Application Research of BIM Technology in Engineering Cost Management

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Abstract. This paper analyzes the problems existing in applying BIM technology to engineering cost management in the construction industry in China at the present stage. Taking BIM technology as the main line and engineering cost management as the goal, the research is conducted with BIM technology being used in the decision-making stage, engineering design stage, engineering bidding stage and engineering construction stage of engineering cost management.

1. BIM Technology
“Building Information Modeling”, which is a technology being called as a “revolutionary” technology, is a concept proposed by Doctor Chunk Eastman from Architecture and Computer School of Georgia Tech Collage: building description system diagram. In 1986, Robert Aish put forward several characteristics about the present BIM. In 1999, Chuck Eastman developed “building description system” into “building information modeling”, which contains all information, functional requirements and performances of different majors. All information of a project, including all information of the design process, construction process, operation and management process are integrated into one building modeling. In 2002, Jerry Laiserin published COMPARING POMMES AND NARANJAS, enabling the word-BIM to be widely used in the engineering construction industry.

In recent years, BIM technology has gradually developed into a kind of multidimensional (three-dimension space, four-dimension time, five-dimension cost, N-dimension more application) model integrated technology, so that all participants of the construction project (include the government competent department, proprietor, designer, constructor, supervisor, cost engineer, operation manager, project user and so on) can operate model in the modeling operation information and information in the entire life cycle from concept generation to complete demolition, thus fundamentally changing the work mode that the employees rely on the drawing in symbolic form to conduct project construction and operation management, achieving the goal of improving efficiency and quality and reducing errors and risks throughout the life cycle of a construction project.

2. Engineering Cost Management
Engineering cost management means to solve the practical problems of cost prediction, control, supervision and analysis in engineering construction through utilizing the technology, economy and law administration approaches comprehensively from different levels in the overall process of engineering construction. Its goal is to obtain the greatest investment benefit with the least manpower,
material resource and financial resource. The basic content of engineering cost management is to appropriately determine and effectively control the engineering cost [2].

At different stages of engineering construction, the entire process of engineering project construction cost management has different work contents. The purpose is control actual cost of construction project. The process of engineering cost management in China is constituted by four stages, which are respectively:

1. Engineering Scheming Stage. The main work of this stage is to conduct technological demonstration to the necessity and feasibility of the proposed project, which is mainly reflected in the compilation and approval of the investment estimation, techno-economic comparison of different construction schemes, as well as the judgment and decision making. Its goal is to carry out financial evaluation and put forward project scheduling decision. In the past engineering practice, the cost management work of this stage was not concerned. However, with the standard development of the engineering construction, the cost management of the scheming stage has attracted the attention of the construction party, which will certainly bring greater improvement to the refinement of the investment estimation work at this stage.

2. Engineering Designing Stage. The main work of the engineering designing stage is divided into: comparison of design schemes and schemes, compilation of design estimate, compilation of working drawing estimate, in which, the design scheme also includes: preliminary design, technology design, construction drawing design preparation, construction drawing design. Their effects on engineering cost are as follows: 20%, 40%, 40% and 20%, respectively. The comparison and selection of the design schemes are usually completed by adopting the value engineering method. Design estimate is an important constituent part of the preliminary design, which is not only the basis of controlling the construction drawing and construction estimate, but also the basis of signing the construction contract and loan contract. Working drawing estimate is the basis of controlling the construction cost and rational using of the fund, the basis of determining the project bidding control price and pre-tender estimate, the basis of allocating the engineering fund and transacting the settlement.

3. Engineering Bidding Stage. The engineering cost management of this stage is to control and analyze the bidding control price of the construction unit and the tender price of the contracting unit, and eventually form the contract price. At this stage, the unit of issuing contract is required to enhance cost control, reduce expenditure, conduct compilation of bidding control price, selection of bid evaluation method, contract discussion and determination of contract price on such basis. To the contracting unit, the appropriate improvement of the profit is the fundamental purpose, so as to have tender offer, analyze and select bidding strategy, compile bidding document. According to the main work of the bidding stage, unit of issuing contract has to utilize the BIM technology to do the work in two aspects, namely: the compilation of bidding control price, the contract discussion and contract price determination.

