The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5-9 June 2022, Oslo, Norway

Development of a FE^2 Multiscale Model of Chloride Ions Transport in Recycled Aggregates Concrete

Arthur FANARA*[1], Luc COURARD[2] and Frédéric COLLIN[3]

[1] Faculty of Applied Sciences, University of Liège, Belgium, arthur.fanara@uliege.be
[2] Faculty of Applied Sciences, University of Liège, Belgium, luc.courard@uliege.be
[3] Faculty of Applied Sciences, University of Liège, Belgium, f.collin@uliege.be

Keywords: *Multiscale Modeling, Concrete Structures, Recycled Aggregates, Waste Management, Durability, Chloride Attacks, Experimental Validation*

It is of common knowledge that reducing the production of CO_2 emissions and preserving natural resources are necessary to the well-being of our civilisations. In the construction industry, recycling old concrete members could be part of the solution to reach theses objectives. Crushing demolished concrete structures creates Recycled Concrete Aggregates (RCA), that can substitute the Natural Aggregates (NA) inside the so-called Recycled Aggregates Concrete (RAC).
However, the durability of RAC is not guaranteed in the current state of research. RCA are indeed composed of natural aggregates partially embedded in an adherent mortar paste, the latter increasing the porosity and water absorption of RAC. Yet, water is necessary for, and even promotes, the penetration of aggressive ions such as chloride ions, possibly reducing the durability of said concrete.
This research aims to better predict the influence of RCA on chloride ions ingress inside concrete. It started with an experimental phase where multiple experiments have been performed to determine the transfer properties and the chloride ions diffusion coefficients of a mortar paste and concretes made from NA or 100% RCA. In this context, the microstructure of the RCA influences deeply the permeability, water content distribution and chloride ingress. Therefore, these properties must be included into a numerical model that integrates the microstructural information in a proper way. A numerical homogenization technique, based on the Finite Element square (FE^2) method [1, 2], is implemented into a coupled multiscale model of water flows and advection/diffusion of chlorides in saturated concrete, in order to model the complex flow behaviour encountered.
Once the numerical model has been developed and validated with existing simple-scale models, the model is compared to experimental results and an application on a bridge pier is performed.

REFERENCES

[1] François Bertrand, Olivier Buzzi, Pierre Bésuelle, and Frédéric Collin. Hydromechanical modelling of multiphase flowin naturally fractured coalbed using a multiscale approach. *Journal of Natural Gas Science and Engineering*, 78:103303, 2020.

[2] V. Kouznetsova, W. A. M. Brekelmans, and F. P. T. Baaijens. An approach to micro-macro modeling of heterogeneous materials. *Computational Mechanics*, 27:37–48, 2001.