

Overhead Accumulative Sliding Construction Technology of Unequal Height of Large Span Spatial Steel

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Abstract. The large span spatial steel was used in chop manufactory of the Chengdu integrated circuit manufacturing project. Because the steel truss was of great importance and the span of the single one was large, the crane was difficult to cover the aerial platform. Overhead accumulative slip construction scheme was based on construction conditions of engineering site. This paper introduced construction process of slippage of unequal height and the selection of equipment and preparatory work before sliding. At the same time, in view of the special unequal height support of the project, the heavy and difficult points of construction were analyzed. The state of the structure in the sliding process and the possible adverse effects on the slip were analyzed in detail, and some suggestions were put forward. To ensure the safety and reliability of the slip construction scheme, the bending, synchronism and the stress of key member of the structure were monitored during the sliding process.

1. Foreword

With the rapid development of the construction industry, the constant renewal of architectural concepts and the ever-increasing use of space requirements, many new types of buildings have emerged. In particular, large-scale public buildings such as airport buildings, convention centers, stadiums, and exhibition halls have adopted large-span and complex space steel structures as the roof structure system. In the process of construction and installation of large-span heavy-duty steel covers, there are problems such as large on-site assembly workload, difficulty in lifting, and high risk of aerial work. This has led to changes in construction technology, such as new construction technologies such as curve slippage, asymmetrical overall improvement, and auxiliary technologies such as dynamic control of computer structures, etc., which promote the construction industry to get rid of traditional methods, and move toward cross-industry, mechanization and high technology.

The stability of the structure before the formation of the space as a whole is the most critical issue in the construction process of the long-span space steel structure. Slip construction technology can



better solve this problem. Slip construction process means that the structural unit of the whole or sub-assembly is first assembled and assembled at the location where the assembly conditions are met. With the traction equipment capable of controlling the synchronization, the method of installing the structure divided into several stabilizers along a certain track from the assembling position to the design position is horizontally moved. The advantages of this process are that: (1) It can solve the structural installation problems where a large number of lifting equipment cannot be irradiated; (2) It saves the construction site; (3) The requirements for lifting equipment and traction equipment are low; (4) The sliding installation and the lower part construction can be paralleled in three-dimensional operation; (5) The construction period is greatly shortened; (6) Partial assembly brackets greatly reduce the construction cost of erecting scaffolding. Disadvantages are that: (1) It requires the rigidity of the structure outside the plane is large; (2) It needs to lay the track; (3) Synchronization control is more difficult when pulling at multiple points.

When the large-span high-altitude sliding construction method is adopted, it is very important that for the design of the steel roof support, the support reaction force can be adjusted by adjusting the relative height of the support ^[1]. Therefore, in many structures, the point of simultaneous traction is designed as a contour bearing ^[2-4]. However, due to the architectural design requirements of some projects, the height of the column top supporting the steel roof truss is inconsistent, which causes the height of the steel roof to be unequal during the sliding process, resulting in poor stability and integrity of the structure. Certain measures must be taken to ensure the structural integrity ^[5]. During the sliding construction of large-scale steel structures in Beijing Wu Kesong Olympic Basketball Hall ^[6], due to the spherical surface of the truss lower surface, the elevation of each truss is different. During the construction, a temporary tree-like support is installed on the slip track to ensure that the middle support point is evenly located on the slip track. This paper takes the large-span steel truss of chip house in the first phase of the IC core (Chengdu) integrated circuit production project as an example to introduce the construction methods and key points of multi-point synchronous push-slip of unequal elevation support roof system.

