Three-dimensional Calculation Analysis of Concrete Engineering Based on BIM Technology

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Abstract: The application of BIM technology in the field of engineering cost is reflected in the establishment of three-dimensional vector models that serve in the preparation of bill of quantities and cost calculation at various stages. The calculation of engineering quantities is the foundation of cost control during the design and construction phase of construction projects. The traditional calculation methods have complex processes, and the application of BIM technology has brought a new revolution to engineering construction. Research and introduce the characteristics of BIM technology, elaborate the engineering quantity theory based on BIM technology, explore the three-dimensional quantity calculation of concrete engineering based on BIM technology, compare the advantages and disadvantages of using BIM quantity calculation tools in different quantity calculation methods, use the Guanglianda BIM series quantity calculation software to conduct research on the application of three-dimensional quantity calculation of construction engineering, and explore the existing problems such as data conversion rate, list quota update, etc.
***Keywords*:** BIM technology, concrete works, three-dimensional computation

1. Introduction

With the development of three-dimensional digital technology, BIM technology has rapidly risen in the construction industry at home and abroad. The rapid development of BIM technology has led to changes in the construction industry. With the maturity of technical conditions, refined cost control has become a new trend. BIM technology integrates engineering data at various stages of a project based on three-dimensional digital technology, which can significantly improve efficiency and reduce risks. The core of BIM technology is model building, which enables information sharing and transmission during the design and operation life cycle of construction projects. Currently, BIM technology is rapidly advancing in developed countries and receiving strong support from relevant industries. The application of BIM technology can shorten the construction period by 5-10% and play an important role in performance and quality. BIM technology in the construction field can assist staff in design and construction related work, and bill of quantities calculation is a key work in construction project management. The calculation based on BIM technology can achieve three-dimensional visualization and improve efficiency and accuracy. Currently, BIM technology cannot systematically implement project structure architecture in the preparation of bill of quantities. How to apply BIM technology in cost management has become an important issue in current project management. The establishment of engineering calculation models based on BIM technology has broad engineering application prospects.

2. Overview of BIM technology for construction engineering calculation

With the development of the construction industry, the scale of engineering construction projects continues to expand, and the development of computer technology provides a technical foundation for efficient control of project costs.[1] The application of BIM technology in the engineering field meets the goal of project management quality, cost, and duration. The application of BIM technology in the engineering cost field is reflected in the use of pricing software to calculate the cost of each stage of the project, and the use of BIM software to establish a three-dimensional vector model for the preparation of the bill of quantities. Currently, BIM technology cannot achieve the attribute setting of the list item. Pricing with bill of quantities is the mainstream mode in project contracting and pricing activities. Relevant construction authorities have issued a series of supporting specifications. The bill of quantities serves as the contract price carrier for both parties in construction project bidding, and the preparation of the bidding bill of quantities is the primary link. Applying BIM technology to prepare the bill of quantities can save time and quality. Figure 1 Technical characteristics of BIM.

BIM is a digital representation of facility entities, based on information and data related to construction projects, and simulates the real information possessed by buildings through digital information simulation [2]. BIM technology is the information expression of physical performance characteristics of buildings, a process that can share building information,

and provides a reference basis for decision-making throughout the life cycle from abstract design to demolition of buildings. BIM has the characteristics of digital resource linkage and model collaboration, including rich equipment information related to buildings, which can be exchanged among project stakeholders. The stage of architectural engineering design has evolved from two-dimensional to three-dimensional, and BIM is the ultimate direction for the development of the construction industry. The application of BIM technology makes project processes such as engineering design and construction more efficient. The engineering calculation based on BIM technology has unique advantages, which are reflected in the fact that complex nodes are prone to omissions and errors using current general calculation methods, and BIM calculation software can avoid human error; Quickly optimize and check the quantities from a three-dimensional perspective. Generally, construction drawings are changed multiple times during the design process, and BIM technology can be used to modify and change the building model. In BIM calculation software, calculation sheets can be output by classification such as floors.

