

Design of Heavy-duty Transfer Steel Platform Based on Finite Element Method

Longjun Yuan¹, Dajiang Geng¹, Minjian Long², Xuesheng Jin¹, Yinguang Wang², Shuliang Wei¹

¹ China Construction Fourth Engineering Bureau No. 6 Construction Co., Ltd., Shanghai 201100, China

² China Construction Fourth Engineering Bureau Co., Ltd., Shanghai 201100, China

Abstract: In order to effectively solve the problems of high cracking risk, high safety risk, large construction period impact and high engineering cost of the basement roof of the scaffolding heavy-duty conversion platform, a construction method of heavy-duty conversion steel platform was proposed by referring to the force principle of the above-ground frame structure. The force mechanism, construction process, operation points and quality assurance measures of this method are clarified by theoretical analysis method combined with on-site engineering practice. Finally, the construction method of heavy-duty conversion steel platform is clarified by comparing with the traditional construction method of scaffolding support and reinforcement. The advantages. The research results show that the heavy-duty conversion steel platform mainly transfers the upper heavy lifting load to the steel beam through the subgrade box, and then transmits it to the pile foundation through the steel beam; It is green and environmentally friendly, and can effectively solve the quality and safety problems of underground structures. Compared with the traditional full-house scaffolding support and reinforcement construction method, the cost saving rate of the optimized heavy-duty conversion steel platform reinforcement method is about 12%, which is worthy of further promotion and application.

Keywords: Finite element, Heavy machinery, Load platform, Steel structure.

1. Introduction

The traditional heavy machinery and equipment carrying platform is generally to set up full-scale scaffolding at the bottom of the basement roof to reinforce the walking route of heavy machinery such as cranes and the beams and floors under the material stacking site, and lay a special roadbed box with great rigidity under the crawler crane. Lay sand between the subgrade box and the slab [1]. However, this heavy-duty conversion platform has shortcomings: (1) There may be a risk of cracking of the basement roof. Most of the scaffolding supports are point supports, and under the condition of heavy mechanical load, it is easy to cause local compression of the basement roof and cracking [2]. (2) The security risk is high. The lower part of the scaffold is supported on the basement floor, and the base is generally the foundation. When the local bearing capacity of the foundation is insufficient, it is easy to cause local instability and damage of the scaffold, thus causing major safety problems [3]. (3) The construction period has a great impact. Unconventional and large scaffolding needs to be erected in a large area for the crane to drive the reinforcement route. The amount of measures is large, and the scaffolding is mostly leased. The scaffolding cannot be removed before the above-ground steel structure hoisting operation is completed. Installation and decoration works cannot be carried out, which will directly affect the construction period of the entire project [4]. (4) The engineering cost is high. On the one hand, unconventional scaffolding has high rental fees, long rental time, and heavy installation, dismantling, and maintenance workloads, resulting in high engineering costs for traditional heavy-duty conversion platforms; secondly, once the basement roof cracks, related engineering repair works The cost is higher [5].

In order to solve the problems of basement roof cracking risk, high safety risk, large construction period impact, and high engineering cost of scaffolding heavy-duty conversion

platform, a construction method of heavy-duty conversion steel platform is proposed by referring to the stress principle of above-ground frame structure. The force mechanism, construction process, operation points and quality assurance measures of this method are clarified by theoretical analysis method combined with on-site engineering practice. Finally, the construction method of heavy-duty conversion steel platform is clarified by comparing with the traditional construction method of scaffolding support and reinforcement. The advantages.

2. Force Principle of Heavy-duty Transfer Steel Platform System

As shown in Figure 1, a profiled steel platform is set up on the roof of the ground floor, the span of the steel platform is the same as the distance between the lower steel concrete columns, and a 2m*5m subgrade box is laid on the top of the platform. The finite element software is used to calculate the driving and hoisting of the crane on the profiled steel platform. Under the most unfavorable working conditions, 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. The load is finally transmitted to the steel platform through the subgrade box, the steel platform to the steel plate, the steel plate to the steel mixed column, and the steel mixed column to the pile foundation. In the entire force transmission system, the basement roof is free from force, which can ensure the safety of the underground structure.

