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RESEARCH AND APPLICATION OF CONSTRUCTION TECHNOLOGY OF GROUND STEEL STRUCTURE OF DOUBLE-LAYER EXHIBITION HALL

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Abstract: This study proposes an innovative construction technology of ground steel structure of double-layer exhibition hall, aiming to solve the problems of top plate cracks, steel structure installation risks and costs during construction. This technology effectively reduces the pressure of basement beams and slabs by setting a conversion steel platform on the top plate of the basement, combining intelligent hoisting and robot welding, improving construction efficiency and quality, and reducing labor costs. Through practical application in the Hangzhou Convention and Exhibition Center project, the new construction technology adopted reduces construction costs, improves construction efficiency, shortens construction period, and meets the national green building promotion requirements. In the future, this technology can be promoted and applied in a wider range of construction projects.
Keywords: Double-layer exhibition hall; Steel structure construction; Intelligent hoisting; Green building

INTRODUCTION

With the rapid development of my country's economy and the deepening of international exchanges, exhibition projects are increasing. In order to meet the needs of large-span and large-space exhibitions, exhibition and museum buildings usually adopt large-span steel structure design. The underground part is generally a reinforced concrete frame structure, and the upper part is a steel structure exhibition hall [1-3]. In order to solve the problems of top plate cracks, steel structure installation risks and engineering costs in the construction of double-layer large-span exhibition halls, this paper proposes an innovative double-layer exhibition hall ground steel structure construction technology. It is expected to be further promoted and applied in exhibition and museum buildings.

1 PROJECT OVERVIEW

Just like Figure 1, the first phase of the Hangzhou Convention and Exhibition Center project covers a total area of approximately 353,000 square meters and a total construction area of 643,200 square meters. This project has 8 exhibition halls, 1 underground floor and 1 above-ground floor (partially 2 floors); two login halls, 1 underground floor and 4 above-ground floors; middle corridor: 1 above-ground floor and partially 2 floors. The basement is a reinforced concrete + steel column structure, and the above-ground structure is mainly a steel frame + large-span truss steel roof combination structure. The steel structure includes 6 standard single-story exhibition halls and 2 double-story exhibition halls.

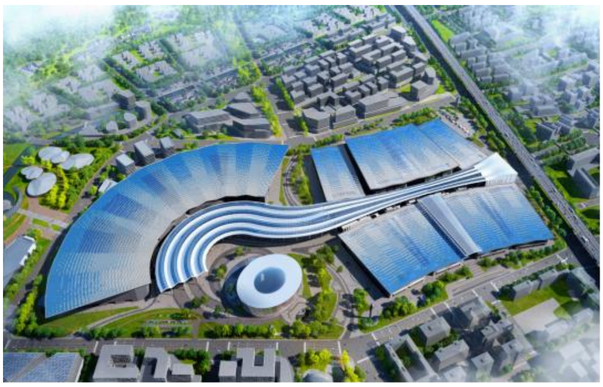


Figure 1 Hangzhou Conference Display Intent

2 PROCESS PRINCIPLE

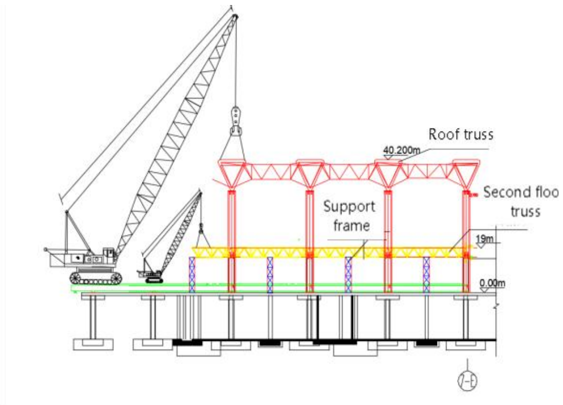


Figure 2 Schematic diagram of the construction of the above-ground steel structure of the double-story exhibition hall

