ISSN: 1813-4890

Construction Technology of Hoisting Steel Truss of Large-span Roof

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Abstract

The large-span steel structure exhibition hall is a widely used exhibition hall form at present, which has the characteristics of large span, many aerial operations, and great construction difficulty. In combination with a convention and exhibition center project under construction in Hangzhou, the construction technology of steel truss hoisting for large-span exhibition hall is summarized from the aspects of construction difficulties and solutions, construction scheme selection, key technology analysis, construction simulation checking, etc., to provide experience for similar projects in the future.

Keywords

Large Span Exhibition Hall; Steel Truss Hoisting; Construction Technology; Construction Simulation.

1. Introduction

Large span steel structure exhibition halls have been widely used in exhibition hall buildings in recent years. The truss of the large-span steel structure exhibition hall has a large span and a complex structural system, which often requires workers to work at heights. The connection methods of different steel structure members are different, and the construction is difficult [2-5]. Therefore, it is of great significance to analyze the key and difficult points in the construction of long-span exhibition hall steel structure project and propose the construction scheme and key technologies.

2. Survey

The lower part of the double deck exhibition hall is a frame structure, including two floors of exhibition space. The roof between the two double deck exhibition halls is connected. The longitudinal length of the exhibition hall is 204m, the roof span is 81m, and the overhang is 12~23m. The span between the two double deck exhibition halls is 40~64m, the column top elevation is about 33m (8m+8m+3m+8m+6m), and the highest point of the roof is about 39m, The roof structure is the same as that of the single-layer exhibition hall. It is a light steel roof panel system. The 81m span direction adopts a triangular space truss system, with the truss spacing of 18m. A longitudinal connection truss is set between the triangular space trusses.

