別紙４

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主　論　文　の　要　旨

論文題目　Impact of damage in concrete caused by inhomogeneous volume change of components on physical properties of concrete and concrete structures
（構成部材・材料の非均質な体積変化による損傷がコンクリート材料・部材の性能へ及ぼす影響）

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論　文　内　容　の　要　旨

This thesis aims to understand the impact of multi-scale cracking induced by the inhomogeneous volume change of components on concrete and concrete structures to enhance the aging management of concrete structures of nuclear power plants (NNPs). In the NNPs, although the reduction in natural frequency over time was found, the mechanism behind this reduction remains uncertain. One hypothesis to explain this phenomenon is cracking that is induced by the inhomogeneous volume change of components, such as shrinkage-induced cracks in the RC member (millimeters scale) and drying and neutron irradiation-induced cracking (micrometers and sub-millimeters scale) in concrete. Therefore, this thesis attempt to grasp how inhomogeneous volume changes affect the concrete properties and structural performance of RC members.

First, to clarify the impact of drying on the RC member, the experimental and numerical study on the effect of drying on the RC shear wall was performed. From the experiment, it was found that the drying reduced the initial stiffness by 50 %, which is coincident with the natural frequency reduction in NNPs, and the slight reduction in the ultimate shear strength between sealed and dried specimen was small. In the numerical study, the Rigid Body Spring Model (RBSM), coupled with the water transfer model, was employed. Through the investigation of the numerical results, a mechanism to explain why the ultimate shear strength slightly decreased due to drying was suggested.

Next, the three-phase – mortar, aggregate, and an interfacial transition zone (ITZ) – mesoscale RBSM for concrete was developed to evaluate the concrete properties subjected to drying. The subroutine to simulate the changes in mechanical properties with cracking has been implemented in this study, and it is found that the presented model can predict reasonably the properties of concrete after drying, compared with the experimental results. Furthermore, through the investigation of numerical results, the mechanism of the influence of drying on concrete properties was clarified.

In the end, the numerical study of concrete subjected to drying and neutron-irradiation was conducted. Neutron irradiation causes aggregate expansion and resultant damage in concrete. As a result, the presented numerical model could reproduce the experimental result.