Great span continuous rigid frame bridge piers earthquake response analysis

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Abstract: In order to analyze the form of piers span continuous rigid frame bridge seismic impact on the order of a continuous rigid frame bridge engineering background, the use of large-scale professional finite element analysis software MIDAS CIVIL build dynamic analysis models were different cross-sectional forms modal pier analysis, using dynamic response spectrum analysis method to calculate the dynamic response of the structure, and comparative analysis of different results, the conclusions of large span continuous seismic analysis and design of the bridge just enough to provide relevant basis.

Introduction

Earthquake as a serious natural disaster, threat to humans as the human' material accumulating and growing. This article is based on "Seismic Design of Highway Bridges Rules" (JTJ / TB02-01-2008), using finite element software MIDAS CIVIL established a high pier continuous rigid frame bridge finite element model, using the dynamic response spectrum analysis of the bridge analysis of the seismic performance.

Project overview

The bridge is located Kunming Jiaozishan travel lanes highway span of 396m, the main axle 103 + 190 + 103 m Single Cell Box uniform continuous prestressed concrete rigid frame bridge with double thin substructure wall pier, bored pile foundation. The upper bridge main beam section is a single box single-chamber box section, box girder roof width 12m, bottom width 6.5m; the lower part of the main pier 2 are the same as the height of the cross-section of double thin - wall pier, pier height 104m, Two Legs and Thin sectional limb center distance 10.5m, vertical bridge to a single limb width 3.5m, the wall thickness of 0.6m, transverse width to a single limb 8.5m, the wall thickness of 1.0m, using C50 concrete pier body.

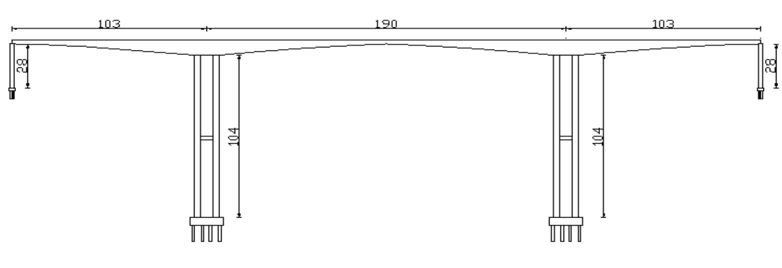

Fig. 1 Continuous rigid frame bridge finite element model

Calculated parameters

Permanent loads

(1)The 1st phase load :Take 26 concrete density.

(2)The 2nd phase load: include pavement, crash barriers, etc. are uniformly distributed load included, the total uniform load of 71.7KN / m.

accidental load

According to "Seismic Design of Buildings" (GB50011-2001) and "China Earthquake Zoning Map" (GB18306-20).

The bridge site area seismic reflection spectrum characteristic period is 0.4S, the basic design earthquake acceleration is 0.2g, corresponding to the basic seismic intensity of seven degrees.

According to "Seismic Design of Highway Bridges Rules" (JTG / TB021-01-2008) 9.3.6 provides concrete bridges, arch bridges damping ratio should be less than 0.05, so here take damping ratio was 0.05. According to seismic code 9.3.1, this seismic calculation using modal response spectrum method of calculation. Level design acceleration response spectrum is determined by the following formula:

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

$$S_{\max} = 2.25 C_i C_g C_d A$$

In the formulas A is a characteristic period,T vibration period of the structure, $S_{\max}$ is the maximum level design acceleration response spectrum, C_i is an important earthquake factor of 1.0, C_g is the site coefficient of 1.0, C_d is damping adjustment factor of 1.0, A is horizontal to the basic design earthquake acceleration peak.

Model

Establishing full bridge finite element model of the structure by using MIDAS CIVIL 2012 of an acceleration response spectrum analysis. With considerarion of the structure of the resistance along the bridge and Transverse Direction seismic action, use the CQC modal combination method. Meanwhile according to "highway bridges and culverts foundation and foundation design specification" (JTG D63-2007) provides that the use of the interaction between the soil and the soil pile spring simulation, as realistic as possible to simulate the pile foundation.

Analysis

Compare Solid with hollow pier pier

The piers of the model were uses two kinds-section in Figure 3, another for solid piers, one for the Hollow Pier. With the analysing of the model response under seismic response spectrum, the results shown in Table 1.

