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Three-Arch, Three-Cable Face Steel-Sided Rigid Tie Composite Arch Bridge

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ABSTRACT: This essay proposes a new structural system for a large span three-arch, three-cable face steel edge main beamrigid tie composite arch bridge. The authors invented a new structural form of a steel edge main girder rigid tie, and developed and designed a key arch-bar three-dimensional six-way space node structure. The analysis of results show that: compared with the traditional arch bridge, the large span three-arch three-cable face steel-sided main beam rigid ties composite arch bridgeis beautiful in shape, hasareasonable structure and efficient construction. It is a high-strength, high-performance composite structural system, with better strength, stiffness, stability and dynamic performance, which overcomes the large span ultra-wide bridge deck arch bridge horizontal thrust, poor transverse stability, and the key technical problems of acable joint control. The proposed structural form has a wide range of engineering application prospects.

KEY WORDS: Arch Bridge; Composite structure; Reasonable axis of arch; Steel edge main beam; Rigid ties; High-performance structural system.

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OUTLINE

As the oldest bridge type of mankind, the arch bridge has been one of the bridge types of choice for large span bridges for more than three thousand years [1].

With the development of the times, especially the progress in the field of material science, arch bridges have derived a variety of structural forms. From the material, mainly including stone arch bridge, concrete arch bridge, steel arch bridge and steel-concrete combination arch bridge. From the structural form, mainly including the upper-bearing, middle-bearing, lower-bearing arch bridge. From the arch axis form, mainly including circular curve, parabolic, suspension chain line arch bridge [2]. Steel-concrete composite structure arch bridge consists of several different mechanical properties of materials, mainly steel, concrete, high-strength steel wire, which under the action of constant load, live load common stress, coordinated deformation, both to improve the ultimate bearing capacity of the hoop concrete, while improving the flexural stability of the steel structure and structural durability, give full play to the respective advantages of different mechanical properties of materials, the forma-

Fig. 1. **Full steel-concretecomposite bridge structure system**
(Fengwan bridge on national highway 321,
L = 80+150+80 m, W = 61 m)

tion of a new high-strength high-performance composite bridge structure system [3, 4, 5, 6] (Fig. 1).

1. STRUCTURE DESIGN

In this essay, we propose a large-span three-arch, three-cable surface steel edge main beam rigid tie composite arch bridge structural system (Fig. 2), invented a new structural form of steel edge main beam rigid tie, and developed and designed an arch-bar three-dimensional six-way space node key structure (Fig. 3). For the traditional concrete arch bridge self-weight is too large, large span steel structure arch bridge cost and other problems [7], to solve the large span ultra-wide bridge deck arch bridge horizontal thrust, transverse stability is poor, adjust the cable joint control difficult and other key technical problems. The following will analyse and discuss from several aspects such as structural design, construction method and stability analysis.

1.1. Overall Design

The new structure system of three-arch, three-cable surface rigid tied arch bridge, i.e., the bridge type adopts down-bearing steel box-concrete composite tied arch bridge, the bridge deck adopts high performance pressed steel plate steel-concrete composite structure, and the bridge pier adopts steel tube restrained concrete composite structure. The main bridge adopts 80+150+80 m three-span under-bearing steel box arch bridge, the main span is 150 m, the side span is 80 m, the bridge width is 60 m, the sagittal span ratio is 1/4.5, the arch axis adopts suspension chain line plus parabola to form a convergent composite curve, the arch axis coefficient is 1.988, the pre-arch is set to L/600, set according to the secondary parabola. There are 3 vertical vertical arch ribs in the cross-bridge direction, the spacing is 24 m, and the cross-sectional form of arch ribs is steel box. The main arch section is 3 m high, the arch ribs are 3 m wide on both sides of the bridge and 4 m in the middle; the side arch section is 2.25 m high, the arch ribs are 3 m on both sides of the bridge and 4 m in the middle; the foot section of the arch is filled with C50 micro expansion concrete.

The bridge adopts Chinese first-class highway standard, the design speed is 80 km/h; the load level is city-A+ highway grade I; the bridge adopts two-way 12 lanes, the main lane is 8 lanes, the auxiliary lane is 4 lanes; the maximum longitudinal slope of the bridge deck is 3.5%; the cross slope of the bridge deck is 2%; the highest navigable water level under the bridge is 9.816 (bead base 9.0 m), the navigable clearance is not less than 6m; the peak acceleration value of ground vibration is 0.05 g. VII degree fortification; design reference period of 100 years.

