Study on Bearing Capacity Evaluation of Tie Arch Bridge Based on Dynamic and Static Load Test

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Abstract. Taking the reinforced concrete tie arch bridge with single span 35m as the engineering background, the load test method of bridge-1 (JTG / TJ 21-01-2015). Load test includes static load test and dynamic load test. By applying the test load equivalent to the design load to the bridge structure, grasp the actual working state of the bridge structure under the test load. By building a finite element calculation model using the large finite element calculation software MIDAS CIVIL, Accumulated the computational experience of the similar bridge type. In the static load test, three control sections are selected to test the deflection of stress (strain) and arch rib L / 4 section, vault section, beam L / 4 section, and middle section of beam span under forward load and partial load conditions. The check coefficient and relative residual deformation (strain) are calculated according to the test data. In the dynamic load test, the impact coefficient of the vault section under different speeds of the loading vehicle is divided into barrier-free driving and obstacle driving. In the absence of no traffic load on the bridge deck and no regular vibration source, the wind load, ground pulsation and water flow near the bridge site are measured. The used microamplitude vibrations to identify the structural autovibration characteristic parameters.

Keywords: ANSYS; Bridge load test; Carrying capacity; Static load test; Dynamic load test; Check coefficient;

1 Introduction

China is a transportation country, but also a transportation power. China has built numerous Bridges in the past decades. According to data released by China Communications News, by the end of 2021, the number of highway Bridges in China had exceeded 960,000, including 7,417 large Bridges and 135,000 Bridges. And it continues to grow at more than 20,000 seats a year. Arch structure has its unique mechanical properties, and has become one of the basic structural systems of the bridge [1]. Tie-pole arch bridge is a structural form of arch bridge, which has the general characteristics of arch bridge and has its own unique characteristics. It is a set of arch and beam advantages in one of the bridge type, it will arch and beam two kinds of base. The structure form is combined together to bear the load together, giving full play to the structural performance and combination function of the beam bending and arch pres-

Z. Ahmad et al. (eds.), *Proceedings of the 2023 5th International Conference on Structural Seismic and Civil Engineering Research (ICSSCER 2023)*, Atlantis Highlights in Engineering 24,
https://doi.org/10.2991/978-94-6463-312-2_11

sure. The horizontal thrust of the arch end is borne by the pull rod, so that the arch end support does not produce horizontal thrust. The arch and the string are connected by hinged vertical rods at both ends. The interior of the tie arch bridge is hyperstatic system, and the outside is static, so it has no impact on the uneven settlement of the pier. Structurally, it can be divided into two combined systems, [2]: with thrust and no thrust.

If the bridge is damaged or collapsed, it will not only affect the transportation, but also bring huge losses to people's lives and property. In order to ensure the safety of transportation and people's lives and property, the carrying capacity of Bridges must be accurately assessed. At the present stage, the specifications for assessing the bearing capacity of bridges are based on Test Methods for Large-span Concrete Bridges ("Iron Group" YC 4-4 / 1978) [3], Regulations for Detection and Assessment of Bearing Capacity of Highway Bridge (JTG / TJ 21-2011) [4], and Test Regulations for Load of Highway Bridge (JTG / TJ 21-01-2015) [5]. Among them, "Highway Bridge Load Test Regulations" (JTG / TJ 21-01-2015) [5] makes clear provisions on the assessment of bridge bearing capacity, which is the main basis for the assessment of bridge bearing capacity. Bridge-forming load test includes static load test and dynamic load test [6]. Static load test refers to the test load equivalent to the design load on the bridge structure, test the deflection, stress (strain) and other values of the bridge structure under the test load, and then calculate the check coefficient and relative participation deformation (strain) of the bridge structure. The dynamic load test test section is not in the loading vehicle. The impact coefficient under the action of the same speed can be divided into barrier-free driving and obstacle driving. By determining the micro vibration caused by wind load, ground pulse, water flow and other random excitation without any traffic load on the bridge deck and no regular vibration source near the bridge site. The overall working performance of the bridge is reflected by the static load test and the dynamic load test [7].

In this paper, taking the reinforced concrete tie rod arch bridge as the engineering background, the bearing capacity of the bridge structure is assessed through the bridge load test, including the static load test and dynamic load test. Then continue to accumulate bridge design, construction and testing experience, to improve the overall construction level of bridge engineering.

