Application of BIM Technology in Construction Cost Management of Building Engineering

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Abstract. Construction cost management is one of the three goals in project management. The level of its management is directly related to the profitability of the company. In recent years, construction companies have put forward more accurate and refined requirements for cost management. The more traditional cost management methods are it difficult to deal with complex and changeable situations. Therefore, this article studies the application of BIM technology in construction cost management of construction projects is of great significance to the construction of Chinese enterprises. This article associates the cost plan with the schedule plan. The core is the component or the set of components. After completing the information association, the cost model is established. Finally, the earned value method is used to complete the control based on the good data support of the BIM-based 5D cost model. Time, space, and element dimensions fully control cost dynamics. With the help of BIM, this article can make up for the difficulty of data acquisition and easy to be affected by human factors in the earned value management method, and improve the earned value management process. This paper studies the latest BIM technology in the construction field, and explores the application method of BIM in cost management. Improve the information level of engineering project management, enhance the dynamic management of project costs, and improve the resource utilization rate of the construction industry. This paper uses BIM calculation software to convert the traditional CAD drawings into three-dimensional models, import them into BIM5D software, and manage them in detail during the construction phase. Its innovation is to use the three-dimensional building model to integrate various data information such as cost, schedule, information, and realize the sharing of data and various information. Research has shown that cost management has been simulated by BIM technology to achieve timely and accurate information support. In this process, the integrated control effect of schedule and cost can be fully utilized.

Keywords: BIM Technology, Construction Engineering, Cost Control, Earned Value Management

1. Introduction
The traditional cost management mode of the construction industry does not dynamically control the cost of each stage, it is difficult to achieve refined management, and cannot meet the current cost management requirements of the entire process. BIM (Building Information Modeling) technology, as an information product that conforms to the development of science and society, can play an important role at all stages. By optimizing project cost management, it can reduce the cost of the enterprise, increase the economic benefits of the project, and increase the company’s market. In the real sense, it solves the problems of over-standard and out-of-control costs caused by poor information communication, inability to update data, and inaccurate data in project cost management, so as to realize the cost management of the whole process of construction projects, reduce enterprise costs, and improve The economic benefits of construction projects promote the sustained and stable development of China's construction industry.

In recent years, the global construction industry has continued to develop and new technologies have emerged. BIM technology has been continuously recognized by industry insiders around the world. Various universities and societies have incorporated BIM technology into the scope of research. Ahmed, N, El directly imported CAD construction drawings into the engineering quantity calculation software to calculate the construction quantity, while providing a visual progress function [1]. Zhang Daiming conducts research on the application and development of the integrated framework for building structural design models based on BIM technology, and builds an information model integration framework system that mainly covers the building and structural design stages, for the development of the next generation of integrated building engineering software systems based on building information model technology Provide technical support [2].

This paper draws on the BIM model and cost management theory in actual engineering projects, prepares construction project cost plans and schedules, establishes BIM-based cost models, truly and accurately predicts, simulates, and controls construction cost trends, and uses cost models during project implementation. Supported by the data, mining the application value of the earned value method of differentiated routes, achieving the coordinated control of the production process and value generation, analyzing the actual application efficiency of BIM technology, and guiding the efficient production of construction projects.

2. Application of BIM Technology in Construction Cost Management of Construction Projects

2.1. How BIM Technology is Implemented in the 5D Cost Model
Generally, the breakdown structure of engineering projects can be divided into technical systems and project implementation processes. Since this article focuses on the construction phase, it mainly introduces the structural breakdown of engineering projects using technical systems. There are usually the following methods:

(1) Divided by product structure. According to the division of the internal structure of the product of the engineering project, taking the construction of the urban sewage treatment station as an example, the engineering project can be decomposed into sewage treatment structures, process auxiliary structures, auxiliary buildings, supporting projects and process pipelines. At the same time, it is necessary to pay attention to the combination of product direction and product production process in the process [3-4].

(2) Divided by professional elements. The realization of engineering project functions requires the cooperation of multiple disciplines, such as architecture, structure, water supply and drainage system, and power supply communication system.

