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Intelligent Engineering Management of Prefabricated Building Based on BIM Technology and CAD Graphics

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Abstract. In order to solve the limitation of traditional engineering management thinking in engineering values, target system, management positioning and other aspects, this paper proposes the intelligent engineering management of prefabricated buildings based on BIM technology and CAD graphics. In this paper, BIM technology is used as the basis to sort out the design ideas, according to the characteristics of construction management and the standard management process of intelligent engineering construction of prefabricated buildings. This paper splits the BIM model, associates the information data model with the BIM model in real time, and constructs the overall framework of the system including the operation layer, the application layer, the logic layer and the processing layer. The system realizes project management such as progress, quality and contract through seven functional modules. The main body and participants communicate and cooperate with each other based on the BIM model to achieve intelligent construction management. The experimental results show that the management effect of workflow system is lower than 85%, and the management effect of B/S system is slightly higher than that of workflow system, higher than 85% and lower than 95%. In this paper, the effect of the system is more than 98%, which shows that the management effect of the system is better when implementing intelligent project management for a financial plaza. The BIM data extraction effect of the system is good, the management effect is good, and the project management effect is good.

Keywords: Prefabricated building; BIM technology; intelligent management; Project management; Information data model; System framework.
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1 INTRODUCTION

With the transformation of the main social contradictions, people's demand for a better life has been rising, and their yearning for a better living environment has been strengthened. Especially affected by the epidemic, the design of building elastic space and the design of urban activity are more factors to be considered in modern architecture. More people believe that building products should have industrial quality, people-oriented green and healthy living space. In the digital era, buildings need to be intelligent and digital [1]. At present, the production efficiency of the construction industry is not enough to meet people's requirements for a better living environment. Therefore, it is imperative to accelerate the transformation and upgrading of the construction industry and promote the high-quality development of intelligent, green and industrialized buildings.

Although the construction industry has given enough investment and attention to prefabricated buildings in the development, the development of such construction projects in the market has been restricted due to the problem that the informatization level of prefabricated buildings in China is not up to the standard at this stage [2-4]. The design of intelligent assembly management system has become a preferred way in many construction industries. It has a good development prospect. Intelligent engineering management of prefabricated buildings based on BIM technology can solve the shortcomings of traditional construction methods.

It can use more information technology in time and be able to deal with information in engineering construction and know the work of all parties involved in construction. In the process of actual use, it can save the design and construction cost and reduces the waste of resources, which is an important part of the current intelligent construction, and is of great importance to support the development of China's information technology and intelligence [5].

2 LITERATURE REVIEW

With the rapid development of the construction industry, the requirements of all walks of life for project management have gradually increased. The traditional architectural design method has been replaced by the prefabricated architectural design method. As a new design method, the prefabricated architectural design method has a good market prospect. The prefabricated building design is to use the prefabricated components for the building structure. It is a new design type and a long-term sustainable building design type. Compared with the traditional building design type, it has great advantages.

Most of the prefabricated components are non-polluting building components, which meet the requirements of green construction today; Compared with traditional architectural design, the resources wasted in the actual construction of prefabricated architectural design are lower and the cost consumption is more reasonable, which can allocate more costs to other aspects and improve the overall quality of the building [6-9].

BIM technology is a technology that uses digital representation of physical entities and building functional characteristics to share and transfer building data by building digital models. BIM technology has the characteristics of coordination and visualization, and the digital model built by BIM technology is completely transparent and visible. Among them, BIM technology and CAD graphics are most widely used in building intelligence and industrialization. CAD software is one of the main technologies used in intelligent design, intelligent construction site, intelligent management platform and other applications in intelligent construction of prefabricated buildings [10].

In the application of intelligent construction of prefabricated buildings, BIM is an important carrier for the integration of other professional technologies in the construction industry, and is the basis for building information to realize intelligent construction. Therefore, BIM and CAD graphics play an important role in the intelligent construction of prefabricated buildings, and are of great significance in promoting the industrialization of new buildings and the high-quality development of intelligent construction [11].

