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VISUALISATION AND VERIFICATION OF POLYMERS IN CEMENTITIOUS MATERIALS USING COMPUTER TOMOGRAPHY – A CASE STUDY

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Summary: CT-measurements are used to visualise the distribution of polymer additives in polymer cement concrete (PCC). It was found that said polymers interact not only with solid particles of the fresh concrete but also with entrained air voids. Thus the air voids can be considered as “particles” and play an important role in the formation of the microstructure of PCC.

1. INTRODUCTION

The material polymer cement concrete is characterised by two interpenetrating binder phases: an inorganic (cement) and an organic (polymer) phase. Typical polymer contents are 5 – 15 % of the cement content. Besides the investigation of mechanical properties, numerous studies have been performed in order to investigate and describe the formation of the microstructure of PCC.

It is known that interactions between particles of the fresh PCC, such as adsorption and repulsion processes, influence not only the stability of the fresh concrete but also the cement hydration considerably. The interactions of the polymer(particles) with the surfaces of other components of the concrete (e. g. cement particles, fillers) have been the subject of studies on electro- and physiochemical interfacial analysis. Furthermore, the distribution of the polymer phase in the cement matrix is of interest as this significantly influences the mechanical properties of the hardened PCC. With computer tomography there is a non-invasive technique at hand to verify some of the aspects contemplated before and draw conclusions as to the quality of the evaluation of the results of electro- and physiochemical interfacial analysis.

2. MATERIALS AND METHOD

For the experiments hardened PCC samples with varying particle polymer contents (0, 5 and 15 % of the cement content) were used. They were scanned in a “GE Phoenix nanotom m research|edition” X-ray computer tomograph at 130 kV and 55 µA. The acquisition and reconstruction software allows for the correction of ring artefacts as well as of artefacts due to random movement of the sample and Feldkamp-artefacts. After reconstruction the 2D cross-sections were analysed with 3D-software “VG Studio Max 3.0”. As the grey scale values of polymers and e. g. air voids are very similar, false-colour rendering was used in order to visualise the distribution of the polymer phase in the cement matrix. For comparison, Cryo-REM images were taken.

3. RESULTS

CT-measurements of PCC samples containing particle polymer additives (15 % of the cement content, **Figure 1** (b)) show significant changes in the microstructure formation compared to concrete samples without particle

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polymer additives (**Figure 1** (a)). Whereas the grey scale values around the air voids in concrete samples without additives seem to be rather evenly spread and thus the pores appear to have sharp and “smooth” edges, the edges of the air voids in PCC containing polymer additives appear to be “cloudy”. The effect of preferred adsorption and film formation of polymers around air voids can be used to identify and separate the polymer phase from the cement phase. This is an effect which could not be shown with any of the methods or analyses mentioned before. In earlier studies mainly the interactions of polymer particles with the solid particles of PCC (e. g. cement, fillers) were investigated whereas air voids were mostly neglected in the considerations. The results of this study show that air voids can be considered as “particles” and thus play an important role in the formation of the microstructure of PCC.

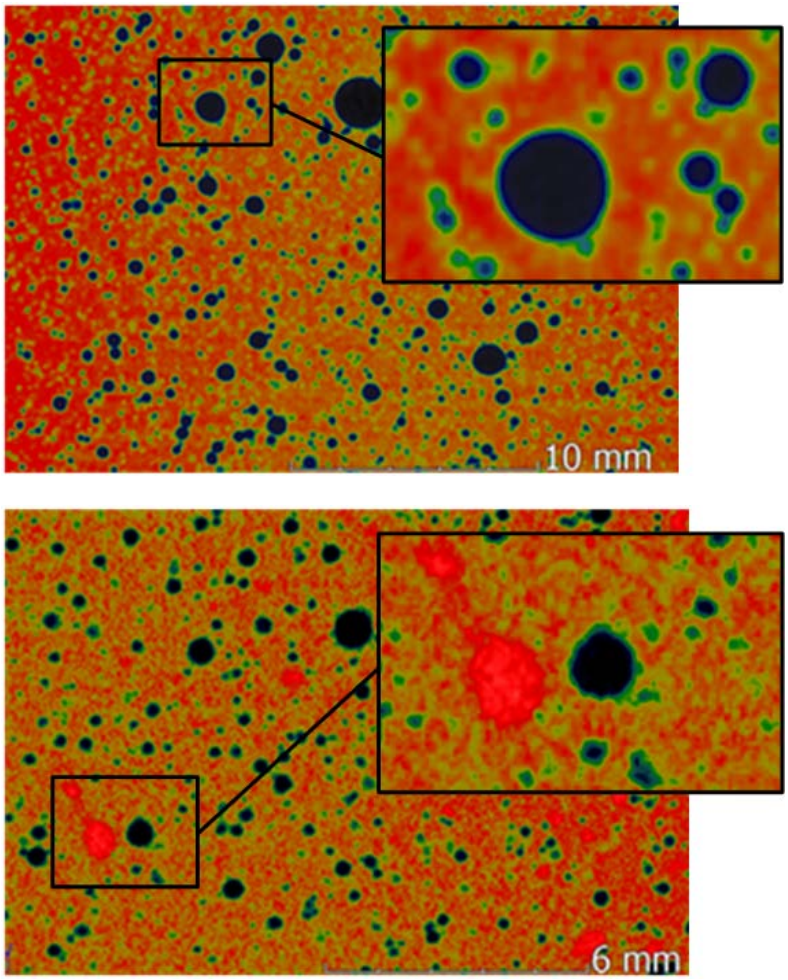

Figure 1: False-colour rendering of CT-images of concrete sample with polymer content of 0 % (a) and 15 % (b) of the cement content