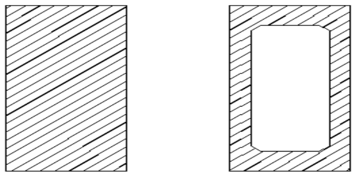

Fig. 2 Pier-section of

Table 1 Seismic Response solid and hollow pier pier

Pier form	Bridge baseband	Spectral response acceleration		Pier top displacement （mm)		Pier bottom moment（KN/M)		Pier bottom axis force	
		Along the bridge	Transverse Direction	Along the bridge	Transverse Direction	Along the bridge	Transverse Direction	Along the bridge	Transverse Direction
Solid Pier	0.216	0.275	0.232	149	89.9	94127	120056	13934	2350
Hollow Pier	0.218	0.263	0.208	139.9	82.7	70744	84562	10586	1524

Table 1 can be seen when the same external dimensions piers were solid and hollow pier pier, the hollow pier fundamental frequency, spectral response acceleration, displacement and internal forces pier at the end of the pier top are less than solid pier, we can see, under the effect of the earthquake, hollow pier has an better than a solid pier seismic effect.

piers comparison of different cross-sectional dimensions

The piers of the model uses 8.0 * 3.5,8.0 * 4.0,8.0 * 5.0,8.0* 4.5 and four cross-sectional dimension, resulting in seismic response as shown in Figure 4 below:

