

Research of Engineering Cost Management in Construction Drawing Design Stage Based on Bim Technology

Ruonan Huang ^a, Jing Li ^{b,*}, Jiali Zou ^c

¹School of Architecture and Urban-Rural Planning, Sichuan Agricultural University, Chengdu, 611830, China

^a201808468@stu.sicau.edu.cn, ^b386632076@qq.com, ^c201808473@stu.sicau.edu.cn

*Corresponding author

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Abstract: By establishing the complete process document of the project construction drawing design stage, applying the BIM technology to create the BIM model of the stage, comparing the cost result with the project time cost, summing up the cost difference, engineering quantity difference and price difference in this stage, finally exploring the phenomenon and reasons of the project cost difference, and finding the effective way of cost control in the construction drawing design stage.

1. Introduction

The project cost management or project cost control in our country mainly focuses on the construction stage and ignores the cost control in the design stage. Moreover, because of the limitation of design management or system, the cost control function of the design unit can't fully be worked in the design stage, which makes the cost management of each stage of the construction project disjointed. Besides, it improves the difficulty of cost control in construction stage and leads to investment waste. At present, the research of cost control based on BIM technology is a hot spot. However, what most people have researched is the whole process cost control and the introduction about management method of each stage is not detailed enough. But they can provide a certain theoretical basis for us to carry out the method of cost control in construction drawing design stage. In view of this, it is very meaningful for us to select the construction drawing design stage as the research object, and it is also hoped to find out the effective way to control the cost in the construction drawing design stage.

Building Information Modeling (BIM) based on the advanced three-dimensional digital building model^[1], which provides designers, architects, developers and end users with a scientific collaboration platform for simulation and analysis to help them design, build and manage the project. BIM, as a sharing platform for information integration, can embody the data of participants as standard digital parameters, insert and update information, modify files and extract data at any time. Therefore, we choose BIM technology as the research tool of cost control management in construction drawing design stage. The research method as followed.

Firstly, choose a completed construction project--the high-level talent apartment of Sichuan Agricultural University Dujiangyan campus as the research case, then establish the three-dimensional model of the construction drawing design stage and export the corresponding bill of quantities by using the Glodon calculation software. The 3D building model is shown in Figure 1.

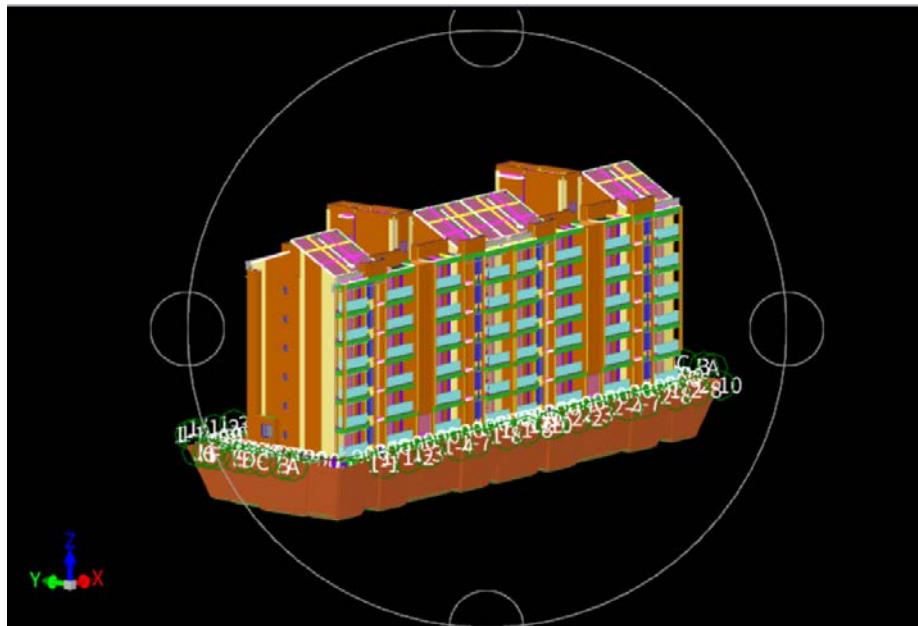


Fig.1 The 3d Building Model of the Project

Secondly, based on the budget quota and related cost documents, draw up the construction drawing budget of the construction project and refine the corresponding construction drawing budget cost index. Cost index refers to the cost per square meter of construction project. The establishment of project cost index enables us to effectively control the project cost and reasonably determine the cost^[2]. Some of the data is demonstrated here in Table.1.

Table.1. Part of the Indexs Calculated for Concrete and Reinforced Concrete Sub-Projects

Project cost	unit	Construction volume index per 100 m ²	Economic indicators of unitquantities (yuan)
concrete column	m ³	89.045	371.988
concrete wall	m ³	15.948	368.156
concrete beam	m ³	8.671	326.357
concrete slab	m ³	21.173	346.544
concrete stairs	m ³	2.971	96.830

Finally, compare the BIM construction drawing budget cost document with the original one, explore the phenomenons and reasons of the project cost difference.

2. Analysis of Influencing Factors of Cost Difference in Construction Drawing Stage

2.1 Accuracy in the Preparation of Virtual Bill of Quantities

In the case of imperfect construction drawings, the virtual list relied on preliminary design drawings and related engineering information of similar projects, and there will be great uncertainty in list items and the determination of quantities of projects^[3-4]. Some work can not be quantified in the design stage, so they need to be estimated according to previous experience. Some work quantitise can't be calculated until the actual construction, such as the length of a pile, the volume of the replacement cushion and so on. Therefore, the virtual bill of quantities in the design stage is often different from the actual situation.

