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The Use of Image Analysis Techniques to Describe a Cluster Cracks in the Cement Paste with the Addition of Metakaolinite

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Abstract : The impact of elevated temperatures on the construction materials manifests in change of their physical and mechanical characteristics. Stresses and thermal deformations that occur inside the volume of the material cause its progressive degradation as temperature increase. Finally, the reactions and transformations of multiphase structure of cementitious composite cause its complete destruction. A particularly dangerous phenomenon is the impact of thermal shock – a sudden high temperature load. The thermal shock leads to a high value of the temperature gradient between the outer surface and the interior of the element in a relatively short time. The result of mentioned above process is the formation of the cracks and scratches on the material's surface and inside the material. The article describes the use of computer image analysis techniques to identify and assess the structure of the cluster cracks on the surfaces of modified cement pastes, caused by thermal shock. Four series of specimens were tested. Two Portland cements were used (CEM I 42.5R and CEM I 52,5R). In addition, two of the series contained metakaolinite as a replacement for 10% of the cement content. Samples in each series were made in combination of three w/b (water/binder) indicators of respectively 0.4; 0.5; 0.6. Surface cracks of the samples were created by a sudden temperature load at 200°C for 4 hours. Images of the cracked surfaces were obtained via scanning at 1200 DPI; digital processing and measurements were performed using ImageJ v. 1.46r software. In order to examine the cracked surface of the cement paste as a system of closed clusters – the dispersal systems theory was used to describe the structure of cement paste. Water is used as the dispersing phase, and the binder is used as the dispersed phase – which is the initial stage of cement paste structure creation. A cluster itself is considered to be the area on the specimen surface that is limited by cracks (created by sudden temperature loading) or by the edge of the sample. To describe the structure of cracks two stereological parameters were proposed: $\bar{A}$ – the cluster average area, $\bar{L}$ – the cluster average perimeter. The goal of this study was to compare the investigated stereological parameters with the mechanical properties of the tested specimens. Compressive and tensile strength testes were carried out according to EN standards. The method used in the study allowed the quantitative determination of defects occurring in the examined modified cement pastes surfaces. Based on the results, it was found that the nature of the cracks depends mainly on the physical parameters of the cement and the intermolecular interactions on the dispersal environment. Additionally, it was noted that the $\bar{A}/\bar{L}$ relation of created clusters can be described as one function for all tested samples. This fact testifies about the constant geometry of the thermal cracks regardless of the presence of metakaolinite, the type of cement and the w/b ratio.

Keywords : cement paste, cluster cracks, elevated temperature, image analysis, metakaolinite, stereological parameters
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