Model Establishment and Detailed Design of Prefabricated Construction Using GSRevit

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Abstract: At present, the construction industry is changing the traditional architectural design mode and construction method, in order to ensure the quality of the project, save resources and reduce costs while building green buildings, energy saving and emission reduction. As a result, assembly building is becoming the mainstream of the current development of the construction industry. This paper takes an assembly residential building as an object to conduct an example study, discusses the assembly building construction process and its difficulties, and the results are favorable to provide reference for assembly building construction and related construction difficulties.

1. Introduction

In recent years, the central and local governments have continued to introduce relevant policies to vigorously promote the assembly of buildings, coupled with the increasingly mature development of assembly technology, the formation of a variety of forms of building technology, such as assembly frame structure, assembly shear wall structure, China's assembly development has entered a period of rapid development[1].

In this paper, we will take the construction assembly project Sany Cloud City building in Fengxi construction project as the research object, discuss the construction technology and project cost in the current assembly building construction, and compare it with the traditional building form, analyze the advantages of assembly building and propose certain solutions to the related problems.

2. The Application of Prefabricated Construction

2.1. Development status of prefabricated construction

China's prefabricated construction can be traced back to the 1950s, when China borrowed the experience of the former Soviet Union and Eastern European countries to promote prefabricated construction in the country, domestic industrial construction enthusiasm, the rapid development of concrete structure-based prefabricated construction. In the 1970s, Beijing did a lot of large-slab housing with prefabricated walls and floors, but by the 1980s, the development of prefabricated construction entered a low period due to poor seismic performance, waterproofing, sound insulation and other problems[2]. Currently in the "14th Five-Year Plan" period, in order to improve the efficiency and sustainability of industrial buildings, and promote the high-quality development of the construction industry, with the reduction of environmental pollution, shorten the construction period, improve the quality of construction and other advantages of the intelligent construction of assembly buildings will certainly become the future development trend, which makes China's assembly building has entered a stage of rapid development.

2.2. Comparison between prefabricated construction and traditional building

Compared with the two technologies, the most important feature is the change of production method, which is mainly reflected in five technologies: standardization of architectural design, factoryization of parts production, assembly of on-site construction, integration of structure and decoration, and informationization of construction process. Its main advantages are reflected in improving the efficiency of engineering construction, enhancing the quality of engineering construction, ensuring construction safety, improving economic efficiency and low carbon and low energy consumption, saving resources and achieving sustainable development.

In general, the main differences between prefabricated construction and traditional cast-in-place reinforced concrete buildings are: firstly, the construction method is different, the new assembly building is assembled with prefabricated components at the site and the building, while the traditional building components are all poured in the form of on-site support. Secondly, the operation mode is different. Thirdly, the construction concept is different, better, more economical and faster, which is the core
element of the new prefabricated construction, realizing the transformation from the rough construction industry to the high-end manufacturing industry.

3. Case Study

3.1. Project Overview

This study is a 25F/2F high-rise building in a district 3# building with a total building height of 89.35m, a total floor area of 14237.30 m² above ground, and a first floor area of 594.48 m²; The service life of the main structure is 50 years, the grade of the construction project is Grade I, the structure type is shear wall, the foundation form is pile foundation + raft slab; the fire-resistance grade is Grade I, the intensity of seismic defense is 8 degrees, and the number of households is 100.

3.2. Model building

Project in the design phase, the application of GS-Revit modeling can detect the safety and stability of the design structure, and is conducive to the subsequent assembly deepening design, for the subsequent construction process to provide visualization of the reinforcement layout details of walls, beams and slabs, etc.. At the same time, the completion of the modeling of revit can be directly imported into the GCCP for cost design, providing a basis for subsequent bidding investment. The whole model association route is shown in figure 1 below.

4. Results and Discussion

The project is an assembly-type intelligent construction project, which adopts "cavity + lap + post-cast" structural technology and CECS standard SPCS 3.0 assembly system in construction.

