# Research And Analysis of Intelligent Construction Platform Technology for High-Rise Buildings

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**Abstract.** In recent years, with the rapid development of China's society and the continuous improvement of scientific and technological power, construction technology has been constantly innovated, from the traditional scaffolding to slipform, and then to climbing mold, lifting mold, construction mechanization, standardization and efficiency has been increasing. The high-rise intelligent integrated construction platform came into being as a "mobile factory" in the air, reducing the labor intensity of workers and improving the overall safety and operational efficiency of the construction. This paper starts from the basic principle of intelligent integrated construction platform, combined with Lanzhou Poly-Tianhui project, which is studied and analyzed from the aspects of design, construction and safety assurance, and systematically expounds the technology related to intelligent integrated construction platform of high rise.

**Keywords:** Intelligent jacking mold frame; functional integration; finite element analysis.

## 1. Overview of the project

Poly-Tianhui project is located in Northwest Material Market in Qilihe District, Lanzhou City, adjacent to Hewanbao East Street on the west, Xijin West Road on the south, Lan Shi land on the north, and Gansu Commercial Storage and Transportation Co. The total building area is about 266,000 square meters, the above-ground building area is about 206,000 square meters, and the underground building area is about 60,000 square meters. This project 12# building will be constructed with intelligent jacking mold frame.


**Figure 1.** The rendering of Poly-Tianhui

## 2. Intelligent jacking die holder

The intelligent jacking system mainly includes supporting power system, formwork system, frame system, hanger system, protection system and subsidiary system.

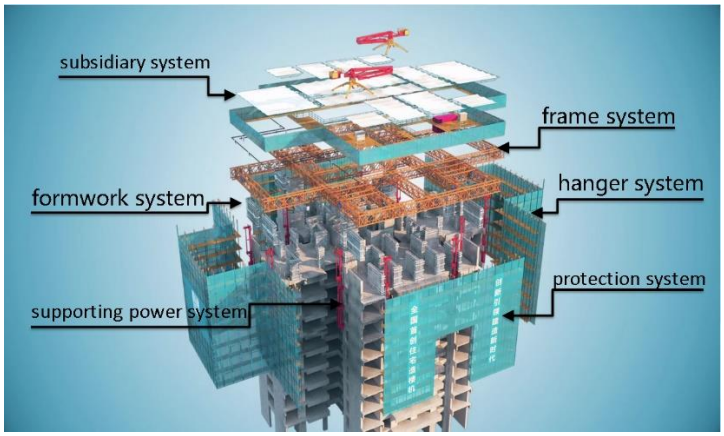


**Figure 2.** The schematic diagram of the system

The intelligent jacking formwork system for high-rise residential construction in this project consists of six systems: steel platform system, support system, power and control system, formwork system, hanging system and safety protection system. According to the structure layout, the platform was set up with 11 support points.

The formwork of the vertical structure is suspended below the steel platform, and the hydraulic cylinder with small stroke (0.8m) and small capacity (lifting force about 70t) and supporting column (gantry column and rail column) and hanging seat are used as the lifting and supporting system of the formwork, and the hydraulic cylinder is lifted 0.4m in height at one time, and the steel platform system above it is driven to lift the formwork system and the hanging seat system together by the hanging seat supporting system on the outer wall. The vertical concrete structure construction is completed by lifting the steel platform system on the upper part of the wall support system.

