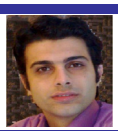
Imperial College London

TRANSCEND MARIE CURIE ACTIONS

P4: The role of microcracks in concrete on water transport

Saeed Dehghanpoor, Nick Buenfeld & Hong Wong

Contact: sdehghan@imperial.ac.uk



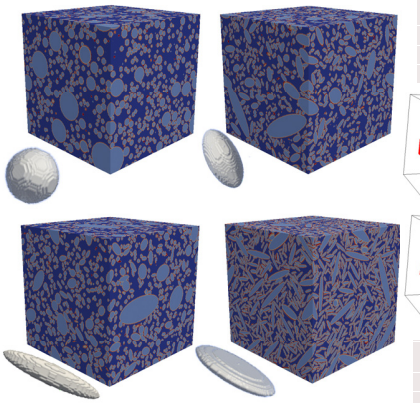
A native of Iran, Saeed Dehghanpoor got his MSc in Civil Engineering from École Nationale des Ponts et Chaussées in France in 2010. He started to work at Imperial College in April 2011.

Project description

The microstructure of concrete and mortar is different from that of neat cement paste. The interface between aggregates and cement paste, known as the ITZ, and the presence of microcracks influence the mass transport properties of mortars and concretes. However, the role of the microstructure and in particular that of the microcracks on mass transport properties is poorly understood. Microcracks allow transport of water and deleterious agents, and when they percolate, the effect may be large and consequently accelerate the deterioration of concrete structures. The main objective of this project is to establish models to predict transport properties of concrete from its microstructure. The models will be applied to a range of samples in order to increase our understanding of the role of microcracks and other phases in the microstructure on transport properties. Since concrete is a highly heterogeneous material, the modeling approach used should be able to capture these heterogeneities. However, analytical and empirical techniques may not be able to reach this level of detail. We will apply numerical homogenization schemes such as finite element, finite difference and finite volume, and attempt to use images of actual microstructure as input to the models. This approach captures the complexity of the microstructure and reduces the need for simplifying assumptions. Numerical predictions will be compared against experimental data from a companion project as validation.

Project results

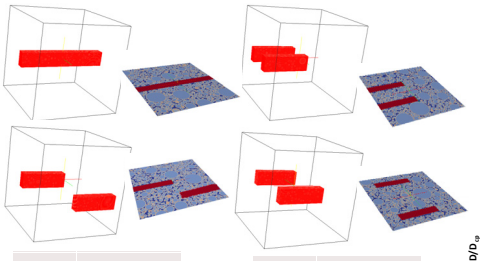
- Diffusivity of mortar and concrete was modeled using a three-dimensional model incorporating various aggregate shapes. (*Paper submitted*)
- Required characteristics of Representative Elementary Volume were investigated.
- Simulations were compared to available experimental and analytical results.
- Effects of variables (aggregate shape, volume fraction, grading and orientation, ITZ width and percolation, w/c ratio, degree of hydration) influencing diffusivity were investigated.
- Effect of microcracks on the equivalent diffusivity was investigated.



Typical mesostructures containing various aggregate shapes

w/c	$D_{cracked}/D_{un\text{-}cracked}$
0.4	22.344
0.5	6.165
0.6	2.320

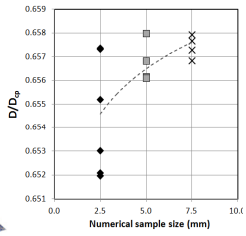
w/c	$D_{cracked}/D_{un\text{-}cracked}$
0.4	17.532
0.5	5.008
0.6	2.031



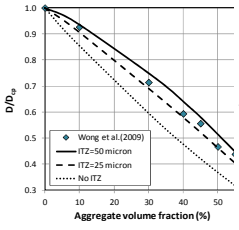
w/c	$D_{cracked}/D_{un\text{-}cracked}$
0.4	19.365
0.5	5.453
0.6	2.146

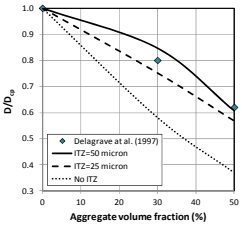
w/c	$D_{cracked}/D_{un\text{-}cracked}$
0.4	16.458
0.5	4.759
0.6	1.978

Idealised cracked mesostructures

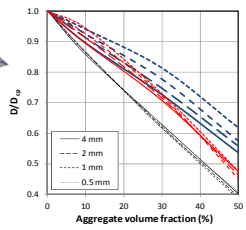


Requirements of REV

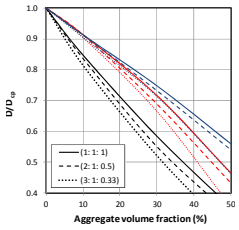


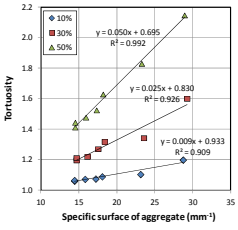


Verification against experimental results



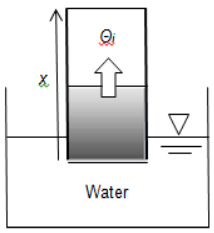
Effect of max aggregate size

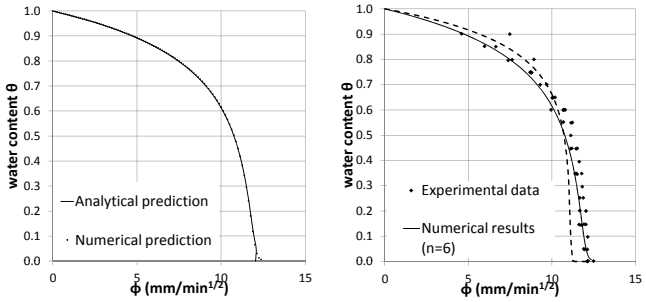




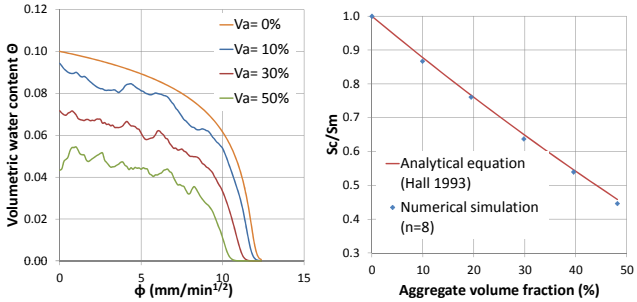
Effect of aggregate shape

- Sorptivity of concrete was modeled using a three-dimensional model . (*Paper under preparation*)
- Simulations were compared with experimental and analytical results.
- Effects of different variables influencing diffusivity were investigated.





Validation of penetration profiles against analytical and experimental results



Effect of aggregate volume fraction on the water penetration profiles and the sorptivity

What I am planning to do for the remaining time

- Develop FEM models for permeation and diffusion of microcracked concrete.
- Perform sensitivity analysis to quantify the effects of microcrack parameters such as volume fraction, width, length, density, connectivity and tortuosity on the equivalent diffusivity and permeability.
- Produce (at least) another two papers from the results of FEM models for the diffusivity and permeability of cracked media.

Outstanding questions

- To what extent microcracks in mortar and concrete do influence different transport properties?
- What is the effect of different crack parameters such as volume fraction, width, length, density, connectivity and tortuosity on the equivalent diffusivity and permeability of the cracked media?
- What are the implications of microcracks on the performance and service life of concrete structures?

ACKNOWLEDGMENTS: The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7 / 2007-2013) under *grant agreement* 264448.