1.2. Main Arch Design

1.2.1. Main Arch Section

The arch ribs are equal-section steel boxes. The arch rib sections are divided into four forms: main span middle arch, side span middle arch, main span side arch, and side

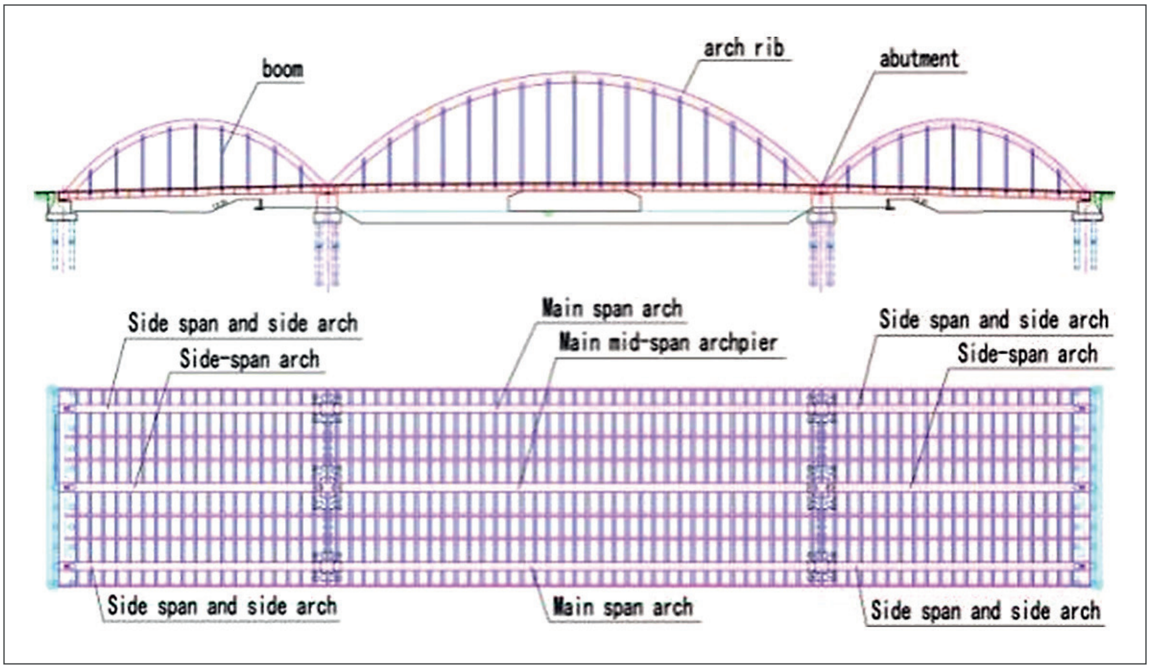

Fig. 2. **Three-arch, three-cable face side main girder rigid tie composite arch bridge structure**

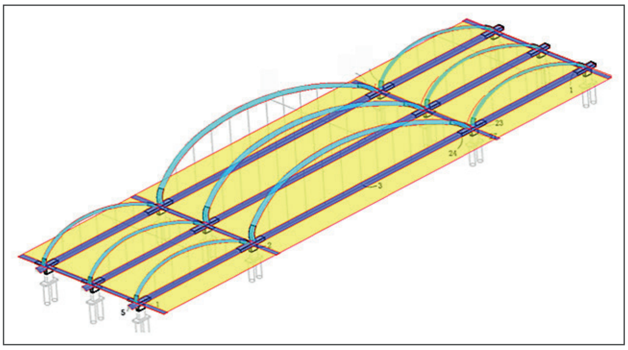

Fig. 3. **Arch-rod three-dimensional six-way space key node construction**

span side arch. C50 micro-expansion concrete is filled in each arch foot section to form a composite steel-concrete section form (Fig. 4), which has greater bending and torsional stiffness.

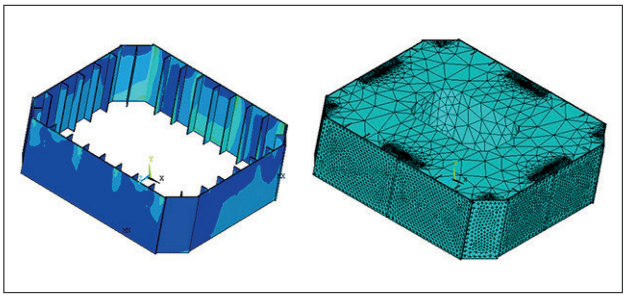

Fig. 4. **Combined section form of arch foot section**

Main span middle arch: section height 3 m; width 3 m, steel plate thickness 30 mm; divided into 9 sections, foot section is filled with C50 micro expansion concrete.

Main span side arch: section height 3 m; width 2.5 m, thickness of steel plate is 24 mm; divided into 9 sections, foot section is filled with C50 micro expansion concrete.

Side span main arch: section height 2.5 m; width 3 m, thickness of steel plate is 20 mm; divided into 7 sections, foot section is filled with C50 slightly expanded concrete.

Side span side arch: section height 2.5 m; width 2.5 m, steel plate thickness 16mm; divided into 7 sections, the foot section is filled with C50 micro expansion concrete.

