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Study on the support scheme in the construction of cast-in-situ beam with support method

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Abstract: *Nowadays, under the background of the vigorous development of national transportation, the number of bridge engineering construction is also increasing year by year. Ensuring the construction quality of bridge engineering is of great significance to ensure vehicle traffic safety and maintain social stability. Therefore, the major construction units are also actively introducing advanced construction methods in order to improve the construction quality. The construction of cast-in-situ beam with support method is the most widely used construction technology at present. In the construction of cast-in-situ beam with support method, the determination of support scheme has become the top priority. In this paper, based on the Jianxin West Road overpass of the north section of the third longitudinal line of Chongqing Expressway and the coaxial common section of rail transit line 5, the determination of support scheme is studied.*

Keywords: *support method cast-in-situ beam construction, support scheme, design scheme*

1. Introduction

Bridge construction is an important step in China's economic development. Many domestic cities have vigorously developed bridge projects to facilitate transportation and promote the development of urban transportation industry and commodity trade. As a bridge capital, the development of bridge construction in Chongqing is changing with each passing day. The north section of the third longitudinal line of Chongqing Expressway and the coaxial common section of rail transit line 5 supported this month starts from baishubao interchange in the north, crosses the planned Jianxin West Road in the south, and ends at the North bridgehead of Jialingjiang bridge in Hongyan village, with a total length of about 2.874km. It is an important link closely connecting Yubei District, Jiangbei District, Yuzhong District, Shapingba District, Jiulongpo District and Dadukou District. Next, taking the application of support in the frame bridge section of K0 ~ K5 station on the main line of Jianxin West Road overpass as an example, the determination of support scheme in the construction of cast-in-situ beam by support method will be studied. The frame bridge section of K0 ~ K5 station on the main line of Jianxin West Road overpass overlaps the plane of Beibin Road Station of rail transit line 5. The station is located directly below the main line road. The main line Viaduct of K0 ~ K5 axis adopts a long-span prestressed simply supported frame system, which is coordinated and unified with the station structure as a whole. There are two pieces in total. The longitudinal span layout is: K0 ~ K2 axis: 25 + 30m; K2 ~ K5 axis: $2\times30+25$m.

2. Design scheme

2.1. Overall scheme of support

Below the K0 ~ K2 axis of the station is the station foundation pit, which has been excavated. The bottom elevation of the foundation pit is 210.017m, the elevation of the slope top is 217.9m, and the depth of the foundation pit is 7.883m. It is excavated horizontally along the road. Both sides of the foundation pit are excavated by natural slope, with a slope ratio of 1:1. K0 ~ K2 axis is proposed to use Bailey beam to cross the slope, and the full hall frame is set on it. The superstructure of the station frame bridge at other positions is constructed by full hall turnbuckle frame.

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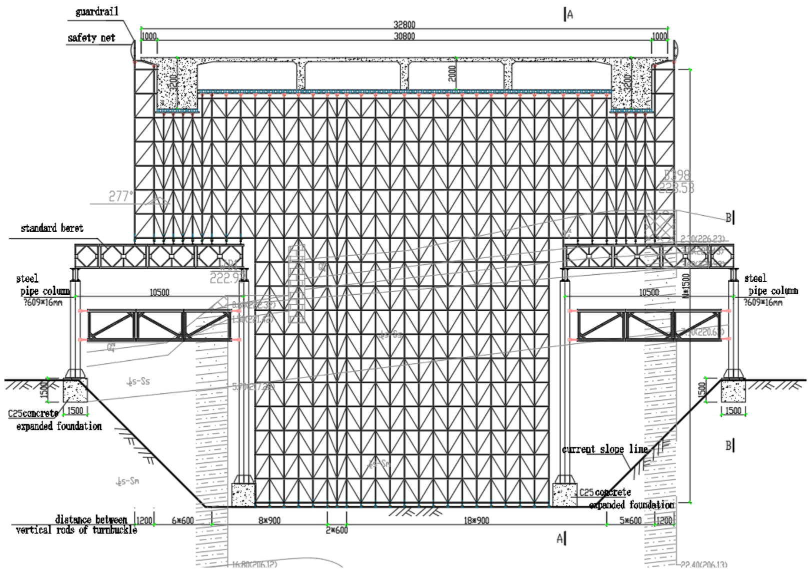

