Coupled migration model of ASR gel with condensed water through crack spaces and structural fatigue life assessment

Yuya Takahashi*, Koki Shibata†, Yasushi Tanaka†† and Koichi Maekawa†

*†School of Engineering, The University of Tokyo
Hongo 7-3-1, 113-8656, Bunkyo-ku, Tokyo, Japan
e-mail: takahashi@concrete.t.u-tokyo.ac.jp, web page: http://concrete.t.u-tokyo.ac.jp/

††Institute of Indusrtrial Science, The University of Tokyo
Komaba 4-6-1, 153-8505, Meguro-ku, Tokyo, Japan
e-mail: yasuxi@iis.u-tokyo.ac.jp

ABSTRACT

This study aims to assess the fatigue lives of structural concretes with various harmful factors, such as water and ASR-gel in cracks. Authors have been developing the 3D multi-scale analytical system which can trace and predict the chemical and physical phenomena of concrete, and recently, anisotropic behaviours regarding pressures, migrations and expansions of substances in pores or cracks are modelled with the poromechanical approach. In this study, the recent models are verified and improved with the laboratory scale tests. Also the real scale experiments are tried to be simulated and finally the models are applied to the fatigue life assessments of the bridge decks.

Focusing on the anisotropic phenomena in ASR-induced expansion of the reinforced concrete, uniaxial confinement tests are conducted. Prism specimens are subjected to ASR expansion under different stress conditions (free case, case with simple restraint by rebar, and case with additional stress by steel rod), which may cause different pressure conditions. The results shows the characteristic anisotropic behaviours, which cannot be explained with simple Poisson's effect. Comparative analyses were conducted to study the properties of ASR-gel and migration processes of gel through the pores are identified. Subsequently the study is scaled up to the structural scale. Past experiments with real scale bridge decks are simulated and it was confirmed that overall trends are well represented with the advanced models.

With the investigated models, the effects of water and/or ASR-gels on fatigue lives of RC bridge decks were studied. Simulations of fatigue with moving load are conducted and, as a result, decrease of fatigue life with the liquid water is obviously appeared. One of the reasons to shorten the fatigue life may be the erosion of cement paste in the situation which concrete becomes sediment-like materials by cyclic actions of high-pressure water in cracks. In ASR conditions, in some cases, fatigue life gets longer because of chemical pre-stress by the expansion, and the existence of the water doesn't affect so much on the fatigue life due to its low rise of water pressure.

REFERENCES

[1] Maekawa K., Ishida T. and Kishi T. "Multi-Scale Modeling of Structural Concrete", *Taylor and Francis*, 2008

[2] Takahashi, Y., Shibata, K., Maekawa, K. "Chemo-Hygral Modeling and Structural Behaviours of Reinforced Concrete Damaged by Alkali Silica Reaction", *Proceedings of ACF2014*, 1274-1281, 2014

[3] Meakawa K. and Fujiyama C. "Rate-dependent model of structural concrete incorporating kinematics of ambient water subjected to high-cycle loads", *Engineering Computations*, Vol. 30, Iss: 6, 825-841, 2013