RESEARCH ARTICLE

Earthquake Performance Analysis of Steel Truss-Concrete Continuous Rigid Frame Bridge

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Abstract
The steel truss-concrete Combination continuous rigid frame bridge is that we use steel truss for Principal stress structure.The seismic performance of a steel truss-concrete Combination continuous rigid frame bridge was studied in this paper. A dynamic spatial finite element model of Qingqiyong Bridge, which is a long span bridge, was created using MIDAS. Its natural frequency and vibration mode can be calculated,the seismic performance and structure stiffness were discussed and analyzed on the basis of calculated results. Design response spectrum and time-history method are used to calculate this bridge, seismic performance is discussed in this paper . Results show that natural frequency of the bridge is small, its period is long, and this kind of bridge is a new kind of earthquake resistant and energy-saving structure. Seismic effect has some effect on the bridge, especially the bending moment Along the bridge. The results of this paper can also provide some references for the design, construction, health monitoring and maintenance of bridges of like.
Keywords: Qingqiyong Bridge; natural frequency; seismic analysis;earthquake;vibration mode

I. Introduction

The quailty of usual prestressed concrete continuous rigid frame bridge is influenced by a lot of factor, its virtual condition is different from its design point more or less. The main disease of usual prestressed concrete continuous rigid frame bridge is all kinds of crack and excessive long-term deflection, it increases the late maintenance costs and security risk. in addition, the usual prestressed concrete continuous rigid frame bridge has a large dead load, the span of the kind of bridge is limited.it is used under the span of 200 meters.

Steel has a A smaller weight than concrete, steel truss is used for Principal stress structure.When the earthquake comes, the structure is soft and has a good ability to absorb energy, this kind of bridge can make the sseismic performance of continuous rigid frame bridge better.

Under the long-term stress or load.steel truss is the main frame, excessive long-term deflection will not come, therefore a lot of problem of usual continuous rigid frame bridge disappeared. In the Analysis of seismic performance, design response spectrum and time-history method are all inseparable from dynamic characteristics. The dynamic analysis is very important for bridge design and Detection, it is Also related to aseismic design of this bridge, results of this paper can also provide some references for the design, construction, health monitoring and maintenance of bridges of like.A dynamic spatial finite element model was created using MIDAS to calculate the seismic behavior of the bridge.

II. Bridge Description

Qingqiyong Bridge, as a part of Jitan highway, is a s steel truss-concrete Combination continuous rigid frame bridgewith three-span(41+70+41 m), which locates at the junction of Guangdong Province and Guangxi Province, through Xiaoyue Mountain in the northwest of Guangxi Province.According to the characteristic of topographic map, steel truss-concrete Combination strcuture is adopted in this bridge, and the whole width and the net width of the bridge are 33m and 30m respectively. The bridge is designed

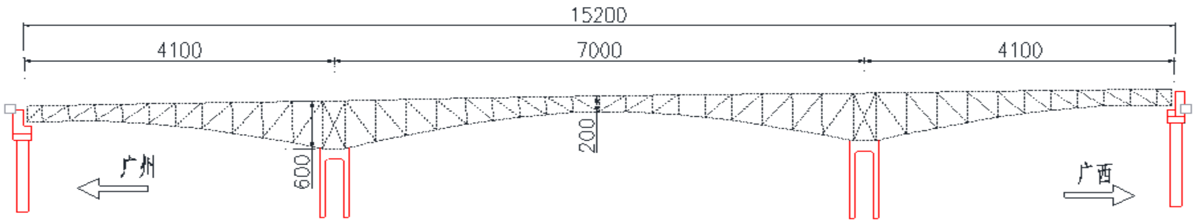

Fig.1 general arrangement diagram of Qingqiyong Bridge

according to the norms of two-way eight-lane highway with a speed of 80km/h and the design load is highway×1.2.

