Unravelling the chemo-mechanical degradation of concrete

With whom? Supervisor: Dr Evzen Korec, Co-supervisor: Prof Hong S. Wong

Why? Concrete, an artificial rock, is the most abundant material humankind has ever created. With approximately 30 billion metric tonnes used each year, it plays a critical role in our infrastructure. Despite concrete's numerous advantages for various purposes, there are issues related to its use, particularly the massive carbon footprint caused by cement production and difficulty guaranteeing the long-term durability of concrete structures. Between 70%-90% of structures degrade prematurely, resulting in substantial economic losses and even structural collapse (e.g. the collapse of the Morandi Bridge in Genoa in 2018 and the Carola Bridge in Dresden in 2024). Concrete degradation typically results from chemo-mechanical processes such as corrosion-induced cracking. Despite more than 50 years of research into this topic, reliable long-term corrosion durability predictions for reinforced concrete structures remain elusive. This is due to several factors, including a lack of fundamental knowledge of the underlying chemo-mechanical processes and the absence of accurate predictive computational models.

What? The objective of this PhD position will be pushing the boundaries of our fundamental understanding of the chemo-mechanical degradation of concrete structures with a particular focus on corrosion-induced cracking and carbonation-induced shrinkage. Building on the previous work conducted by the supervisors [1–5], your research will involve investigating the durability of current and future concrete structures, including the development of pioneering applications such as self-healing concrete and concrete batteries. To achieve this, you will conduct novel experiments and develop a new generation of physics-based predictive models. While the emphasis of the PhD candidate's research is expected to be tilted towards modelling, the ratio of experiments-to-modelling can be adjusted according to the candidate's particular strengths and preferences. Candidates interested in Earth Sciences will have the opportunity to investigate the aforementioned degradation mechanisms within the context of geomaterials. You will have the opportunity to conduct experimental work in Imperial's Advanced Infrastructure Materials Laboratory, a world-class concrete materials characterisation facility.

Where? You will work in an emerging group based in the Materials Section of the Department of Civil and Environmental Engineering at the Skempton Building on the South Kensington Campus. There will also be opportunities to interact with, and potentially conduct research visits to, our network of collaborators, including research groups based at the University of Oxford and Czech Technical University in Prague.

Requirements?

The successful candidate should demonstrate their motivation and capacity to conduct pioneering research, including a passion for continuous learning, regardless of their academic background. A civil engineering degree is **not** a necessary prerequisite. Individuals with a passion for their subject and a curious nature are particularly welcome to apply! Minimum requirements are:

1) First-Class Honours degree (70% and above) or the International equivalent in engineering/physical sciences or mathematics. Candidates who possess a degree in these disciplines but who do not fulfil the criterion of a First-Class degree are also encouraged to apply if they can demonstrate exceptional motivation and potential (e.g. outstanding results from

engineering practice/research projects). They should provide a detailed explanation of their circumstances and suitability for this position.

2) The ability to communicate fluently in English.

Funding? This PhD position provides funding for tuition fees at the level of Home (UK) students and a tax-free stipend at the standard UKRI London rate (£22,780 pa for 2025/26). International students are also welcome to apply, provided that the difference in home and international fees can be covered by an additional source of funding such as a national scholarship or funding obtained from an alternative source. For exceptionally outstanding candidates, we can provide support in applying for Imperial PhD Scholarships.

How to apply?

Applicants are encouraged to contact Dr Evzen Korec by email (e.korec20@imperial.ac.uk) to express their interest in the position, explaining why they are suitable for the role. Required materials for the initial interest email:

- *Candidate interest statement*: the specificity and personality of the candidate's interest statement will be highly valued.
- *Current academic CV*, including details regarding degree results, and, if possible, class ranking.

You **do not** need to apply via the Imperial College Registry at this stage. Applications will be reviewed regularly until the position is filled. Successful candidates will then be invited to formally submit a PhD application using the Registry system.

References

[1] E. Korec, P. Grassl, M. Jirásek, H. S. Wong, E. Martínez-Pañeda, On the corrosion-induced cracking of aerated concrete: new model indicates RAAC panels can collapse before any surface cracking, npj Materials Degradation 9(1): 44, 2025 (https://www.nature.com/articles/s41529-025-00596-5)

[2] E. Korec, M. Jirásek, H. S. Wong and E. Martínez-Pañeda, Unravelling the interplay between steel rebar corrosion rate and corrosion-induced cracking of reinforced concrete, Cement and Concrete Research, 186: 107647, 2024 (https://www.sciencedirect.com/science/article/pii/S000888462400228X)

[3] E. Korec, M. Jirásek, H. S. Wong and E. Martínez-Pañeda, Phase-field chemo-mechanical modelling of corrosion-induced cracking in reinforced concrete subjected to non-uniform chloride-induced corrosion, Theoretical and Applied Fracture Mechanics, 129:104233, 2024. (https://www.sciencedirect.com/science/article/pii/S0167844223004962)

[4] E. Korec, L. Mingazzi, F. Freddi and E. Martínez-Pañeda, Predicting the impact of water transport on carbonation-induced corrosion in variably saturated reinforced concrete, Materials and Structures, 57(4):1–16, 2024. (https://link.springer.com/article/10.1617/s11527-024-02374-2)

[5] E. Korec, M. Jirásek, H. S. Wong and E. Martínez-Pañeda, A phase-field chemo-mechanical model for corrosion-induced cracking in reinforced concrete, Construction and Building Materials, 393:131964, 2023. https://www.sciencedirect.com/science/article/pii/S0950061823016781