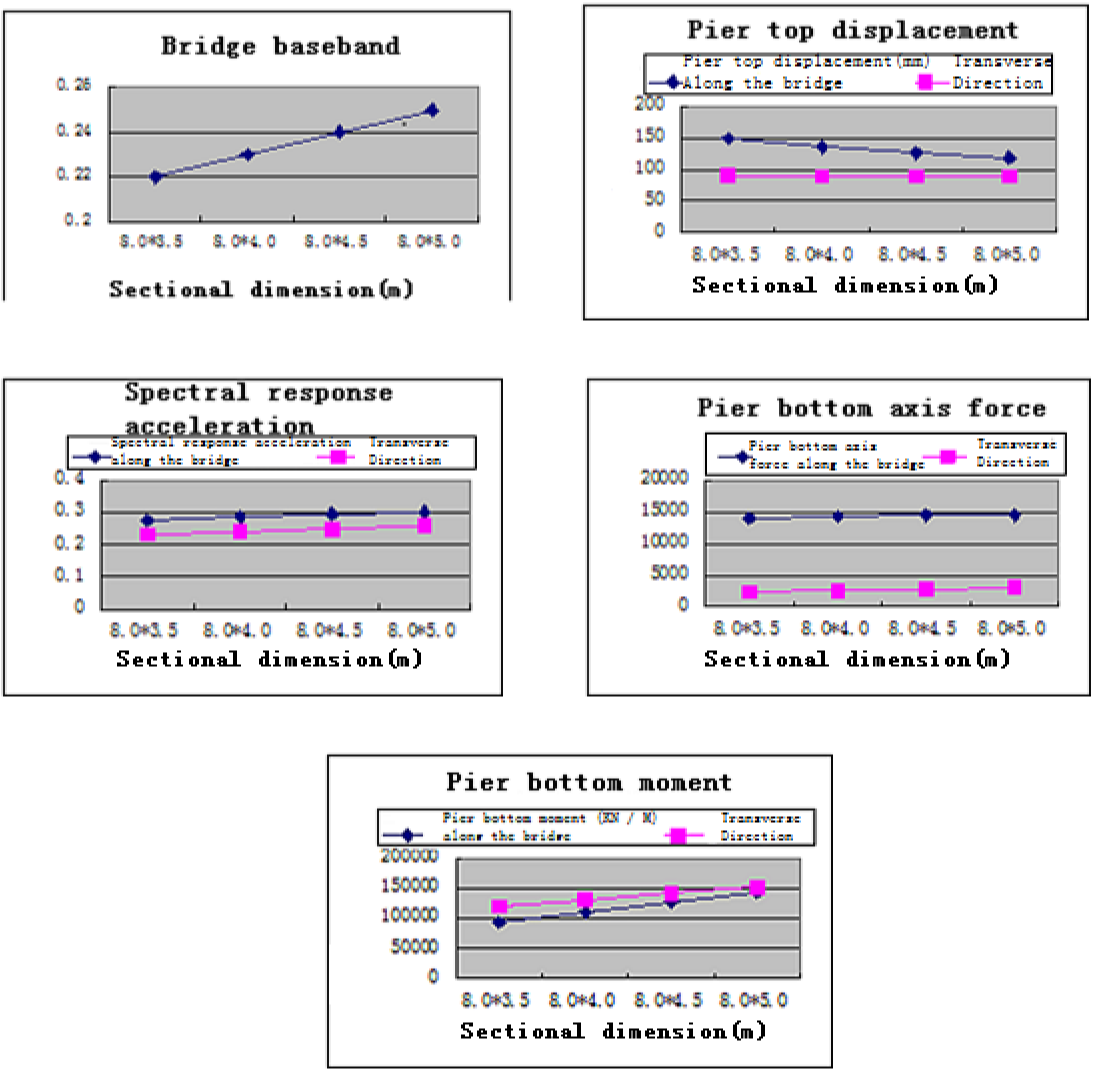

Fig. 3 Bridge pier seismic sectional dimensions vary with circumstances

As can be seen from Figure 3, the increased cross-sectional dimensions of the pier, although the pier top displacement value will be reduced, but the displacement is not obvious; while the larger cross-sectional dimension piers, the bridge, the greater the stiffness, the more the fundamental frequency large, dynamic response spectrum greater the acceleration, and increased cross-sectional dimensions of the pier will make the seismic response of the internal forces at the end of the pier becomes large. So from the point of view of seismic design, increased cross-sectional dimensions piers, would adversely earthquake.

Pier-section comparison

Were used to model a single rectangular pier 8.0 * 7.0, 6.16m diameter circular and rectangular pillar pier Pier of Double Thin 8.0 * 3.5, three-section of the area are equal, the results in the table below under seismic response as follows:

Table 2 seismic response under different sections of the pier forms

Pier form	Bridge baseband	Spectral response acceleration		Pier top displacement(mm)		Pier bottom moment（KN/M)		Pier bottom axis force	
		Along the bridge	Transverse Direction	Along the bridge	Transverse Direction	Along the bridge	Transverse Direction	Along the bridge	Transverse Direction
Thin-walled pier	0.216	0.275	0.232	149.0	89.9	94127	120056	13934	2350
Rectangular Pier	0.260	0.292	0.240	109.0	83.7	233447	30169	2036	2468
Round pier	0.265	0.295	0.240	103.3	86.7	234668	29065	2177	2346

Table 2 shows the result of a single rectangular piers in the three-section compared to double thin wall pier, the fundamental frequency is large, the reaction in the seismic response of a larger spectrum of acceleration, the internal forces at the end of the pier is greater, so double thin - wall pier than single rectangular pier has better seismic performance, and compared to a circular pier, the pier in seismic response of rectangular spectral response acceleration at small point, the end of the pier top displacement and internal forces of the pier or less.

Summary

Horse across the river through the earthquake response analysis of rigid frame bridge can draw the following conclusions:

1, In static structural bearing capacity to meet the design, the hollow pier with respect to the solid pier has better seismic performance.

2, In the bridge seismic design, focusing on the concept of seismic ductility, ductility plays an important role in the bridge, and control the stiffness of the piers of the bridge seismic response, but also should consider the requirements of structural shifts in the seismic response of the bridge.

Acknowledgements

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Reference:

[1] The People's Republic of China Ministry of Construction .GB50011-2001 "Seismic Design of Buildings" [S] Beijing: China Building Industry Press .2002

[2] Highway Planning and Design Institute Limited .JTG D63-2007 "highway bridges and culverts foundation and foundation design specifications" [S] Beijing: China Communications Press .2007

[3] Chongqing Communications Research and Design Institute of .JTG / TB021-01-2008 "Seismic

Design of Highway Bridges Rules" [S] Beijing: China Communications Press (2008)

[4] Zhong Aijun, Guan country "bridge seismic" [M] Beijing: China Communications Press .2011

[5] Fan Lichu, Zhuo Weidong "bridge ductile seismic design" [M] Beijing: China Communications Press .2001