4.1. General construction flow

The main work content of the project includes: pre-project preparation (including the preparation with prefabricated parts, handling of prefabricated parts), foundation construction, basement construction, foundation frame construction, masonry construction, door and window construction, decoration construction, machinery installation construction, completion acceptance, etc.. Among them, the assembly construction process of the standard floor is shown as figure 2:

![Figure 2. General flow chart of construction](image)

The reinforcement arrangement should be adjusted according to the characteristics of the construction site during the construction of the assembled project for different situations.

4.2. Prefabrication construction preparation

To carry out formal construction of PC structure, firstly, on the basis of the design drawings, deepen the prefabricated components required for construction, including the design of pre-drilled holes and lifting point positions, etc., and generate deepening design processing drawings. According to the construction specification, the lifting calculation formula is shown below.

\[
\sigma_{cc} \leq 0.8 f_{ck}
\]

(1)

Where: \( \sigma_{cc} \)—for each construction link in the load, the standard combination of the role of the normal compressive stress of concrete at the edge of the positive section of the member, shall meet the requirements of the following equation(1).

\[
\sigma_s \leq 0.7 f_{yk}
\]

(2)

Where: \( \sigma_s \)—for each construction link in the standard combination of loads under the action of the member of the positive section edge of the concrete normal tensile stress, it is appropriate to meet the requirements of the following equation(2).

A laminated plate part of the lifting calculation as an example, where the concrete capacity = 25kN/m³, lifting
power coefficient of 1.5, plate length = 3420mm, plate width = 2260mm, plate thickness = 60mm.

1) Lifting load calculation:
   Volume = 0.461m³, deadweight = 11.537kN
   Lifting total load = lifting power coefficient×self-weight = 17.306kN

2) Load bearing capacity calculation of lifting parts:
   Number of lifting points=4, each lifting point internal force=total load of lifting/4=4.326≤standard value of bearing capacity=11.000kN

Other parts of the calculation are specified in GS-REVIT. After the verification meets the requirements, the drawings can be adjusted to provide the basis for the subsequent production of prefabricated components in the prefabricated component factory. The production of prefabricated components is mainly carried out in the prefabricated components factory, except for some steps such as mold table cleaning, which need to be carried out manually, all other steps can be carried out by the prefabricated components production equipment.

4.3.Prefabricated assembly structure construction process

Prefabricated components need to be transported to the site for processing and acceptance completion in industrial production, and then stored at the designated location after acceptance at the site. According to the construction plan, prefabricated walls, laminated panels and prefabricated stairs will be lifted in turn. Among them, the construction process of prefabricated components mainly includes PC component entry, component acceptance, stacking and lifting. Each process should strictly comply with the relevant norms and standards during construction.

The lifting process of prefabricated walls is presented as an example. When lifting precast walls, the lifting process of prefabricated walls adopts the way of "two-point lifting", and the lifting process is mainly shown in the following figure 3:

![Flow chart of prefabricated wall lifting](image)

**Figure 3. Flow chart of prefabricated wall lifting**

When lifting prefabricated components, the following specification requirements should be followed:

First, when placing the line, the main control line should be used as the benchmark, and the wall contour line and wall edge line 300mm control line should be placed; Second, the lifting part should be protected and cleaned before lifting, and the vertical pre-reinforcement should be checked and corrected at the same time; Third, hanging mode for two-point lifting, the horizontal angle of the spreader rope should not be lower than 45°, and should not exceed 60°; Fourth, pause when lifting to 500mm from the ground and check whether the component is lifted flat, otherwise level the component and install it again; Fifth, the components should be checked for verticality and flatness immediately after installation.

According to the Assembly Standard, the evaluation of assembled buildings shall comply with the following provisions: pre-evaluation is appropriate at the design stage, and the assembly rate shall be calculated according to the design documents; the evaluation of the project shall be carried out after the completion and acceptance of the project, and the assembly rate shall be calculated according to the information of the completion and acceptance and the evaluation grade shall be determined. The formula for calculating the assembly rate of a building is shown in the following equation.

$$P = \frac{Q_1 + Q_2 + Q_3}{100 - Q_4} \times 100\%$$

Where: $P$—assembly rate;
$Q_1$—Actual score of the main structure indicator;
$Q_2$—Actual score of enclosure wall and internal partition wall indicators;
$Q_3$—Actual scores of decoration and equipment pipeline indicators;
$Q_4$—Comprehensive score of evaluation items missing in the evaluation items.