Upper structure of bridge is the combination of steel truss and precast concrete bridge deck.upper chord of steel truss is connected to precast concrete bridge deck by shear connector.the steel truss is variable height. The height of steel truss at pierIs 6 meters, when The height of steel truss at midspan is 2 meters, intersegmental distance includes 4 meters and 3.5 meters.

Precast concrete bridge deck is divided into chip with the length of 5 meters each.the cross section of is upper chord of steel truss 0.4m×0.4m. the thickness of steel plate is 0.8~1m. The H section of lower chord has a height of 0.5m and a width of 0.4m. the thickness of flange steel plate includes 0.03m and 0.014m. The thickness of Beam web is 0.014m. The lower chord of pier use a cross section, the size is 0.6mx0.5m.

III. Establishment of Finite-Element Model Description

Linear elastic beam element is used to establish the three-dimensional space FEM of Qingqiyong Bridge. the material consists of steel and concrete,the elasticity modulus of which are 206GPa and 30GPa, the density is 2500kg/m^3 And 7680kg/m^3 ,Poisson's ratio is 0.3 and 0.167. MIDAS is used to do the calculation of Qingqiyong Bridge. There are 3632 nodes and 2964 elements all The bridgeIn practical structure, bridge pier and steel truss is Incomplete consolidation. There is some sliding displacement between bridge pier and steel truss. Web member adopt hinge joint when it is connected to the upper chord and down chord , and the node of chords use rigid connection

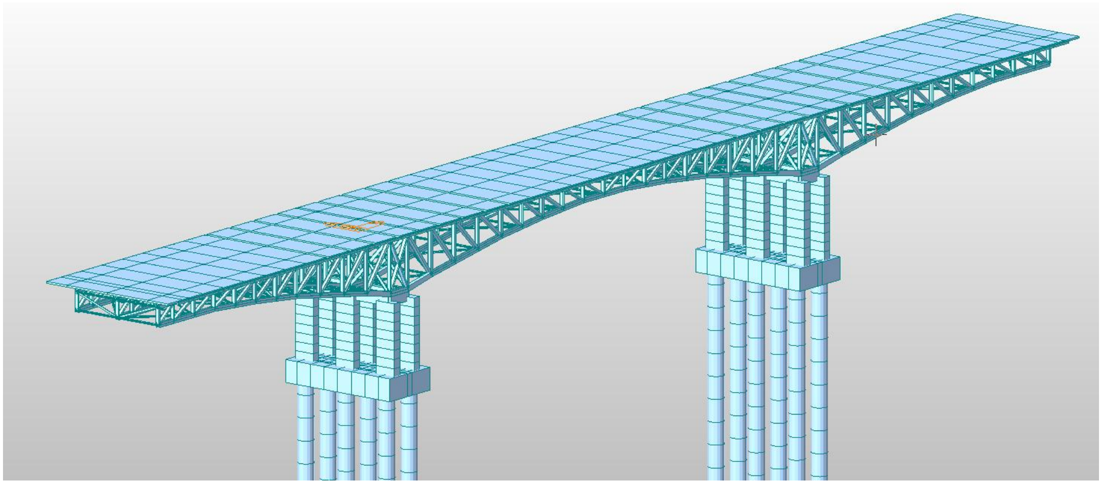

Fig.2 Finite element model of Qingqiyong Bridge

IV. The seismic wave input

According to the division of The ground motion parameter zoning map of China and Seismic intensity zoning map of Guangdong province, acceleration amplitude for this area is 0.15g. The soil type of engineering site is Soft ground soil. Categories of north of construction sites is type 3 , and Categories of south of construction sites is type 2 , seismic peak acceleration with probability of 3% in 50 years is 310.1 gal. Design response spectrum and time-history method are used for computing and analysis. We use three time-history sample curve with damping ratio of 0.05(see figure).

