Chapter 13
Analysis and Control of Measurement Accuracy of Super High-Rise Building Engineering

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Abstract Super high-rise buildings have the characteristics of large investment, long construction period, various functions, complex system, super high structure, and difficult construction. In the early stage of project construction, sufficient analysis and research are required. According to the specific characteristics of the building, the surrounding environmental traffic, geology and hydrology, climate conditions and other conditions, combined with the subjective conditions of construction and construction, a comprehensive balance analysis is required to make various resource allocation plans and implement measures. In terms of dynamic deformation monitoring, through three technical means of measuring robot, high-frequency GPS, and photogrammetry, real-time monitoring and data analysis of buildings are carried out, and the deformation conditions of buildings are predicted in advance, and corrective measures are taken to realize the actual situation once. The research on the construction measurement technology of super high-rise buildings has a positive role in promoting the development of super high-rise building construction technology itself, and has also played a role in promoting and reforming domestic construction methods and construction concepts. Through the application research of this technology, it has reserved scientific and technological innovation talents for engineering projects and enterprises, and provided valuable experience for the construction measurement control of similar large-scale construction projects. It has significant technical, economic, and social benefits.

13.1 Introduction

Super high-rise buildings are large in volume and large in construction area, and the required investment is often over several billion yuan. The capital pressure of the construction unit is very heavy. The financial pressure is reflected in the high cost of the construction period. Once the project is delayed, it will often cause a sharp increase in investment costs and reduce investment returns [1]. The construction

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difficulty and technical requirements of super high-rise buildings are higher than those of general construction projects. Therefore, the research on super high-rise construction technology is of great significance not only to the entire society but also to the construction industry. Surveying is the leading work of super high-rise building construction. It not only runs through the whole process of super high-rise building construction, but also an important means to connect the spatial position relationship of each divisional and subdivisional project [2]. However, due to many factors such as high measurement accuracy requirements, difficulty in erecting instruments and equipment at high altitude, limited visibility conditions, and the impact of meteorological factors on the swing of super high-rise buildings, etc., all factors will affect the construction measurement work. Controlling its construction process is the most difficult point in super high-rise surveying work [3]. Super high-rise buildings are buildings that extend vertically upwards. This feature determines that the construction of super high-rise buildings can only be carried out layer by layer. The working space is very small and the construction organization is very difficult. It is necessary to effectively use the working time and space to improve the construction efficiency.

Super high-rise buildings have the characteristics of huge investment, high construction period cost, multiple functions, complex system, super high structure, and difficult construction [4]. Therefore, before construction, we must first analyze the characteristics of the project in depth, clarify the key points of the project's construction technology, and then formulate a targeted construction technology route. The general contracting management improves the utilization efficiency of working time and space, and finally achieves the purpose of shortening the construction period and improving the efficiency of investment [5]. Relevant scholars believe that the selection of suitable templates in construction projects and the comprehensive application of multiple templates in the entire construction industry have become the development trend of formwork projects [6]. In view of the application of wood plywood formwork, he believes that there are mainly the following problems [7]. First, there is a problem with the overall quality of the product. There are many domestic manufacturers of wood plywood template, but most of the manufacturers' products are low in price, so their quality is not satisfactory. This resulted in less turnover of the formwork (about 3–5 times), resulting in a large amount of waste of wood. Second, the phenomenon of "small workshops" is widespread. There are more than 4,500 wood plywood formwork manufacturers, and the number is extremely large. However, most manufacturers have small production scales, backward equipment, and relatively low management level. This is also the reason that the wood plywood template produced by the manufacturer is of poor quality and weaker competitiveness. It is difficult to form a large-scale operation, and it is even more difficult to participate in international competition. At present, many construction and scientific research units at home and abroad are conducting research on the application of super high-rise building construction technology, but most of the units are still immature in the research of super high-rise building construction measurement technology, even if some units have already mastered the construction of super high-rise buildings [8]. The subject research of super high-rise building measurement technology is based on the needs of enterprises and the development trend of the construction industry. The comprehensive research from the basic theory of super high-rise building measurement to specific measurement methods has very important engineering practical and popularization value for the construction of super high-rise buildings.

