Fatigue Performance of Cracked Bridge Diaphragm Repaired by SMA/CFRP Composite Patch

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Abstract

Under long-term service conditions, fatigue cracks are easily generated at the arc-shape cutouts in diaphragm of the orthotropic steel bridge decks when subjected to vehicle-induced vibration and cyclical wheel loads. For repairing cracks in diaphragm, this paper proposes the carbon fiber reinforced polymer (CFRP) sheets patched crack-stop hole method and shape memory alloys (SMA)/CFRP composite patched crack-stop hole method which introduces prestress by activating SMA. Moreover, in the numerical study the diaphragm model and reinforcement schemes are introduced, and the corresponding finite element model is established. The failure modes and fatigue lives of diaphragm specimens under different repair methods were obtained and compared by fatigue loading tests. It can be found that the bonding of CFRP sheets and SMA/CFRP composite patches can effectively postone the initiation of fatigue cracks and inhibit the propagation of cracks, which are ideal repair methods for strengthening the fatigue cracks of diaphragms in orthotropic steel bridge decks.

Keywords: bridge engineering; crack of diaphragm; structural reinforcement; finite element simulation; fatigue test.

1 Introduction

Orthotropic steel decks are widely used in various structural forms and bridges due to its advantages of light weight, high strength and high load-bearing capacity[1-3]. However, there are many welding parts in orthotropic steel decks and its connection is complex. With the increase of service life and overloaded vehicles, the fatigue cracking problem of steel bridge decks is becoming increasingly prominent[4-6]. Fatigue crack at the arc-shape cutouts of diaphragm account for about 60% of all fatigue cracks, which is one of the main fatigue repair objects of orthotropic steel bridge decks[7-8]. CFRP is pasted on the fatigue crack through structural adhesive, increasing the stiffness of the cracked area, reducing its stress under fatigue load, and postponing the development of fatigue cracks. Zheng and Yue et al. carried out the middle-cycle and high-cycle fatigue tests on the unreinforced and CFRP-reinforced steel beams, and found that the fatigue life of the steel beams strengthened with CFRP increased by 2,98-6,74 times[9]. Ghafoori et al. strengthened cracked steel beams with CFRP plates and prestressed CFRP plates, and the fatigue life of steel beams strengthened with prestressed CFRP plates increased by more than 5 times comparing with steel beams strengthened with CFRP plates[10]. Hosseini and Ghafoori et al. found that the fatigue life of the steel plate can be

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