3rd Periodic report – Publishable summary

2020

Overall objective of the project

The main goal of the LORCENIS project has been to develop long lasting reinforced concrete for energy infrastructures with lifetime extended up to a 100% under extreme operating conditions. At the same time, our society must face environmental aspects (increased CO2 emissions) challenging the energy request from carbon-based sources more efficiently at short term and to move to renewable energy sources at a longer term.

The LORCENIS concept with cost-efficient operation has been based on an optimal combination of novel technologies involving internal curing, customised protection, repairing (healing) and self-diagnosis methodologies. The functionality of the developed concrete materials was verified from a proof of concept (TRL 3) to technology demonstration (TRL 6-7), supported by numerical tools to capture the multi-scale evolution of damage and models for service life prediction. 4 scenarios were considered for demonstration:

S1: Concrete infrastructure in deep sea and (sub-)arctic zones: offshore windmills, gravity-based structures, bridge piles, harbours.
S2: Concrete and mortar under mechanical fatigue: offshore windmills, sea structures.
S3: Concrete structures exposed to high temperature thermal fatigue: concentrated solar power plants.
S4: Concrete structures subjected to acid attack: sewage plant.

Moreover, LORCENIS considered analysis of cost-effectiveness and commercial potential of project outcomes within their exploitation strategy, as well as including the environmental and sustainability concerns through LCA and LCC analysis. Safety and health considerations were also addressed.

LORCENIS was realized by a well-balanced consortium of multidisciplinary experts from 9 universities and research institutes and 7 industries from 8 countries, including 2 SMEs.

Main results achieved

The activities of LORCENIS were organised in 7 main activities.

Durability tests in accelerated lab-scale exposure conditions (TRL 4-5) designed for each scenario were carried out in WP3 on stable concrete formulations to give recommendation for the prototype design. The formulations were used as reference and modified by implementing 10 different self-responsive materials during the development of stable admixtures with active internal curing, self-sealing and self-healing properties. The involved partners realised the preparation and upscaling of the materials, and screening of their compatibility with mortar formulations. Based on the requirements set-up for mix designs according to the scenarios demands, the evaluated materials properties for all the selected 11 reference mix designs were within the specifications.

LORCENIS developed self-responsive materials for incorporation into concrete as TRL3-4 and in stable concrete formulations containing self-responsive materials verified at TRL 4-5. The selection of the most promising technologies for demonstration activities was based on labs-scale performance results (TRL3-5) obtained from specimen exposure to simulated conditions like freeze/thaw cycles, immersion to aggressive media and temperature cycles. The recommended LORCENIS technologies were applied in 12 concrete prototypes designed for the 4 main scenarios and exposed in WP5 for validation (TRL 5) and demonstration under relevant industrial and operational conditions (TRL 6-7). Self-responsive functionality of the developed concrete materials under severe operating conditions were successfully proved with enhanced lifespan that could be estimated based on the performance factors.

A multiscale service life predicting modelling approach for reinforced concrete structure in highly corrosive environment permitted to verify and validate a full modelling chain linking the different scales and created an advanced engineering software tool called SEBASTOS. Currently, the software works with few degrees of freedom, and is reasonably fast to predict end-of-life. A “1 minute-on-a-laptop” ambition is realistic. In parallel, the full LCA and LCC analyses with a sustainability and market analysis including cost impacts were performed following a sustainability approach.

The awareness and dissemination plan, data management plan (DMP) and the plan for the exploitation and dissemination of results (PEDR) were concluded. Biannual LORCENIS Newsletters are published on the external website (www.lorcenis-eu.com). The international LORCENIS conference was successfully arranged in Gent, Belgium in September 2019.

The work of an Advisory Board (AB) with invited experts on energy sector infrastructures contributed to discuss the LORCENIS strategies during the project period towards future market take-up.

Impacts and added value

LORCENIS will contribute to add value to the European manufacturing sector on reinforced concrete energy infrastructure, through an adaptation to the global competitiveness pressure by technology improvements. The well-targeted project consortium with representatives along the whole value chain (product manufacturers, tool developers, energy infrastructure contractor and operators) will be able to approach new business developments according to market needs, expected market up-take and standardisation, safety and environmental requirements and needs tackled.

The scaling-up protocols of various optimised nano-additives capable of providing self-responsive ability compatible with the concrete matrix are beneficial for the construction industry. The ambition is to withstand extreme operating conditions achieving 100% of crack healing through the incorporation of the ideal dosage of each nanomaterial with improved stability, mechanical properties, quicker self-healing activity and competitive production costs. The overall potential is very high since LORCENIS will offer a route to precisely engineer concrete for specific applications, reducing costs and increasing performance. Developing cement and concrete related nanotechnology have a sustained and important impact on the future of the construction industry enabling entirely new applications for concrete.

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