At present, many large-scale construction enterprises with corresponding construction qualifications and construction experience have gradually formed their own characteristics of super high-rise building construction technology through continuous construction and production practice summary. However, the key technologies, methods and measures to deal with the main points and difficulties in the construction of super high-rise buildings have their own characteristics and cannot be directly applied. Dynamic deformation monitoring of super high-rise buildings obtains the vertical displacement, horizontal displacement, deflection and other deformation data of super high-rise buildings under self-weight load, wind load, sunshine, temperature and other external factors through monitoring. This provides a correction basis for construction surveys, so as to grasp the deformation laws of super high-rise buildings, and provide a basis for assessing the safety of buildings.

13.2 Super High-Rise Building Project Implementation Planning

13.2.1 Super High-Rise Building Construction Organization

Super high-rise building is a huge system project with long construction period and difficult organization. Only by strengthening overall planning can the smooth progress of super high-rise building construction be ensured. The effective means to strengthen the overall planning of super high-rise building construction is construction organization design. Construction organization design is to create the necessary production conditions for the completion of super high-rise building construction tasks, and to formulate advanced and reasonable construction technology. It is a basic technical and economic document that guides the preparation and construction of super high-rise buildings. The fundamental task of super high-rise building construction organization design is to make overall planning from five aspects of manpower, capital, materials, mechanical equipment, and construction methods under specific time and space constraints. The organized, planned, and orderly construction of super high-rise buildings ensures the smooth realization of the construction quality, safety, construction period, and cost targets of the entire project.

Construction organization design is also an important means of scientific management of construction projects and an important basis for construction resource organization. It has the dual functions of strategic deployment and tactical arrangements. The design of construction organization can enhance the system of general contract management. Super high-rise buildings have many functions and complex systems. The construction process is a huge system project. Through construction organization and design, the general contractor can take the overall situation and coordinate

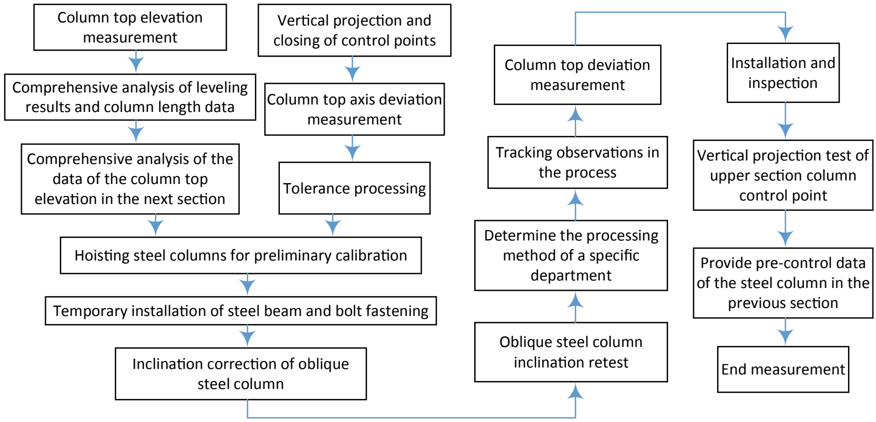

Fig. 13.1 Steel structure measurement process of super high-rise building engineering

all parties, and complex construction activities will have a unified action guide. The design of construction organization can enhance the predictability of general contract management. Super high-rise buildings have high construction technology content and high construction risks. Through the design of construction organization, the general contractor can grasp the various unfavorable conditions that may be encountered in the construction in advance, so as to make various preparations in advance, and make full use of various favorable conditions to eliminate hidden dangers in the construction. Construction organization design can enhance the coordination of general contract management. Due to the large number of units and personnel involved in the construction of super high-rise buildings, the coordination workload is large. Through the construction organization and design, the general contractor can close the relationship between the design and construction, technology and economy, front and rear of the project, and coordinate the various units. In short, through the design of construction organization, the general contractor can significantly improve the organization and management level of the construction of super high-rise buildings. Therefore, the preparation of construction organization design is the core of all work in the preparation stage of super high-rise building construction, and it occupies a very important position in construction organization and management. The steel structure hoisting measurement process of super high-rise building engineering is shown in Fig. 13.1.

