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Adjustable Slope-shaped Bearing and its Quick Installation Method for Long and Large Longitudinal Slope Bridges with High Piers

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Abstract

With the rapid development of society, the number of bridges in China has increased rapidly. Under various complex environmental conditions, the construction and maintenance of bridges become more complicated. Bearings are the most vulnerable part of a bridge, and due to multiple factors, pier bearings tend to be on the small side, susceptible to damage, and difficult to install and maintain. In this paper, a method for customizing special slope bearings according to the slope requirements of different piers is proposed. As long as the installation position and direction of the bearing are correct under the premise of standard construction, the slope requirements of the bridge can be met, the self-recovery performance of the long longitudinal slope bridge after sliding can be realized, the structural safety can be guaranteed, the durability of the sloping bridge can be improved, and the maintenance cost of the bridge in the later stage can be reduced.

Keywords

Bridges; Pier; Customized Bearings; Slope Bearings.

1. Engineering Background

According to statistics, as of 2021, the total number of highway bridges in China has reached 735,300, and the total number of railway bridges of various types has also reached 180,000, which even exceeds the cumulative construction of the past few thousand years [1]. Many road and railway bridges require a lot of manpower and material resources for maintenance and management after they are completed. However, due to the lack of attention to some bridges, a lot of maintenance work has been neglected, resulting in a worrying state of use for many bridges [2].

In the bridge structure, especially at the junction of the bridge and the pier, the bridge bearing is often the part that is prone to damage and cause accidents. Due to economic considerations, bridge supports often have a small length and width, resulting in a limited contact area with the beam body. These factors can easily lead to bridge accidents due to problems such as vehicle overload, eccentric loading, and foundation settlement [3,4]. Therefore, it is of great significance for the study of supports.

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High-speed mountainous area, high mountain valley deep, long longitudinal slope of high pier bridge is relatively more, traditional bridge slope construction method: when the site prefabricated T beam, small box girder, the bottom of the beam should be embedded with steel plate, generally in the bottom of the beam steel plate to carry out pre-embedded slope adjustment, there are also some bridge slope construction using beam bottom prefabricated concrete wedge-shaped block slope adjustment.

When the embedded steel plate at the bottom of the beam is installed accurately, and the support is installed horizontally, as shown in Figure 1, the gravity G is transmitted to the substructure by the support, and the support is stressed vertically, and the horizontal component force will not be generated.

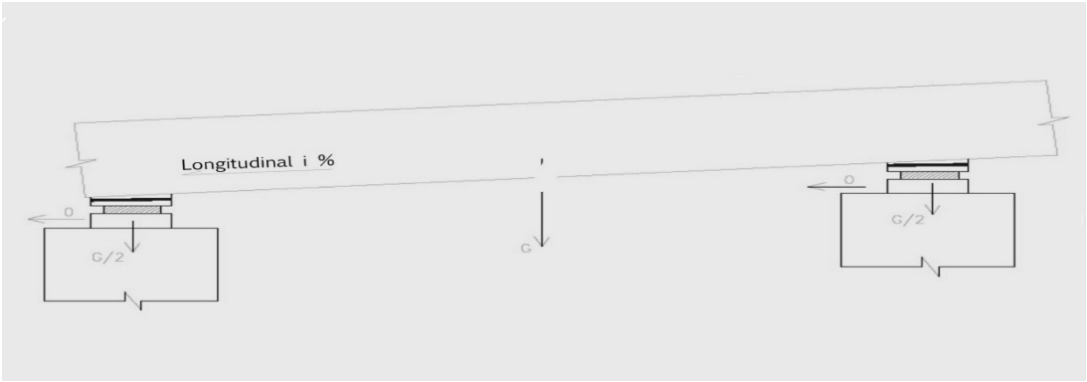

Figure 1. Schematic diagram of the force on the bridge bearing

When the embedded steel plate at the bottom of the beam is not installed horizontally, the roof of the bridge bearing is not horizontal, or the bottom plate of the support is not installed horizontally, the superstructure load produces the horizontal component of the uphill direction of the support (as shown in Figure 2) The plate slides into the PTFE sliding plate, causing the shear damage to the PTFE sliding plate, and the horizontal component continues to promote the pier stud offset, resulting in the bridge pier stud deviation, beam body slippage and the beam body and the support detachment and other diseases, seriously threaten the bridge operation safety.

