Control and Implementation Technology for Horizontal Swivel

Daoping Xie, Dingxu Wen and Zhiwu Xue
(*Cccc Wuhan Harbour Engineering Design And Research Co.,Ltd., Wuhan, Hubei, 430070, China*)

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Abstract: The horizontal swivel method used in bridge construction can avoid the effect to operation and safety, when we need to cross the existing railway, highway, bridge and arterial traffic road. This is advantaged than other construction methods. Through the horizontal swivel of the T-structure bridge of LiMin road, we propose the corresponding requirements and measures for the construction process, structural safety and construction control, at the same time, the difference between the brick wall and sand box for temporary locking is analyzed. According to accurate swivel test data and reasonable control implementation technology, the beam is accurately swiveled to the design position; this can be used as experience in future similar construction.

1 PROJECT OVERVIEW

The horizontal swivel method install turntable on the bearing platform of bridge, places the pier shaft and cantilever beam above it, so that it achieves gravitational equilibrium. The traction system provide the moment of couple to rotates around the center of the turntable.

Liming Road Bridge is located beyond the north second ring road of Chengdu. The main bridge crosses the Baoji-Chengdu Railway in s straight line. The swivel structure incorporates spherical hinges turning system of slide-way support and central spherical hinges. T-structure cantilevers are 41+41m. Angle of swivel is 90 degrees. Total weight of swivel system is about 68000kN.

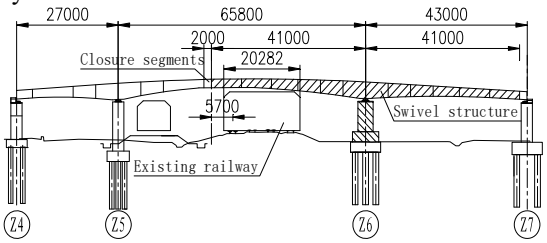

Fig.1: Swivel Bridge overall arrangement

2 KEY POINTS OF CONSTRUCTION

The swivel construction implementation control mainly includes: turntable construction phase and swivel system construction phase.

Before and after the swivel construction, the posture of the whole swivel structure is ensured to be in a controllable range, through various control measures.

2.1 Turntable construction

Turntable construction primarily involves spherical hinges and slide-way. They are the key factor to successful swivel implementation, and also directly impact the precision. So, the installation accuracy should be controlled strictly.

(1) The deviation between the central position of spherical hinges and theoretical center is not greater than ±1mm.

(2) The error of flatness and concentricity of spherical hinges is less than ±1mm.

(3) The error of slide-way surface is less than ± 1mm.

In order to ensure the installation system of swivel system, the spherical hinges incorporates one central measure point and eight horizontal measure points. The slide-way involves 60 horizontal measure points with 30 points on inside and outside surfaces. Measuring points are distributed in Fig.2.

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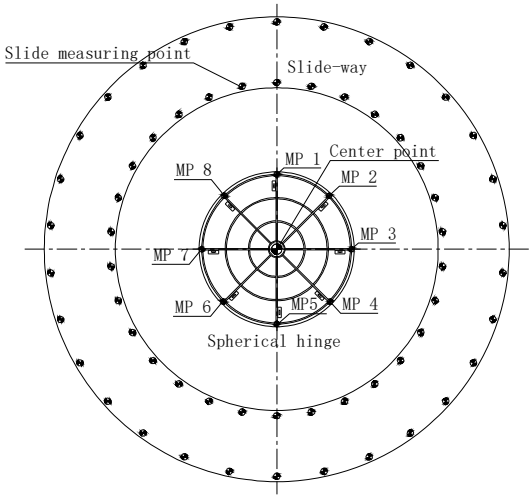

Fig.2: Measuring points layout of Spherical hinges and slide-way

In order to avoid swivel and overturn of turntables before the swivel construction, temporary locking is installed between the turntables. By conventional methods, the sand box supports and screw-thread steel anchors are used to lock at same time, and the wedge blocks are inserted between support feet and slide ways to avoid swivel. This project is supported by the brick wall, and anchored by six steel rails between the upper and lower turntables, which can lock together, as shown in Fig. 3.

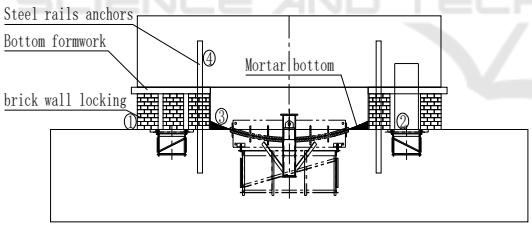

Fig.3: The diagram of Brick wall lock

Construction situation of traditional method and present method is shown in Fig. 4.

Fig.4: Construction situation of traditional method and present method

2.2 Swivel construction

When the swivel system construction is completed, the swivel construction can be implemented. Swivel construction includes test swivel and formal swivel. Test the swivel before the formal swivel construction.

Test swivel provides data references to formal swivel, including the following data: starting force and time duration for different points, average distance of beam-end swivel displacement distances at 3s, 5s and 10s. Relevant data of test swivel measurement are shown in Table 1.

Table.1: Rotor test results summary of the data

Measurements number	Traction force（kN）	When test swivel，the beam-end moving distance (mm)		
		3s	5s	10s
1	328	22	29	49
2	315	20	28	48
3	306	19	28	51
Average value	316	20	28	49

When test swivel is started for the first time, greater traction force is 520kN. The subsequent traction force is relatively uniform stabilize at 316kN. According to the equation of traction force, the Friction coefficient of the rotating system is calculated as 0.034, which less than theoretical value.