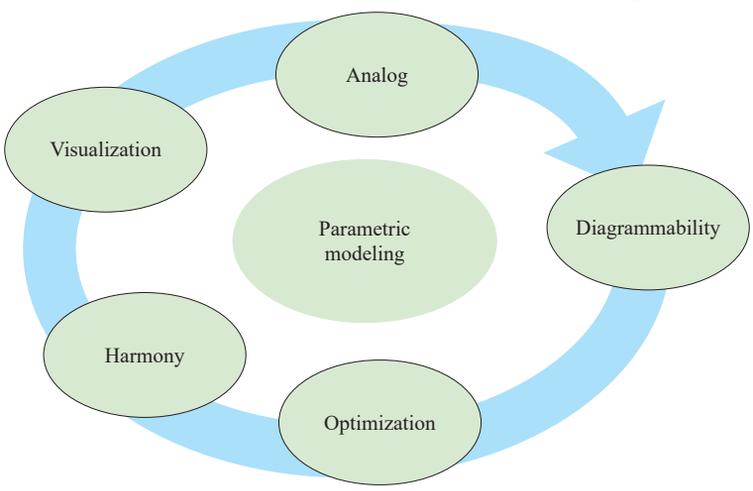

Figure 1. BIM technical features

The accuracy of engineering quantity calculation methods is of great significance for improving the efficiency of preparing bidding control prices and reducing the workload of cost personnel. The three-dimensional engineering calculation based on BIM technology has unique advantages, reflected in the fact that standard layers can be directly copied in building building modeling to improve modeling efficiency. The engineering quantity can be directly obtained by using the three-dimensional model after deepening the design by the design institute. Realize automatic deduction at the junction of connected components, and provide common methods for building overlapping to avoid manual calculation. After completing the engineering quantity statistics, the software classifies and summarizes the engineering quantity according to the engineering quantity, and can output the project engineering quantity calculation sheet according to the classification of materials, etc. [3]. The engineering quantity changes at any time as the BIM model fineness changes. The linear general calculation method is simple, and information updating is prone to occur in the calculation, resulting in inaccurate engineering quantity calculation. BIM technology makes information processing more unified and transparent. Currently, mainstream building engineering modeling software is constrained by component construction deduction rules, and is suitable for creating Revit models. Saving secondary modeling time by using plug-ins for import will be widely used.

3. Application of BIM technology in construction engineering cost calculation

The construction industry has made a significant contribution to the development of China's national economy, but in recent years, the proportion of the total output value of the construction industry has gradually declined. With the adjustment of the national economic structure, the era of relying solely on expanding the investment scale to achieve profit growth has become history. The construction industry has put forward higher requirements for the level of project management [4]. With the improvement of construction technology, the quality of construction projects has been ensured, and construction project cost management has become the focus of attention in the industry. The current low level of informatization in the construction industry restricts the improvement of cost management. How to use information technology to strengthen project cost management has become an urgent issue to be solved. Reasonable use of BIM technology in engineering quantity calculation can improve work efficiency, and it is necessary to ensure that the BIM model construction method conforms to existing pricing and measurement standards.

3.1 The value of BIM technology in construction project cost management

Construction project cost management is a systematic management method with a high degree of information dependence, which requires a high ability of the main body to collect, process, and apply relevant information. For example, in order to achieve dynamic control of project cost during construction, timely cost information feedback is required, and partial consideration of business by the participating parties can cause cost information flow gaps at all stages of the construction project. [5] Currently, the domestic construction industry mostly adopts the DDB project mode of recording information and data expression in text form. In order to enhance the effectiveness of project cost management, there is an urgent need to deepen the application of information technology. The efficiency of project cost estimation is a key factor that affects the success or failure of cost management. Due to the large amount of budget work in the bidding stage and the large number of visa changes in the completion stage, the work tasks are increased.

With the development of construction projects in the direction of complexity, the importance of deepening collaboration among relevant units such as design supervision units has become increasingly prominent. The emergence of BIM technology has brought a technological revolution to the construction industry, and building information models have the potential to integrate construction project data information. The BIM model includes various related professional content such as water supply and drainage. Reasonable use of the visualization features of the BIM model during the design phase can avoid increasing costs due to changes by conducting virtual collision checks on different professional content involved in the proposed project. [6] BIM software can achieve data sharing and integration between upstream and downstream software, providing a medium for promoting collaborative collaboration among various participants. The application of BIM can efficiently complete the work of engineering quantity statistics, and the efficiency of using BIM based quantity analysis software is higher than that of traditional methods. The advantages of BIM technology are gradually recognized by the construction industry, and university research institutions have established specialized BIM research teams to conduct application research. The calculation of engineering quantities is the best entry point for BIM technology. The implementation of engineering cost management based on BIM technology needs to change the ideological concepts of managers. The research on BIM calculation model standards is an effective application of the technology. Rational use of BIM technology in engineering quantity calculation can improve work efficiency. BIM modeling software is oriented towards designers, and directly using BIM design models to extract engineering quantities increases the difficulty of work. Therefore, it is of great significance to study the BIM calculation model establishment standards.

3.2 Construction project cost BIM calculation software

With the improvement of the bidding system, the cost management level of China's construction industry has been significantly improved, but there is a significant gap between the construction project cost management level and that of developed countries [7]. At present, there are many problems in the construction project cost management industry in China, such as the disconnection of management mode from the market, cost resource sharing and work coordination. The main reasons include the lag of information technology, and the inability of traditional project cost management methods to meet requirements. The application of BIM technology in project cost management can improve work efficiency and achieve information recording and sharing. In recent years, the gradual popularization of BIM technology has led to the gradual development of computational software, including two-dimensional and three-dimensional computational software. In recent years, some regions have used BIM technology for building construction, and commonly used three-dimensional computing software includes Guanglianda and Shenji Miaotan. Figure 2 Guanglianda three-dimensional calculation operation process.

