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Visualization Management Technology of Super Tall Building Construction Process Based on BIM-GIS Technology

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Abstract. A BIM-GIS based visual management technology of super tall building construction process is proposed to improve the quality of super tall building construction management and enhance the visual management effect. First, BIM technology is introduced to realize the establishment of the 3D model of the building structure of the building project based on Revit 2015 software. According to the construction project of the super high-rise building, it is divided into civil model and steel structure model to complete the construction modeling of the super high-rise building. Then, the BIM model is converted into the 3D GIS scene model. Finally, the construction simulation function design and database design are carried out to realize the visual management of the construction process of the super tall building. The experimental results show that the method applied in the construction process can make the project participants understand the whole construction process more clearly, and it can monitor and manage the project progress in real time, which can better simulate the construction process and realize the visual management function.

Keywords. BIM-GIS technology, supertall buildings, construction process, visual management

1. Introduction

People are paying more and more attention to the construction quality of such buildings due to the increasing number of super high-rise buildings worldwide in recent years, so the construction requirements for such buildings are becoming more and more stringent, and the challenges they face are becoming more and more complex. The construction process of super high-rise buildings involves the cooperation of multiple professional fields and highly complex engineering operations, so advanced management technology is needed to provide real-time guidance and monitoring [1,2]. The traditional construction management method has some problems, such as poor information flow, difficulty in obtaining information and lack of real-time data support for decision-making [3]. Therefore, many researchers begin to focus on the research and application of visual management technology, in order to improve the efficiency and quality of construction management through digital and visual means.

At present, many scholars have carried out relevant research and obtained certain research results. For example, literature [4] proposes a construction visual management

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system for building decoration projects with the support of BIM technology. This system uses BIM technology as support, and carries out feature registration of 3D visualization information of construction projects in the way of similarity feature matching, so as to obtain BIM information fusion decision, and is used for 3D feature information fusion scheduling. Then, an adaptive filter model is established to realize the 3D visual reconstruction of the construction project. Another example is the construction visualization management system designed in literature [5], which takes a bridge construction project as the research object, optimizes the modeling parameters of BIM technology, improves the parametric family library of bridge structure and construction facilities in the project, and realizes the construction of bridge structure and its construction model. The collision of steel bars is also checked and the collision during construction is analyzed. By using BIM model to simulate the layout scheme of the construction site, the 3D construction of visual disclosure is realized by using BIM model to simulate the layout scheme of the construction site. Finally, BIM technology is combined with construction monitoring to realize the visualization of bridge construction monitoring layout. Literature [6] proposes a BIM based rail transit construction process management platform system. In the construction management of the system, factors such as site construction personnel in the construction management of the system, building materials, application machinery and environmental conditions should be integrated and imported into the BIM model to conduct construction management based on multi-source information, so as to solve the problems of unified monitoring of the construction process, deployment of personnel and materials, and accurate control of construction progress. The above three methods all focus on the application of BIM technology, but the construction management effect is still not good. Therefore, this study proposes a visualization management technology for the construction process of super high-rise buildings based on BIM-GIS technology. It is hoped that the visualization of the construction of super high-rise buildings can be realized through this study based on BIM technology and GIS technology. Improve its construction management efficiency and construction management quality to help the safe and orderly construction of super high-rise buildings.

2. Construction Modeling of Super High-rise Building Based on BIM-GIS Technology

2.1. Establish BIM Construction model of Super High-rise Building

This study based on Revit 2015 software to achieve the establishment of construction project construction structure 3D model in order to realize the visual management of super high-rise building construction, it can be divided into civil model and steel structure model according to the super high-rise building construction project, it also completed the deepening design of its nodes in order to optimize the super high-rise building modeling, the specific design is as follows:

1) Civil construction model

The establishment of civil BIM [7] model is mainly divided into three parts, the specific steps are as follows:

(1) Establish elevation and axis network

According to the design drawing, select the appropriate sample file, complete the elevation and shaft network establishment in the CAD drawing facade according to the design drawing according to the design drawing, select the appropriate sample file.

(2) Create structural columns and walls

Link CAD drawings, create structural columns and walls, and then link them again to Revit software. Lock the drawings and avoid errors in the model through the axis network established in Revit software.

(3) Drawing structural beams and floors

In Revit, the "Column and Wall command" is used to draw structural beams in super-tall buildings in Revit. Through the placement and selection of each axis network node in CAD drawing, the segmented drawing of each axis network node is realized through the placement and selection of each axis network node in CAD drawing. The CAD drawing of the beam body is connected to Revit software, and the structure frame is constructed according to the drawing method. According to the design requirements in CAD drawing, set the level height and link the corresponding architectural plan to Revit. The "floor command" in the structure function table is used to complete the floor drawing, and then set the floor position according to the CAD design drawing.

The civil BIM model of super high-rise building can be established after completing the above steps.

