Zero Emissions Reinforced Carbonated Concrete

Supervisor (primary) Imperial College London: Prof. Rupert J. Myers

Supervisor (secondary) Imperial College London: Prof. Hong Wong

Applications are invited to fill a PhD position funded through internal or external scholarships, or from a student's own funding.

The PhD student will produce and optimise the first zero (or negative) carbon, cost-competitive, and scalable reinforced carbonated concrete with at least equivalent functionality (i.e. strength and carbonation-induced corrosion resistance) to conventional reinforced Portland cement concrete. This will be achieved through an ambitious novel approach to concrete component manufacturing incorporating CO_2 mineralisation, natural fibres, basalt fibre-reinforced polymer, and potentially functional grading. The concept will be demonstrated mainly through experimental work, with the potential for larger scale demonstration depending on research progress.

The PhD will be based in the Materials Section of the Department of Civil and Environmental Engineering (Skempton Building, South Kensington Campus). On a day-to-day basis they will work alongside ~30 PhD students and ~10 postdoctoral research associates in the Materials Section, including several in their research group, led by Prof. Myers. The Section hosts the Advanced Infrastructure Materials laboratory, which is a world-class facility for concrete materials characterisation.

This PhD project offers excellent training and development opportunities in a highly stimulating environment, as well as access to a network of internationally leading academics, industrial partners, and research facilities.

Project details

The key aim of this PhD project is to establish the properties and performance of carbonated basalt fibre-reinforced polymer concrete. Results will be compared to conventional steel reinforced concrete. Enforced carbonation will be enhanced using natural fibres, to approach complete carbonation of concrete within hours to days. The work will also consist of mix design optimisation of mortar to inform design of concrete mixes, and life cycle assessment of the concretes to quantify their environmental footprints including CO_2-eq. emissions.

Concrete and steel are the two most difficult to decarbonise materials due to their massive scale (~40 Gt/year) and CO_2 emissions (15-20% of global CO_2 emissions) that are intrinsic to their production. Concrete carbonation (i.e. reacting concrete with a concentrated CO_2-containing gas or liquid) has exceptionally high decarbonisation potential since: (1) CO_2 reacts with the calcium (Ca) in its cement matrix to permanently bind it in calcite ($CaCO_3$) (providing long term CO_2 storage); and (2) we produce much more waste CO_2 (21.5 Gt in 2018)1 than any other material except concrete (it is scalable to several Gt of CO_2 storage globally). However, its main limitation is that carbonation reduces pH to near-neutral, establishing critically damaging steel corrosion active conditions for reinforced concrete (75% of the EU concrete market). Therefore, concrete carbonation is currently limited to low CO_2 dosages (negligibly impacting pH; e.g. ~0.02 wt.% CO_2 in CarbonCure technology) or to non-reinforced concrete (25% of the EU concrete market). Successful development of a cost-competitive carbonated reinforced concrete that is comparably durable and strong as

conventional concrete (i.e. steel reinforced concrete) would be a remarkable research achievement with huge potential economic and environmental benefits.

This PhD project will use experiments, including both chemical and mechanical characterisation, to study the novel mortar and concrete materials. This is a heavily experimental PhD project that will utilise the suite of state-of-the-art materials characterisation equipment available in our Advanced Infrastructure Materials, Structures, and Environmental Laboratories, which is a facility that is essentially unparalleled in terms of quality within the UK.

Academic requirements and experience

Required

- A good first class degree (or international equivalent) in a STEM subject, e.g., Civil / Materials / Chemical / Structural Engineering, Chemistry, Materials Science).
- Laboratory experience.
- Programming experience.
- Strong interest in materials research.
- Excellent English communication skills.

How to apply

Applicants wishing to be considered for this opportunity should send the following application documents to Prof. Rupert J. Myers (r.myers@imperial.ac.uk):

1. Current CV including degree result and, if possible, class ranking

Application via the Imperial College Registry is not necessary at this stage.

Applications will be regularly reviewed until the position is filled.

Funding notes

Applicants interested in this project and seeking funding via scholarship schemes (see here: https://www.imperial.ac.uk/study/pg/fees-and-funding/scholarships/) or can self fund are welcome to apply.