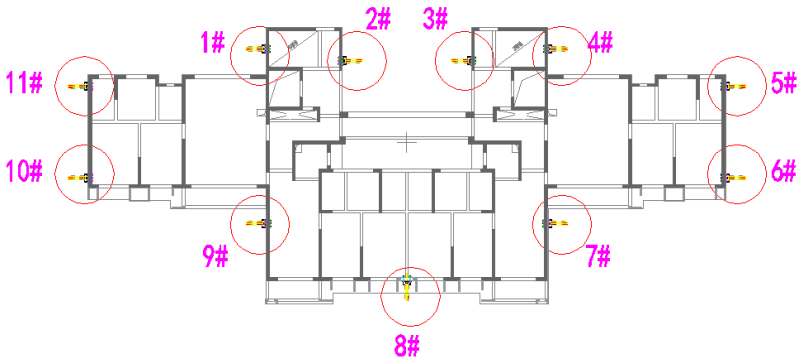


**Figure 3.** Mould frame plan layout

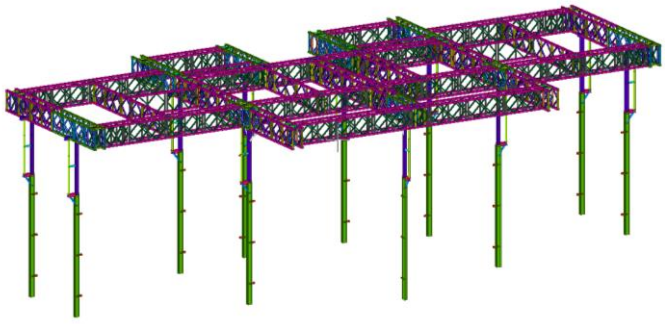

**Figure 4.** The overall three-dimensional schematic diagram of the beryl frame platform system

## 3. Function Integration

Formwork system: Aluminum alloy combination formwork is mainly used in this project. The configuration mainly includes standard formwork, non-standard formwork (according to the size of the matching mold to compensate for the size of the standard formwork area outside).

Hanging rack system: Hanging rack mainly serves the construction of part of the exterior wall structure as well as the operation rack and lean construction, providing a working surface for the construction of the exterior wall, so when hanging rack is arranged, it is mainly arranged along the outside of the exterior wall, and the width of the walkway plate is arranged along the outer circle of the exterior wall according to 750mm.

Canopy system: In order to ensure the all-weather construction of this project under non-extreme weather, canopies are set between platform trusses, which are numbered and designed in different forms according to their specific sizes, with manual single-slope tilt canopies. Rainwater collection system is set at the bottom of the canopy, and rainwater is reused.

Spraying cooling and spraying maintenance system: The platform was integrated with a cooling spraying system designed to turn on the spraying system while the canopy was closed to shade the sun to reduce the body temperature of the working surface. At the same time, in order to strengthen the quality control of concrete strength and timely maintenance of wall column concrete, a circle of spray pipes was arranged on the inside of the hanging frame to spray maintenance on the outer wall part.

Lighting system: In order to ensure the night construction of this project, night lighting is installed on the site at the fixed point on each layer of the hangers, and the lighting lines on each layer of the hangers are set separately, with separate switches set up for management, and all the lines are protected by PVC pipes. In addition, LED lights are installed on the inner side of each layer of protective net to meet the lighting requirements and save energy effectively.

Fire-fighting system: Temporary fire-fighting water tank is set at the truss level of intelligent jacking mold platform, and water outlet is set at each floor position, which can be connected with a long hose according to the situation, and also used as water for concrete maintenance and watering to maintain concrete.

Lightning protection grounding system: The mold frame is set up with lightning protection grounding measures, and copper core wire is used to connect the beryl frame platform with the vertical wall reinforcement to play the effect of lightning protection.

## 4. Finite element analysis

（1）Finite element analysis

MidasGen was used for finite element analysis and design verification of the molded frame, the beryl frame truss platform and support system were simulated with beam units, and the finite element model of the overall platform model is shown in the following figure：