Figure 1: Typical cross section of K0 ~ K2 axis support layout

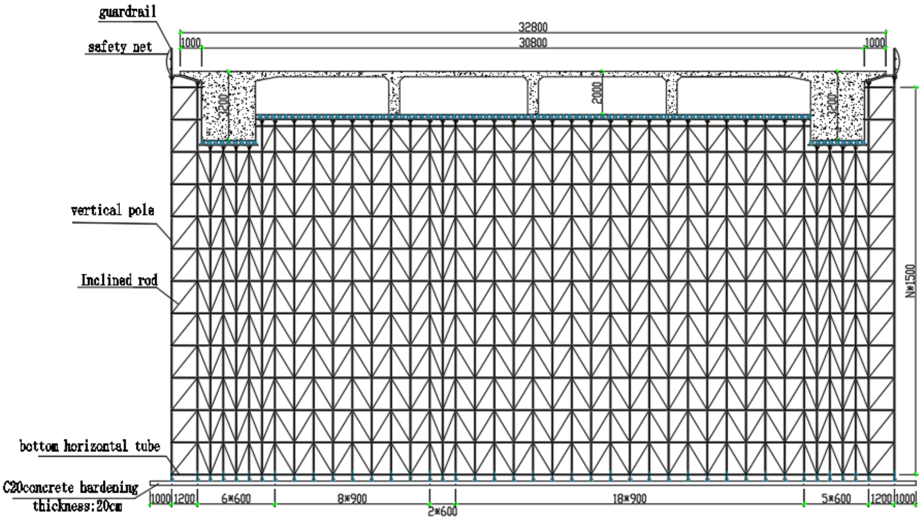

Figure 2: Typical cross section of K2 ~ K5 axis support layout

2.2. Parameters of turnbuckle steel pipe support

The vertical pole of turnbuckle steel pipe support adopts φ sixty × Q345 steel pipe of 3.2mm, cross bar and slash φ forty-eight ×Q235 steel pipe of 2.75mm, and the vertical step distance of the cross bar is 1.5m.

Side stringer: 600 (transverse bridge direction) ×600mm (along the bridge)

Transverse main beam and top plate between main beams: 900 (transverse bridge direction) × 600mm (along the bridge)

The free height of the top of the vertical pole shall not be greater than 65cm, and the top seat adjusting bolt shall be used to adjust the bottom elevation of the main beam. The bottom shall be leveled with the base adjusting bolt, and then the main column and cross bar shall be assembled. The distance between the sweeping rod and the ground shall not be greater than 50cm.

When the height of the frame body does not exceed 8m, vertical inclined rods shall be set on each floor of the first span facing inward from the outside around the support frame body, and vertical inclined rods shall be set on the overall bottom layer and top layer of the frame body, and vertical inclined rods shall be set every 5 spans from bottom to top, longitudinally and horizontally in the internal area of the frame body. When the frame height of the full formwork support does not exceed 4

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steps, the top-level horizontal inclined rod may not be set. When the frame height exceeds 4 steps, the top-level horizontal inclined rod shall be set.

When the height of the frame exceeds 8m, the vertical inclined rods shall be arranged all over, and each section shall be set continuously from bottom to top. One horizontal bar shall be set at the bottom and top of the support respectively, and one bar shall be set every 6 steps in the vertical direction of the support.

Foundation treatment of K0 ~ K2 axis: the turnbuckle steel pipe support in this section is located on the beret or at the bottom of the station foundation pit. According to the construction sequence arrangement of the station and interchange, during the construction of the superstructure of K0 ~ K2 axis, the concrete bottom plate of the station within the foundation pit has been poured. Since the bearing layer of the bottom plate is bedrock, the bearing capacity of the foundation can meet the relevant requirements of support erection.