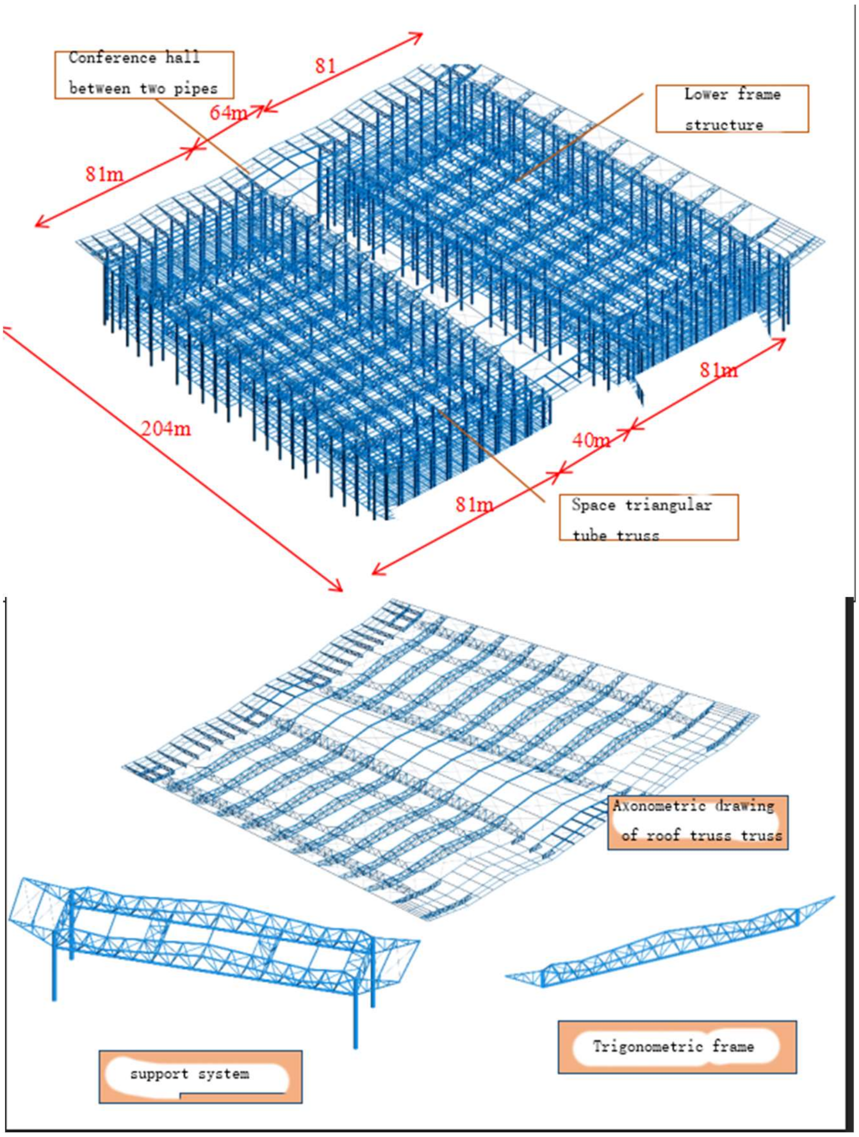


Figure 1. Roof steel truss drawing

3. Key and Difficult Points and Solutions

Difficulty 1: The main components of the project are round pipe columns, box columns and pipe trusses, and the market stock of large diameter steel pipes is small; At this stage, regular rolling is required. The production cycle is long, and the supply cycle is generally 45~60 days. How to ensure the reasonable and timely supply of large diameter steel pipes and meet the needs of the project is the focus of the project.

Solution: 1. During the material supply period, send personnel to the steel plant to witness the production process and inspection process of the steel plant to ensure that the accusation process of the steel plant conforms to the procedure. 2. After the materials enter the processing plant, the size and appearance of the steel plate shall be inspected, and the sampling re inspection shall be carried out in strict accordance with the specifications.

Difficulty 2: The truss span of the exhibition hall is up to 81m, and the maximum section weight is about 80t. The installation method and equipment selection of roof truss are difficult. Solution: according to the design load of the exhibition hall with basement and the first floor, the steel platform can meet the requirements of the truck mounted crane; The construction period on site is tight, and the roof truss is planned to be constructed at the same time. The construction process of "in-situ assembly and subsection hoisting method" is adopted to speed up the construction progress.

4. Site Construction Scheme

4.1. Installation Ideas

The hoisting of single double-layer exhibition hall structure adopts three-dimensional construction. The lower frame shall be hoisted first. At the same time, the roof cantilever truss, the two-layer plane truss and the roof inverted triangular truss are assembled outside the site. After the flat car is transported below the installation position in the site, 350t crawler crane and 200t crawler crane are used to synchronously lift the two-layer and roof truss in sections during installation. Installation sequence of each structure: frame structure → second floor truss → roof truss → cantilever truss.

4.2. Truss Hoisting

Analysis of hoisting condition of roof truss.

Plane size of roof structure 204 × 94m, the truss is divided into indoor section and overhanging section on both sides. The indoor section truss adopts triangle space truss structure. The truss section width is 5.2m, the height is 3.8~6.8m, the span is 81m, and the maximum elevation is 40.2m. The specification of the lower chord of the truss is P800 * 35mm, the upper chord is P600 * 25mm, the web member is P245 * 8~P400 * 16mm, and the weight of a single truss is about 160t. The total number of roof trusses of a single hall is 9, which are divided into 2 sections, totaling 18 sections.

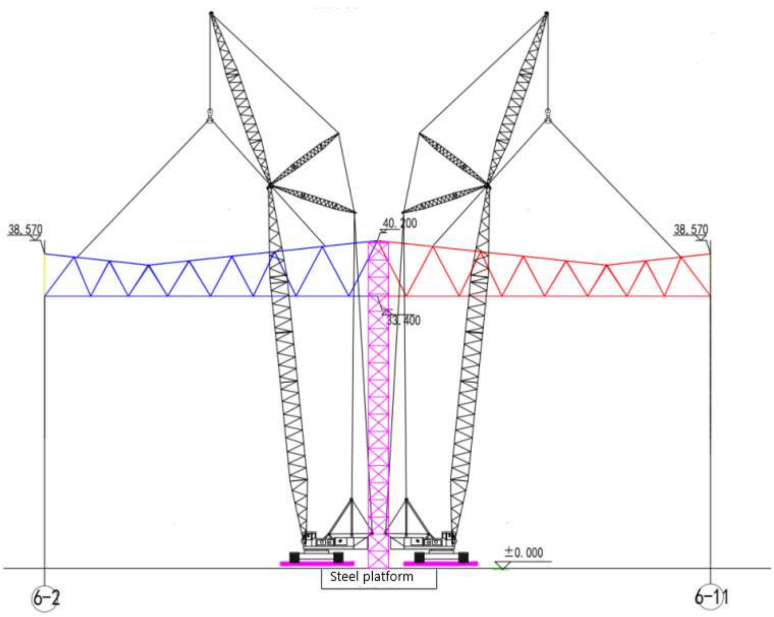


Figure 2. Schematic Diagram of Roof Truss Hoisting

Table 1. Analysis of the most unfavorable lifting conditions

Serial No	Truss position	Length m	Weight t	Use the crane	Hoisting radius m	working condition	Lifting capacity t
1	6HJ1-6HJ1-14	40.5	80	350tCrawler crane	18	36m main boom, 36m auxiliary boom	100.1
2	6HJ1-6HJ1-18	40.5	80				
The rated lifting capacity is greater than the sectional weight of the truss, meeting the lifting requirements.							

