Portland Cement Pastes Analysed by Synchrotron and Laboratory X-ray Imaging

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Portland Cement (PC) is the most used construction material[1] and the derived building materials have very complex hierarchical microstructures. Quantitative characterization of their microstructures is of paramount importance for assessing the performance and durability of the final products.[2]

As cement performance is controlled by its phase composition and microstructure, in particular, the pore network plays a critical role in the mechanical properties and durability. The chemical and hydration changes in PC binders affect their performances mainly because of the binding properties of the main component, the so-called C-S-H gel.[3] Here, we analyse porosity in PC pastes using laboratory and synchrotron X-ray micro-tomography with different water to cement mass ratios (w/c) after 28 days of hydration. Monochromatic synchrotron X-ray microtomography is used for reference and the main aim is determining volume percentage of different components with focus on porosity. It will be shown, as expected, that higher amount of water (that increases fluidity of pastes) results in higher porosities at 28 days of hydration. Therefore, in the histogram and tomograms more pores, hydrated materials, and less anhydrous materials would appear with increasing w/c (see Figure 1).

The excellent spatial resolution (and slightly better contrast) of synchrotron experiments serve as reference for data analysis. Despite 0.2-0.3 μm voxel-sizes in all the used experimental setups (see Figure 2), the laboratory tomograms show some limitations that will be discussed. In this work, a two-steps approach is followed. Firstly, we will report the analysis of the histograms by classifying in the three types of components based on grey-levels: i) pores, ii) hydrated components; and iii) unreacted cement phases. Secondly, segmented pore contribution will be further analyzed and the results from laboratory tomograms will be compared with the reference values derived from synchrotron data.

Keywords: cement, porosity, tomography, image analysis, microstructure

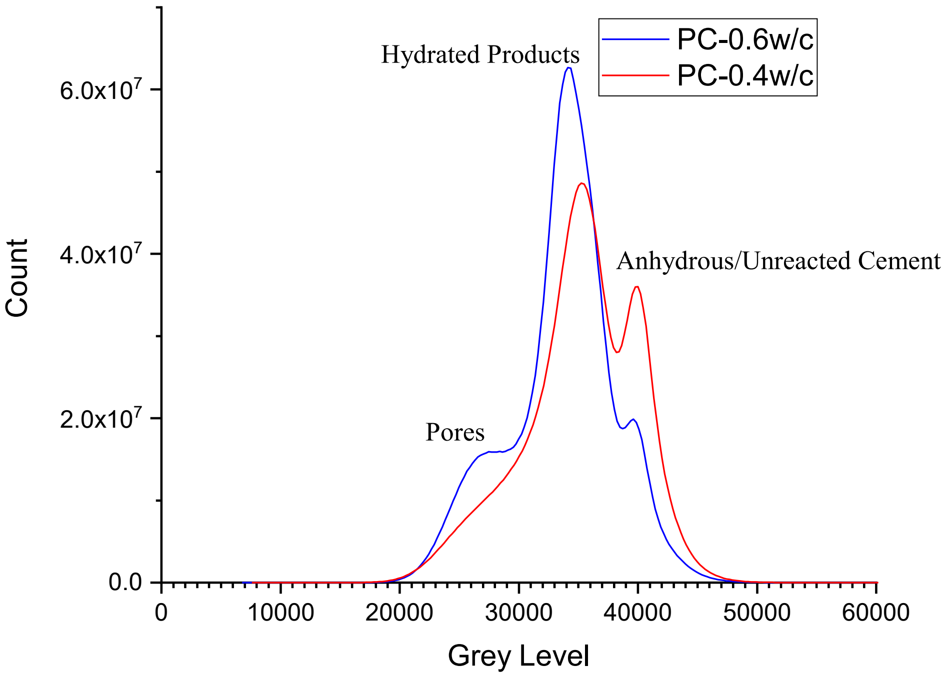

Figure 1: Grey-level histogram of synchrotron microtomograms of Portland cement pastes, with peaks labelled. Blue curve: PC with w/c=0.60. Red curve: PC with w/c=0.40.