1.2.2. Composite Arch Axis Line Equation

Arch axes commonly used in arch bridges are circular arc, parabolic and suspension chain lines [8]. The circular arc line is simple, convenient construction, but deviates from the pressure line, so that the main arch sections are not uniform, commonly used in small span arch bridge; parabolic line and suspension chain line is closer to the constant load pressure line. Suspension chain line is currently the most common arch axis type used in large and medium span arch bridges. The vertical coordinate on the arch axis is proportional to the moment value of the simply supported beam under the same load of the same span, so that the arch cross-section is only subject to axial force and no bending moment, and the arch axis that meets this condition is called reasonable arch axis [9, 10].

The arch has a uniformly distributed vertical load along the arch axis (such as self-weight), the bridge reasonable arch axis derivation process is as follows.

When the arch axis changes, the load also changes.p(x) is the self-weight per unit length along the arch axis, and the load set along the horizontal direction is q(x).

From the resulting, substitute the following equation.

Since it is specified that y is positive upward, x is positive to the right, and q is positive downward, the right side of the above equation has a positive sign.

After integration, we get:

If p(x) = constant = p, then

that is

Since when x = 0, the constant A = 0, that is

Integrating once more, we get

Since when x = 0, y = 0, so

Finally, we get

The arch is under the action of self-weight load, and the reasonable arch axis is the suspension chain line.

Considering the influence of horizontal thrust, in order to reduce the arch's own horizontal thrust and save the horizontal ties, the arch foot adopts convergent design. Due to the change of the angle of the supporting surface of the arch foot, under the action of general load, in order to seek the corresponding reasonable arch axis of the arch foot section, it can be assumed that the arch is in the state of no bending moment, but the arch is under the action of uniform static pressure, and its reasonable arch axis is circular curve. According to the load q(s), the radius of the circular curve can be determined.

According to the above formula, the arch axis adopts the suspension chain line and circular curve arch foot together to form the convergent composite arch axis, and the two curves meet the continuous and conductible conditions at the transition point, and the arch axis coefficient m is 1.988.

1.2.3. Transverse Coupling System

There are 5 wind braces for the main span arch rib, the cross braces are steel box section, 2 m wide and 2 m high; the thickness of top, bottom and web are 20 mm; there is no transverse wind brace for the side span arch rib.

1.2.4. Boom

The boom adopts galvanized high-strength low-relaxation prestressing steel wire with three cable faces, and the main bridge arch rib has 210 booms in total, using longitudinal double booms. Longitudinal bridge boom spacing 8m, double boom spacing 0.6 m, horizontal spacing 24 m.

The steel cables of the boom are made of extruded double-layered large pitch twisted stranded cables, with 73 Φ7 mm galvanized high-strength low relaxation prestressing steel wires for each boom bundle of the main span side arch and side arch; 91 Φ7 mm galvanized high-strength low relaxation prestressing steel wires for each boom bundle of the main span middle arch and side arch; the standard strength is fpk = 1670 Mpa. High-density polyethylene (PE sheathing) double sheathing protection.

1.3. Main Beam Design

1.3.1. Steel Edge Main Beam Rigid Ties

There are 4 types of longitudinal girders: (1) 1 longitudinal main beam with steel box structure, height 1.95 m, width 3.0 m, thickness of top and bottom plates and webs are changed from 32 mm of main span to 20 mm of side span; (2) 2 longitudinal side beams with steel box structure, height 1.66 m, width 2.5 m, thickness of top and bottom plates and webs are changed from 32 mm of main span to 20 mm of side span. (3) Two I-beams (4 transverse) are installed between the main longitudinal beam and the side longitudinal beam, with a height of 1.75 m ~ 1.86 m. The main span is 0.6 m wide, with a top and bottom plate thickness of 20 mm and a web thickness of 16 mm; the side span is 0.4 m wide, with a top and bottom plate thickness of 16 mm and a web thickness of 12 mm. The secondary longitudinal beam is disconnected at the position where the crossbeam is met.

The steel side main girders are rigid ties, instead of flexible horizontal ties, through three groups of side main girders and many cross girders to form a rigid frame, and concrete to form a combined section, with the advantages of large bridge deck stiffness, good overall performance [11].

1.3.2. Steel Crossbeam

There are 3 types of full bridge crossbeams: (1) pivot crossbeam, steel box structure crossbeam is set at the bearing position, beam height 1.66 ~ 1.95 m, width 3.0 m, top and bottom plate thickness 30 mm, web thickness 30 mm, pivot crossbeam is disconnected at the main and side longitudinal beam position. (2) Common crossbeam with I-beam structure, beam height 1.66 ~ 1.95 m, width 0.6 m, top and bottom plate thickness 24 mm, web thickness 20 mm, common crossbeam is disconnected at the position of main and side longitudinal beams. (3) Cantilever crossbeam with I-beam structure, beam height 0.516 m ~ 1.016 m, top plate width 0.4 m, bottom plate width 0.2 m; top and bottom plate thickness 16 mm, web thickness 12 mm.