ISSN: 1813-4890

5. Key Technology Analysis

5.1. Technical Measures for Steel Platform and Steel Ramp

5.1.1. Steel Platform Design

For crane traveling and truss hoisting, in order to ensure the finished product protection and construction safety of the completed project, the crane traveling route on the basement roof shall be reinforced as necessary. The reinforcement method is to set a profile steel platform on the top of the concrete column and beam in the basement, and lay a subgrade box on the platform. Steel plates or short columns are padded under the main beam of the platform to vertically transfer the load on the platform to the lower concrete structure.

When the crawler crane travels on the top plate of the basement, it needs to lay (4.5~9) m × (1.5~2.5)m × A 0.2m subgrade box weighs about 5 tons. A B500X500X20 transfer steel beam and a connecting beam are set under the base box of the roof truss hoisting road line. A 3cm thick buttress plate is laid under the transfer steel beam for lifting to separate the floor slab from the measures, and the beam column bears the live construction load.

Table 2. Section size of Maximum crane

Maximum crane for upper platform	Longitudinal rail section size	Cross track section size
350t Crawler crane	B500x500x20	B500x500x20

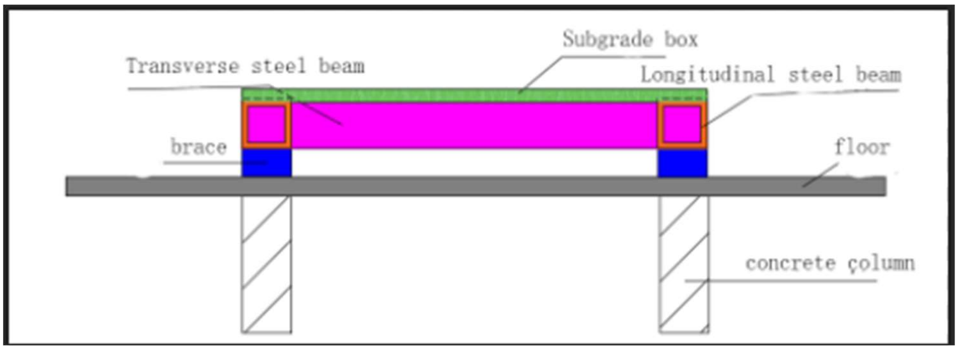


