A Critical Fatigue Crack in a Long-Span Truss Bridge; Cause Investigation and Measures

Takafumi Nishikawa, Qu Wang, Daiki Tashiro, Shozo Nakamura, Toshihiro Okumatsu

Nagasaki University, Nagasaki, Japan

Contact: nishikawa@nagasaki-u.ac.jp

Abstract

This paper presents a report on a critical fatigue crack in a long-span truss bridge and a series of measures from cause investigation to preventive retrofit for the damage. The severe damage occurred and propagated due to a fatigue crack at the bottom of a diagonal member of the bridge. The findings obtained by the web-based long-term monitoring reveals that the member being mainly investigated and the other several diagonal members have excited in two wind velocity ranges. Wind directions of both the case are approximately perpendicular to the bridge axis. Componential analysis of vibration suggests that in-plane vibrations are vortex-induced and vibration out-of-plane is buffeting due to strong wind. The vibration induced by the strong wind was the main cause of the crack. Based on the findings, a preventive measure has been taken to suppress wind-induced vibration by changing the dynamic characteristic of diagonal members.

Keywords: fatigue damage; wind-induced vibration; truss bridge; long-term monitoring

1 Introduction

In wind engineering, the long-span bridge is a wind-sensitive structural system [1]. Wind-induced fatigue of a flexible structure is a critical limit state for structural design consideration [2]. Many examples of fatigue damage have been reported for steel and composite-structure bridges [3, 4], and some of them were caused by wind-induced vibration. For instance, fatigue cracks were found on steel components and joints of a railway bridge over the Elbe River in Germany in 2000 [5]. In that case, cyclic loads introduced in the hangers by wind-induced bending vibrations caused severe damage including fatigue cracks at joint welds of the hangers. Repetto and Solari [6, 7, 8] focused along/across wind-induced fatigue damage of structures, and proposed mathematical methods to estimate fatigue damage in the conditions.

Control of wind-induced vibration has become an important topic in the field of long-span bridges. Fujino and Yoshida [9] described vortex-induced vibration (VIV) in the first-mode vibration with wind velocity of 16‑17 m/s occurred in the Trans-Tokyo Bay Highway Crossing Bridge. In that case, the maximum amplitude exceeded to about 50 cm in the direction perpendicular to the bridge axis. Furthermore, the wind velocity range caused the VIV in the first vibration mode of the bridge was investigated by wind tunnel tests. Full-scale measurements on the Great Belt East suspension bridge were carried out by Frandsen [10]; it presents that VIV occurred with lower wind velocity of around 8m/s in directions nearly perpendicular to the bridge axis. Miyata et al. [11] observed and analyzed actual dynamic response of Akashi-Kaikyo Bridge during strong typhoons. The analytical displacement showed good agreement with static deflection at winds in the direction perpendicular to the bridge axis;

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