2. Roof System Construction Plan

2.1. Project Overview

The IC core (Chengdu) integrated circuit manufacturing project is located alongside the Binhe Road in the Western Park of the Chengdu-based High-tech Zone. The planned road network surrounding the proposed site is well developed and the transportation is convenient. The overall plan of the project is shown in Figure 1. Among them, the first phase of the planning and construction of the chip plant A02 has class 100 clean workshops nearly 70,000 m², local clean area requirements to reach class 10, which is the ultimate industrial cleanliness production requirements, and the overall structure of the airtight and decorative materials High stability requirements. In order to meet the wafer lithography yield rate, the factory requires the micro-vibration of Gordon system VC-E. For this reason, in addition to measures for foundation treatment and basic types, the clean room is also designed with a waffle board of nearly 40,000 m² and a thickness of 800 mm, and a 40,000 m² × 2 tall formwork support system is used below, synchronized construction with the sliding of the upper long-span steel structure truss. Construction technology and construction organization are very difficult.

The chip house adopts a large-span steel truss structure consisting of two consecutive spans Q345B-H steel cross-section members. The total weight of the steel structure of the roof is about 5900 t, the longitudinal length is 412.8 m, and the two spans are horizontal. The single span spans 48m. Fully symmetrical, the longitudinal spacing of the lower supporting reinforced concrete frame columns is 9.6m, and there are 44 axes in the longitudinal direction, of which the plane layout of the 1-22 axis is shown in Figure 2. The site photo is shown in Figure 3, where the arrows indicate the bearings. The height of the main truss lower center is 22.9m, the height of the center of the truss ridge is 29.834m, and the structure of the truss is shown in Figure 4, where the dotted line box is where the support is located.

Each truss is divided into 5 production units, which are processed at the factory and then transported to the construction site. High strength bolts are used between the units. The trusses, connecting beams, and supporting tie rods, which are arranged between the main truss and the upper and lower strings, are connected into an integral structure of the roof, and are also connected by high-strength bolts.



Figure 1. Project general layout

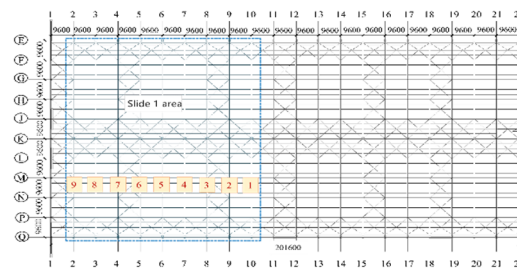


Figure 2. The layout of the plant structure

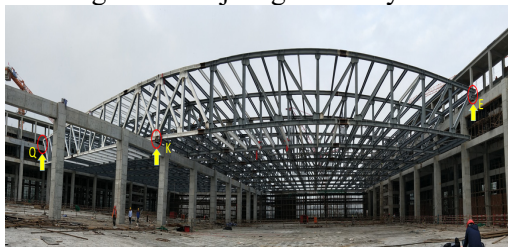


Figure 3. The partial roof system

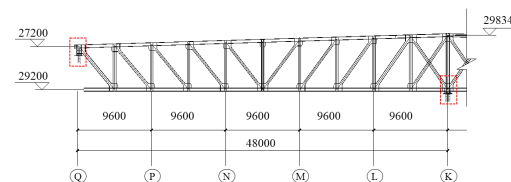


Figure 4. The structural form of the main truss

2.2. Construction Plan

The selection of construction methods for large-span steel structures is closely related to their structural types and site construction conditions. The installation methods for large-span truss structure systems include high-altitude bulk method, sub-lifting method, integral lifting method, and high-altitude sliding method^[7]. Among them, the slipping process is a construction process that utilizes a traction device capable of controlling the synchronization to move several units of the structure through the slide rails to a specified position. The method requires the erection of bottled platforms and tracks, and the subunits are assembled and connected on the platform. The advantage is that it can solve the position where the lifting equipment cannot radiate, it can be constructed in parallel with the civil works, save the construction period, and does not require large lifting equipment. The disadvantages are that it requires a large out-of-plane stiffness, and it is difficult to control the synchronization at multiple points.

Due to the urgency of the project construction period, the total tonnage of the steel structure is over 5,900 tons and the span is 96m, and the roof needs to be poured with concrete. During construction, the waffle slab floor is not finished yet, and there is resistance to microseismic requirements, so that the hoisting machinery can't be constructed in the waffle slab floor. The lower chord line of steel roof is 22.900m, located on the third floor, and the two floors below and the left and right spatial structure are all working rooms, which is the cast-in-place concrete frame structure. The chip plant is densely distributed around office buildings, power stations, warehouses, substations and so on. Due to the limited construction site conditions of the steel roof, considering the high altitude operation and the intersection of the civil engineering, the hydraulic synchronous jacking method is adopted.