4. Engineering Construction Stage. The management of the engineering cost in the construction stage is not only the final stage of realizing the overall engineering cost management objectives, but also the main stage of realizing the value of the construction project. The effective management of this stage determines the overall management effect. At the construction stage, the engineering cost management has entered into the practical operation stage. Due to the differences in construction organization design, engineering change and engineering measurement method, as well as various unforeseen factors in the implementation of the project, the cost management in the construction stage is rather difficult. Because the works of the participation units, such as the construction unit, supervising unit, equipment and material supplier, are mutually intersecting, interactional and restricted at this stage, it will inevitably exert great influences to the engineering cost because of different interest subjects. Therefore, in order to do a good job in the cost management at this stage, it is required to coordinate well different subjects. This stage can also best reflect the characteristics of the whole process, the whole elements and the omnidirectional cost management in the project cost management. The cost management work at the engineering construction stage includes: engineering
price payment management, engineering change management, engineering claim management and engineering cost regulation. This stage is to reduce the engineering cost as much as possible under the premise of meeting the reasonable quality standard and ensuring the planned construction period. The construction price is reduced under the condition of ensuring reasonable quality and construction duration, so as to effectively control the investment. The engineering cost management is conducted through controlling engineering change, reducing claim and perfecting contract price method.

3. Application of BIM Technology in Engineering Cost Management Process

3.1. Project Scheming Stage
This stage is mainly to confirm the investment estimate index and optimize the scheme. On such basis, a scientific decision will be made to the project and an appropriate investment scheme will be conducted, so as to realize the reasonable resource allocation. Through using the BIM database established of the enterprise level or industry level, some key indexes will be selected according to the architectural drawings for the further comparison, analysis and final confirmation of the investment schemes. In comparing different investment schemes, BIM software automatically calculates the work amount, cost and other indexes according to different requirements. In addition, through three-dimension exhibition, the schemes will be compared for selection visually and conveniently.

Through the cloud platform, the BIM model of the similar historical projects will be directly extracted from the database, which will be modified simply on the basis of the scheme characteristics of this project. The model is parameterized. Every component can obtain different cost indexes, such as the corresponding project amount, cost and function. Based on the modification, BIM system will automatically correct the cost index[3]. Through these indexes, the engineering cost will be estimated rapidly. This will be more convenient than the traditional compilation estimate index. If it is desired to conduct well investment estimation at this stage, the accumulation of investment estimate and scheme optimization are the preconditions. In conducting comparative analysis to the investment estimate object, the traditional method is that the cost engineers analyze and compare relying on their work experience according to the historical data provided by the local industrial department, which will affect the accuracy of the estimate index to some extent.

