3D Computational Analysis of Concrete Engineering Based on BIM Technology

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Abstract. In order to improve the accuracy and efficiency of engineering quantity calculation, this study is based on BIM technology and takes concrete engineering as the research object. Through three-dimensional computational analysis method, comprehensive quantification and visualization of concrete engineering are achieved, improving the accuracy and controllability of the construction process. Firstly, the advantages of BIM based 3D computing were introduced. Subsequently, BIM based structural seismic analysis was proposed, and the structural analysis model based on Revit software was formed simultaneously with the creation of the structural geometric model. While creating the geometric model, the analytical model automatically connects at the nodes. The process of creating a geometric model is carried out in the order of layer by layer construction from low to high in the actual construction project. On the basis of the Revit model, a magician developed by Shanghai Bicheng was used to cut the components, and then the IS BIMQS plugin was used to attach the calculation rules to the list, directly extracting the engineering quantity from the model. Through comparative analysis, it is found that different methods of calculating engineering quantities have their own advantages and disadvantages. Choosing the appropriate output method and calculation tools can efficiently utilize the BIM model information during the design phase and accurately calculate engineering quantities. This study demonstrates the superiority of three-dimensional computational analysis of concrete engineering based on BIM technology, which not only improves the accuracy and consistency of engineering quantity, but also achieves significant advantages in project management and decision-making. This provides empirical research support for promoting BIM technology in the field of concrete engineering in the future, and provides useful experience and reference for the digital transformation of construction engineering.

1 Introduction

With the continuous deepening of people's understanding of BIM technology, how to achieve the implementation of BIM technology has become a concern for the engineering construction industry. In the stage of engineering bidding, the preparation of bidding control prices is an important step, and the key work is to quickly and accurately calculate the engineering quantity [1]. With the increasing volume and structural difficulty of engineering projects, the workload of engineering quantity calculation is large, the operation is complex, and it is time-consuming and laborious. How to apply BIM technology to calculate engineering quantities more conveniently and accurately is of great significance for improving the quality and efficiency of bidding control price preparation, accelerating the speed of bidding control price preparation, and reducing the workload of cost personnel. The engineering quantity has transitioned from the earliest fully manual calculation stage to the Excel spreadsheet calculation stage, and then gradually transitioned to the calculation software stage. It is further divided into the two-dimensional calculation software stage using planar deduction for engineering quantity calculation and the three-dimensional calculation software stage using automatic deduction in three-dimensional space. This has achieved a significant breakthrough, but in actual implementation, it still relies on the calculation personnel to carry out tedious manual modeling, and the workload is still large. In recent years, there has been an increasing number of unconventional shaped buildings such as streamlined and irregular surfaces, which has brought greater difficulty to engineering calculations. To quickly and accurately obtain the bill of quantities, it is necessary to change the manual modeling method and improve computational efficiency through the application of BIM [2].

BIM technology is an object-oriented, rich data, parameterized, and intelligent digital representation of building facilities. In the current field of architecture, large-scale construction projects are becoming increasingly comprehensive and complex, and many design and construction units have begun to introduce BIM technology. Through BIM technology, two-dimensional drawings are converted into three-dimensional models with reliable parameter information, and models are used to replace drawings. The names, quantities, and dimensions of the required materials can

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be directly generated in the model, and this information will always be consistent with the design. When there are design changes, the information of these changes will also be automatically reflected in the relevant material list to ensure the accuracy of the calculation, thus creating a new working mode. In engineering calculation work, the application of BIM technology based calculation software to establish a new platform can significantly improve the level of calculation services and work quality. While studying the current situation of BIM calculation, we will propose theories, methods, and suggestions based on practical cases that can improve the precision calculation of concrete engineering quantities through BIM technology [3]. By comparative analysis, it can be concluded that different engineering quantity calculation methods have their own advantages and disadvantages. Choosing appropriate quantity calculation methods and tools can efficiently utilize BIM model information during the design phase and accurately calculate engineering quantities.

