Research on cost management of prefabricated construction based on BIM

Zhen Wen1, Hanxi Zhang1*

1 Chongqing College Architecture and Technology, Chongqing, 401331, China
*Corresponding author’s e-mail: fangdichanxueyuan@126.com

Abstract. In recent years, prefabricated construction has been widely concerned with its significant advantages of high efficiency, environmental protection and energy saving. However, the prefabricated construction in China is in the initial stage, with more theoretical research than practical cases. Even with strong policy support, the development of prefabricated buildings is relatively slow. There are many reasons for this. The main reason is that the cost of prefabricated construction is too high for most developers to bear. This paper attempts to study the effect of BIM Technology on the whole process of cost management, aiming to solve the problem of cost compression in the implementation stage of prefabricated construction project and overcome the bottleneck of prefabricated construction development.

1. Introduction

With the characteristics of low energy consumption, green environmental protection and sustainable utilization, prefabricated construction has become the highlight and representative of the industrialization transformation of construction industry in China. From the perspective of environmental protection, it protects the environment and is conducive to sustainable development; from the perspective of consumers, it has good durability and high safety; from the perspective of investors, it has high economic benefits; from the perspective of practitioners, it has improved working environment and increased employment opportunities. Although the government has issued many policy support, China is still in the transition period from the traditional construction industry to the new construction mode. From the perspective of the pilot, the market response is not optimistic, and many problems have been exposed, among which economy is a very important factor. Compared with the traditional construction mode, prefabricated construction increases the cost of construction process such as component production, circulation, assembly etc. The cost increase also limits the development of prefabricated construction. Applying BIM technology to whole process cost management of construction phase of prefabricated construction, this paper aims to direct the cost management of construction stage of prefabricated construction, which reduce the incremental cost of construction stage and realize the effective control of project cost through the advantages of BIM Technology such as visualization, simulation and information sharing, which can effectively promote the development of prefabricated construction. [1].

The whole process cost management runs through the whole process of decision-making, planning, design, construction and operation of a project. The whole process cost management of construction project strives to control the project cost within the limit, correct the deviation, ensure the realization of project objectives, and achieve better economic and social benefits. For prefabricated constructions, it is very important to analyze the influencing factors of the whole process cost management in the construction stage of prefabricated buildings for reducing incremental costs and promoting. Due to the
different production methods of the prefabricated building and the traditional construction mode, the composition ratio of the two is different. The cost composition during the construction of prefabricated buildings mainly includes: design cost, production cost, transportation cost, and installation cost. Prefabricated buildings need to control the cost from the design stage, take the prior control as the starting point of design, so as to reduce the production cost, transportation cost and installation cost of components, continuously improve the level of prefabricated construction, improve the construction technology, and then realize the cost management of prefabricated buildings. The whole process cost management of prefabricated buildings takes the time of prefabricated building formation as the main line, which refers to the whole process from project establishment to completion and later evaluation. This paper studies the whole process cost management of prefabricated construction from the four aspects of component design, production, transportation and installation [2].

2. Whole process cost management of prefabricated construction

2.1. Design stage
Cost management in the design stage is mainly concentrated in two parts: preliminary design cost and in-depth design cost management. The preliminary design cost refers to the construction plan and BIM modelling design cost. In addition, compared with the traditional cast-in-place method, the design of prefabricated construction has one more progress of detailed design. This is due to that the prefabricated construction is composed of prefabricated components. In the design stage, the type of all components, production technology, equipment model, layout location, disassembly scheme and other factors should be considered clearly. Generally speaking, in order to install it conveniently and quickly, in addition to professional disassembly and assembly of components, it is also necessary to consider disassembly and assembly according to floors. This part is very important, which will affect the progress of the whole project after establishing the BIM model in the later stage. Therefore, at this stage of in-depth design, designers should consider the types and specifications of components, strive to standardize the design, and reduce diversity as much as possible, which is more conducive to cost management.

2.2. Prefabricated component production stage
A major feature of prefabricated buildings is that the factory production of components produced in some component factories is carried out indoors, and is not affected by climate and season. Once there are quality problems or quality defects, they can be solved in the production process. In this way, the quality of components can be effectively guaranteed, the rework after on-site installation can be reduced, the waste of materials can be reduced, and the construction efficiency can be improved. But in reality, the cost of prefabricated construction is much higher than that of cast-in-place. Because China’s prefabricated construction is in the early stage, the number of prefabricated component factories and its scale are small. The cost of building a component factory is relatively high, and a large amount of mechanical equipment needs to be invested in the initial stage of the factory. In addition, the daily operating expenses of the enterprise will be converted into the cost of prefabricated components. Therefore, when the market demand is not saturated, it means that the cost of each component is shared with the high input, and the construction cost is greatly increased, resulting in an increase in the overall cost of prefabricated construction. Therefore, only when the prefabricated building volume is large enough, the amortization cost of prefabricated components will decline, also the overall cost will decline.