Key points of test and formal swivel:

(1)Based on safety regulations and requirements, swivel is completed within the limited time.

(2) Observe the gap between support feet and slide ways; promptly adjust positions of sliding plates.

(3) Pay extra attention to status and position of swivel system and lower the swivel speed before reach the right position to prevent excessive swivel.

The speed and time control of formal swivel: linear velocity of beam end is 1.2m/min. Angular velocity is 0.0293rad/min.

2.3 Turntable status and control

In the process of formal swivel, the ball hinge plays a major role in support the swivel system. At the same time, due to the influence of moment force and other factors, the support feet fall on the Slide-way usually. These combined to support the swivel system by three points, so as to ensure the stability of the whole structure. As shown in Fig. 5.

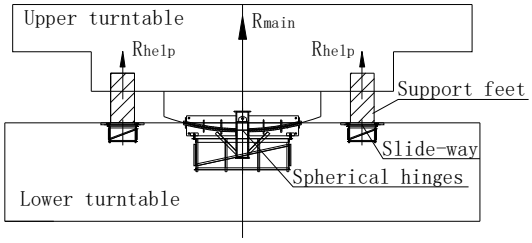

Fig.5: The weighing jacks layout

The following measures must be taken, according to the structural characteristics and operating requirements of the turntable.

(1) The Slide-way surface should be cleaned to avoid impurities on the Slide-way to hinder the normal swivel，before formal swivel construction.

(2) Daub lubricating oil on the Slide-way to reduce the friction coefficient, and ensure the clearance distance between the support feet and the Slide-way no more than 5mm, by filling the PTFE skateboard.

(3) Construct sealing concrete between the upper and lower turntable as soon as possible, when formal swivel is completed.

3 CONTROLS OF SAFETY AND CONSTRUCTION

3.1 Removal of temporary locking

Temporary locking is removed before swivel construction. The removal process should involve safety measures to prevent sudden changes of the stress states. Main measures are stated as following:

(1) Install the steel bracket to support the turntable. This as a safety support before and after the temporary locking is removed.

(2) Look at Fig.3; we need symmetrically demolition temporary locking by the order form one to four. Brick bottom dies and brace wedges are removed, anchor tracks are cut off, and mortar bottom dies are removed lastly.

Sand box locking and brick wall locking are compared in the following aspects as Table 2.

Table.2: Comparison of temporary locking methods

No	Items	Locking mode	
		Sandbox method	Brick wall method
1	Traits	Sandbox bears the pressure, and screw-thread steel bear's tension.	Brick wall bears the pressure, and the track bears tension
2	Stress	Small pressure-bearing surface.	Large pressure-bearing surface.
3	Remove	Sandbox is easy to remove by unloading sand.	Brick wall bears pressure. Remove difficultly.

Both structures meet requirements of temporary locking. In construction, brick wall structures have large pressure-bearing surfaces and small stress. But temporary lock and template are difficult to be removed and cleaned.

3.2 Weight and balance weight.

It is very important to carry out the weighing experiment before swivel, which is related to the balance of the whole swivel system.

The weighing jacks are used for weight measuring unbalanced moment and frictional resistance, which installation between the upper turntable and the lower turntable. The weighing jacks layout in Fig.6.

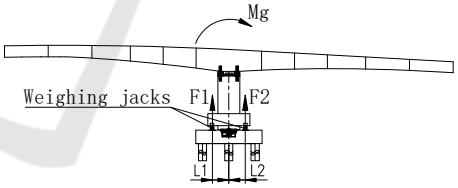

Fig.6: The weighing jacks layout

The principle is: equilibrium between external lift force, unbalance moment M_G and friction moment M_f . This involves two cases: friction moment is less or larger than unbalance moment.

The actual measurement is that friction moment is greater than unbalance moment. Left lifting force F_1 is 2500kN. Right lifting force F_2 is 4400kN. The lift arm is $L_1 = L_2$ =3.3m.

When the F_1 of the left lifting:

$$F_1 L_1 = M_f - M_G \quad (1)$$

When the F_2 of the right lifting:

$$F_2 L_2 = M_G + M_f \quad (2)$$

According to the results of weight, balance weight and position are determined. 15 00kN.m of balance moment are needed.

3.3 Swivel process control

During the swivel process, to ensure safe and smooth operation, the following key points are controlled:

(1) Observe the gaps between support feet and PTFE skateboard and adjust the position of PTFE skateboards.

(2) When beam end distance to the design location is one meter, stop the continuous swivel and start inching operation, according to the test swivel result.

(3) The central line and elevation of beam end is regulated to theoretical position. Continuous jacks are used to align the central line of beam. Vertical jacks are used to adjust the horizontal and vertical gradient and elevation.

4 SUMMARY

After careful preparation, calculation and strict field control implementation, the formal swivel was completed within 70 minutes. The precision reached 10mm. The process and key points of swivels are concluded as following:

(1) This methods of removal temporary locking can ensure safety of structure, for the temporary locking use brick wall method.

(2) Test swivel results can be used in formal swivel, to prevent inadequate or excessive swivel.

(3) Safety and accuracy of formal swivel can be ensured, by the control implementation technology of the whole swivel system.

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