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Design of Bridge Adaptive Bearing Based on Hydraulic Control

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Abstract: *At present, the total number of modern Bridges in China exceeds 1 million, and Bridges across the sea and river bear a huge amount of passenger and freight transport. Because the bridge span is large, so because of weather, war and other reasons when the damage, can only be set up pontoon repair. Limited by hydrological conditions and other factors, the disadvantages of emergency repair of pontoon bridge are very obvious, among which the disadvantages of difficult operation and low traffic speed directly limit the overall emergency repair progress. Therefore, the bridge bearing based on hydraulic control in this paper can control the adaptive bearing to actively compensate and adjust with the help of the rapid calculation of the calculation system without blocking the channel, so as to greatly improve the passage efficiency and reduce the cost of emergency repair.*

Keywords: *Adaptive bearing, Compensation calculation, Hydraulic system, Bridge repair*

1. Introduction

China has a vast territory and a wide range of areas, so the number of Bridges is large and the design style is complex. When faced with the problem of bridge damage, the method of setting up a floating bridge is generally used for emergency repair work. However, the traditional bridge pier is not adaptable to different water conditions due to its heavy weight, so the train is prone to overturn due to its low speed and low load [1].In this case, it is particularly important to develop a device that can respond quickly and carry out directional compensation [2].

With the development of new technology and the continuous iteration of war forms, the pontoon bridge continues to develop in the direction of heavy load, fast mobility and high adaptability. However, for the wide and deep rivers, the technical difficulties encountered have not been completely solved. Therefore, the development trend of pontoon bridge in the future must be to adapt to long bridge, deep water, high velocity and waves. The hydraulic adaptive bearing test system for pontoon bridge is to achieve this goal, by monitoring the changes of the bridge, automatically adapt to the pressure brought by high-speed water flow and complex environmental changes to the pontoon bridge. The health management system of hydraulic adaptive bearing for pontoon bridge can assist in health monitoring, which further improves the overall stability and reliability of the system. The application of the system designed in this paper can simplify the construction process, save resources, save time, and greatly improve efficiency. Provide simpler and faster conditions for ongoing operations in different environments. Reach the standard of heavy load, high tactical performance, strong mobility and standardization of components. To achieve the goal of adapting to the application environment of long bridge, deep water, high velocity and wave.

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2. Overall system design scheme

This system mainly involves five links. When the bridge is loaded, the displacement, acceleration and other sensors on the bridge will continuously collect real-time data and send it back to the computer compensation calculation system. At the same time, the display system will intuitively display the load status of the bridge. After precise calculation, the compensation calculation system automatically generates the compensation scheme and transmits it to the adaptive bearing. The adaptive bearing compensates and adjusts, controlling the external influence within the expected range, and intuitively displaying the bridge state by the display system. The overall design idea is shown in Figure 1.

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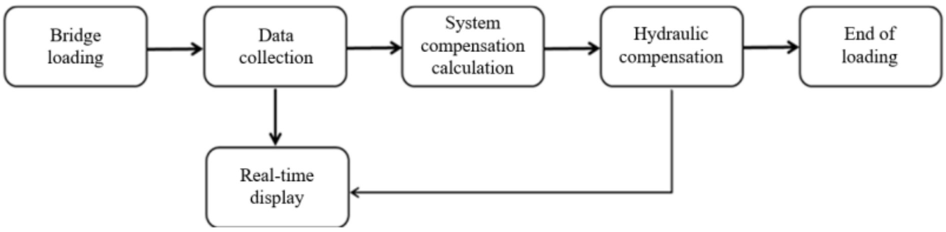

Figure 1: Overall design scheme

3. Experimental system design

The core technology of the system is adaptive bearing based on hydraulic transmission control. In order to study the stability of the bridge body before and after compensation, the team set up a test bed for specially testing support data[3] for accurate research and analysis. The experimental model of the system consists of hydraulic cylinder, gantry frame, stress beam, adaptive support, bottom plate and reinforcement support and several sensors. Because the transverse influence of the bridge under load is much less than the longitudinal influence, this experiment focuses on simulating the longitudinal unilateral force.

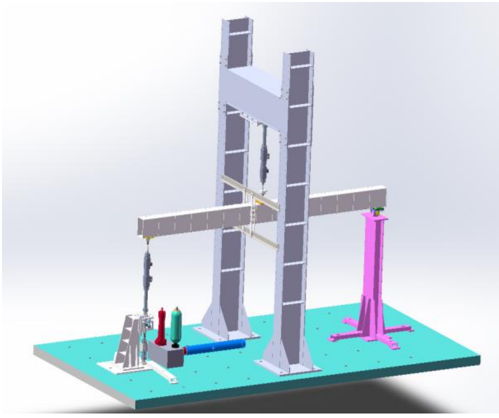

Figure 2: The three-dimensional model of the experimental system

Figure 3: The operating table of the experimental system

3.1. Hydraulic force cylinder

The hydraulic cylinder is the executing element in the fluid transmission system, and it is also the device that provides longitudinal vibration excitation for simulating the actual situation in this test system. The two ends of the hydraulic cylinder are respectively connected with the main beam and the gantry frame through the steel pad with the help of bolts, in order to maximize the combination with the contact surface, the maximum degree of reduction of the actual situation of the force. The hydraulic force cylinder is connected with the control system, which can start and stop independently and produce different excitation in a variety of modes.