The rigid tie bar of the steel side main beam, instead of the flexible horizontal tie bar, forms a rigid frame through three groups of side main beams and many beams, and forms a composite section with concrete. It has the advantages of large rigidity of the bridge deck and good overall performance [11].

1.3.3. Composite Structure Bridge Deck System

Three groups of steel side girders and many steel crossbeams form a rigid frame, in the rigid frame cavity parts arranged 100 mm high stiffening ribs of 10 mm thin steel plate, stiffening ribs open 50 mm round hole, spacing 100 mm, across the bridge deck reinforcement, forming a PBL shear key with holes, and the bridge deck reinforced concrete together to form a steel-concrete combination deck system, the overall performance of the bridge deck, stiffness, good seismic ductility and structural durability.

2. CALCULATION AND ANALYSIS

2.1. Finite Element Model

Midas/Civil and ANSYS large finite element software were used to build the full bridge finite element model and the local finite element model respectively. The Midas/Civil finite element model for the full bridge calculation and analysis has a total of 3472 units (210 truss units, 9 tensile-only units and 3253 beam units) and 2693 nodes in total. The base bottom surface is solidified, and the top of the base and pier cap, arch foot and horizontal ties, and arch foot and cap beam all adopt rigid connection in elastic connection [12, 13]. The spatial finite element model is shown in Fig. 5.

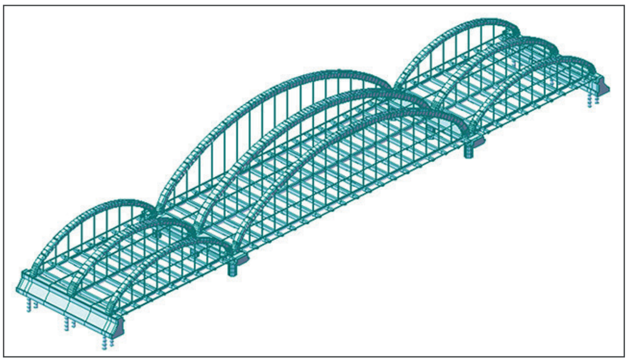

Fig. 5. **Composite Nielsen arch bridge finite element model**

2.2. Calculated load and boundary conditions

Design load: city-A, highway I; live load is loaded according to two-way 12-lane space, transverse reduction factor 0.5, longitudinal reduction factor 0.97, crowd load

Fig. 6. **The most unfavourable combination of action stress diagram**

is loaded according to 3.5 kPa/m^2. The overall temperature load is considered as 25 degrees of warming and 25 degrees of cooling, and the temperature difference between the diagonal cable and the main beam is ±10 degrees.

We consider mainly 5 kinds of load combinations, combination I: constant load + crowd load + lane load + uneven settlement; combination II: constant load + crowd load + lane load + temperature combination + live load cross wind + uneven settlement; combination III: constant load + crowd load + lane load + temperature combination + live load downwind + uneven settlement; combination IV: constant load + cross wind + uneven settlement; combination V: constant load + downwind + uneven settlement.

2.3. Static force analysis

According to the results of finite element analysis, the internal force and bearing capacity of steel mixed arch rib section and steel arch rib section are calculated, and the results of this calculation take two pieces of arch ribs in the hole of this most unfavourable position, the most unfavourable combination as shown in Fig. 6: self-weight + second phase + boom + bollard + vehicle + warming + transverse wind load, the maximum value of 115.9MPa; the minimum value –194.3 MPa, to meet the specification requirements.

In order to verify whether the steel pipe filled with concrete is more beneficial to the structure, the concrete inside the steel pipe is removed to verify the strength index by comparison, and according to the calculation results (Fig. 7), the structural stress level decreases significantly after the steel pipe is filled with concrete.

2.4. Arch Footing Partial Verification

ANSYS finite element analysis software was used to establish the local spatial solid models of the longitudinal

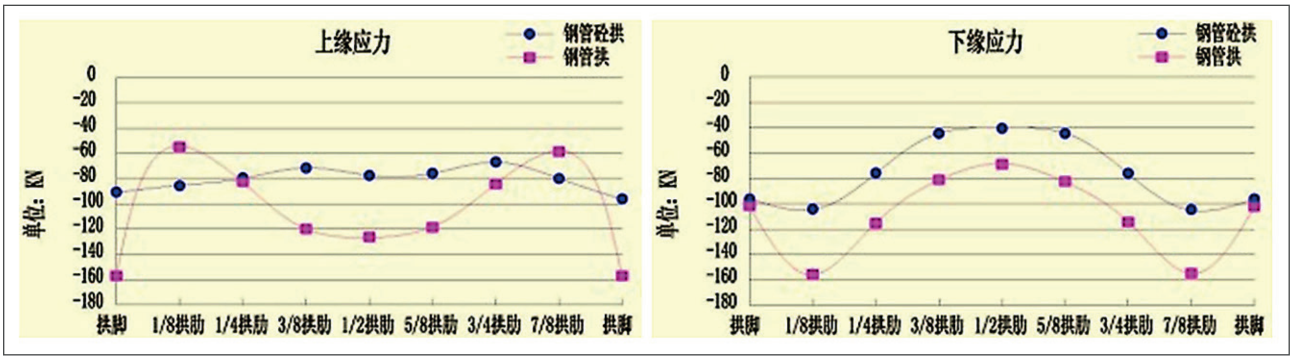

Fig. 7. **Comparison of steel stresses in combined section of steel pipe concrete arch**

