Application research of BIM5D technology in engineering projects

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Abstract. Based on BIM technology, BIM3D model is built through Autodesk Revit software, structural conflicts and collisions are checked through Autodesk Navisworks Manage software, and construction simulation is conducted, so that BIM5D information base is integrated with new point cloud 5D calculation software and new point list cost software which realizes 5D management. By means of construction simulation for further optimization model, the fine management of construction process is realized.

1. Introduction

In the rapid development of information and digital era, the emergence of the concept of BIM and deepening, together with the development and application of BIM technology, brings infinite possibility to the modern construction industry. BIM technology, which has the characteristics of visualization, coordination, simulation, optimization, and parameterization, can build a 3D model, including all geometry information, professional attributes and status information, which optimizes the construction process, allocates resources properly and improves the quality of construction.

Many domestic engineering projects have successfully applied BIM technology. For example, Guangzhou Chow Tai Fook financial center project applied BIM technology to shorten the construction period and significantly reduce the total project cost, so that the material loss was lower than 30%~50% of the industry benchmark value[1]. BIM technology was also applied in Tianjin 117 building, during which construction period benefit was 54 million yuan, engineering cost was saved 5,056,400 yuan, and 65,000 cubic meters of high-strength concrete was successfully poured at one time[2].

However, in the process of traditional schedule management, drawing changes, schedule adjustment and other problems are exposed, which result in late completion of the project, inaccurate resource demand planning, project rework and chaotic cost management. Therefore, this paper focuses on the research and analysis of BIM technology, which builds BIM3D model, integrates BIM4D model and forms BIM5D model, so as to realize BIM5D management. Through construction simulation, possible problems can be found in advance, construction organization scheme can be optimized, and construction process can be managed in detail. The feasibility of BIM5D technology is demonstrated and analyzed in combination with a residential project.

2. BIM5D technology

BIM5D model is a collective information base based on BIM3D model, which is composed of association and integration of progress information and cost information. It can be expressed as:
BIM5D=BIM3D+time+cost. On the basis of the drawing function, the 3D of BIM technology realizes 3D visualization, which is more intuitive, has complete information and can share information. The 4D of BIM technology, namely adding 3D and time dimension, can realize the construction simulation, reasonably arrange the schedule plan, optimize the construction organization design plan, discover the possible working conditions, and make the response plan in advance. The 5D of BIM technology is 4D plus cost dimension to integrate construction cost information, form BIM5D model information base, monitor construction cost situation in real time, and reduce deviation from final cost of completion[3].

In essence, the framework system of BIM5D model is the same with that of BIM3D model, while the structure of model graph meta data is different. The 3d rendering of BIM3D model is static, which cannot analyze and manage data information. BIM5D model integrates the geometric data of 3D model with time information, cost information and other information, which can comprehensively analyze the situation of planned schedule, budget cost, actual schedule and actual cost at any time point[4].

3. Construction of BIM5D model

3.1. Construction and integration of BIM3D model

The BIM3D model is constructed according to the requirements of the drawings, in which the three-dimensional modeling software is used to construct various professional models[5], including architectural models, structural models, electrical models, and HVAC models. The BIM structural model firstly creates the elevation and the axial network, and builds the components one by one according to the order of the structural wall, the structural column, the structural foundation, the structural beam, and the structural floor, and parameterizes the attributes such as size, positioning, and structural material label. Similarly, the BIM building model creates elevations and grids, then builds the building walls, doors and windows, stairs, ramps, and roofs one by one, and defines the material properties of each component by editing the material browser.

In this paper, a residential project is the research object. The Autodesk Revit series software is used to construct the building model, structural model, site model and HVAC model. As shown below, Figure 1 is the building model, Figure 2 is the structure, Figure 3 is the site model, Figure 4 is the HVAC model, and Figure 5 is the 3D model integrated by each major.
3.2. Progress correlation of BIM4D model

Based on the BIM3D model, the new point of the cloud 5D calculation software is used as a plug-in form combined with Autodesk Revit software to correlate the progress information and construct the BIM4D model. The project is decomposed into several task sets according to the level, work type, process and other levels. Each task set is associated with the time schedule, which can realize the project breakdown structure to become a dynamic construction process, and also consider the workload size and resource supply. How much labor, how to determine the content of the task, and use resources have to be in a balanced and efficient manner. The division of task collection and time schedule needs to be consistent with the component information, such as type, floor, name, material, element, ID and other information. In this paper, the residential building is divided into task sets according to floors and structural members, the project schedule is recorded, and the corresponding components are attached, as shown in Figure 6.

3.3. Cost correlation of BIM5D model

Based on the BIM4D model, the BIM5D model is constructed by correlating cost information. In order to obtain cost information such as contract budget cost, fixed price, and unit price of human materials, the model is exported to the new point list cost software, and the specific practices and price information are set according to the valuation of construction and decoration engineering in Jiangsu Province, and then the cost information is fed back to the real-time, so that model components are associated with cost information. Click on any component and the corresponding list practices correspond to the code, engineering quantity, unit price, and total price.

After the 3D model is associated with the schedule and cost information, the BIM5D model is integrated and the BIM5D information base has been obtained. As the progress of the project, the actual progress, change data, and actual cost information are entered, the BIM5D information base is automatically updated, and the real-time working conditions are analyzed to realize construction cost control. BIM5D management is shown in Figure 7. The time-cost graph can visually see the real-time deviation of schedule and cost.
4. Fine simulation of construction process

The refined simulation of the construction process can reflect the working conditions and progress of any node at any time, count the consumption of labor, materials and mechanical equipment, simulate the construction process visually, output the animation form, and discover the possible existence of the construction organization design plan in advance. The problem can be solved in time to reduce engineering changes during the construction process, minimize losses and reduce construction costs. The schematic diagram of the construction simulation is shown in Figure 8. The foundation pit excavation including the excavator and tower crane can also be simulated in real time. The working condition and resource consumption of the construction task are shown in Figure 9. It can be clearly seen whether the progress is advanced or delayed, and the labor, material, machinery and total costs are specifically consumed.
5. Conclusion

Based on BIM technology and combined with a residential project, this paper mainly analyzes the construction process of BIM3D model, BIM4D model and BIM5D model, simulates the information integration of BIM3D model with schedule and cost, which realizes BIM5D management. The fine construction simulation is further optimized and verified, which verifies the feasibility and practicability of BIM5D technology.

BIM5D technology has high application value in engineering projects including reducing waste of manpower, material resources and financial resources, reducing the cost of engineering changes, improving resource utilization, and creating high-quality and high-level projects, thereby improving the economic benefits of the construction industry. However, BIM5D technology is in the initial stage of development in China, and there are still some shortcomings. There is no unified IFC standard in China, and it is difficult to realize information interaction. It is necessary to promote the application and deepening of BIM5D technology in construction projects and realize information management.

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