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Seismic Performance of Prefabricated Continuous Girder Bridge

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Abstract

Bearings are the weak link in the seismic design of bridges. Taking a continuous girder bridge as a calculation example, it is proved that the bearing damage of bridges is considered under the conditions of large earthquakes. That is, the bearing, as a fuse-type unit, can be preferentially damaged to control the beam displacement and the pier effectively. Earthquake response at the bottom.

Keywords

Cable stayed bridge; Seismic analysis; Dynamic performance; Structural design.

1. INTRODUCTION

In recent years, there have been many strong earthquakes around the world, which not only caused heavy casualties, but also damaged urban infrastructure, especially bridge structures, resulting in huge property losses. The research work on the problems related to the seismic resistance of bridge structures has become particularly urgent.

2. PROJECT OVERVIEW

Taking the five-span prestressed concrete continuous girder bridge as the engineering background, the span is arranged as 96+3×160+90 meters. The upper part of the main bridge adopts five-span prestressed concrete variable-height straight web continuous girder, single box and single room. The width of the top plate of the single box girder is 13.50m, the width of the bottom plate is 7.0m, and the width of the cantilever is 3.25m. The beam height is 8.5m at the main pier, and 3.5m at the mid-span of the main span and the end of the side span. The main pier of the lower structure adopts a cylindrical solid pier with a cap beam, with a diameter of 5m. The upper box girder is made of C55 concrete, and the pier cap and pier body are made of C40 concrete. The seismic performance of the bridge under earthquake action is analyzed. The finite element program MIDAS Civil is used to establish a three-dimensional finite element model of the whole bridge, and the seismic performance of the bridge under earthquake action is analyzed, as shown in Figure 1. The influence of the bearing damage and the nonlinearity of the limit device on the elastic-plastic seismic response of the bridge structure is analyzed. Not only the element hysteresis curve model that can comprehensively consider the bearing damage, the contact with the limit device and the material nonlinearity, but also the element hysteresis curve model is proposed. It is confirmed that when the movable support loses its sliding performance, that is, it is damaged and contacts with the limiting device, it can not only limit the displacement of the beam body, but also effectively reduce the seismic response of the fixed pier.

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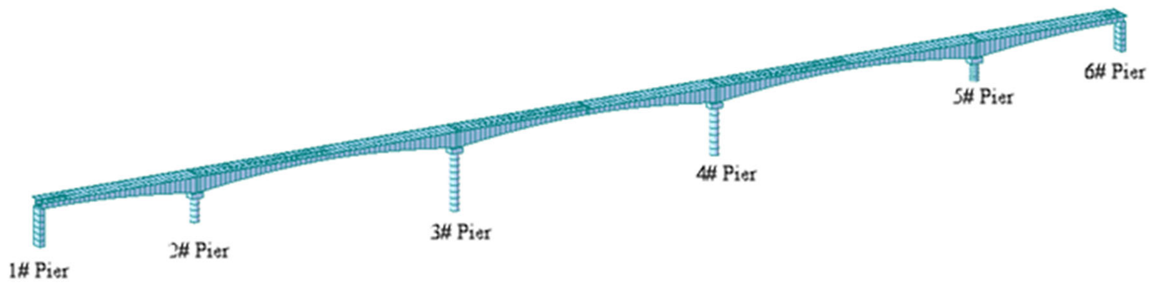

Figure 1. Structural calculation finite element model

3. STRUCTURAL FINITE ELEMENT MODELING

In the calculation and analysis, the interaction of the foundation, the pile foundation and the pile-soil structure is not considered, the pier bottom is consolidated with the ground, and the limit device is used to simulate the bearing damage (see Table 1). The piers adopt nonlinear elastic-plastic elements, and the nonlinear deformation law adopts the modified Takeda calculation model (Modified Takeda Type). Diameter of circular section. In order to simplify the analysis, the effect of the collision force is omitted in the finite element model, the limit devices are arranged along the transverse direction of the bridge, and only the seismic response of the transverse direction of the bridge is studied.

