Research on Design and Construction of High-Altitude Structure Support System: A Case Study of Daduhui Project

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Abstract: Combined with the location and characteristics of the high-altitude structural beam of the Daduhui project, the scheme of erecting large section steel beam as the formwork support platform is finally selected, through the detailed comparative analysis of the application of different load matrices. The scheme determines the key control points in the construction of high-altitude structural beam, and proves that the formwork supporting construction scheme can provide reliable support for high-altitude structural beam through engineering practice. Technically, this structural form is concise, safe, reliable, economical and reasonable, and easy to install. It not only saves the amount of steel pipe support, effectively shortens the installation period of formwork support, but also the section steel can be reused, reducing the cost. In addition, the technology also solves the construction problems of high-altitude beam and slab, and provides a valuable reference for other similar projects.

Keywords: High Altitude Structure; Profile Steel Platform; Formwork Support; Design and Construction

1. Introduction

With the continuous progress of urbanization, the construction of high-rise buildings and complex structures is increasing, and the construction technology of high-altitude structure has become an important topic in modern building engineering. As the key component connecting different floors, the construction quality and safety of high-altitude structural beam directly affect the stability and service life of the whole building[1,2]. However, the construction of high-altitude structural beams faces many challenges, such as high working height, large load, narrow construction space and so on. Therefore, how to select the appropriate formwork support scheme to ensure the safe and reliable construction of high-altitude structural beams has become an urgent problem for engineering and technical personnel[3-5].

In recent years, a lot of research and practice have been carried out in the field of high-altitude structure construction at home and abroad, and a variety of formwork support schemes have been proposed, including floor type formwork support, cantilever steel platform, cantilever steel platform and large section steel beam support platform[6-8]. Each scheme has its scope of application, advantages and disadvantages, and needs to be comprehensively analyzed and selected according to the specific engineering conditions. For example, although the floor type formwork support technology is mature and easy to assemble and disassemble, when the erection height is high, the safe operation is difficult and the cost is high; The cantilever steel platform and cantilever steel platform can reduce the erection height, but the installation and removal are more complex, and the requirements for construction equipment are higher; The large section steel beam support platform has the advantages of simple stress form, convenient installation, economic and reasonable, but the safety of steel beam and support needs to be considered[9,10].

Daduhui project is located in the old urban area of Huzhou City, Zhejiang Province. It is a typical high-rise building complex project, including multi story commercial podium and high-rise residential buildings. The project encountered technical difficulties in the construction of high-altitude structural beams in the construction process, especially the two structural beams at the position of the j-axis at the elevation of+32.250 M. due to the large span, large section size and no structural support on both sides, the construction was extremely difficult. In order to solve this problem, the project team combined with the actual situation of the project, through the comparative analysis of different formwork support schemes, finally selected the scheme of erecting large section steel beam as the formwork support platform.

Taking the Daduhui project as an example, this paper introduces in detail the key technologies and control points in the construction of high-altitude structural beams. Firstly, by comparing and analyzing the advantages and disadvantages of different formwork support schemes, the scheme of using large section steel beam support platform is determined. Secondly, the detailed structural safety calculation of the selected scheme is carried out to ensure its reliability in the actual construction. Finally, the key technical points and precautions in the construction process are summarized, including the setting of steel support platform, the pre arch of formwork, the installation and removal of I-steel and the erection of formwork support. Through the practice of this project, it is proved that this scheme can not only effectively solve the construction problems of high-altitude structural beams, but also has high economy and practicability, which provides a valuable reference for similar projects.

2. Project Overview

The Daduhui project is located in the old urban area of Huzhou City, Zhejiang Province, the former site of the Great Hall of the people, with Jiangnan industry and Trade Street in the East and Laodong Road in the south. The total construction area of the project is 112885.26 square meters (22996.38 square meters underground), including a 29 story commercial and residential building and podium above the ground and a 24 story apartment hotel and podium. The podium is a 7-storey shopping mall and the number of underground floors is 2. The commercial and residential building has a building area of 20094.36 square meters, a frame shear wall structure, and a building height of 99.50m; The apartment hotel has a building area of 19391.36 square meters, a frame core tube structure, and a building height of 95.9m; The podium has a building area of 49250.39 square meters, a frame structure, and a building height of 37.3m.