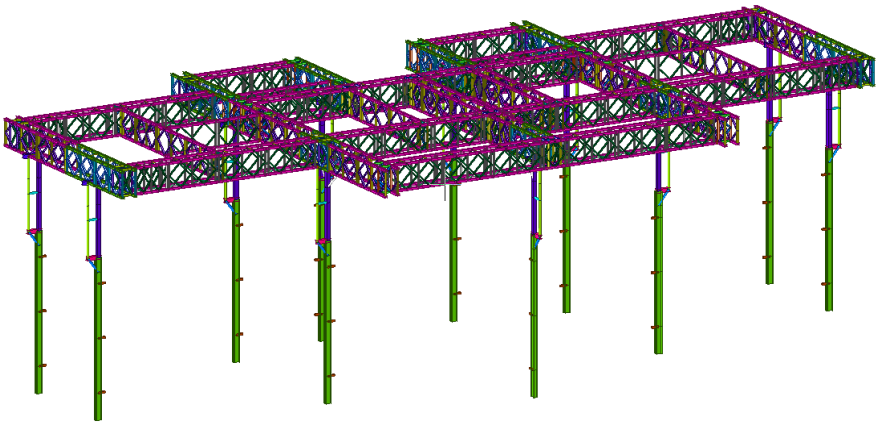

**Figure 5.** Calculation model of mold frame

(2) Construction phase analysis results

1) Displacement results of the structure

①Brief of the displacement situation.

The displacement calculation working condition uses a combination of standard values (1.0D+1.0L+1.0W) and the displacement is shown below:

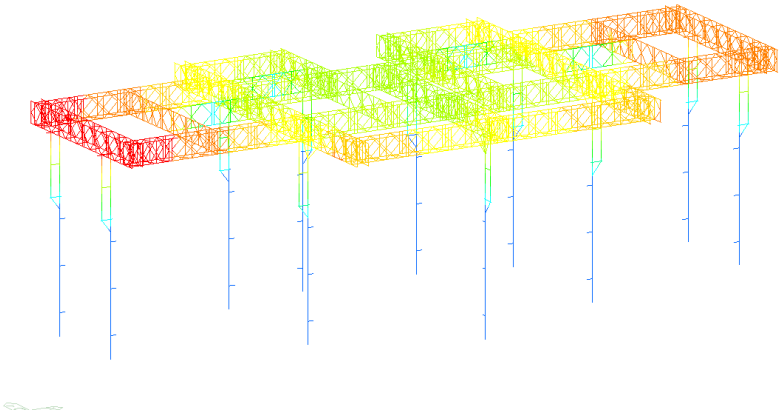

**Figure 6.** Structural displacement diagram (unit: mm)

Considering the effect of wind load, the possible extreme value of combined displacement is 31.2mm, which is located in the area of east and west of the beryl frame platform.

②Z-directional deformation of mold frame and deflection of beryl frame platform (as follows)

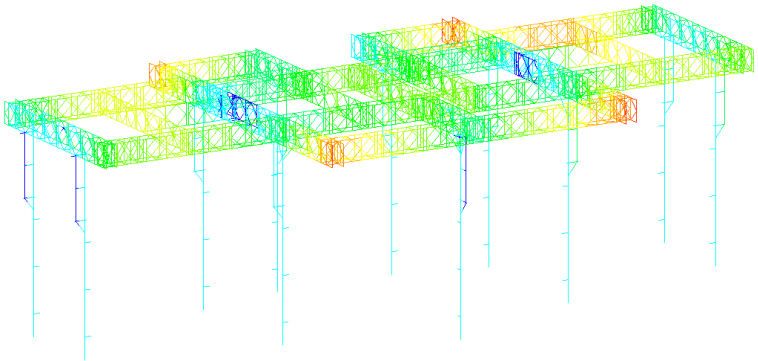

**Figure 7.** Overall Z-directional displacement diagram of the mold frame system (unit: mm)

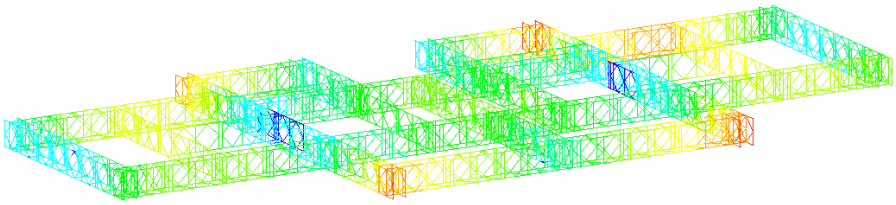

**Figure 8.** Z-directional displacement diagram of beryl frame platform (unit: mm)

The maximum Z-directional displacement of the beryl frame platform occurred at the position of the southeast corner of the beryl frame platform, with a displacement value of -11.3mm. The Z-directional starting displacement of the overhanging end is -2.3mm, the ending displacement -11.3mm, and the deflection is 9mm. According to The Steel Structure Design Code, the allowable Z-directional displacement is 7250/200=36.25mm. The overall deflection of the beryl frame platform meets the specification requirements. According to the Steel Structure Design Code, it is known that the deflection in the middle of the beryl frame platform is 3.6mm and the allowable Z-directional displacement is 45400/400=113.5mm. The overall deflection of the beryl frame platform meets the specification requirements.

