Evaluation of an Excessive Deflection Long-span Concrete Beam Bridge

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Summary

As long-span prestressed concrete (PC) beam bridges are constructed widely recently, two fatal problems: the excessive sustained deflection and cracks appear gradually. In order to assessing these effects, a cast in situ concrete bridge with three spans (65m+100m+65m), constructed by free cantilevering method ten years ago is evaluated. Firstly, the actual deflection of the bridge in service is demonstrated, and the cracks are classified. Then the characteristics of bridge deflection and cracks propagation are represented. In order to evaluate the material property and the working performance of the bridge, both static and deflection influence line test are proceeded. Based on this, rigidity identification is studied. Also, the random vehicle load model is simulated through Monte Carlo method. Consequently the bearing capacity and serviceability of the old bridge is evaluated. Finally, some suggestion of long-term deflection prediction and structure design is given.

Keywords: existing concrete bridge; prestressed; long-span; long-term deflection; crack; load test; evaluation; bearing capacity

1. Description of background bridge

The bridge was constructed by free balanced cantilevering method from Mar. 1994 to Oct.1996. Before the main span closure, forced operation had to be applied to ensure two ends on proper level.

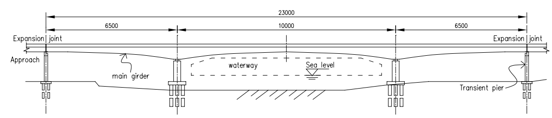


Fig. 1: Elevation of background bridge （Unit: m）

In Oct. 1998, the original cement road surface of bridge was replaced by blacktop, which was average 12.5cm more than 8.0cm marked in design drawing.

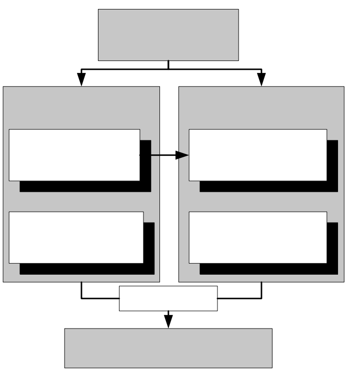


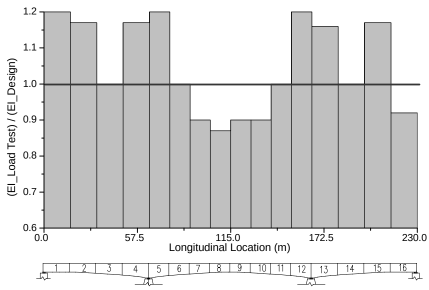
Fig. 2: Evaluation process of background bridge

In first 2 years, deflection of midspan increased about 16cm, and 1cm per year from 2000. To stop sustained deflecting, main span was applied 2 external prestressed tendons in 2001. Cracks near support existed at the beginning and cracks of midspan are unstable; cracks of left half span are relatively more than another half at main span.

2. Assessing of the bridge

In order to evaluate the status of the bridge and determine the bridge is safe to use or not, the structural resisting force and action effect including actual traffic load should be deducted first (Fig.4). In order to quantify the effect of cracks on the rigidity of superstructure, rigidity identify based on static method is adopted. Also, longitudinal load redistribution due to rigidity changing can be appraised.

Load test was proceeded in Jan. 2008. It is found that bottom edge of midspan right girder was cracked even under truck loads equal to 0.1 maximum Code traffic effect which indicated scarcely any compress reservation there, and the prestress loss at midspan can be estimated (about 70%). In regard of action effects, traffic load of expressway which the bridge located is simulated through the vehicle data based on Monte Carlo methods. Consequently, the main girder was checked based on Chinese Code (JTG D62-2004 and JTG D60- 2004). The evaluation is consisted of safety checking under ultimate limit state of bearing capacity and serviceability.

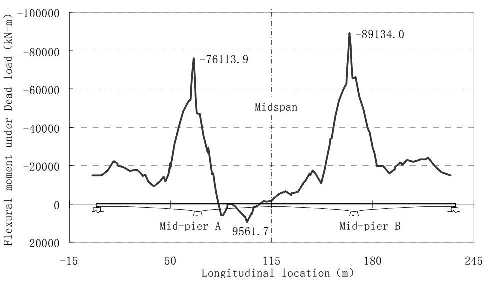


The initialization FE model is based on designing drawing, and then the rigidity of segments is modified until the FE results and experimental data are close enough. The current flexural rigidity (EI_ Load Test) near the midspan is 87% to 90% compared with the designing value (EI_ Design). EI used in FE model are all small or equal to EI_ Load test. And the results show that main span flexural moment of dead load increased by -331 kN-m, +396kN-m and +495kN-m near the left pier section, midspan and the right pier section.

Fig. 3: Flexural rigidity (EI) identify

According to the definition of Characteristic Value (CV), Frequent Value (FV) and Quasi-permanent Value (QV) of an action, values of each section under random vehicle stream are calculated. The moment effects QV under random vehicle load are apparently larger than standard.

Based on the data analysis above, the safety of the bridge about bearing capacity and serviceability is checked. For midspan section both main span and side span, there are still 24.8~31.7% moment resisting force reservation; for midspan cross section, action effect is close to the resisting. Under action effects, bottom slab largest normal stress is 2.8MPa in tension, and largest principal tensile stress at main over pier section is 1.7MPa. The largest principal compressive stress of deck slab at midspan section is 20.8MPa also larger than the allowable value (16.2MPa).



Offset of sagging moment (Fig.4) is one of the reasons lead to asymmetric cracks. Other possible causing of excessive deflection includes: (1) prestress parameters used in FE analysis are still based on Code. If prestress loss amplified to 70%, the deflection of midspan would increase 6.9cm. (2) Considering the effect of transversal cracks of bottom slab by geometric method, the deflection would increase 9.2cm. (3) lacking concrete creep data of the bridge, the actual creep coefficient may be different from Code model.

Fig. 4: Flexural Moment under Dead load (self weight + prestress)

3. Conclusion of evaluation

Through the evaluation of the background bridge, the effects of closure error, road surface thickness distribution and actual vehicle load are apparently different from designing. To assess the status of structure objectively, the resisting force and action effects including the factors above should be surveyed and studied first. And this paper provides an evaluation process of similar existing bridge.

Vehicle load simulated is apparently larger than Code, new designing and existing bridge assessment on the same expressway should consider this effect. Although the bearing capacity of the background bridge can meet the requirement, action effect is close to the resisting at the midspan cross section of girder. Proper retrofitting should be taken.

When predicting the long-term deflection, the effect of cracks on deflection should be taken into account if the bridge is design to a non-all prestressed bridge.