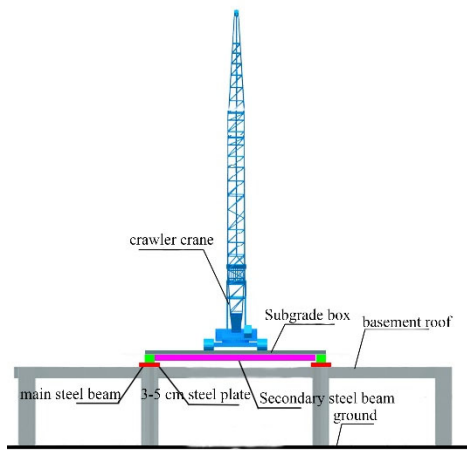


Figure 1. Force mechanism of heavy-duty transfer steel platform

3. Main Process Flow

3.1. Construction Simulation Check

In order to determine the specifications and dimensions of the main beam and secondary beam of the steel platform economically and reasonably, and to determine the thickness of the steel plate between the steel-concrete column and the section steel platform, the design institute combines the installation positions, walking routes and the most unfavorable construction conditions of heavy machinery and equipment formulated on site. Through the optimization calculation of Midas finite element software, the specifications of the main beam and the secondary beam with the smallest amount of steel are finally obtained, and the thickness of the steel plate to ensure the emptying of the steel platform and the basement roof is obtained.

3.2. Steel Platform Design Deepening and Processing

The model of the steel platform finally determined by the finite element simulation is sent to the design institute for review, and the steel platform design drawing and detailed node diagram are issued, and the steel platform is deepened and processed on site according to the design drawing issued by the design institute.

3.3. Grid Loft Spring

In order to ensure the smooth force transmission between the steel platform and the steel-concrete column, and to avoid the adverse effect of the eccentric compression on the steel-concrete column, the wire mesh lofting is carried out.

3.4. Steel Platform Joint Welding (Or Bolting)

In order to ensure the overall mechanical performance of the steel platform, the main beam, the secondary beam and the steel plate of the steel platform are welded and connected, and the four sides of the steel beam joint are beveled butt welded, which can effectively reduce the maximum mid-span bending moment of the primary and secondary beams.

3.5. The subgrade Box on The Top of The Steel Platform Is Fully Paved

When large machinery is driving on the steel platform, in order to ensure that safety accidents do not occur due to improper operation of the crane driver, as shown in Figure 2, the subgrade box on the top of the steel platform must be fully

paved.



Figure 2. Subgrade box full

3.6. Steel Platform Inspection and Acceptance

After the steel platform is laid, it shall be checked and accepted in accordance with the relevant acceptance procedures. The weld joints shall be subjected to third-party flaw detection as required and a formal three-inspection report shall be issued. The main point of acceptance is the backing plate at the bottom of the steel platform. The design is consistent, whether the laying position is in the center of the column top, which is the key control factor to ensure the safety of the structure.

4. Quality Assurance Measures

(1) Strictly abide by the requirements of the specification: strictly follow the "Code for Construction of Steel Structure Engineering", "Code for Welding of Steel Structure", "Technical Specification for High Strength Bolted Connection of Steel Structure", "Carbon Structural Steel", "Low Alloy High Strength Structural Steel", "Twisted shear type high-strength bolt connection pair for steel structure", "Technical specification for anti-corrosion of building steel structure", "Mandatory standard for construction engineering", "Construction quality acceptance standard for steel structure engineering" and other relevant national steel structure quality standards. Design, construction, testing.

(2) Strictly implement the quality system: establish the project quality management system and quality assurance system, formulate the "Project Quality Assurance Plan", formulate various quality management systems on the construction site, and improve the project measurement and quality inspection technologies and means. Strengthen the training of construction personnel, so that the professional skills of on-site management personnel and operators meet the needs of the construction of the project. Scientifically and rationally equip construction machinery, do a good job in the maintenance and maintenance of the equipment, keep the machinery and equipment in good working condition, and ensure the quality of the project and the progress of the project. The quality pre-control method is adopted to control the project quality to achieve the purpose of "prevention first". The installation process must strictly implement and abide by the "three preventions" (control before, during and after the event) and the "three inspection system" (self-inspection, handover and mutual inspection, special inspection).