Figure 3. Steel platform style

5.1.2. Route Planning

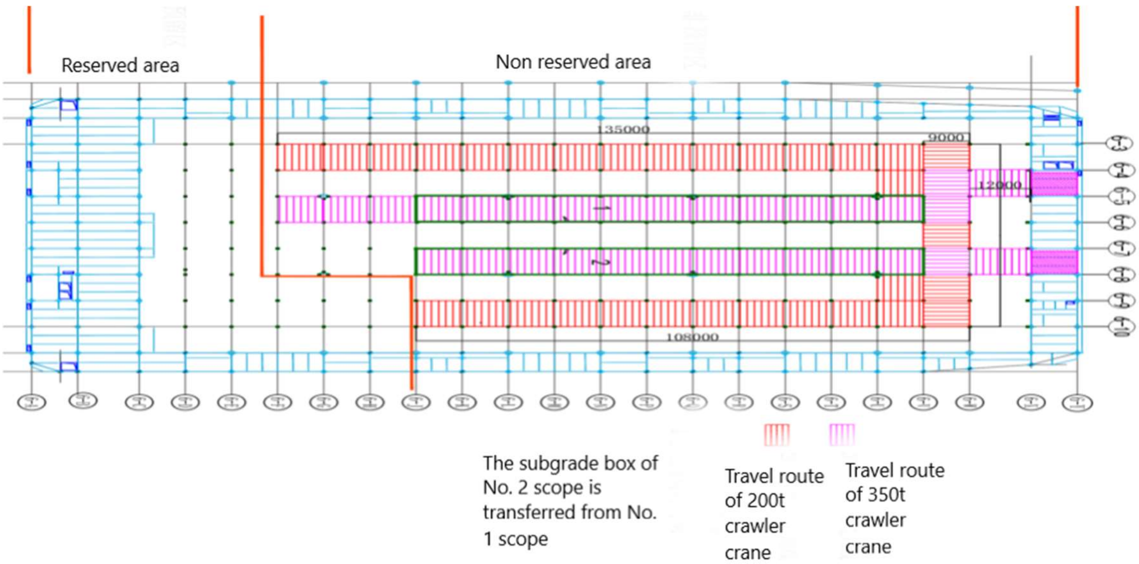


Figure 4. Line layout

5.2. Temporary Roof Support Setting

As the roof truss is in inverted triangle form, and the upper chord elevation is about 40m, the weight of the structure section is about 60t. In order to ensure the stability during installation, special support frame groups shall be set. The cross section of the support frame's upright pole shall not be less than P219x10, and the cross section of the web pole shall not be less than P114x4. In order to ensure the stability of the support frame, the lower bottom platform shall be rigidly connected with the steel platforms on both sides, and B400x12 members shall be fully welded. At the same time, a group of wind barriers shall be pulled to connect with the steel platforms or subgrade boxes on both sides, and the pulling angle shall be kept at 45° or above. (If there is no connection point for the wind rope or it hinders the crane's traveling road when being pulled, the embedded parts shall be pulled after the top plate is set).

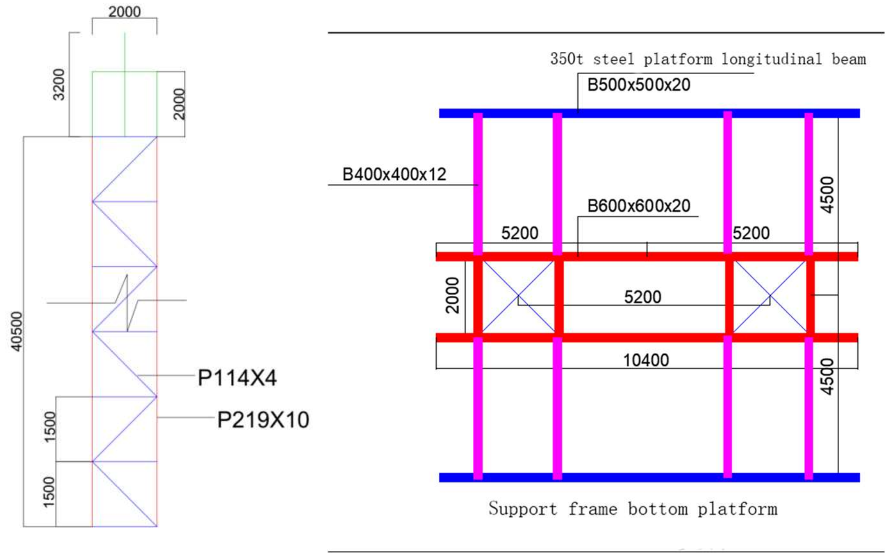


Figure 5. Vertical view of support frame group 2

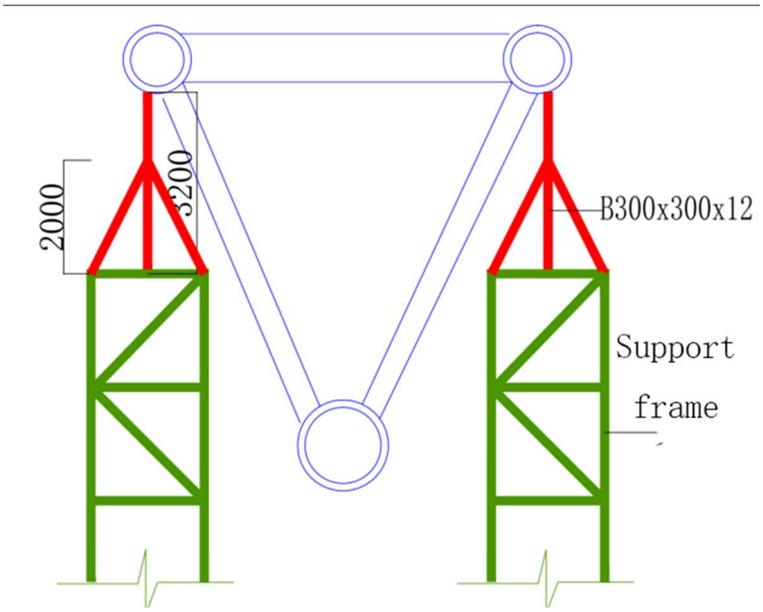


Figure 6. Schematic Diagram 2 for Top Connection of Roof Support Frame of Double deck Exhibition Hall