beam, the most unfavourable section at the opening of the arch ribs and the foot of the arch in the bridge state. The boundary conditions of the main beam are loaded with the actual displacement and the actual internal force calculated by Midas Civil, and the solid 92 unit is used to simulate the steel structure, the solid 65 unit to simulate the core concrete of the arch footing, the link 180 unit to simulate the boom, and the beam web and the flat link are simulated by the beam188 unit [14].

2.4.1. Stress Test at Arch Rib Openings

The local model of arch rib is taken into bridge state boom maximum tension position section, length 4 m. The local model of arch rib is divided into 233,788 units, 459,614 nodes, finite element model as shown in Fig. 8, stress analysis results as shown in Table 1.

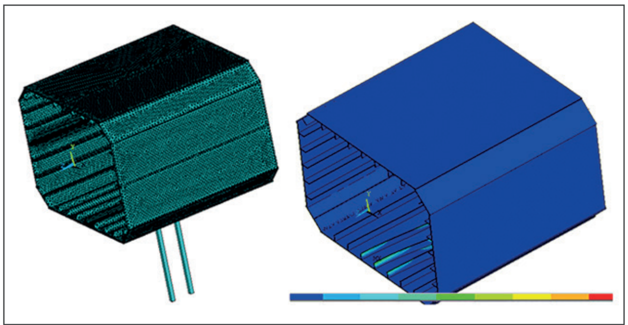

Fig. 8. **Local finite element model of steel arch rib section**

2.4.2. Calculation of Stress at the Anchorage of Arch Foot

The local model of the arch rib is taken into the bridge state boom maximum tension position section, 4 m long. The local model of arch rib is divided into 233,788 units and 459,614 nodes, and the finite element model is shown in Fig. 9, stress analysis results are shown in Table 1.

Table 1
Flexure analysis results

Modal	Modal Eigenvalue	Instability mode
1	59.72	Main span transverse instability
2	99.04	Main arch symmetric instability
3	110.53	Main arch asymmetric instability
4	118.57	Asymmetric instability of side span
5	124.72	Side span symmetrical instability
6	125.33	Side arch asymmetric instability
7	149.85	Side arch symmetrical instability
8	153.73	Main bridge transverse instability
9	167.08	Main bridge symmetrical instability

According to the results of finite element analysis, the stress in the steel part at the foot of the arch is minimum 0.2 MPa and maximum 61.3 MPa, the stress in the core concrete part is within the range of –8.2 MPa ~ 0.1 MPa, no tensile stress is generated in the concrete at the connection of the arch foot, the maximum compressive stress is –9.3 MPa, the stress values at the foot of the arch meet the specification design requirements and are in a safe range.

2.5. Structural Stiffness

The Technical Specification for Steel Pipe Concrete Arch Bridge (GB 50923-2013) stipulates that the maxi-

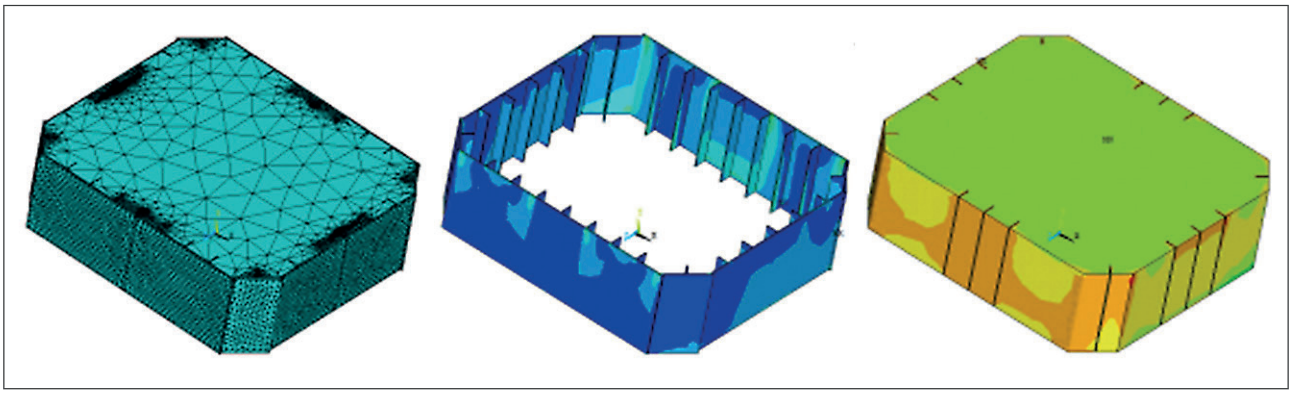

Fig. 9. **Local stress at the anchorage of arch foot**

mum vertical deflection caused by vehicle load should not be greater than L/800, L being the calculated span of the arch bridge structure.