2 Bridge introduction

A single span of 35m is designed to cross the current urban road, See Figure 1 for the bridge elevation drawing. The structure form of the bridge adopts the lower-bearing reinforced concrete tie-rod arch bridge. The calculated span is 35m, the arch axis is a secondary parabola, and the equation of the arch axis is: Y= (4 fx / L2) (L-x), where L=35m. The arch rib adopts reinforced concrete structure, the section form is I-type, gradually rectangular at the end block. The height of the I-shaped arch rib is 1.1m, the width of the web is 0.5m, and the width of the upper and lower fender is 0.8m. The height of the rectangular arch rib is 1.1m and the width is 0.8m. The tie-beam section is 1. 2m×0.8m Box, using prestressed to balance the arch rib horizontal thrust, boom is made of two layers of high strength wire outsourcing PE set, factory production, field installation, boom spacing of 3.8m, beam and end beam are prestressed concrete structure, motor vehicle road deck thickness of 25cm rectangular precast slab, through the cast-in-place wet joint and beam connection. The horseshoe prefabricated slab thickness is connected to the beam by cast-in-place wet joints. The whole bridge is the whole structure of the just arch and just beam bridge deck.

The design load grade of the bridge is highway level, the crowd load is 3.5 kN/m2 and the design driving speed is 20 km/h; the bridge width is 2.5m (sidewalk) + 0.8 m (arch rib) + 0.5m (curb) + 8m (lane) + 0.5m (curb) + 0.8m (arch rib) + 2.5m (sidewalk) =15.6m, and the height limit of the bridge is H=4.3m.

The longitudinal slope of the bridge is flat slope, the transverse slope of the bridge deck is a bidirectional slope of 1.5%, and the inner slope of 1.0% (no slope for the arch ribs).

The arch rib, tie beam, end beam and middle beam adopt C50 concrete, C40 concrete for wind support, and C35 concrete for support cushion stone.

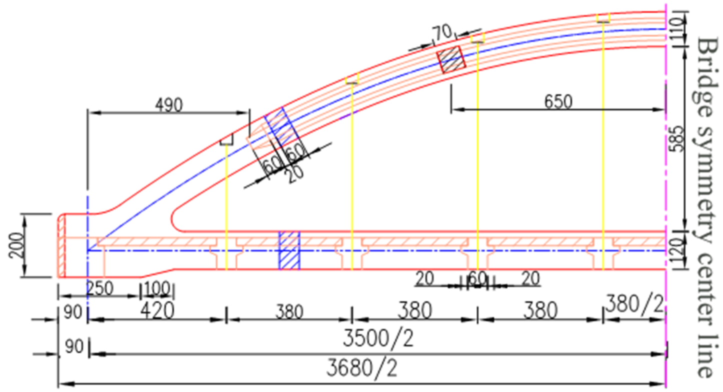


Fig. 1. Elevation of Bridge (unit: cm)

3 Dead work

Before the load test, the frequency method is used to test the cable force of the reinforced concrete tie rod arch bridge under 35m, Test analysis flow chart is shown in Figure 2. This method uses the highly sensitive sensor temporarily fastened on the cable to pick up the pulse signal under the environmental vibration, analyze the frequency spectrum, judge the frequency of the peak on the power spectrum map, and then obtain the cable force according to the relationship between the frequency and the cable force.

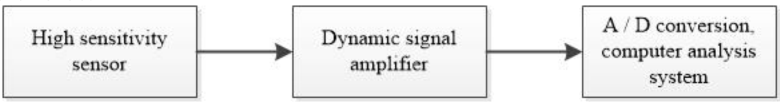


Fig. 2. Test analysis flow chart

The test results are shown in Table 1, which shows that the measured value of the boom and cable force is basically consistent with the design value.

Table 1. Derrick cable force test results table

Hanging rod number	Cable force design value (kN)	Measurement value of cable force(kN)
Left side arch rib 1 # boom	500	505.6
Left side arch rib 2 # boom	500	521.3
Left side arch rib 3 # boom	500	458.6
Left side arch rib 4 # boom	500	492.5
Left side arch rib 5 # boom	500	525.2
Left side arch rib 6 # boom	500	486.7
Left side arch rib 7 # boom	500	485.2
Right side arch rib 1 # boom	500	514.8
Right side arch rib 2 # boom	500	299.1
Right side arch rib 3 # boom	500	538.9
Right side arch rib 4 # boom	500	514.9
Right side arch rib 5 # boom	500	459.8
Right side arch rib 6 # boom	500	478.8
Right side arch rib 7 # boom	500	384.0

4 Static test

4.1 Contents of static load test

Static load test generally uses loads or loading vehicles to load the bridge structure, which is a non-destructive test. The purpose of static load test is to evaluate the actual working performance of the bridge structure by testing the deflection and stress (strain) under the equivalent load, Then, the carrying capacity and operation quality of the bridge structure [8] are judged. The static load test determines the test condition and test section [9] based on the most adverse force principle and the representative principle.

The bridge engineering software MIDAS Civil is used to calculate and analyze a single-span bearing reinforced concrete tie-rod arch bridge under 35m, and the static dynamic calculation model of the bridge structure is established. The whole bridge is divided into 367 nodes and 421 units. According to the relevant bridge design specifications, considering the actual operating load of the bridge, the indicators in the bridge design specifications are calculated.

The computational model plots are shown in Figure 3.