(3) Strictly carry out material inspection: before the platform is installed, the material group needs to check the quality status of the components used, and the qualified components can be put into use; the process handover form is written in the form of a self-inspection of the team and signed after passing the self-inspection of the team, and reported to the project quality department for full-time quality. The inspector shall review the inspection, and sign the approval to transfer to the next process construction after passing the inspection; the installation project that fails the inspection shall be implemented in accordance with the "Disqualification Handling Procedure".

(4) Strictly carry out construction quality inspection: The construction team must strictly implement the project installation construction plan and quality inspection during the installation process, standardize the operation and conduct process quality control. The inspection contents include component installation positioning axis, lay-out quality, component installation quality status identification, team self-inspection quality record, component elevation, orientation, axis deviation, docking misalignment, matching clearance, installation size deviation, component welding, welding appearance quality, NDT report.

(5) Welding quality control: electric heaters or flame heaters should be used for preheating and interlayer temperature maintenance before welding, and special temperature measuring instruments should be used to measure them. The preheating heating area should be on both sides of the welding groove, and the width should be more than 1.5 times the thickness of the welding part, and not less than 100mm. The preheating temperature should be measured on the reverse side of the welding part. The front welding point is not less than 75mm in all directions. When preheating with a flame heater, the front temperature measurement should be carried out after the heating is stopped.

During welding, the interlayer temperature between the welds should always be controlled between 120°C and 150°C, and each welded joint should be welded at one time. Before welding, pay attention to collecting meteorological forecast data. If severe weather is expected to come, welding should be abandoned. If the welding seam has been welded, it is necessary to stop welding at least 1/3 of the thickness of the plate before the advent of bad weather; and strictly do the post-heat treatment, and record the temperature between layers.

The quality inspector shall supervise and inspect the welding quality in accordance with the requirements of "Steel Structure Welding Specification", "Steel Structure Construction Quality Acceptance Specification", construction drawings and technical documents. The inspection should include the division of inspection batches, sampling inspection, inspection items, inspection methods, inspection timing and corresponding acceptance criteria.

During the sampling inspection, there is one weld for each welding seam installed on site. If the number of welds in the sampling inspection is less than 2%, the batch of acceptance shall be deemed qualified; when the failure rate is greater than 5%, the batch of acceptance shall be positioned as unqualified; The weld extension lines on both sides of the qualified part are added one place each.

The non-destructive testing shall be carried out after the visual inspection is qualified. When the steel grades III and

IV and the welding difficulty level are C and D, the non-destructive testing results 24 hours after the completion of welding shall be used as the basis for acceptance; the nominal yield strength of the steel shall not be less than 690MPa or the. When the goods are in the modulation state, the non-destructive testing results 48 hours after the completion of welding shall be used as the basis for acceptance.

Non-destructive testing: 100% inspection shall be carried out for the first-class welds, and the qualified grade shall be Class II and above of the B-level inspection of "Manual Ultrasonic Flaw Detection Method and Quality Grading Method of Steel Welds" (GB11345). Sampling inspection shall be carried out for the second-level welds, and the sampling ratio shall not be less than 20%, and the qualified grade shall be grade III and above of the B-level inspection of "Steel Welding Seam Manual Ultrasonic Flaw Detection Method and Quality Grading Method" (GB11345). Non-destructive testing is not required for fully penetrated tertiary welds.

Appearance inspection: Generally, visual inspection is used. The inspection of cracks should be supplemented by a 5x magnifying glass and carried out under suitable lighting conditions. If necessary, magnetic particle inspection or penetrant inspection should be used. The size measurement should be done with measuring tools and calipers. The appearance of the first-level weld shall not have defects such as under-welding, root shrinkage, undercut and poor joints, and the first-level and second-level welds shall not have surface pores, slag inclusions, cracks and arc scratches and other defects.

