Stress Evaluation and Fatigue Prediction in a Steel Girder Bridge

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Summary

One of the primary damages of steel girder bridges is the fatigue cracks which suffer from the local stress concentration caused by heavy traffic. In this paper, dynamic stress responses of such a bridge subjected to traffic-induced load is studied to investigate the capability of a FE model in evaluating stress response and extend to predict fatigue life in local members. Good agreement is found in the comparisons between the measurement and the simulation results either for main member or secondary members. By refining the mesh size, the stress concentration effect could be simulated accurately to evaluate the fatigue phenomenon. Furthermore, by the parametric analysis including the vehicle's load, the running speed, and the road roughness, the results reveal that the quality of the pavement significantly influences the dynamic stress responses of the secondary members and indicates the importance of maintenance of the road pavement.

Keywords: steel girder bridge; traffic-loading; stress evaluation; fatigue prediction.

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 superstructure of Tokyo Metropolitan Expressway [1] is important. The deterioration of these steel bridges is mainly due to fatigue cracks caused by heavy traffic, especially in secondary structural members such as sway bracing, vertical stiffener and gusset plate of lateral bracing [2]. The appropriate evaluation of stress concentration of these members under the actual traffic load is therefore essential for the bridge maintenance.

The behavior of steel bridges under traffic loads has been studied mainly with respect to the global motion and main girder members. Fukada et al. [3] evaluated the validity of the countermeasure due to running ordinary trucks. The effect of vibration reduction was examined by the dynamic response analysis due to running vehicles. Pengphon et al [4] identified the causes of fatigue cracks found in a plate girder-on-steel frame pier bridge by FEM models as well as field tests. The results indicated that fatigue cracks are caused by dysfunctional bridge bearings, poor structural details and deformations of some members. Su et al. [5] measured and compared the dynamic responses of simply-supported girder bridges. The reproducibility of stress components in main members from numerical simulation is good, the stress responses of secondary members, 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. In the previous studies, the stress responses of the bridge, obtained from either measurement or measurement, are mainly focused on the main structural members. Few researches investigated the stress concentration effect in the secondary members by numerical simulation which was validated by the field measurement. Furthermore, the secondary member stresses, which plays an important role in fatigue damages on steel girders, have not been analyzed in detail based on both numerical simulation and full-scale structure measurement.

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