

Construction Technology of Steel Structures in Large Public Buildings

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Abstract. With the continuous development of the Chinese economy and the rapid development of large public buildings, the application of steel structures in large buildings is gradually increasing. The use of steel structures is crucial for meeting the needs of large-span, super high-rise buildings, rapid construction, and achieving sustainable development of buildings. Therefore, studying and analyzing the construction technology of large-scale building steel structures has important practical significance. This study is based on a library construction project, focusing on the installation of embedded bolts, steel columns, steel beams, and high-strength bolts in the construction of large building steel structures, as well as the technical schemes and construction processes of welding, anti-corrosion coatings, and fireproof coatings. I hope to provide reference and suggestions for actual construction.

Keywords: Large public buildings; Steel structure construction; Technical program; Construction process

1. Introduction

With the continuous development of China's economy and the rapid growth of the construction industry, large public buildings are experiencing a high-speed development trend. Steel structures, as green and environmentally friendly materials, are widely favored in the construction of large buildings due to their high strength, light weight, reliability, and fast construction. It is not only a result of national policy guidance but also a product of technological progress [1]. In order to promote green and environmentally friendly construction as proposed in the "Eleventh Five-Year Plan," there is a strong push to develop the steel structure industry, aiming to replace wood and concrete with steel in construction [2]. Therefore, conducting research and analysis on the construction technology of large building steel structures is of great practical significance.

Steel structures have many advantages, such as high strength, light weight, rapid construction, strong load-bearing capacity, flexibility, and seismic resistance. They are necessary for large-span, super high-rise buildings, special needs, and rapid construction, as well as for sustainable development [3]. The construction process of steel structures involves design, fabrication, installation, and inspection. Steel is the main material used, and the connection methods include welding, bolting, and riveting, each with specific technical requirements and processes. Lang Shen [4] addressed issues related to anchor bolts, including the inability to anchor them into the reinforcement cage, positioning deviation, and conflicts with reinforced concrete structures to improve construction quality. Bin Xia [5] conducted research on lifting, seating, and fixing measures for building steel structures using a three-dimensional simulation model based on structural finite element software. Xueyi Ma [6] summarized the technical points in welding construction, including preparation, preheating, and heat preservation. Tao Lan [7] studied the influence of surface treatment and materials on the anti-slip coefficient of weather-resistant high-strength bolted connections. Zhen Guo [8] analyzed and summarized quality control points for anticorrosive coating construction in assembled steel structure projects. Chuanli Lv [9] Combining

the application of steel structure hoisting in a large public building, this paper explores common quality, safety and other issues during construction, as well as corresponding measures. Xinxin Fan [10] Based on a steel structure building project in Zhengzhou, an analysis was conducted from the aspects of structural system, construction design, and key node design to ensure the accuracy and efficiency of the deepening design, as well as the economic and timeliness of the construction plan of the engineering project.

Based on the literature review, existing research on the construction technology of large-scale building steel structures primarily focuses on improving specific construction links. However, there is a lack of comprehensive studies and systematic optimization of the entire construction process. This paper aims to address this gap by discussing the technical solutions and specific processes for the construction of large-scale building steel structures. The main focus will be on the installation of pre-positioned embedded bolts, steel columns, steel beams, high-strength bolts, as well as welding, anticorrosion coating, and fireproof coating. The objective of this paper is to provide technical references and suggestions for actual construction.

2. Project Overview

2.1 General project overview

This new project is a library in Guangzhou, the total land area of the project building is 8126.92m², with a total construction area of 52065.81m², which belongs to a large public building. The project has 9 floors above ground and 6 floors underground, with a maximum building height of 43.8m, and the structural form of the building is steel frame-concrete shear wall structure, which is a kind of high-rise public building.

2.2 Analysis of the project's key points

(1). Deepening design: The complex structure of the project presents challenges in deepening design, including a large workload due to various member sizes and complex nodes. Proper distribution and clear representation of members and nodes in the drawings are necessary.

(2). Project duration: The steel structure construction requires a significant amount of steel and involves tight scheduling. Ensuring high-quality completion within the given timeframe is a major focus. Safety management is also challenging due to the height of the construction.

(3). Organization and management of vertical transportation machinery: The project's vertical transportation machinery is limited, and coordination with civil construction is required. Effective organization and management of these machines are crucial for the project's schedule and safety.

(4). High protection requirements for overhead welding: Welding tasks at high altitudes, such as steel column butt joints and beam-column connections, necessitate strict measures for rain and wind protection, as well as safety precautions.

(5). Deepening design, production and processing, on-site installation of rotary staircase: rotary staircase structure is complex, deepening design, production and processing and installation are difficult.