In the traditional CAD technology, if the completion of building 3D model components requires manual modeling, only the relevant geometric information can be obtained. With the continuous development of new technology, the use of laser 3D scanning oblique images can automatically and rapidly build large-scale urban 3D model images, but the indoor scene of buildings can still not be presented by software. Using BIM model technology in the CAD software environment can present the good adaptability and efficiency of the building interior model to the construction personnel.

In addition, the original two-dimensional image form has not been able to express all kinds of information of buildings more intuitively, and the three-dimensional model has been increasingly concerned. In recent years, the 3D model of modern buildings has evolved from an efficient and simple 2D CAD image to a 3D image. Although the traditional manual modeling method can achieve good post-effect, the efficiency is extremely low. Therefore, starting from the CAD drawings, using semi-automatic or automatic technology to identify buildings can quickly complete the building 3D model construction, and find an optimal solution for the development of 3D images [12-13].

3 METHODS

3.1 Design of Intelligent Engineering Management System for Prefabricated Buildings

The intelligent engineering management system of prefabricated buildings designed in this paper is based on BIM technology. It integrates the relevant information of intelligent engineering management of prefabricated buildings into a whole, and shares and circulates information. The whole system includes operation layer, application layer, logic layer and data layer. Figure 1 shows the overall framework of the system.

Figure 1: Overall framework of the system.

In the data layer in Figure 1, the BIM model is associated with the construction management business data, and the construction management business data is stored through various storage methods, including distributed file storage, spatial database and relational database. The data layer can form a data resource center, supporting simultaneous query of various multidimensional data. In the logic layer, M/S (mobile terminal/server) and B/S (browser/server) are used to process data in order to achieve the acquisition of building construction site processing data and a large number of users accessing the system at the same time [14]. On the basis of the logic layer, the application layer uses the middleware to receive the instructions from the end user group, which are processed by the system module and then transferred back to the end user group by the middleware.

The management of the entire system is realized through the system module. The operation layer is mainly the end user group, which is composed of supervisors, designers, owners' management personnel, BIM engineers and construction management personnel. The system automatically identifies the identity of users and judges their permissions, and allows them to operate the data in the system according to the data flow rules and perform audit, writing or query. Relevant users in the end user group complete the summary and analysis of intelligent engineering management of prefabricated buildings through the system module in the application layer through the M/S and B/S modes in the operation layer, and form the construction details through the data layer, and realize the information sharing through all participants in the system construction [15].

3.2 Hardware Design of Intelligent Engineering Management System for Prefabricated Buildings

The BIM-based intelligent engineering management system for prefabricated buildings proposed in this paper adopts the C/S hardware architecture, and the overall development mode of the hardware adopts the Web mode to realize the leapfrogging of the management system and ensure the remote management of the construction business. On the hierarchical system of system hardware, we set up client browser, database server and application server. Each server is connected to each other through a dedicated interface to ensure the connectivity between servers. The physical equipment of the BIM-based prefabricated building construction management system includes client and server [16-17].

The server of the system selects three servers with the model of kmpt2.0, and the database server selects the server with the model of Oracle3.5. We divide the client of the system into two different types of operations: a LAN computer used to operate information on the construction site. The other is the Internet computer responsible for operating all other management information. The hardware architecture of the management system designed in this paper is shown in Figure 2.

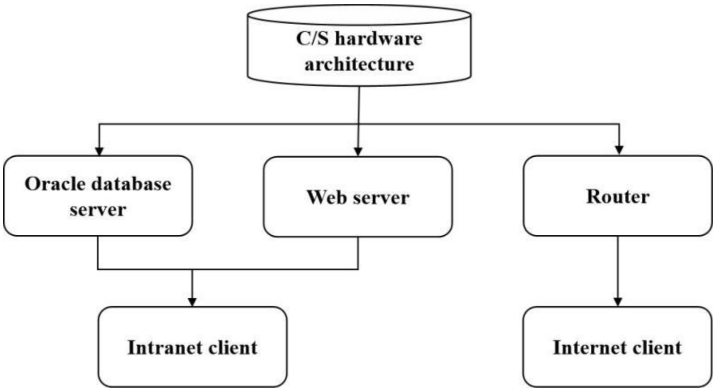

Figure 2: Physical architecture of management system hardware.

