Seismic response analysis of tied arch bridge

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Abstract. Selecting the appropriate seismic response spectrum function, using the finite element software of Midas-Civil to establish the model of tied arch bridge. At the same time, the internal force and displacement response of the bridge key interface of the vertical is analyzed by using the response spectrum analysis method under the earthquake action.

Introduction

Earthquake is not only a serious threat to people's lives and property safety, but also will lead to a lot of secondary disasters[1,2]. The bridge engineering as an important part of traffic lifeline engineering, due to the collapse of the bridge structure and and the destruction of all kinds of infrastructure, which cut off the lifeline of the quake zone, caused great inconvenience for the earthquake region when the quake occurred[3,4]. Therefore, to improve the seismic performance of the bridge is an important measure to reduce the loss of earthquake, it is very important to analyze the seismic response of the bridge.

Model unit selection

In the process of modeling, using the space beam element to simulate the main arch and bracing, three-dimensional truss element is used to simulate the boom and tied. When dealing with the condition of boundary, the connection between the main girder and main arch ring we will adopt rigid connection. The rigid connection between the main arch ring and the main beam, the bearing and the main beam are adopted.

Response spectrum function determination

In this paper, the acceleration response spectrum of the horizontal design of the three dimensional model is shown as follows:

$$S = \begin{cases} S_{\max}(5.5T + 0.45)T < 0.1s & T < 0.1s \\ S_{\max} & 0.1s \le T \le T_g \\ S_{\max}(T_g / T) & T > T_g \end{cases}$$

In the formula, $S_{d\max} = 2.25 C_i C_s C_d A$, T_g is the response spectrum characteristic period, T is the self-vibration period of structure, C_i is the important factor of the seismic resistance, C_s is the site influence coefficient, C_d is the structural damping adjustment coefficient, A is the earthquake basic acceleration peak value.

The response analysis of the vertical bridge direction under earthquake action

The response analysis of the vertical bridge direction under earthquake action as shown in Figure 1-4 and table 1-2. Figure 1 is the axial stress nephogram of main beam and arch under earthquake action, Figure 2 is the bending moment nephogram, Figure 3 is the shear force nephogram, Figure 4 is the displacement nephogram. Table 1 is the displacement value of the main control points of the vertical bridge direction under earthquake action, Table 2 is the internal force value of the main control points of the vertical bridge direction under earthquake action.

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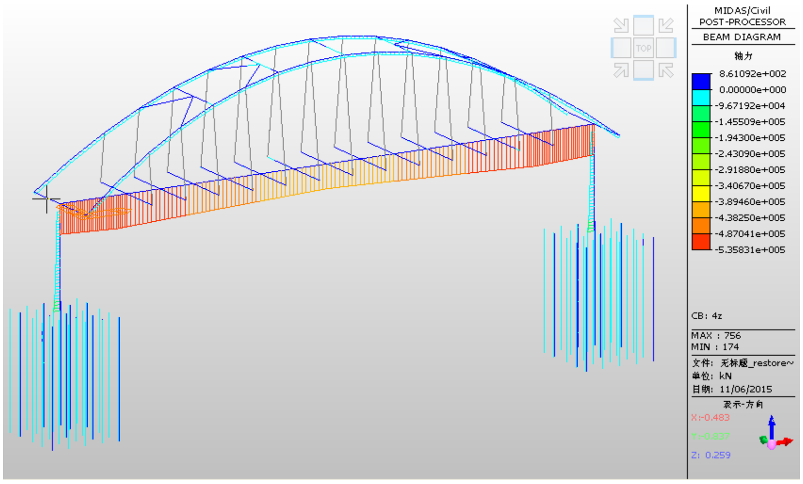

Fig 1. the axial stress picture of the bridge structure of the vertical bridge direction under earthquake action

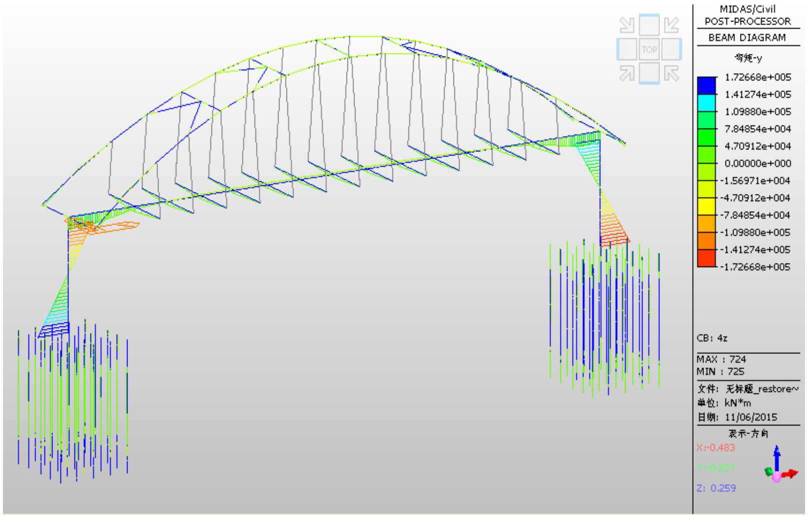

Fig 2. the bending moment picture of the bridge structure of the vertical bridge direction under earthquake action

