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Fatigue endurance limit of epoxy asphalt concrete pavement on the deck of long-span steel bridge

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Abstract

Fatigue crack damage in the epoxy asphalt concrete pavement of long-span steel bridge deck is still one of the most severe problems even though the fatigue endurance performance has been studied for a long time. In this study, it aimed at exploring the mechanism why the fatigue damage of the epoxy asphalt concrete occurred, as well as finding out the reason why fatigue test results in laboratory were different from those in practical engineering application. A finite element mechanics method was first applied to analyze the maximum strain value of the epoxy asphalt concrete pavement at different load positions, then fatigue performance of the epoxy asphalt concrete was investigated using a four-point bending fatigue testing method, and finally a three-parameter fatigue equation model, which was demonstrated to be feasible and rational, was utilized to determine fatigue endurance limit for the first time. The fatigue damage of the epoxy asphalt concrete occurred in a short time once the strain level with driving load was larger than fatigue endurance limit. In contrast, the fatigue damage did not appear in a long time if the strain level was less than the fatigue endurance limit. It is suggested that the fatigue endurance limit be adopted as a control parameter in the design phase of epoxy asphalt concrete pavement. These findings advance previous design specifications in the world, and could help extending service life of epoxy asphalt concrete pavement of long-span steel bridge deck.

Keywords: Long-span steel bridge deck; Epoxy asphalt concrete pavement; Fatigue damage; Fatigue endurance limit; Three-parameter model; Finite element mechanics method

1. Introduction

Epoxy asphalt concrete is widely applied in the pavement of long-span steel bridge deck because it has good performances in high temperature, fatigue and corrosion resistance [1]. Most of well-known bridges such as the American Golden Gate Bridge, Australian West Gate Bridge, Chinese Hu Men Bridge, Hang Zhou Bay Bridge etc. use the epoxy asphalt concrete as surfacing layer of pavement. Studies suggest that the fatigue crack damage of epoxy asphalt concrete pavement occur under action of vehicle loading in early service time [2–4]. Even though some of laboratories report that the epoxy asphalt concrete exhibits good fatigue endurance performance [1,5–8], its pavement in the actual field undergoes significant fatigue distress [9,10]. The disagreement between the laboratory test and the actual engineering application suggests that investigating the cause behind the problem be highly desired.

In this study, to solve the issue of fatigue crack in the epoxy asphalt concrete pavement of long-span steel bridge deck, a finite element method (FEM) was firstly used to analyze mechanics performance of long-span steel bridge

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Table 2.1
Main structure parameters of steel box girder.

Diaphragm height (mm)	U rib interval (mm)	Sectional dimension of U rib (height × upper width × the width below) (mm)	Diaphragm interval (mm)	Deck thickness (mm)	Diaphragm thickness (mm)	U rib thickness (mm)
1500	300	300 × 300 × 180	2500	18	16	8

deck pavement, and to understand the disadvantage of the pavement at traffic load. In addition, fatigue performance of the epoxy asphalt concrete pavement was studied, and its fatigue endurance limit was demonstrated by a three-parameter fatigue equation model for the first time. The feasibility and rationality of the model was experimentally verified. Finally, it is suggested that the fatigue endurance limit be incorporated into the design specifications of the epoxy asphalt concrete pavement of the long-span steel bridge deck. Thus, previously documented design methods and technical specifications could be improved, and the service life of the steel deck pavement layer could be extended.