In Figure 1, the Oracle database server in the system controls the operation of the intranet client, and the operation of the internet client is controlled by the router. Both of these control methods can access the prefabricated building construction management system. The hardware equipment models and parameters of the BIM-based prefabricated building construction management system designed in this paper are shown in Table 1. Set multiple switches and firewall devices in the hardware to improve the speed and security of the system's multi-client services [18].

Hardware device	*Model*	*Parameter*
Data server	Windows Server2010	Memory 8GB, CPU 2.5GHz
Application server	Windows Server2010	Hard disk 256GB, memory DDR3 4GB
Development tool	ASP.NET	Easy development
Client	General PC	Install Microsoft Windows

Table 1: System hardware equipment parameters.

3.3 System Module Function

The main composition of the system module is shown in Figure 3.

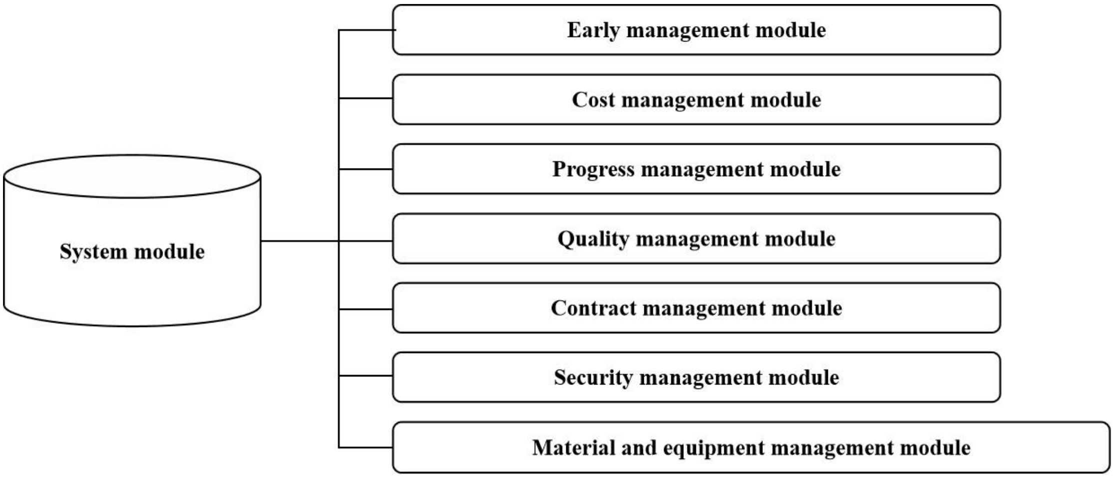

Figure 3: System module composition.

The system module is mainly divided into seven parts, including the project pre-management module, progress management module, cost management module, quality management module, contract management module, safety management module and material and equipment management module. The specific functions of each module are as follows:

3.3.1 Early management module

At the early stage of the project, many documents will be formed during the implementation of planning. This module is responsible for maintaining and saving these documents, and at the same time providing query services to the end user group [19-20].

3.3.2 Cost management module

Statistics of the investment cost of the whole project will improve the budget accuracy of specific construction. Develop a cost control model using the timeline, cost breakdown structure and BIM model. The function of this module mainly includes investment statistics and engineering quantity statistics.

3.3.3 Progress management module

For the owner in the operation level, a planning system needs to be prepared, which includes the overall construction schedule, the preliminary work plan and the annual project plan. The general construction schedule can be implemented only after the preliminary work plan of the project is approved, and the annual project plan will be implemented finally. The progress management module also needs to provide progress control analysis methods such as banana curve method or network planning method.

3.3.4 Quality management module

As a quality assurance system, the quality management module consists of equipment quality, construction quality and design quality. The quality management module manages and controls the equipment quality, construction quality and design quality, and feeds back the information related to the project quality to the operation level. At the same time, the module also needs to provide quality control analysis methods such as causal analysis diagram method or permutation diagram method [21].

3.3.5 *Contract management module*

This module is the comprehensive management of issues such as signing, claiming and resolving disputes in construction projects.

3.3.6 *Security management module*

This module is responsible for monitoring the important areas and structures in the whole construction process, so as to provide a strong basis for selecting the construction scheme. The safety control model is composed of time axis, risk analysis structure and BIM structure, and its specific functions mainly include safety rectification, video monitoring and hazard source identification.