13.2.2 Construction Schedule of Super High-Rise Buildings

The construction schedule is an important part of the construction organization design, and it is also an important means for the implementation of the project management plan. The construction schedule plan is the time plan for the construction of a project, which stipulates the start and end time, construction sequence and construction speed of the project construction, and is an effective tool to control the construction period. There are four main types of schedule plans: total schedule plan, unit project schedule plan, sub-project schedule plan, and resource requirement plan.

The overall construction schedule is the manifestation of various construction activities on the construction site in terms of time. The preparation of the overall construction schedule is to make time arrangements for all construction projects on the site according to the construction plan in the construction deployment and the project deployment procedures. Its role is to determine the construction period of each construction project and its main sub-projects, preparations, and full-site projects, as well as the start and completion dates, so as to determine the needs of labor, materials, finished products, semi-finished products, and construction machinery on the construction site. Therefore, the correct preparation of the overall construction schedule is an important condition for ensuring that the construction project is delivered on time and reducing the construction cost of super high-rise buildings.

13.2.3 The Construction Layout and Evaluation Method of Super High-Rise Buildings

The construction layout is the basis for site management and the realization of civilized construction, and is an important content of construction organization design. It has strong technical, economic, and policy characteristics, and requires overall planning and careful treatment. The general construction plan shall be reasonably arranged for the layout of construction machinery and equipment, storage yards of materials and components, on-site processing sites, on-site temporary transportation roads, temporary water supply and power supply lines, and other temporary facilities.

The construction period of super high-rise buildings is long and has obvious phase characteristics. Therefore, the construction layout should be dynamically adjusted in time to meet the requirements of the construction process at each stage. Before compiling the general construction plan, the construction steps should be determined first, and then the construction plan divided by stages should be compiled according to the different stages of the project schedule. Generally, it can be divided into the stages of earth excavation, foundation construction, superstructure construction, and mechanical and electrical installation and decoration. In order to reduce construction investment, attention should be paid to the orderly conversion in the dynamic adjustment of the construction layout, and the adjustment of the main construction temporary facilities (such as main roads, warehouses, offices, and water and electricity lines) should be avoided as much as possible, so as to realize the high sharing of the main construction temporary facilities at all stages.

The analytic hierarchy process provides a simpler evaluation method for decision-making events that cannot be expressed by quantitative analysis. According to the degree of understanding and grasp of the problem in the previous step, the various elements contained in the research problem are classified and grouped according to the principle of whether they have common attributes, and the elements with common properties are regarded as some elements in a new level of analysis. These elements themselves are divided accordingly according to another characteristic to form higher-level factors different from this kind, and so on until finally a goal level of the highest level is formed. This is a general goal level that all the element research and evaluation must achieve.

With the numerical scale, you can start in the lowest level and use the corresponding judgment matrix to express it.

$$B = \begin{pmatrix} b_{11} & \cdots\cdots & b_{1n} \\ b_{21} & \ddots\ \ddots & b_{2n} \\ \vdots & \ddots\ \ddots & \vdots \\ b_{41} & \cdots\cdots & b_{4n} \end{pmatrix} \tag{13.1}$$

The value of b_{ij} in the judgment matrix is determined after comprehensive analysis of the collected data and information, referring to expert opinions and the experience of relevant analysts. Under normal circumstances, in the analytic hierarchy process, people refer to the consistency test as *CI*, and its expression is

$$CI = (\lambda_{\max} - n)/(n - 1) \tag{13.2}$$

For quantitative indicators, fuzzy subsets can be determined:

$$r_{nt}^{t} = \left[r_1\ r_2\ r_3\ r_4 \right] \tag{13.3}$$

Calculate the comprehensive evaluation about the V_t of each evaluation criterion layer:

$$B^t = r_{nt}^{t} \cdot r_1 \cdot r_4 \tag{13.4}$$

Take the rank matrix C to obtain the total evaluation value:

$$F = C^T \cdot B \cdot r_{nt}^{t} \tag{13.5}$$

13.3 Dynamic Deformation Monitoring of Super High-Rise Building Engineering Structure

13.3.1 Fully Automatic Robot Measurement

We establish a reference station at a location far away from the building with good visibility, and set up a rear-view station at a location with a wide field of view and unobstructed background, and use forced centering to ensure point accuracy. We set up instruments at the base station every day, and set up a prism at the rear-view station, and perform automatic observation after the positioning is completed. To ensure the comparability of monitoring data, the monitoring time is set from 6 a.m. to 8 p.m., and the monitoring interval is 15 min. The daily data is processed and analyzed by professional software, and the change curve of observation points within a day is obtained, and the change trend of the building body is grasped.