As shown in Figure 3 and Figure 4, the design elevation of the support of each roof frame of the roof system is unequal, the elevation of the two supports is higher than that of the middle support, and the elevation of the Q-axis of the side support and the E-axis frame column is 27.200m. The elevation of the K-frame column in the middle bearing is 22.900m, a difference of 4.9m. The three axes of each truss frame are provided with longitudinal reinforced concrete coupling beams on the Q axis, K axis and E axis. The sliding track can be laid directly on it. The hydraulic ejector acts on the truss joints above the sliding shoes, as shown in Figure 5.

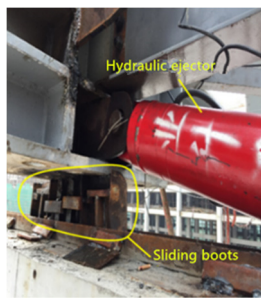


Figure 5. Slipper and push device at the seat

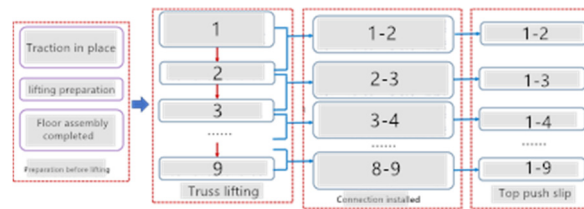


Figure 6. Cumulative slip construction

This project was divided into three slip sections for construction, namely 1-10 axis, 11-28 axis, and 29-43 axis. Only the assembly platform was set up between the axis 1 to the axis 2 and the axis 43 to the axis 44 respectively. This article mainly introduces the construction of the first slip section of the 1-10 axis as an example. The shaded area is shown in Figure 2. In order to be consistent with the construction sequence, the trusses in the first slip zone are renumbered according to the order of lifting and landing. In Figure 2, the truss at the 10th axis is the truss that is lifted from the first pick, so it is numbered 1 and the second pick is hoisted. The truss to be lifted on the 9th axis is No. 2. In turn, the truss lifted from the No. 9 pick is the No. 2 axis at No. 9. The number of the truss according to the construction sequence is shown in the box in Figure 2.

The No. 1 truss was lifted between the 2nd and 3rd axes and assembled at high altitude. The other trusses are assembled on the ground. Then two crawler cranes were used to lift between the 1 and 2 axes at the design elevation. The truss in place was assembled into a stable space structure system. Finally, a hydraulic pusher was used to slide the truss structure to the design installation position by means of “slicing + cumulative” slip. Fully utilized the deflection of the connecting beam between the steel trusses and the adjustment ability of the nut of the embedded anchor bolt. The cumulative number of turns decreased to the installation elevation. Finally, the connecting beams and support members between the segments were installed. The construction process was shown in Figure 6.

2.3. Hydraulic Push System

At present, there are three types of traction for accumulative slip of large-span steel truss in China: push, pull and traction^[9]. The sliding construction adopts hydraulic pusher sliding device, different from the traditional hoist wire rope. Pusher slip during starting and braking won't because of the extension of flexible steel wire and steel structure shaking or trembling. On the other hand, the sensor monitors the propulsion force and stroke of the hydraulic ejector and uses a computer system to control the coordination between the crawlers. When accidental overload or out-of-synchronization occurs, the system will make adjustments and issue alarms in time. Signals ensure safe and reliable slippage. In addition, a rigid contact connection is made between the hydraulic ejector and the to-be-slidded member, which facilitates the synchronization control between the slip (jacking) points. The hydraulic push-slip system is mainly composed of hydraulic ejector, hydraulic pump source system, sensor monitoring and computer synchronization control system. The setting of this project slip system is divided into the following aspects.

