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To cite this article: Bin Ma *et al* 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **234** 012010

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Seismic Response research of Mufti-span Continuous Girder with Column Pier

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Abstract. In order to research the seismic responses of the continuous girder with double-column usually used in medium and small span bridges, the dynamic model was established by using the finite element program Midas. The seismic responses data such as the displacement of beam end and pier top, the horizontal force of fixed supports, the shear force and bending moment of the pier bottom were analyzed in the comparison of different spans, pier heights and column diameters of continuous girder. Conclusions are as follow: the longitudinal seismic response in continuous beam bridge is little affected by the spans, while the transverse seismic response is significantly affected. The transverse maximum horizontal force of fixed support is larger than the longitudinal, which indicates that fixed supports of the abutment are more likely to be destroyed. The shear force and bending moment of the transverse pier bottom are both larger than the longitudinal. Rectangular pier can be chosen to make full use of the material performance, which is beneficial in the seismic design. The research can provide references for the seismic design of this kind of bridge.

1 Introduction

In recent years, earthquakes were frequently occurred in our country. A large number of the survey data shows that most of the bridge damage happened after the Wenchuan earthquake. For example, the expansion device was destroyed in the longitudinal bridge, concrete girder was cracked, sliding support lead to void of girder and the bending-shear failure was occurred or crushed at the end of beam, excessive movement of the main beam lead to lowering of gird in the pier column. It can be seen that the connecting device of continuous girder were more likely to be destroyed in the earthquake, causing greater damage. Therefore, it is necessary to investigate the seismic response of the continuous bridge by the different load condition, considering the sliding friction of the support and studying seismic response of continuous beam bridge.

2 Engineering Background

Based on the practical engineering, the superstructure of the bridge is two-celled single box girder with the height of 25m, Deck width is 12m, which is made of 8cm C40 concrete and 8cm asphalt concrete pavement. The substructure is designed in the pile column pier. The friction pile foundation is the length of 45m. The pot rubber bearing is adopt in the support of the box girder. The vertical bearing capacity of the abutment support and the pier support are 1800kN and 4800kN respectively. C40 concrete is used in the main girder of the superstructure, C30 concrete is used in the substructure



and C25 concrete is used in cushion, cap and bored pile. The level of design load is highway-II and seismic fortification intensity is VIII degree.

3 The Finite Model

Finite element model was established by the finite element software MIDAS. Timoshenko beam element was calculated in the model of the main girder of the superstructure and the pier column of substructure. Soil spring element was analyzed in the interaction between pile and soil, the stiffness of soil spring was calculated by m method. The yield displacement of pot rubber bearing was 3mm and ratio damping was 0.05 in the time-history analysis.

According to the assessment report of the whole project, the artificial seismic waves were provided in this paper and the maximum response of the earthquake wave was selected. The peak acceleration is 0.313g.

4 Parametric Analysis of Seismic Response

In order to study the seismic response of the continuous bridge with different pier heights, spans and pier diameters, the parametric analysis was carried out in two cases.

Keeping the pier diameter as a constant 1.2m, the seismic response was studied by the pier height of 5m, 10m, 15m, 20m, 25m and 30m in the continuous girder of three-span, four-span, five-span and six-span respectively. On the other hand, when the continuous beam was five-span, the seismic response in the continuous beam was analyzed by the pier height of 5m, 10m, 15m, 20m, 25m and 30m with the pier column diameter of 1.2m, 1.5m and 1.8m respectively.

The seismic responses were investigated in the longitudinal and transverse of the continuous girder such as the maximum displacement of the beam end, the maximum displacement of the pier top and movable support of the pier top, the horizontal force of fixed support, the maximum shear force and bending moment of pier bottom.

4.1 The Seismic Responses Analysis of the Continuous Girder by Different Spans and the Height of Pier

Visual simulation has powerful information integration, performance capabilities, user-friendly expression, interactive performance and strong secondary data analysis capability. This paper used the visual simulation method to design transport simulation system about saline water and salt transport in.

4.1.1 The Longitudinal Analysis. The most unfavorable values of seismic response were given in Fig.1 by different pier heights and spans under seismic wave along the longitudinal continuous girder.