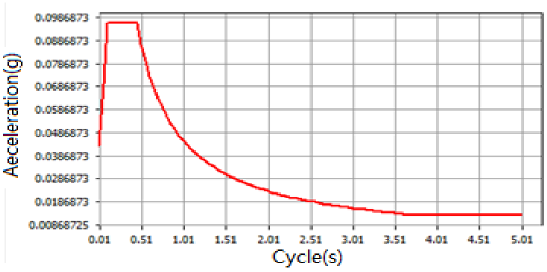

Fig.3 Design response spectrum with probability 3% in 50 years

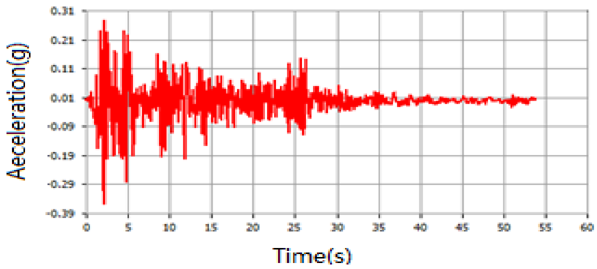

Fig.4 Time history curve 1 with probability in 50 years

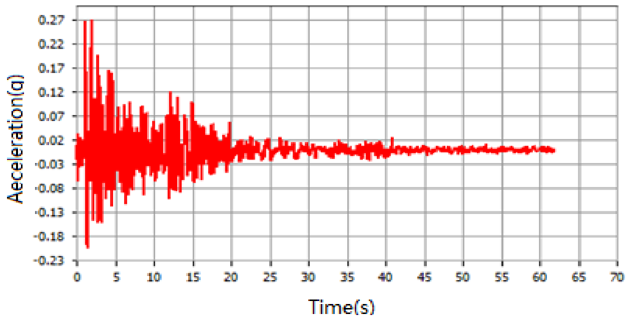

Fig.5 Time history curve 2 with probability in 50 years

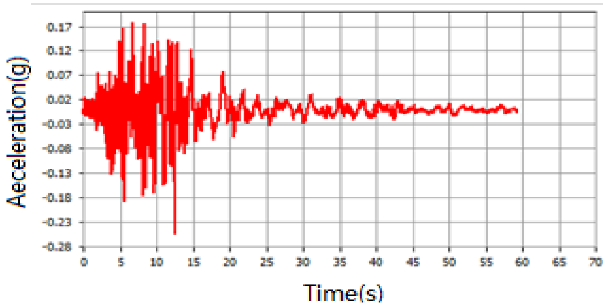

Fig.6 Time history curve 3 with probability in 50 years

V. FEM results and results analysis

The method of Rits in MIDAS is used to calculate the Dynamic Characteristics and vibration mode. Generally, participation factor of structure mass is concentrated in the first few vibration modes when doing dynamic analysis. For simple structures, firs three order modes are selected as the controlling vibration modes, for large and complex structures, more vibration modes should be selected as the controlling vibration modes. The structure of Qingqiyong Bridge is special, structural stiffness is uneven,the stiffness of precast concrete bridge deck is much larger than that of steel truss, therefore , steel truss-concrete Combination continuous rigid frame bridge belongs to complex construction.

We calculate its vibration modes, besides, first 10 orders of vibration modes and natural frequencies are selected as controlling parameters of dynamic calculation.

The FEM calculation results are listed in table 1.

Table 1 Parameters of dynamic characteristics

vibration mode	Natural frequency	cycle	Vibration mode description
1	0.757314	1.320456	deck translationally
2	1.720753	0.581141	deck vertically and symmetrically bended
3	2.313862	0.432178	Deck Transverse and symmetrically bended
4	2.626315	0.380762	Deck vertically but dissymmetrically bended

5	2.86806	0.348668	Deck vertically and in the same direction
6	3.687568	0.271181	deck vertically and symmetrically bended
7	3.73007	0.268092	deck vertically and symmetrically bended
8	3.856731	0.259287	Deck vertically but dissymmetrically bended
9	4.522822	0.221101	Deck vertically but dissymmetrically bended
10	5.898905	0.169523	deck vertically and symmetrically bended

