings	AMSOLUTION
T3.4 Evaluation of compatibility of additives in concrete	SIKA
T3.5 Development of Concrete Mix Designs intergrating novel additive technologies	HC
T3.6 Design and integration of the multifunctional self-monitoring reinforcing system	RINA-C
WP4 – Multifunctional and multiscale modelling and simulations of materials, components and structures	**CEA**
T4.1 Completed EnDurCrete MODA template	RINA-C
T4.2 Multiscale modelling of the ageing mechanical and diffusive properties of the new materials due to hydration and degradation	CEA
T4.3 Computational analyses of micro-mesostructures for model testing and corrosion and cracking investigations	CEA
T4.4 Computational analyses of macrostructures for service life estimation	RINA-C
WP 5 – Lab-scale performance testing and development of monitoring tools for concrete components & structures	**UNIVPM**
T5.1 Lab-scale performance testing	ZAG
T5.2 Calibration and laboratory testing of self-sensing/monitoring properties	UNIVPM
T5.3 Advanced NDT tools for non-intrusive in-field inspection	UNIVPM
WP 6 – Prototyping, demonstration and solutions performance validation	**ACCIONA**
T6.1: Demonstration and Validation Plan	UNIVPM
T6.2 Prototyping, demonstration and performance validation in a maritime port in Spain	ACCIONA
T6.3 Prototyping, demonstration and performance validation in a tunnel in Spain	ACCIONA
T6.4 Prototyping, demonstration and performance validation in an offshore structure in Norway	KVAERNER
T6.5 Prototyping, demonstration and performance validation in a bridge in Croatia	INFRA PLAN
T6.6: Analysis of the results and validation of EnDurCrete solutions	RINA-C
WP 7 – Environmental and economic sustainability	**GEO**
T7.1. Environmental and economic viability of the novel products based on LCA and LCCA	GEO
T7.2. Standardisation	ZAG
T7.3. Assessment of the exposure likelihood of the new nano-modified EnDurCrete products	CEA
T7.4 Health, safety and risk assessment and management activities	CEA
WP 8 – Training, dissemination and exploitation	**FENIX**
T8.1: Dissemination and Communication	FENIX
T8.2: Exploitation and IPR management	FENIX
T8.3 Business models	RINA-C
T8.4: Training Activities	GEO
WP9 – Project Management	**HC**
T9.1 Project Coordination	HC
T9.2 Consortium Management	HC
T9.3 Administrative and Financial Management	HC

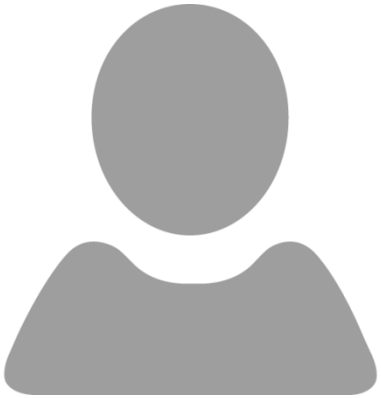


MILESTONES

	Milestone and WP related	Due month
MS1	Design requirements for structures consolidated *WP1*	M05
MS2	Lab Concrete specimens integrating novel additives produced for testing *WP3*	M16
MS3	Novel Portland Composite Cement optimised and successfully characterized *WP2*	M18
MS4	Durability performances assessed at lab scale for EnDurCrete solutions and calibration of structural monitoring techniques *WP5*	M24
MS5	Final mix design of efficient novel additive and coating technologies available for real environment demonstration *WP3*	M24
MS6	Prototypes installed in the four demo sites *WP6*	M30
MS7	Micro/meso scale models calibrated through WP5 testing *WP4, WP5*	M36
MS8	Macroscale simulations for life service prediction of concrete structures *WP4*	M40
MS9	LCA, LCCA, HSE (including nanosafety) and standardisation activities duly performed *WP7*	M42
MS10	Endurcrete public workshop organized near one of the demo-sites *WP8*	M42

CONTACT INFO

- **For further project information please contact:**



Dr. Arnaud Muller
HeidelbergCement
Tel.: +49 6221 4811 3676
arnaud.muller@heidelbergcement.com

www.endurcrete.eu

Follow project latest news on social network profiles:

B[UILD] SMART!

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 760639.

Francesca Tittarelli

f.tittarelli@univpm.it
www.univpm.it

Fiera Milano Rho, 13 | 16 marzo 2019

Padiglione 4
B[UILD] SMART! INVOLUCRO

Padiglione 10
B[UILD] SMART! COSTRUZIONI

GRAZIE PER L'ATTENZIONE