2.3 Overall construction deployment

(1). Deepening design: Use design calculation models and structural drawings to establish a deepening design model. Submit the model for review and confirmation by the design institute. Use specialized design software to ensure accuracy and aesthetics. The deepening design management team will create a detailed plan and hold regular coordination meetings to ensure timely production of drawings.

(2). Project schedule: Develop a detailed construction progress plan and strictly adhere to it. Use cranes for low-level steel structure installation.

(3) Difficulty in safety management: equip enough safety management personnel; make installation platform in advance at the installation position of the steel column docking position to

ensure the construction safety; equip the operation with qualified safety protection products; strengthen the workers' safety education and safety briefing to avoid unauthorized operation.

(4). Vertical transportation machinery organization and management: Properly organize and manage the number, location, operation, and scheduling of hoisting machinery. Emphasize safe use management.

(5). High welding protection at high altitude: Install operation platforms and use methods such as rainproof sheds at welding openings to ensure optimal welding conditions.

(6). Deepening design, production processing, and on-site installation of rotating stairs: find experienced deepening design and component processing units to carry out; Control the accuracy of the embedded parts on site in advance, measure and lay out before installation, and ensure the accuracy of the installation of the rotating staircase. During hoisting, adjust and confirm the hoisting angle of stairs in advance according to the deepening model.

3. Steel construction deployment

This monolithic steel structure project is a steel frame structure, which is divided into two parts: underground steel structure and above ground steel structure. The underground steel structure is composed of 9 box-type columns, 39 round tube steel columns and H-type steel beams, while the above ground part is mainly composed of 3 box-type columns, 29 round tube columns and H-type steel beams. The main material of steel is composed of Q355B and Q355GJC. When the plate thickness is $\geq 36\text{mm}$, Q355GJC is used. 10.9 grade friction type high strength bolts are used for high strength bolts, 5.6 grade common bolts are used for mounting bolts, and 8.8 grade bolts are used for connecting bolts, as shown in the figure.

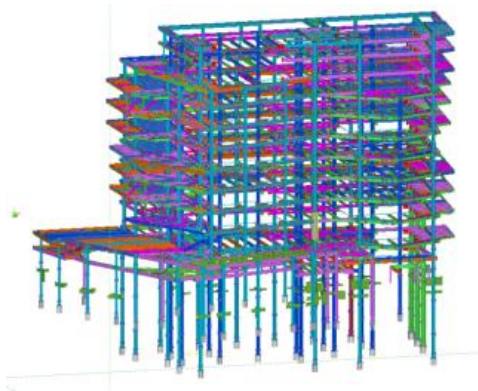


Fig. 1 3D model of steel structure

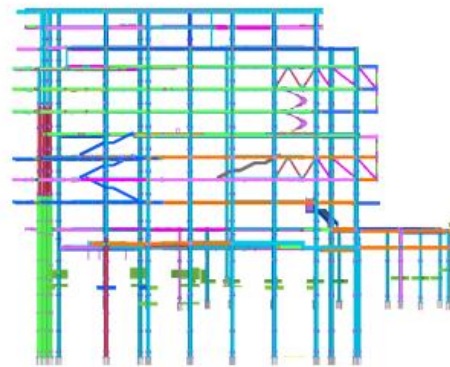


Fig. 2 4-axis axial view of steel structure

3.1 Steel Structure Installation Ideas

The underground part of the steel columns and beams will be installed first, according to the actual progress of the site, the installation will be carried out in the direction of the L-axis from the A-axis, and the installation of steel columns will be carried out after the completion of part of the concrete foundation pouring, the installation of steel columns will be carried out after the completion of the steel columns installation. The above ground part is installed from B-axis to K-axis direction, and the steel beam is installed after the steel columns are adjusted.

3.2 Technical measures

(1) Technical measures for the construction of pre-embedded bolts

As the foundation part of the whole steel structure, the pre-embedded accuracy of the pre-embedded bolts is directly related to the quality of subsequent installation and positioning of steel columns and beams, and the installation accuracy of the pre-embedded bolts should meet the requirements in table 1.

Table 1.Positioning requirements for pre-embedded bolts

Numble	sports event	Allowable deviation(mm)
1	Positioning axes of buildings	3.0
2	Positioning axis of columns on the foundation	1.0
3	Elevation of foundation bearing surface	± 2.0
4	Pre-embedded bolts (anchor bolts) offsets	2.0

1) The positioning plate is used during the installation of embedded bolts to ensure accuracy. It is made of Q235 steel plate and has bolt apertures larger than the diameter of the bolts by more than 2mm.

(2) A steel ladder is used for lifting steel columns. It is hung on one side and securely connected. The inner side of the ear plate hole of the hanging sling should be polished to avoid damaging the wire rope. A ground personnel can assist the operator by tying a wire rope to the top of the column. The length of the ladder depends on the height of the column, and it should be tied or welded to the column body for columns over 6m. The ladder is made of $\Phi 12$ round steel with a width of 400mm and a step distance of 350mm. Welding points should be checked to prevent accidents and a rope with a diameter of 18mm is used for safety. Specific practices as shown in Figure 3.