2）Design stress ratio

The stress ratio of the structure is shown in the figure, and the peak stress ratio is 0.8<1,which meets the requirement.

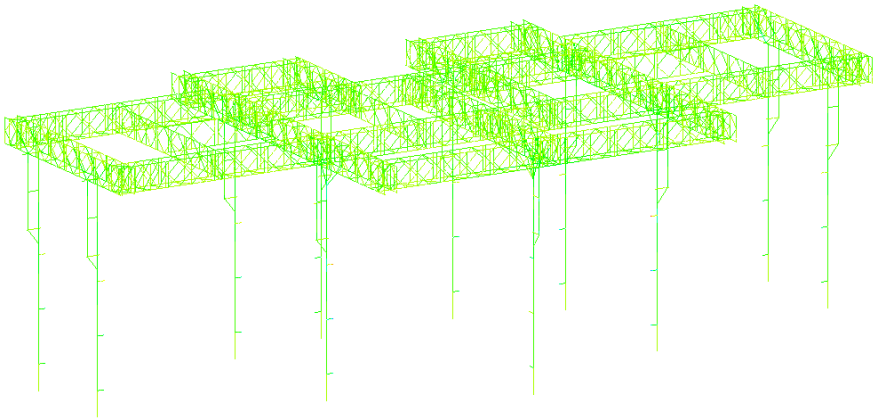

**Figure 9.** Mold design stress ratio

（3）Analysis results of the jacking stage

1）Displacement results of the structure

①Brief of the overall displacement.

The displacement calculation working condition uses a combination of standard values (1.0D+1.0L+1.0W) for the overall combined displacement as shown in the following figure：

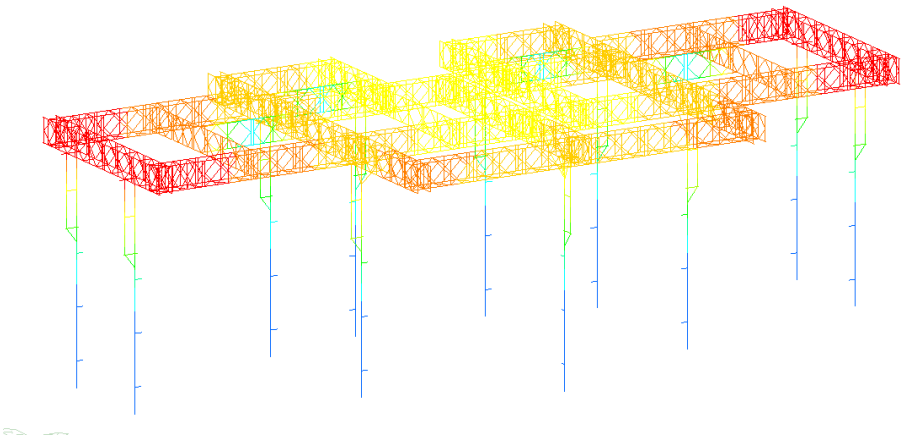

**Figure 10.** Overall displacement diagram of the structure (unit: mm)

Considering the effect of wind load, the extreme value of possible combined displacement in the jacking state is 77mm.