On the whole, the change of the observation point on the core tube is smaller than that of the outer steel structure, indicating that the stability of the core tube structure is stronger than that of the outer steel structure. The displacement change of the observation point changes with time, showing a fluctuating trend, and the whole shows an irregular curve change. The displacement change measurement accuracy of the four monitoring points is shown in Fig. 13.2.

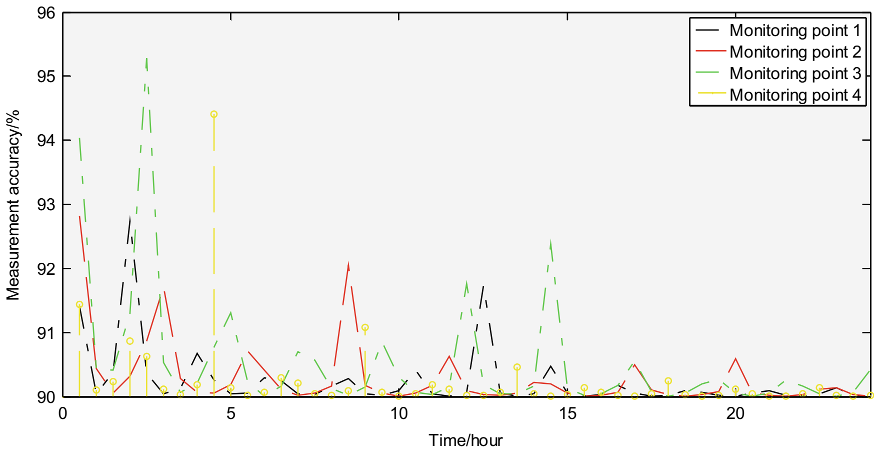

Fig. 13.2 Measurement accuracy of displacement changes of each monitoring point

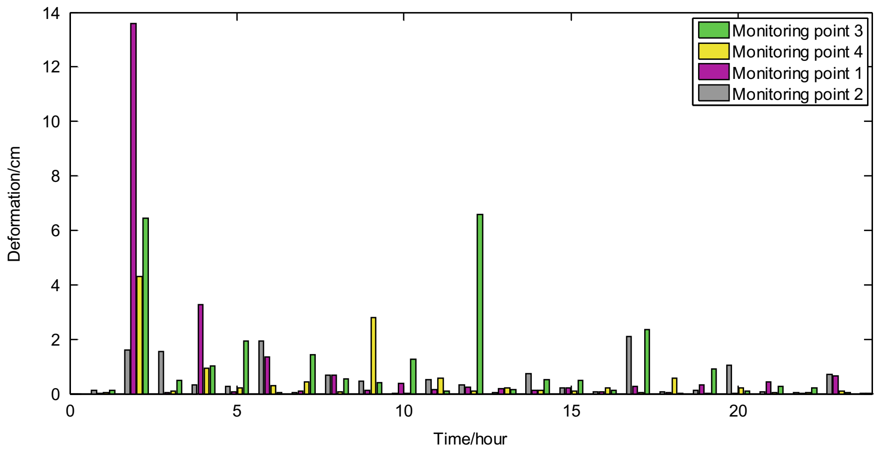

Fig. 13.3 Deformation monitored by GPS

13.3.2 GPS Monitoring Analysis

During the research work, we set up mobile stations on C1, C2, C3, C4 anchor bolts, and collect top deformation data in real time. After the data collection is completed, the data is processed according to the deformation monitoring GPS special software Trimble T4D. Data post-processing is mainly divided into three steps: first, the Trimble Business Center software settles the coordinates of the monitoring points and reference points; second, the Convert To RINEX software performs data format conversion; third, the Trimble T4D software performs deformation analysis, and the coordinates of the monitoring point and the reference point are settled.