According to Midas/Civil calculation results, considering the working conditions such as vehicle live load, the maximum vertical displacement of arch rib is 0.036 m ⩽150/800 = 0.18755 m, which meets the design requirements; the maximum vertical displacement of crossbeam is 0.072 m ⩽150/800 = 0.18755 m. Both stiffnesses meet the design requirements.

2.6. Structural Stability

Large-span arch bridge is extremely prone to structural instability (Fig. 10), and its stability is the key to the bridge. The stability analysis takes into account all the loads, the moving load is arranged according to the most unfavourable working condition of the arch foot axial force, the design wind speed is 24.0 m/s (10m high from the ground, 1% frequency, 10 min average maximum wind speed value), and the resistance coefficient of single arch rib section is 1.4.

The structural stability calculation of the bridge is carried out by the spatial finite element method, and the static stability analysis calculation model of the structure is the same as the structural dynamic characteristics analysis calculation model. In the calculation, the live load is applied to the bridge deck respectively, and the stability safety factor K of the structure is defined as Pcr/PT, where Pcr is the ultimate bearing capacity of the structure, PT is the sum of the self-weight of the structure and the operating live load in the bridge state, in fact K is the loading multiplier about PT when the structure reaches the ultimate bearing capacity.

2.7. Structural Dynamic Response

The dynamic characteristics of the structure were analyzed (Fig. 11) with a structural fundamental frequency of 1.127 Hz, which is far from the possible resonance region (Table 2).

3. CONSTRUCTION

3.1. Construction scheme

The steel members such as arch ribs and steel box girders can be processed and made in sections in the factory and assembled with brackets on site. The rest of the components can be cast-in-place construction process or off-site prefabricated lifting process [15].

Main construction steps:

1. Filling cofferdam; bored pile placement, construction of pile foundation and bearing platform.
2. Prefabricated steel components, processing steel components in the factory according to 1:1.
3. Driving into the bracket steel pipe pile foundation, erecting bracket and pre-pressing.
4. Bracing construction of longitudinal beams, installation of crossbeams and ordinary longitudinal beams.

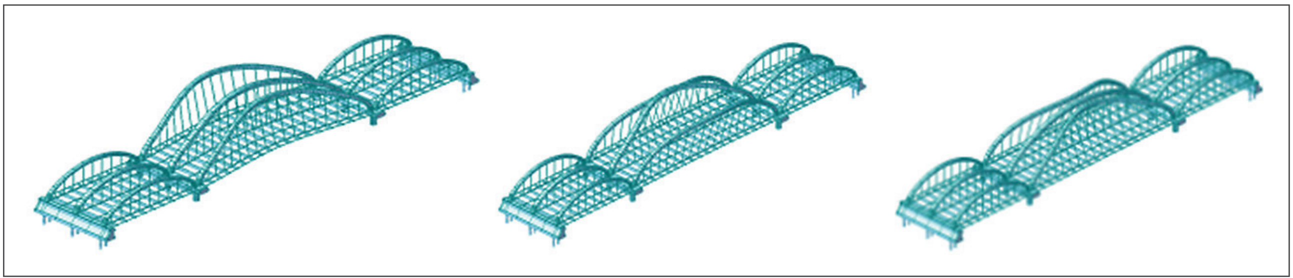

Fig. 10. **Arch bridge first third order instability mode**

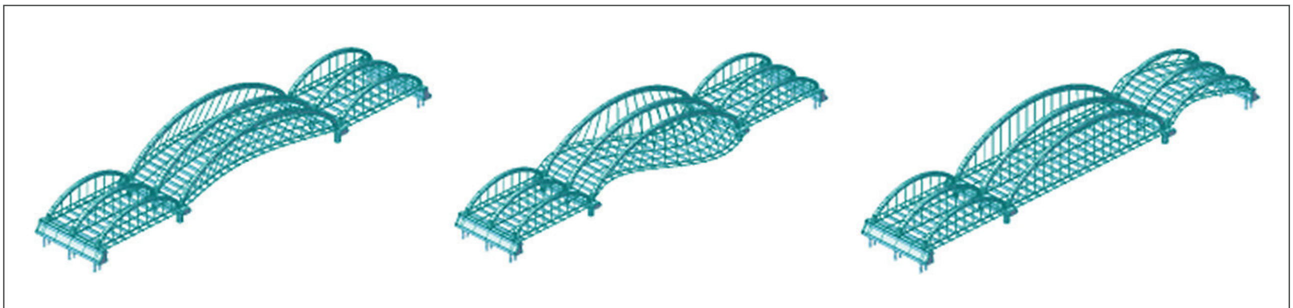

Fig. 11. **The first three orders of self-oscillation frequency of the arch bridge**