②Z-directional deformation of the mold frame system and the deflection of the beryl frame platform (the following figure)

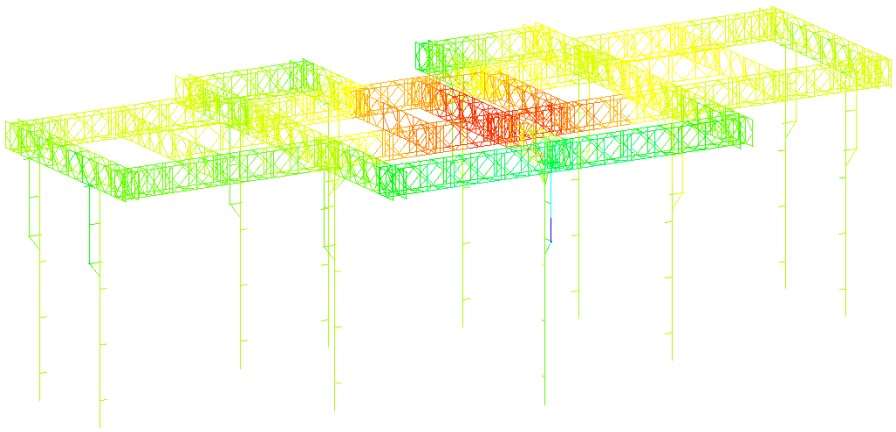

**Figure 11.** Contour diagram of the overall Z-directional displacement of the mold frame (unit: mm)

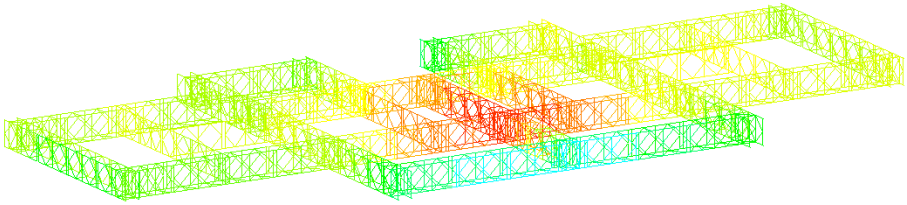

**Figure 12.** Contour diagram of Z-directional displacement of beryl frame platform (unit: mm)

The maximum Z-directional displacement of the beryl frame platform occurs in the middle position of the beryl frame platform, and the displacement value is -6.2mm. The Z-directional starting displacement of the overhanging end is 0mm, the ending displacement -3.9mm, and the deflection is

3.9mm. According to the Steel Structure Design Code, the allowable Z-directional displacement is 7250/200=36.25mm. The overall deflection of the beryl frame platform meets the code requirements. According to the Steel Structure Design Code, the central deflection of the beryl frame platform is 6.3mm and the allowable Z-directional displacement is 45400/400=113.5mm. The overall deflection of the beryl frame platform meets the code requirements.

2) Design stress ratio

The stress ratio of the structure is shown in the figure, and the peak stress ratio is 0.9<1, which meets the requirements. The system is safe and reliable.

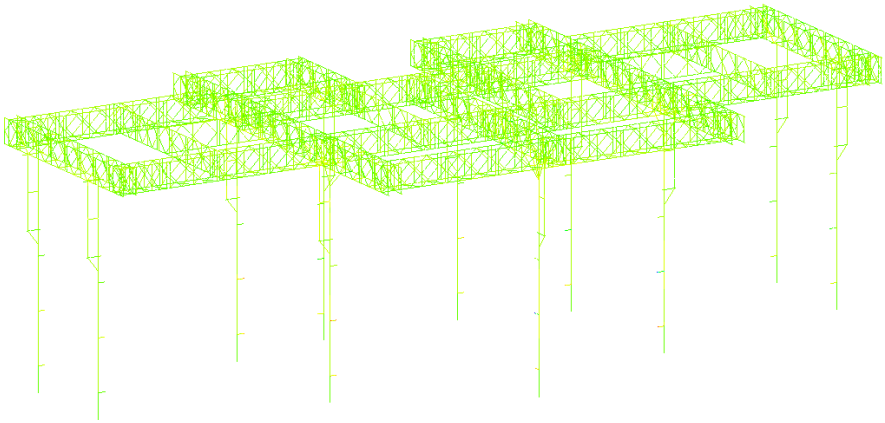

**Figure 13.** Overall design stress ratio of the mold frame

3) Support Reverse Force

The position of the maximum support reverse force is shown below, the maximum vertical and support reaction force is 30.7T. Therefore, the use of 70T jacking capacity of the cylinder can meet the jacking requirements.

