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PhD Training Network on Durable, Reliable and Sustainable Structures with Alkali-Activated Materials DuRSAAM

Abstract
DuRSAAM is a collaborative PhD framework creating a critical mass of experts skilled in innovative alkali-activated material (AAM) concrete, as a key enabling technology for a sustainable and resilient built environment. AAM technology presents a new generation of materials, ideally conceived to respond to the need for more efficient, durable, eco-friendly and reliable construction, and utilizing by-product resources as raw materials. Modern concrete will be produced with low carbon footprint (CO2 emissions reduced by 80%), lower energy consumption and reduced use of primary resources (>1.5 t raw materials are quarried per t Portland cement clinker; this will be reduced by >60%), and with an addressable market for AAM binders of 5 B€/yr. DuRSAAM answers unmet industry demands, to facilitate emerging AAM technology for continued market entry and to unlock its potential in society.

The consortium brings together 7 academic and 15 non-academic partners, to excel in the scientific development and exploitation of AAM concrete, advancing design, modelling and practice beyond the state-of-the-art. It holds a unique focus on: (1) today's concerns of users and engineers that the durability and sustainability of AAM concrete is yet insufficiently quantified; and (2) provision of an AAM technology for rehabilitation of structures to meet the growing demand for renovation, to be developed in parallel with AAM for new concrete structures.

The network will deliver world-leading training in this multidisciplinary field through 13 PhDs in interrelated aspects of AAM concrete, fibre reinforced high-performance concrete, and textile-reinforced mortar, as well as sustainability assessment. The outcomes will be instrumental in delivering a sustainable future in Europe's construction industry, which is increasingly driven by the growing demand for durable yet cost-effective solutions, driving a greater focus on reliable and comprehensive eco-efficient material technologies such as AAM.

Academic partners	Country	Scientist-in-Charge
UNIVERSITEIT GENT	Belgium	Prof. Stijn Matthys
TECHNISCHE UNIVERSITEIT DELFT	The Netherlands	Prof. Guang Ye
KARLSRUHER INSTITUT FUER TECHNOLOGIE	Germany	Prof. Frank Dehn
THE UNIVERSITY OF SHEFFIELD	UK	Prof. John Provis
SVEUCILISTE U ZAGREBU GRADEVINSKI FAKULTET	Croatia	Prof. Marijana Serdar
PANEPISTIMIO PATRON	Greece	Prof. Thanasis Triantafillou
EIDGENOESSISCHE TECHNISCHE HOCHSCHULE ZUERICH	Switzerland	Prof. Guillaume Habert

Faculty of Civil Engineering, University of Zagreb will be responsible for 2 ESR projects (early stage researcher):

ESR8 Chloride ingress and corrosion of steel in AAM concrete

Objectives: For the application of optimised AAMs in an aggressive marine or environment where de-icing salts are used, it is of paramount importance to prove their resistance to chloride ingress and the influence on corrosion of steel in concrete. The core aim of this ESR project is to develop understanding of chloride ingress and resulting chloride-induced corrosion of steel in AAMs and propose methodology of their mitigated.

To achieve this aim, the following objectives are defined:

- Perform experimental campaign focusing on testing the corrosion behaviour of AAMs on three levels: 1) on pore solution level, where steel is directly tested in extracted or prepared pore solution from AAM, 2) on laboratory samples level, where samples with embedded steel are exposed to natural and accelerated corrosion induced by chlorides, 3) on real scale level, where real scale samples are exposed to real environments in field exposure sites,
- Validate the application of testing methods developed for classical OPC systems for testing chloride ingress into AAMs, as well as electrochemical testing methods for testing corrosion activity,
- Develop phenomenological models of behavior of steel in AAM concrete during initiation and propagation of chloride-induced corrosion, with special highlight on differences in the degradation mechanism compared to classical OPC systems (binding of chlorides, propagation of corrosion products through pore system, crack formation, etc).

Planned secondment(s): SI1: Aurubis (Dr. Manolova), 2 weeks, production and valorisation of raw materials obtained as byproducts; SI2: Gradmont (Mr. Muminovic), 2 weeks, application of AAM concrete in real systems; SA1: USFD (Prof. Provis & Dr Bernal), 3 months, joint research on corrosion of steel in AAM systems; SA2: KIT (Prof. Dehn), 3 months, joint research on durability, collaboration with ESR7.

ESR9 Combined environmental actions

Objectives: In real cases it is rarely that structures have to sustain only one type of environmental action, rather structures are exposed to combined effect of mechanical loading and several environmental actions at the same time. The aim of ESR9 is to simulate the degradation process in AAMs under combined effect of at least two environmental or mechanical actions. While other ERS are focusing on a specific degradation mechanism or application of AAM, the aim of this ESR is to consider synergetic effect of the combination of environmental ad mechanical actions, which is more realistic loading scenario. The simulations and experiments will consider the effect of shrinkage, freeze-thaw, carbonation and chloride transport separately and in a coupled manner, together with mechanical loading. To achieve this aim, the following objectives are defined:

- Evaluating the effect of structural damage and cracks due to mechanical loading or cracks due to environmental deterioration (carbonation, freeze-thaw, etc.) on the macro- and meso-structure of AAM
- Evaluate the effect of joint action of mechanical loading and environmental action, such as chloride-induce corrosion
- Perform simulations for structural components under service life conditions to predict the distribution and extension of cracks and damages due to mechanical loading of the structure and using this information obtain the transport properties of concrete with new appearing cracks
- Validate simulations on a set of real cases to investigate the long-term performance of the AAMs in different environmental conditions.

Planned secondment(s): SI1: Gradmont (Mr. Muminovic), 2 weeks, application of AAM concrete in real systems; SI2: Aurubis (Dr. Manolova), 2 weeks, production and valorisation of raw materials obtained as by-products; SA: TUD (Prof. Ye), 6 months, focus on meso- and macro-scale modelling of AAMs.