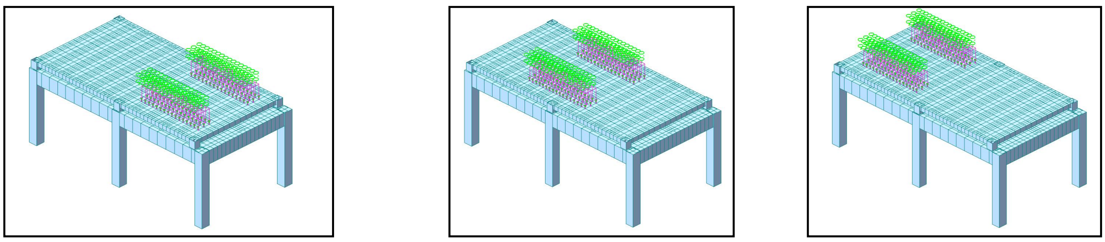
In Figure 2, a steel platform is set up in the air on the top plate of the basement. The platform span is the same as the spacing between the lower steel-concrete columns, and a 2m×5m roadbed box is laid on the top. The most unfavorable working condition disturbance of the crane when driving and hoisting on the steel platform is calculated by finite element software, and a steel plate with a thickness greater than the maximum deflection of the steel platform beam is laid between the lower part of the steel platform and the steel-concrete column to achieve the padding of the concrete floor and beam. The mechanical dead load and live load are transmitted to the steel platform through the roadbed box, and then to the steel plate from the steel platform, and finally to the steel-concrete column and pile foundation, ensuring that the basement top plate is not stressed, thereby ensuring the safety of the underground structure. The ground steel structure hoisting adopts a large crawler crane for three-dimensional segmented high-precision intelligent construction. The overall construction sequence is frame structure, second-floor truss, roof truss lifting and cantilever truss, and welding is performed by welding robots.

3 KEY POINTS OF CONSTRUCTION TECHNOLOGY

3.1 Overlap Conversion Steel Platform

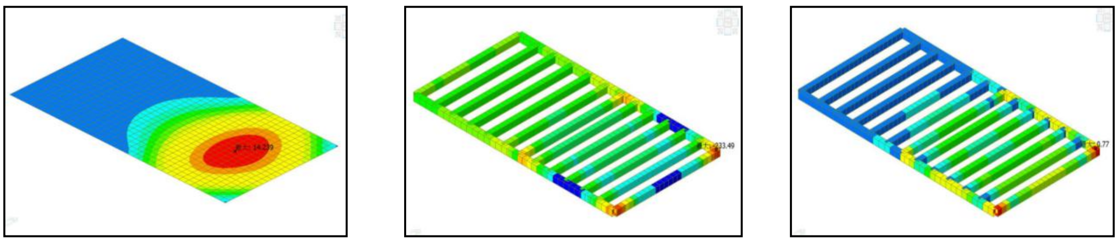
In order to economically and reasonably determine the specifications and dimensions of the main beam and secondary beam of the steel platform, and determine the thickness of the steel pad between the steel-concrete column and the steel platform, a force analysis of the 200t crawler crane heavy-load conversion steel platform is carried out.

200t crawler crane: The main steel beam model specification is □400×400×20mm, the secondary steel beam model specification is □400×400×12mm, the steel pad thickness is 30mm, the secondary steel beam spacing is 1.4m, and the calculation selects two spans with a column spacing of 9m×9m for force analysis. As shown in Figure 3-6.



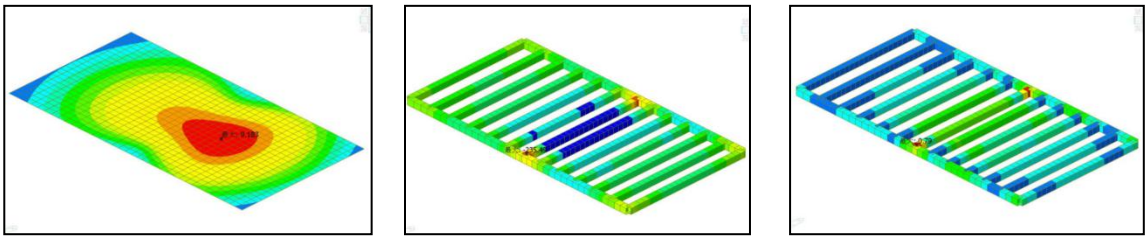
(a) Lifting condition 1 (b) Lifting condition 2 (c) Lifting condition 3

