Application of BIM Technology in Cost Control during the Stage of Production and Transportation of Assembly Building

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Abstract. Green building has become an important evaluation criterion for house construction. Prefabricated buildings are an effective means to achieve the goal of green building. However, the high cost during the construction process hinders the popularization and application of prefabricated buildings. Based on the current research, Building Information Modeling (BIM) Technology is an advanced technology in the construction industry, which has high efficiency in cooperation with prefabricated buildings. Based on BIM technology, it has better development in cost control of prefabricated buildings. Compared with traditional buildings, it has fast construction speed, high safety level, environmental protection, and other advantages. This paper analyzes the cost of influencing factors in the production and transportation stage, and establishes the cost management process of prefabricated buildings based on BIM technology. It analyzes the application of BIM technology from cost control, cost accounting, and cost analysis at this stage and finally verifies the feasibility of cost management based on BIM technology by taking a prefabricated building as the research object.

Keywords: prefabricated building, BIM technology, cost control, production and transportation stage.

1. Introduction
In the Fifth Plenum of the 19th Central Committee of the Communist Party of China, it was emphasized that the new development concept of innovation, coordination, greenness, openness, and sharing must be firmly implemented. Nowadays, green building has become an important evaluation criterion for house construction. The high energy efficiency of traditional buildings has led to the transformation and upgrading of construction at this stage. Prefabricated buildings are an effective means to achieve the goal of green buildings. Prefabricated buildings are essentially rapid construction projects. Compared with traditional buildings, they have the advantages of a short construction period, better construction efficiency, and good construction quality. However, the high cost during the construction process hinders the development of prefabricated buildings. BIM technology is widely used in the field of building construction and has significant advantages in building simulation, optimization, and cost management. By using the digital, information and systematic characteristics of
BIM Technology, we can complete the monitoring of the project construction process, optimize the construction scheme, improve the construction efficiency and reduce the construction cost.

2. Overview of prefabricated buildings

2.1. Prefabricated Buildings

Prefabricated building refers to a building form in which prefabricated components are first produced through a prefabricated component factory, then transported to the construction site, and assembled and hoisted through different connection methods. It has the advantages of a short construction period, energy-saving and environmental protection, and so on. The development of prefabricated buildings conforms to the concept of green sustainable buildings stipulated by our country and is an effective way to realize buildings' industrialization. Prefabricated buildings can be divided into three structural systems according to different structural types: prefabricated concrete system, prefabricated steel structure system, and prefabricated wood structure system.

2.2. BIM technology

Science and technology are the primary productive forces. The development of industrialization has begun to enter the information age. Information technology has shown its extremely high application value from all walks of life. The development of building industrialization has encountered many problems that require information technology to solve. BIM is a platform for big data sharing, with features such as visualization, simulation, and collaboration. BIM Technology is derived from the concept of life cycle management, which significantly improves the design efficiency of assembly architecture designers and breaks the limitations of two-dimensional design. Moreover, the data-sharing platform provided by BIM Technology is an excellent way to solve the whole process management of construction, and it also promotes the development of architectural design and the development of high-tech information technology of prefabricated buildings. During the life cycle phase of construction projects, all parties can obtain data information and process data through the BIM platform and can update and share data in real-time, and through the BIM model, they can work on each stage of pre-construction planning, design procurement, production and transportation, construction and operation and maintenance.

3. 4M1E cost influencing factors analysis

4M1E refers to the five elements of man, machine, material, method, and environment management.

Man: (i) Labor costs: labor costs in the production costs of prefabricated components accounted for a large proportion, to a certain extent, labor costs affect the production costs of components, with the aging of the social population, people's living standards continue to improve, labor costs are also rising significantly. (ii) The basic quality of production personnel: in the production process of components, personnel is directly involved in the production of components, so whether the production process is standardized and the basic quality of production personnel directly related, high-quality personnel in the production process will be the quality of components, the use of materials to be well controlled, will save production costs; And the construction method is not appropriate, the immature technical personnel will increase the production cost. (iii) Labor efficiency of production personnel: The higher the labor efficiency of the production personnel, the shorter the time used for component production, which will save time and speed up component production, thereby saving component production costs. (iv) Component stacking and protection: In addition to determining the quality of the component during the production process, it will also be affected during transportation and stacking. If the personnel protect the component adequately, the production cost of the component will be saved.