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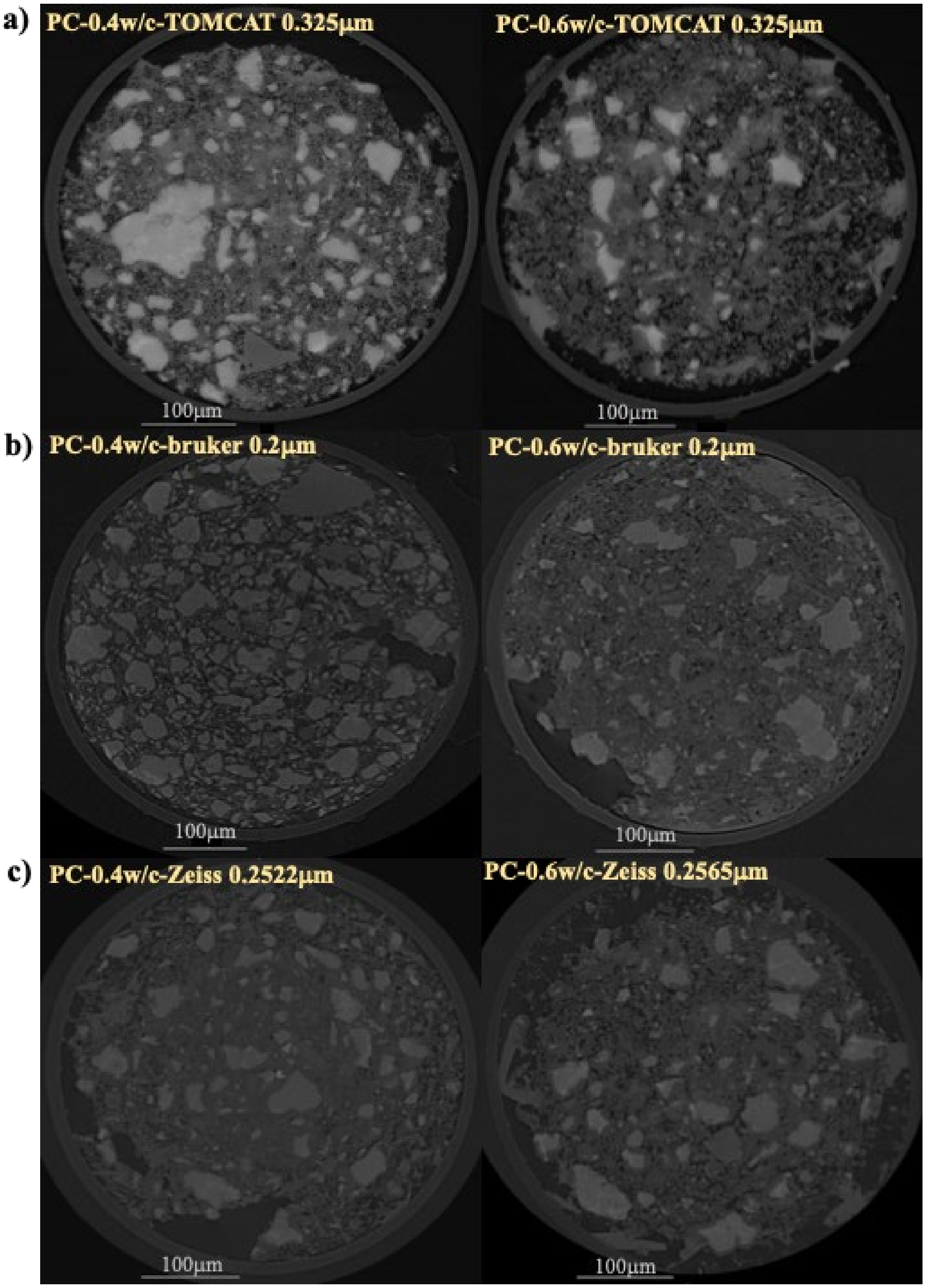

Figure 2: Reconstructed horizontal orthoslices of PC-0.4 w/c [left]; PC-0.6 w/c [right] samples. Scanned by a) Synchrotron at TOMCAT beamline at SLS with 0.325 μm voxel size (Paganin reconstruction); b) Bruker laboratory tool with 0.2 μm voxel size c) Zeiss X-radia laboratory tool with 0.25 μm voxel size.