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Author(s)	高橋, 駿人
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学 位 論 文 内 容 の 要 旨

博士の専攻分野の名称 博士（工学） 氏名 高橋 駿人

学 位 論 文 題 名

Study on the microscopic alteration of cementitious materials subjected to high temperature and water action using non-destructive integrated CT-XRD method
(非破壊 CT-XRD 連成法を用いた高温および水の作用を受けたセメント系材料の微視的変質に関する研究)

One of the durability concerns for concrete structures is the exposure of high temperature like a fire event, which can lead to shorten the service life. In addition, contact with water can also degrade the performance of concrete due to the leaching of calcium. Furthermore re-curing method with water for damaged concrete at high temperature can be an option for the recovery of the concrete performance. While the properties of cement pastes mainly account for the durability of concrete, exposure to high temperature and water action cause the alteration in the microstructure of the concrete. Thus, it is important to clarify the mechanisms of thermal decomposition at high temperature and leaching of hydrated cement system. Although research efforts have been conducted in the past it should be needed to observe the alteration mechanism from microscopic viewpoint.

This research aims to investigate the alteration of cementitious materials subjected to high temperatures before and after intrusion of pure water by the use of newly micro-tomographic method, so-called non-destructive integrated CT-XRD method (hereinafter the CT-XRD). Compared with conventional techniques, this methodology is significantly beneficial in terms of performing the CT and XRD measurement on the same specimen repeatedly using a synchrotron white X-ray. The X-ray CT method can provide dataset about internal microstructure three-dimensionally, but the distribution of minerals is difficult to evaluate for a hydrated cement system due to the small difference of X-ray absorption characteristic. On the other hand, X-ray diffraction is useful to identify a crystalline mineral. However, this methodology limits the ability to understand the change of the microstructure of concrete over time because this is destructive method. In order to solve this problem, the advantage of coupling CT and XRD measurement can be proposed, and thus the development and application have started. Firstly, experimental works were designed to develop and improve this methodology. From CT image analysis of mortar sample with different aggregate types, phase segmentation algorithm was developed, which can separate the phases into aggregate, cement paste, and void space including cracking area. This segmentation process can be applicable to direct physical simulation. According to XRD measurement, the verification was carried out by comparison with conventional powder XRD technique. It revealed that the CT-XRD could evaluate the crystals properly with a given limitation for low energy band. In addition, the CT-XRD indicated the advantage that can detect the presence of crystals which cannot be detected after grinding in preparing sample for the conventional powder XRD technique. Finally, the carbonated cement paste that was heated at 200, 400, 600 and 800 °C followed by immersion in pure water was evaluated by the CT-XRD. The results suggest that sample heated at 400

showed the resistance of leaching at most. In addition, rehydration of clinker minerals generated due to heating at 800 °C could be identified although the hydration product was easily dissolved into water. Moreover, the effect of re-curing in water or in air was investigated. Quantitative analysis of crack amount revealed that water re-curing for cementitious materials subjected to heating was effective to restrain of crack propagation.