Figure 3 Simulation of Working Conditions under the Action of 200t Crawler Crane



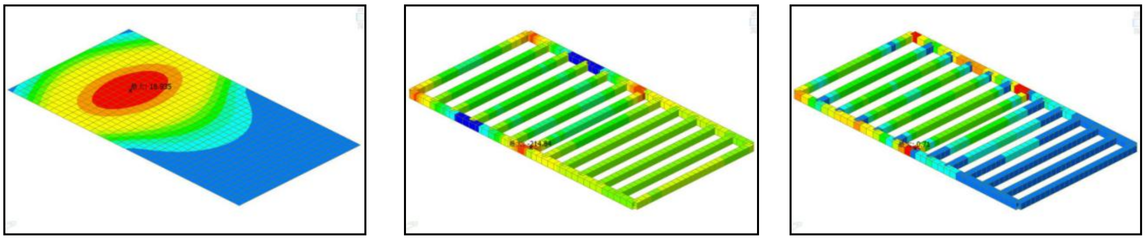
(a) Z-axis deformation 14.3mm (b) Maximum stress of steel beam 242.8N/mm^2 (c) Maximum stress ratio 0.77

Figure 4 Force Analysis of Lifting Condition 1



(a) Z-axis deformation 9.2mm (b) Maximum stress of steel beam 198.2N/mm^2 (c) Maximum stress ratio 0.79

Figure 5 Force Analysis of Lifting Condition 2



(a) Z-axis deformation 16.9mm (b) Maximum stress of steel beam 214.8N/mm^2 (c) Maximum stress ratio 0.71

Figure 6 Force Analysis of Lifting Condition 3

After calculation, considering only the action of 200t crawler crane, the maximum z-axis deformation of 9m×9m column spacing 1 span floor reinforcement 16.9mm, the maximum stress of the platform beam is 242.8N/mm^2, the maximum stress ratio is 0.79, and the final load is transmitted from the platform to the concrete column.

During the design deepening and processing of the steel platform, the design drawings and detailed node drawings are issued after review, and on-site processing is carried out according to the design drawings. In order to ensure the smooth transmission of force between the steel platform and the steel-concrete column and avoid the adverse effects of eccentric compression, the axis grid is set out and the line is elastic (Figure 7), and the main beam, secondary beam and steel plate of the steel platform are welded and connected (Figure 8). The groove butt welding method is used to effectively reduce the maximum mid-span bending moment of the main and secondary beams. At the same time, in order to prevent safety accidents caused by improper operation of the crane driver, the roadbed box needs to be fully laid on the top of the steel platform (Figure 9) to enhance safety.

Figure 7 Steel Platform Axis Grid Layout

Figure 8 Steel Platform Welding

Figure 9 Roadbed Box Full Paving

3.2 Truss Pre-Assembly and Support Frame Erection

In order to improve the efficiency and accuracy of truss on-site installation, a combination of physical pre-assembly and computer virtual pre-assembly (Figure 10) is adopted to inspect the finished truss components and verify each other, so as to ensure the processing and manufacturing accuracy of the components shipped from the factory. The support frame assembled on site adopts standard lattice support (Figure 11), the support frame section is 2×2, and the vertical height is 1.5m per grid. The cross-section of the lattice frame vertical rod is P89×4, the cross-section of the web rod is P64×3.5, the bottom platform is made of HM300×200×8×12 steel to make a field shape, and the specifications of the other bottom rods are also HM300×200×8×12.