As shown in Fig.1, the maximum displacement of beam end increased at first and then decreased with the increase of pier heights. The seismic response of pier height 20m and six-span continuous beam bridge were the largest, it can be seen that the maximum displacement value of beam end was 101mm. Fig.2 demonstrates the maximum displacement value of beam end was observed at time of 5.06s, the residual displacement was 12mm after seismic wave loading. The maximum displacement of pier top movable support was largest in the condition of six-span continuous girder bridge with high pier height 5m, the maximum value was 57mm. From Fig.3, it can be seen that the maximum displacement value of movable support observed at time of 5.65s, the residual displacement not happened. The horizontal force of fixed support was the largest in the condition of six-span continuous girder with the pier height of 5m, which decreased rapidly with the pier height from 5m to 10m. The maximum value was 548.96kN, which was about 15% of the vertical bearing capacity. The anchor bolt of the support could not be damaged.

The maximum shear force and bending moment of the pier bottom were the largest at the pier height of 5m, which decreased with the increase of pier height and declined rapidly from 5m to 10m. The bending moment and the shear value were large when the height of the pier column was short, which indicated that the bending failure, bending-shear failure and shear failure may be occurred. Therefore, Some measures should be taken.

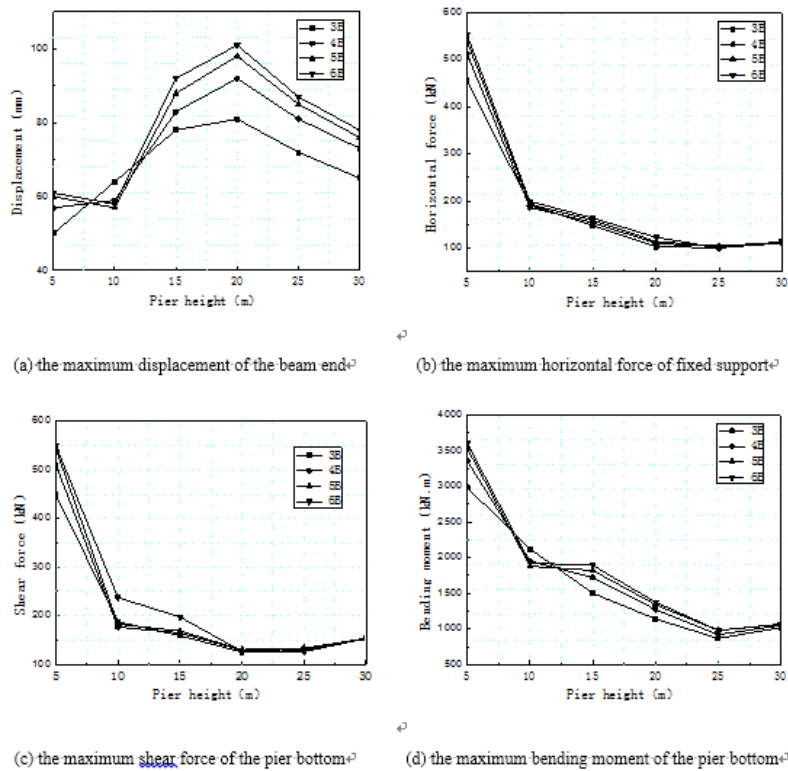


Fig.1. The seismic responses of the longitudinal continuous bridge by different combination of pier height and spans

