Premature Fatigue Failure in a Horizontally Curved Steel Trough Girder Bridge

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Summary

Fatigue cracking was observed in a three cell, three span, continuously curved steel trough girder bridge in far western NSW. The bridge over the Darling River at Wilcannia had been in service for about 11 years and the fatigue cracks were all associated with asymmetric internal stiffeners.

The bridge was investigated using a structural dynamics based approach and the results showed that the premature fatigue failure was due to the design of the asymmetric internal stiffeners that were not continuous over the full perimeter. As the stiffeners form a partial height U-frame, this allowed the webs, above the stiffeners, and the deck to rack under load. A calibrated FEA model of the bridge was used to investigate a range of solution options including continuing the stiffeners over the full perimeter and the complete removal of the stiffeners. As the confined space inside the box girders was not conducive to welding or cutting, a very unusual and innovative solution using external rib stiffeners was devised, modelled and adopted.

Keywords: High cycle fatigue; Composite box girder bridge; Damping; Finite element method; Modal analysis; Strain measurement.

1 INTRODUCTION

The bridge was designed in 1988 to NAASRA [1]. It generally complies with Section 3 and Clause 7.7.3 provisions of the Code for composite box girder bridges. The origin of the design criteria is the AASHO Standard Specification for Highway Bridges (AASHTO [2]). The design criteria stem from a research and prototype testing of straight bridges of similar construction. Whilst this bridge is described as a trough girder bridge, it is identical to the North American description of a multiple spine composite concrete-steel box girder bridge (Sennah & Kennedy [3]). Figure 1 shows a general view of Wilcannia Bridge with the original 19th Century lift span bridge visible in the background. The bearings for the bridge are pot-type bearings, with two fixed bearings at each pier and one sliding guided bearing and two free sliding bearings at each abutment.

The NAASRA 1976 code provided that “transverse bending stresses resulting from distortion of the girder cross section and from vibration of the bottom flange plate need not be considered” and that “ internal diaphragms are not required at points intermediate between support diaphragms”.

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