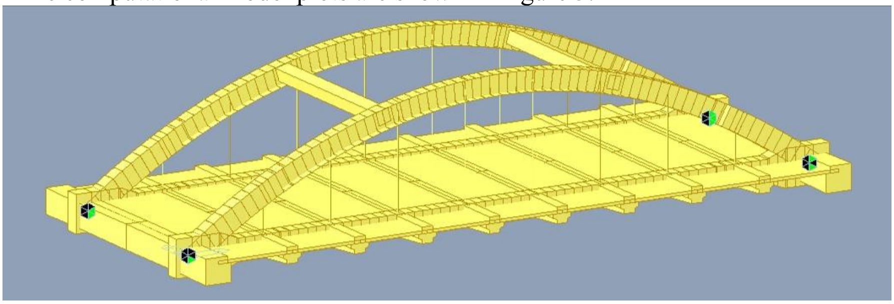


Fig. 3. Calculation model diagram

4.2 Test cross-section selection and measuring point layout

In the preliminary preparation work, the basic condition of the bridge span was investigated: there is no obvious defect in the arch foot of the bearing reinforced concrete tie-rod arch bridge under a single span of 35m, the geometric size of the main components is basically consistent with the design, and there is no abnormal deformation.

According to the [5] requirements of Highway Bridge Load Test Regulations (JTG / TJ 21-01-2015), the test control section selects section A-A, vault section B-B and C-C middle section of the beam span. The test section of the static load test is shown in Figure 4.

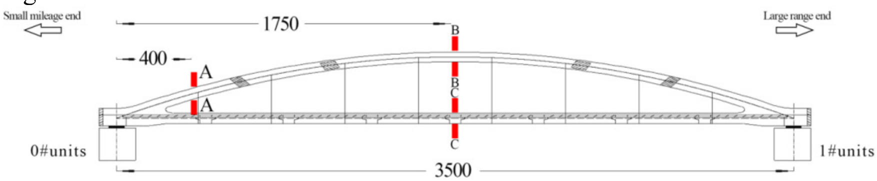
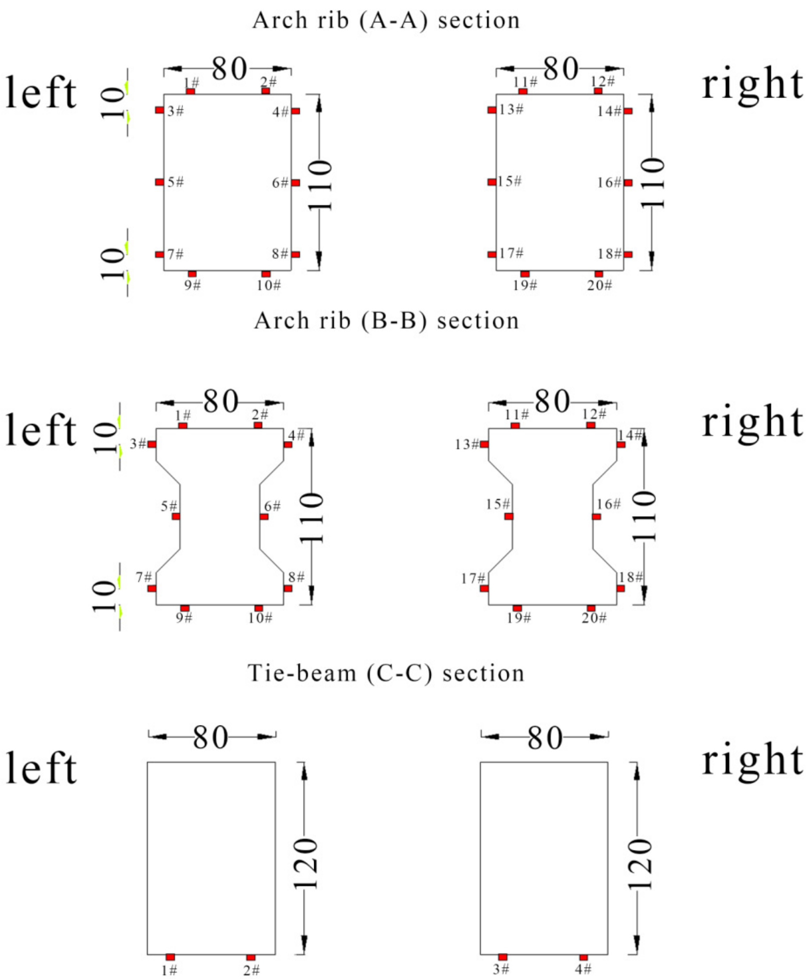


Fig. 4. Static load test section (unit: cm)

