

# Study on the Cost Control of Construction Engineering Project Based on BIM

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**ABSTRACT:** For a construction engineering project, the management of cost control is the most important thing and it throughout each part of the construction engineering. Effective cost control of engineering project can bring great benefits for engineering project in terms of economy, but with the improvement of people's requirements in buildings' function, appearance and comfort, the additional information on the construction project is growing, especially for some large-scale projects, there are more construction units, long construction period and large amount of information. Using the cost control of traditional model can lead to workload and can easily lead to loss of control, resulting in unnecessary waste. In this paper, on the basis of reading a lot of literature and referencing previous research results, a project is regarded as a study object. It combines the cost control and BIM technology to analyze the different roles of BIM technology at the different stages of engineering project. Through comparing with the cost control of traditional mode, it illustrates the advantages of BIM technology. Finally, it concludes the application status of BIM technology in the current engineering project cost control, hoping to strengthen the combination of BIM technology and engineering project cost control.

**KEYWORDS:** Cost control, Engineering project, Bim technology.

## INTRODUCTION

In 2002, in the essay of comparison between apples and oranges, Jerry Laiserin firstly proposed the term of Building Information Modeling, and had been widely recognized by the industry [1]. In 2011, the chapter about BIM in "Government Construction Strategy" document released by British Cabinet Office expressly requested that to achieve a fully collaborative 3D • BIM in 2016, all the documents will also be information management [2]. Currently, more than half of the construction projects start to use BIM technology in USA. In Britain, the starting of BIM technology is later than that in USA, but the British government has begun to force people to use BIM technology. In recent years, along with the impact of the foreign construction market and the promotion of national policy, many large domestic enterprises have begun to explore BIM technology actively, thereby enhancing the international competitiveness. Some enterprises even set up professional BIM teams, advancing in exploration, and have achieved some results<sup>[3]</sup>. BIM technology not only brings technical upgrading, but also indirectly affect the production of organization models and management methods, and will influence people's ways of thinking in a longer-term [4].

Based on the above studies, through comparing with the traditional cost control model, this paper analyzes the different roles of BIM technology in different stages of construction.

## RELATED PRESENTATIONS OF BIM

### Overview and Technical Features of BIM

Building Information Modeling, BIM establishes the building information modeling based on the various relevant data of construction engineering project, and it imitates the real information possessed by the buildings through digital information simulation. It has the following characteristics (Shown as Table 1).

## CASE STUDY

### Introduction of the Project

Project A has 24 floors, the building area is 10979 m<sup>2</sup>, the ground construction is divided into two parts, which are commercial buildings and residential buildings, the height is three meters, and the 2 underground floors are

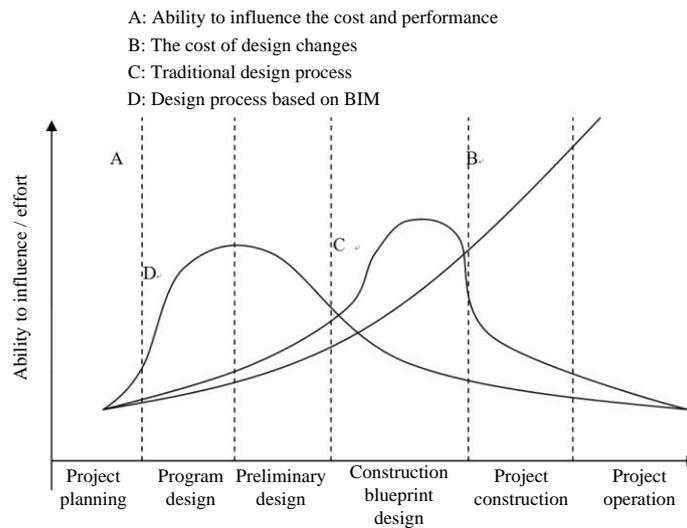
**Table 1.** The technical features of BIM.

<b>Parameterization (digitization)</b>	<b>BIM models are presented in digital forms, the components in models can be expressed in the forms of parameters.</b>
Visualization	It can simulate and design a building model, and it can also simulate things that can not be operated in the real world.
Simulation	To show up the line-type components of the previous blueprints through the three-dimensional stereoscopic physical graphics.
Optimization	BIM model provides geometric information, physical information, and regulation information, it also can provide the actual existence of the building after changes, which can timely optimize the design of the construction program.
Characteristic of plotting	BIM can use 3D technology to carry out visual display for buildings, after the visual display, simulation and optimization, the sophisticated blueprints and programs can be provided to owners.

underground buildings, the rendering is shown in the following Figure 2.

### Advantages of BIM

The differences between BIM design process and traditional design process is shown as Figure 1.