Foundation treatment of K2 ~ K5 axis: the turnbuckle steel pipe support in this section is located on the soil foundation. The site needs to be leveled and the ground needs to be rolled and compacted. For areas with poor soil quality, the covering soil with a thickness of not less than 1m on the surface shall be removed, and graded crushed stone shall be used for replacement after rolling and compaction. The foundation bearing capacity shall be controlled as ≥ 200KPa. The surface is hardened with 20cm thick C20 concrete. Along the transverse direction of the bridge, the hardened area of C20 concrete exceeds the support erection range by ≥ 1.0m, and drainage ditches are set around.

2.3. Technical parameters of steel pipe column + Bailey beam

"Steel pipe column + Bailey beam" is composed of foundation, column, beam, Bailey beam and distribution beam, and the distribution beam is full of supports. Column, beam, Bailey beam and distribution beam are made of Q235 steel.

2.3.1. General layout

Bailey beam is arranged transversely along the bridge with a span of 1x10 5m, and the columns are located at the top and toe of the foundation pit slope respectively. Along the longitudinal direction of the road, the spacing between Berets is 0.9m. Restricted by the frame pier column, this range is unconditionally provided with Bailey pieces. It is proposed to set more Bailey pieces on both sides of the pier column, two or three pieces in a group, and the spacing between the pieces is 0.45M. I20a distribution beam is set on the Bailey pieces to support the load of the superstructure.

2.3.2. Foundation

The column of the support system at the bottom of the foundation pit adopts C25 concrete strip expanded foundation, with the size of 1.5x1 5m, the foundation is located on the poured concrete bottom plate of the station. Since the bottom plate is bedrock, the bearing capacity of the foundation can meet the construction requirements.

Laterally along the road, the top rock stratum of the left side slope is buried shallowly, and the C25 concrete strip foundation is adopted for the support system on this side, with a size of 1.5x1 5m, the surface covering soil shall be removed to the bedrock, and the expanded foundation shall be poured, and the bearing capacity of the base shall not be less than 400kPa.

Laterally along the road, the top rock stratum of the right side slope is deeply buried, and C25 concrete strip foundation is still used on this side, with the expanded foundation size of 1.5x1 5m, the miscellaneous fill on the surface of the existing soil needs to be removed, rolled and compacted, and the 1.0m graded gravel replacement layer shall be implemented. The bearing capacity of the foundation after replacement shall not be less than 200KPa.[1]

2.3.3. Column

Column adopts Φ 609x16 steel pipe, the column bottom is connected with the foundation through flange and embedded M20 bolts, and the column top is provided with 2cm thick column top steel plate and 12mm thick stiffener plate to support the beam, which is fixed by welding.

2.3.4. Crossbeam

The beam is made of 2h800x300x26x14 double spliced H steel. The two h steels are connected by top and bottom 200x200x12 steel plates to form a whole, with a spacing of 1.5m. In order to avoid local instability of I-beam, the beam with large stress on the top of column needs to be provided with vertical stiffener of Web.

2.3.5. Bailey beam

The longitudinal beam adopts single-layer Bailey beam with a transverse span of 10.5m. Berets are connected longitudinally with pins and transversely with flower windows. The beret frame and the upper distribution beam are fixed with riding bolts, and the beam is fixed with channel steel welded stopper.

2.3.6. Distribution beam

Along the bridge direction, when the spacing along the bridge direction of Bailey sheet is ≤ 0.9m, I10 I-steel is set above the Bailey sheet as the distribution beam to support the upper scaffold. The spacing of the distribution beam in the transverse bridge direction is the same as the longitudinal spacing of the upright pole of the full support.

Along the bridge direction, when the spacing along the bridge direction of Bailey sheet is greater than 0.9m, i25a I-beam is set above the Bailey sheet as the distribution beam to support the upper scaffold. The spacing of the distribution beam in the transverse bridge direction is the same as the longitudinal spacing of the upright pole of the full hall support.

3. Erection of steel pipe column Bailey frame

The truck crane is used as the lifting equipment for the installation of steel pipe column Bailey frame. The large steel pipe column is hoisted and bolted in place by sections, and then the beam, Bailey frame and section steel distribution beam are hoisted on the column in turn. Finally, the surrounding safety settings are improved.

