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The Design and Implementation of High-rise Building Construction Based on GPS Positioning Technology

Abstract: Baseline observation as well as height measurement is the important content of the quality control of high-rise building construction. In order to strengthen the quality of construction projects, meet the requirement of completion time, improve the accuracy and efficiency of locating observation and explore a scientific way of observation suitable for high-rise building construction, this paper studies the design and implementation of high-rise building construction based on GPS positioning technology.

Key words: High-rise building construction; GPS positioning technology; design, implementation

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0 Introduction

GPS positioning technology was originally designed to provide real-time and accurate navigation service to the armed forces. It was also used in military activities like emergency communication and intelligence collection. With the continuous improvement of this technology, in addition to those functions, it can now carry out static relative positioning with high precision, which shows GPS positioning technology has a favorable development prospect.

So far, GPS positioning technology has been widely used in the industries like transportation and aerospace, showing its certain applicability. However, no systematic theoretical research and examples of successful application of this technology can be found in the field of high-rise building construction. With the hope of promoting the effective combination of GPS positioning technology and construction industry, improving the construction effect and efficiency, this paper studies the design and implementation of high-rise building construction based on GPS technology. Because there is no standard definition for high-rise or super high-rise building in the construction industry, in subsequent analysis, buildings discussed in this paper are collectively called high-rise building.

1 Technical design of high-rise building construction based on GPS positioning technology

1.1 Design basis

The design bases of GPS network technology generally are measurement procedure and measurement task statement.

1.1.1 GPS measurement procedure

GPS measurement procedure is the technical code made by departments of surveying and mapping in our country.

1.1.2 Measurement task statement

Measurement task statement is the technical contract requested by customers or construction managers. It's mandatory, specifying the requirements of measurement range and precision, stipulating the completion time and the effect of the project.

In general, the design of the GPS scheme begins with the stipulation of the accuracy and relative indexes of GPS network on the basis of the measurement contract. Then the connection mode between each site as well as measuring frequency and time will be specified according to measurement procedure and local reconnaissance.

1.2 Positioning accuracy design

The positioning accuracy of GPS network is affected by the use of the network. Accuracy is the main measurement index of GPS network technology design. It's divided into 5 grades, which has direct effect on the pattern, measurement mode and data processing of GPS network. During construction, the accuracy should be designed according to the specific requirements of owners and resource allocation. The previous construction experience and code can also be used for reference. The accuracy of the chord length between two GPS sites with different grades can be calculated by formula $\sigma = \sqrt{a^2 + (bd)^2}$ (in which σ represents the error (mm) in the chord length of the GPS baseline vector; a represents the fixed error (mm) in the nominal accuracy of the GPS receiver; b represents the proportional error coefficient in the nominal accuracy of the GPS receiver (ppm • D); d represents the distance (km) between two adjacent points in the GPS network).

1.3 Graphic design

Although the graphic design of GPS network is affected mostly by the owner's demands, it is also influenced by other factors like cost, personnel, equipment, facilities and subsequent maintenance. Due to the complexity and tediousness of high-rise building construction, it is necessary to attach greater importance to graphic design so as to meet the demands of owners and reduce resource consumption.

1.3.1 Basic principles

(1) In general, the GPS network is a closed ring or a composite line formed by the independent

observation edge with the aim of enhancing the check level and the stability of the network.

(2) The points in the GPS network should overlap with each control points on the ground.

(3) The points in the GPS network should overlap with the benchmark. The non-overlapping points can usually be measured by means of leveling on the basis of specific situation. The leveling points can also be set in the net to provide the basis for the benchmark analysis.

(4) Based on the targets which can be surveyed connectedly through traditional ways, orientation points with better line of sight are set around each point in the net to build a direction for the connection survey.

1.3.2 Graphic type

The non-synchronous observation edge of the GPS network usually forms a geometric pattern, mainly including triangles, stars and rings (see Figure 1 below).

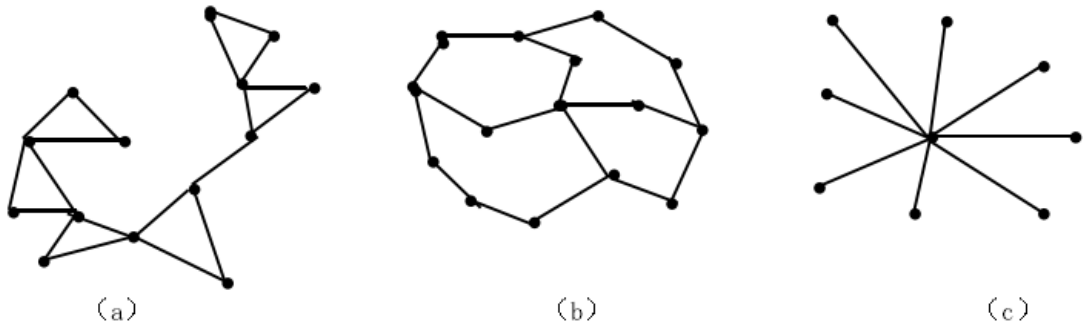

Figure 1. The graphic type of the GPS network; a-triangular network; b-ring network; c-star network

