The Application of BIM Technology in Construction Management - An Empirical Study Based on A Hotel Project

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ABSTRACT

The characteristics of construction projects and the higher requirements of owners make it increasingly difficult to achieve project goals. BIM technology is an effective tool to achieve project goals. This paper introduces the PDCA dynamic control principle that should be followed when using BIM technology, and analyzes the application focus of BIM technology in construction project management from four aspects: cost management, quality management, safety management and schedule management. Combining with a hotel project, we introduce the specific application of BIM technology in construction projects, and how to realize dynamic supervision and control of the whole process of construction projects through the help of BIM technology, so as to finally achieve the project objectives.

Keywords: *BIM technology; Project management; Dynamic control*

1. INTRODUCTION

Traditional project management methods have become inadequate in meeting the objectives of construction project management. How to solve the many problems in construction project management, explore and study the effective management techniques and management methods is one of the current challenges facing the engineering construction industry. In recent years, information technology has developed comprehensively, and the construction industry has been impacted by information technology [1]. BIM is an important part of the development of information technology in the construction industry, BIM has the characteristics of visualization, integration, parameterization, etc. BIM technology based on 3D digital model can cover all information of engineering components, relying on this model, multi-dimensional construction simulation can be carried out, and also avoid the traditional management mode of "information islands" in the traditional management mode [2], and can dynamically manage and adjust the quality, cost, schedule and safety in the construction process, which has incomparable advantages that traditional project management methods cannot match.

2. THE ORETICAL BASIS AND KEY POINTS OF BIM TECHNOLOGY APPLICATION IN CONSTRUCTION MANAGEMENT

The dynamic variability of construction projects determines that the management of construction projects requires the application of dynamic control principles, that is, the PDCA cycle is used to achieve the management objectives of construction projects through control measures.

The key points of using BIM technology in construction projects is firstly to establish a new management awareness, strengthen the recognition and acceptance of BIM technology by organization members, set up a reasonable and efficient organizational structure, clarify the power and obligations of project management parties and the division of responsibilities, form an integrated and standardized management system, and build a smooth organizational process. Secondly, the technical and management preparations before construction should be done. During construction, based on the management idea of dynamic control, comprehensive consideration of the project's multiple

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constraints and multi-objective feature, balanced project objectives.

2.1 Theoretical Basis

The dynamic control principle (PDCA cycle) is a basic method used in carrying out construction management. The dynamic control principle is to comprehensively, timely and accurately control the project construction information through tracking the process, objectives and activities in the process of completing the engineering construction project, and regularly compare the actual objectives with the planned objectives, so as to timely find and correct the deviation between the predicted objectives and the planned objectives, and finally achieve the overall planned objectives [3]. The dynamic control schematic is shown in Figure 1.

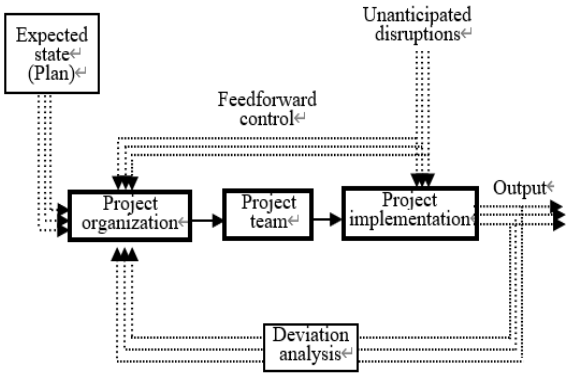

Figure 1: Schematic Diagram of The Project Dynamic control principle

2.2 Quality Management

The main applications of BIM technology in quality management include auxiliary inspection of the completion of project quality objectives by using various sensors, Internet of Things and other means, statistical analysis and monitoring and tracking of quality inspection and correction rate and distribution of quality problems. It also includes dynamic control and simulation of quality plans, quality programs and implementation, quality inspection and rectification, and real-time analysis and discrimination of quality risks combined with data analysis methods and early warning systems.

2.2.1 Auxiliary Quality Checks

The construction company can develop a weekly and monthly inspection system during the construction process and carry out quality inspection with the help of IOT technology. Project quality management personnel use cell phone photography, RFID, infrared sensors, laser scanners, GPS and other information sensing devices to inspect the quality of the project, connect the quality information of building components with the BIM platform, upload quality inspection information to the BIM platform, and exchange and communicate quality information. The BIM platform analyzes the heterogeneous quality data collected, issues an early warning for the parts that do not meet the specification standards and quality requirements, and proposes a plan to suggest rectification, then the construction company can issue a rectification notice, and after the rectification completed, system can be used to automatically carry out analysis and calculation, and automatically calculate the qualifications rate, and analyze whether it meets the system's preset qualification standards.

