Assessment of weathering effects on acoustic behavior of mortars exposed to different environments using X-ray micro-CT

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Keywords: x-ray tomography, mortar weathering, acoustic properties

Summary: The aim of the study is to assess the effect of weathering on acoustic properties of mortars. X-ray micro-tomography was used to monitor the physical changes of mortar samples undergoing weathering cycles. In function of the number of cycles, the weathering zones were quantified as well as the appearance of fractures in three dimensions. This information was used as input to model acoustic parameters and validated with the macroscopic parameters and sound absorption spectrum which was quantified before and after weathering.

1. INTRODUCTION

Weathering of mortars is traditionally studied by research techniques such as optical microscopy, SEM, MIP, and by indirect assessments using water absorption. The development of construction materials has improved the sustainability and energy efficiency of buildings. Additionally, Saint-Gobain has defined several comfort indicators focused on wellbeing in habitat and develops construction solutions.
The sound comfort is, among others, a significant component for buildings design. From the acoustic quality of the concert halls to the silence of a hospital, the noise level can contribute as much to the establishment of a calm atmosphere promoting well-being as the establishment of a stressful environment. This acoustic comfort is designed by controlling the sound level in buildings. It consists in attenuating the noise outside the room and making acoustic correction in order to get rid of the reverberations due to the interior noise in the room. In this context, Saint-Gobain sets R&D effort on the development of acoustic solutions which would reduce the noise in urbanized areas.
Here, micro-CT was used in combination with the traditional techniques. The material under investigation is a mortar for facades applied in an outdoor environment subject to climate changes. The aim of the current study is to characterize mortar samples and look at the influence of weathering on the acoustic properties and performances of the mortars.

2. EXPERIMENTAL METHOD

In order to fully understand the effect of weathering on acoustic performances, three mortar samples (diameter=40mm, length=30mm), named Sample 1, Sample 2 and Sample 3 were used in this study. Micro-CT was performed to characterize the weathering depth and the occurrence of cracks in 3D. Mortar samples were scanned in initial condition and after subjecting the specimens successively to two conditioning series of four cycles based on the standard test NF EN 1015-21. The first series consists of four heating-freezing cycles where the samples are heated by infrared radiation to maintain a surface temperature of 60°C for 8 hours and then stored in deep freeze cabinet at -15°C for 15 hours. The second one consists of four humidification-freezing cycles where the samples were partially immersed with the rendered side in water at 20°C to a depth of approximately 5 mm for 8 hours and then stored in deep freeze cabinet at -15°C for 15 hours. Between the two series, the samples were stored for at least 48 hours in standard conditions (20°C and 65% relative humidity). The micro-CT scanning was carried out on the HECTOR scanner [1], the high-energy scanner of the Ghent University Centre of X-ray Tomography (UGCT).

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The micro-CT images were reconstructed with the Octopus Reconstruction software [2] and the 3D image analysis was performed with Avizo. Complementary analysis before and after weathering using the three-microphone impedance tube method proposed by *Utsuno et al.*[3] were done in the frequency range 100 Hz – 4000 Hz. The sound absorption coefficient measurements were performed for a normal incidence

3. PRELIMINARY RESULTS

Figure 1.a shows a reconstructed slice of the mortar. In order to visualize the effect of the weathering on acoustic behavior of mortars, absorption coefficients are estimated with measured and calculated macroscopic parameters. Therefore, porosity, tortuosity, resistivity and characteristics length were obtained with 3D analysis. A good prediction of the sound absorption (Figure 1.b) is observed for all of the three samples.
Complementary scans after weathering experiments will show a change in sound absorption due to for instance cracks and how the intrinsic parameters will be influenced by the weathering.

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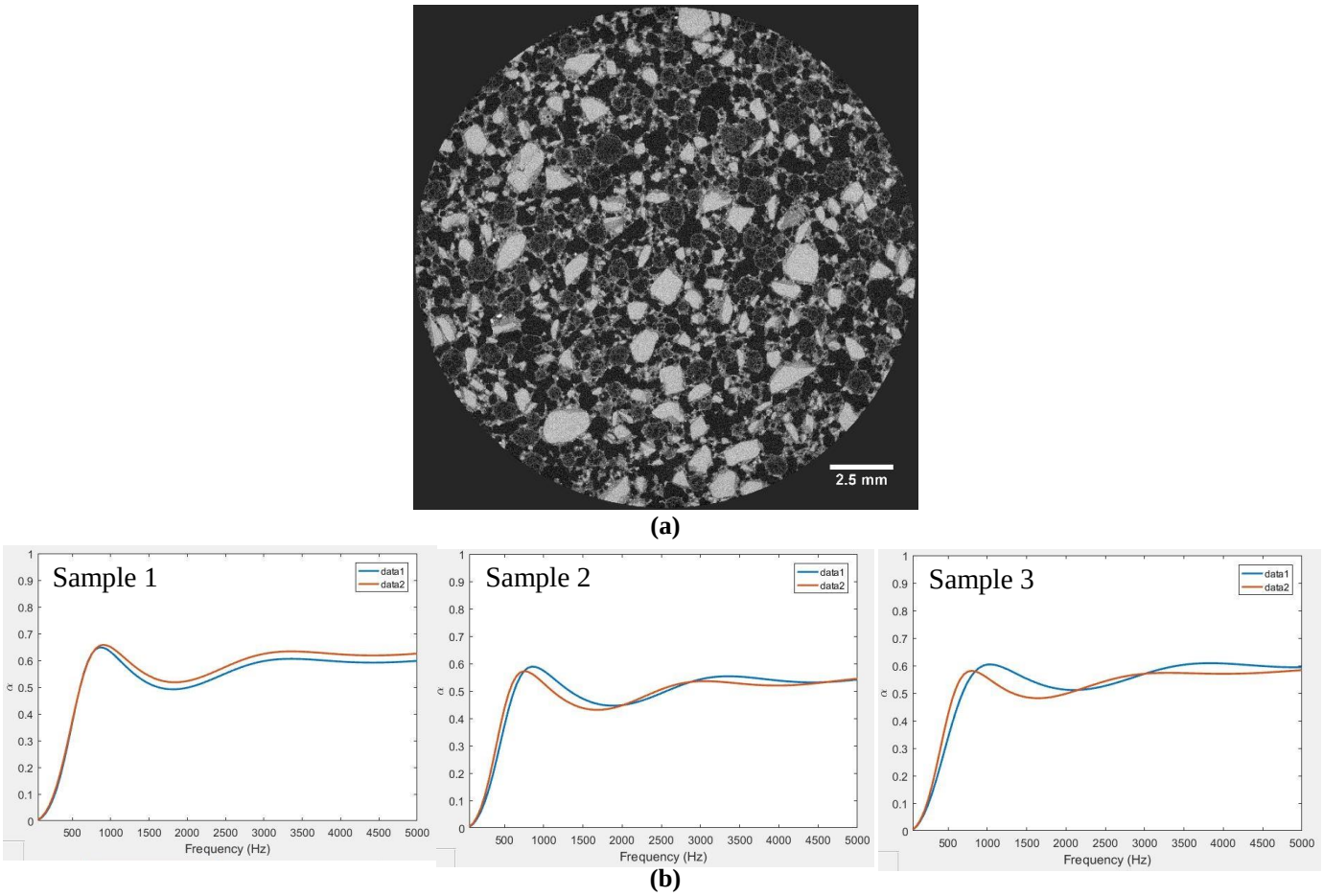

Figure 1: (a) Tomographic slice of mortar sample (b) Sound absorption spectra computed from micro-CT images (blue) and experimental measurements (red)