There are two structural beams at the j axis of the roof podium+32.250m elevation. The beam span is 9m, the maximum beam section size is 400 × 1100mm, and there is no structural beam slab between -0.050~+32.500m below. The construction is difficult. See Figure 1 for details.

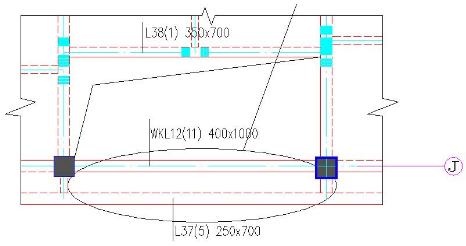

Figure 1. Structural Layout of Roof Podium +32.250m Structural Plane J × 30 Axis Area

3. Analysis of Construction Difficulties

(1) Risk superposition of high-altitude and edge operation: the beam construction surface is 32.35m away from the floor surface, forming a fully suspended working environment. The constructors need to carry out formwork erection, reinforcement binding and other processes in an open space without external protection. The dual protection pressure of personnel falling prevention and material splash prevention has increased significantly. The impact of high-altitude wind load is prominent (the wind speed is 15%-20% higher than the ground), which is easy to cause the vibration displacement of the formwork system.

(2) The load transfer of large section cantilever structure is complex: the single span beam line load is up to 16.4KN/m, and it is easy to generate eccentric force when the load is transferred through the formwork support pole. During the beam concrete pouring process, the superposition effect of pump pipe impulse impact force (about 2 KN /m^2) and vibration and tamping load (about 1 KN /m^2) is significant.

(3) It is difficult to control the stability of long and narrow space frame: the erection width of formwork support is only 1175mm. The longitudinal stability of the frame only depends on its own member connection, lacking the lateral constraint of the horizontal structure layer, and the torsional stiffness of the frame under horizontal load is insufficient.

(4) It is difficult to control the quality of concrete forming. The requirements for deformation coordination control of formwork system under temperature difference and humidity change are strict, and the deterioration of maintenance conditions caused

by high-altitude environment needs to be overcome.

4. Formwork Support Design Scheme

For the construction of J-axis suspended beam of+32.250m skirt building surface structure, the key is to solve the problems of its formwork support and its support carrier. To solve this problem, the following four options are available.

4.1 Cantilever Steel Platform Set at -0.100m Structure (Super High Formwork Support)

The steel pipe formwork support shall be directly erected on the -0.100m structural plane to the+32.250m structure, with the vertical and horizontal spacing of 900mm and the step distance of 1800mm. According to the formwork support specification, the height width ratio of the formwork support shall not be greater than 3, that is, the width of the formwork support shall not be less than 11m, and the longitudinal and transverse cross bracing and horizontal cross bracing shall be set according to the specification requirements, as shown in Figure 2 and Figure 3 below.

The scheme uses common materials, is easy to assemble and disassemble, and has mature erection technology. However, due to the high erection height of the support frame, up to 32.35m, the safe operation is difficult, and the erection and use cycle are long, the amount of steel pipe materials is large, the erection is time-consuming, labor-consuming, and the construction cost is high.

4.2 Cantilever Steel Platform Set at +26.650m Structure

The cantilevered 16# I-steel beam is set in the+26.650m structure, and the 10# I-steel is used as the inclined lower support in the+21.450m structure. The 10# I-steel inclined lower support is welded with the 16# I-steel cantilever beam, and the steel pipe formwork support is erected on the cantilever beam, as shown in Figure 4 and Figure 5 below.

The cantilever steel beam in this scheme needs to be set according to the spacing of the upper formwork support, and the installation of 16\i-steel beam needs the cooperation of tower crane, and the installation of the lower diagonal brace is difficult; However, only one layer of formwork support is required.