5. Analysis of the Advantages of Heavy-Duty Conversion Steel Platform

Compared with the traditional full-house scaffolding support and reinforcement construction method, this construction method has the following characteristics:

Reasonable stress: The steel platform is reinforced as a steel platform made of box-shaped steel beams on the upper part of the steel-concrete column, the subgrade box is laid on the upper part, and a 3-5 cm steel plate is laid between the lower part of the steel platform and the steel-concrete column to make the concrete floor slab. Cushioning with the beam, the mechanical dead load and live load finally transmit the force from the steel-concrete column to the pile foundation, so as to prevent the crane from walking directly on the floor and causing the floor to be damaged due to insufficient bearing capacity.

Safe and reliable: The conversion steel platform is assembled and welded (or bolted) of section steel, with mature technology and simple installation; it will not affect the underground structure and is safe and reliable.

Fast installation: high degree of mechanization, low labor intensity and short construction period.

Low cost: mainly for section steel assembly welding (or bolt connection), high degree of mechanization, low labor intensity, short construction period, steel platform and roadbed box can be used for multiple turnovers, and the overall project cost is low.

Green and environmental protection: The steel platform and roadbed box can be used for multiple turnovers, energy

saving and environmental protection, in line with the development goal of "carbon neutrality and carbon peaking".

6. Engineering Applications

The first phase project of Hangzhou Convention and Exhibition Center is located in Nanyang Street, Xiaoshan District, Hangzhou City. The site covers a total area of about 353,000 square meters and a total construction area of 643,200 square meters. There are 8 exhibition halls in this project, 1 floor underground and 1 floor above ground (partially 2 floors); two login halls, 1 floor underground and 4 floors above ground; central corridor: 1 floor above ground and 2 floors above ground. The basement is a reinforced concrete + steel column structure, and the ground is mainly a combination of steel frame + large-span truss steel roof. The steel structure is mainly composed of six standard single-storey exhibition halls 1#-5# and 8# and two double-storey exhibition halls 6# and 7#.

Due to the large span of the roof truss of the exhibition hall of 81m and the heavy weight of the sections, it is difficult to use large machinery to hoist the crane outside the exhibition hall. The application of the heavy-duty transfer steel platform proposed in this paper can not only protect the concrete floor structure but also meet the requirements of hoisting Construction safety and feasibility.

After cost calculation, when the traditional full-house scaffolding support and reinforcement construction method is used, the cost incurred is 18.725 million yuan, while the cost of the optimized heavy-duty conversion steel platform reinforcement method is 16.6 million yuan, which can save 2.125 million yuan. The savings rate is about 12%.

7. Conclusion

In this paper, a construction method of heavy-duty transfer steel platform is proposed, and the force mechanism, construction process, operation points, quality assurance measures and method advantages of this method are clarified

by theoretical analysis method combined with on-site engineering practice. The main conclusions are as follows:

(1) The heavy load conversion steel platform mainly transfers the upper heavy lifting load to the steel beam through the subgrade box, and then transfers it to the pile foundation through the steel beam.

(2) The heavy-duty conversion steel platform has reasonable force, safety and reliability, fast installation, low cost, and environmental protection, which can effectively solve the quality and safety problems of the underground structure.

(3) Compared with the traditional full-house scaffolding support and reinforcement construction method, the cost saving rate of the optimized heavy-duty conversion steel platform reinforcement method is about 12%, which is worthy of further promotion and application.

Acknowledgment

Thanks for the support of the China Construction Fourth Engineering Research Project (CSCEC4B-2022-KTA-10).

References

- [1] Li Hang. Key points of hoisting and construction control of bridge steel structure main tower [J]. Transportation Industry, 2021 (27): 41-42.
- [2] Ding Ran. Talking about the hoisting of large tower equipment [J]. Chemical Design, 2021,31(05):23-29+1.
- [3] Dong Ruitao. Analysis and discussion on the hoisting scheme of large tower equipment [J]. Engineering and Construction, 2022, 36(01): 188-189.
- [4] Guo Zhong, Song Erxiang, Lin Shijie, Liu Guanglei, Xu Yuqi, Fu Hao, Tong Ximing, Jiao Gongqi. Numerical analysis of bearing characteristics of large-scale equipment hoisting and replacing foundation [J/OL]. Industrial Architecture: 1-13
- [5] Yang Guanglei. Research on construction technology of building steel structure hoisting [J]. Bulk Cement, 2022(03): 109-111.