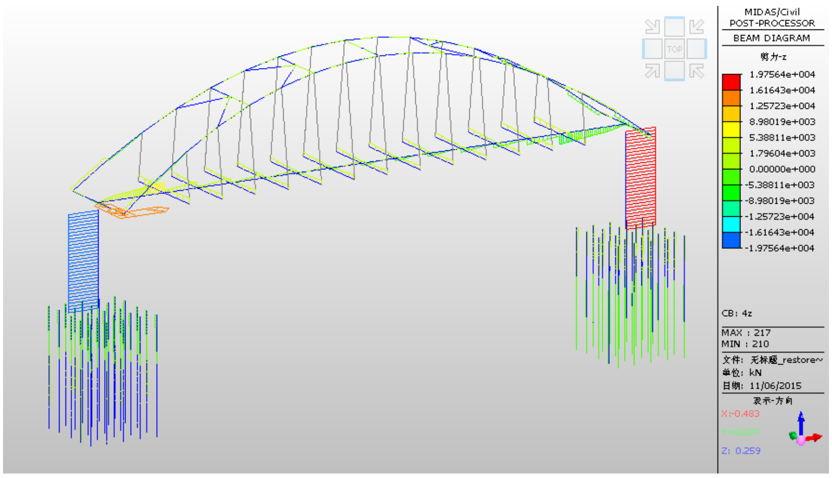

Fig 3. the shear force picture of the bridge structure of the vertical bridge direction under earthquake action

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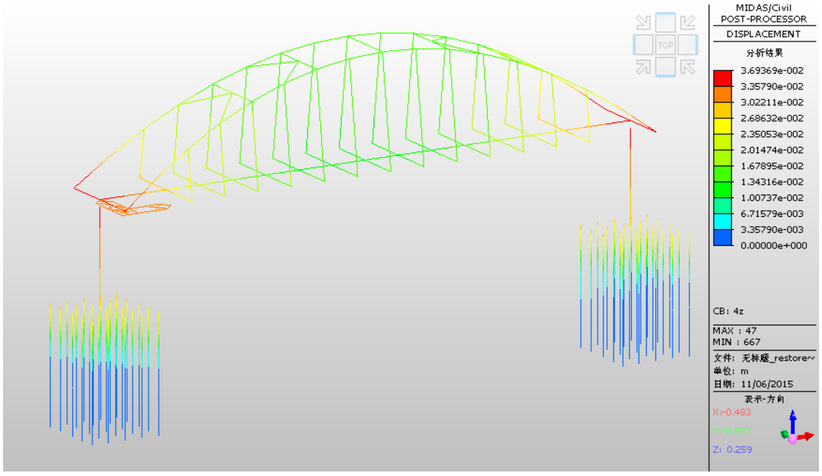

Fig 4. the displacement picture of the bridge structure of the vertical bridge direction under earthquake action

Table 1. the displacement value of the control points of the vertical bridge direction under earthquake action

displacement	arch foot （cm）	1/4 arch （cm）	vault（cm）	main beam （cm）
Longitudinal displacement DX	3.5	1.3	0.9	0
Lateral displacement DY	0.7	0.72	0.71	0.3
vertical displacement DZ	4.19	1.9	1.6	1.11

Table 2. the internal force value of the control points of the vertical bridge direction under earthquake action

internal force	arch foot （cm）	1/4 arch （cm）	vault（cm）	mid-span of main beam
axial stress（KN）	45791.3	40184.8	37977.7	419839.0
shear force -y（KN）	92.1	43.4	46.8	9.15
shear force -z（KN）	1963.7	115.7	15.7	1293.4
torque（KN*m）	52.5	15.3	12.6	525.3
bending moment-y （KN*m）	11645.0	367.1	381.5	10873.1
bending moment-z （KN*m）	243.6	470.5	68.3	24861.3

Through the analysis of Figure 4 and table 2, it can be seen that the vertical displacement is the major response displacement, followed by the vertical displacement, and finally is the transverse displacement, which under the action of vertical seismic load. The maximum vertical displacement of the main arch occurs at the arch foot and the value of the maximum vertical displacement is 4.19cm.The minimum vertical displacement of the main arch occurs at the vault and the value of the minimum vertical displacement is 1.6cm, and consistent with the law of gradual decrease from the

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arch foot to the vault. The maximum vertical displacement of the main beam occurs at the mid-span and the value of the maximum vertical displacement is 1.11cm under the action of the vertical earthquake. The maximum longitudinal displacement of the main arch occurs at the end of beam, which the vault is 3.5cm. From the above analysis we can see that the maximum load response is vertical displacement and longitudinal displacement, the lateral displacement responses is smaller, when the tied arch bridge structure under the vertical seismic action .

Through the analysis of figure 1-4 and table 1, the following conclusions can be obtained: earthquake response of axial force and bending moment(-y) of the bridge structure is greatest, the shear force (-y) and torque is the smallest, shear force(-z) and bending moment(-z) between the two, under the action of vertical seismic load. The axial force and bending moment in the vertical seismic response are consistent with the law of gradual decrease from the arch foot to the vault, the maximum value of the bending moment(-z) is in the position of the 1/4 arch and the value is 470.5. The maximum axial force of arch foot is 45791.3KN, and the vault axial force is 37977.7 KN. The maximum shear (-z) value of the arch foot is 1963.8KN, the maximum value of bending moment is 11645.0KN, and the minimum value of bending moment is 381.5KN. The bending moment, axial force, shear force and torque value of the main beam are also consistent with the law of gradual decrease from the arch foot to the vault, the cross axial force is 419839.0KN, the value of bending moment (-y) is 10873.1KN, because of the shear force was small and can be neglected.

Summary

(1) The maximum vertical displacement of the main arch occurs at the arch foot and the value of the maximum vertical displacement is 4.24cm.The minimum vertical displacement of the main arch occurs at the vault and the value of the minimum vertical displacement is 1.45cm, and consistent with the law of gradual decrease from the arch foot to the vault.

(2) Earthquake response of axial force and bending moment of the bridge structure is greatest, the shear force and torque is the smallest, shear force and bending moment between the two, under the action of vertical seismic load.

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