2.3.1. Hydraulic pusher. The thrust force T exerted by the ejector must overcome the static friction force F_1 between all the shoes and the slide rails to initiate the slip. Friction force $F_1 = R_1 \times 1.2 \times 0.15$, R_1 is the bearing reaction force each sliding shoe bears, and 0.15 is the friction coefficient between the sliding shoe and the slide rail, generally considered to be 0.13 to 0.15. This item takes the upper limit value 0.15, 1.2 is the non-uniform coefficient of friction of each sliding shoe. Considering the entire roof system, the total friction force is $F = 5900 \text{ t} \times 1.2 \times 0.15 = 1062 \text{ t}$. The total thrust force required for steel structure slip is 1062 t. In this sliding construction, a total of 51 push points were set, and each point was equipped with a YS-PJ-50 hydraulic ejector. The rated pushing driving force of a single YS-PJ-50 hydraulic ejector is 50t, and the design value of the total jacking thrust at the pushing point is $2550 \text{ t} > 1062 \text{ t}$, which can meet the requirements of sliding construction, sliding a zone and

sliding The layout of the hydraulic ejector in the second zone is shown in Figure 7. The black dot ● is the ejector. Since the counter bearing force of the intermediate bearing is far greater than the bearing of both sides, the interval of the ejector arranged in the longitudinal direction of the intermediate bearing is smaller than the two-sided bearing. The slip-accumulated slip is from left to right, and both the slip region and the slip region are cumulative slips from right to left.

2.3.2 Hydraulic pump system. The number in the box in Figure 7 is the YS-PP-60 hydraulic pump source system, which provides hydraulic power to the hydraulic ejector and completes corresponding actions under the control of various hydraulic valves. The number of ejectors controlled by each hydraulic pump source system is shown in Figure 7. The hydraulic pump source system is suspended on the steel chord of the steel structure and the system moves with the roof structure slipping. The weight of a single device is 2.5t, and the plane size is 1500mm x 1350mm.

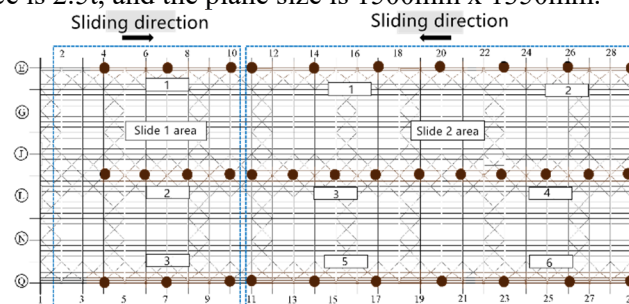


Figure 7. Layout of hydraulic press

2.3.3. Sensor monitoring and computer synchronization control system. Hydraulic synchronous push-slip construction technology adopts sensor monitoring and computer centralized control. Through data feedback and control command transmission, synchronous action, load balancing, attitude correction, stress control, operation lockout, process display and fault alarm can be automatically realized. A variety of functions. The hydraulic synchronous push-slip system equipment of this project adopts CAN bus control and three-level control from the main controller to the hydraulic ejector, realizing independent real-time monitoring and adjustment of each hydraulic ejector in the system. This makes the synchronous control of the hydraulic synchronous slip process more accurate and more timely, controllable and safe. The operator can observe the hydraulic pushing process and related data in the central control room through the hydraulic synchronous computer control system man-machine interface.

2.4. Slides and Shoes

2.4.1. Slide design. The quality of the slide rails is the key to ensure the smooth implementation of the slip. The phenomenon of the rails and rails caused by the quality problems of the slide rails will not only affect the synchronization in the slipping process, but even cause serious slippages. The three tracks used in this project are respectively arranged along the E-axis, K-axis and Q-axis in the longitudinal direction. The plate is embedded on the longitudinal connecting beam at a certain interval, and the channel steel as the track is placed on the pre-embedded steel plate. And the profile is shown in Figure 8. The other requirements for the laying of the track are as follows:

- ① The centerline of the slip track is consistent with the centerline of the support;
- ② The 16a channel steel adopted in the track is welded with the embedded member of the supporting beam, and the side block is used to ensure the integrity of the track;
- ③ The allowable deviation of height difference at the track section should be less than 1mm;
- ④ Double grouting and leveling below the track;
- ⑤ Grease the bearings and rails before slipping.