Fig. 3 Schematic diagram of attached climbing ladder

2) Steel column sling set

Calculate the required diameter of the steel wire rope for lifting the heaviest steel column. Use high-strength rings as lifting rings and wrap the wire rope with rubber tube for protection.

(3) Technical measures for steel beam construction

Preprocess the steel beams in the processing plant and lift them on-site using a tower crane. Prior to the formal lifting of the steel girders, the girders were attached to some of the steel girder connection plates and bolts and lifelines were pulled. Connect steel beam connecting plates and bolts before lifting. Set lugs at each 1/3 of the beam length for lifting. Use 20mm steel wire rope for lifting.

4. Steel structure on-site construction process

4.1 General flow of steel structure erection process

Steel structure embedded parts are placed, concrete columns of civil construction are poured, and concrete strength meets design requirements; tower crane installs steel columns of the first underground part; tower crane installs steel columns of the underground part to the second underground part; tower crane installs steel beams of the second underground part and the first underground part; tower crane installs steel columns and steel beams of the above ground part. According to this method to complete the subsequent installation layer by layer.

4.2 Specific construction process of steel structure

(1) Buried bolt process

Mark the bolt group center line on the tied column base reinforcement. Position the steel plate on the base reinforcement, aligning the cross wires with the reinforcement marks. Insert pre-embedded bolts into the steel plate bolt holes, adjust the elevation, and secure with nuts. Weld the bottom reinforcement and positioning steel plate using a 12mm diameter steel bar. Apply grease and greaseproof paper to protect the bolt thread part.

(2) Steel column installation process

Lift the steel column using a lifting hook, rotating and moving slowly. Align the bottom center line of the upper column with the top center line of the lower column. Temporarily fix the columns with ear plates and connecting plates using mounting bolts. Adjust the column elevation with steel wedges and torsion adjustment with pads. Adjust the verticality using jacks and tighten the mounting bolts. Weld the columns and remove the connecting ear plates after welding.

(3) Steel beam installation process

Clean the steel beam friction surface and attach mounting bolts. Hoist the steel beam to the mounting position and align the bolt holes. Temporarily fix the beam with mounting bolts and replace with high-strength bolts. Screw the high-strength bolts and apply paint on the connecting plate.

(4) Welding process

Ensure high-strength bolts, operating platform, windbreak, and protective frame are in place. Apply the first layer of fireproofing paint. Clean the bevel, check liner plate and arc-inducing plate, and preheat. Perform positioning welding, root bottoming, filler welding, and surface welding. Conduct post-heating and inspect the appearance. Repair and re-preheat if unqualified, fill in the inspection form if qualified. Grind the detection area and conduct ultrasonic flaw detection.

(5) On-site fireproof paint coating process

Set up construction scaffolding and operation platform. Pre-treat the steel structure to meet fireproof coating requirements and prepare the fireproof coating. Spray the first layer of fireproof coating. After the first layer dries, spray the second layer of fireproof coating while correcting edges and interfaces. Perform quality checks. If qualified, protect the finished product and complete the process handover. If not qualified, return to the site for repairs and reapply the first layer of fireproof coating.

5. Summary

Based on a library construction project, this research analyzes the technical scheme and construction process of pre-set embedded bolts, steel columns, steel beams, installation of high-strength bolts, as well as welding, anticorrosive coatings and fireproof coatings for large-scale building steel structure construction, and comes up with the following conclusions:

(1) By analyzing the major difficulties of the project and, for each of the major difficulties, specifically put forward countermeasures, and then put forward the overall construction deployment of the steel structure construction, specifically the underground steel structure consists of 9 box-type columns, 39 round tube steel columns and H-type steel beams, and the ground part mainly consists of 3 box-type columns, 29 round tube columns, and H-type steel beams. The main material of steel is composed of Q355B, Q355GJC, etc., which provides guarantee for the smooth construction of steel structure.

(2) The installation technology of pre-set embedded bolts, steel columns, steel beams and high-strength bolts has an important impact on the quality and safety of steel structure construction. Adopting scientific and reasonable technical program and construction process can ensure the quality of building construction and improve the stability and durability of steel structure.

(3) Welding and painting are important links in steel structure construction, which need to adopt strict construction technology and quality control measures to ensure the welding quality and the

corrosion resistance and fireproof performance of paint, which is of great significance to improve the overall stability of steel structure.

To summarize, steel structure construction is a systematic project that requires strict control of every link to ensure the final construction quality and building performance. At the same time, continuous research and technological innovation are essential to improve the efficiency and quality of steel structure construction.

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