2.2.2 BIM Technology Dynamic Simulation Control

According to the visualization of dynamic construction process simulation by BIM technology, we can compare different construction solutions comprehensively, select the optimal solution and assist in technical delivery. Through the BIM model, the construction focus and difficulties of each project are delivered in a visualized state, which facilitates the staff to carry out the construction, while a virtual demonstration is made before the construction to help the management staff to carry out pre-control on the quality of the project. The BIM platform can be used for comprehensive control in the early stage and dynamic supervision in the middle and late stage to improve the quality management level.

2.3 Progress Management

BIM technology can be applied to situations such as digital weekly reports, construction logs, coordinating the work of various construction units, preparing and optimizing progress plans, and monitoring progress in real time.

2.3.1 Schedule Preparation and Optimization

Using BIM technology to prepare the schedule, should collect the schedule preparation basis according to the overall schedule target and actual situation of the project, and use WBS work decomposition tool to decompose the project into assignments. The BIM model is used to divide the decomposed assignments according to the process logic and management logic, determine the reasonable construction sequence, and dynamically simulate the real-time status of assignment and the changes of various resources with the construction progress. By calculating the number of labor and machinery shifts, combining the number of available workers and available machinery, and determining the duration of each process, obtain a preliminary project schedule. Finally, the construction progress will be simulated and checked in the BIM platform. The progress plan that passes the inspection will be woven into the official project progress plan, and if it does not pass the

inspection, it will be recompiled again, thus ensuring the reasonableness of the plan.

The BIM model can dynamically connect the progress plan with the implementation of engineering components, and can visually display the progress plan and construction process through network diagram, dynamic diagram, animation demonstration and other forms, which provides a convenient tool for all parties involved in the project to visually understand the project situation. BIM technology can dynamically simulate the construction phase process and key node construction process, and by simulating multiple construction solutions and comparing their feasibility, the optimal solution is finally selected to facilitate the adjustment of the implementation schedule.

2.3.2 Dynamic Monitoring of Progress Execution

BIM technology can be used to accurately track the construction progress, and by comparing the deviation between the actual progress and the planned progress, analyze the causes and the degree of impact, so that timely measures can be taken to dynamically adjust various resources and sites, timely control the actual progress of the project and ensure the project completed in time. The duration of the project is long, and the use of BIM technology can achieve dynamic adjustment of the schedule at any time to cope with some uncertainties such as weather and design that may affect the construction schedule. In the construction preparation stage, the BIM model simulates the actual implementation process of the project, aids in the preparation of the schedule, and coordinates and optimizes the schedule. During the project construction process, we dynamically view the project progress with the help of IOT and other technical means, compare the planned progress with the actual progress, and make adjustments to the progress and management personnel accordingly. For assignments that are not completed on time, the planned assignments are reassigned and reassigned according to the actual situation, and actual tracking records are kept, including details such as actual start and completion times and reasons for delays. Feedback to the overall plan at each level, and then adjust the overall progress accordingly to ensure the schedule requirements, so as to achieve the dynamic monitoring of the overall progress.

2.4 Cost Management

BIM technology can assist project cost managers in cost monitoring, cost accounting and data analysis to manage costs [4].

2.4.1 Auxiliary Cost Calculation

The BIM software can automatically perform the calculation of the construction volume of the building components. And as the construction process advances, the granularity and maturity of the BIM model becomes more and more perfect and precise, and the BIM model can more and more accurately calculate the precise amount of construction components, and through such means as quota material, so as to achieve the reduction costs from material waste. Moreover, the calculation of project quantity and cost is automatically handled by BIM platform, which reduces the workload of cost engineers and improves the efficiency of project cost calculation. Secondly, the BIM platform's information base of construction materials, components, construction machinery, labor costs and other production factors can reflect the changes of market prices in real time and ensure the accuracy and transparency of cost information.

