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# Addressing Construction Challenges of Attached Lifting Scaffolds in Super High-Rise Buildings with Four-Corner Variable Cross-Sections

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**Abstract:** ***In recent years, attached lifting scaffolds have become increasingly prevalent in the construction of super high-rise office buildings. Compared to conventional external scaffolding systems for high-rise structures, attached lifting scaffolds offer distinct advantages, including standardized management, specialized operation, enhanced safety and reliability, comprehensive protection, material and labor efficiency, improved construction site conditions, and assured project timelines. By transforming high-altitude operations into low-altitude tasks and converting suspended work into scaffold-internal activities, this technology embodies significant low-carbon attributes, high technological sophistication, and superior economic, safety, and operational convenience. Unlike traditional methods that necessitate continuous vertical transportation of steel pipes, fasteners, and channel steel for scaffold erection along with peripheral protective net installation, the modern attached lifting scaffold is formed integrally in a single installation, requiring only subsequent lifting operations and maintenance. The material efficiency and substantially reduced high-altitude operational risks associated with this innovative scaffold system demonstrate its marked superiority over traditional steel pipe scaffolding in super high-rise construction applications.***

**Keywords:** Super high-rise office building with four inward-recessed corners, Attached lifting scaffold design, Construction and safety assurance measures.

## 1. PROJECT OVERVIEW OF SUPER HIGH-RISE OFFICE BUILDING

A super high-rise office building in Guangzhou has 5 underground floors and 50 above-ground floors, with a standard floor height of 4.5 meters and a building height of 229.85 meters. The office building has a ground floor plan with a total length of 49.4m and a total width of 49.4m, and a top floor plan with a total length of 31.2m and a total width of 31.2m. However, the four corners of the plan are recessed inward from bottom to top each floor, with a recessed size of 135~160mm. This results in a reduction in the size of the straight segments on the four sides of the plan each floor, while the size of the straight segments at the four inward-folded corners increases. The upper and lower planes at the four corners are irregular, and the outer edges of the upper and lower structures are misaligned, showing an inward shrinkage. See the following figure for details:

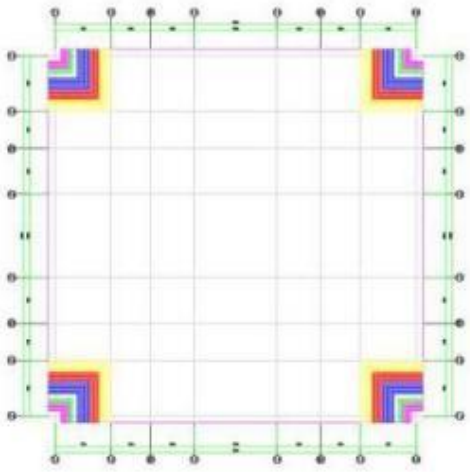

**Figure 1:** Outline Drawing of the Office Building Structure Perimeter

## 2. DESIGN OF ATTACHED LIFTING SCAFFOLD

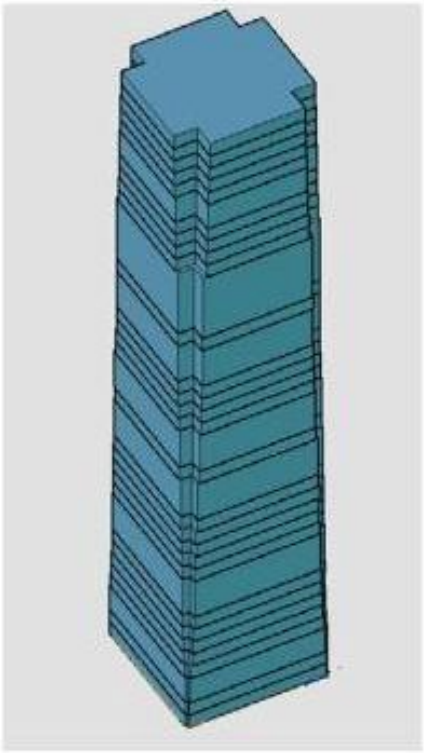

**Figure 2:** BIM Rendering of the Office Building

### 2.1 Scheme Selection

Considering the special situation that the four corners of this super high-rise office building are recessed inward layer by layer, two erection forms are planned for the attached lifting scaffold:

First: Erect attached lifting scaffolds on the entire external facade of the building, and erect inclined climbing scaffolds at the inward-recessed parts of the four corners.