**Figure 1.** Differences between BIM design process and traditional design process.



**Figure 2.** Project rendering.

Application of BIM Technology in Various Stages of the Construction Project

(1) Investment decision-making stage. Project decision-making is a process to select the investment program, the reasonable or not of the decision directly affects the construction success or failure of the project, according to the statistics of relevant materials, the influence of investment decision-making stage to the project cost is up to 80%-90% [5], so right decision-making is the premise of project cost control.

In this stage, using one of BIM software functions-components operational nature, connects the project programs and financial analysis tools by BIM model, modifies the parameters and obtains the investment earnings indicators of each project programs real-timely, through the rough 3D BIM proposed construction project model drawn by 2D plane blueprint, quickly extract and gather the total project amount data, combining with related earnings indicators, in the situation of without blueprint and precise BIM model, estimate the cost information of the proposed project.

In this project, the first and second floor are for commercial buildings, the third to twenty-fifth floor are residential buildings, the twenty-sixth floor is the engine room floor, when estimating, the whole project can be simplified as G1 public buildings, G2 public buildings, residential standard floor and engine room floor, and build four BIM models, through BIM construction project model, using the engineering quantity summary function of the software that comes with itself, it can easily summarize the project's construction area information. The export table of each floor of project A is shown as Table 1.

**Table 1.** Export table of each floor of project A.

Which floor	Construction area (m <sup>2</sup> )	Height of the floor (m)	Standard height of the floor (m)
Third floor	451.325	3.000	10.920
Fourth floor	453.625	3.000	13.920
Fifth floor	455.925	3.000	16.920
Sixth floor	455.925	3.000	19.920
Seventh floor	455.925	3.000	22.920
Eighth floor	455.925	3.000	15.920
Ninth floor	455.925	3.000	18.920
Tenth floor	458.225	3.000	21.920
Eleventh floor	458.225	3.000	24.920
Twelfth floor	458.225	3.000	27.920
Thirteenth floor	458.225	3.000	30.920
Fourteenth floor	458.225	3.000	33.920
Fifteenth floor	458.225	3.000	36.920
Sixteenth floor	458.225	3.000	39.920
Seventeenth floor	458.225	3.000	42.920
Eighteenth floor	458.225	3.000	45.920
Nineteenth floor	458.225	3.000	48.920
Twentieth floor	458.225	3.000	51.920
Twenty-first floor	458.225	3.000	54.920
Twenty-second floor	458.225	3.000	57.920
Twenty-third floor	458.225	3.000	60.920
Twenty-fourth floor	458.225	3.000	63.920
Twenty-fifth floor	458.225	3.000	66.920
Twenty-sixth floor	458.225	3.000	69.920
Total		10979	

After obtaining the summary table of construction area, according to investment earnings indicators, the initial investment estimates can be successfully completed. Market economic information is shown in Table 2.

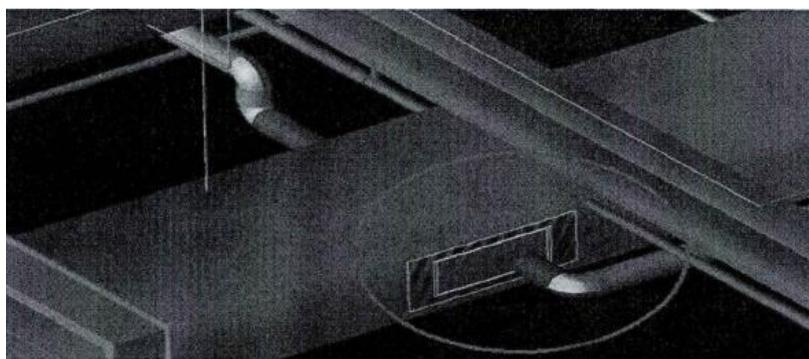
**Table 2.** Market economic indicators.

Name	Unit	Price
Underground buildings	yuan/m <sup>2</sup>	2673
Commercial buildings	yuan/m <sup>2</sup>	2088
Residential buildings	yuan/m <sup>2</sup>	1902

According to the table above, it can be calculated that the estimated construction cost of underground buildings is 74.459 million yuan, the estimated construction cost of commercial buildings is 36.106 million yuan, the estimated construction cost of residential buildings is 97.957 million and the estimated construction total cost is 208.522 million yuan.

(2) Design stage. Design stage is the key part of the project program cost control, data displays that the cost of design stage is a small proportion of the whole project, but it has great influence on the project construction cost. The design in traditional way, which is according to the investment estimation approved by the design plan which is provided by the construction unit to carry out the preliminary program design, and then based on the preliminary program design estimates the construction cost limitation to design the construction drawing, but when using the CAD to draw pictures, the project quantities statistics and price calculation usually need to be completed by people, which waste a lot of time and labor force and the results is inaccurate, the error is too large.