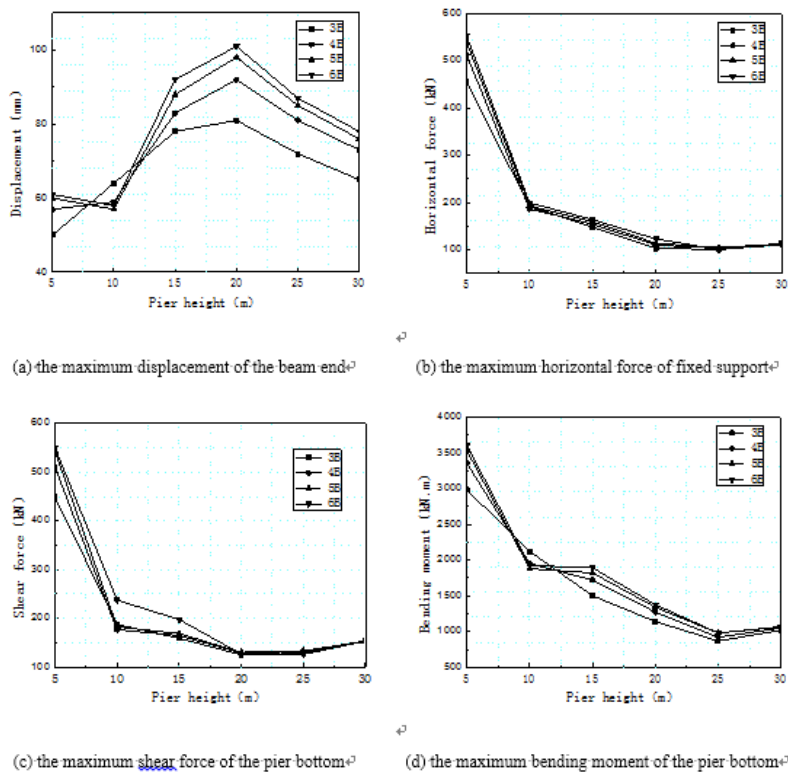


Fig.2. The maximum displacement time-history of beam end

Fig.3. The maximum displacement time-history of pier bottom movable support

4.1.2 The Transverse Analysis. The most unfavorable values of seismic response are given in Fig.4 by different pier heights and spans under seismic wave along the the transverse continuous girder.

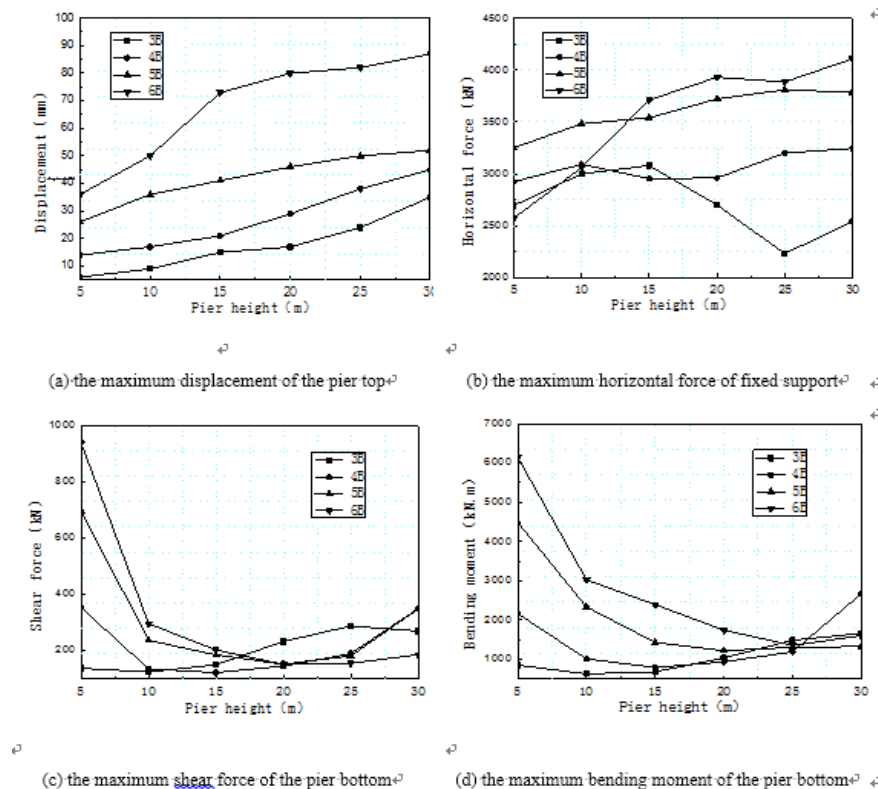


Fig.4. The seismic responses of transverse continuous girder by different combination of pier heights and spans