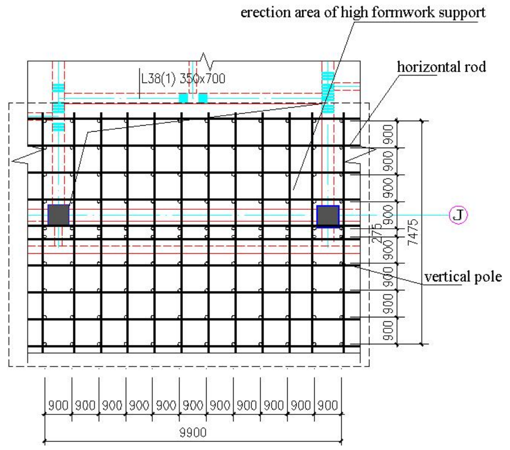

Figure 2. Floor Type High Formwork Support Frame Plan

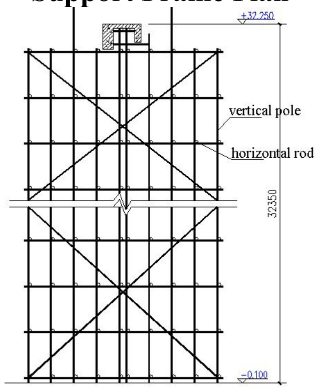

Figure 3. Sectional View of Floor Type High Formwork Support Frame

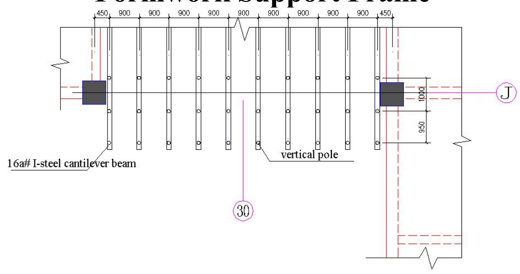

Figure 4. Schematic Plan of Cantilevered Steel Beam at + 26.650m

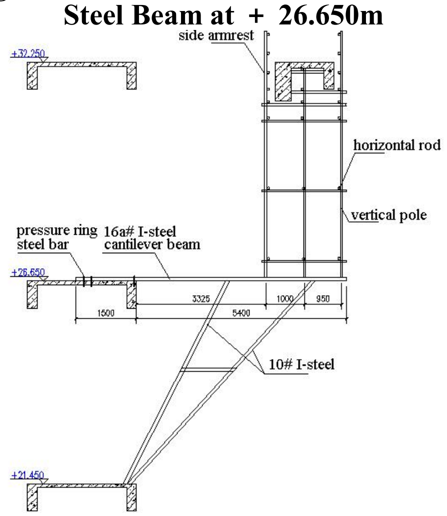

Figure 5. Cantilever Formwork Erection Section (Cantilever Type)

4.3 Cantilever Steel Platform Set at +21.450m Structure

The+21.450m structure is provided with a cantilevered 16# I-steel beam, and the+26.650m structure is embedded with lifting rings. Two ф 18mm steel ropes are used as cable-stayed cables, and a steel pipe formwork support is erected on the cantilevered beam. Compared with scheme 2, the inclined strut is changed into inclined tie rod in this scheme. Although the inclined tie rod is more convenient to install, the height of the formwork support is increased by one layer, forming a 10.80m super high formwork support, as shown in Figure 6 and Figure 7 below.

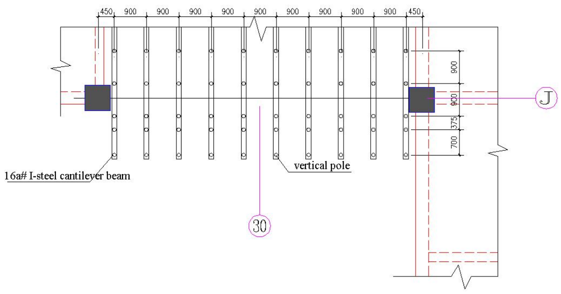

Figure 6. Cantilever Steel Beam Plan at + 21.450m

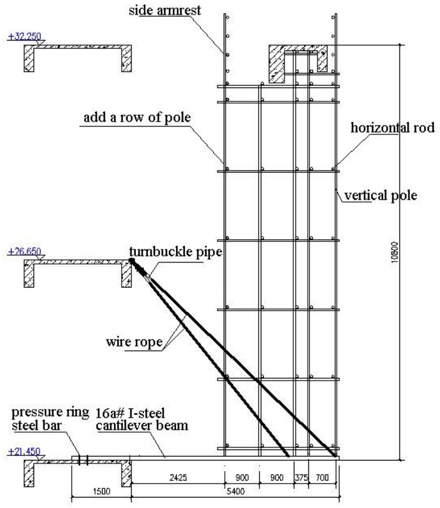

Figure 7. Profile of Cantilever Formwork Support Erection (Cantilever Type)

