Post-Fracture Redundancy Evaluation of a Twin Box-Girder Shinkansen Bridge in Japan

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Summary

As the national bridge inventory ages and traffic volumes increase, the government is spending more on maintaining their existing structures to extend the service life of the current bridge inventory. This includes two-girder bridges that are classified as fracture critical and non-redundant. Owing to the increased inspection costs associated with these fracture-critical bridges, there is a need to evaluate alternate load paths and to implement retrofit methods on existing bridge structures to avoid bridge replacement. In this paper, after-fracture redundancy of two-girder bridges is investigated through a case study for a four-span continuous steel-concrete composite twin box-girder bridge. The finite element analysis was carried out to evaluate the load-carrying capacity after failure of one girder of the two-girder bridge. Two types of the main-girder damage, including fracture of the bottom flange only, and fracture of both bottom flange and the web were considered respectively in this study. Typical damage locations including mid-span section of the main girder and the sections near the intermediate support were also considered in the numerical analyses. On the basis of the numerical results, the present continuous steel-concrete composite box-girder bridge was classified as a redundant bridge, and the concrete deck was considered as the key member for ensuring the bridge redundancy after severe damages occurred on the main girders.

Keywords: Post-Fracture, Redundancy Evaluation, Twin Box-Girder, Field Test, FEM.

1. Introduction

In recent years, the rapid deterioration of steel and steel-concrete composite bridge structures has become a serious technical and economic problem in many countries. As the bridge inventory ages and traffic volumes increase, the government is spending more on inspection and health monitoring of their existing structures to ensure the safety, serviceability, and durability of the current bridge inventory. This includes two-girder bridges that are generally classified as fracture critical and non-redundant structures.

Composite steel and concrete structures have been extensively used in both highway and railway bridges due to the benefits of combining the two construction materials, their higher span to depth ratio, reduced deflections and higher stiffness ratio than traditional steel or concrete beam structures. According to the cross-section, there are two general types of girder bridges: I-girders and box girders. I-girders are commonly used in curved bridges because of their constructability, but they have relatively low torsional stiffness due to their open web sections. In comparison with the I-girder bridges, the box girders are able to resist significant torsion if their shapes are maintained with sufficient internal bracing, and this bridge type was initially popular for that reason [1]. Especially for railway bridges used for high-speed trains, two box-girder bridges are widely used due to the fact that relative high torsional stiffness and relatively small deformation under the eccentric load conditions are the major concerns in the railway bridge design. However, the major drawback of twin-girder superstructures is that, historically, they have been considered as non-redundant. In other words, the tension flange of a two-girder bridge system has no alternate load

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