As shown in Fig. 13.3, the data observed for a continuous day are processed. Comparing and analyzing the different observation results, it can be obtained that the total deformation at each moment is less than 14 cm; the maximum deformation of the building is not much different. The data is obviously affected by on-site construction, and obvious abnormalities can be found in the data.

13.3.3 Close-Up Photogrammetry

Close-range photogrammetry can accurately record the deformation information of any point of the object in an instant, and then obtain the instant point position relationship; the field time is short, the labor intensity is small, and the operation method is more flexible depending on the purpose of the operation. The image information is rich, the display ability is objective, and it can provide complete and instant three-dimensional spatial information; it can measure the dynamic target under the condition of the synchronization device; it does not need to touch the measured object.

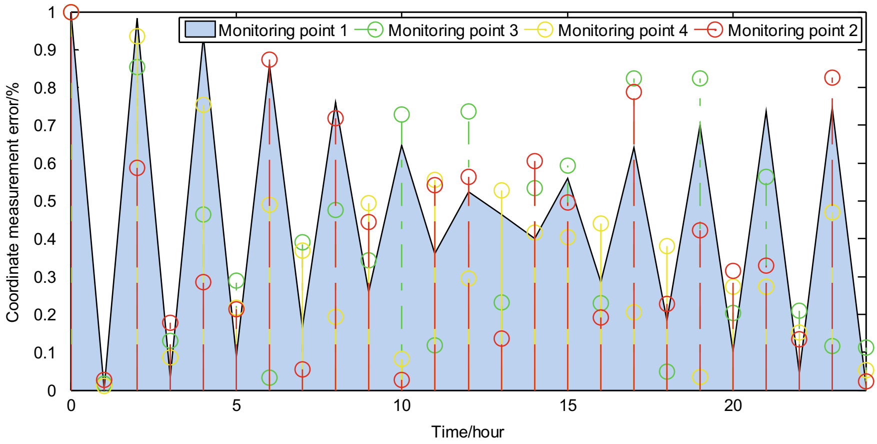

Fig. 13.4 Coordinate measurement error of each monitoring point

The requirements are high, but compared with the traditional geodetic survey, it can greatly reduce the workload of the field; the photo can be stored for a long time, which is conducive to inspection, analysis, and comparison.

Two high-precision camera lenses are set up at the control point on the side of the building every day, and the monitoring points are taken synchronously. During this period, the tripod must not be moved or touched. A special shutter release is used to ensure that the position of the camera does not change. We take photographic observations of the same side building for several consecutive days, and analyze the deflection and deformation of the super high-rise building through monitoring image processing at different times.

In the actual shooting process, the quality of the photos taken directly affects the processing of the office, which is significantly affected by wind and air visibility, and the accuracy of the results is poor when the weather conditions are bad. According to the changes in the observation results over multiple days, the overall deformation of the building is not large, and the top deformation error is within 1%. The coordinate measurement error of each monitoring point is shown in Fig. 13.4.

13.4 Conclusion

This article analyzes and studies the general ideas, construction essentials, and difficulties of super high-rise building construction planning, and summarizes a set of effective construction planning ideas and methods suitable for the construction and production of the enterprise. Preliminary discussion on the key points and implementation solutions of difficulties in the construction of super high-rise buildings has laid the foundation for the implementation of the next stage of the project. In terms of dynamic deformation monitoring, starting from three aspects of building settlement monitoring, elastic compression deformation monitoring, and structural dynamic deformation monitoring, the method of dynamic deformation monitoring for super high-rise buildings is studied; three technologies such as measuring robots, GPS, and close-range photogrammetry are used. Through comparative analysis, the advantages and disadvantages of the three monitoring methods are explored, and effective data with certain guidance is obtained. The deformation status of the building is predicted in advance, and the actual situation is tested and set up at one time, reducing the possibility of rework. Through the application research of this technology, it not only reserves scientific and technological innovation talents for engineering projects and enterprises, but also provides valuable experience for the construction survey control of the project.

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