2.3. Transportation stage
Transportation is a necessary link for prefabricated components to enter the construction site from the warehouse. The transportation cost mainly includes the labor cost of loading and unloading vehicles and the cost of distribution and transportation. Transportation cost is related to transportation mode, route, distance, number, type, weight and shape of components. At present, the main problem in the
The transportation stage of prefabricated buildings is that there is no standard for prefabricated components, which leads to different sizes and specifications of components. Moreover, due to the small size of the prefabricated construction, the transportation departments lack the knowledge about the transportation of prefabricated components or have not formed a professional transportation plan, resulting in low transportation efficiency and high cost. At present, the cost management at this stage is mainly focused on preparing the transportation plan in advance, loading the truck according to the shape and size of the components and the installation sequence of the components, and transporting them to the construction site in a reasonable time to improve transportation efficiency and economic benefits.[3]

2.4. Construction stage
The on-site installation of prefabricated components is one of the core technologies in the prefabricated construction stage. This part of the cost mainly refers to the cost of hoisting components, installation labor costs, special construction machinery costs and measures costs[4]. China's construction enterprises have not their own construction workers, meanwhile workers' skill training lags behind the production technology. The prefabricated construction is in the early stage of development, and the installation workers are not mature. Therefore, there are large unstable factors in the on-site assembly efficiency of components, and there are many links in the entire process from design to installation, which will also affect the construction efficiency and economic benefits of prefabricated constructions [5].

3. Cost management of prefabricated construction based on BIM
BIM Technology is capable of establishing digital model by creating project information database, and simulates, inspect and optimize the whole process of project design, component production, transportation, construction, installation and operation. BIM Technology has the advantages of establishing visual three-dimensional model, cooperating with the construction parties, simulating the construction process, and optimizing conveniently and quickly. BIM technology applied to cost management method of prefabricated construction can adopt the accurate control in the early stage to continuously optimize the plan; strictly control the cost during the event and timely engineering changes; compare and analyse after the event to manage cost for the whole process.

3.1. Design stage
The cost management in the design stage emphasizes the quota design, that is, the investment quota in the approved commencement report is the upper limit of the design cost, and the cost management is added in the preliminary design, construction drawing design and professional design. The design stage is a crucial part of the whole process cost management of prefabricated construction. The specific work can include the following aspects:

3.1.1. Pre-control: By using BIM technology to optimize the three-dimensional model in the design stage, real-time control and modification of the project can be realized more effectively, and the cost control of the project can be better realized. Using BIM Technology to effectively control the engineering changes in the construction stage, and truly realize the effective cost management.

3.1.2. Construction progress control: Realize 5D management of construction projects by using BIM digital technology. During the construction process, select the construction node or time period to detect the planned cost and actual cost of the project at any time, analyze the cost difference, and facilitate the correction of deviations at any time, and realize the cost management of the whole process.

3.1.3. Measurement of quantities: In the design stage, the designer will design according to national norms and standards. The introduction of BIM technology can quickly retrieve effective design
parameters from the BIM database, and implement quota setting in conjunction with design specifications, thereby ensuring cost reduction in project design and construction.

3.1.4. Cost management: Use BIM technology to simulate construction and construction progress, and calculate BCWS and BCWP at any point in time or time period. Analyse and compare with the owner's budget and limit control. Costs are calculated in a regular and planned manner, deviations are discovered in time and reasonable measures are put forward to correct them, so as to achieve dynamic control of the cost.

3.2. Production component stage
According to the design results in the design stage, the component production processing drawings and model pre-made tables can be produced. The model is established by using BIM detailed design drawing, and the data in the information database is injected into the precision of the detailed component. In the production stage, due to the data sharing of the model, manufacturers can extract component information accurately and quickly, which improves the efficiency of component production. Compared with traditional plan drawings, BIM 3D models can more intuitively show design intent and component details to production personnel. To avoid the production delay caused by the time difference of information transmission, it brings convenience to the communication between designers and production personnel. When the components are produced, the BIM model is used to design the mold to display the specifications, shape, size, strength requirements and the position of the embedded parts in three dimensions, which provides convenience to the manufacturers. The use of BIM model information database enables manufacturers to fully understand component information, prepare raw materials and technical support required for production, realize the intensive management of component production, and reduce the cost of the production stage.

3.3. Transportation stage
In the traditional construction mode, the cost control of transportation stage is simple and clear. In the transportation stage of prefabricated construction components, the economic cost and time cost will be generated due to the factors of transportation mode, route, specification and size, which will affect the fluctuation of transportation cost. The ideal situation is to choose the most convenient and safe route in punctual and timely time, and transport the prefabricated components to the construction site at the lowest cost. And BIM technology has a positive effect on realizing transportation modernization, informatization, and intelligent management, and realizing effective cost management in the transportation stage.