Table 2
Dynamic characteristics analysis results

Vibration Order	Period (s)	Frequency (Hz)	Self-vibration type
1	5.575	1.127	First-order transverse vibration of main span
2	2.810	2.236	First-order transverse vibration of main arch
3	2.629	2.390	Second-order transverse vibration of main arch
4	2.617	2.401	First-order vertical vibration of main span
5	1.860	3.379	First-order vertical vibration of side span
6	1.400	4.487	Second-order vertical vibration of side span
7	1.350	4.655	First-order vertical vibration of side span
8	1.342	4.683	First-order transverse vibration of side span
9	1.242	5.059	First-order vertical vibration of the main bridge
10	1.237	5.079	Second-order vertical vibration of the main bridge

5. On-site casting of bridge deck slabs.
6. Build the arch rib bracket and pre-pressure.
7. Slinging the main arch and installing wind bracing.
8. Installation of boom and tensioning.
9. Dismantle arch rib bracket.
10. Installation of bridge deck pavement, railings and decorative plates and other ancillary structures.
11. Dismantle the main beam bracket.
12. Static and dynamic load test.
13. Completion and acceptance, open to traffic operation.

3.2. Construction Process Analysis

Midas/Civil finite element software was used for the construction phase simulation analysis. Theoretical vertical curves are used as the reference for structural discretization. Simulate steel box beam, arch rib and cross beam with beam unit. Simulate the boom and horizontal bar with truss unit; Boundary condition treatment: a) permanent solidification at the bottom of the foundation; b) rigid connection in elastic connection between the cap beam and pile foundation [16, 17, 18]. The structure is discretized as a spatial rod system model, and the whole bridge is divided into 1546 nodes and 1949 units, and the geometric model of the whole bridge is shown in Fig. 12.

Combined with the construction process to divide the construction phases, divided into eight construction phases:

The first construction stage is the construction of piles, piers, cap beams and bridge abutments, and the consolidation of the base bottom surface.

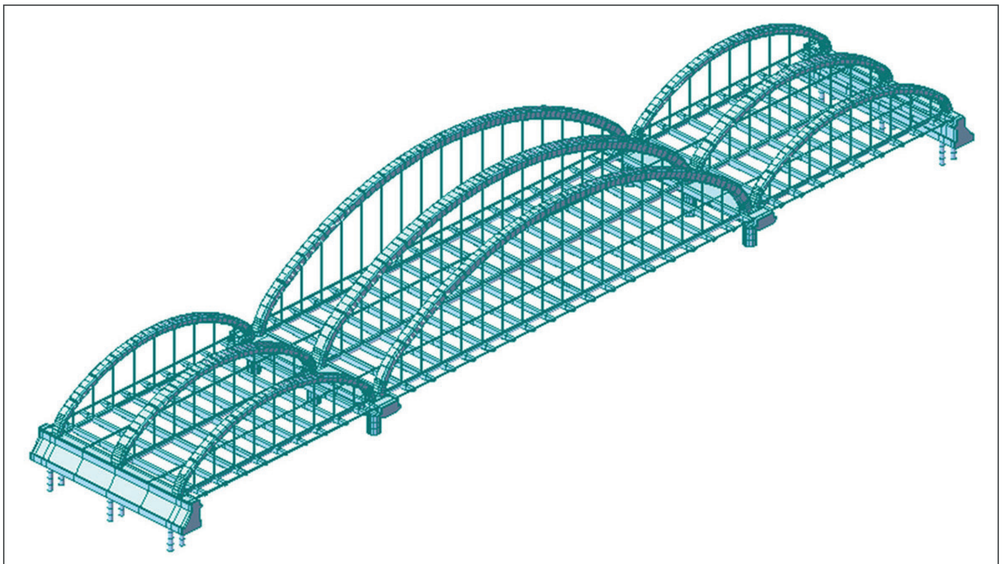

Fig. 12. **Arch bridge construction model**

Table 3

Table of maximum tensile and compressive stresses in the main beam of the boom for cable replacement