3.3.7 *Material and equipment management module*

Use analytical methods such as ABC method to manage the input and output of equipment and materials according to different stages and conditions of the project.

3.4 Construction Schedule Management of Prefabricated Buildings Based on BIM Technology

3.4.1 *BIM model establishment and information real-time update of prefabricated building*

Based on the current development of BIM technology, this paper applies this technology to the schedule management of prefabricated buildings. First, the establishment of BIM model is studied. Figure 4 shows the framework of progress management based on BIM technology.

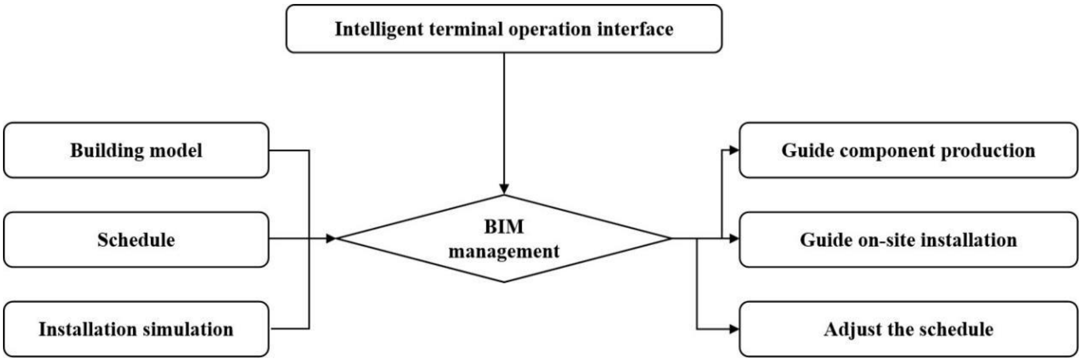

Figure 4: Structure of progress management framework based on BIM technology.

When modeling, we introduced the Autodesk BIM software Revit. On this basis, we used the project management software to prepare the schedule of the prefabricated building.

Step 1: When applying Revit software for modeling, import the building scheme into the software as a file and create a new 3D model project.

Step 2: Display the positioning information such as the report grid in the construction scheme on the corresponding nodes of the model.

Step 3: Create the exterior wall structure, pile structure, beam structure and other components of the prefabricated building.

Step 4: Create the door and window structure.

Step 5: Draw the stairs connecting each floor in the prefabricated building.

Step 6: Complete the drawing of the parts list and views in all directions according to the content displayed in the current model.

According to the types of different components in the building, the basic structure of the whole project is decomposed, and the decomposed structure is stored in the corresponding WBS work package. After creating the BIM model, import the model into Navis-works software. BIM models created by the above Revit software are usually stored in .rvt format files, which can be directly imported into Navis-works software. If other BIM models are applied, their files need to be converted to .ifc format and then imported. In this process, it is necessary to ensure that the component file set is consistent with the WBS work package in type division, so as to realize the automatic association between the fabricated components and the schedule.

In the process of construction, it is necessary to collect the relevant information affecting the construction progress at the construction site, and use the following formula to calculate the weight value of the impact of each influencing factor on the construction progress, so as to realize the quantification of its impact degree:

$$T = \lim_{k\to\infty}(D + D^2 + D^3 + \cdots D^h) \tag{3.1}$$

In formula (3.1), T represents the comprehensive impact relationship matrix of prefabricated building construction progress; D represents the factor standardization direct impact matrix. In formula (3.1), D can be calculated by the following formula:

$$D = min\left\{1/\min_i \sum_{j=1}^{n} a_{ij}, 1/\max_j \sum_{i=1}^{n} a_{ij}\right\} \tag{3.2}$$

In formula (3.2), a_{ij} represents the degree of influence of one factor i on another factor j. At the same time, the collected information will be summarized and uploaded to the cloud to achieve continuous improvement of the prefabricated building construction project database.

3.4.2 Construction schedule analysis of prefabricated buildings

In the construction stage, in order to ensure the progress, it is necessary to repeatedly check the BIM model through construction simulation and find out the existing schedule problems. In the process of schedule management, the visualization function of BIM model is used to observe the construction process of the virtual assembly building, and judge whether the construction process is qualified and whether the process logic is reasonable. In each construction simulation, the project progress must be comprehensively checked. If there are problems or inconsistent with the objectives, corresponding modifications must be made to ensure that the final project progress is the best. This process can be shown in Figure 5.