Currently, there are many types of BIM calculation software in China, and the commonly used BIM whole process software in the market is mainly foreign software. The commonly used software is analyzed from aspects such as software installation and update, operation process, and functional applicability. The Guanglianda work platform software users can download and update for free, with a concise and simple software interface and operation. The multifunction switch of the Swivel interface can operate multiple projects at the same time. The modeling operation process of Guanglianda is simple, and logistics directly generates reports on the model to apply quotas. Luban software cannot nest quotas to generate pricing reports. Guanglianda data processing operation is simple and fast, and Luban software cloud application function realizes data update and processing. Guanglianda has a self-checking function for the bidding list, and the Swale pricing method and its conversion function are highly applicable. The use of Guanglianda software requires encryption locks, while Luban software uses no encryption programs, and the encryption of Swale software is at a medium level. Guanglianda has the advantages of fast installation and update, and high safety factor [8]. There are some problems in using BIM calculation software to calculate engineering quantities, and cost personnel need to create a separate model to increase the burden. The research suggests that the same model is used for design calculations, and Revit software is widely used in the BIM system of China's construction industry. Revit software is selected to optimize the design, and the combination of Revit and Guanglianda

calculation software is used to improve the model utilization rate and avoid multiple modeling.

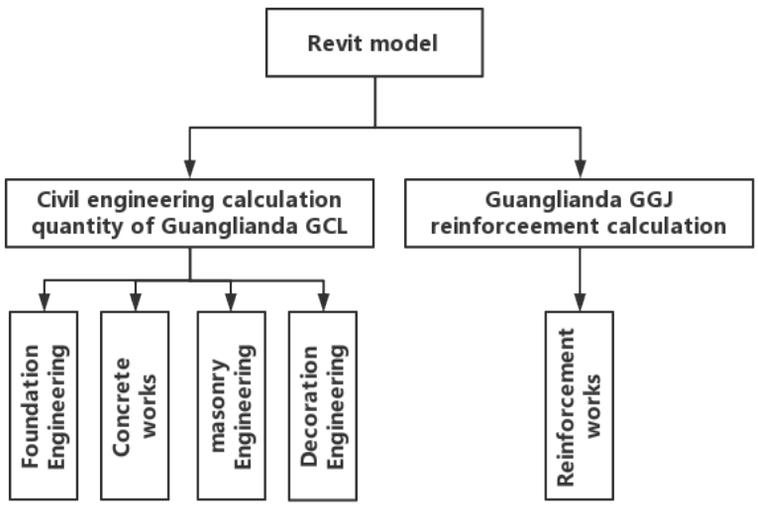

Figure 2. Guanglianda three-dimensional calculation operation process

4. Application of three-dimensional calculation of concrete engineering based on BIM technology

The calculation of engineering quantities is the main content of project cost. In the early stage of the project, the owner can control the cost through the calculation results of different schemes, and the construction party can reasonably allocate materials according to the calculation results of engineering quantities. The calculation of concrete engineering quantity is the core content of engineering quantity measurement. Currently, there are some problems in the application of concrete engineering quantity technology in China, such as the cumbersome and inefficient drawing process, and the high professional quality requirements of quantity personnel. BIM technology is a combination of computer digital information technology and graphics technology, with the characteristics of visualization and simulation. The application of BIM technology has changed various aspects of the cost industry, and simulation based on BIM technology has changed the project cost management mode. The application of BIM technology to three-dimensional concrete quantity modeling is of great significance for engineering cost control.

4.1 BIM technology for building concrete engineering calculation process

The research selected urban rail transit concrete projects, combined with Guanglianda software for quantity analysis, and used GCL and GGJ software for quantity calculation. To achieve BIM based engineering calculation, create a building structure model in Revit software, create a concrete calculation model for engineering quantity calculation, and import the model into Guanglianda Civil Engineering Calculation GCL software to form a civil engineering model for engineering quantity calculation. Create a building structure model in Revit software and export the GFC format file. The success rate of exporting the GFC format from Revit software is equal to that of importing the GFC calculation software. Independent foundation works mainly involve earthwork excavation and backfilling and site leveling processes. The earthwork excavation and backfilling quantities are calculated using the excavation earthwork input working face size of the foundation pit, and the slope coefficient is selected as 0.5 based on geological and other standards. The software automatically calculates the excavation and backfilling earthwork quantities. Figure 3 Application process of Revit+Guanglianda.