From Fig.4, it can be seen that the seismic responses of the transverse continuous girder were the largest by the spans and changed differently by pier heights. The maximum displacement of pier top was occurred in the far away from the abutment piers, which increased with the increase of pier heights and spans. The maximum displacement of the movable support of pier top increased with the increase of the pier height in the condition of the 3-span or 4-span continuous girder, which changed differently in the 5-span or 6-span continuous girder. In general the maximum displacement of pier top movable support was the largest in the condition of 5-span continuous girder bridge with pier height 30m, the value was 66mm. The horizontal force of the fixed support in abutment was the largest, which was decreased uneven as the pier height decreased in the three-span continuous beam bridge. The horizontal force of abutment fixed supports was 2000kN at least, which was greater than the vertical bearing capacity 1500kN of the support, the support anchor may will be destroyed, causing bearing off. According to the finite analysis, the seismic responses rules of the transverse and longitudinal can be summed up by the combination of different spans and the pier height. The seismic response of the longitudinal was little affected by the spans, yet the transverse's was significantly influenced. The maximum horizontal force of the fixed support decreased as pier heights increased under the longitudinal earthquake action, which changed differently by the spans varies with the height of the bridge under the transverse earthquake action. The horizontal force of the transverse fixed support was much larger than the longitudinal, which was easy to be damaged. The maximum shear forces and bending moments of the longitudinal decreased with increase of the piers height, while the transverse's changed differently by the spans varies. It is unfavourable to the force of the longitudinal

pier in 3-span or 4-span continuous girder, while it is unfavourable to the force of the transverse in 5-span or 6-span continuous girder.

4.2 The Seismic Responses Analysis of the Continuous Bridge by Different Column Diameter and the Height of Pier

4.2.1 The Longitudinal Analysis. The most unfavorable values of the longitudinal seismic response were given in Fig.5 by the five-span continuous girder and the pier height of 1.2m,1.5m and 1.8m respectively. As shown in Fig.5, the seismic response of the continuous beam bridge with different pier diameter varies slightly with the pier heights, but the overall trend was basically same. The displacement response of the same height pier was changed irregular with the increase of the diameter of the pier column. The horizontal force of fixed support, shear force and bending moment of pier bottom increased with the increase of the pier column diameter with the pier height unchanged. When the piers height was low, the shear and bending moment of piers increased quickly as the diameters increase, causing brittle failure.

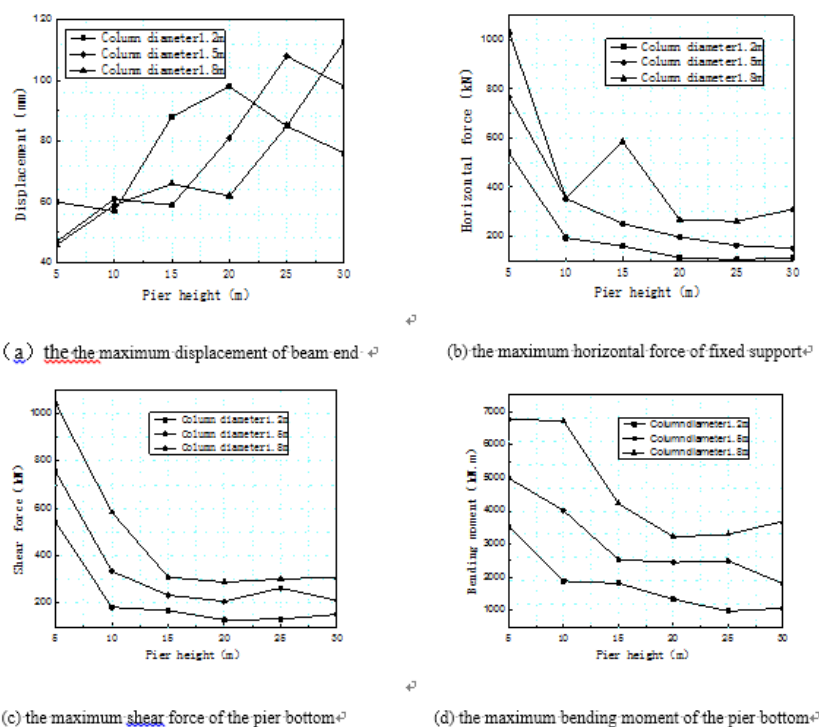


Fig.5. The seismic responses of longitudinal continuous girder by different combination of pier heights and column diameters

4.2.2 The Transverse Analysis. The most unfavorable values of the transverse seismic response were given in Fig.6 by the five-span continuous girder with the pier height of 1.2m,1.5m and 1.8m respectively.