Table 1. Bridge Model Boundary Conditions

Location	DX	DY	DZ	RX	RY	RZ
Pier 1#	1	1	1	1	1	1
Pier 2#	1	1	1	1	1	1
Pier 3#	1	1	1	1	1	1
Pier 4#	1	1	1	1	1	1
Left end of beam	0	1	1	1	0	1
Right end of beam	0	1	1	1	0	1

Note: “0” represents free, “1” represents a constraint.

(1) Case 1: Ignore the friction of the support, referred to as the pier elastoplastic scheme, which is the usual scheme for continuous girder bridges to perform elastoplastic seismic analysis.

(2) Case 2: Consider the friction of the active support, do not consider the role of the limit device, referred to as the support friction scheme. The support is simplified to an ideal elastoplastic model, and the friction coefficient of the active support is μ_d=0.02, the yield displacement is x_y=0.005, and the stiffness after the support slides is 0.

(3) Case 3: After the support slides for a certain distance, the limit device prevents it from sliding relatively, and does not consider the destruction of the limit device, that is, according to the elasticity consideration, referred to as the elastic limit device scheme. The initial displacement of the support limit device is 0.1m.

(4) Case 4: The limit device enters the shaping state, or the support undergoes shear failure, referred to as the nonlinear limit device scheme. This scheme is achieved by adjusting the critical yield force and stiffness of the limit device in the model.

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4. MODEL OF THE MOVABLE SUPPORT UNIT OF THE FINITE DEVICE

Under the action of earthquakes, the range of activity of the support with the support limit device is limited, and when the longitudinal deformation of the girder bridge is large, it may cause collision contact problems, so that the connecting components such as the support and limit device between the main girder and the pier of the substructure may enter a nonlinear state. This process can be described in the following five points:

(1) The movable support does not start to slide, the support is in an elastic state, and the bridge pier is elastically connected to the main beam.

(2) The movable bearing begins to slide, but the stiffness of the bearing is small and can be ignored, and there is only friction between the pier and the main beam.

(3) When the displacement reaches a certain level, the movable support continues to slide, the limit device starts to work, the bridge pier and the main beam are connected through the limit device, and the transmission force is the sum of the friction force of the movable support and the force of the limit device.

(4) The movable support continues to slide, the limit device becomes nonlinear, and the transmission force is still the sum of the friction force of the movable support and the force of the limit device.

(5) The main beam moves in the opposite direction and unloads it.

A sliding friction element (ideal elastic-plastic model) is used to simulate the movable bearing, and a bearing element that can consider both the friction of the bearing and the dual nonlinear effects of the limit device is established according to the characteristics of the sliding friction element and the collision contact element.

5. DYNAMIC CHARACTERISTICS CALCULATION AND ANALYSIS

Select El Centro wave (peak acceleration 0.3569g, duration 53.72s) and expand the factor of 2 to simulate large earthquake conditions, respectively input the combination of horizontal + vertical (2/3) and vertical + vertical (2/3) combination Earthquake.

By calculating the dynamic characteristics of the bridge, it can be seen from Figure 2 and Figure 3 that:

(1) When scheme 1 is adopted, the bending moment and curvature of the pier bottom of each bridge pier is the largest, and it enters a plastic state in an all-round way, which is very likely to be damaged. When scheme 2 is adopted, the bending moment and curvature of each pier bottom are the smallest.

(2) When scheme 3 is adopted, considering the friction of movable supports and the elastic effect of limit device, the bending moment and curvature of each pier bottom are compared with scheme 2 and 4, and the internal force of movable piers 2# and 5# The change is very obvious.

(3) When scheme 4 is adopted, considering the friction of movable supports and the nonlinear effect of the limit device, the section bending moment and curvature of the bottom of each pier are reduced compared with scheme 3, but the plastic middle movable pier The curvature of the pier bottom hardly changes, while the curvature of the fixed pier bottom decreases by 22.8%, which is very obvious. It shows that when the limit device enters the nonlinearity, more ground motion energy is dissipated, thereby effectively reducing the seismic response of the fixed pier bottom.