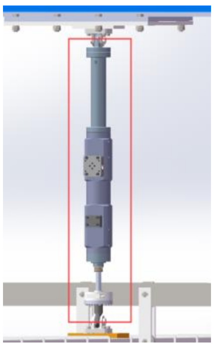

Figure 4: Force cylinder

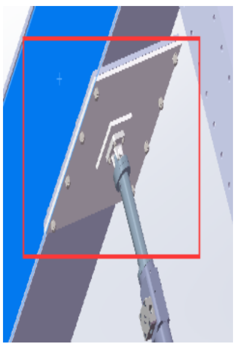

Figure 5: Upper connecting surface

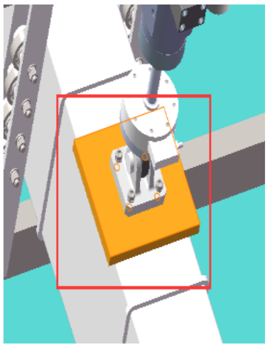

Figure 6: Lower connecting surface

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3.2. Gantry frame and main beam

The gantry frame is the support structure of the whole experimental device. The gantry frame is connected with the ground by bolt studs, and the stress bars are welded on the connecting side of the gantry frame and the ground to ensure the stability of the experimental structure and the safety of the experimental process. The middle part of the lower side of the upper beam of the longmen frame is the force area of the hydraulic cylinder. Due to the interaction of the force, the hydraulic cylinder applies force in both directions, and the gantry plays a single direction constraint at this time.

There are three connections between the main beam and the experimental device. The middle part of the main beam is connected with the hydraulic force cylinder by steel pad and bolt, and receives vibration excitation from the hydraulic cylinder under various actual conditions. The two ends of the beam are connected with the bearing support and the adaptive compensation support respectively. The connection at the fulcrum completely locks the degree of freedom in the horizontal direction, leaving only slight movement space in the vertical direction to prevent damage caused by excessive stress on the main beam. At the same time, longitudinal pulley guide rail is added around the force cylinder to ensure stability. The main beam simulates the support part of the bridge body that is directly loaded. In order to be as close to the actual situation as possible, the main beam is specially customized. On the basis of the ordinary beam plate, welding is carried out on the weak point of the force, and at the same time, solid reinforcement rings are added around the whole main beam to increase the strength of the main beam [3].