2.4.2 Dynamic Cost Control

For the frequent design changes in the project, dynamic adjustment of the BIM model can instantly reflect the actual changes in construction components, and the associated cost data will be intuitively fed to the management. At the same time, it is also possible to upload prices and other cost-related information to the BIM platform through the cost information acquisition port in conjunction with the construction materials and models generated during the construction process. All parties involved in the construction can call relevant cost information data according to the authorization level, so that they can pay attention to the cost status in the construction process in real time and achieve fine management of costs.

2.5 Security Management

BIM technology can do the daily safety inspection, risk source management and form the safety management log during the construction process [5].

2.5.1 Safety Data Monitoring and Priority Accident Handling

At the stage of construction safety management, technicians need to combine the specific conditions of the project to optimize the BIM query module, to ensure that construction and construction managers can further understand the construction safety of the project site according to this module, It is also helpful for the managers to grasp the potential safety risks in the construction process, and to do early warning and prevention work for these risks, so as to reduce the probability of occurrence of safety risks and ensure the implementation of construction. In addition, the use of BIM technology information data collection and collation function can assist the managers for the construction site safety risks and predicted accidents and other priority settings, and combined with these priority settings to do a good job related to safety prevention work, put forward

targeted solutions to minimize the threat caused by safety risks and accidents.

2.5.2 Risk Prevention, Control and Management

The application of BIM technology can help managers collect data information of the site and the surrounding environment during the construction process, and improve the reliability of the information. The use of engineering risk control function in BIM model can also strengthen the risk identification, risk prevention and risk control work before the construction is carried out, and further optimize the engineering risk warning function; meanwhile, according to the multifaceted construction information data, analyze the problems in the safety management work of each link of the project to ensure the safety of construction operation.

3. EMPIRICAL STUDY

3.1 Project Introduction

The construction site is located in the southern foot of Baiyun Mountain, Guangzhou City, Guangdong Province, the northern side of Guangzhou Garden integrated service area. The project park includes three parts: front area, core area and comprehensive service area, with a planned land area of 9449m^2, construction area of 16732.11m^{2}and above-ground construction area of 8004.79m^2. The structure type of the project is frame structure, the design life of the structure is 50 years, seismic intensity 7 degrees, fire resistance grade II, roof waterproof grade III. The project includes 2 underground floors and 3 aboveground floors, with an interior elevation of ±0.000 total height of 14.9m. The main construction includes underground garage on the negative two layers, equipment room and casual dining area on the negative layer, casual dining area on the ground floor, banquet hall and box on the first floor, box and multi-function hall on the second floor. The 3D model diagram of the project is shown in Figure 2. The 3D electrical model of the project is shown in Figure 3. The 3D water supply and drainage model of the project is shown in Figure 4.

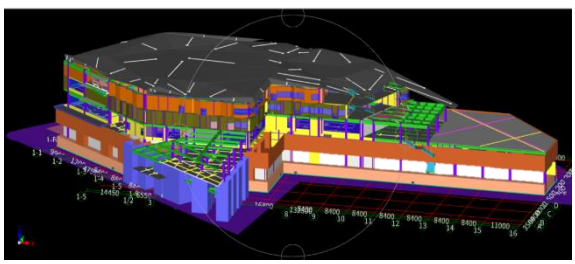

Figure 2: Schematic Diagram of the 3D Model of The Project

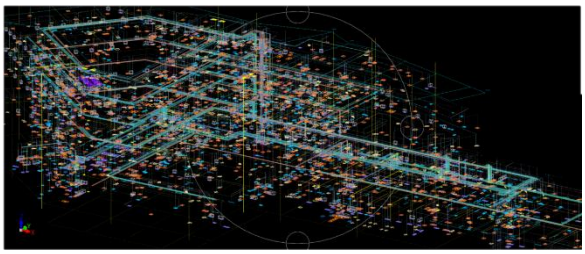

Figure 3: Schematic Diagram of the Project's Three-dimensional Electrical Model

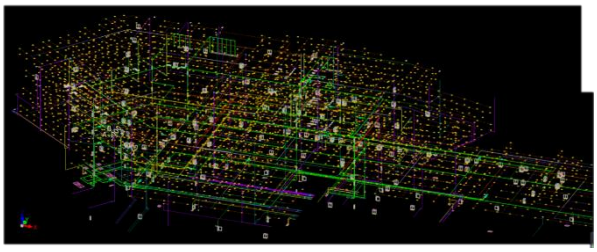

Figure 4: Project Three-dimensional Water Supply and Drainage Model Schematic Diagram