4. Support erection

4.1. Setting out of support upright position

According to the structural dimensions of the design drawings, measure the distance and position of the inner and outer vertical poles along the center line of the line with a ruler, and mark with a marker pen. Vertical pole setting: set a base at the lower part of the vertical pole, adjust the base wrench, measure the elevation with a level gauge, make the base wrench at the same horizontal height, and then hang a line at four corners to adjust the middle wrench, so that the bottom end of the vertical pole is on the same horizontal line; The vertical poles of the first floor shall be staggered with different lengths, and the vertical distance of staggered poles shall not be less than 50cm.

4.2. Lay the lower support of vertical pole

Lay the lower support of the vertical pole, and pay attention to placing the lower support on a flat and solid ground to ensure the stress area of the foundation, and there shall be no void at the bottom. The adjustable base is adopted at the bottom of the vertical pole. The base shall be accurately placed on the measuring and setting out positioning line, and the axis line of the base shall be perpendicular to the ground.

4.3. Support bottom elevation control

In order to ensure the horizontal of the cross bar, control the elevation of the bottom of the vertical bar and make the vertical bar and the horizontal bar can be connected smoothly, the elevation of the lower bracket needs to be carefully adjusted. The method is to erect the bar at both ends along the bridge direction, and the cross bridge direction is divided into three control points: left, middle and right.

4.4. Installation of upright and cross bar

According to the design combination of vertical bar and cross bar, install vertical bar and cross bar from bottom to top. In addition, a reliable connection shall be set between the support system and the abutment and pier, and the vertical rod shall be connected with casing socket and fixed with bolt. Diagonal bracing or cross bracing setting: a vertical diagonal bar shall be set every 5 spans and every floor along the outer longitudinal direction of the frame body, or a fastener steel pipe cross bracing shall be set between 5 spans, and a vertical diagonal bar shall be set at each transverse floor of the end span.

4.5. Jacking installation

In order to facilitate the high-altitude operation of the support and save time, the jacking extension can be roughly adjusted on the ground, and then transported to the top of the support for installation.

Set left, middle and right control points horizontally to accurately call out the jacking elevation, and then mark the jacking extension with obvious marks for verification. Finally, call out the jacking elevation in turn with the method of wire interpolation, and the extension shall be controlled within 30cm.

4.6. Installation of bottom formwork, horizontal and vertical wooden brace and elevation review

After the retest of the jacking elevation, the steel beam at the bottom of the beam and the longitudinal beam of the wooden brace can be installed. After the installation of the longitudinal beam is completed, the control points shall be retested and the rest shall be adjusted by pulling the wire. After meeting the design requirements, the bottom formwork shall be nailed to the wooden brace under the bottom formwork with iron nails.

4.7. Installation of box girder bottom formwork

The bottom formwork of box girder is 1220 × two thousand four hundred and forty × For 15mm bamboo plywood, iron nails shall be used to nail the bottom formwork and wood ridge.

4.8. Edge protection

After the support is erected, the edge protection facilities shall be installed in time.

4.9. Support acceptance

After the erection of the support is completed, the next process can be carried out only after inspection and acceptance. It is necessary to focus on whether the splicing of various components is firm, whether the steel pipe column and beam are installed as required, whether the foundation at the bottom of the formwork support is solid, and whether the safety net and various safety protection facilities meet the requirements.

5. Support preloading

After the support is installed, relevant units and personnel shall be organized to check and accept, and then preloading shall be carried out. Preloading must be carried out when the style of cast-in-situ beam and support of the first span changes.

5.1. Preloading purpose

The support shall be preloaded with a load of not less than 120% of the total construction load. Preloading shall be loaded in stages to eliminate the inelastic deformation of the support, determine the elastic deformation value, and test the stability and reliability of the support.

5.2. Preloading material

According to the calculation of preloading load and considering the feasibility of the scheme and the turnover times of preloading materials, 5T and 2.5t preloading blocks combined with 1t sand bags are used as preloading load and hoisted to the preloading position.