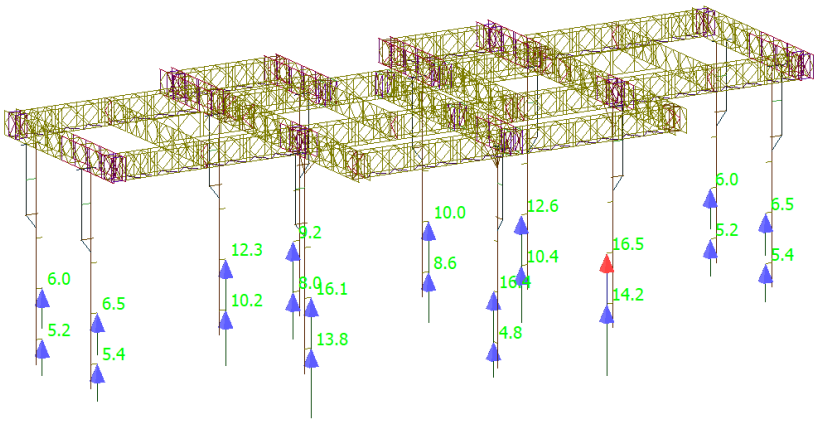


**Figure 14.** Support Reverse Force

## 5. Assurance measures for construction safety

1.Anti-tilting and fall prevention device: column lifting anti-tilting and fall prevention device principle of action column start jacking, jacking cylinder drive the upper commutation box and column rise, jacking cylinder reach 400mm stroke, rely on the lower commutation box and column force, recovery on the commutation box, at this time fall prevention is to rely on the lower commutation box and column every 100mm of the 300mm long groove common action, through the lower commutation box will be force to C-frame, and then the C-frame transmits the force to the pivot point, thus preventing the column from falling suddenly.

2. The jacking process of intelligent jacking mold frame in this project adopts static level meter for the whole level monitoring. Level meter parameters: magnetostrictive sensor, range 1000mm, output signal 4-20mA, display error 0.1mm. The jacking synchronous control system has fully automatic synchronous deflection correction function, which can ensure that the travel error of each cylinder is within 3mm.

3. Underwriting protection：It is the bottommost walkway plate protection of the smart jacking mold hanger. The intelligent jacking mold hangers n-1 layer and the bottom walkway plate set two patterned steel plate + flip plate mechanism, the normal construction state flip plate open against the structural wall, forming a tight pocket bottom protection to prevent falling objects, the jacking state will flip back the flip plate, does not affect the jacking.

## 6. Conclusion

In this paper, the intelligent and integrated system of intelligent jacking mold frame is highlighted. Combining with the actual situation of this project, the construction has been studied and analyzed from the aspects of design and construction safety assurance, and the reasonable application of intelligent integrated construction platform for high-rise is determined, which can give full play to the characteristics of good safety, fast construction speed, large load capacity, strong adaptability and all-weather operation of the platform.

Adding intelligence to the construction platform is not only a way to increase the automation of the building, but also to integrate the many fragmented technologies of the building from design to construction, turning the production of the entire building into a coherent process. In the lightness, safety and economy of equipment operation, the miniaturization and serialization of the pivot point system, the standardization and generalization of each component to realize the turnover use. Construction tools are reasonably laid in the platform and synchronized with the platform as a whole to reduce material turnover, and small steel processing yards and other construction facilities are integrated on the top floor to further improve construction efficiency. Realizing the interpolation of facade and efficient three-dimensional flowing operation, which provides more space for serving lean construction.

High-rise intelligent integrated construction platform technology is not only to solve the construction problems of this project, but also to provide a breakthrough to the existing construction technology, which shows a development direction of the future construction technology for the practitioners of construction engineering, and also provides a direction for the industrialization of building intelligence.

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