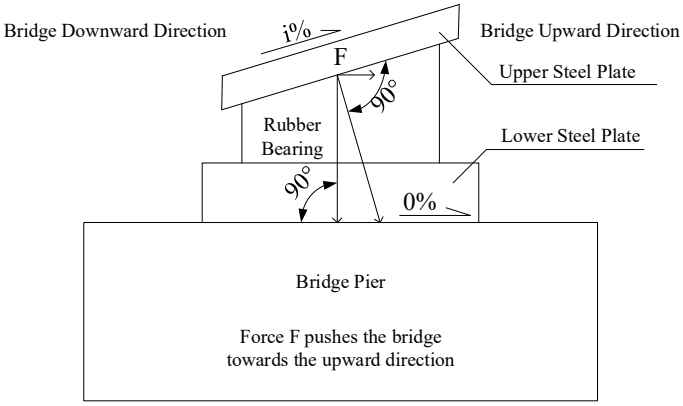

Figure 2. Schematic diagram of the slip force of the support

In general, the traditional bridge slope construction method requires high precision, high cost and difficult maintenance in the later stage. Based on the problems existing in the slope construction of traditional bridges, in order to ensure the construction accuracy and reduce the difficulty of control, and improve the efficiency of beam prefabrication, the bearings are customized according to the slope requirements of different bridge piers, and the beams are erected under the premise of normal construction, so as to ensure that the installation position and direction of the bearings are correct, the

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bridge slope requirements can be met, the long-term performance of the long longitudinal slope bridge can be realized after sliding, the structural safety is ensured, the durability of the slope bridge is improved, and the safety of the bridge operation in the later stage is reduced.

2. Adjustable Slope Bearing

2.1 Customized Slope Basin Bearing Structure Composition

The custom slope bearing is composed of the upper seat plate of the custom slope bearing, the stainless steel slide plate, the intermediate steel lining plate, the bearing rubber plate, the lower seat plate of the bearing, and the bolt assembly under the bearing.

2.2 Slope Customization

At present, there are many height-adjusting methods used at home and abroad, and most of the support height-adjusting schemes are combined with several basic supports, and a height-adjusting device is added to the bearing, so as to achieve the purpose of height-adjustment, and the height-adjusting methods mainly include four ways: backing plate height, spiral height, wedge height, and filling elastic material height-adjustment [5,6].

In this paper, according to the slope parameters of each pier number, the height difference of the four corners of the support (calculated according to the four corner sizes h1, h2, h3, h4) is designed to make the longitudinal and transverse slopes of the upper plate of the bearing consistent with the longitudinal and transverse slopes of the bridge, so as to ensure the horizontal stress and displacement of the support.

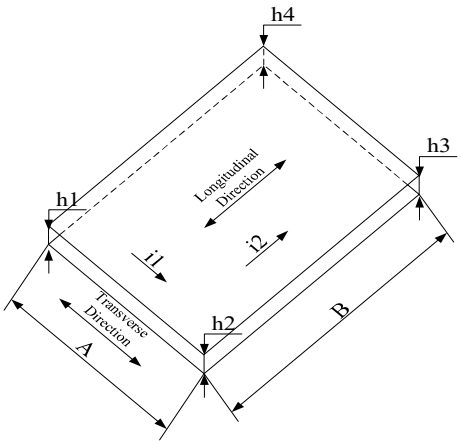

Figure 3. Schematic diagram of slope parameter design

The customized slope bearing prints the information of "bridge direction identification", "slope", "pier (platform) number" and "left and right width" on the surface of the support according to the use position to ensure that the slope of the support is accurately consistent with the slope of the beam.