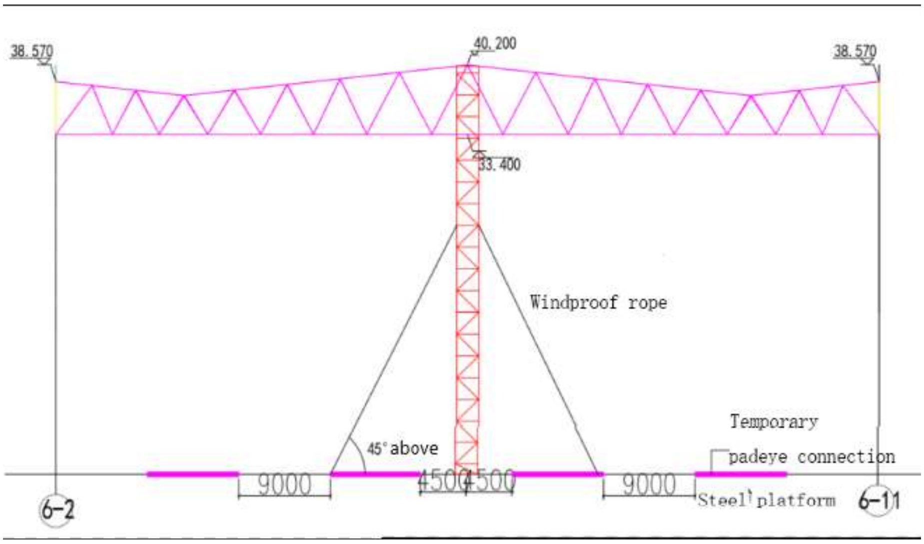


Figure 7. Schematic Diagram of Bracing Column Wind Rope

6. Construction Simulation Checking

6.1. Checking Calculation of 350t Crawler Crane Steel Platform on the Floor

The calculation and analysis of 350t crawler crane going up to the floor shall be based on the design data and actual site conditions, and the calculation and analysis of the steel beam and floor shall be carried out according to the actual load in the construction stage. The most unfavorable slab span is selected for this check calculation, and the Midas gen 8.3.6 finite element analysis software is used for modeling to simulate the working condition of crawler crane lifting on the floor.

