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　TAN Yingyao

学　位　論　文　題　名

Evaluation of transport properties of cement-based materials subjected to water attack using non-destructive integrated CT-XRD method

(非破壊 CT-XRD 連成法を用いた水の作用を受けたセメント系材料の輸送特性の評価)

Concrete is used in underground radioactive waste disposal facilities due to its stable chemical properties to fulfill the requirement of structural stability. However, these facilities are inevitably in contact with ground water for a long time, which brings the danger of concrete structure being damaged by leaching. Leaching refers to the process by which soluble compounds in concrete are dissolved and carried away by water. This process can increase the porosity and permeability of the concrete, making it more susceptible to further leaching and the ingress of harmful substances. Therefore, it is of great significance to analyze the transport properties of concrete under the impact of long-term leaching deterioration. However, as a heterogeneous material, the different phases in concrete, including aggregates, bulk cement paste, the interfacial transition zone (ITZ) and pores, response differently to leaching process. The response, especially change in transport properties, of these phases under leaching together form the picture of the progressive deterioration of concrete. Although research efforts have been made on evaluating leaching deterioration in the past, quantitative analysis on transport properties taking into account the alteration of different phases from the microscopic point of view is still needed.

This research aims to study the alteration of cement-based materials under leaching from a microscopic perspective using non-destructive integrated CT-XRD method and employs the random walk algorithm to provide quantitative estimation results of the transport properties of different phases present in concrete. How to reliably relate this information to leaching deterioration of cement-based materials and ultimately provide quantitative parameters is the purpose of this research.

Integrated CT-XRD technique using synchrotron radiation X-ray source can provide high-precision three-dimensional geometric information and phase distribution information of specimen non-destructively and simultaneously. Based on this information, random walk algorithm was introduced, and a transport properties analysis method was developed. To apply this method, a series of natural dissolution tests under different conditions were conducted. It was found that the dissolution front of portlandite was identified, enabling to separate the leached region and non-leached region in the specimen. With an original developed image reconstructed method, the analysis of transport properties change from the aggregate surface to the leached region was carried out. The diffusion coefficient of calcium ion in the leached region was about 50 times larger than that of the non-leached region, while it was about 10 times larger in ITZ as compared with the non-leached region. Using the quantitative transport properties obtained from CT-XRD method and random walk algorithm, numerical simulation by the SiTraM2D software was conducted for the dissolution of Portlandites in

concrete after 10 years immersion. Results of the calculation showed that the dissolution front ranged from 6.2 to 7.2 mm deep inward the concrete, indicating non negligible effect of ITZ. In addition, it was implied that the diffusion of Sr2+ ion was influenced by the carbonation as well as the Portlandite dissolution.