Second: Erect attached lifting scaffolds on the main external facade of the building, and erect cantilevered I-steel external scaffolds at the inward-recessed parts of the four corners.

After comprehensively considering factors such as safety and economy, the second erection form of the attached lifting scaffold is adopted for this super high-rise office building.

### 2.2 Specific Design

Floors 1-4 of this project are commercial with a height of 5 meters, and the floor standing external scaffolding is used.

Floors 5-50 of this project are office buildings with a standard floor height of 4.5 meters. Attached lifting scaffolding is adopted, with a design height of 19.5m, covering 4.5 floors, and the covering height does not exceed 5 times the floor height. The width of the scaffold body is 0.6m; 10 walkway boards are set on the scaffold body, with a step height of 1.9m-2.0m; 2 sealed flip boards are set at the 1st and 5th walkway boards. The specific design of the super high-rise climbing scaffold is as follows:

The initial assembly of the climbing scaffold starts from the wall columns on the 5th floor, with a total of 60 machine positions, one group set on each facade, divided into 4 groups. The west facade 1-15 is Group 1, the north

facade 16-30 is Group 2, the east facade 31-45 is Group 3, and the south facade 46-60 is Group 4, with each panel width ranging from 1.85 to 3.9 meters.

As the structure retracts inward, the climbing scaffold of this building starts to remove the end machine positions after protecting up to the floor slab of the 15th floor. When protecting the 16th floor structure, a total of 52 machine positions are set, divided into 4 groups: the west facade 2-14 is Group 1, the north facade 17-29 is Group 2, the east facade 32-44 is Group 3, and the south facade 47-59 is Group 4.

As the structure retracts inward, the climbing scaffold of this building starts to remove the end machine positions after protecting up to the floor slab of the 29th floor. When protecting the 30th floor structure, a total of 44 machine positions are set, divided into 4 groups: the west facade 3-13 is Group 1, the north facade 18-28 is Group 2, the east facade 33-43 is Group 3, and the south facade 48-58 is Group 4.

As the structure retracts inward, the climbing scaffold of this building starts to remove the end machine positions after protecting up to the floor slab of the 40th floor. When protecting the 41st floor structure, a total of 36 machine positions are set, divided into 4 groups: the west facade 4-12 is Group 1, the north facade 19-27 is Group 2, the east facade 34-42 is Group 3, and the south facade 49-57 is Group 4.

Starting from the 5th floor, cantilevered I-steel external scaffolding is erected every four floors at the inward-retracting parts of the four corners. After the climbing scaffold is lifted, the cantilevered external scaffolding at these parts is removed.