2 ADVENTAGES OF BIM BASED 3D COMPUTING

Compared with traditional calculation methods, 3D calculation based on BIM technology has obvious advantages: the construction unit can entrust the design institute to provide a detailed BIM model for design, and directly obtain the engineering quantity through the model during the bidding stage, avoiding secondary modeling, which not only improves efficiency but also saves time. Figure 1 shows the BIM model, as follows:

1. In the process of building a building model, standard layers can be directly copied, while non-standard layers can be modified after copying, greatly improving modeling efficiency [4].
2. Realize automatic deduction at the connection points of connected components, and the calculation software provides common methods for building overlapping in engineering quantity statistics. Choose according to the drawings, avoid manual calculations, and improve accuracy.
3. After completing the engineering quantity statistics, the software categorizes and summarizes the engineering quantity by itself. The summary method is comprehensive and can be classified by floor, material, etc., and output the project engineering quantity calculation sheet.
4. During the bidding stage, the calculation cycle is significantly shortened, the accuracy of engineering calculation is improved, and changes in engineering quantity are made at any time as the precision of the BIM model changes.

There are two ways to calculate BIM quantity: one is to freely select various information quantities of required engineering components through the built-in engineering schedule function of the modeling software Revit; BIM models can also be imported into various 3D calculation software on the market through transfer software for engineering quantity calculation and generation of engineering quantity lists[5].

3 COMPARATIVE ANALYSIS OF CONCRETE ENGINEERING CALCULATION BASED ON BIM TECHNOLOGY AND TRADITIONAL CALCULATION METHODS THROUGH EXAMPLES

The first step in cost budgeting is the calculation of engineering quantities. Only when the calculation of engineering quantities is accurate and complete enough can cost control be better carried out. Therefore, how to accurately extract the engineering quantities required for a project from the BIM model is the focus of research by industry insiders at this stage. According to the data obtained from the Lianda index library, concrete engineering accounts for between 20% and 40% of the total cost of construction projects, and the quantity of concrete directly or indirectly affects the quantity of other sub projects, making it the most influential sub project on project cost. Therefore, this paper selects concrete engineering for three-dimensional calculation research based on BIM technology. By comparing three three-dimensional calculation methods, their respective advantages and disadvantages are compared[6].

3.1 Advantages of BIM

3D visualization is one of the biggest advantages of BIM, especially in the modern construction industry, which is of great significance. Compared to traditional 2D CAD, the 3D visualization features of BIM themselves are an intangible value. Due to the increasingly complex and abstract structure and form of modern buildings, traditional architectural designers need to use rich spatial imagination to depict the complex components and structures of buildings. However, three-dimensional models established using BIM technology can intuitively display the space, structure, appearance, and complex node parts of the entire building, greatly improving the designer's understanding of architecture and helping them design more excellent architectural works. During the construction period of the building, participants can utilize the powerful 3D visualization advantages of BIM technology to better assist in modeling, collision inspection, pipeline optimization, construction simulation, cost management, and other applications, shorten the construction period, and reduce construction costs. During the operation and maintenance period of a building, managers can quickly understand and master

![Fig.1. BIM model](image)
the physical information, spatial information, and equipment and facilities related to the building using BIM models, improving the efficiency of building operation and maintenance and reducing maintenance costs [7]. As shown in Figure 2.

![Figure 2. BIM modeling and 3D visualization relationship](image)

### 3.2 Introduction to Current BIM 3D Computing Methods

(1) Traditional 3D computing software is represented by 3D computing software such as Glodon, Swire, and Luban. It is necessary to model based on CAD drawings, and then match the corresponding list quota calculation rules to propose the engineering quantity in the model. (2) The secondary development data conversion tool converts BIM design model data into a data format that can be read by BIM calculation software through the BIM design software API interface. Both Luban and Glodon have conducted in-depth research in this area. Lubntrans, developed by Luban, and GFC data conversion tools developed by Glodon, can import BIM models created using Revit into their own computational software. They only need to conduct model checks and improvements based on inventory and quota rules, avoiding secondary modeling, and achieving the integration of BIM models and computational models during the design phase [8].