4.4 Erection of Large Section Steel Beam as Formwork Support Plane

In the+26.650m structure, according to the position of structural beam, three 50a# I-steel beams are respectively erected as the erection platform of formwork support, and the steel pipe formwork support is directly erected on the steel beam, as shown in Figure 8 and figure 9 below.

The scheme has the advantages of simple stress form, convenient installation, and only one layer of formwork support needs to be set up, with less turnover materials and less cost investment. However, because there is no structure on one side, it is necessary to set the steel corbel as the steel beam erection fulcrum.

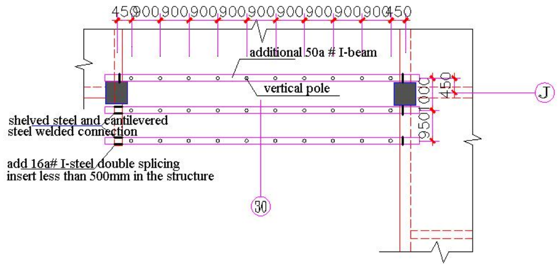

Figure 8. Lay Down Profile Steel Main Beam Plan at + 26.650m

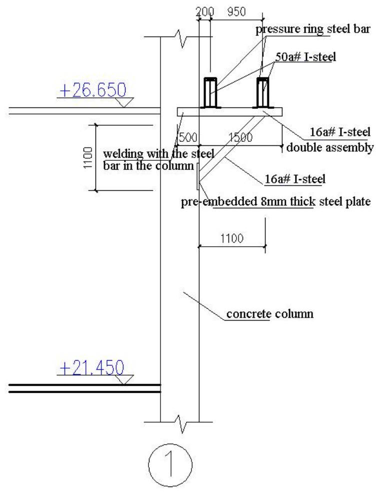

Figure 9. Profile of Formwork Support for Erection of Section Steel Main Beam

Through comparative analysis, scheme 4 has certain advantages in economy, feasibility and convenience. What needs to be considered is that the load of the whole formwork support system acts on the 50a# I-steel beam. As long as the safety of steel beam and steel beam support is fully considered, it is feasible, so scheme 4 is finally selected.

5. Safety Calculation of Steel Beam Supporting Platform Structure

During the calculation, considering the influence of the self weight of the upper structure reinforcement and concrete, the self weight of the formwork support, the construction load, wind load, etc., calculate the load on a single vertical pole, and then check the main beam of 50a# according to the vertical pole layout; Finally, check the profile steel support platform as shown in Figure 10 below (profile steel bracket). After calculation, the 50a# steel beam and the end 16# steel support frame platform meet the design requirements.

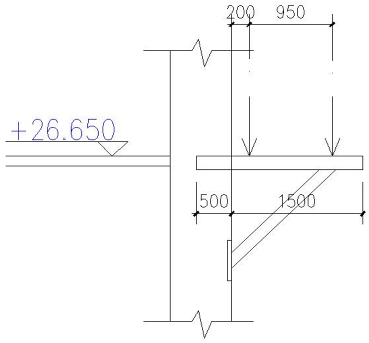

Figure 10. Bearing Stress Diagram

6. Construction Points of Steel Beam Support Platform

6.1 Profile Steel Support Platform Shall be Set at One End without Structural Beam

(1) On the structural frame column with no structural end at the elevation of+26.650m, double 16# I - steel are added. The spacing of the double I-steels is 200mm. The I-steels extend into the concrete structure for not less than 500mm and are firmly welded with the main reinforcement in the column. The length of the I-steels extending out of the concrete structure is 1500mm. The elevation of 16# I-steel surface is about 100mm higher than the elevation at + 26.250m structural surface. When erecting 50a# I-steel, the profile steel pad can be placed.