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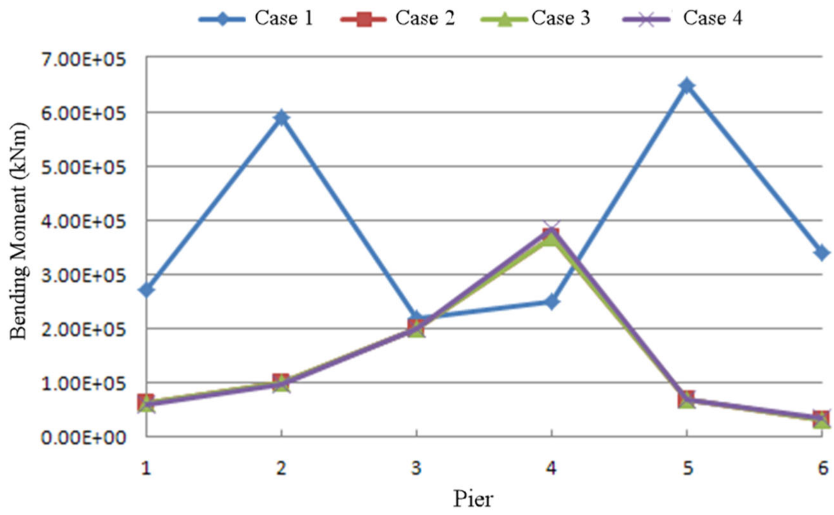

Figure 2. Bending moment at the pier bottom in longitudinal and vertical ground motion

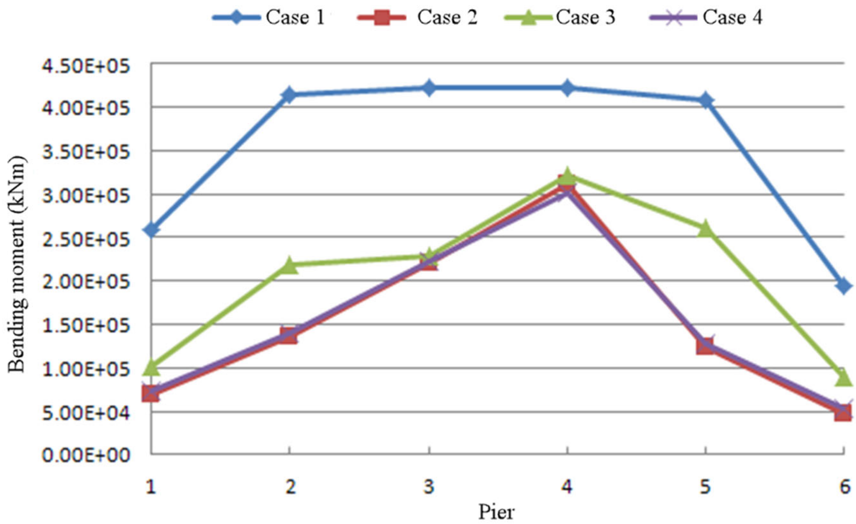

Figure 3. Bending moment at the pier bottom in horizontal and vertical ground motion

6. CONCLUSIONS

In this paper, a finite element model for the overall calculation of the bridge considering the elastoplasticity of the bearing, the limit device and the pier body is established and the seismic response analysis is carried out. The results show that:

(1) Under the condition of large earthquake, when the movable bearing loses the sliding performance, it is very likely to cause the damage of the bridge pier. In the seismic design, it is necessary to configure a certain amount of steel bars for the bridge pier to ensure its ductility.

(2) The use of limit devices can effectively limit the displacement of the beam body, reduce the seismic response of the fixed piers, and at the same time balance the distributed seismic force between the piers.

(3) When the movable support loses sliding performance and comes into contact with the limiting device, it can not only limit the displacement of the beam body, but also effectively reduce the seismic response of the fixed pier.

(4) For different bridge structures, by changing the initial distance between the limit device and the movable support, the stiffness and yield strength of the limit device, as well as the friction coefficient and stiffness of the support, it is possible to seek to effectively prevent the upper part. It is an optimal solution that the structural displacement is too large, the seismic

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response of the fixed piers can be reduced, and the balanced distribution of the input energy of the ground motion among the piers can be obtained.

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