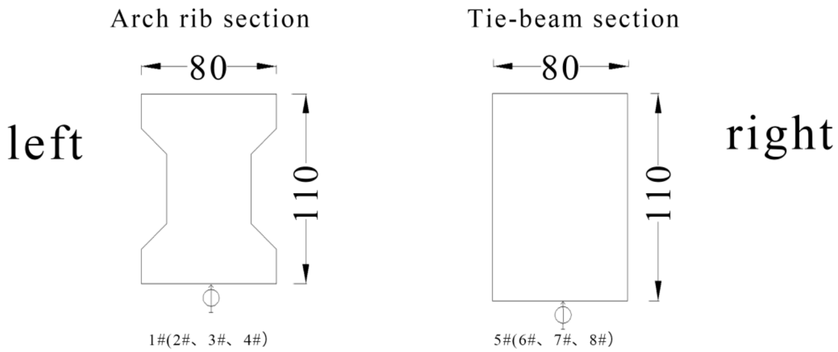
The static load test contents are as follows:

- Test the strain (stress) at the A-A~C-C cross-section.
- Test the deflection of arch rib L / 4 section, vault section (B-B section), beam L / 4 section, middle section of beam span (C-C section).
- Test the settlement of bearings at table 0 # and table 1 #.

- The static-load test measuring points are arranged as follows.
- Stress measuring points: arrange 4 strain (stress) measuring points in A-A-C-C section, A total of 12 measuring points, using static strain test system.
- Deflection measuring points: arrange 2 measuring points at L / 4 section, vault section (B-B section), beam L / 4 section, and beam span section (C-C section); arrange 2 settlement measuring points at 0 # and 1 # branches with 12 measuring points.
- The stress and deflection test section and measuring point layout are shown in Figure 5.



(A) Stress (strain) measuring points



(B) Deflection measurement point

Fig. 5. Static load test measuring point layout (unit: cm)

4.3 Static load test condition

The design load grade of a reinforced concrete tie arch bridge with a single span of 35m is highway-grade. According to the MIDAS CIVIL finite element calculation model, the static test load adopts truck (2 in total. Each vehicle weighs 350 kN) acts as. Using graded loading, level 1 is 1 loading vehicle, and level 2 is 2 loading vehicles. Each unloading amount is the same as the loading amount.

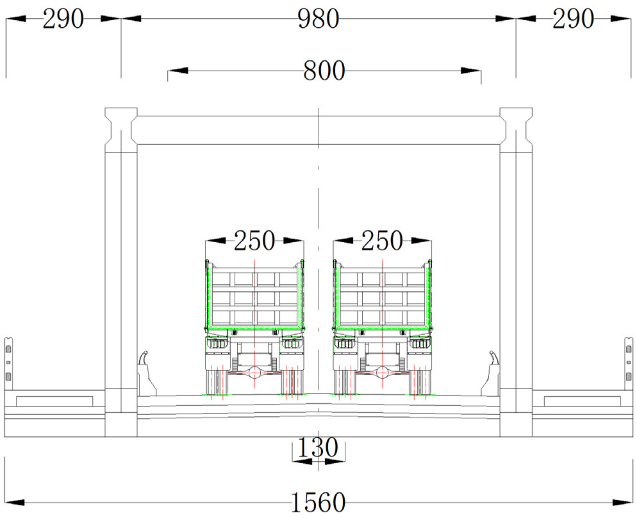
The model is established according to the calculation principle of [5] in the Highway Bridge Load Test Regulations (JTG / TJ 21-01-2015). See Table 2 for the control section of the reinforced concrete tie arch bridge of a single span of 35m under the test load and the design load. The test load efficiency is 0.88~0.95, which meets the range requirements of the "Regulations for Highway Bridge Load Test" (JTG / TJ 21-01-2015) [5] 0.85~1.05.

The lateral distribution of the medium and partial load is shown in Figure 6. The longitudinal arrangement of the loading vehicle is shown in Figure 7.

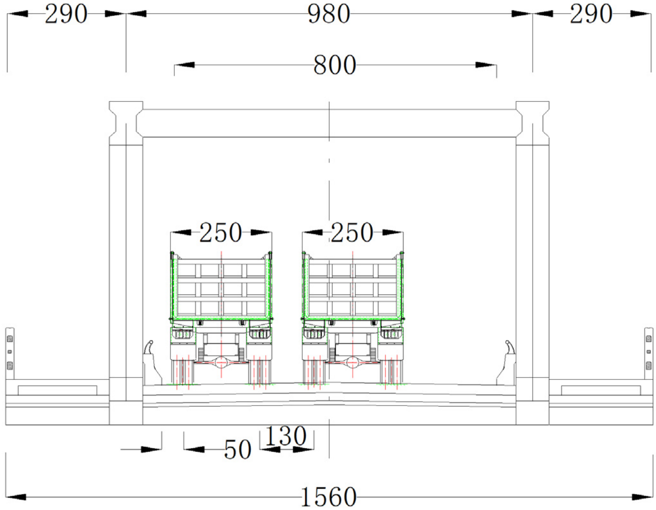
Table 2. Static load test condition

Order number	Control section	Section position	Project	Component number	Calculated value under the test load	Under standard load The calculation of the value	Finder charge productiveness /
1	(A-A) Mid-load	Small mileage end arch foot Near the section	bending moment (kN.m)	1#arch rib	-68.5	-77.7	0.88
				2#arch rib	-68.5	-77.7	0.88
	(A-A) unbal-	Small mileage	bending moment	1#arch rib	-74.7	-78.6	0.95