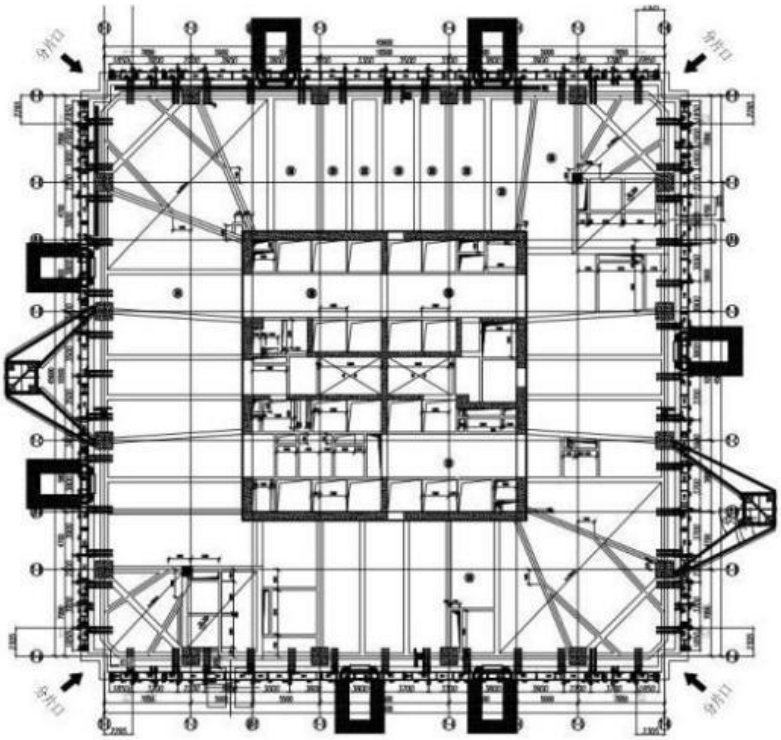

**Figure 3:** Plan Design Drawing of Attached Lifting Scaffold on the 5th Floor

## 3. CONSTRUCTION TECHNOLOGY AND RELATED REQUIREMENTS FOR ATTACHED LIFTING SCAFFOLDING

### 3.1 Construction Preparation

3.1.1 Technical Preparation

Familiarize with construction drawings, understand structural dimensions, master the main construction process, clarify the distribution of vertical transportation equipment such as tower cranes and elevators, and determine the plane distribution of machine positions and scheme design for the attached lifting scaffolding.

3.1.2 Safety Technical Disclosure and Training

Relevant personnel of the construction project department and operators of the attached lifting scaffold shall receive comprehensive safety technical disclosure regarding the attached lifting scaffold after the attached lifting scaffold enters the site. After the attached lifting scaffold enters the site, operators of the attached lifting scaffold shall first organize three-level safety education and pre-job training on construction technology, construction safety, civilized construction, and labor discipline. Before the construction of each process, the technical person in charge of the attached lifting scaffold shall prepare detailed construction technical disclosure for the scaffold operators, which must include operation standards, technical requirements, safety points, etc., and require relevant personnel to sign and file it.

### 3.2. Requirements for Leveling Frame

The climbing frame used in this project is a bulk all steel scaffold, and the frame body uses the ground frame as the climbing frame operating platform. Strength of the leveling frame: The leveling frame is required to bear a uniform load of 5KN/m*, the fasteners at the main nodes do not slip or break, and the frame settlement is less than 10mm; Stability of the leveling frame: The platform elevation of the leveling frame at any position shall not produce deformation greater than 10mm under a horizontal thrust of 1kN. The leveling frame shall be rigidly connected to the structure every 3 meters, and the height is preferably within 1 meter below the elevation of the horizontal support truss.

### 3.3. Installation Process of Attached Lifting Scaffold

Erect the platform frame and adjust horizontally → Lay the walkway boards → Install vertical poles and auxiliary vertical poles → Add auxiliary support poles and diagonal tension rods → Horizontal rigid bracing → Install the second and third walkway boards → Install horizontal trusses → Install safety vertical nets → Install the lower section guide rail and the first wall-attached component and unload → Install the middle section vertical poles and auxiliary vertical poles → Continuously assemble the frame body until the installation of each frame of 2 layers is completed → Continuously assemble the frame body until the installation of each frame of 3 layers is completed → Continuously assemble the frame body until the installation of the frame body is completed → Lay the power line → Install lifting equipment (enter the operation stage)

### 3.4. Embedding Form and Requirements

3.4.1 Installation of Embedded Holes

When the aircraft stands attachment holes are pre-embedded in the structural beam, 2 pre-embedded pipes are pre-embedded on the beam along the center line of the design position for each Stand, with a spacing of 350~300mm. When the stand attachment holes are pre-embedded in the structural floor slab, they are pre-embedded on the same vertical line of the slab along the center line of the design position for each seat. Due to the change in the plane position of the beams between building floors, the position of the pre-embedded holes shall be determined based on the building axis. The formwork at the pre-embedded location needs to be Opening for pre embedding, and the time for forming opening shall be determined by the construction site. The plane position of the pre-embedded holes is determined according to the reserved schematic diagram of the attached lifting operation safety protection platform, and the pre-embedded pipes are Φ40 PVC pipes. The pre-embedded pipes must be firmly bound with steel bars to prevent being shaken or displaced during concrete pouring.

3.4.2 Installation method of through-wall bolts

In accordance with the relevant provisions of "Technical Code for Safety of Tool-type Scaffolds in Construction" JGJ202-2010 and "Technical Specification for Safety of Attached Lifting Scaffolds in Construction" DBJ/T15-233-2021, the wall-attached supports shall be connected to the building with anchor bolts. The number of nuts for tension bolts shall not be less than 2, or spring washers plus a single nut shall be used. Both spring washers plus a single nut and double nuts are a type of friction anti-loosening for threaded connections. This

project adopts double screws and double nuts, using M30 through-wall bolts, with washers and nuts installed at both ends, and the thread exposed beyond the nut shall not be less than 3 threads.