Concrete engineering includes formwork and components, and concrete components include types of beams, slabs, and columns. Using three-dimensional calculation software, the quantities of formwork can be extracted, and the quantities of concrete components can be calculated using norms. The built-in list of Guanglianda software is set according to domestic measurement specifications, and the engineering quantity of piles at the junction takes precedence over the beam and slab, increasing the accuracy of engineering quantity calculation. Masonry works include both aboveground and underground parts. Guanglianda software calculates masonry work quantities based on built-in algorithms, and uses the software's brush function to complete other work quantities calculations for the same material. Guanglianda software can calculate the quan-

tity of decoration works. Wall engineering includes painting methods and establishing a separate decorative structure layer. Generally, establishing a separate decorative structure layer is used to obtain accurate quantities. Guanglianda reinforcement calculation software is used for calculation of beam and column foundation quantities, and lists and applies statistical reinforcement quantities to the reinforcement. Select not to calculate bending for rebar quantity statistics, and calculate bending using rebar diameter. The configuration of reinforcement using cross sections involves different types of reinforcement structures such as structural reinforcement in the layout of beam reinforcement. Using computational software statistics can scientifically handle the problem of component construction and overlapping. The application of Guanglianda BIM technology reduces secondary modeling time, and the three-dimensional computing software is based on the BIM model. Use the GFC plug-in developed by Guanglianda for Revit series to import models, and analyze the model conversion rate based on the statistical component quantities in the GCL of Guanglianda. Using the GFC plug-in can convert the model to 100%, and using BIM technology for three-dimensional calculation can improve the calculation efficiency.

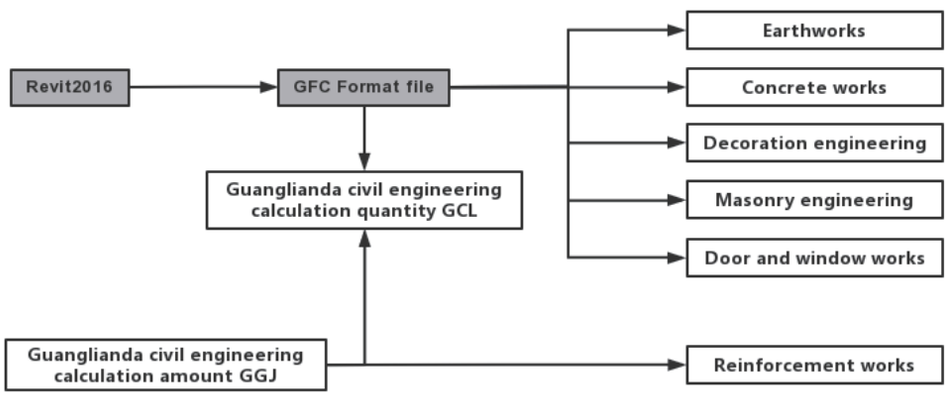

Figure 3. Revit+Guanglianda application process

4.2 Shortcomings in the application of BIM technology engineering calculation software

At present, the application of BIM technology in construction engineering measurement software has problems such as component form limitations, data conversion rates, and list quota updates. Due to the novelty and uniqueness of the project, the current calculation software contains component forms that cannot fully cover the actual needs of the project, resulting in models that cannot be established and cannot accurately calculate the quantities of the project. Software developers can establish a database platform, and metrologists can upload heterogeneous components. As the number of models uploaded by metrologists increases, other metrologists can search for heterogeneous components from the database to improve the accuracy of the model. When BIM technology is used for engineering quantity calculation, the model is created by relevant modeling software and imported into Guanglianda calculation software. Revit software has a high degree of freedom in modeling. Currently, the storage interaction plug-in on the market is based on the IFC standard, which is broad. Revit's support for IFC standards cannot meet the requirements of China's engineering quantity calculation models. The conversion rate of GFC plug-in models is 100%, but the low conversion rate of attribute information leads to incorrect statistics of engineering quantities. Data conversion rate optimization requires strengthening constraints on the modeling methods of designers. Modellers should strictly follow rules to ensure work specifications, ensure conversion rates, and improve attribute conversion rates.

5. Conclusion

The construction industry is an important pillar industry for the development of the national economy, and the rapid development of the construction industry puts forward higher requirements for project management. The development of BIM related software drives the development of construction engineering technology, and many BIM software applications provide information technology support for construction engineering management. Engineering measurement is the core work in construction projects, and relevant scholars have made many studies on BIM measurement. This article takes concrete engineering as the research object, and conducts research on three-dimensional computational modeling based on mainstream BIM software. Through literature analysis, it identifies the problems in Revit engineering computation, and

selects appropriate problem solutions. Different engineering quantity calculation methods have their own advantages and disadvantages, and selecting suitable calculation tools can accurately calculate engineering quantities.

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