Study on loading mode of upper arch Bridge under static load test

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Abstract. Bridge load test is a very important means to evaluate the structural performance, construction quality and bearing capacity of the completed bridge, among which static load test is a very important basis to judge the structural stiffness and bearing capacity of the bridge. However, the specification does not give detailed test method or suggestion for loading method of static load test of upper arch bridge. In this paper, based on the analysis results of field test data, a more reasonable loading method is obtained.

1. Introduction

The upper arch bridge is a kind of bridge system widely used in highway construction. On the other hand, in the modern bridge load test, most of them are load tests for unhinged arch statically indeterminate structure, but there are few tests for two-twisted arch and three-hinged arch bridge, so the assessment of the bearing capacity of arch bridge has been a research subject of bridge boundary at home and abroad. Based on the Shuangla River bridge located at K8+296.377 in the section from The Third Middle Luo to the six Ku section of National Road G219, this paper analyzes the test data of bridge completion load test of the upper bearing arch bridge, and obtains the more accurate loading vehicle layout. The elevation of shuangla River Bridge is shown in Figure 1.
2. Test Design
This load test is divided into 6 steps, that is, test data collection, loading method determination according to the data, loading vehicle arrangement, instrument placement, static load test, data processing and final result analysis. The specific process is shown in Figure 2.

![Figure 2. Test flow chart.](image)

In this test, the deflection is directly measured by dial meter, and the range dial meter is 10mm. The dial indicator is set on the control section, and the deflection is read out directly by loading the loading vehicle cloth on the bridge deck. The measured data is compared with the theoretical data obtained by Midas finite element software modeling to determine whether the loading method is reasonable. The specific layout of the disturbance measurement points is shown in Figure 3.

![Figure 3. Arrangement of test points.](image)

In this static load test, three off-loading conditions were carried out, namely, the maximum positive moment off-loading condition of L/4, the maximum positive moment off-loading condition of L/2, and the maximum positive moment off-loading condition of 3L/4. In the loading process, four double-axle vehicles are adopted, which are loaded tail-to-tail, and arranged in parallel from the horizontal bridge to the two loading vehicles. The layout of double-axle loading vehicles is shown in Figure 4.

![Figure 4. Loading deck plan.](image)

In order to obtain the bridge response under the most unfavorable load, the static load test analyzed the data of the bridge under biased load condition and arranged the percentage tables on the upstream
and downstream sides of the bridge, so that the deflection data and the bridge response under static load could be obtained more directly and intuitively.

3. Results analysis and discussion
According to the finite element software MIDAS, the theoretical deflection calculation of the bridge is compared with the measured deflection data. The deflection conditions of the maximum positive bending moment of L/4 are shown in Table 1, the maximum positive bending moment of L/2 is shown in Table 2, and the maximum positive bending moment of 3L/4 is shown in Table 3.

| Loading position | Number of measuring points | Measured elastic deflection (mm) | Residual deflection (mm) | Theoretical deflection (mm) | Deflection check coefficient |
|------------------|---------------------------|---------------------------------|--------------------------|----------------------------|----------------------------|
| Partial load     | 1# (upstream side)        | 0.84                            | 0.02                     | 2.156                      | 0.39                       |
|                  | 2# (downstream)           | 0.70                            | 0.00                     | 2.156                      | 0.32                       |

Table 2. L/2 Control section JM2 maximum bending moment deflection under off-loading condition measured.

| Loading position | Number of measuring points | Measured elastic deflection (mm) | Residual deflection (mm) | Theoretical deflection (mm) | Deflection check coefficient |
|------------------|---------------------------|---------------------------------|--------------------------|----------------------------|----------------------------|
| Partial load     | 1# (upstream side)        | 1.16                            | 0.01                     | 2.219                      | 0.52                       |
|                  | 2# (downstream)           | 0.94                            | 0.06                     | 2.219                      | 0.42                       |

Table 3. L3/4 Control section JM3 maximum bending moment deflection under off-loading condition measured.

| Loading position | Number of measuring points | Measured elastic deflection (mm) | Residual deflection (mm) | Theoretical deflection (mm) | Deflection check coefficient |
|------------------|---------------------------|---------------------------------|--------------------------|----------------------------|----------------------------|
| Partial load     | 1# (upstream side)        | 0.68                            | 0.05                     | 2.156                      | 0.32                       |
|                  | 2# (downstream)           | 0.59                            | 0.05                     | 2.156                      | 0.27                       |

4. Conclusion
Based on the analysis of the experimental results, the following conclusions can be drawn

(1) The measured deflection of the bridge under off-load condition is less than the deflection calculated by theory, and the deflection check coefficient conforms to the standard requirements.

(2) It shows that the load test vehicle layout of the arch bridge should be the most unfavorable layout according to the influence line, but at the same time, the internal force of each section should not exceed the designed internal force under each working condition.

(3) It is shown that the arrangement can better reflect the bridge response under the most unfavorable load.

(4) On the surface, the bridge works well under the test load, and the bearing capacity of the structure reaches the design load level.
References

[1] Yang Gen-jie. Analysis of mechanical property of single arch rib prestressed concrete beam arch combination bridge[J]. Journal of Railway Engineering Society, 2017, 34(6):37-42.

[2] Cheng Huabin, LIU Yingchen. Evaluation of bearing capacity of old highway Bridges based on static load test [J]. Zhejiang TrafficJournal of vocational and technical college,2009,10(4):4-9.

[3] Zhao yu, he shanhai, li chunfeng, et al. An evaluation system of bearing capacity of prestressed concrete box girders with existing cracks based on crack characteristics [J]. Journal of tongji university: natural science, 2010,38 (9): 1272-1275.

[4] Massonnet,Ch.:La repartition transversale des charges dans les ponts a arcs’multiples. IABSE Publicaiions IX 1949, p.341-366.

[5] K.Beyer: Die Statik im Stahlbetonbau, 1956,p.565-567.