2.4.2. Slipper design. Slide shoes use structural bearing shear design. In the process of water smoothing, the occurrence of "clamp" and "track" phenomena should be strictly prevented. As shown in figure 9.

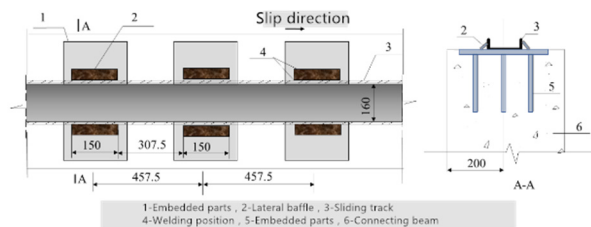


Figure 8. Elevation of slip track

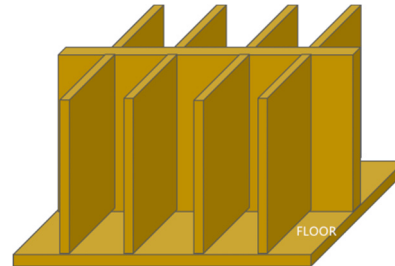


Figure 9. Slipper schematic

3. Construction Process and Difficulties Analysis

3.1 Construction Process

The main flow of sliding zone construction is as follows:

- (1) Set up the assembly platform with a width of 10m between axis 1 and axis 2, and lay the slide rail on the connecting beam.
- (2) In figure 2, truss 1 2 hoisting in place, on the assembling platform connecting between two truss beam, purlin, support, such as longitudinal, makes it a stable space structure.
- (3) The structure of the assembly completed along the longitudinal slippage 9.6m.
- (4) Swing truss 3 into the original no. 2 position of the truss, on assembling platform assembling between truss and truss 2 3 connecting beam, purlin, support, such as longitudinal, makes it a stable space structure.
- (5) The finished structure of the assembly will slip 9.6m along the longitudinal slip.
- (6) Repeat the above steps to complete the lifting, assembly and slip of the truss in the zone.
- (7) Structural setting, filling the remaining steel girder, and completing the installation of steel structure in zone 1.

3.2 Key Difficulty Analysis

A sliding module composed of two trusses was used to analyze the stress of the roof structure in the sliding process, as shown in Figure 10. Roof system in the process of the sliding bearing was very complex, normal slip in addition to the vertical direction under gravity load, in the process of bearing reaction force, also withstand the pusher device level to the jacking force, sliding boots, and the friction between bearing and sliding boots and bearing mechanical bite, not synchronous displacement between the internal force and other aspects of influence. In addition, the vibration caused by various reasons in the sliding process also has an effect on the internal force of the roof system. It was particularly noteworthy that, due to the difference in support elevation, as shown in figure 10, the sliding module can also bear the torque caused by the space force system around the X-axis. In addition, the anti-torsional stiffness of the space dry system sliding module composed of the bar was low, so it could be accompanied by a large torsional deformation in the slip process. This deformation, in turn, would change the slip state, not only affecting the contact state of the slipper and the slide, but also significantly adjusting the force of some parts of the module or some connecting parts. For one of the truss also inherit the purlin, connecting beam and support role, not only in its own plane truss overall bending and shear deformation, but also outside the plane would have the flexural deformation, shear deformation and torsional deformation occurred. Due to the space stress state of the truss in the sliding process, especially the high unconformity of the sliding boots, the warp deformation of the space warp was also caused.