In the component transportation stage, the most favourable transportation route should be selected in priority. The transportation route refers to the assembly of various grades of highways and urban roads with a certain length, direction and quality standards for vehicle operation. The visualization and simulation characteristics of BIM Technology are conducive to the establishment of three-dimensional digital terrain model in the engineering area. By simulating the relevant road condition information of the transportation link, combined with the component specification data information, the most suitable transportation route is selected. BIM Technology can also be combined with RFID technology to record the component information and vehicle information, optimize the transportation route in time according to the road conditions, complete the transportation process more efficiently, and realize the cost management in the transportation stage.

3.4. Construction stage
Compared with traditional construction methods, prefabricated construction has higher technical requirements for hoisting machinery and construction techniques during the construction stage. Reasonable layout of construction site plays an important role in assembly speed and cost. BIM Technology can realize the visual management of the construction site, whether it is the plane layout of the construction site or the safety channel set according to the requirements. Using the simulation of
BIM Technology, it can organize simulation construction at the construction site according to the construction plan and specification requirements, and conduct collision detection on the routes of large construction machinery and construction vehicles, optimize the placement of roads and equipment at the construction site, optimize the assembly process and construction procedures, grasp the technical key and difficult links, make risk warnings and safety warnings, and check and prevent hidden dangers. It can also simulate different construction schemes for comparison, so as to improve the project progress and improve the effectiveness of cost management in the project implementation stage. The cost management of the project construction stage is roughly divided into three aspect:

3.4.1. Process calculation: the BIM Technology construction management software can be used to set the model and unit time, calculate the unit time quantities, and technically improve the cost progress and enhance the efficiency of project management according to the actual needs of the project construction. At the same time, through the software calculation function, the project progress and cost operation status can be searched randomly; On the other hand, resource requirements can be calculated based on the engineering quantity, and reliable data is provided for the resource demand plan based on the capital revenue and expenditure plan output within the planned time; finally, the BIM model integration and the storage of the calculation data are simple and easy to find. For instance, when performing single subcontract settlement, click the subcontract area to quickly view the subcontract and related payment records.

3.4.2. Process changes: In engineering changes, the use of BIM technology simplifies the complexity of design changes. The correction of the model will become faster for the use of the software, and the use of the software also drives the automatic adjustment of the engineering quantity. BIM model is applied to the project management process, which can quickly find the changes of management and construction schedule, and take countermeasures to reduce the cost loss, for example, whether the changed parts need to be adjusted, or whether the purchase plan can be stopped for the unnecessary materials. The change data will be automatically stored.

3.4.3. Process Pricing: according to the characteristics of process pricing and the specification requirements of bill of quantities, the BIM model is improved and supplemented to generate bill of quantities. Then, the comprehensive unit price of the sub items is calculated by referring to the sub items of the bill of quantities, combining with the market price information and enterprise quota and other relevant data to form the total project cost. All the relevant cost information is summarized into BIM model, and finally the project cost information model is generated. It is also possible to incorporate the relevant content of the contract into the model, so that the cost-related work such as later project construction and completion settlement can be carried out based on the project cost information model.

4. Conclusion
This paper studies the cost management of prefabricated construction based on BIM, and analyzes the role of BIM technology in the cost management of prefabricated construction in the construction stage; this paper puts forward the cost management scheme based on BIM Technology in the four stages of prefabricated building aiming at the cost management and control problems in the four stages of design, production, transportation and construction in the process of building stage of prefabricated construction. Effectively improve the problem of cost management and control in the whole process of prefabricated construction, which enable to make prefabricated construction be better promoted and developed.
Acknowledgments
Authors wishing to acknowledge assistance or encouragement from colleagues, special work by technical staff or financial support from organizations should do so in an unnumbered Acknowledgments section immediately following the last numbered section of the paper.

References
[1] Hyung Keun Park, Jong-Ho Ock. Unit Modular In-Fill Construction Method for High-Rise Buildings[J]. KSCE Journal of Civil Engineering, 2016, 20(4): 1201-1210
[2] Marianna Marchesi, Dominik T. Matt. Design for Mass Customization: Rethinking prefabricated Housing Using Axiomatic Design[J]. Journal of Architectural Engineering Technology, 2017, 23(3): 05017004-1-05017004-20.
[3] Franco K.T. Cheung, Jonathan Rihan. Early stage multi-level cost estimation for schematic BIM models[J]. Automation in construction, 2012, (27): 67-77.
[4] Ajibade Aibinu, Sudha Venkatesh. Status of BIM Adoption and the BIM Experience of Cost Consultants in Australia[J]. Journal of Professional Issues in Engineering Education and
[5] Ahmad Jrade, Julien Lessard. An Integrated BIM System to Track the Time and Cost of Construction Projects: A Case Study[J]. 2015, (2015), Article ID579486, 10 pages