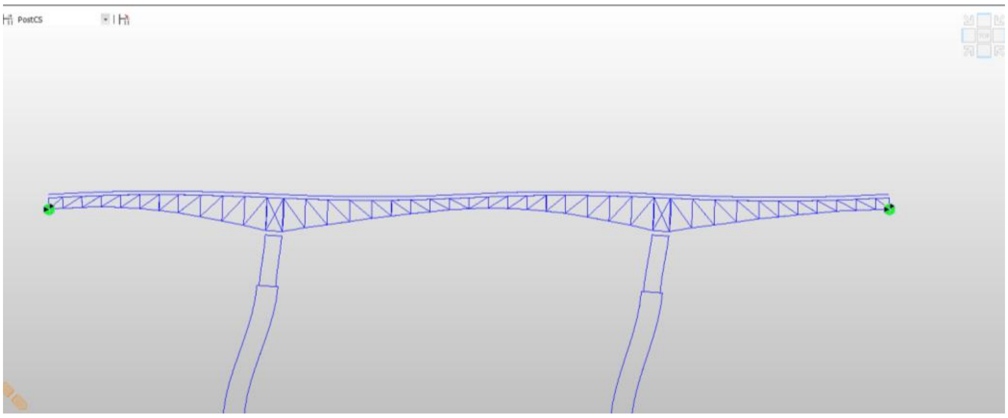

Fig 7 first order vibration mode

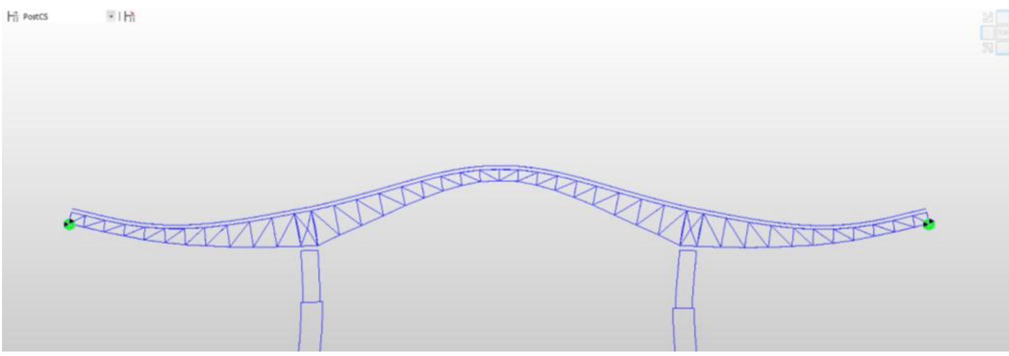

Fig8 second order vibration mode

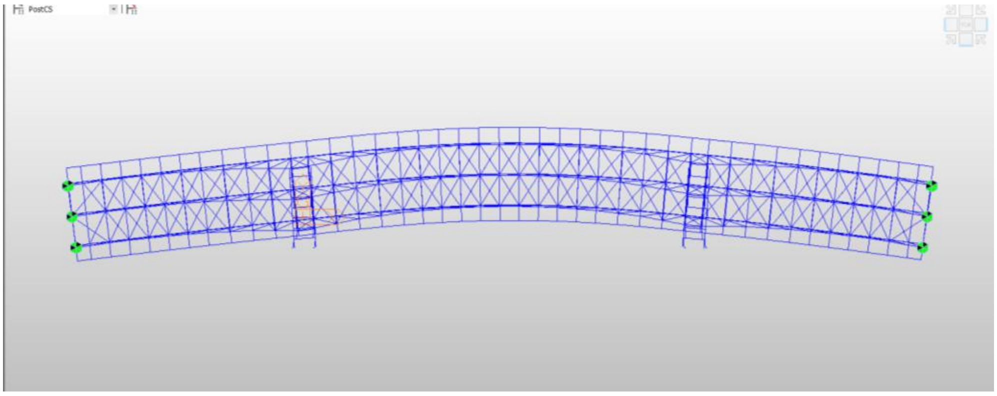

Fig9 third order vibration mode

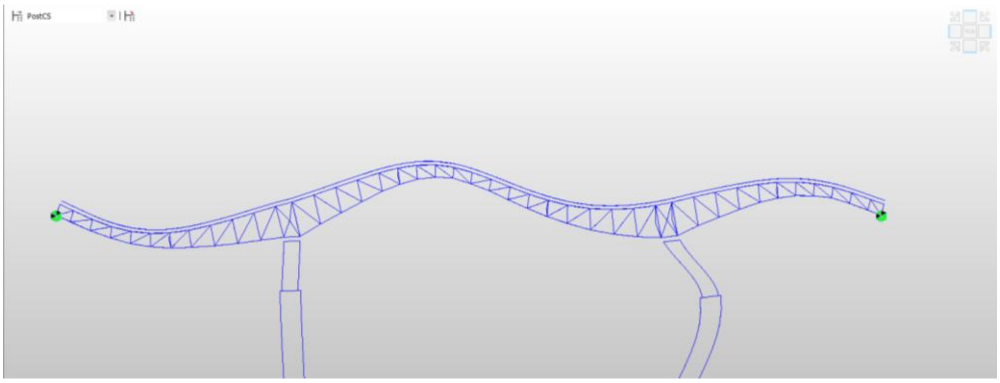

Fig10 forth order vibration mode

VI. Seismic response analysis

Based on the FEM model forward,we use design response spectrum and time-history method to calculate this bridge. The goal is to explore Seismic response characteristics of steel truss-concrete Combination continuous rigid frame bridge, and analyze the influence of earthquake to performance of bridge. For steel truss-concrete Combination continuous rigid frame bridge, the vibration response of bottom of pier , midspan, and the main girder is key reaction. Highway bridge seismic design code of China takes earthquake dynamic earth pressure and earthquake dynamic water pressure into account.

Table 2 the comparison of control sectionunder dead load and earthquake(KN)

control section	Dead load (My)	Dead load (MZ)	Earthquake (My)	Earthquake (Mz)
midspan	17404	4.7	6234	2142
Main girder	624	46	1867	4361
Bottom of pier	20431	82	8647	3427

VII. Summary and Conclusions

The earthquake characteristics of Qingqiyong Bridge can be concluded as follows:

(1)NO.1 of vibration mode is translational motion along the bridge,NO.2 of the mode is deck vertically and symmetrically bended. NO.3 of the mode is transverse deck.NO.4 of the mode is deck vertically and dissymmetrically bended

(2)The first vibration mode is translational motion along the bridge，the mode makes the all structure move along the bridge, the stiffness of pier is relatively smaller, it is because the precast concrete bridge deck is much heavier than steel truss, the stiffness of upper part is bigger than the stiffness of lower part .

(3)The third mode is transverse Deck,it is torsion vibration,the all structure get a Transverse move , pay attention to Mz when calculate seismic performance Higher mode has some influence on Internal force of steel truss-concrete Combination continuous rigid frame bridge, especially on shearing force of main tower We must calculate enough Modal order using design response spectrum, or else the Seismic response of structure will be underestimated. Earthquake has high proportion Contribution of main girder, especially My , it comes to 35% of dead load, We must pay attention to it when we have a design.

(6)The natural frequencies of Qingqiyong bridge are mainly concentrated in the scope that arranges from 0.H7z～5Hz. In the first 10 order vibrations, when subjects to load, first few order vibrations may be stimulated simultaneously, therefore, when mode superposition method is adopted to calculate the bridge dynamic response, multiple vibration modes should be considered simultaneously.

VIII. Acknowledgments

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