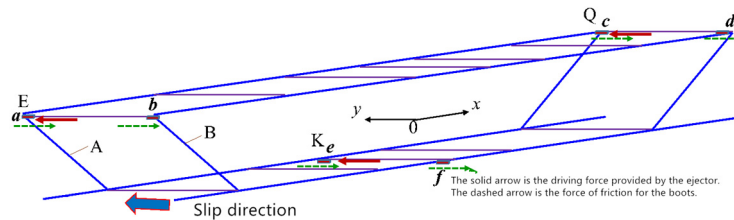


Figure 10. The stress state of the sliding module

During the actual construction, due to the special tension in the construction period, the secondary pouring mortar at the bottom of the slide had not yet obtained the necessary strength to start sliding. When the slide boots passed through the section between the embedded steel plate, the channel steel webs would collapse due to insufficient strength or insufficient filling of the slurry under the pressure of the slide boots, leading to serious card rail. Due to the displacement control of the hydraulic ejector, when the card track occurred, it not only caused the slip to be out of sync, but also increased the force of some rods or connections. For example, when the b supported in figure 10 shows the card track, the E axis was stagnant, but the K axis and the Q axis continue to slide, and the control system's non-synchronous value increases sharply before the response. On the other hand, the hydraulic power of a support was rapidly increasing, which leads to the longitudinal bar and joint abnormal force between a and b supports.

Based on the above the stress analysis of slip process against the project range elevation in the process of the actual sliding bearing and sliding construction, large span steel structure sliding construction process should pay special attention to the following questions.

3.2.1. Quality control of sliding rail and sliding boots. The quality of slide track and slipper is the key to ensure smooth operation, otherwise, it will be easy to cause the rail, nibble and even force the slippage to stop. Therefore, we should from the aspects such as strength, stiffness and roughness improve the quality of the slide rail profiles, strictly control the track section of the joint elevation difference in the range of the allowable deviation 1. Make sure that the secondary grouting at the bottom of the track meets the necessary strength requirement before slipping. Sliding boots quality fit and unfit quality will affect the sliding boots and uniform distribution of slide rail contact surface compressive stress degree, recommended integral and good stiffness, force transmission path clear, smooth floor and surrounding an arc sliding boots.

3.2.2. The reasonable arrangement of sliding top thruster. Pushing device directly control the slip. The arrangement of the pushing device and specification selection mainly by slide friction between sliding boots and size to determine, and by the bearing the same nature, roof truss by friction with not only the size of the slide rail and contact state between sliding boots, more depends on the size of the sliding boots counteracting force. Therefore, it is often used in sliding construction to adjust the support counterforce of the same truss^[4]. This project does not take any measures to adjust the force of the support, only apply butter between the slide track and the slide boots to reduce the friction coefficient. The support force of the middle support is far greater than that of both sides, and the sliding shoe slip needs to be overcome by different friction force, and the hydraulic jacking type number is consistent. Therefore, it is necessary to determine the reasonable arrangement of the ejector by calculation, so as to ensure that the top thrust applied by each slide matches the friction force that needs to be overcome.

3.2.3. Hydraulic jacking computer control system. Displacement control is usually adopted in the process of slippage, and this project is no exception. A sliding process can be divided into several levels. The maximum number of slip of each level of this project is 500 mm. When a certain a pushing device level slip up to 500 mm, the displacement of the pusher as overflow, will automatically stop. On the other hand, if the slippage has yet to reach 500 mm, even pushing device sync displacement

difference reached as shown in figure 11 (in this engineering practice a slip moment computer control system in the process of sliding screens) of 430 mm, as is shown in the computer control system will not stop sliding. It can be seen that the maximum slip of each level can't effectively control synchronization, and it is suggested to increase the maximum limit value of unsynchronized displacement in the control system.