	ance loading	end arch foot Near the section	(kN.m)	2#arch rib	-62.2	-65.6	0.95
2	(B-B) Mid-load	vault section	bending moment (kN.m)	1#arch rib	64.3	70.7	0.91
				2#arch rib	64.3	70.7	0.91
	(B-B) unbal-ance loading	vault section	bending moment (kN.m)	1#arch rib	74.4	82.0	0.91
				2#arch rib	54.1	59.4	0.91
3	(C-C) Mid-load	The beam spans the middle section	bending moment (kN.m)	1#binder	415.4	444.3	0.93
				2#binder	415.4	444.3	0.93
	(C-C) unbal-ance loading	The beam spans the middle section	bending moment (kN.m)	1#binder	452.8	486.0	0.93
				2#binder	378.1	402.7	0.94

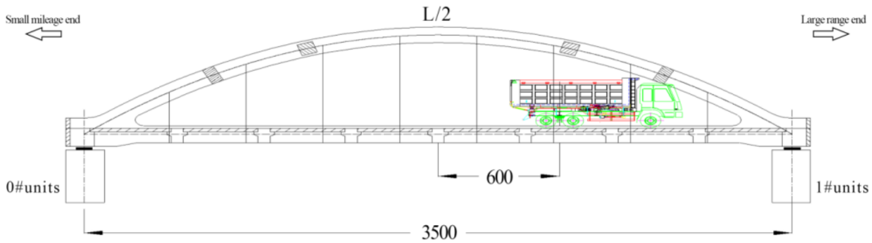


Layout drawing of the forward vehicle

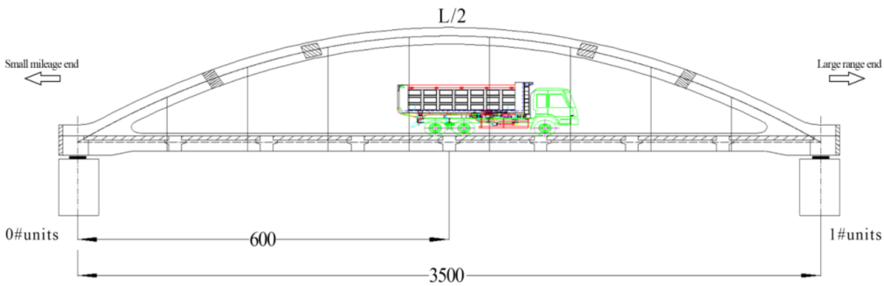


Layout of offset vehicle

Fig. 6. Layout map of lateral distribution of loading vehicle (unit: cm)



A-A Longitudinal layout drawing of the cross-section loading vehicle



Longitudinal layout drawing of the B-B / C-C cross-section loading vehicle

Fig. 7. Longitudinal position drawing of loading vehicle (unit: cm)

4.4 Evaluation of the static-load test results

According to the Highway Bridge Load Test Code (JTG / TJ 21-01-2015) [5], the static load test is evaluated based on the following principles:

- The calculated stress (strain) check coefficient is less than 0.9, and the deflection check coefficient is less than 1.0;
- Relative residual deformation (or strain) size of 20%. The smaller the relative residual deformation (or strain), the more the bridge structure tends to the elastic working state;
- When the test load is applied to the bridge structure, the crack expansion of the new bridge shall not exceed the specification allowable value, and the expansion width shall be closed to 1 / 3 of the specification allowable value after unloading;
- No other abnormal conditions occur during the load test.

4.5 Analysis of the static-load test results

Deflection results. The digital display percentage table is used to test the deflection of a bearing reinforced concrete tie-rod arch bridge with a single span of 35m. During the test, the digital display percentage table is directly set at the measuring point, and the measuring point is arranged as shown in Figure 5. Read the relative elevation of the measuring point before, after loading and after unloading in each working condition. Through the calculation formula in [5] of Highway Bridge Load Test Procedure (JTG / TJ 21-01-2015), the peak value, elasticity value and deflection residual value can be obtained. The comparison between the measured and calculated values of A-A~C-C cross section is shown in Table 3. The deflection values are positive upward and negative downward.