2) Steel structure model

Tekla18.1 software is used to establish the steel structure model of super high-rise buildings in this study. The steps are as follows:

(1) Establishment of axis and axis view. The new project of Tekla18.1 software is opened, double-click the existing axis, the axis property menu pops up, and set the related properties of the axis according to the CAD drawing. The single machine will modify and save as to complete the establishment of the axis of the steel column model after setting the relevant properties. Select the built axis, right-click and select Create View to create the view.

(2) Establishment of the column foot model of cruciform steel column. The model was established on the basis of TEkla18.1 software, and the foundation plate of model 1047 is used to complete the modeling of the column foot model of the cruciform steel column by setting relevant parameters such as graphics, bolts and stiffeners [8].

(3) Establishment of steel reinforced concrete column model. The steel structure in this kind of project is usually a cross-shaped steel concrete column, so this study uses the command of intersecting section or intersecting plate to establish the cross-shaped steel concrete column in Tekla18.1 software. The cross-shaped steel column is welded by seven plates, which is different from the ordinary I-steel column which can be established in the plan. The drawing of cross-shaped steel-concrete columns needs to be built on the facade [9], and the completed cross-shaped steel-concrete columns are shown in figure 1.

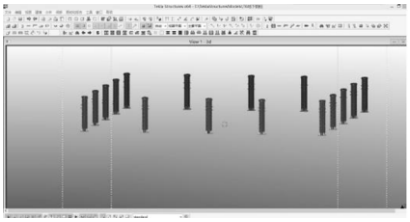

Figure 1. Cross-shaped steel concrete column.

3) Deepening design of beam-column joints

The layout of steel bars and steel columns is difficult for the construction of super high-rise buildings. Since the accuracy of the construction drawings cannot meet the construction requirements, it can be further designed through the model first, and guide the construction while completing the construction feasibility verification. The deepening design of steel-concrete joints of super high-rise buildings by using BIM technology can verify the feasibility of their construction [10]. Examples of the position relationship between steel columns and rebar, the deepening design is carried out, as shown in figure 2.

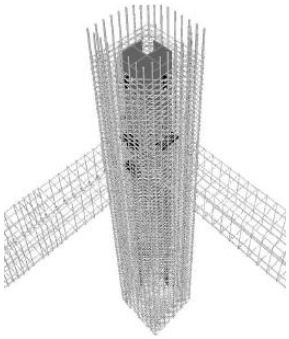

Figure 2. Position relationship between steel concrete cross column and steel bar.

2.2. Unified Design of Scene Space Benchmark of GIS and BIM

It should be unified with the scene space reference of GIS to facilitate the fine construction simulation in the later stage after the construction model of super high-rise building is established. It is necessary to solve the exact spatial topological relationship between multiple sub-modules in the BIM model in the integration of large-scale BIM model and 3D GIS scene, and ensure the accurate relative spatial relationship between adjacent BIM models. The specific processing process is as follows: First, set the coordinate of the center point of the GIS scene as P, and the coordinate of the corresponding actual measurement point is (X_P, Y_P, Z_P). Then, the actual coordinates and attitude of the entity object in the scene are obtained. Its actual coordinates are (X_1, Y_1, Z_1), and the attitude rotation Angle of the model is θ. The coordinate transformation matrix of the architectural model is constructed as follows:

$$T = [L|(R, \theta)] \tag{1}$$

Where, T represents the coordinate transformation matrix; L represents the translation vector and the translation displacement of the building model; R represents the rotation matrix, which represents the attitude rotation of the architectural model. Finally, the coordinates of each vertex are transformed to complete the translation through the coordinate transformation matrix, rotation and scale transformation of Revit model, and finally realize the unification of BIM model in 3D GIS.

3. Visual Management Design of Super High-rise Building Construction Process

3.1. Visual Simulation Design of Super High-rise Building Construction

The key construction technologies and progress simulation demonstration are carried out based on Navis Works Manage2015 software as a platform for model integration after completing the construction of BIM-GIS super tall building simulation model. The specific operations are as follows:

Create a project and name project. When naming, the name in the schedule should be the same as the name of the collection, so as to ensure that the collection is attached quickly and accurately. Then, the external tool in Revit is used to export the model, and a new file is created to import the model file. The file type selected for concrete structure is NWC format, and the file type selected for steel structure is IFC format. The main model of high-rise building is integrated by Navisworks 2015 software. Prepare for subsequent construction simulation demonstrations. Finally, the construction technology or construction progress simulation is carried out, it is that the "data source" tool is used to synchronously link the construction steps or construction plans to the virtual construction with the help of software such as Navisworks. The simulation process is as follows:

(1) The Timeliner automatic attachment function mentioned is used above to associate the collection with the schedule;

(2) The corresponding type attribute is set in "Task type" after the schedule is associated with the model set, which includes four types: construction, demolition, temporary and existing. Construction refers to the model that needs to be simulated for this time, and demolition refers to the model that needs to be simulated for this time. This command is generally used in the simulation of engineering demolition. Temporary refers to the models that need to appear in a certain period of time during the simulated construction process, such as forklift, etc. Existence refers to the models that have always existed during the whole simulated construction process, and the corresponding task type is set according to the relevant schedule tasks.