Materials: (i) Raw material prices: steel, concrete and other prefabricated components in the total cost of the price of a relatively large proportion, about 25% to 50%, the same, a variety of materials affected by the market fluctuations are relatively large, the total cost of component production is
relatively large. (ii) Material utilization rate: The higher the utilization rate of the material, the more the material is saved, and the lower the production cost will be.

Mechanical: (i) Equipment utilization rate: The main influencing factors of the equipment utilization rate are flow rate and organization plan. Proper preparation of the organization plan and flow rate will increase equipment utilization and avoid resource waste caused by idle equipment. (ii) Mold cost: The cost of the mold is related to the splitting and standardization of the pre-designed components. The more complex the types of prefabricated components, the more molds will be, and the higher the mold cost will be. (iii) Selection of vehicles: Choose a reasonable transportation vehicle according to the weight and length of the prefabricated components.

Methods: (i) Production process selection: according to the characteristics of different components to choose different process combinations of production methods, different processes, production efficiency will be different, will have different effects on the components. (ii) Secondary handling fee: The transportation stack location depends on the construction schedule to avoid costs due to the secondary handling. When the secondary handling is unavoidable, the number of components and the transportation distance determine the secondary handling's increased cost. (iii) Component maintenance methods: The maintenance methods include heat storage maintenance, steam maintenance, and sprinkling moisture maintenance. Different maintenance methods are selected according to the construction progress and weather conditions, and the costs caused by different maintenance methods are also different.

Environmental aspects: Transport routes: the choice of transport routes and factories and site distance, transport conditions, the higher the distance of transport costs, while the road conditions on transport efficiency also have a certain impact, poor road conditions will produce more material loss and increase transport costs.

4. Cost management process of prefabricated construction based on BIM technology

4.1. Cost control based on BIM

(1) Control of production cost

The main difference between prefabricated buildings and traditional buildings is the different production methods of components. Prefabricated buildings are prefabricated in factories, while traditional buildings are produced on-site. At present, our country's prefabricated building standards are not perfect. In the process of prefabricated building construction, prefabricated components account for a large proportion, and there are many types of molds. This shows that the material control in the production stage significantly influences the cost control at this stage. The production of prefabricated components can be divided into three stages according to the production process: preparation stage, production stage, and storage stage. Preparation stage: The preparation stage is mainly to determine the various types and quantities of prefabricated components. Through the statistics of the BIM information platform, you can find the usage of various materials, suppliers and other information, refer to this information, select the appropriate supplier, and complete material procurement work. In this way, mistakes made by small details neglected in the production process can be avoided in the early stage, thereby improving the product quality and productivity of components.

Production stage: Various components have been classified in the design stage, so various molds are selected in the production stage, and various information is passed into the production system to form mechanical identification information, and the component production is carried out through the production system. The prefabricated component factory's production system will monitor each component's production process and warn if there is a failure so that the staff can check and repair and deal with various failures in time. At the same time, during the production process, the production system will make various records, such as the production time of the components, the actual consumption of materials, and the number of production components.
Storage stage: This stage combines RFID (Radio Frequency Identification) technology based on BIM application. Each component has a corresponding chip when it leaves the factory. Later, the component information can be obtained by identifying the chip, and the real-time status of the component can be inquired. All component information is uploaded to the BIM platform to provide a basis for managing component production, transportation, hoisting, and other processes.

(2) Control of transportation costs

The transportation cost mainly includes the transportation cost of the prefabricated components from the factory to the construction site, the storage cost of the prefabricated components, and the secondary transportation fees caused by improper storage. Because of the large number of prefabricated components, the cost of transportation is relatively high. A reasonable transportation plan has a direct impact on the cost of prefabricated buildings.