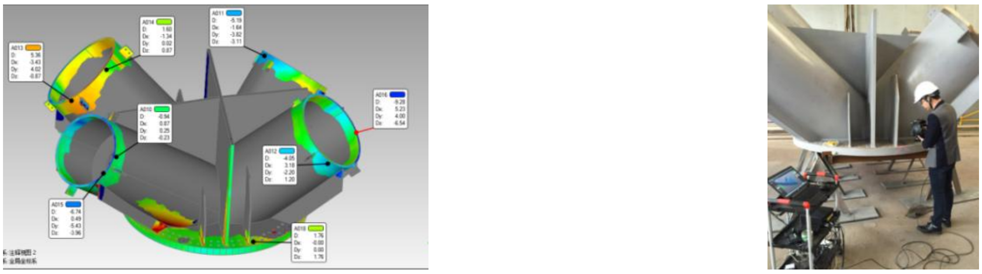


Figure 10 Analysis of Virtual Pre-Assembly Model

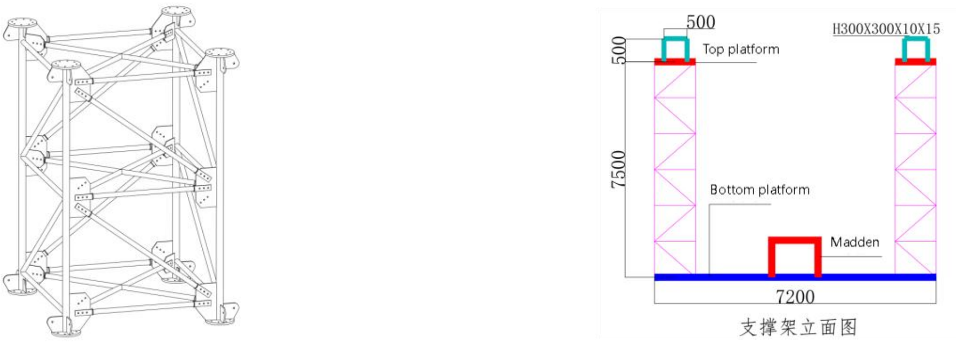


Figure 11 Schematic Diagram of Support Frame

3.3 Hoisting of Steel Structure of Double-Layer Exhibition Hall

The hoisting of steel structure of double-layer exhibition hall adopts high-precision intelligent three-dimensional construction. The installation sequence is: first hoist the lower frame, and assemble the cantilever truss of the roof, the second-floor plane truss and the inverted triangle truss of the roof off-site, and then transport them to the installation location using a flatbed truck. During hoisting, use a 200t crawler crane to hoist the roof and the second-floor truss synchronously in sections. The specific installation process is: frame structure → second-floor truss → roof truss → cantilever truss.

In addition, through the high-precision intelligent hoisting construction method combined with BIM technology and electronic monitoring, the traditional hoisting method is changed, mainly through close observation of the machine and BIM technology to calibrate the hoisting route, while manual monitoring is carried out on site to comprehensively control potential risks. The hoisting process is as follows: (1) Install cameras, proximity sensors and monitoring equipment on site; (2) Manually identify the construction environment and analyze the hoisting path; (3) In the same spatial coordinate system, establish an alarm device based on the prefabricated components and the construction site; (4) Determine the optimal hoisting path through computer image analysis; (5) Calculate the required hoisting data and guide the tower crane operator to complete the hoisting of the prefabricated components; (6) Set the initial parameters of the tower crane and adjust it to the target position; (7) Use an electronic camera to obtain images in real time during the hoisting process to determine whether the hoisting path meets the preset standards, and transmit the results to the monitoring equipment through wireless transmission; (8) When the hoisting meets the preset path, a prompt sound is issued to allow the hoisting to continue until all prefabricated components are hoisted; (9) If a deviation is found, an alarm is issued and the hoisting is stopped. The operation is restarted after adjustment using monitoring until all hoisting is completed.

Figure 12 Schematic Diagram of High-Precision Intelligent Hoisting

4 CONCLUSION

The double-story exhibition hall ground steel structure construction technology proposed in this study provides an efficient and economical solution to the quality, safety and cost challenges faced by large-span space buildings in construction. By setting up a conversion steel platform on the top plate of the basement, combined with intelligent lifting technology and robot welding, the construction efficiency is significantly improved, the labor cost is reduced, and the safety of the underground structure is effectively guaranteed. The application of this technology in the Hangzhou Convention and Exhibition Center project has proved its advantages in shortening the construction period, improving the quality and safety of the project, and has been highly praised by the owner and related units. In the future, with the continuous improvement of requirements for green buildings and construction efficiency, this technology is expected to be promoted in a wider range of construction projects, promoting the sustainable development of the construction industry.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

References

[1] Li Jingyuan, Wang Zhe, Yu Yinquan, et al. Analysis of key issues in the design of large-span heavy steel structure trusses for Nanchang Cultural and Sports Center. Building Structure, 2024, 54(13): 23-29.
[2] Dong Zhaohai, Hou Shuangjun, Zhou Yuqing, et al. Structural design of gymnasium in Lishui Nancheng Sports Complex. Building Structure, 2023, 53(S2): 445-449.
[3] Wang Hongchen, Lu Ji, Yin Longxing, et al. Design of long cantilever and large-span steel structure for Xi'an City Exhibition Center. Building Structure, 2024, 54(11): 84-92.