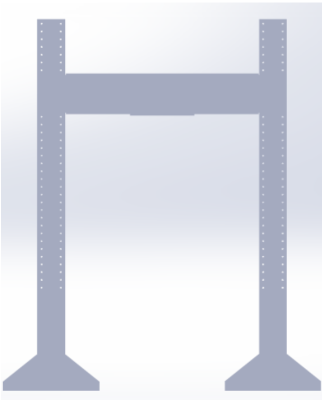

Figure 7: Gantry frame

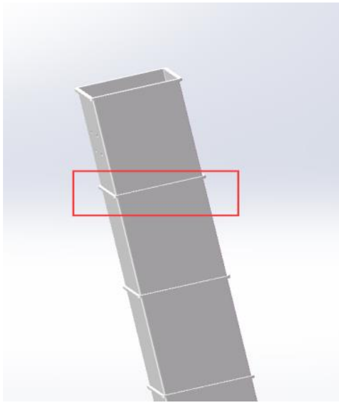

Figure 8: Additional welding structure of main beam

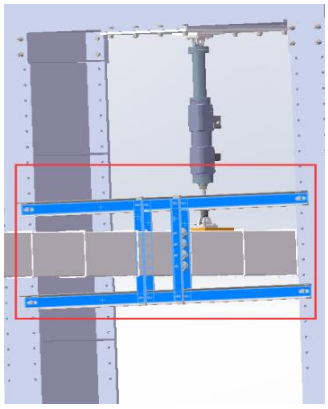

Figure 9: Pulley guide

3.3. Sensing system and adaptive bearing

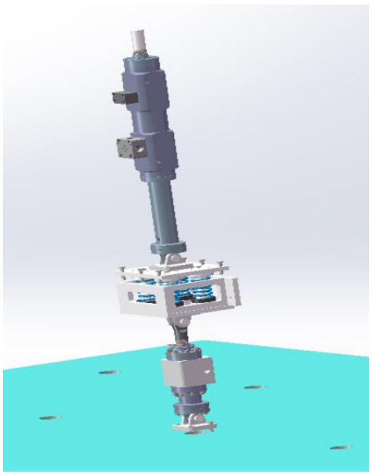

Figure 10: Adaptive support

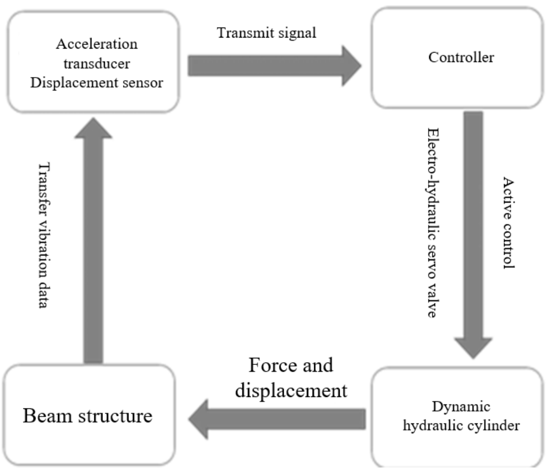

Figure 11: Adaptive support workflow

A variety of sensors such as displacement, speed and acceleration are placed inside and outside the support, as well as the main beam force concentration part, to detect the vibration of the main beam in various cases. Four high-strength springs are placed under the adaptive bearing to enhance the compensation effect of the bearing on the external influence. After the vibration signal of the main beam is collected by the sensor, the signal is transmitted to the operation controller. After the calculation of the

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calculation system, the controller actively controls the electro-hydraulic servo valve to adjust the dynamic hydraulic cylinder. The hydraulic cylinder adjusts the state of the main beam by applying force to eliminate the external offset in real time. The whole process takes almost zero time, so the device can compensate and adjust the action in real time.

4. Analysis of experimental process and results

4.1. The experimental process

In this experiment, a comparison method was used to simulate the sloshing migration of the main beam with or without support assistance. After data collection, quantitative analysis is carried out to analyze whether compensation is effective.

4.2. The experimental results

After a large number of experimental data analysis, the optimal scheme is obtained. After active compensation of bearings, the displacement variation of main beams decreases by 30%-40% compared with the natural condition without bearings. This data indicates that the experiment is successful and the experimental data reach the expectation. Figures 12 and 13 are partial screenshots of experimental data. (Different ordinate scales)

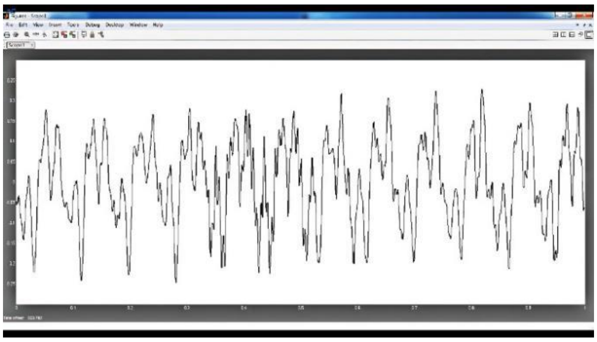

Figure 12: Fluctuation data of bearings without active compensation (ordinate scale: 0.5)

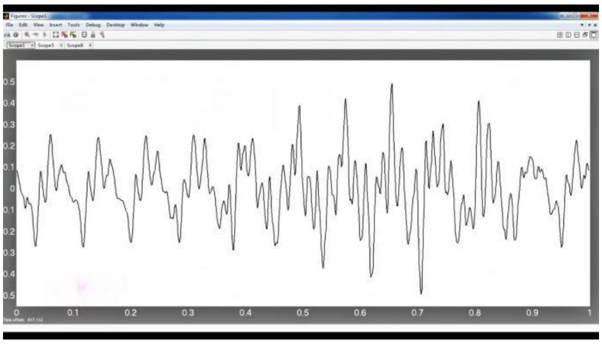

Figure 13: Fluctuation data of bearings with active compensation (ordinate scale: 0.25)

5. Conclusion

In view of the various problems of bridge failure and the shortcomings of various methods, this study is a hydraulic adaptive bearing. Through the research, design, modeling, manufacturing, assembly and final experiment of each part, its expected function is proved, and the expected goal is achieved. By detecting the bridge state and combining with the calculation system, the system can compensate and adjust the bridge state in real time, so as to ensure the sway control of the bridge in a reasonable range. The application of the device can be quickly called and assembled with supporting standard equipment without affecting the original channel, so as to complete the rapid rush through of the bridge. After later development, the system can be adapted to more environments, with a span of 80 meters and a driving speed of 50km/h. And realize real-time data upload. The scheme proposed in this paper has sound design, scientific and reasonable, stable and reliable operation, suitable for various road conditions and various

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environments, and has broad application prospects and promotion value.

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