6.1.1. Mechanical Performance of 350t Crawler Crane

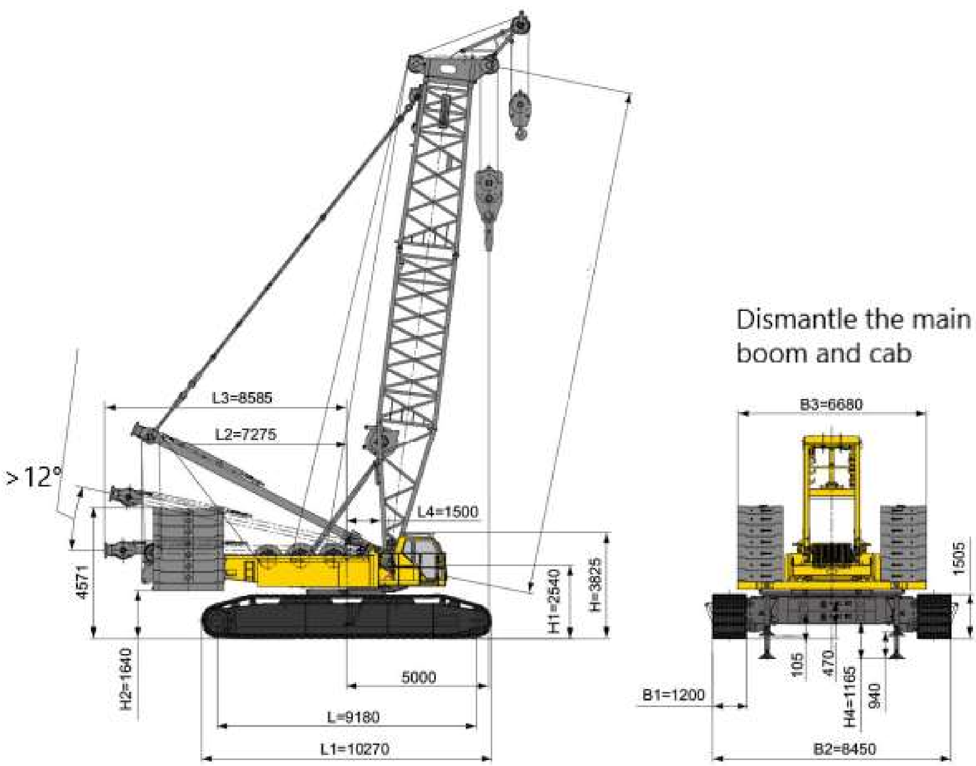


Figure 8. Mechanical drawing

6.1.2. Calculation of Crawler Crane Lifting Conditions

Calculation of hoisting conditions.

The ground contact area of a single crawler crane is Ac=1.2 × 8.9=10.68m2. Dead weight of crawler crane G=170t; Lifting weight Ga=100t; Hook 2t; Counterweight Gp=150t; Hoisting radius R=16m; Track length L; Track width B.

(1) 0 ° hoisting condition:

In the figure: G is the dead weight of the crawler crane; Ga is the lifting weight; Gb in the main and auxiliary boom; Gp refers to matching weight; R is the hoisting radius; Q1, q2 are the maximum and minimum values of the track pressure when the boom is placed along the track direction; Qa and qb are the maximum and minimum pressures of the two tracks when the boom is placed perpendicular to the track direction.

Calculation of hoisting pressure of 0 ° crawler crane.

As shown in Figure b, the static balance equation is established based on the center of gravity.

σ1=G/2BL=(150+170+102)*10/(2*10.68)=198KN/m2.

σ2=M/W=(150*6-19*8-102*16)*10/(9*10.68*2/6)=-275KN/m2.

qa=σ1+σ2=-77KN/m2.

qb=σ1-σ2=473KN/m2.

Calculate the maximum track pressure load on one side F=473KN/m2.

(2) 90 ° hoisting condition

In the figure: G is the dead weight of the crawler crane; Ga is the lifting weight; Gb in the main and auxiliary boom; Gp refers to matching weight; R is the hoisting radius; Q1, q2 are the maximum and minimum values of the track pressure when the boom is placed along the track direction; Qa and qb are the maximum and minimum pressures of the two tracks when the boom is placed perpendicular to the track direction.

Calculation of hoisting pressure of 90 ° crawler crane.

As shown in Figure b, the static balance equation is established based on the center of gravity.

σ1=G/2BL=(150+170+102)*10/(2*10.68)=198KN/m2.

σ2=M/W=(150*6-22*8-102*16)*10/(2*1.2^3*9/6/3.65+2*1.2*9*3.65^2/3.65)=-62KN/m2.

qa=σ1+σ2=136KN/m2.

qb=σ1-σ2=260KN/m2.

Calculate the maximum track pressure load F=260KN/m2.

Therefore, the maximum track pressure load is selected for calculation F=473KN/m2.

Calculate the internal force of the crane acting on the floor.

9m is selected for calculation × The internal force of the upper floor of the crane shall be calculated for two spans with a column spacing of 9m.

Load combination.

When calculating deformation, partial factors are not considered, and the following load combinations are considered:

1.0D (dead weight)+1.0 live.

When calculating the stress, consider the following combinations:

1.3D (dead weight)+1.5 live.

Calculation of reinforcement scheme.

Transverse steel beam and longitudinal steel beam: 500 * 500 * 20.