(3) Set the appearance parameters in the Timeliner "Configuration" command, set the relevant parameters in the Timeliner "simulation" tool, and click play to get the progress simulation result of the project. The simulation of construction technology is the same as above, according to which the visualization management of super high-rise building construction can be realized.

3.2. Super High-rise Building Construction Management Database Design

Various factors are designed, including the basic attribute data of building BIM model, elevation data, image data, two-dimensional GIS basic attribute data, engineering quantity data, progress data, construction quality data and other data generated during the construction process in the process of managing the construction process of super high-rise buildings. Provide solid data guarantee for visual management system, carry out database design in order to scientifically manage massive data. It can be divided into three categories by classifying the data required by the construction management system of super high-rise buildings: terrain data, spatial data and attribute data. The construction management database is designed based on the SQL Server architecture and its table is improved. The user information table is shown in table 1 below.

Table 1. User information table.

Column name	Data type	Allow emptying	Remark
Name	Varchar(50)	Unchecked	Username
ID	Int	Checked	Subscriber number
Password	Int	Checked	Cipher

Complete the building engineering model table design based on the design objectives and application scenarios of the system, which is shown in table 2 below.

Table 2. Building model table.

Column name	Data type	Allow emptying	Remark
Model Name	Int	Unchecked	Model name
Uploader	Int	Checked	Uploader
Part Name	Varchar(50)	Unchecked	Divisional project name
Part ID	Int	Checked	Divisional number

The author has to obtain the construction progress in real time in order to visualize the management of the construction, so the design and construction schedule is shown in table 3 below.

Table 3. Construction Schedule.

Column name	Data type	Allow emptying	Remark
Part Name	Varchar(50)	Unchecked	Divisional project name
Part ID	Int	Checked	Divisional number
GJName	Int	Unchecked	Component name
Position	Int	Checked	Member position
Mater Type	Int	Checked	Material type
Completion	Varchar(50)	Checked	Completed quantity
Person Name	Int	Checked	Informant
Data Time	Int	Checked	Filling time
Department	Int	Checked	Construction unit

The design of the construction quality control table is shown in table 4 below.

Table 4. Construction quality control table.

Column name	Data type	Allow emptying	Remark
Part Name	Varchar(50)	Unchecked	Divisional project name
Part ID	Int	Checked	Divisional number
Process Type	Int	Unchecked	Type of construction technology
Control Par	Int	Checked	Quality control parameter
Total Volume	Int	Checked	Population quantity
Unqualified Quantity	Int	Checked	Unqualified quantity

Thus, the database design of the visual management system for the construction process of super high-rise buildings is completed to provide a guarantee for their visual construction management.

4. Simulation Experiment Analysis

A super high-rise building project was taken as an example to carry out experimental research in order to verify the proposed visual management technology. The Internet of Things is applied for networking to complete the sampling of visual construction information of super high-rise buildings in this study. The construction information of super tall buildings can be transmitted by 132 Mibit/s remote control bus, and the sampling frequency of construction visual information can be between 12 and 24 kHz according to the designed network. The pixel size of visual information is set to 2000X2000 and the matching feature component is 1.6 in this study, and then the construction model of super high-rise building is established on the Revit 2015 platform. The construction process simulation was completed according to Navis Works Manage2015 software, and the simulation results are shown in figure 3 below.

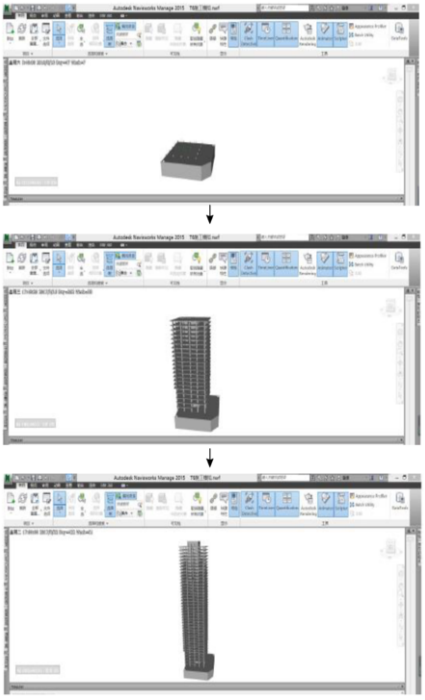

Figure 3. Visualization results of construction simulation.

As shown in figure 3, the proposed method can be used to carry out construction simulation and verify that it can effectively realize the visual management function for the construction of super high-rise building projects. The application of the proposed method in construction simulation can make the project participants understand the

whole construction process more clearly, and it can monitor and manage the project progress in real time.

5. Conclusion

A visual management technology of super tall building construction process based on BIM-GIS technology is proposed to improve the management effect of super tall building construction process. This technology mainly uses BIM technology to complete the construction visualization model of super tall buildings, and then converts it into a 3D GIS model to lay the foundation for its construction simulation. Finally, the construction simulation function is designed based on Navis Works Manage 2015 software, so that it has the function of construction visualization management. The experimental results show that the proposed method can simulate the project construction well, it has good construction visualization simulation function and good application value.

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