**Sustainable concrete materials selection**

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

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 develop code and methodology to identify concretes with high technical (e.g., durability, compressive strength), environmental, and economic performance, based on first principles (thermodynamic modelling) and modified inventory analysis data. This research project can lead to reducing CO2 emissions from concrete production (~8% of anthropogenic CO2 emissions), improving the performance of concrete (one of the main infrastructure materials), and enabling novel improved processes for recycling high volume wastes (e.g., bauxite residue). It also has the potential to result in commercially valuable data and code.

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 Dr. 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**

There are many poorly explored cement paste and concrete compositions due to the vast range of supplementary cementitious materials (i.e. Portland cement substitutes) available. A key barrier to identifying promising compositions is a lack of methodology and code to perform fast and reliable evaluations of their properties.

Recently, Dr Myers’ group has been working on a novel two stage materials selection approach to tackling this problem. The first stage of this approach uses thermodynamic modelling, machine learning/data analysis, micromechanical modelling, life cycle assessment (LCA), and technoeconomic analysis (TEA) to rank candidate cement paste, mortar and concrete mix designs. The second stage involves conducting experimental studies for performance validation on several of the top ranked candidates where needed. The two-stages enable practical validation of the most promising mix designs from the myriad available (it is not possible to assess all of them in detail, but it is possible to assess a small promising subset of them in detail). Since the approach is general, in principle it will be applicable to all cement systems. The output of this approach is the identification of optimal concrete materials with respect to technical (e.g., 2 and 28 days compressive strength), environmental, and economic performance, validated using laboratory experiments and/or literature data. This approach is a quicker-yet-reliable and more general way to assess the technical, environmental, and economic performance of concrete mix designs.

The first stage of this approach requires new streamlined methodology for assessing concrete deterioration. Existing work in this area has mainly been on development of methodology to assess deterioration of concrete by freeze-thaw action. It is expected that the PhD student will develop methodology for assessment of concrete deterioration caused by another mechanism, e.g., chloride-induced corrosion. Methodology for predicting compressive strength that can be incorporated into the modelling approach will also be developed and applied. Life cycle assessment is incorporated by modifying published inventory datasets. The whole approach is implemented in Python and hosted on Github.

This is a heavily computational PhD project that will routinely code in Python and perform modelling using suitable software (thermodynamic modelling in GEM-Selektor, life cycle assessment in OpenLCA, etc.). Later in the project, the suite of state-of-the-art materials characterisation equipment available in our Advanced Infrastructure Materials, Structures, and Environmental Laboratories, may be utilised for validation of model results. This facility is essentially unparalleled in terms of quality within the UK. This is a highly creative and novel PhD project since the methodology envisioned/involved is radically different from existing thinking and approaches in concrete durability modelling.

**Academic requirements and experience**

***Required***

* A good first class degree (or international equivalent) in a STEM subject, e.g., Chemistry, Metallurgy, Physics, Materials Science, Chemical Engineering, Environmental Science, Geology, Civil Engineering), or a course with strong emphasis on materials.
* Laboratory 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 Dr. 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.