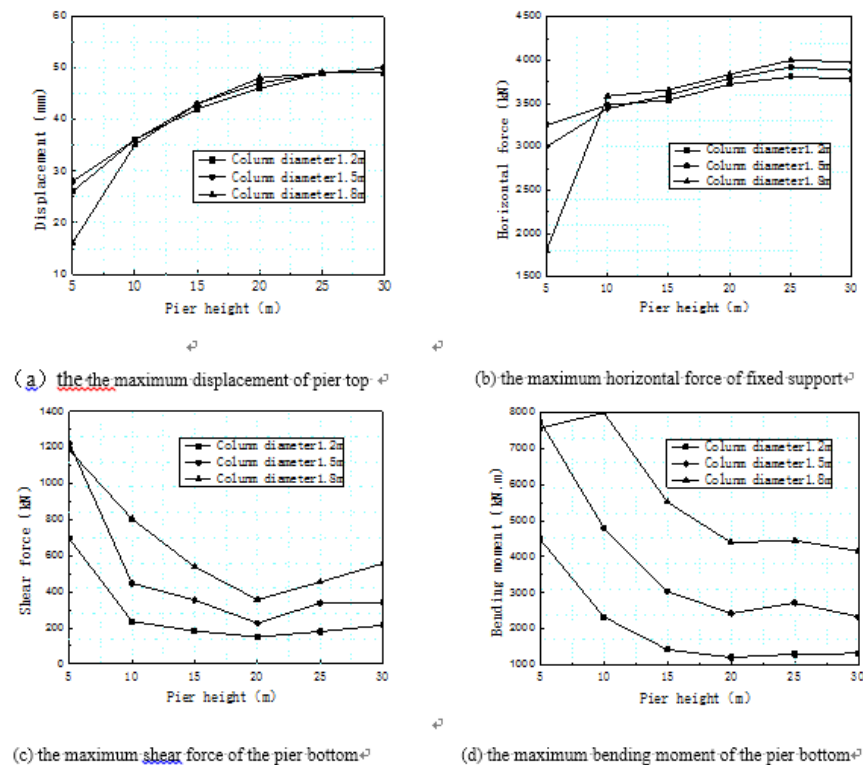


Fig.6. The seismic responses of transverse continuous girder by different combination of pier heights and column diameters

From Fig.6, it can be seen that the seismic response of the continuous beam bridge with different pier diameters varies slightly with the pier height, but the overall trend was basically same. When the pier height increased to 15m, the maximum horizontal force of pier top was little affected and changed slowly by the column diameters, so does the the maximum horizontal force of fixed supports. The maximum shear and bending moment of the pier bottom increased with the increase of the pier stiffness.

According to the finite analysis, the seismic responses rules of the transverse and longitudinal can be summed up by the combination of different column diameters and the pier heights. When the pier height increases to the certain height, the maximum displacement of the pier top was unchanged with the column diameter changes, nor does the longitudinal. The maximum horizontal longitudinal force of fixed supports decreased as the pier stiffness decreases, while the transverse's increased. When the pier height increased to 10m, the maximum horizontal force of fixed supports was little affected and changed slowly. The maximum shear and bending moment of the pier bottom increased with the increase of the pier stiffness. The shear force and bending moment of the transverse pier bottom were both larger than the longitudinal.

5 Conclusions

This paper discusses the seismic responses of the continuous girder based on practical engineering under earthquake. Based on the finite results obtained, the following conclusions can be draw:

- The longitudinal seismic responses was little affected by the spans, while the transverse's was significantly affected.
- The maximum horizontal transverse force of fixed support was much larger than the longitudinal, which was easily to be damaged especially in the abutment.
- the shear force and bending moment of the transverse pier bottom were both larger than the longitudinal. Rectangular pier can be chosen to make full use of the material performance, which was beneficial in the seismic design.

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