2.3 Bearing Installation

When the bridge is prefabricated, all adopt the flat slope pre-embedded beam bottom steel plate, and the beam bottom steel plate can be fastened by bolts with the embedded sleeve and the bearing, and can also be connected by welding with the bearing. The slope of the bottom of the beam is leveled by the custom slope basin bearing, and the beam body is erected under the premise of normal construction, and only needs to ensure that the bearing, installation position and direction are correct to meet the slope requirements of the bridge.

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3. Technological Innovation Points and Performance Advantages of Bearings

3.1 Innovation Points of Slope Bearing for Long Longitudinal Slope Bridges:

(1) Using factory CNC machining customization technology, the slope accuracy level reaches 0.1%, and the factory mass production is realized;

(2) Reduce the difficulty of beam making, shorten the beam making cycle, and ensure the project duration;

(3) Simplify the bearing installation process and improve the bearing installation accuracy;

(4) Reduce the contact of multi-layer steel plate surface, reduce the cumulative error of slope, and the bearing and the beam body are closely connected, so as to greatly improve the service life of the bearing and the safety factor of the bridge;

(5) Inherit the performance of the original bearing, such as strong pressure-bearing capacity, simple structure, compact structure, small sliding friction coefficient and flexible rotation;

(6) Realize one-time slope formation and accurate slope adjustment;

(7) Improve the durability of slope bridges and reduce the operation and maintenance costs of bridges in the later stage.

3.2 Performance Advantages of Slope Bearings for Long Longitudinal Slope Bridges:

(1) Formulate the bearing slope adjustment process, adopt the factory CNC machining customization technology, adjust the height difference of the four corners of the bearing upper seat plate, make the longitudinal and transverse slope of the upper seat plate of the bearing consistent with the longitudinal and transverse slope of the bridge, simplify the bearing installation process, and improve the installation accuracy of the bearing.

(2) Ensure the level of the surface of the bearing, avoid the joint between the support and the beam body, the uneven force, and the slope is not accurate, so as to greatly improve the service life of the bearing.

(3) Avoid diseases such as pier stud deviation, deformation, cracking and separation between the beam body and the support due to the bias, deformation and dislocation of the bearing. In order to realize the small bearing to solve the big problem, the skill to avoid various quality diseases after the slippage of the structure, to ensure the safe operation of the structure.

(4) The customized slope bearing technology is a customized treatment that transforms the blind slope of the construction site into the "special bridge design" of the factory, and realizes accurate construction.

4. Application on Engineering Examples

The customized slope bearing for the long longitudinal slope bridge developed in this paper has been procured and implemented in major highway engineering projects such as Zhitong Expressway Civil Engineering Project No. 1, Zhitong Expressway No. 2 Project, Zhitong Expressway No. 4 Project, Ruanchen Expressway No. 3 Project and Yongxin Expressway No. 2 Bid.

5. Conclusion

(1) The technology of adjustable and variable slope support for longitudinal slope bridge realizes the high precision of slope adjustment and one-time slope installation through CNC machining customization and mass production in professional factories. This type of slope bearing simplifies the installation process, reduces the accumulated slope error, improves the service life of the support and the safety factor of the bridge.

(2) Through mature technical support, the quality of slope support is stable, only the bottom of the beam is embedded with the flat slope steel plate, which can improve the efficiency of beam making,

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improve the installation accuracy, ensure the structural safety, improve the durability, reduce the later maintenance costs, and bring significant social and economic benefits.

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References

[1] Huang Pengfei. Research on bridge damage recognition method based on CNN-LSTM hybrid architecture neural network[D].Qinghai University,2021.

[2] Lu Chen. Research on damage identification method of beam structure based on bias estimation[D].Shaoxing University of Arts and Sciences,2019.

[3] Zhao Yongpeng. Research on data communication technology of bridge health monitoring system[D]. Chang'an University, 2012.

[4] Cao Peng. Analysis of force and spatial stability of small radius bent bridge[D]. Wuhan University of Technology, 2009.

[5] Luo Hui et al. Adjustable high bearing performance of large stroke in subsidence area[J]. Journal of Civil Engineering and Management, 2020, 37(2):20-26.

[6] Wang Fan. Research on the performance of new type of high-stroke adjustable bearing[D]. Huazhong University of Science and Technology, 2019.