Experimental report

26/09/2022

Proposal: **1-05-88** **Council:** 4/2021

Title: In-situ study of the water uptake in air-entrained cement mortar during freezing and thawing

Research area: Engineering

This proposal is a new proposal

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Samples: D20
water saturated, air-entrained cement mortar

Instrument	Requested days	Allocated days	From	To
NEXT	5	3	27/08/2021	30/08/2021

Abstract:

We will use dual-modality neutron and x-ray tomography to study the uptake of water in air-entrained concrete. We will perform measurements in-situ during freeze-thaw cycling to better understand the interaction between the water and the air pores in the material and eventually visualize the freezing-induced cracks. We will also investigate the potential of better differentiating super-cool water from ice by filtering out the higher end of the neutron spectrum to benefit from the increased contrast between liquid water and ice at lower neutron energies.

Experimental report for proposal 1-05-88

Johan Hektor

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1 Introduction

This report concerns the experiment 1-05-88 carried out at the D50 tomography beamline during the 20213 cycle. The aim of the experiment was to study the uptake of water in air- entrained concrete during freeze/thaw-cycling using x-ray and neutron tomography. The sample we studied was a 10mm high 10mm in diameter cylinder made from air-entrained cement mortar which consists of cement paste, aggregates and a pore structure.

We used a purpose build freezing cell, fig. 1, based on a Peltier element connected to a PR-59 temperature controller and regulated using a PID regulator implemented in LabView. The Peltier element was, in turn, cooled by circulating mix of water and glycol through the system. The temperature in the cell was monitored by two termocouples, one mounted above the sample and one mounted between the Peltier element and the sample.

2 Measurements

We did x-ray and neutron tomography of the sample in its initial state and during the 1st, 7th, and 19th freezing cycle (in both frozen and thawed condition). We used a voxel size of approximately 20 µm for both modalities. A checkerboard plot showing a vertical slice through the sample is shown in fig. 3. The bright features in the x-ray data (dark squares) are air bubbles which in theory should be fill with water/ice upon temperature cycling. However, from our data we see very little evolution of the air bubbles. Instead we see from the neutron data that the grayscale in the voxels belonging to the cement paste is decreasing as a function of temperature cycling, see fig. 2. We believe the grayscale is an indication of the amount of water in the cement paste, high values in grayscale means higher water content. If this interpretation is true it seems our sample is drying rather than taking up water during the temperature cycling.

The temperature history is plotted in fig. 4. For the sample to fully freeze we expect the temperature above the sample to go below 0 °C. As seen in fig. 4 this only happened for 19 of the attempted 38 cycles. This is clearly a problem with our freezing cell which we attribute to poor insulation, condensation forming on the Peltier element and poor contact between the sample and the bottom of the cell. The cell will be further developed to minimize these issues before our the next experimental campaign. In addition we will also perfect our cement recipe to have better control of the water intake.

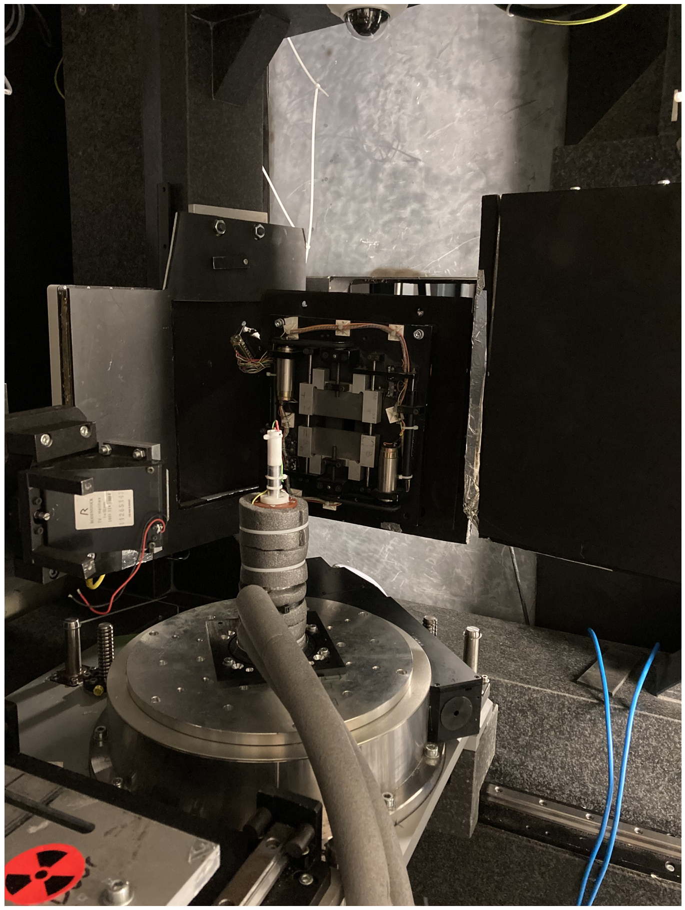

Figure 1: The freezing cell mounted on the rotation stage at D50.

