Experimental Research on Transverse Load Distribution of Prefabricated Hollow Slab Concrete Bridges with Hinge Joint Cracks

Yanling LENG
Research Assistant
Research Institute of Highway, MOT,China
yl.leng@rioh.cn

Jinquan ZHANG
Professor
Research Institute of Highway,MOT,China
jq.zhang@rioh.cn

Ruinian JIANG
Associate Professor
New Mexico State University, USA
rjiang@nmsu.edu

Sonya COOPER
Professor
New Mexico State University ,USA
socooper@ad.nmsu.edu

Haifang HE
Associate Research
Research Institute of Highway,MOT,China
hf.he@rioh.cn

Shoushan CHENG
Associate Research
Research Institute of Highway,MOT,China
ss.cheng@rioh.cn

Summary

A load test was performed on a simple span bridge model consisting of eight 5 meter length prefabricated concrete hollow core slab beams that were laterally connected by continuous concrete hinge joints. The effect of hinge joint crack length on the transverse load distribution among the slab beams was studied. It was found that hinge joints under service loads are partially rigid. Cracking of the joints between the two adjacent edge beams has greatest influence on the transverse load distribution. Critical crack lengths of joints were determined based on a criterion of the "Single Plate Load Effect", that is, a beam behaves without connection to the adjacent beams. This test leads to further research on the failure mechanics of prefabricated hollow core concrete beam bridges and their retrofit techniques.

Keywords: Bridge engineering; Transverse load distribution; Prefabricated concrete hollow slab beam bridge.

1. Introduction

China has approximately 170,000 prefabricated concrete hollow core slab bridges, which accounts for 25% of the total bridges in China. The common span varies from 8m to 25m. Concrete hinge joints act as transverse connections. Unfortunately though, hinge joint damage is common and prevalent. Hinge joint damage occurs within as early as 2 to 5 years after the bridge is built. "Single Plate Load Effect" means a slab beam loses sufficient lateral connection with the adjacent beams. Under such circumstances, the slab beam will be overloaded even under the design loads due to the lack of a lateral connection, affecting the safety, usability and durability of the bridge.

Fig. 1: Bridge Model Test

A model bridge with a scale of 1∶2 (one-half) was built based on standard design drawings of 10-meter prefabricated concrete hollow core slab bridges in China (see Fig. 1). The objectives of the experiment are to solve two major problems. First, to what extent will the crack length of the hinge joint lead to the appearance of "Single Plate Load Effect"? Second, how to strengthen prefabricated concrete hollow core slab bridges without interrupting traffic. This paper primarily focuses on the first issue. The influence of the crack length of edge and middle hinge joints on a transverse load distribution was investigated. Critical hinge joint crack lengths were determined, which can be used as a reference for assessing the technical condition of fabricated concrete slab beam bridges.

https://doi.org/10.2749/222137813806521405

2. Design of the Test Model

The main design components are summarized in Table 1.

Table 1 Dimension of the Prototype and the Test Model

Items	Span (m)	Width of beam (m)	Height of beam (m)	Height of hinge joint (m)	Thickness of Pavement deck (m)
Prototype	9.96	0.99	0.60	0.14	0.10
Test model	4.98	0.23	0.22	0.084	0.05

3. Analysis of Experimental Results

As shown in Fig. 2. The transverse load distribution based on deflection measurements is between that calculated from the "Hinged Plate Method" and the "Rigid Transverse Beam Method", a little closer to the latter.The results proved that the crack of the #1 joint has the greatest influence on transverse load distribution. When the load was placed at the midspan of the #1 beam, the beam received 29% of the total load with a crack length of 0.1L in the #1 joint, which exceeded the beam design load; it received 87% of the total load when the crack length reached 0.8L(as shown in Fig.3).

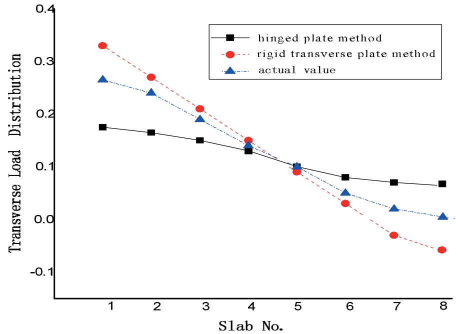

Fig. 2: Transverse Load Distrib. at the Midspan of #1 Beam

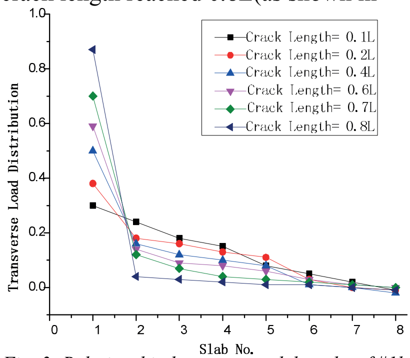

Fig. 3: Relationship between crack lengths of #1hinge corresponding transverse load distribution

On the other hand, cracking of the middle joints had a smaller impact on the transverse load distribution, as shown in Fig.4. When a point load was applied at the mid-span of the #4 beam, the beam received 16% of the total load when the crack length of the #4 hinge joint reached 0.2L; it received only 24% of the total load when the crack reached 0.8L.

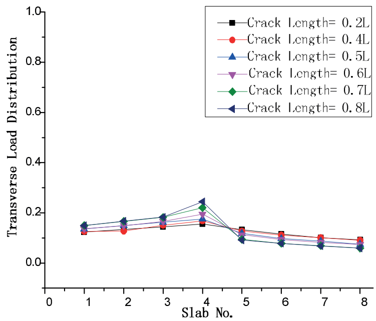

Fig. 4: Relationship between crack lengths of # 4hinge jo corresponding transverse load distribution

The design transverse load distribution factor is 0.27. Therefore, when the #1 joint cracks to 0.1L, the load shared by the #1 beam (29% of the total load) has already exceeded its design load; on the other hand, when the #4 joint cracks to 0.8L, the load shared by the #4 beam (24% of the total load) is still under the design load. Based on test results, we conclude that the critical crack length of the edge joint is 0.1L, while that of the middle joint is L.