3.2 BIM Technology Application

3.2.1 BIM Technology Application Guarantee

According to the construction enterprise's own characteristics and the project construction external environmental factors, constraints, quality goals, schedule goals, cost goals, safety goals, a management team consisting of three levels of leadership group, management group and technical group was set up, and through several meetings, the ideas were unified and policy documents such as system, division of responsibilities, management process and implementation plan suitable for BIM application in this project were formulated. Members of the management team and the BIM technical leader developed the project construction method through several consultations in the pre-construction period. During the implementation of the project, the person in charge of BIM technology will hold a summary meeting at the end of each month in the form of a computer meeting to report the application of BIM technology this month and submit a monthly report to the leaders of various departments of the company.

3.2.2 Quality Management Applications

(1) Pre-construction development and improvement of project quality program. Quality management is an important part of engineering management. In the construction plan preparation stage of this project, the technical staff of the project team prepared a project quality plan suitable for this project with the help of BIM model, simulated the construction situation according to the timeline, and found some places where quality problems and quality hazards might occur. For example, there are many pipes in the basement, crossed fire hoses and ventilation pipes as well as complex interlocking of

plumbing and electrical systems. According to the findings, the technicians use BIM technology to optimize and adjust the pipe network lines to avoid construction quality problems.

(2) Dynamic management and control during construction. The application of BIM technology in this project is also reflected in the auxiliary quality inspection, which realizes the real-time tracking of project quality and dynamically monitors the potential quality problems of the project.

The BIM team has established a quality inspection system, sending special inspectors every Monday to inspect the project areas they are responsible for managing, mainly using RFID, infrared sensors, laser scanners to collect site data, track and identify the hidden sources of quality in the construction process and the parts with quality problems according to the cell phone terminal to achieve rapid positioning, and upload the collection results to the BIM platform. BIM platform analyzes the quality information through the backstage, gives the quality inspection results, and once quality problems are found in the relevant parts, transmits them to BIM technicians through the cell phone terminal, BIM technicians visit BIM technology platform in time after receiving the information, record the responsible person and management staff of the relevant parts, upload the relevant details and designate the responsible person to rectify the parts with quality problems and Specify the rectification period. The relevant responsible person will upload to the platform after the completion of rectification, and the platform will automatically generate inspection logs, and the staff will use the BIM platform to analyze the quality problems. The management also builds a quality issue database through the uploaded quality issues. In order to provide better quality assurance, the responsible person can enter the site for manual acceptance and check whether the rectification is qualified according to the actual situation of quality problems. Inspection qualified and end the problem, or use the BIM platform to generate correction orders, sent directly to the site to urge the responsible person to rectify. The project manager regularly checks the information of quality issues in the platform and supervises the rectification of the problems, and all departments can check the quality issues at any time through the platform.

3.2.3 Progress Management Application

(1) formulation and optimization of the construction schedule during the planning stage. Based on the BIM model, the construction simulation function of BIM technology is used to arrange the construction process of the project on the timeline, transform the static 3D model into a dynamic five-dimensional model, and simulate the formulation and optimization of the schedule of the whole construction in a dynamic situation. In addition, the BIM platform is also based on the simulated key points, key parts and key processes of the construction site, and the stacking place of materials and machinery facilities on site to correct and optimize some problems in the planning process, such as pipeline crossings and process overlaps.

(2) The person in charge of production sends the weekly construction plan to each regional person in charge through the BIM platform according to the overall plan, and the regional responsible person uses various IOT collection technologies to upload the daily collected construction details, site progress, weather conditions, labor statistics, material usage conditions and other information related to progress on site to the BIM platform. Correspondingly, the BIM platform automatically analyzes and compares the actual progress status with the planned progress, suggests solutions and preventive measures for problems that may slow down the progress, analyzes whether the parts and process procedures need to speed up, and the project leader combines these opinions to prepare a plan for the next week's work progress. At the same time, the weekly assessment progress and daily progress are fed back to the total progress layer by layer to achieve real-time dynamic tracking of progress.

The auxiliary progress management of BIM Technology in this project is also reflected in assisting the owner to establish and improve a reasonable progress control system, assisting in setting the progress objectives of milestone nodes issued by the owner, and coordinating the preparation and approval of the progress plans of the owner and the construction enterprise. The BIM platform system automatically generates daily, monthly, quarterly and annual reports of the planned progress to achieve the purpose of dynamic tracking, analysis, early warning and adjustment of the whole process of project progress for the owner.