The cost control in the transportation stage is mainly the choice and optimization of transportation scheme. Before transportation, BIM technology is used to simulate the loading, transportation route, site placement, and load limit of the components' road route. By optimizing transportation schemes and routes, problems can be avoided, and transportation costs can be reduced. Select the optimal transport vehicle and loading scheme by the type, weight, and height of the prefabricated components; According to the BIM technology, the production and transportation are combined with the construction site installation schedule to reduce the cost of components stored on-site, and the optimal unloading location is selected to avoid secondary handling. The data of the BIM platform makes the information of components in each stage of production and logistics transportation clearer. In this stage, the application of BIM Technology makes everything standardized and orderly, which provides technical support for the industrialized production and information management of prefabricated components.

4.2. Cost accounting based on BIM

Because the process of prefabricated buildings is complex, it takes much energy to use traditional accounting methods, which may lead to miscalculation and omission, etc., so BIM technology is introduced to conduct accounting management. All kinds of payments will be recorded in the BIM information platform, and the project quantity information and material use information will be stored in the BIM model. After completing the stage or the project, the information in BIM5D will be used for direct cost accounting. Cost accounting through BIM technology not only improves work efficiency, but also makes the results more accurate, avoiding the problems of traditional accounting methods.

4.3. Cost analysis based on BIM

The project cost analysis uses the project cost accounting data to systematically analyze the cost formation process and the factors that affect the cost rise and fall, to find an effective way to reduce costs. Using BIM technology analysis of cost, schedule, and other information, help to strengthen project management, reduce the risk resistance ability of the project, cost analysis necessary process is: the use of BIM technology to establish a model, the actual cost to carry on the statistics and summary, and were compared with planned cost and contract cost, detailed calculation and analysis, and then through the method of earned value cost deviation analysis, the final cost of rectification. Besides, useful cost management methods can be saved in the BIM platform, which lays a good foundation for other engineering projects and subsequent cost management work.

5. Application of BIM Technology in Cost Control in a Precast Building

5.1. Case overview

Building No. 13 in a residential project adopts a prefabricated shear wall structure with a building area of 10290.95 square meters, of which the above-ground building area is 9420.33 square meters, with a total of 29 floors from minus 2 to 27. Apply BIM technology to the cost of prefabricated buildings,
and use BIM technology in the production and transportation stage to verify the effectiveness and practicability of BIM technology for cost control of prefabricated buildings. This project list pricing is based on the calculation of the engineering quantity, and the contract is affected by it and is not affected by other factors.

5.2. Cost management during production and transportation

The components' production quality directly affects the quality and schedule of the construction and further affects the cost. It is necessary to consider and analyze the personnel, materials, equipment, methods, and environment. The BIM platform provides various information about the prefabricated components, such as the size of the steel bars, the pre-embedded location, etc. Therefore, the information in the BIM platform is used to guide the prefabricated component factory to produce the prefabricated components, so that the component production is orderly and the information is appropriately managed. At the same time, each prefabricated component is coded with RFID technology, and the status of the component can be inquired in real-time by scanning the code. In the material procurement stage, the BIM platform is used to generate the required material list. The optimal material supplier is selected in the database, and the purchased quantity and other information are recorded in the BIM platform to facilitate a real-time understanding of the usage and inventory quantity. A solid foundation has been laid for the development of follow-up work. BIM technology can summarize and analyze the daily completed workload, convenient for making the next plan, reducing the cost of material stacking, improving production efficiency, and ensuring construction efficiency. The information provided by the BIM platform during the construction phase of this project can save about 110,000 yuan in production costs.

After the component production is completed, check the shape, quantity, quality, and other information of the prefabricated component through the BIM model to simulate the transportation, and then conduct the actual survey of the route, select the optimal transportation tool and transportation route, and arrive at the construction site. When unloading the components, they must be stacked in strict accordance with the layout plan, reducing secondary mixing, reducing project costs, and saving transportation cost about 50,000 yuan.

6. Conclusion

One of the critical reasons restricting prefabricated buildings' development is that the cost of prefabricated buildings is too high. The cost of component production and transportation is one of the main components of prefabricated buildings' cost. Through effective control of the cost of various stages of component production and transportation, the cost of prefabricated buildings is reduced. At the same time, it actively responds to the national development strategy and promotes the development of prefabricated buildings in China. Besides, the introduction of BIM technology into the management of prefabricated buildings makes the whole process of prefabricated buildings visible and more refined, and the prefabricated buildings will develop faster at the cost management level.

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