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5.3. Preloading weight

The support shall be preloaded with a load not less than 120% of the total construction load. Preloading shall be loaded in stages to eliminate the inelastic deformation of the support, determine the elastic deformation value, and test the stability and reliability of the support.

According to the calculation of preloading load and considering the feasibility of the scheme and the turnover times of preloading materials, 1m3 soil bag is used as the preloading load and hoisted to the preloading position.

Preloading load calculation:

① Take K10 ~ K12 as an example, reinforced concrete load;

The unit weight of reinforced concrete is 25kn / m3

For the weight calculation of reinforced concrete of frame beam, take K10 ~ K12 cross section, as shown in the figure:

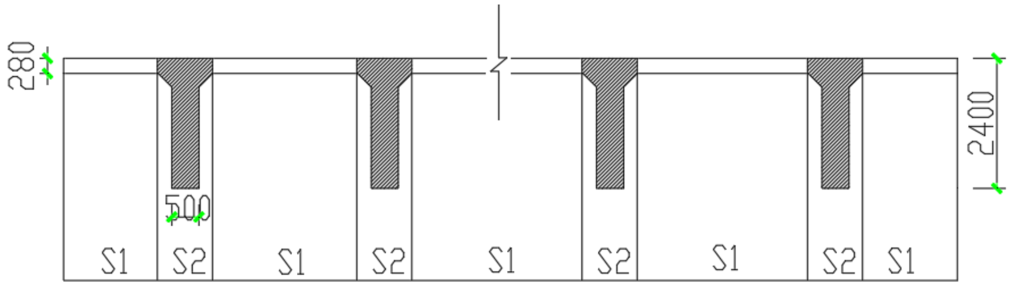

Figure 3: Schematic diagram of transverse division of preloading area of frame beam

S1 flange slab concrete load calculation: 0.28 * 2.5 = 7kn / ㎡;

S2 small longitudinal beam and small transverse beam concrete load calculation: 2.4 * 2.5 = 60kn / ㎡;

S3 is a rectangular end beam with a height of 3.8m, and the load is 3.8 * 2.5 = 95kn / ㎡.

② Loads of construction personnel, construction machines and tools, materials and other walking transportation or stacking

According to the load code for the design of building structures (gb50009-2012), the load of construction personnel, construction machines and materials shall be taken.

③ Self weight of formwork

Load code for the design of building structures (gb50009-2012) takes the standard value of formwork self weight.

Then the preloading load is:

S1 flange plate preloading load: (7 + 0.5 + 3) * 1.2 = 12.6kn/m2

S2 flange plate preloading load: (60 + 0.5 + 3) * 1.2 = 76.2kn/m2

S3 flange plate preloading load: (95 + 0.5 + 3) * 1.2 = 118.2kn/m2 [2]

5.4. Preloading steps and observation methods

The crane is used to lift the load onto the formwork at both ends and stack it evenly. During stacking, it is carried out step by step from the pier body to the flange and loaded symmetrically horizontally, so as to truly simulate the concrete load and achieve the purpose of preloading. The load shall be placed evenly and stably.

Measure the elevation of each point before stacking and record it as H0. Then load it in three times according to 60%, 80% and 100% of the calculated preloading load. After each level of loading is completed, the next level of loading shall be stopped first, and the deformation of the support shall be

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monitored every 12h. When the average value of 12h deformation at each monitoring point is less than 2mm, the next level of loading can be carried out. Among them, H1 is recorded after 60% loading and stable deformation, and H2 is recorded after 80% loading and stable deformation.

Observe immediately after loading to 100%, and then continue to observe at intervals of 6h, 12h and 24h. After 24 hours of observation, and the difference between the observed average values of preloading deformation is no more than 2mm, the support preloading can be considered to be stable, and the elevation of each point is recorded as H3.

Then conduct one-time unloading, measure the elevation again 6h after unloading, and record it as H4.

During the whole loading process, special personnel shall be assigned to observe the deformation of the support. If the deformation is too large or the elevation measured in the graded loading is too large, the loading shall be stopped immediately, and the loading can be continued only after reinforcement measures are taken.