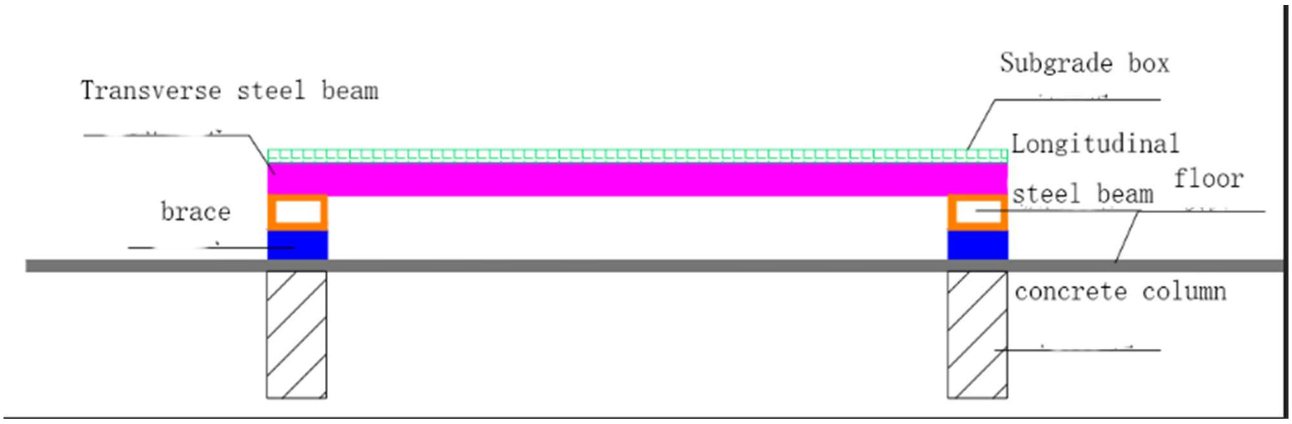
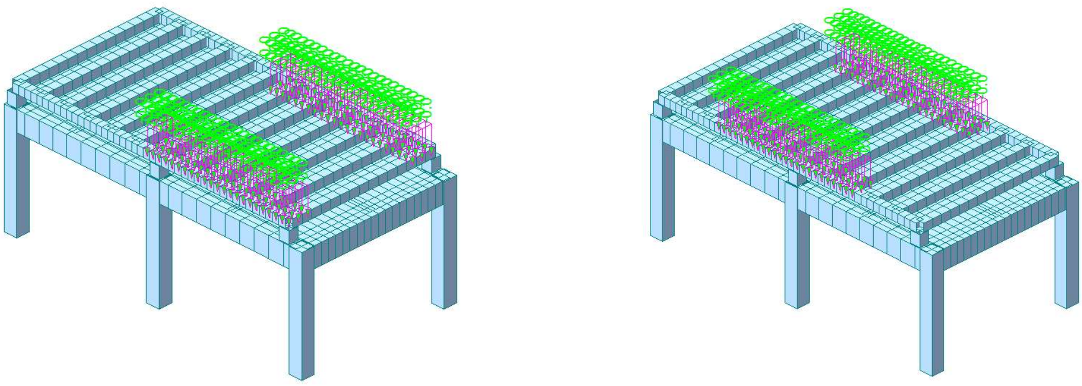


Figure 9. Reinforcement Diagram

Working condition of steel platform



Hoisting condition 1 Hoisting condition 2

Figure 10. Hoisting condition

Calculation results.

Calculation of axial force of steel platform frame column.

Hoisting condition 1.