1.4 Benchmark design

What GPS positioning system collects is the baseline vector, one of the WGS-84 coordinate system. However, what high-rise building construction adopts is the national coordinate system. Therefore, the technology design of the GPS network begins with the specification of the coordinate system and the initial value adopted by GPS positioning, which is the benchmark of the GPS network. The benchmark is usually divided into position reference, azimuth reference and measure reference. The azimuth reference is usually confirmed by the initial azimuth angle or the baseline vector. The measure reference is usually confirmed by the side margin of the electromagnetic wave on the ground, two or more space values between initial points, or the baseline vector. The position reference is usually confirmed by the initial coordinates. Thus, the benchmark design of the GPS network is to confirm the position reference of the net.

1.5 Setting-out design

The base point of the GPS of high-rise building is generally set in special positions, such as the center of the building or the compositional axis. It relies on the temporary base point outside the building receiving GPS signal to gain its coordinate value. This method has small errors and high accuracy. Based on that, we can carry out setting-out work through traditional measuring way.

2 Preparations for field operation and the drawing-up of technical design

2.1 The grasp of the surroundings of high-rise building and data collection

2.1.1 The grasp of the surroundings of high-rise building

To grasp the surroundings of high-rise building generally means to survey the measurement area. That is to say after receiving the task instruction or signing the GPS positioning measurement task statement, the construction side surveys the construction region to provide basis for the formulation of technical solutions and cost budget according to the construction scheme.

2.1.2 Data collection

The following data needs to be collected according to the mastery degree of the surroundings of high-rise building:

(1) All kinds of drawings: construction drawings, topographic maps, geoid undulation drawings, road facilities map, etc.;

(2) The traffic conditions, climatic conditions, topographic and geological conditions of the construction area;

(3) Various control points: leveling point, GPS receiving point, traverse Point, coordinate value, etc.;

(4) Construction enterprise qualification: construction technology level, management level, the quality of constructors, etc.

2.2 Preparations for GPS locating observation facilities and personnel

(1) Setting up relevant facilities, instruments, computer, etc.;

(2) Setting up communication facilities and mobile facilities;

(3) Setting up construction equipment and developing the budget for building materials;

(4) Organizing GPS locating observation team and specifying the responsibilities of each person;

(5) Developing the budget for position measurement of the system.

2.3 The drawing-up of GPS

locating observation plan

The field process of GPS positioning refers to locating observation. Before conducting locating observation, the drawing-up of observation plan is helpful to collect data and improve the accuracy of positioning.

(1) Determining the basis of observation plan

(2) Drawing up observation plan

2.4 The formulation of technical design

After the completion of the above work, the GPS positioning technical design needs to be formulated. Generally speaking, GPS positioning technical design defines:

(1) Construction requirements and work intensity

(2) The basic information of high-rise building

(3) Layout scheme

(4) Selected-points observation

(5) Data analysis

(6) Others

3 The field operation of GPS positioning of high-rise building Construction

3.1 Siting

GPS locating observation requires not only intervisibility, but also the high flexibility of graphic entity of the net. Therefore, compared with traditional way of siting, GPS positioning siting is more convenient and simple. The performance of siting has a direct effect on the conduct of observation and the accuracy of positioning. So before siting, we need to grasp the surroundings of the building and the control framework of basic measurement. The following principles also need to be followed:

(1) Preventing the interference effect of electromagnetic field;

(2) The point should be set up in a wild place where the condition is favorable to installation;

(3) The terrain nearby the point is flat and can be preserved for a long time.

3.2 Laying marks

Each point of GPS network is mostly set in the center of markstone to ensure the accuracy of laying. The markstone of each point should be stabilized to ensure the effective application during the construction of high-rise building. Special attention should be paid on the stability of the points outside the construction area. The name of each point should be discussed and confirmed with construction managers. During the construction, there are more staff in the area, and different construction team is responsible for their own construction process, which increases the difficulty in protection. In order to protect the markstone of each point, when laying the point, we need to avoid the construction area and assign specific person to manage it. After each mark is laid, the following materials should be submitted:

(1) The name of each point;

(2) The siting map of GPS Network;

(3) Documents for approval of land occupancy and measurement engagement letter;

(4) Works summary of siting and laying marks.

3.3 Observation work

3.3.1 Basic technical requirements

Compared with traditional measurement methods, GPS locating observation technology is more rigorous in operation mode and index measurement, especially in high-rise building construction.

3.3.2 Erecting the antenna

(1) In general, the antenna is placed on a tripod and is coincided with the center of the mark. The circular level of the base needs to be free from bubbles.

