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Water transfers (imbibition, drying) in cementitious materials followed by MRI (Magnetic Resonance Imaging)

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Nowadays, cement-based materials are widely used, whether in construction or even in the conditioning of radioactive waste. However, the performance of these materials could be substantially affected by the penetration of water. Indeed, the infiltration of water facilitate the ingression of aggressive agents such as Cl, CO2, etc. and can cause many types of degradation such as chloride infiltration and freeze-thaw damage [1] [2]. Therefore, a comprehensive understanding of water transport in cement-based materials is fundamental. For that aim, we focus on the physical mechanisms that control water transfers in mortar. More precisely, we study in detail the mechanisms of water imbibition and drying of a simple mortar sample. We in particular take advantage of visualization in time of the spatial distribution of water inside the sample by (non-invasive, non-destructive) MRI.

The imbibition tests observed by MRI show that for some samples the penetration of water can be heterogeneous, i.e. the water appears to follow some paths through the structure, temporarily not invading some regions. As a consequence, in such case, the imbibition dynamics is not described by the standard Washburn model [3]. When the imbibition is homogeneous, i.e. when a saturating front progresses in the material, the Washburn model applies under the assumption of a less than nanometric pore size. This process might also be described by a diffusion process.

The results obtained for drying are even more surprising. We systematically observe a homogeneous desaturation, which is usually the hallmark of dominant capillary effects, but at the same time, the drying rate continuously decreases and is essentially independent of the air flux velocity, which are usually the hallmarks of the development of a gradient of concentration at the approach of the free surface. In order to reconcile these contradictory observations we suggest that the extraction of water results from a diffusion process through the structure, but with two very different coefficients depending on the saturation: for relatively large saturation (say, more than 0.5) the diffusion coefficient has some approximately constant value; for lower saturation it strongly drops to a much lower value. This would allow the development of a saturation gradient in a thin layer close to the free surface, not visible by MRI, but yet a homogeneous desaturation in the rest of the sample still having a larger saturation.

The mechanical water penetration and extraction from a mortar appear to follow more complex processes than standard capillary processes. Diffusion from one site to another, easier at large saturation could be the main driving effect.

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References

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Time Block Preference

Time Block B (14:00-17:00 CET)

Participation

In person

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