(3) Divided by plane and spatial location. For example, there are a number of buildings and related structures connected to them in the station. The buildings are divided into different layers, different heights, and different sections [5]. At this time, the results obtained according to the project breakdown structure are not enough to support the application of BIM technology in cost management. This is not to say that the work breakdown structure does not play a role, but the decomposition level and detail level of the control elements of each project after the decomposition is
formed. They are all different, leading to the independence of different control elements, and breaking the internal connection between each control element.

2.2. Earned Value Management Indicators
An important function of the earned value management method is to predict the future cost of the project (Estimate At Completion, EAC), which refers to obtaining the cost situation at the time of the project report and estimating the total cost required to complete all subsequent workloads. This kind of predictive analysis has two functions, one is to remind the remaining cost of the project, to predict the final impact caused by the current cost changes, and the other is to remind the funds required for completion in order to arrange in advance [6-7]. The cost forecast when the project is fully completed is composed of the actual expenditure of the project and the predicted value of the future cost of the project. The forecast formula is:

\[ EAC = ACWP + \frac{BAC - BCWP}{CPI} = \frac{BAC}{CPI} \]  

(1)

Among them (Budget Cost At Completion, BAC) is the total budgeted cost of the project, which can be obtained from the cost budget before the project starts; it has the same meaning as the note given above, ACWP represents the actual cost of the completed work; BCWP represents the completed work. The cost of budget; CPI stands for project cost performance index [8-9]. From the experience of a large number of project examples, if the cost performance changes, the general trend will not be reversed. Therefore, the premise of predicting EAC is that the remaining current cost change trend of this hypothetical project is fixed and will continue to the end. In practical applications, EAC will have the following three variations:

1) When the CPI value = 1, the actual cost of the project is consistent with the budgeted cost, ACWP = BCWP and the prediction formula is transformed into:

\[ EAC = ACWP + BAC - BCWP = BAC \]  

(2)

2) On the premise of not changing the scope of work, the change of the CPI index becomes stable when the project progresses to 20%, and the final change range of the CPI value does not exceed ±0.10. When the BAC reaches 20% is selected as the reporting point, the total cost forecast formula is:

\[ EAC = \frac{BAC}{CPI_{20\%}} \pm 0.1 \]  

(3)

3) If the CPI value is getting smaller and smaller when the project progresses to 20%, the final CPI value will decrease compared with CPI20%. It can be seen that the total cost interval prediction formula is:

\[ EAC \in \left[ \frac{BAC}{CPI_{20\%}}, \frac{BAC}{CPI_{20\%}} \pm 0.1 \right] \]  

(4)

When the project reaches 20%, the BAC is adjusted according to the current CPI to predict the EAC. The method is simple and easy to use, and has a certain degree of reliability. It is suitable for construction projects with long construction periods and large investments [10]. In the process of project management, this method can be used to effectively predict the total cost, and it does not need to spend too much management cost, which has strong practical operability.

3. Experimental Research on BIM Technology in Construction Cost Management of Construction Engineering

3.1. Establish BIM5D Model and Work Breakdown Structure
To build and complete the 3D model, the task that needs to be completed is to load the cost information and schedule information into the 3D model. This is a very critical step. First, complete the association of the schedule information with the 3D model. Due to the large number of 3D model components, the 3D model of the project is huge. There are countless components. The one-to-one
association of components and progress information has been inefficient and impossible to achieve. Normally, all components are classified and the integration of the same type of component set (ie, the aforementioned work package) is completed and the progress information Associate, and determine the overlapping relationship and overlapping sequence between the component sets based on the construction process, and check and simulate the model to confirm that the model is accurate.

The specific operations are as follows:
1. Import the designed 3D model or the 3D model converted from CAD drawings into the software. The models include civil engineering model, steel bar model, electromechanical model, and site model.
2. According to the pre-set flow section, number of layers, component category and construction schedule to overlap.
3. Import the budget file into the software. The budget file needs to be associated with the component. The budget file is divided into contract budget and cost budget. The contract budget is the price when the construction party wins the bid, and the cost budget is the price set by the construction party based on its own real costs.

3.2. Preparation of Schedule Network Diagram and Cost Schedule
Indicate the project activities according to the serial numbers 1 to 10, followed by wall and pillar engineering on the first floor and ceiling engineering 1, paint engineering on the same floor as the second and third floors; the four-story wall and pillar engineering 7; and the ground engineering on the first, second and third floors. 8. Roof insulation project 9 and outdoor decoration project 10.