(2) In particular cases, if the antenna is installed in the light-back platform of the tripod, the top of the platform needs to be removed in case it blocks the signal of GPS. The locating mark at this situation is cast on the light-back platform. If the top can not be removed, the signal will be interrupted, thus reducing the accuracy of GPS positioning. Eccentric observation is suitable for this situation.

(3) The direction of the antenna should be pointed to North. The error influence of the phase center should be reduced with the consideration of the influence of electromagnetic field.

(4) The antenna erected for high-rise building construction should be fixed from three directions in case it's blown down.

3.3.3 Conducting observation

After the signal receiver collects and inputs the data information, observers can read and inquire the information according to the operation manual of the equipment. They can not inquire the information freely without knowing the operation procedure. In general, no parameter can be modified when signal is being received.

3.3.4 Observation record

The GPS locating observation for high-rise building construction can be recorded by observation record and handbook. Any observational data should be kept strictly.

3.4 Operating mode

3.4.1 Static positioning mode

Static positioning is usually used in the construction of the monitoring system of high-rise building, benchmark control and building positioning. This mode requires the observation base line form a closed graphic structure (see Fig. 2 below) to improve the accuracy of the locating observation. In addition, the rapid static positioning mode can be used to conduct construction positioning (see Fig. 3 below). This mode can cut off power, thus reducing energy consumption.

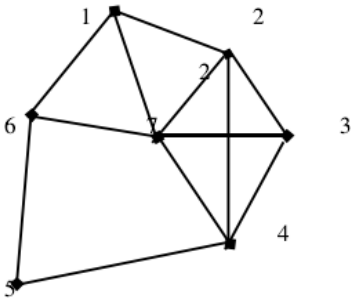

Figure 2. Static positioning

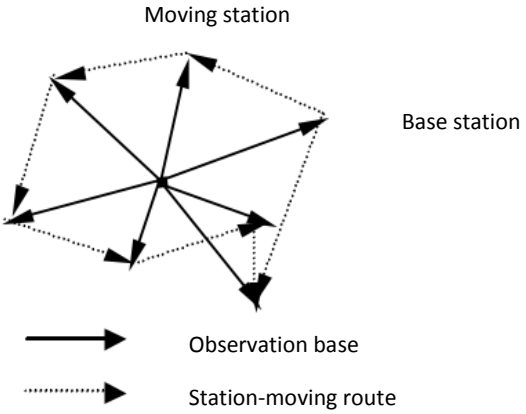

Figure 3. Rapid static positioning

3.4.2 Dynamic positioning mode

Dynamic positioning mode is generally divided into quasi-dynamic and dynamic positioning mode. Quasi-dynamic positioning mode is to select a base point to install the receiver tracking the satellite. The mobile receiver is installed in position 1 (see Fig. 4). Then on the premise of continuously tracking the satellite, the mobile receiver will be moved to position 2, 3, 4... for observation. Dynamic positioning mode is to install the receiver on certain base point to track the satellite (see Fig. 5 below), then move the receiver continuously to observe. Both of the two modes are suitable for high-rise building construction.

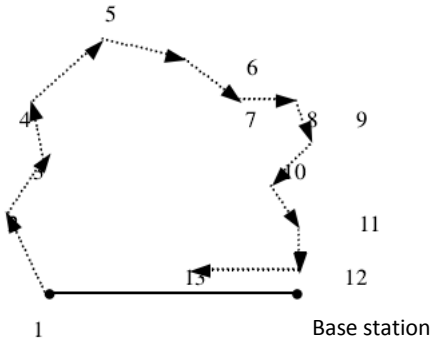

Figure 4. Quasi-dynamic positioning

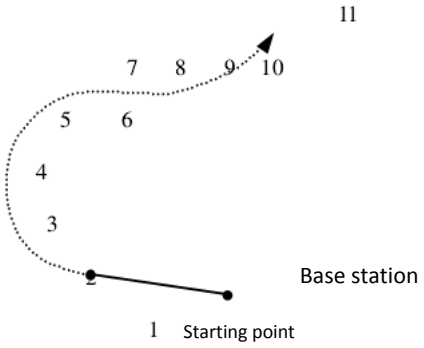

Figure 5. Dynamic positioning

4 Conclusion

As a new technology, GPS positioning technology has been widely used in the engineering control survey. The unique superiority and advancement of this technology has been recognized by a great number of engineers. At present, our country's economic development is at an important period. The extensive use of various kinds of engineering equipment and facilities, as well as the application of new technology and new materials lets the construction industry of our country show a new picture of flourishing. With the further research and popularization of GPS positioning technology, especially its application in high-rise building construction, GPS technology has gained constant accumulation and improvement in the aspects of theoretical research, implementation method, signal-receiving mode, signal processing and software development. In the future, GPS positioning technology will become a widely-used method of surveying, positioning and deviation control in high-rise building construction.

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