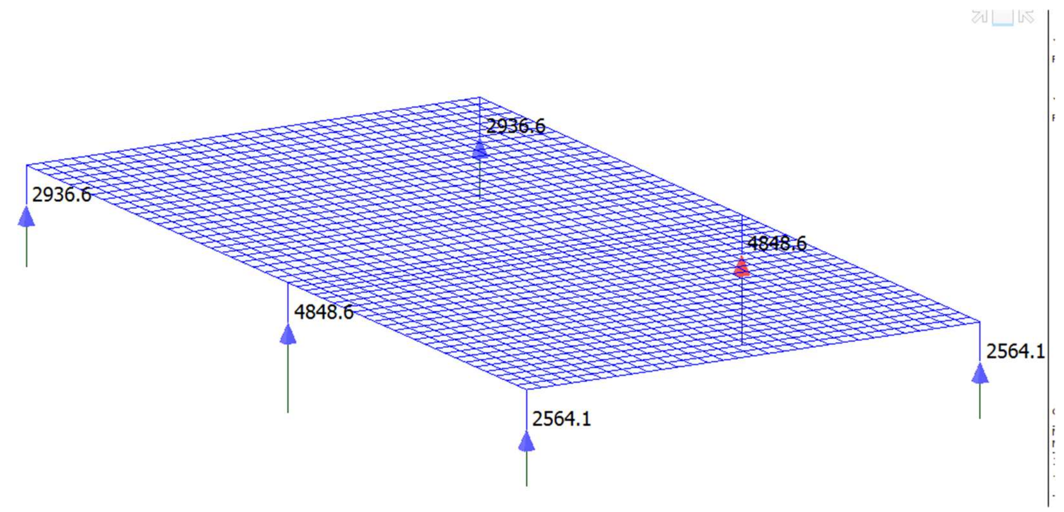


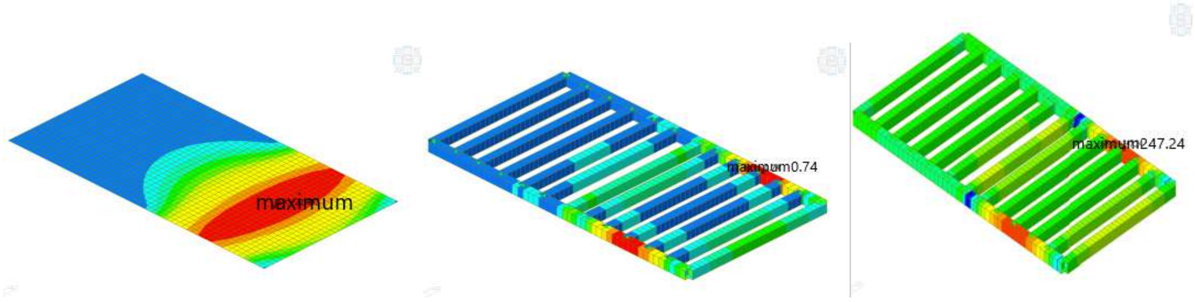
Figure 11. Maximum reaction 4848.6kN

ISSN: 1813-4890

Conclusion: After calculation, only 350t crawler crane is considered to go up to the floor (floor thickness is 250mm). After the floor is reinforced (subgrade box thickness is 200mm), the load under the lifting condition is transferred from the platform to the column, and the maximum axial force of the column is 4848.6kN.

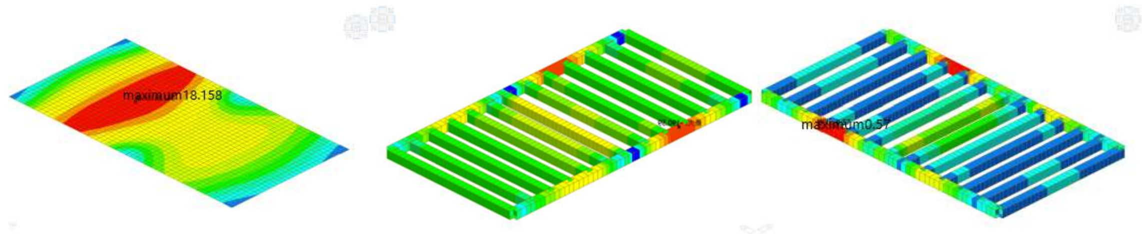
Checking calculation of steel platform.

Hoisting condition 1.



Deformation in z-direction 22.45mm Maximum stress ratio 0.74 Maximum stress of platform beam 247.24N/mm2

Hoisting condition 2.



direction deformation 18.16mm Maximum stress of platform beam 190.59N/mm2 Maximum stress ratio, 0.57

Figure 12. Schematic diagram of steel platform checking calculation under various working conditions

Conclusion: After calculation, only 350t truck crane is considered to go up to the floor (the floor thickness is 250mm). After the 9mx9m column spacing is 1 span of the floor slab (the thickness of the subgrade box is 200mm, the longitudinal steel beam section is 500mm * 500mm * 20mm, and the transverse steel beam section is 500mm * 500mm * 20mm), the maximum z-direction deformation is 28.32mm, the maximum stress of the platform beam is 289.6N/mm2, the maximum stress ratio is 0.86, and the final load is transferred from the platform to the concrete column.

6.1.3. Conclusion and Construction Suggestions

In this section, the hoisting simulation calculation is carried out for the steel structure hoisting unit. The settlement structure shows that the maximum stress of the hoisting unit is 39.29Mpa, and the maximum deformation is 10.45mm, both within the allowable range, meeting the hoisting requirements. It is safe and feasible to adopt the installation scheme and reinforcement scheme determined in the construction organization design for the main steel structure of the project. The construction shall be carried out in strict accordance with the requirements of the construction organization.

7. Conclusion

This paper takes a convention and exhibition center project in Hangzhou as an example, starting from the key points of construction, proposes solutions, and then proposes a construction scheme, analyzes key technologies. Finally, through the simulation of the construction process, the feasibility of the scheme is verified, which also provides experience for similar projects in the future.

Acknowledgments

Thanks for the financial support of the project CSCEC4B-2021-KTB-27) on the construction technology and intelligent safety control of the steel structure of the super span exhibition hall.

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