Semi-plenary lecture

Multi-scale periodic homogenization of ionic transfer in cementitious material

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In aggressive conditions, corrosion is the main cause of damage in reinforced concrete structures where chloride diffusion can produce serious damage. The penetration of chlorides, through concrete cover leads to the corrosion of steel rebar in reinforced concrete [1].

In this context, many researches have been developed around the degradation of reinforced concrete by the chlorides penetration. The aim of the majority of studies conducted is the determination of the effective diffusion coefficient of chlorides in cementitious material [2]. Experimental measurements have been developed under natural and accelerate conditions of ionic diffusion of chlorides.

The multi-scale nature of their microstructure and the reactive characteristics of cement-based materials add difficulties for the determination of the effective properties of ionic diffusion. The multi-scale modeling based on homogenization techniques, which allows to obtain the macroscopic behavior from the microscopic one, is the appropriate way to overcome these difficulties. In this context, two methods have been developed: the volume averaging [3] and the periodic homogenization techniques [4]. Moreover, the multi-scale character of cement-based materials requires several homogenization procedures for taking into account all the scales in the global behavior of the macroscopic scale.

In this context, a multi-scale periodic homogenization procedure of the ionic transfers in saturated porous media is proposed [5]. A first periodic homogenization of the nonlinear Nernst-Planck-Poisson-Boltzmann system will be conducted from the nanoscale to the capillary one accounting for the electrical double layer phenomenon. A second homogenization procedure will be performed from the capillary scale to macroscopic scale, where the electrical double layer effects are naturally negligible.

A numerical parametric study will be conducted on three dimensional elementary cells in order to highlight the effects of the electrical double layer on the ionic transfer parameters. Finally, some comparisons with experimental results obtained by electrodiffusion tests on several cement pastes or mortars samples will be conducted and the variability of the results will be discussed.

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