3.2.4 Cost Management Applications

(1) Construction and optimization of three-dimensional temporary facilities arrangement. The construction site of this project is relatively small. In order to ensure the convenience of construction and reduce the cost due to material transportation and mechanical facilities arrangement, BIM model is used to arrange the construction site in advance. Simulating construction conditions, determining the distance between the construction site and raw materials, and focusing on the arrangement of work area, living area, facility placement area, and raw material placement area, reduces additional handling costs while facilitating construction.

(2) Accurately calculate the amount of raw materials and receive the materials with a limit. The technicians use the uploaded BIM construction plan to create flowing sections so that the software can quickly and accurately

calculate the work content and volume of different flowing sections and accurately determine the detailed amount of each part. The actual construction personnel on site check the quantity of work according to the construction progress, and the cost engineers complete the work such as production value statistics. At the same time, you can query the corresponding project quantity from different ports, calculate the actual amount of raw materials used, and compare the actual amount with the planned amount. Timely adjust and arrange the plan and schedule to ensure that the consumption of raw materials is within the controllable range.

BIM technology can be used to quickly and accurately calculate the amount of various materials, so as to implement the quota for issuing and receiving various materials. At the same time, it adopts a combination of rewards and punishments to settle with the collaborative team according to the specified standards. When the actual amount of material consumption exceeds the standard, the excess cost will be borne by the collaborative team; when the material loss is reasonably controlled under the standard, the collaborative team will be rewarded according to a certain proportion, so as to urge the collaborative team to use the construction materials more efficiently and reasonably and reduce the material waste in the construction process.

3.2.5 Security Management Applications

In the pre-construction stage, according to the BIM model, determine the possible safety hazards of the engineering design and the possible conflicts during the construction process. Addressing safety hazards at the source. During the construction, relevant staff conducted regular safety inspections, and the project management team set up more than ten safety checkpoints to conduct regular inspections and identify relevant safety risks. According to the BIM platform information, inspection points are set up especially near high level hazards to prevent accidents, and the process of handling safety issues is similar to quality management, which will not be repeated here.

3.3 Project Benefits and Results

The project achieved the expected goals through the use of BIM technology. In terms of safety, the goal of no fatalities, serious injuries and minor injuries has been achieved. In terms of quality, it is better than the initially set goal of reaching qualified. In terms of progress, the project was completed 38 days ahead of the set schedule. In terms of cost,6.37 million yuan was saved compared to the original plan. The comparison table between the actual progress and the planned progress of the project is shown in table 1, and the comparison table between the actual cost and the planned cost is shown in table 2.

Table 1: The Comparison Between the Actual Progress and The Planned Progress (Unit: days)

Subprojects	The actual progress	The planned progress
Earthwork	54	63
Structural Work	126	139
Electrical Engineering	78	86
Water Supply and Drainage Engineering	84	92
Decoration Engineering	117	126
Exterior Project	33	39

Table 2: The Comparison Between the Actual Cost and The Planned Cost (Unit: yuan)

Subprojects	The actual cost	The planned cost
Earthwork	5,049,263.51	5,372,893.36
Structural Work	38,764,853.62	40,339,682.86
Electrical Engineering	37,468,231.54	39,727,685.31

Water Supply and Drainage Engineering	5,726,354.29	6,199,605.47
Decoration Engineering	34,638,251.46	36,979,284.35
Exterior Project	9,285,578.21	9,632,381.28

4. CONCLUSION

In general, BIM technology is mainly applied in four aspects of this hotel project management: quality, schedule, safety and cost. In terms of project schedule management, BIM is used to dynamically simulate the construction situation and prepare schedule plan in the pre-construction stage, and the information management platform is used to synchronize the site progress during the construction process, and weekly and monthly assessment are assigned according to the actual project progress to achieve dynamic control of the progress. In cost management, the BIM model is used to reasonably arrange the temporary facilities on site during the planning stage, link the actual project amount and other information to automatically summarize and calculate, and assist staff to calculate the cost and carry out the quota picking. In terms of quality and safety management, BIM simulation is used in the pre-construction stage to improve the design, eliminate unreasonable solutions in construction, eliminate quality and safety hazards, realize control and synchronous data sharing on the construction site through the docking of IOT facility port and BIM platform, determine whether there are quality and safety problems, and realize accurate tracking of project quality and safety problems.

APPENDIX

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