In this process, the progress data and the BIM model are dynamically connected. Therefore, the linkage modification between the progress plan and the BIM model can be realized by controlling the progress. During the modification process, the component progress information on the model will also be modified synchronously to realize the dynamic optimization of the schedule [22].

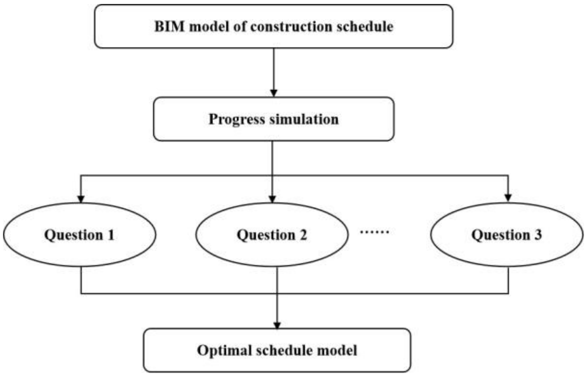

Figure 5: Schematic diagram of construction schedule optimization process of prefabricated buildings.

3.5 Experimental Analysis

In order to verify the performance of this system, we take a financial plaza in a city as an experimental object. In this project, BIM technology provides a reliable management means and information basis for management, design, planning and construction.

The system in this paper can operate in any network environment. Even the tablet computer in the 3G environment can still meet the needs of browsing and inputting data. The system contains seven first-level management functions. The parts directly related to the construction of BIM technology include pre-management, quality management and progress management, and the parts related to the whole project construction include material and equipment management, contract management, cost management and safety management. Both the main party and the participants have their own permissions and setting procedures. If the construction management personnel upload the project related data through this system, the system will automatically send a notice to the supervision management personnel to remind them to review the data uploaded by the construction management personnel.

In the actual construction stage of the intelligent prefabricated building project, we need to import the BIM design model into this system, implement WBS decomposition, and connect the construction progress. At the same time, we should integrate the decomposed BIM model with the actual engineering information such as site layout, construction resources, safety, quality and so on, obtain a 3D construction information model and store it in the BIM database to form a BIM data platform, which is convenient for supervisors, owners' managers, construction managers and designers to work together.

4 RESULTS AND DISCUSSION

Select the relevant information in the model, and click the button to display the information in the interface. This interface can realize information extraction, and the data will be automatically stored in the BIM database after successful extraction, which will improve the data support for the cost management module. Compare and analyze the management effects of the system, B/S system and workflow system, and the results are shown in Figure 6.

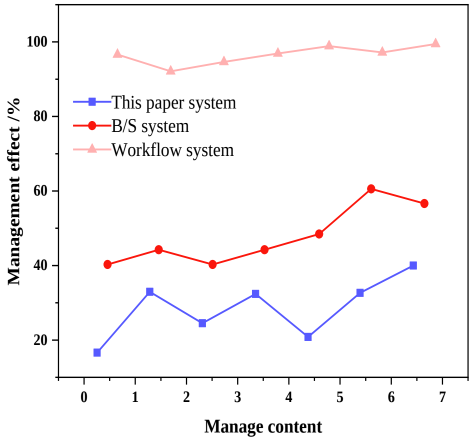

Figure 6: Comparison of management effects.

As can be seen from Figure 6, the management effect of workflow system is lower than 85%, and the management effect of B/S system is slightly higher than that of workflow system, higher than 85% and lower than 95%. The effect of each relationship content of the system in this paper is more than 98%, which shows that the management effect of the system in this paper is better when implementing intelligent project management for a financial plaza [23].

5 CONCLUSION

This paper puts forward the intelligent engineering management of assembly building based on BIM technology and CAD graphics. This paper designs an intelligent engineering management system for prefabricated buildings based on BIM technology to solve the common engineering management problems at present. The author takes BIM technology as the basis to build an assembly building model, which can effectively extract data and realize dynamic management. Through analysis, we can see that the system designed with this technology has good management effect and excellent development prospects.

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