Travail de Fin d'Etudes : Modelling of drying phenomena in concrete with recycled aggregates

Auteur : Fanara, Arthur
Promoteur(s) : Courard, Luc
Faculté : Faculté des Sciences appliquées
Diplôme : Master en ingénieur civil des constructions, à finalité spécialisée en "civil engineering"
Année académique : 2019-2020
URI/URL : http://hdl.handle.net/2268.2/9028

LIÈGE université
Sciences Appliquées

Arthur FANARA
20150700
2nd year of Master in Civil Engineering
Academic Year 2019-2020

Master Thesis: Summary

Modelling of drying phenomena in concrete with recycled aggregates

Promotor: L. COURARD

Concrete is the most used building material in the construction industry, with a production estimated to be about 1 billion tons/year in the European Union. Natural aggregate (NA) is one of the main ingredients of concrete, whose production reached about 2.8 billion tons in Europe in 2017. It is today evident that natural aggregates and sand are becoming a scarce resource and their availability becomes therefore an important challenge.
Furthermore, environmental concerns regarding the construction industry have risen, particularly regarding CO_2 emissions and waste production from construction and demolition activities (C&D Waste).

That's why the construction industry needs to develop and implement processes able to incorporate recycled products into its building materials. Recycled Concrete Aggregates (RCA) produced from crushed C&DW as a replacement of natural aggregates is one of those solutions which has made it a thoroughly studied field.
RCA consist of coarse particles containing natural aggregates as well as residual cement paste which impairs negatively their properties compared to NA. Indeed, the use of RCA inside concrete increases the porosity and may therefore reduce its durability. The focus of this master thesis is to analyse the influence of RCA on transfer properties (water retention curves, permeability and porosity) and drying behaviour of concrete. Indeed, a better knowledge of those properties will help to determine the effect of RCA on the durability of concrete as water and vapour transfers are the necessary condition to observe degradation processes like carbonation, chloride ion diffusion or alkali-aggregate reaction.

A numerical model for drying phenomena of concrete samples with recycled aggregates is developed in this thesis. To support this modelling, an experimental programme with sorption and desorption tests as well as porosity and permeability determination, is implemented.
To better study the influence of the RCA alone, several concrete mixes are studied: a reference composition with natural aggregates and the same composition with RCA (same granulometric curve), a mix with natural aggregates but another cement type and, finally, a mortar without any aggregates. The three concrete compositions have the same paste content and type as it highlights the influence of the change of aggregates/cement type.
The modelling is performed with a nonlinear finite element software developed at the University of Liège (called Lagamine). It follows the theory of nonlinear finite elements modelling of flows in porous media and consists of a coupled thermo-hydraulic study of the material.
An application is also carried out in the form of an exterior parking lot's column subjected to real outdoor conditions: at constant and variable temperature, the relative humidity will vary between 40% and 95%, with multiple cycles of 6 months.

Results show that, as predicted, concrete made from Recycled Concrete Aggregates (RCA) is more porous than its Natural Aggregates (NA)-based counterpart. Its water absorption and intrinsic permeability are also superior than for regular concrete. In terms of water retention properties, both concretes are similar, with no significant differences.
The first indicator of durability measured in this thesis is the resistance to carbonation, which showed that concrete made from RCA is more prone to carbonation than concrete with NA.

Nota Bene: this master thesis has been performed during the COVID-19 period when lockdown was applied from March 19th to May 31st, 2020.