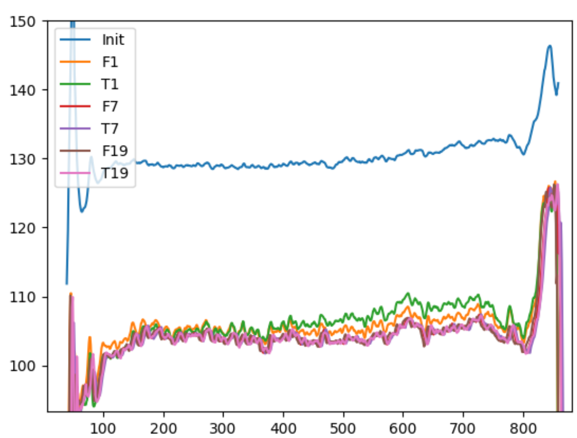

Figure 2: Mean grayscale value in the cement paste for all neutron tomographies as a function of slice number.

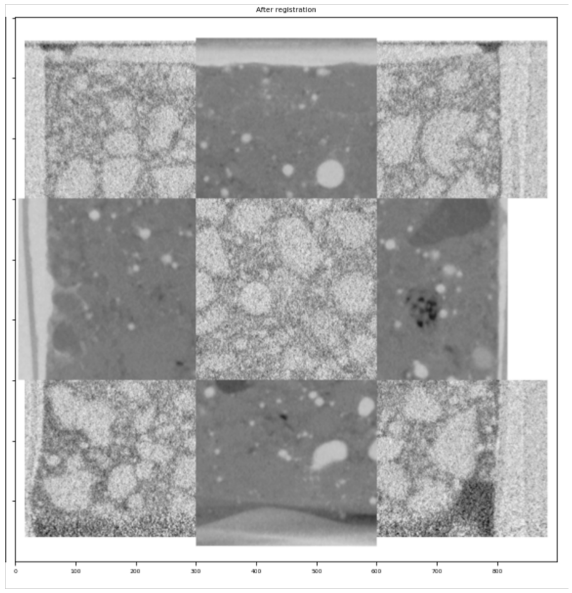

Figure 3: Checkerboard image of a vertical slice. The bright squares are from the neutron data and the dark squares are from x-rays.

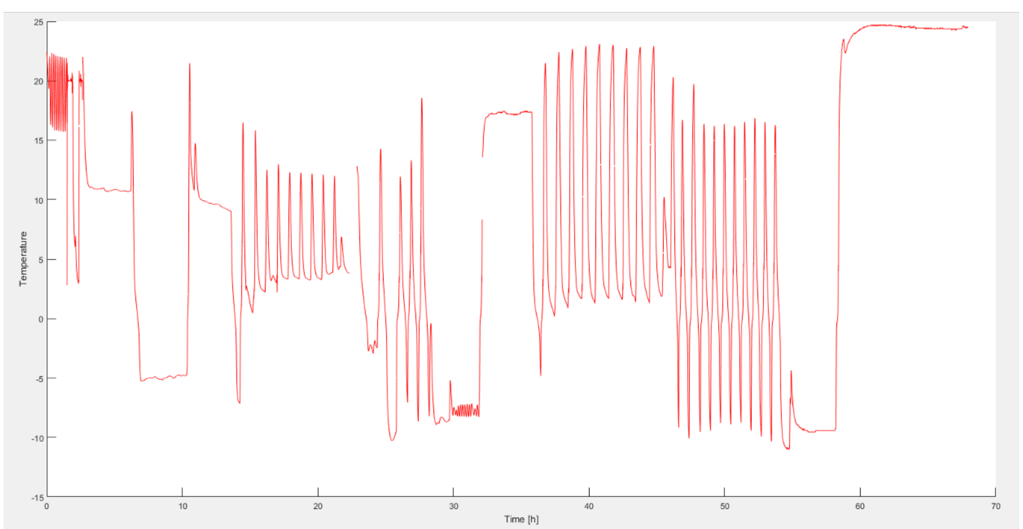

Figure 4: Plot of the temperature above the sample as a function of time. The long periods of constant temperature is where measurements where made.