Figure 11. Screen display of a computer control system

3.2.4. Synchronicity. The sliding top push point is set in the support of the main truss, and the ejector is in contact with the structural rigidity. The slippage velocity or accumulated slip of the three supports in the sliding process determines the synchronism of the overall slip construction. At the same time, due to the high position of the top thruster, when the slip difference is too large, the integral of the structure and the deformation of the plane of the main truss will have a certain effect. Therefore, the control of synchronization is critical to the whole project. In the process of sliding, through artificial real-time synchronization monitoring in the process of structure sliding or at each slip point arrangement of laser range finder to measure bearing of slippage, using computer synchronous control system of hydraulic slide pusher system manual at any time to adjust structure of three bearing slippage, guarantee of the structure of the differential slip under control. References ^[4,11] mentioned that the maximum unsynchronized displacement measured was 30mm. Reference^[12] introduced that by taking certain measures, it is ensured that each drawing point is kept synchronously in the process of slippage, and the synchronization accuracy is plus or minus 5m. Aiming at the characteristics of the large span of this project, the overall stiffness of the structure is small, and the unsynchronized limit of 100mm is too idealized, which needs further discussion.

In conclusion, in order to ensure the safety and smooth implementation of slip construction, it is necessary to monitor the slip process in combination with the special conditions of this project.

4. Overview of Monitoring

Long-span roof while in the structure design and calculation phase can meet the requirements of the relevant specification, but often accompanied by morphological changes in the construction process, the differences between the constraint conditions and the different load condition. The formation of its structure is a process from the local to the whole. Whether the construction stage or the forming, the stress state may be different from the design value. ^[10] In the process of sliding construction, the structure of large span steel structure may lose its balance in the construction process, or collapse due to the loss of stability of the structure, or the failure of the local node's strength. Once an accident occurs, its effects and consequences are extremely serious. ^[11] In order to ensure the construction safety and orderly, and ensure security, applicability and durability of the structure in the use of stage, the construction process of the long-span structure, especially the glide phase is of great significance to the implementation of monitoring. It can provide safety guarantee for the construction. This project through the field of real-time monitoring to the structure of synchronicity, the key link in the process of sliding nodes to monitor the stress and the vertical deflection sliding process smoothly, to ensure the structure safety. At the same time, it also provides reference data for the monitoring and research of steel structure slip construction in China.

Due to the complex condition of the slip monitoring site. In order to ensure that the slippage construction of steel structure is not affected, the sliding construction of the structure under several working conditions is monitored, as shown in table 1. The working condition indicates the number of truss trusses of

the sliding body, such as the slip of the partial roof formed by the roof truss formed in Figure 2. A trusses the first trusses in one area, and B trusses the second in one area. The main contents of the monitoring are:

Table 1. Slip condition

Monitoring content	Conditon 1	Conditon 2	Conditon 3	Conditon 4	Conditon 5
Middle deflection	-	1-2-3	1-2-3-4-5	1-2-3-4-5-6	1-2-3-4-5-6-7
Synchronicity	-	1-2-3	1-2-3-4-5	1-2-3-4-5-6	1-2-3-4-5-6-7
A truss stress	1-2	1-2-3	1-2-3-4-5	1-2-3-4-5-6	1-2-3-4-5-6-7
B truss stress	-	-	1-2-3-4-5	1-2-3-4-5-6	1-2-3-4-5-6-7

(1) Roof bottom chord maximum interference degree monitoring, monitoring roof in a single common across the bottom chord of observation (G, N points), according to the use of total station in the construction process shown in the elevation difference change, calculate the change of immunity of measuring points.

(2) Roof slip point synchronization monitoring. By observing the total station instrument, the distance change of the three supports is measured and the synchronism of the slip process is measured. Namely, the horizontal distance of the three measuring points is consistent, which proves that the synchronization is better and vice versa.

(3) Stress monitoring of the main control points of the bar. Before the construction, the key element of stress was determined by finite element simulation, and the stress change of the bar was monitored with the actual construction condition on the key nodes. Then, according to the constitutive relation of the material, the stress change of the bar is known through the measurement of strain change.

4.1. Monitoring Results and Analysis

The deflection of the main truss, the maximum slip difference of three supports and the stress of the main truss are shown in table 2 under different working conditions.