(2) A 16# I-steel diagonal beam is set at the lower part of the 16# I-steel beam. The horizontal and vertical distances between the diagonal point and the structure are 1150mm, and the angle of the diagonal is 45°, so that the support forms a stable triangular support system. Specifically, 250 × 250 embedded parts can be embedded in the structure first during the structural construction. After the side formwork is removed, the steel beam and the embedded parts can be welded to form a triangular frame stress.

6.2 Pre-camber the Supporting Surface Formwork

By checking the deflection of 50a# I-steel, the maximum deflection value of steel beam ν_{max}=11.807mm is obtained. Adjust the pre-camber value of the formwork support according to the calculated deflection value and the camber requirements specified in the formwork specification. Since the beam span in this area is 9m, considering the compression deformation of the overall formwork support, we set the camber height to 30mm.

6.3 installation and removal of 50a# I-steel

(1) According to the hardware manual, the theoretical weight of 50a# I-steel per meter is 93.6kg/m, so the total weight of a single 10m long 50a# I-steel is 936kg. A QTZ100 (ZJ6012) tower crane is installed in this area. According to the instructions of the tower crane, the maximum boom amplitude of this tower crane is 60m, and the minimum rated lifting capacity is 1200kg, so it can fully meet the lifting requirements of a 50a# I-steel.

(2) When hoisting the 50a# I-steel, first use the tower crane to lift the 50 a# I-steel above the installation position, slowly put down the I-steel, and adjust both sides with hemp rope to make the I-steel vertical to the triangular support or structure, and ensure that the laying length on both sides is not less than 400mm; First install the inner I-steel, and then install it outward in turn. After installation in place, the I-steel is not prevented from overturning. ф20 round steel can be used as the compression ring reinforcement on the triangular support frame to fix the I-steel by welding, and the three 50a# I-steels are connected by staggered welding ф20 reinforcement, with a spacing of about 2000mm, so as to improve its overall stability.

(3) When removing the I-steel, all the vertical rods, cross bars, fasteners of the frame body and the scaffold plates, connecting reinforcement, and pressing ring reinforcement on the platform shall be removed before removal. Due to the completion of superstructure pouring, when the 50a# I-steel in the middle is hoisted, it can be pulled to the outside with a manual hoist, and then lifted away from the site with a crane. Due to the size limitation of the hole, the I- steel at the innermost side can be hoisted at one end, and the other end can be tensioned with a manual hoist, which is slowly relaxed while being hoisted until it is perpendicular to the ground, and then lifted away from the site after the manual hoist is removed.

6.4 Formwork Erection

(1) The erection parameters of formwork

support shall be designed and calculated in advance in combination with 50a# I-steel. The requirements of special scheme shall be strictly implemented in the erection process. Since there is no structural tie in this area, vertical and cross bracing structure strengthening measures shall be taken.

(2) Before erection, the position line of formwork support pole shall be snapped in advance on the 50a# I-steel, and the ф25 rebar head with a height of not less than 150mm shall be welded on its position.

(3) The outermost pole of the formwork support shall be no less than 1.2m higher than the pouring structural plane. Three horizontal protective railings shall be set at the positions of 0.2m, 0.6m and 1.2m, and a safety net shall be hung on the outside of the support body for protection.

6.5 the platform bottom is protected by fully paved scaffold pieces

(1) After the three 50a# I-steel are installed in place, the horizontal steel pipes are directly erected on them, the spacing of steel pipes is 300mm, and the fasteners are used to clamp each 50a# I-steel, and the upper part is covered with scaffold pieces for protection.

(2) As this area is located in a patio, 1.2m high protective railings are used around the -0.100m structural plane of this area, and warning signs are hung to prohibit personnel from entering the area.

7. Conclusion

Combined with the location and characteristics of the high-altitude structural beam of the Daduhui project, the project selected the scheme of erecting the large section steel beam as the formwork support platform through a variety of comparative analysis. During the construction process, the structure was stable, and no adverse conditions such as abnormal deformation of the lower support system were found. Practice has proved that the scheme is safe and reliable, which not only saves the amount of steel pipe support, effectively shortens the formwork support installation period, but also the steel can be used in turn, reduces the cost, and solves the construction problems of high-altitude beams and slabs.

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