Table 3. Comparison table of measured and calculated values of deflection of A-A-C-C section

Station position(NO.)	Section near the arch foot of the small mileage end (A-A) MminMid-load			Section near the arch foot of the small mileage end (A-A) Mminunbalance loading		
	The measured value (mm)	Calculated value (mm)	The verification coefficient	The measured value (mm)	Calculated value (mm)	The verification coefficient
Arch rib L/4 section left (1#)	0.42	1.17	0.36	0.44	1.27	0.35
Arch rib L/4 section right side(2#)	0.44	1.17	0.38	0.37	1.07	0.35
Vault section left(3#)	-0.29	-0.70	0.41	-0.34	-0.81	0.42
Vault section right side(4#)	-0.29	-0.70	0.41	-0.28	-0.58	0.48

Tie beam L/4 section left(5#)	0.32	0.67	0.48	0.30	0.67	0.45
Tie beam L/4 section right(6#)	0.34	0.67	0.51	0.35	0.66	0.53
Left side of the middle span of the tie beam(7#)	-1.07	-1.77	0.60	-1.28	-2.10	0.61
Tie beam middle section right side(8#)	-1.24	-1.77	0.70	-0.99	-1.44	0.69
Station position(NO.)	Arch section (B-B) Mmax middle load/tie beam span Section (C-C) Mmax medium load			Arch section (B-B) Mmax partial load/tie beam span Arch section (C-C) Mmax offset load		
	The measured value (mm)	Calculated value (mm)	The verification coefficient	The measured value (mm)	Calculated value (mm)	The verification coefficient
Arch rib L/4 section left(1#)	-0.12	-0.19	0.63	-0.17	-0.24	0.71
Arch rib L/4 section right side (2#)	-0.07	-0.19	0.37	-0.05	-0.14	0.36
Vault section left(3#)	-0.39	-1.23	0.32	-0.46	-1.43	0.32
Vault section right side (4#)	-0.40	-1.23	0.33	-0.36	-1.03	0.35
Tie beam L/4 section left (5#)	-0.76	-0.90	0.84	-0.90	-1.10	0.82
Tie beam L/4 section right (6#)	-0.79	-0.90	0.88	-0.60	-0.71	0.85
Left side of the middle span of the tie beam(7#)	-1.93	-3.06	0.63	-2.17	-3.58	0.61
Tie beam middle section right side (8#)	-2.04	-3.06	0.67	-1.64	-2.54	0.65

Based on Table 3, the structural check coefficient of beam deflection ranges from 0.32 to 0.88, within the suggested range in the appraisal regulations, indicating that the overall stiffness of the inspected bridge span structure is good. And the residual deformation at all measurement points is within 20%, indicating that the bridge is basically in an elastic working state. When the test load is applied, the bridge structure is observed, and no cracks or other abnormal situations occur.

Stress results. This stress (strain) test of a single 35m span under-hung reinforced concrete tie-arch bridge adopts positional encoding magnetic induction digital strain testing technology, which is a non-destructive testing technology [10]. Before evaluation, the influence of temperature on the test results is corrected. The layout of the measuring points is shown in Figure 5. During the static load test, the stress (strain) values at each measuring point are read before, after, and after unloading for each loading case. According to the calculation formulas given in the "Code for Load Test of Highway Bridges" (JTG/T J21-01-2015) [5], the peak, elastic, and residual values of each measuring point are calculated.

The comparison of the measured and calculated stress (strain) values at sections A-A to C-C is shown in Table 4, where stress is positive when tension and negative when compression.

Table 4. Section, Comparison table of measured and calculated values of stress (strain) on A-A～C-C section

Test control cross section And measuring point number		Medium load			Unbalanced load		
		The measured value (Mpa)	Calculated value (Mpa)	The verification coefficient	The measured value (Mpa)	Calculated value (Mpa)	The verification coefficient
Section near arch foot of small mileage end(A-A) Mmin	1#	0.02	0.05	0.40	0.04	0.07	0.57
	2#	0.03	0.05	0.60	0.03	0.07	0.43
	3#	-0.02	-0.03	0.67	-0.01	-0.02	0.50
	4#	-0.02	-0.03	0.67	-0.01	-0.02	0.50
	5#	-0.21	-0.39	0.54	-0.22	-0.43	0.51
	6#	-0.18	-0.39	0.46	-0.21	-0.43	0.49
	7#	-0.38	-0.74	0.51	-0.47	-0.84	0.56
	8#	-0.36	-0.74	0.49	-0.46	-0.84	0.55
	9#	-0.39	-0.82	0.48	-0.47	-0.93	0.51
	10#	-0.46	-0.82	0.56	-0.57	-0.93	0.61
	11#	0.02	0.05	0.40	0.02	0.03	0.67
	12#	0.03	0.05	0.60	0.02	0.03	0.67