Table 2. Monitoring results

Monitoring content		Conditon1	Condition2	Condition3	Condition4	Conditon5
G point deflection (mm)	Maximum deflection	-	71	-82	-26	-44
	Average deflection	-	10.9	-56.8	-4.3	-2.1
N point deflection (mm)	Maximum deflection	-	59	-98	-27	64
	Average deflection	-	53.8	-77.3	-2.0	10.9
Support slip difference (mm)	Maximum slip	-	504	505	407	352
	Average slip	-	153.0	149.9	189.5	143.6
A common stress	Maximum stress position	-22.6	-13.8	19.8	27.0	38.0
		Lower chord	Lower chord	Lower chord	Lower chord	Lower chord
B common stress	Maximum stress	-	-	16.3	48.2	16.7
		-	-	Lower chord	Lower chord	Lower chord

position

4.1.1. deflection monitoring results. As shown in table 2, the sliding process had some influence on the deflection of the monitoring points. It was possible to increase the span, and might reduce the span of deflection. On the one hand, this was because the structure would produce a certain vertical tremor in the process of sliding construction. In addition, the structural support would produce upward support. However, the total deflection value was not more than 100mm, which was 1/480 of the span. Because the main force of the structure during the sliding process was the lateral force exerted by the ejector, the vertical deflection of the structure was small during the slip process. So the deflection of the structure during the construction process of the high-span steel roof was not affected greatly, and the limit value of the structure deflection was not exceeded during the construction.

4.1.2. synchronization monitoring results. In the process of slippage, the maximum slip difference of the three supports at some time reached 500mm, due to the causes of the rails or nibbling at the supports. But the duration was short and was monitored in real time. After the monitoring party's on-site timely warning and communication, the slip party made adjustments immediately. In addition, with the increase of the number of slippage, the overall stiffness of the structure increased and the synchronization gradually improved. In general, the slip difference in most slip periods was not more than 200mm, and the slip difference had little effect on the stress of the structural member. Considering the large span of the whole roof, the overall stiffness was low, and the ability to adapt to the non-synchronization was strong. Therefore, the stress caused by excessive unsynchronized displacement was basically within acceptable range.

4.1.3. Stress monitoring results. Due to the complexity of the structure in the process of slippage, the gravity load of vertical direction and the counterforce of the support; The horizontal direction shall bear the force of friction between the top thrust of the ejector, the friction between the sliding boots and the support, and the mechanical bite force between the sliding boots and the support. The bending moment produced by asynchronous slip; The vibration caused by various reasons in the sliding process.

Through the stress monitoring system in the slip process, the stress change resulted of the bars under the stress state were obtained. According to the data of the monitoring results, the maximum stress of the structure occurred in the lower chord, and the maximum stress was no more than 30Mpa. Because of the purline connecting the main truss in the lower chord, when the structure slip or when the non-synchronous slip occurs, the lower chord of the purline connection would be more complicated. But overall bar produced by stress relative to the link of the whole structure and smaller as a whole, and slip the first common stress in general slightly larger than the second nature, and satisfied the requirement of structure deformation and bearing capacity of the construction.

5. Conclusions

(1) This project had successfully used the hydraulic jacking construction scheme to slide the large span steel structure into place. Not only the technology was simple, safe and reliable, but also solved the problems like site construction lacking of space, pressing time, civil engineering and steel structure working at the same time.

(2) This paper introduced the project overview of the large-span steel structure involved in the project, and the difficulties and emphases that may be encountered in the construction. Through the analysis, the equipment to be used in construction was arranged reasonably, and the construction process was reproduced accurately and carefully.

(3) This paper introduced the overall construction scheme and the slip construction process, analyzed the difficult points in the process of sliding construction, and gave the corresponding construction Suggestions. It could provide reference for similar projects.

(4) Combined with the actual condition of slip construction, the stress state of the whole structure in the sliding construction process was analyzed. It was found that the structural stress deformation was complex in the whole process, and the actual stress state was different from the theoretical simplification analysis, and further research was needed.

(5) The real-time monitoring and analysis of the synchronism, deflection and stress of the key bars in the process of structural slippage ensured the safety and smoothness of the construction process. The practical experience was provided for the construction monitoring technology of high altitude construction of large span steel roof in China.

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