4. Application Analysis of BIM Technology in Construction Cost Management of Construction Engineering

4.1. Earned Value Analysis
Choose every four days as a test benchmark to collect and sort out the progress status and cost of the project activities. The performance status of the activities is expressed as a percentage. On the 12th day of the project, Activity 8 was completed on time, and Activity 1 and Activity 10 were not completed. Edit the earned value and actual cost of the decoration project at the end of the first 4 reference points as shown in Table 1 below:

| Evaluation index | Sub-project | Activity/day |
|------------------|-------------|--------------|
|                  | A,B         | 3            | 7685 | 11742 | 14982 | 1800 |
|                  | C           | 6            |      |       |       |       |
|                  | D           | 10           | 37467 | 52837 | 28370 | 37260 |
|                  | E           |              |      |       |       |       |
|                  | F           |              | 31980 | 25320 | 28390 |       |
|                  | ACWP        |              | 79430 | 168320 | 237560 | 262340 |

Calculate the progress deviation of the project activities in each week. The overall project progress performance indicators SPI are: 1, 1, and 0.87. The project progressed in the first 3 cycles according to evolution and the execution was in good condition. The progress was slightly lagging behind in the fourth week. The activity progress indicators SPICK on the route are: 1, 0.91, 0.95, 0.84. The management team analyzed that the project was carried out in an orderly manner in the first three weeks of the project. In the fourth week, the activity progress on the key route was lagging. The cause of the delay is weather, but it is not an unsolvable problem. In essence, it is caused by failure to pay attention to construction preparations, blindly seeking quickness, and failing to consider the risk factors in the construction process. If the situation is allowed to develop, the decoration engineering task It is possible to postpone the completion, and strengthen overall coordination during the
subsequent construction process to ensure that the activities are carried out strictly as planned, and the person in charge of the construction site is responsible to the management team.

Calculate the cost deviation of the project activity in each week. The overall cost performance index CPI of the project is: 0.89, 0.92, 0.93, 1.01, and the cost is slightly different. The cost performance index CPICK of the activities on the key route is: 0.99, 1.05, 1.03, 1.02, it can be seen that the cost deviation on the key route is well controlled, and the cost efficiency reaches the expected goal. The experimental results are shown in Figure 1.

![Figure 1. Reference point ACWP calculation diagram](image)

After calculating the overall cost performance index CPI of the project in the next three weeks is 0.93, 0.92, 0.91, the cost deviation is well controlled, but the actual cost still needs to be reduced. The activity cost performance indicator CPICK on the key route is 0.98, 0.97, 1.04, and the cost deviation CV is +0.3700 yuan, mainly contributed by non-critical route activities 8 and 10 after strict procurement control. During this period, we will strengthen communication with material suppliers, order bulk orders to reduce procurement prices, and try to establish long-term cooperative relationships. After four weeks of material procurement management and control, the cost was significantly reduced. At the same time, the material supply list provided by the BIM model set a quota for picking materials, requiring on-site construction personnel to use limited materials to complete the construction tasks.

4.2. Project Performance Control Analysis

Comprehensive analysis, in the first 3 weeks of the decoration project, the cost and schedule were not well controlled. After the earned value analysis of the key route, the source of the problem was determined and the solution was taken to solve the cost deviation and schedule deviation in a targeted manner, and the project performance control chart was compiled. The trend is shown in Figure 2.
Figure 2. Project Earned Value Control Index

Cost management is simulated by BIM technology, realizing timely and accurate information support, simulation of cost planning, consistent coordination of the actual cost incurred process, and efficient and concise data analysis afterwards, which greatly reduces the inability of cost control in the past. BIM support the earned value method of route differentiation also allows the cost control process to have a clearer focus and core, in which the integrated control effect of schedule and cost can be brought into full play.

5. Conclusions
This article explores the BIM-based cost decomposition, cost plan, schedule plan and other content preparation ideas and methods. Only the above-mentioned basic component cost model can be established and completed, providing a solid foundation for cost control. This article uses Glodon’s BIM5D software to establish a 5D cost model, combined with the earned value method of distinguishing routes to complete the schedule cost integrated control practice, which can more accurately control the cost deviation and schedule deviation during the project implementation process, and has a good early warning control effect and correction Measures can also meet expected control requirements.

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