	13#	-0.02	-0.03	0.67	-0.01	-0.04	0.25
	14#	-0.02	-0.03	0.67	-0.02	-0.04	0.50
	15#	-0.19	-0.39	0.49	-0.22	-0.33	0.67
	16#	-0.20	-0.39	0.51	-0.20	-0.33	0.61
	17#	-0.40	-0.74	0.54	-0.36	-0.62	0.58
	18#	-0.42	-0.74	0.57	-0.35	-0.62	0.56
	19#	-0.44	-0.82	0.54	-0.41	-0.69	0.59
	20#	-0.42	-0.82	0.51	-0.39	-0.69	0.57
Section near arch foot of small mileage end		Medium load			Unbalanced load		
		The measured value (Mpa)	Calculated value (Mpa)	The verification coefficient	The measured value (Mpa)	Calculated value (Mpa)	The verification coefficient
Vault section(B-B) Mmax	1#	-0.71	-0.97	0.73	-0.65	-1.14	0.57
	2#	-0.74	-0.97	0.76	-0.91	-1.14	0.80
	3#	-0.62	-0.89	0.70	-0.63	-1.05	0.60
	4#	-0.59	-0.89	0.66	-0.67	-1.05	0.64
	5#	-0.35	-0.54	0.65	-0.42	-0.64	0.66
	6#	-0.37	-0.54	0.69	-0.39	-0.64	0.61
	7#	-0.12	-0.18	0.67	-0.13	-0.23	0.57
	8#	-0.13	-0.18	0.72	-0.16	-0.23	0.70
	9#	-0.07	-0.10	0.70	-0.08	-0.14	0.57
	10#	-0.06	-0.10	0.60	-0.09	-0.14	0.64
	11#	-0.74	-0.97	0.76	-0.63	-0.79	0.80
	12#	-0.67	-0.97	0.69	-0.63	-0.79	0.80
	13#	-0.62	-0.89	0.70	-0.41	-0.73	0.56
	14#	-0.65	-0.89	0.73	-0.45	-0.73	0.62
	15#	-0.32	-0.54	0.59	-0.32	-0.44	0.73
	16#	-0.37	-0.54	0.69	-0.30	-0.44	0.68
	17#	-0.12	-0.18	0.67	-0.08	-0.15	0.53
	18#	-0.13	-0.18	0.72	-0.11	-0.15	0.73
	19#	-0.05	-0.10	0.50	-0.05	-0.08	0.63
	20#	-0.06	-0.10	0.60	-0.06	-0.08	0.75

Section near arch foot of small mileage end		Medium load			Unbalanced load		
		The measured value (Mpa)	Calculated value (Mpa)	The verification coefficient	The measured value (Mpa)	Calculated value (Mpa)	The verification coefficient
Mid-span section of tie beam (C-C) Mmax	1#	1.04	2.92	0.36	1.45	3.15	0.46
	2#	0.93	2.92	0.32	1.34	3.15	0.43
	3#	0.95	2.92	0.33	0.79	2.69	0.29
	4#	1.00	2.92	0.34	0.86	2.69	0.32

As shown in Table 4, the verification coefficient of beam structure stress (strain) ranges from 0.29 to 0.80, which falls within the scope suggested by the evaluation regulations, indicating that the overall force-bearing condition of the checked bridge span structure is relatively good.

The residual stress (strain) at all measurement points has not exceeded 20%, indicating that the bridge is basically in an elastic working state.

When the test load was applied, observations were made on the bridge structure, and no cracks or other abnormal conditions were found.

5 Dynamic loading test

5.1 Dynamic response test

Dynamic response tests are divided into obstacle-free driving tests and obstacle-filled driving tests. One 350kN loading vehicle is selected to test the dynamic stress (strain) under various working conditions such as obstacle-free driving at 10km/h, obstacle-free driving at 20km/h, obstacle-filled driving at 5km/h, and obstacle-filled driving at 10km/h. The impact coefficient is calculated.

Place two dynamic stress (strain) measurement points in the test section at B-B. The measured impact coefficient at the B-B section under different speeds is shown in Table 5.

Analyzing the measured impact coefficient of the B-B cross section, we can find that the first peak value of the impact coefficient for obstacle-free vehicle test is 0.184, with a speed of about 10km/h, and the measured impact coefficient for obstacle-free vehicle test is between 0.094 and 0.184; the first peak value of the impact coefficient for obstacle vehicle test is 0.840, with a speed of about 5km/h, and the measured impact coefficient for obstacle vehicle test is between 0.770 and 0.840. According to the design specifications, the theoretical impact coefficient is 0.215. According to Clause 6.6.5 of the "Highway Bridge Load Test Regulations" (JTG/T J21-01-2015), using the maximum value of 0.184 for obstacle-free vehicle test as the judgment criterion, it is smaller than the design value adopted, indicating that the structure will not generate excessive impact under the normal operating state of the design load.

