HOKKAIDO UNIVERSITY

Title	Multi-scale Structural Evaluation Method of Reinforced Concrete Member under the Effect of Frost Damage [an abstract of dissertation and a summary of dissertation review]
Author(s)	WANG, Zhao
Degree Grantor	北海道大学
Degree Name	博士(工学)
Dissertation Number	甲第13794号
Issue Date	2019-09-25
Doc URL	https://hdl.handle.net/2115/75852
Rights(URL)	https://creativecommons.org/licenses/by/4.0/
Type	doctoral thesis
File Information	WANG_Zhao_abstract.pdf, 論文内容の要旨

Hokkaido University Collection of Scholarly and Academic Papers : HUSCAP

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　WANG Zhao

学 位 論 文 題 名

Multi-scale Structural Evaluation Method of Reinforced Concrete Member under the Effect of Frost Damage

(凍害を受けた鉄筋コンクリート部材のマルチスケール構造性能評価法)

Frost damage is one the most important durability issues for reinforced concrete structures built in cold and wet areas. Once frost damage initiates, cracks are induced and enlarged in concrete which leads to severer strength and stiffness reduction. Besides, the bond properties between concrete and reinforcement bars are also weakened due to the degradation of concrete cover and concrete-reinforcement interfaces. As a result, the structural behaviors usually show significant deterioration and the lifetime of structures is shortened under the effect of frost damage. Thus, to predict and evaluate the reinforced concrete structural performance under frost damage is urgently needed so that effective maintenance and repairment could be proposed.

In fact, several scales exist for the fundamental mechanisms of frost action to the structural performance: (1) pore pressures owing to ice formation initiate in microscale which accounts for the propagation of meso-cracks in concrete; (2) the meso-cracks result in the macroscopic residual deformation of concrete, strength and stiffness reduction of concrete and deteriorated bond properties; (3) the degradation of concrete material and bond in macroscale material level is further upscaled into structural level to affect the structural performance. This study has developed a multi-scale evaluation methodology for reinforced concrete structures under the effect of frost damage following the above-mentioned “material (micro-meso-macro)-structure” system.

The methodology starts from explaining the mechanism of frost action in the porous skeleton. Both strengthening effect of elastic properties due to ice-filled pores and damaging effect by meso-cracks due to internal pressures are considered by implementing the comprehensive strengthening/damaging models into the mesoscopic simulation application – RBSM (Rigid Body Spring Model). 2D RBSM is adopted for the meso-macro simulation of concrete with frost damage while axisymmetric RBSM is newly developed to simulate the bond degradation. Based on the parametric study of simulation results, macroscale deterioration constitutive models of material and bond are proposed, and various experimental data are used to verify the models. The deterioration constitutive models are further upscaled and integrated into the 3D structural analysis with FEM (Finite Element Method). The structural behaviors of reinforced concrete beam are analyzed with this methodology and experiments are conducted to show its reliability and applicability.