2. Finite element mechanics analysis model of steel bridge deck pavement

Before design of epoxy asphalt concrete on steel bridge deck pavement, a finite element method was used to analyze mechanical state of steel bridge deck pavement under action of the vehicle loading. In order to effectively evaluate the case with the most disadvantage condition, it was practical to set the fixed structure parameters of steel bridge deck to investigate the stress and strain numerical status of the interface between asphalt mixture and steel deck. Therefore, the investigation could provide theoretical support and design basis for mix design of epoxy asphalt concrete pavement. Herein, Chinese famous long-span suspension bridge was taken as an example, and the mechanical property of steel bridge deck pavement at different load position was analyzed using the finite element method. Table 2.1 lists the main structure parameters of steel box girder. Dynamic modulus of epoxy asphalt concrete was 12,000 MPa at 20 °C, and Poisson's ratio was 0.25. Elastic modulus of steel deck was 210,000 Mpa, and Poisson's ratio was 0.3. For single-axle double wheels group, axle weight of rubber tire was 10 tons, ground area of the tire

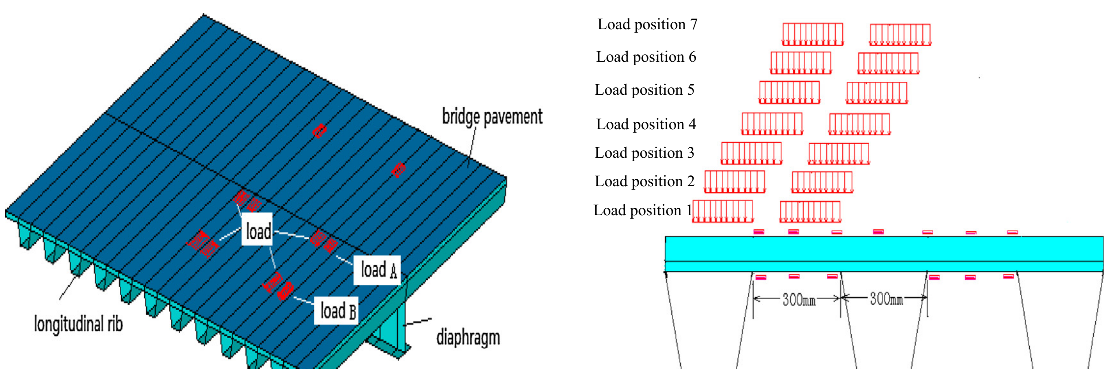

Fig. 2.1. Finite element analysis model of pavement.

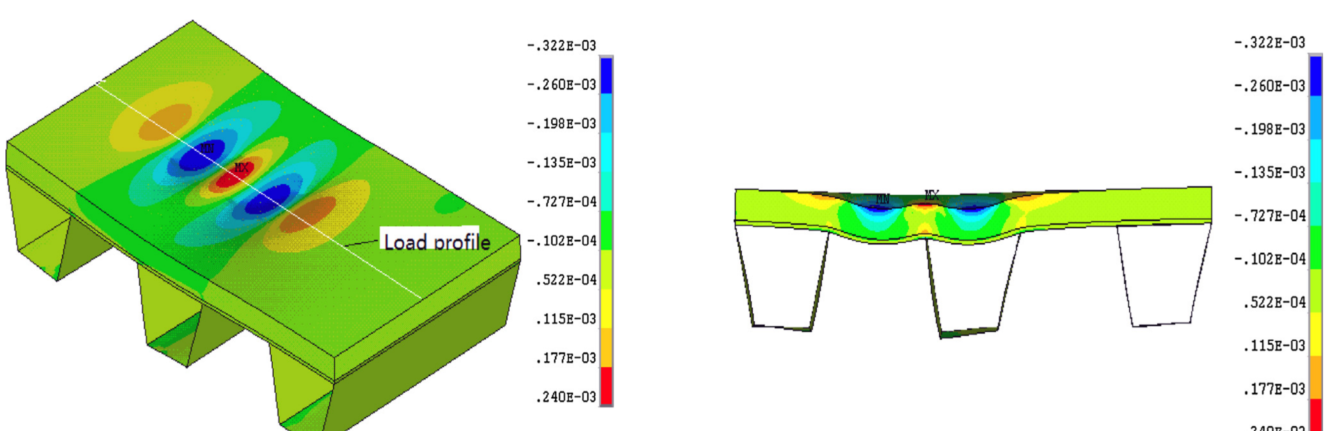

Fig. 2.2. Partial lateral strain distribution of pavement.

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