### 3.3 Selecting Examples to Compare Three 3D Computational Quantities

This paper selects the No. 1 office building project of a certain school as a case study. The project is planned to be built in City A, with a building area of 5183.01 m² and a total of 5 floors. The total cost of building decoration is approximately 8.5 million yuan. The revit model established by the BIM team of the school has been used as the research foundation. Based on this, the widely used GlodonGCL civil engineering calculation software isBIMQS plugin has been selected as the calculation tool. The workflow is as follows: ① Using GlodonGCL to establish the main component model of the standard floor of the dormitory building (including columns, beams, walls, slabs, stairs), hang the corresponding list calculation rules, and obtain the concrete engineering quantity of the main structure; ② Export the Revit model to a GFC file through a plugin, and then import the GFC file into the GlodonGCL calculation software. After processing the model, connect the corresponding list calculation rules to obtain the concrete engineering quantity of the main structure; ③ On the basis of the revit model, a magician developed by Shanghai Peer Solution Information Technology Co., Ltd. was used to cut components, and then the isBIMQS plugin was used to hook up the calculation rules of the list, directly extracting engineering quantities from the model; ④ Through comparative analysis, the following results were obtained: Table 1 shows the engineering quantities calculated for each component under the three calculation methods, and Table 2 summarizes the advantages and disadvantages of each calculation tool [9-10].

#### Table 1. Quantity of each component under three calculation methods

<table>
<thead>
<tr>
<th>Calculation Mode</th>
<th>Quantity of Each Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode 1</td>
<td>128.138</td>
</tr>
<tr>
<td>Mode 2</td>
<td>129.145</td>
</tr>
<tr>
<td>Mode 3</td>
<td>129.147</td>
</tr>
</tbody>
</table>

#### Table 2. Comparison of advantages and disadvantages of three calculation methods

<table>
<thead>
<tr>
<th>Calculation Mode</th>
<th>Superiority</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Using Guanglianda GCL secondary modeling to calculate the quantity</td>
<td>1. It has a large market share and is familiar to everyone; 2. Can be applied to the list quota rules all over the country, and the engineering quantity can be automatically deducted.</td>
<td>1. The workload of repeated modeling is large; 2. It is difficult to create a complex volume.</td>
</tr>
<tr>
<td>The revi model is derived by GCF and entered into GCL to calculate the quantity</td>
<td>1. Built-in national list, quota calculation rules, engineering quantity can be automatically deducted; 2. No secondary modeling is needed, and the engineering quantity is calculated efficiently; 3. More in line with China's standard requirements.</td>
<td>1. There is data loss during model conversion; 2. The requirements of the transformation model are extremely high, and there are strict requirements on the name of the construction, so the applicability is poor; 3. It takes time to modify and improve the model.</td>
</tr>
<tr>
<td>Using isBIMQS plug-in to directly calculate the quantity</td>
<td>1. Secondary modeling is not needed.</td>
<td>1. The rules of component volume are not in line with China's standard requirements.</td>
</tr>
</tbody>
</table>
extract quantity from model needed, and the work efficiency is improved; 2. Being able to create volumes with complex shapes and flexible calculation; 3. The extraction of engineering quantity has high precision; 4, there is no need to convert model information, and no information is lost; 5. Support the coding of bill of quantities and enterprise material management.

deduction do not meet the requirements of the specification, and the deduction must be made manually. 2. The list can't export statistical tables that meet the requirements of the list specification; 3. The localization degree of calculation rules of components is low;

4 CONCLUSION

This paper selects the No.1 office building project of a certain school as a case study. The project is planned to be built in City A, with a building area of 5183.01 m² and a total of 5 floors. The total cost of building decoration is approximately 8.5 million yuan. The development of BIM related application software directly drives the development of BIM technology, which brings good news to engineering cost practitioners. Different engineering quantity calculation methods have their own advantages and disadvantages. Choosing appropriate quantity calculation methods and tools can efficiently utilize BIM model information during the design phase, accurately calculate engineering quantities, and ultimately achieve refined cost control that is in line with China's national conditions.

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References