Full-scale Fatigue Simulations for Reinforced Concrete Bridge Slabs with Multi-scale FEM System with Solid-Liquid Two Phase Model

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Abstract

This paper presents fatigue analysis studies with a full-scale bridge model with multi-scale integrated analysis and a study of the disintegration progress on the upper surface of bridge deck slabs. A full-scale bridge model considering one span of reinforced concrete (RC) decks on steel girders was developed, and it was shown that the relationship between the fatigue lives of the full-scale model and the single-panel model can be reversed whether the condition is dry or wet. Fatigue damage propagation can originate from internal horizontal cracks under wet conditions. In addition, a numerical analysis of fatigue using a disintegration propagation model was conducted, and it reproduced the behavior and damage progress in actual structures. With the sensitivity analyses with various parameters, the dominant factor governing the disintegration progress on the RC slabs was determined, which can be applied to the prediction of disintegration progress.

Keywords: Fatigue; Road Bridge Slab; Simulation; Disintegration; Full-scale.

1 Introduction

In recent years, there has been a great deal of interest in the maintenance of reinforced concrete (RC) deck slabs of road bridges in Japan, and the deterioration progress of RC deck slabs has often been discussed [1,2]. Among the damages that occur in RC deck slabs, fatigue and delamination of the aggregate–mortar interface (so-called disintegration) due to cyclic water pressure rises in concrete are the main concerns [1]. Although techniques for inspection, investigation, and repair of damage propagation have been steadily developed for RC slabs, the mechanisms of damage propagation and residual performance after damage are not yet clearly understood or evaluated. In particular, disintegration has recently begun to attract attention, so quantitative prediction methods have not yet been established. It is questionable whether the current maintenance and management policy is optimal from the perspective of extending the service life of structures and asset management.

About the research in this field, in addition to the conventional experimental investigations [3], numerical analysis has recently been carried out to investigate the fatigue and disintegration of slabs under cyclic loading [1,2]. However, it has been pointed out that there are further remaining issues regarding the predictability of horizontal crack penetration, which leads to the splitting of deck