At the same time, in the preparation of the engineering list of the decorative engineering block wall, in view of the fact that the preliminary design drawings don't indicate what kind of materials will be used, we have compiled the virtual bill of quantities, calculated the cost of using marble, granite, ceramic tile and paint, and comprehensively evaluated the project function, cost, time limit and equipment, labor consumption, etc.

Because natural marble is solid and abrasion-resistant, generally will not seep stains, and won't change its color through direct sunlight, so the surface of the wall is beautiful and its durability is excellent, whereas its unilateral cost is close to 300 yuan per square meter, and needs regular maintenance. On the contrary, the appearance of the wall used ceramic tile or paint is not that good, but its unilateral cost is only around 100 per square meter, and doesn't need to spend lots of time to maintain while meets the basic function of the wall. Therefore, the programme of using paint as the material has the best technical and economic effect.

Table.2.Comparison of Cost and Unilateral Cost of Decoration Project with Different Materials on Wall Surface of Block Material

Selection of materials	External wall construction cost(yuan)	Unilateral cost(yuan/m ²)	Similar project cost indicators(yuan/m ²)
marble	7117.29	289.32	300-1000
granite	7636.10	310.40	300-1000
ceramic tile	3780.05	153.66	300-1000
coating material	2635.90	107.15	50-100

By putting forward a variety of schemes and compiling different virtual bill of quantities, we conclude that the most economical method is to select paint as the material. However, if we do not compile the virtual bill of quantities, it may lead to unnecessary engineering changes. If the scheme with higher cost is chosen in the design stage, it may exceed the budget of the investor; If we choose a low cost scheme in the design stage, it may lead to the discovery that the construction requirements can't be met in the actual construction, thus causing project changes. The compilation of accurate virtual bill of quantities can help us to shorten the construction period and provide the possibility for cost control in advance.

2.2 Project Changes

Although the project characteristics and the calculation of engineering quantity of some projects are very clear, the cost calculated by is still quite different from the actual one, as shown in Table.3.

Table.3. Calculations for the Quantities of Reinforced Concrete Element

elements	Calculated quantities(m ³)	Actual quantities (m ³)
column	3496.049	3764.425
beam	340.424	541.264
straight wall	1086.912	1179.000
slab	750.928	774.883

The reason for the cost difference is that there are often various uncertain factors in the construction process, such as the price of labor, machinery and equipment may fluctuate during the construction period due to the long construction period, and the appearance of extreme weather will change the construction conditions or the unforeseen geological and hydrological conditions during the process. It is also possible that the designer did not consider the actual situation, therefore, the design can not be implemented, resulting in engineering changes.

3. Results

3.1 Develop the Use of Virtual Bill of Quantities and Improve the Accuracy of It

A virtual bill of quantities is a list-making mode in which the contracting party or consulting organization sets up the list items and estimates the amount of work according to the rules of quantity calculation, units of measurement and other specific list items according to the preliminary design drawings or unfinished construction drawings, referring to the list items and engineering technical indexes of similar construction projects in the past^[5]. The control price of the virtual bill of quantities is a kind of bidding method derived from the traditional bidding and valuation method of the bill of quantities. It is mainly used in the period of the construction design drawings has not been completed and the project is in the preliminary design stage, while the construction units are

eager to start. Its advantage is that it can not only save the progress of the project, but also benefit the control and management of the project cost.

In the process of compiling the list with reference to similar projects, the budget personnel should grasp the key points of compiling the virtual list, carefully examine and proofread the compiled list, and make full use of the similar project cost index and the practical experience of engineering construction. Meanwhile, by compiling the virtual bill of quantities of different schemes, designers can choose the design schemes with good technical and economic effects, thus laying a solid foundation for controlling the cost.

3.2 Vigorously Promoting Quota Design

Quota design is a design that meets the technical requirements based on the limit of investment or cost. In real life, if there is no investment limit, there may be a breakthrough in the total investment due to designers' pursuit of high efficiency buildings. In the above case, If we use marble, the total cost is 7117.29 yuan, which is three times higher than the cost of using paint! In fact, using paint can completely guarantee the efficacy of building parts while have a low cost. Through practice, it is proved that the implementation of quota design can greatly urge the design unit to strengthen the cost consciousness, optimize the design, reduce the engineering change and truly achieve the maximum output with the least input.

3.3 Strengthening Design Supervision and the Communication and Coordination among Various Parties

At present, the supervision of the design stage which has the greatest influence on investment is still developing slowly, and most of the supervision is concentrated in the construction stage. The implementation of design supervision and effective supervision of the whole process of design work can not only rationalize the design more, but also urge the design unit to improve the management system and reduce the unnecessary loss caused by the fault of the designer.

Maintaining a good communicational and coordinated work of the construction side of employer, the design unit and the construction side of contractor is of great importance. First, in the construction drawing design stage, the supervision party should do a good job in the feasibility of construction and audit whether the cost is economical and other work, thus avoiding some expense in the construction brought by the designer's lack of consideration and urging the design unit to improve the quality of their design; Once there are problems during the construction, contractors should feedback to the designer or construction units to minimize cost losses. Second, avoid unreasonable design changes as much as possible.

4. Conclusion

In a word, in order to effectively control the project cost and reduce unnecessary engineering losses, it is necessary to strengthen the cost management in the design stage of construction drawings. Construction, design and construction parties need to coordinate and cooperate, actively communicate, establish information sharing and effective communication mechanism, and vigorously promote the application of BIM technology in engineering. It is essential to develop the BIM design standards to allow future model users (planners, cost estimators) to take full advantage of the BIM potential^[6]. The key point of cost control in construction drawing design stage is the preparation of virtual bill of quantities and its accuracy. In addition, strengthening engineering change management can also play a role in cost control management.

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