INDUSTRIAL PILOT PROJECT

Frost durability of concrete addressed by dual-modality neutron and x-ray tomography

THE INDUSTRIAL CHALLENGE

A lot of effort is done to ensure that building material is durable and sustainable but some properties are investigated in a rather coarse way. We are therefore looking into new technologies to help us understand what happens when concrete freeze.

WHY USING A LARGE SCALE FACILITY

Water is an important player in almost all types of degradation. The state and whereabouts of water in the complex pore structure of concrete is in almost every case studied with indirect methods (eg. volume change due to ice formation in the pores). A frost resistant concrete contains air entrainment agents. How efficient the agents are, depends largely on how well they interact with the cement. Neutron scattering measurement allows studies of water and X-ray tomography allows us to study the structure of the solid material. With this combination we have a chance to validate other techniques - and thereby our product development strategy - which is exiting!

HOW THE WORK WAS DONE

Cement mortar with different moisture levels were studied at different temperatures in the D50 NeXT dual-modality neutron and x-ray tomography experimental station at Institut Laue Langevin (ILL), Grenoble. We were excellent supported by instrument scientist Nicolas Lenoir at ILL.

THE RESULTS AND EXPECTED IMPACT

The combination of x-ray and neutron imaging allowed separation of all phases in the samples (air-entrained cement mortar). An example is showed in Figure 1, where it is possible to distinguish between water-filled pores (left) and air-filled pores (right). With that it is possible to study each phase by itself which opens up to the opportunity to target on what that is most important in each and every case.

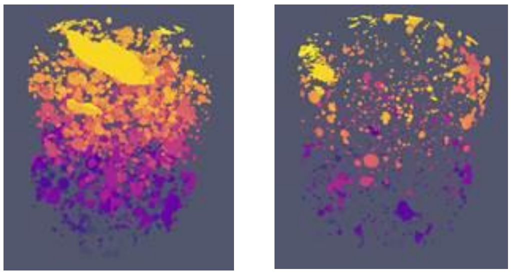

Figure 1. A result of dual-modality neutron and x-ray tomography, where the x-ray detects the structure of the cement mortar and the neutrons detect the water. Figure is showing: to the left all water-filled pores and to the right the air-filled pores.

During the freeze/thaw study it was possible to follow individual air voids and how their degree of saturation changed (Figure 2). The samples were exposed to temperature cycles from room temperature to -13ºC three times.

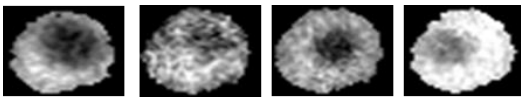

Figure 2. The same air void during four measurements at different temperatures: (1) room temperature, (2) -13ºC, (3) -13ºC at the second freezing cycle (4) after 2nd thawing. Notice the increased amount of water inside the pore. The grey scale indicates from white (water) to black (air).

This study show that this method can be a complement in future product development where we can study the interaction of cement and air entraining agents.

Contacts: Stefan Sandelin – Cementa AB, stefan.sandelin@cementa.se
Katja Frid – Division of Building Materials, Lund University, katja.frid@mau.se
Jonas Engqvist – Department of Construction Sciences, Lund University, jonas.engqvist.lth.se

Vinnova's project No: 2019-02556 **Duration:** August 2019 -- January 2021

Funded by Sweden's Innovation Agency, Vinnova, in order to build competence and capacity regarding industrial utilisation of large-scale research infrastructures such as MAX IV and ESS.