Change BoomCable Number	Maximum Beam Tensile Stress (MPa)	Maximum Beam Compressive Stress (MPa)	Change BoomCable Number	Maximum Beam Tensile Stress (MPa)	Maximum Beam Compressive Stress (MPa)
1-1-1	107.234	159.039	2-1-1	135.762	163.284
1-1-2	107.233	159.039	2-1-2	148.726	163.296
1-2-1	107.233	159.039	2-2-1	135.764	163.307
1-2-2	107.233	159.040	2-2-2	135.767	163.340
1-3-1	107.232	159.040	2-3-1	135.769	163.376
1-3-2	107.231	159.042	2-3-2	135.774	163.441
1-4-1	107.231	159.043	2-4-1	135.778	163.485
1-4-2	107.230	159.044	2-4-2	136.063	163.561
1-5-1	107.229	159.045	2-5-1	135.787	163.605
1-5-2	107.228	159.047	2-5-2	142.028	163.666
1-6-1	107.228	159.048	2-6-1	135.794	163.690
1-6-2	107.227	159.049	2-6-2	139.710	163.721
1-7-1	107.227	159.049	2-7-1	135.797	163.722
1-7-2	107.227	159.050	2-7-2	135.796	163.707
1-8-1	107.228	159.050	2-8-1	135.794	163.691
1-8-2	107.228	159.050	2-8-2	135.792	163.656
1-9-1	107.229	159.050	2-9-1	135.789	163.612
1-9-2	107.231	159.051	2-9-2	135.779	168.385
1-10-1	107.229	159.052	2-10-1	135.558	168.463
1-10-2	107.228	159.049	2-10-2	136.537	168.528
1-11-1	107.226	159.053	2-11-1	135.352	168.558
1-11-2	107.223	159.054	2-11-2	135.459	168.606
1-12-1	107.222	159.059	2-12-1	135.544	168.635
1-12-2	107.214	159.223	2-12-2	138.849	168.674
1-13-1	107.209	159.612	2-13-1	135.896	168.685
1-13-2	107.201	160.226	2-13-2	156.249	168.696
1-14-1	107.195	160.643	2-14-1	136.469	168.688
1-14-2	117.006	161.251	2-14-2	170.840	168.669
1-15-1	107.180	161.568	2-15-1	137.239	168.642
1-15-2	126.839	162.062	2-15-2	182.869	168.595
1-16-1	107.162	162.302	2-16-1	140.020	168.552
1-16-2	133.357	162.659	2-16-2	192.402	168.483
1-17-1	107.143	162.821	2-17-1	136.325	168.429
1-17-2	136.201	163.048	2-17-2	198.743	168.342
1-18-1	107.125	163.142	2-18-1	132.983	168.281
1-18-2	135.362	163.262	2-18-2	184.432	168.183
Maximum tensile stress (MPa)		198.743	Maximum tensile stress (MP)		168.696

The second construction stage is the construction of the side span arch footing, lifting and assembling, setting temporary consolidation.

The third construction stage is the construction of the remaining sections of the side span arch ribs.

The fourth construction stage is the construction of the mid-span arch footing, activating temporary boundary conditions.

The fifth construction stage is the construction of the remaining arch ribs of the middle span.

The sixth construction stage is the tensioning of the booms of the two side spans and activation of the corresponding crossbeams, longitudinal beams and longitudinal connection tubes.

The seventh construction stage is the tensioning of the booms of the middle span and activation of the corresponding crossbeams, longitudinal beams and longitudinal connection tubes.

The eighth construction stage is the tensioning of the horizontal ties and the removal of the temporary boundary conditions.

4. CONCLUSION

This essay proposes a new structural system of three-arch, three-cable face steel edge main girder rigid tie combination arch bridge, which consists of under-bearing steel box-concrete combination tie arch bridge, high performance stiffened steel plate steel-concrete combination structure deck system, and steel pipe restrained concrete combination structure pier, together forming a full combination structure bridge system. Through the analysis of the design and research of the three-arch, three-cable face steel edge main girder rigid tied arch bridge, the following conclusions are drawn:

(1) The structural load-bearing capacity meets the design requirements. After the most unfavourable combination of constant load, live load, temperature and other loads, the maximum stress of the structural system is 115.9 MPa, which meets the requirements of the design specification.

(2) The overall stiffness of the structure is large. Considering the vehicle load, the maximum vertical displacement of the arch rib is 0.036 m $\leqslant$ 15/800 = 0.18755 m, which meets the design requirements of the code; the maximum vertical displacement of the crossbeam is 0.072 m $\leqslant$ 15/800 = 0.18755 m, which meets the design requirements of the code.

(3) The structural dynamic performance is good. The first-order self-oscillation frequency of the main girder is 1.127 Hz, which is the transverse drift of the main span deck, and the overall stiffness of the main arch and deck structure is good.

(4) The structural stability is good. The first-order buckling stability analysis eigenvalue is 59.72, greater than the design specification requirements of not less than 4.0 requirements, arch bridge and bridge deck structural stability is good.

(5) Arch bridge arch ribs, steel girders and other steel members can be processed in sections in the factory, the site cable tower without bracket installation. The rest of the components can be cast-in-place construction process or off-site prefabricated lifting process, advanced technology, reasonable forces, construction and environmental protection.

In summary, this paper proposes a three-arch, three-cable face side main beam rigid ties combination arch bridge, reasonable structure, advanced technology, economic cost, beautiful shape. The main arch and deck structure meet the requirements of strength, stiffness, stability and dynamic characteristics, and have better mechanical performance and economy than the traditional arch bridge, which has a wide range of engineering application prospects.

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