Table 5. Table of actual impact coefficient of barrier-free driving

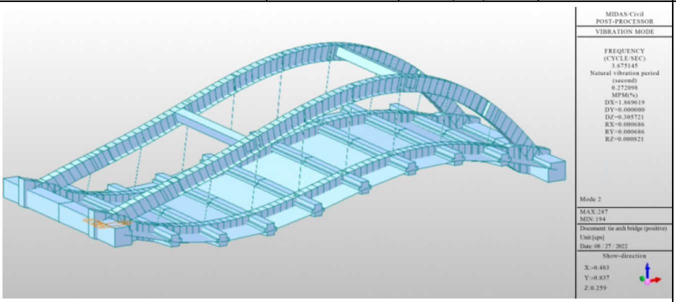
The test location	Working condition	Measured impact coefficient
B-B Cross section	10km/h Barrier-free driving	0.184
	20km/h Barrier-free driving	0.094
	5km/h Barrier-free driving	0.840
	10km/h Barrier-free driving	0.770

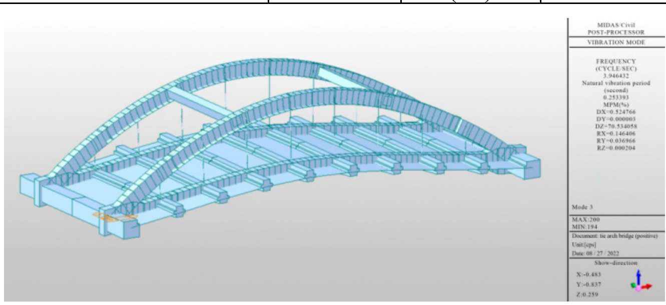
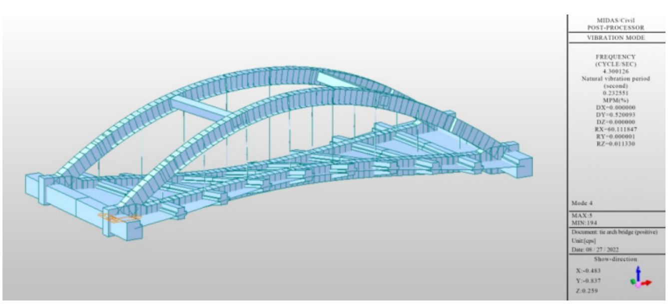
5.2 Dynamic Characteristic Test

This time, the environmental random excitation method (pulsation method) is used to test the dynamic characteristics. The environmental random excitation method refers to the case where no traffic loads are applied to the bridge structure and there is no regular vibration source generated by construction or other effects near the bridge structure. Only micro-vibrations generated by random excitation such as wind loads, ground pulsation, and water flow are relied on to identify the self-vibration characteristic parameters such as vibration mode, frequency, and damping ratio of the bridge structure.

The measured and theoretical values of the natural frequencies of a single-span 35m reinforced concrete tie-arch bridge are shown in the following table. The ratio of measured to theoretical natural frequencies is 1.27, and the measured damping ratio is within the normal range.

Table 6. Test results of dynamic characteristics

<table>
<tr><th>Mode charac-teristics</th><th>Mode diagram</th><th>First order frequency measured value(Hz)</th><th>First order frequency calculated value (Hz)</th><th>Measured val-ue/calculated value</th><th>Damp-ing ratio</th></tr>
<tr><td rowspan="2">Vertical first order</td><td colspan="4">
</td><td rowspan="2">0.04</td></tr>
<tr><td></td><td>4.7</td><td>3.7</td><td>1.27</td></tr>
</table>

Mode charac-teristics	Mode diagram	First order frequency measured value(Hz)	First order frequency calculated value (Hz)	Measured val-ue/calculated value	Damp-ing ratio
Vertical second order					
		5.1	4.0		
Vertical third order					
		5.5	4.3		

6 Conclusion

This article takes a single span 35m bottom-supported reinforced concrete tie-arch bridge as the engineering background. By conducting static and dynamic load tests on the bridge, the structural response of the bridge structure under test load and the dynamic characteristics of the bridge under environmental excitation are mastered. The load-bearing capacity of the tie-arch bridge is determined to ensure the operating quality and traffic safety of the bridge. We will continue to accumulate experience in bridge design, construction, and testing, and improve the overall construction level of bridge engineering.

The structural stress (strain) verification coefficient is between 0.29 and 0.80, the deflection verification coefficient is between 0.32 and 0.88, and the residual strain (stress) and deformation at all measuring points have not exceeded 20%. They are all within the reasonable range specified in the "Load Testing Procedures for Highway Bridges" (JTG/T J21-01-2015) [5].

The impact coefficient of the obstacle-free driving test is between 0.094 and 0.184, and the theoretical impact coefficient calculated in accordance with the design specification is 0.215, and the measured values are all less than the design value. The ratio of the measured natural frequency to the theoretical calculated value is 1.27, and the measured damping ratio is within the normal range.

In summary, the load testing on a single span 35m under-slung reinforced concrete strut arch bridge shows that the load testing method for evaluating the load-bearing capacity of strut arch bridges is accurate, effective, and reliable, and has good promotional significance in the calculation of load-bearing capacity for similar bridges.

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