With the introduction of BIM technology, designers can extract the related design indicators from the historical data in the BIM model database, they can adjust and optimize design program intuitively and rapidly, and carry out limitation design fast to ensure the economy and rationality of design. At the same time, you can take advantage of collision and check function of the BIM software to reduce the claims caused by design errors and avoid rework situation, for example, in the underground pipeline layout process, due to design errors, the spatial position between plumbing pipes and cable racks is wrong, when meeting problems in the construction process, cable racks must be removed. The series of rework and downtime increases the cost of labor force and machine wastage. The following Figure 3 shows the schematic diagram of the basement pipeline collision detection results.



**Figure 3.** Collision detection pipeline.

(3) Bidding stage. Currently, in China it mainly uses the project quantity list valuation model. And in the *Tendering and Bidding Law of the People's Republic of China*, it clearly states that: "Starting from the issued date of the tender documents until the date of the tender picking up the bidding documents, which shall not be less than twenty days." In order to pursue business interests and save time, developers and construction units have to catch up period. This leads to the tender making time tense. In the tense tender making process, it is inevitable to has mistakes in the calculation or inputting the project quantity, even has omission, repetition and miscalculation. So if in the bidding process, construction unit can provide BIM models, the cost personnel can extract the engineering quantity data as soon as possible and as quickly as possible. The most important thing is that it not only shortens the tender' production time, saves time cost, but also greatly improves the accuracy of the project quantity in the process of making tender.

(4) The stage of signing contract. In the bidding stage, the application of BIM software has been calculated engineering quantity and cost accurately, and through collision and detection function, it solves the possible conflicts, reduces the

claims in construction process to ensure the contract be carry out smoothly in accordance with the construction period agreed by the two sides. In addition, it also can take advantage of the sharing capability of BIM information to make all the participants of the project communicate smoothly, avoiding delay the time of signing the contract due to communication problems and influencing the construction period. BIM technology can also simulate the problems that involved in the disclaimer of the contract, and make measures which have the targeted limited risk or transferred risk.

(5) Construction preparation stages. Construction organization design stage. Construction organization design is the guiding document of the construction process, mainly including engineering overview, construction program, progress assurance measures, quality assurance measures, civil construction, site plane layout, labor allocation and mechanical selection. using the visibility of BIM technology, it can optimize construction program, while provides aided design for the level diagram and layout diagram of construction site.

Cost planning stage. It is an essential job to draw up construction cost planning in the construction preparation stage. In BIM model database, The historical data of the completed and similar projects has a strong reference and guidance for the new project cost plan. The projects which are managed by BIM, after the end of the projects, their cost data information can be stored in computer. When there are new similar projects, it can extract the appropriate information quickly and accurately, guide the drawing up of the project cost plan, improving the accuracy and reducing the cost.

(6) Construction stage. The so-called construction stage is a stage that in accordance with the requirements of design documents and blueprints to organize the construction. More than 80% of the project cost is used for construction stage. So the cost control at this stage is the most important thing in the whole project cost control. Because of the construction process is dynamic, and it has a lot of links, needs a lot of time, the market price fluctuations and other factors, the cost control at this stage is the most complex. The main task of the project cost management of the construction stage is to realize the actual costs not exceeding the planned investment through project payment control, engineering change cost control, preventing and dealing with the cost of claims and excavating the potential of saving project cost<sup>[6]</sup>, In the following part, it will be analyze through cases.

Engineering quantity calculation. Engineering quantity calculation is the key part of cost control, in the traditional mode, after the contractor submit the completed engineering quantity to the owner, the owner needs to refer to the contract and the list of engineering quantity to make comparison one by one, also needs to check the completed engineering quantity on the site whether meet the requirements. In this way, it waste a lot of time and labor force, and it is easy to occur bias and error. But the application of BIM technology completely break the shackles of the traditional model, because BIM technology is associated with the time, the cost personnel can real-time update BIM model database in accordance with the construction process and live dynamic changes, and stat the engineering quantity of a certain period, reducing the check time to the engineering quantity and understanding and supervising the contractor's construction progress in real-time.

Engineering change. Engineering change refers to all types of changes in the contract work scope of the contractor in accordance with the design documents issued by supervision and supervision change instructions, including the increase or decrease of the contract work contents, the change of contract engineering quantity, design change due to geological reasons, the size and elevation changes of the structures caused by the actual situation, any work outside the contract and so on. The change in construction process is likely to lead to actual cost exceeding the budget price, therefore, must focus on controlling the influence of the project cost control.

