PhD Proposal

Effect of shape and surface characteristics of inclusion on concrete fracture: experimental investigation and numerical simulation

Context: As one of the widely used construction materials in the world, cement-based materials are used in various engineering applications, from civil construction to nuclear power plants. Once they are formulated, they are generally submitted to an environment with lower relative humidity comparing with their initial fully saturated state. Drying shrinkage cracks are then created by water loss. In addition to dimensional changes induced by shrinkage cracks and mechanical degradation of cementitious material, its transport properties are also influenced by the saturation state. As a result, the durability of cementitious materials and structures needs a good understanding of the cracking mechanisms subjected to drying.

Purposes: Due to the complexity of inter-structure and composition, the process of dry shrinkage cracking exhibits obvious multi-scale characteristics: at the microscopic scale, the rupture of atomic bonding leads to tensile and slide failure; at the mesoscopic scale, potential defects in the internal structure lead to the initiation and propagation of micro-cracks; at the macroscopic scale, unstable regions appear due to stress concentration, and crack propagation leads to instability failure. The failure modes of material should be studied at different scales. In order to get a good estimation of macroscale behavior of cementitious material and improve the design of concrete materials and their corresponding structures, it is necessary to study the non-uniformity of mesoscale structure of cementitious materials and develop numerical models to study the material damage.

Details: The further thesis aims to understand the micro-mechanisms that drive fracture propagation in concrete via a series of experimental tests and numerical simulations. The emphasize is put on the roles of the shape of aggregates and the strength of the aggregate/mortar interfacial transition zone (ITZ) on concrete fracture. Experimental tests with multiple forms of inclusion will be performed to study the shrinkage cracking of cementitious materials. The geometry of inclusion will be controlled by 3D imprint. Crack morphology will be analyzed with the help of XCMT technique. In parallel with the experimental part, by using Peridynamic approach, a 3D numerical code will be developed to study the hydro-mechanical coupling in concrete. Concrete will be considered as a three-phase material that consists of hard aggregates with a surrounding weak zone called interfacial transition zone (ITZ) embedded in a cement mixture paste. The drying processes of cementitious materials will be simulated in the framework of partially saturated porous media, considering the full coupling between mechanical and hydraulic properties/mechanisms. The experimental investigation and numerical results will enhance the understanding of engineers in the durability study of concrete materials and structures.

Keywords: Concrete Fracture, Inclusion shape, Surface characteristics, Drying

Candidate profile: Applicant having a background in subjects related to modelling cementitious materials using DEM/PD techniques are particularly welcomed. A relevant master's degree and/or employment experience will be an advantage. Applicant should have a high proficiency in English or French.
Interested candidates should send by E-email a detailed CV, a cover letter, copies of their latest transcripts (Bachelor and master, or L3, M1and M2, engineering school years). Letters of recommendation are welcome.

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