4.4.Analysis of important and difficult points and response

4.4.1.Pre-positioning of reinforcement

When the precast wall panels of each layer are finished lifting, it is necessary to ensure that the precast sleeve of the upper bottom layer, and the precast reinforcement of the next level are fully docked. Once any position offset occurs, it will affect the lifting of the precast wall. According to the study, the reserved reinforcement is mainly susceptible to the concrete pouring and vibrating of the pre-buried inserts in the conversion layer.

Countermeasures: At present, there are three main methods of positioning reinforcement: angle iron and PVC pipe with fixed inserts, inserts in the lower layer of the conversion layer planted with raw reinforcement and fixed inserts in the frame of fixed steel plates. In order to ensure the normal progress of prefabricated wall lifting, the prefabricated reinforcement in the conversion layer before lifting should be pre-calibrated with the fixed steel plate clamps, and the prefabricated reinforcement should be positioned with the clamps before the subsequent pouring of the top plate of each layer, which ensures that the sleeve of the bottom plate of the upper prefabricated external wall and the lower prefabricated reinforcement, can be positioned smoothly against the hole.

4.4.2.Pulp leakage, unable to produce pulp

There are mainly the following reasons for the leakage of grout and the inability to produce grout during grouting[4].

1) PC components may lead to blockage of grouting channels at the base connecting cavity due to non-cleaning of the installation contact surface and non-standardization of pad placement prevention during lifting;
2) Part of the bin in the PC wall is too long and the grouting path is too long;
3) The temperature is too low when grouting or the slurry is not blended as required, and the slurry is used for too long, resulting in reduced fluidity of the slurry;
4) The pressure during grouting does not meet the requirements, the grouting time is not sufficient and the grouting is not checked and replenished in time;
5) The grouting machine or the inside of the discharge pipe contains unexhausted air bubbles.

Countermeasures: Before grouting, technical briefing and technical training should be conducted. Before the first grouting, grouting test should be conducted to determine the parameters such as grouting pressure and speed; before the parts are lifted, the parts should be cleaned, the grouting holes and grouting holes should be checked for smoothness and the grouting device should be inspected. In case of grouting leakage and no grouting during the grouting process, grouting must be stopped immediately, and if there is an obvious leakage, it should be considered to be closed again. After the grouting is finished, it should be tested in time and the leaking point should be grouted twice.

4.4.3. Winter grouting

The project starts from September 1, 2021 to August 8, 2022, in which the lifting of prefabricated components is mainly carried out in winter according to the construction schedule, while the sleeve grouting construction requires that the temperature below 5℃ shall not be constructed. The winter in Xi’an region is severe, with the average winter temperature at -1℃~8℃, and the long period of time without grouting will lead to the delay of the construction schedule.

Countermeasures: To solve the above problems, the following measures are proposed to ensure construction quality and schedule[5].
1) In winter grouting use special low-temperature grout suitable for environments above -5℃ to ensure that grouting is carried out normally in winter;
2) Adopt post-grouting process. This project uses SPCS system for construction, grouting are carried out after the installation of walls, columns and beams and slabs, the main body comes with insulation and forms a confined space can ensure the grouting temperature;
3) Pay attention to the slurry insulation. Grouting equipment should be wrapped with fiber insulation felt, and pouring materials using a cage with insulation to ensure that the grouting machine is properly discharged.

5. Conclusions

Compared with the traditional construction method, assembled can not only improve the construction quality, save material and labor cost, but also shorten the construction period, and achieve energy saving and environmental protection. However, at the present stage, the construction cost of prefabricated construction is still higher than that of cast-in-place concrete structures due to the lack of mature technology development, etc.. Besides, there are no clear specifications for solving the construction problems encountered in the construction, which still need to be explored and analyzed. This paper introduces the construction process of prefabricated construction and discusses and analyzes the three construction difficulties to provide solutions to the problems encountered in the construction of prefabricated construction in the future. Although there are still many disadvantages of prefabricated construction compared to traditional buildings, the national government has been promoting the development of prefabricated construction, and the advantages of prefabricated construction will become more and more obvious.

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