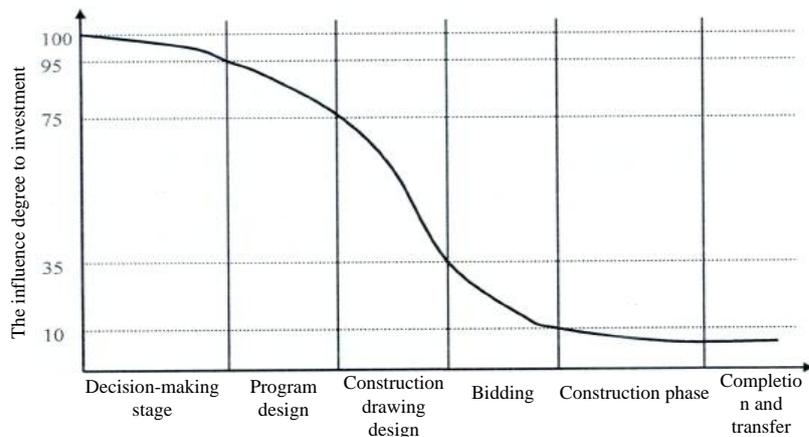
In this case, the owner changes all the "C1515 metal casement windows" to "C1818 steel windows" in the project, and the height of windowsills increase from 900mm to 600mm, thus it causes the changes of component project quantity surrounding windows. In the traditional model, cost personnel can only manually change project quantity based on 2D plane blueprint, which waste time and labor force, but the application of BIM technology makes cost personnel can change the property of "C1515 metal casement windows" in BIM model directly, the system will automatically generate the changed project quantity, greatly improve work efficiency.

Claim management. Claim is similar to change in the terms of influencing cost control, so the approach to deal with it is similar, too. Therefore, It will not be repeated.

(7) Complication calculation stage. Complication calculation stage is the final stage of the whole project, in this phase it requires the building unit and construction unit to check the project quantity. As each small pipes, pillars, doors, windows, walls and so on in the construction project will be carried out visa in site or within the range the last week. And during the construction stage there will be intersected operation and covert construction, which bring great challenge for the check of project quantity of both sides. Due to the longer construction period, so in the completion of the transfer process, it generally appears the problems that the information is incomplete, the information is lost and the blueprint is wrong. Under the traditional model, the cost personal will check the project quantity of building unit and

construction unit one by one, but because of the shortcomings of the blueprint, it is difficult to accurately present the real situation of construction site which leads to a larger settlement error, inconsistent with the actual costs of the project.

There are full and detailed engineering information in BIM model, and after filling and completion of the construction stage, the information that can fully express the completion engineering entity, and speed up the completion rate and save the cost of time, which avoiding the occurrence of wrangling events of the two sides. The Figure 4 reflects the general rules of influencing project program investment at all stages.



**Figure 4.** The influence of each stage to investment during the construction.

## CONCLUSION

This paper analyzes the traditional model's and BIM technology's application for cost control in the decision-making stage, design stage, bidding stage, signing contract stage, construction preparation stage, construction stage, complication stage and complication calculation stage of the construction engineering project, reflecting the advantages of BIM technology. Different from the previous blueprint design, BIM technology completely records the to project information in the project model, based on project information database, and it carry out recording, keeping, collaborative sharing to the entire project information in the manner of the model. It points out that it is very necessary to promote BIM in construction project.

## REFERENCES

- [1] L. Jerry, "Comparing Pommés and Naranjas", *China Academic journal Electronic Publishing House*, no. 8, pp. 136-139, 2011.
- [2] L. T. He, "Application Situation of BIM in Globalization", *Engineering Quality*, no. 3, pp. 12-19, 2013.
- [3] B. M. Yang, "New Thoughts of Project Cost Management", *Construction Times*, no. 4, pp. 24-29, 2010.
- [4] B. Zhang, F. F. Bai, "Function of Building Information Modeling BIM and Standard Formats of IFC for Sharing and Exchanging in the Construction Informatization", *Pioneering With Science & Technology Monthly*, no. 3, pp. 16-19, 2010.
- [5] L. J. Liu, "Application of Risk-oriented Audit in the Field of Project Cost Control", *Urban Construction Theory Research*, vol. 16, no. 4, pp. 44-49, 2013.
- [6] H. C. Fang, *Cost Management Research of the Whole Process based on BIM*, Dalian: Dalian University of Technology, 2012.
- [7] Z. Z. Jiang and S. Z. Ding, *Construction Project Program Management*, China Architecture & building press, 2014.
- [8] W. Dong, "Railway Survey and Design in BIM Information Management are Discussed in This Paper", *Railway Investigation and Surveying*, no. 5, pp. 86-88, 2013.
- [9] Z. J. Wang, *Evaluation of the Construction Project Cost Management Performance based on the Theory of Dissipative Structure*, Beijing: Beijing University of Civil Engineering and Architecture, 2013.
- [10] J. B. Wang, *Study on the Construction Stage' Cost Progress Control of Real Estate Projects Based on Earned Value Method*, Beijing: Beijing University of Technology, 2013.