Stress Measurement and FEM Simulation of a Steel Girder Viaduct

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Summary

Urban highway networks typically rely on a large number of aged viaducts needing an efficient and effective maintenance. Though their numerical models exist, the level of accuracy has not been clear in terms of secondary member stress induced by traffic loading. In this paper, dynamic stress responses of a steel girder viaduct subjected to truck loading is investigated through field tests and numerical simulations. The strain responses are recorded when a truck with known weight passes the bridge. The validity of the measurements is first confirmed. Then a bridge-vehicle interaction numerical analysis is performed. The secondary member stress analysis shows that the stresses are sensitive to parameters such as the drive path and mesh size. The calibrated model reproduces the measurement with the accuracy of about 20 % and indicates that the pavement condition indeed affects the dynamic stress levels.

Keywords: steel girder viaduct; traffic loading; stress, measurement, FEM.

1. Introduction

Many highway bridges in Japan were constructed in the high economic growth period and deterioration of aged bridges are of major concern of the owners and users. The maintenance of steel bridges, which account for 77% of the road network of Tokyo Metropolitan Expressway is important. Because the deterioration of these steel bridges is mainly due to fatigue cracks, appropriate evaluation of stress on these bridges based on measurement data is therefore needed.

The behaviour of steel bridges under traffic loads has been studied mainly with respect to the global motion and main girder members. Su et al. [1] measured and compared the dynamic responses of simply-supported girder bridges and continuous-slab girder bridges. The stress responses of main girders were reproduced using FEM. The study on the stress responses of non-main members (e.g., cross beam and lateral bracing), on the other hand, has been limited; numerical simulations have been performed while detailed comparison of simulation with field measurement data is yet to be performed. Thus, the secondary member stresses, which plays an important role in fatigue damages on steel girders, have not been analysed in detail based on both numerical simulation and full-scale structure measurement whereas analyses and measurements have been reported on the dynamic characteristics of global vibration modes and main member stress responses.

In terms of analysis methods, research attempts in the past are mostly by numerical static analysis to reproduce loading test results. Even when loading tests are performed dynamically, analyses were mostly static. For example, Yamamura et al. [2] analysed dynamic loading test result to evaluate traffic load using the static analysis. While the static analysis is considered effective in design review in general, inclusion of dynamic effects in the simulation is essential for fatigue stress analysis considering vehicle-bridge interaction and other advanced investigation.

In this study, stress responses of main girders and secondary components (e.g., cross beam and lateral bracing) are measured under the traffic load of 25 ton truck passages at a steel girder viaduct on the Tokyo Metropolitan Expressway Route 3. The bridge and truck were modelled and the stress responses were reproduced. The variations in the stress measurement were first examined. The stress responses of secondary components as well as those of main girders are then reproduced by numerical simulations. Simulation parameters affecting the stress evaluation are clarified. Using

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