Cracking and Fracture of 2D and 3D concrete specimens subject to External Sulfate Attack

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Amidst the numerous ways in which concrete can undergo degradation, this research aims to examine the phenomenon of external sulfate attack as a type of chemical degradation.

Concrete, being a heterogeneous material, can display different internal structures and constitutive behaviors depending on the level of observation used in the investigation. The meso-level is an intermediate level of analysis in which concrete is considered to consist of a homogeneous mortar matrix surrounded by coarse aggregates. In the context of finite element analysis, the weakest part of the meso-structure and the areas of possible fracture are represented here using zero-thickness interface elements, sometimes also called cohesive elements. These elements are placed in the regions where the aggregates meet the matrix and within the matrix itself, highlighting the zones where concrete is most vulnerable.

From a mechanical perspective, non-linear behavior is assumed to take place solely at the interface elements. In order to model this behavior, a constitutive law that combines both elasto-plasticity and fracture mechanics is utilized for these elements. On the other hand, for the rest of the concrete structure, a linear elastic constitutive model is employed [1].

With regard to the reactive transport problem, the model is based on the pioneering work of Tixier and Mobasher [2]. This work was first introduced in a meso-mechanical analysis with interfaces by Idiart et al. [3] in two dimensions and later expanded incipiently to three dimensions by Pérez et al. [4].

The coupled analysis was performed using a staggered method in which the two problems were cyclically solved. The reactive transport results were first obtained and then used as input for the subsequent solution of the mechanical problem. This cyclic approach allowed for a more accurate and comprehensive analysis, as the results of each problem influenced the solution of the other. The problem is addressed by utilizing the DRAC5 program, which was developed by the MECMAT research group at the Universitat Politècnica de Catalunya (UPC). In recent times, the parallelization of the code has significantly enhanced its capabilities, enabling the analysis of progressively larger meshes.

In this paper, the numerical model is described and the results obtained from both 2D and 3D cases are analyzed and discussed. Special attention is paid to the capability of the approach to reproduce the experimentally observed cracking patterns, such as the “onion peeling” effect, as well as the numerical performance of the parallel implementation including scalability with no. of processors.

References

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