### 3.5 Structural Requirements

3.5.1 Segment Joint

Since the frame is lifted in segments, the bottom of the first lifted segment is one floor higher than the bottom of the other later lifted segment. Therefore, small crossbars and green mesh protection shall be added on the top layer of the first lifted frame and the side of the bottom layer of the other later lifted frame. After the frame is lifted synchronously, the protective mesh shall be removed. The segment joint shall be protected with a flip plate, and the external facade shall be protected with a segmental rotating mesh. During use, the flip plate and the walkway plate shall be closed, and the rotating mesh shall also be closed for protection; during lifting, the flip plate and the segmental rotating mesh shall be opened.

3.5.2 Tensile Measures for Top Diagonal Ties

To meet the protection requirements of the construction layer, the frame shall exceed the main operation surface by at least 1.5m, and the upper cantilever shall not exceed 6 meters. Due to the high floor height of this project, the upper cantilever of the frame is large. After the frame is lifted in place, fixed rigid ties shall be used on each floor to connect the upper part of the frame with the main structure to prevent the frame from overturning, and diagonal ties shall be added at the top with an angle of about 45 degrees.

3.5.3 Tower Crane

The tower crane position for this project has been determined. When arranging the plane layout of the climbing frame, a dedicated movable walkway board for the tower crane jib shall be placed at the Propose the position of the attached arm of the tower crane  The movable walkway boards at the tower crane jib are set at steps 1 to 7 of the frame and are of the movable reversible type. When the frame is being lifted, open and secure the protective net and movable walkway board one floor height below the tower crane jib, allowing the tower crane jib to pass through the walkway board of that floor smoothly. Transverse reinforcing pipes are installed on the 1st and 2nd floors;  when encountering the tower crane jib, they shall be disassembled, and after the lifting is completed, all reversible components and reinforcing transverse pipes shall be immediately restored to their original positions. When performing the above operations, workers must wear safety belts properly.

3.5.4 Construction Elevator

During the climbing stage of the climbing frame, the construction elevator of this project does not enter the climbing frame. After capping, the climbing frame at the construction elevator position is dismantled first, and the section opening is closed with a steel plate punching net.

3.5.5 Dumping Platform

A total of 7 dumping platforms are arranged in this project, which are self-elevating dumping platforms and independent of the climbing frame.

## 4. SAFETY ASSURANCE MEASURES FOR CONSTRUCTION OF ATTACHED LIFTING SCAFFOLD

### 4.1 Safety Assurance Measures for Installation Construction

Erecting the climbing frame is a high-altitude operation. Operators must wear safety helmets and safety belts correctly, and strictly follow the installation technical requirements.

Before erecting the climbing frame, during the assembly stage, during the lifting period, and during the dismantling period of the climbing frame, a warning line shall be set up on the ground, which is 8-10m away from the outer edge of the building, and special personnel shall be assigned to guard, and other unrelated personnel are not allowed to enter.

The climbing frame of this project is assembled layer by layer to ensure that the climbing frame protection exceeds the structural surface by at least 1.5m at any time. The climbing frame materials enter the site in batches, and are assembled while entering the site, so no ground assembly site is required, and the site demand is small. During the assembly of the climbing frame, the cooperation of tower cranes and other mechanical equipment is required. The climbing frame guide rails need to be installed by tower cranes, and materials such as dumping platforms also need to be transferred by tower cranes. During the installation period, it is necessary to actively cooperate and negotiate with the tower crane and other teams to avoid affecting the installation progress of the climbing frame.

### 4.2 Safety Assurance Measures for Dismantling Construction

The attached lifting scaffold of this project will not be lowered. After the main structure is capped, high-altitude dismantling will start. Since the tower crane has not been dismantled, considering the performance of the tower crane comprehensively, all lifting times of this project are within the coverage range of the tower crane. The height of the attached lifting scaffold to be dismantled is 19.5m, which is dismantled in sequence by unit. According to the different weights of each unit and the different lifting weights within the coverage range of the tower crane, the attached lifting scaffold is lifted as a whole unit or as upper and lower sections of a single unit.

## REFERENCES

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[2] Lu Yonghui, Safety Technical Specification for Attached Lifting Scaffold in Construction of Guangdong Province, Beijing: China City Press, 2021.