5.5 Preloading qualified

5.5.1. Preloading warning value setting

During the preloading monitoring of the support foundation, when the data do not meet the following conditions, the support shall be checked in time, and the preloading can be continued after finding out the causes and handling:

① The average settlement of each monitoring point for 24h is less than 1mm;

② The average settlement of each monitoring point for 72h is less than 5mm;

In the process of preloading, when the average settlement of each monitoring point in the first 72 hours is greater than 5 mm, the support foundation shall be treated, and then preloaded again.

5.5.2. Support preloading

In the process of support preloading monitoring after all loading, when one of the following conditions is met, the support preloading shall be determined to be qualified:

① The average settlement of each monitoring point in the first 24 hours is less than LMM;

② The average settlement of each monitoring point in the first 72h is less than 5mm;

In the process of preloading, if the above provisions are not met, the cause shall be found out, the support shall be treated, and then the preloading shall be carried out again.

5.6 Data processing

Inelastic deformation = h0-h4. After the pressure test, it can be considered that the inelastic deformation has been eliminated.

Elastic deformation = h4-h3. According to the elastic deformation value, the formwork elevation shall be adjusted during construction to make the beam line shape meet the design requirements after the support is deformed.

6. Support removal

The support removal shall be carried out after the construction of the side span closure section is completed. Before demolition, the construction management personnel shall make safety disclosure to all operators.

6.1. Removal of full support

The removal of formwork must be checked by experience and comply with the relevant provisions of specifications and regulations. The formwork removal time must be strictly controlled. There must be a formwork removal application and approval before formwork removal. The removal of the frame shall be carried out according to the removal sequence designed in the construction scheme.

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The removal shall follow the principle of first up and then down, then erection, first removal and step-by-step cleaning. The removal sequence of components is opposite to the installation sequence. It is strictly prohibited to carry out up and down at the same time. The removal sequence is as follows: adopt the principle of full hole multi-point, symmetrical, uniform and slow, remove the support from the middle span to the side span, and gradually move from the middle of the span to the fulcrum at both ends symmetrically.

During unloading, operators shall transfer all accessories to the ground one by one, and throwing is strictly prohibited.

The components and parts transported to the ground shall be inspected, repaired and maintained in time, and the dirt on the rod and thread shall be removed. If the deformation is serious, they shall be sent back for repair; After inspection and correction, accessories shall be stored according to varieties and specifications and kept properly.

When removing the rod, inform each other and coordinate the operation. The loosened rod parts shall be removed and transported out in time to avoid false support and leaning.

When removing the support, draw a safety zone, set warning signs and send someone to take care of it. If the lifting equipment is used, send a special person to command. Before removing, clean the appliances, excess materials and sundries of the scaffold. The removal shall be carried out in strict accordance with the principle of supporting first and then removing, and then supporting and first removing. It shall be carried out layer by layer from the top to the bottom. It is strictly prohibited to carry out the upper and lower layers synchronously, throwing is strictly prohibited, and the height difference of removal shall not be greater than 2 steps.

6.2. Removal of steel pipe column Bailey frame

The Bailey frame of steel pipe column shall be removed with the cooperation of crane, and the removal operation shall be carried out in the reverse order of installation. Remove the bottom formwork, distribution beam, Bailey beam, cross beam and column from top to bottom. It is strictly prohibited to remove it from top to bottom at the same time. The demolition operation shall be carried out continuously, and throwing and scattering of components and fittings are strictly prohibited.

7. Conclusions

This paper analyzes and expounds the scheme design, support erection, support preloading and support demolition of the support method in the construction of bridge cast-in-place beam, hoping to play a reference role in the construction of the same type of bridge construction.

References

[1] Dapeng Zhou Analysis on construction measures of bridge cast-in-situ box girder support [J] China new technology and new products, 2013 (12): 207-208
[2] Ronghui Yang, Fujian Lu Research on bridge engineering support construction [J] Theoretical research on urban construction (Electronic Edition), 2012 (1): 46-47