3.2 Project Design Stage
After the decision making of the project investment, the key point of cost management lies in the design stage. China adopts limit amount design at present. What is formed at the design stage is the building estimate: for the project invested by the government, the budgetary estimate approved by the relevant department will be regarded as the maximum limit of the proposed project cost. The traditional design method is that the professional designers will design the building construction design, structural working drawing design, water and electricity installation drawing design and fire protection construction drawing design respectively. Generally, the architectural designer will firstly design the construction design, which will then be delivered to the structure designer, water and electricity installation designer to design separately. After designing the entire drawing, different drawings will be prepared, thus forming the final building construction drawing. There is a problem of coordination. Because different designers have different concentrations in designing, there might be component contradiction and inconsistent component position between the structure drawing and building drawing, or discrepant equipment installation drawing and structure drawing. The main reason lies in the incompatibility among different professional design softwares. Since the designs of different majors have diversified requirements to the functions of the design software, the structure software has no decoration design function and engineering amount statistics function. The equipment installing software has to mapping function and engineering amount calculation function to all buildings and structural components. The utilization of BIM technology at this stage can minimize the occurrence of this phenomenon. Meanwhile, with the most powerful visualization modelling function of the software, the three goals of rationalizing the engineering cost, improving the fund utilization
rate and promoting the efficiency of investment control can be realized. BIM technology solves the problem of inconsistent design, combines the traditional design software and the information technology with rapid development. It establishes the cooperative work platform of the design speciality, so as to ensure that the data among different majors can be conveyed accurately and timely. Meanwhile, it can be grasped by designers of other majors to adjust their own drawings accordingly, thus avoiding the collision of several professional drawings and unmatched professional drawings, solving the problem of compatible software of different majors at the same time. In other words, the building model can be introduced into the structure software while the structure model can also be introduced into the building design software. Meanwhile, both the building model and structure model can be introduced into the corresponding measurement and valuation softwares, as well as the project management software at the contracting and construction stages, such as the three-dimension site plane layout software, bidding software, BIM5D software and formwork software. At present, the softwares with such function in modeling are represented by: Revit and MagiCAD of BIM software. Revit is the generic term of the serial software developed by Autodesk Company. It is designed for BIM components and is one of the most widely used software in BIM system of Chinese construction industry. As a kind of application program, it integrates the functions of RevitEMP, Revit Architecture and Revit Structure softwares. The core feature of the Revit software is parametric component, compatible 64-bit support, work share and value integration. Its design feature is multi-material modeling and design visualization, and the analysis feature is the analytical model, conflict inspection and document compilation feature[4].

Revit software can be used to design according to the thought modes of the architect and designer. Through using the tools established for supporting the building information modeling work, it possesses the design and analysis functions. With the function of this software, it can ensure the consistency of the building model from design to construction. MagiCAD software is a design software which is frequently used in building electricity, water supply and drainage, ventilation and air conditioning engineering. It combines the spatial model with the parametric design information, draws the two-dimensional diagram and the three-dimensional diagram at the same time. Drawing while calculating enables the model to be more visualized. It can accomplish the coordination of 5 aspects, namely: interior professional coordination, trans-disciplinary coordination, coordination between the building equipment and the building speciality, collision check of various pipes.

3.3 Project Bidding Stage
At the project bidding stage, the work of the unit issuing contract is to compile the bidding document and confirm the bidding control price. The work of the contracting unit is mainly divided into two aspects: the first is to utilize the BIM technology to prepare tender offer and compile tender document; the second is to analyze and select the bidding strategy. The data in the BIM database will be conducive to confirm the tender offer and strategy until confirming the contract price. The technology can be used to promote the accuracy of the basic work of the two contracting parties, and maximize their own interests. Both the two contracting parties at this stage are able to utilize the scheming stage and design stage to establish the same model and carry out their own work. The unit issuing contract utilizes the unified model to conduct bidding scheme and compile bidding control price through the bidding software, while the contracting unit uses the unified model to approve the bill of quantity, offer and strategy through the bidding software and review reconciliation software until confirming the contract price. The model established by the contracting unit with the BIM technology at the design stage can be directly imported into the software used at the construction stage. There is no need to establish the model once again. It can not only realize the unification of the model, but also realize the visualization of the model. However, the BIM software of the design stage is different from that of the construction stage. It requires the data connection for the realization.
3.4 Project Construction Stage
Utilizing the characteristics of coordination, modelling and visualization of BIM technology, the project management software, measuring and pricing software of the BIM software is utilized to control the engineering amendment, conduct well on-site visa management, settlement payment(review reconciliation software), process the engineering warranty expense and other works, do dynamic monitoring to the implementation engineering cost(BIM5D), so that the practical cost generated in the project will not exceed the planned investment. BIM project management comprehensive software is to combine the BIM model in project management with the BIM measuring and pricing models, comprehensively exhibiting the project process, cost, service condition of the talent and machine. In having real-time monitoring of the structure safety status, the management and analysis of the construction process will be conducted dynamically, and the timely proposal of prevention and improvement measures will be provided with reliable technical support and service. To the construction enterprise, BIM technology is undoubtedly an effective tool of further increasing the engineering profit. Because the profit rate of the construction enterprise is relatively low, introducing BIM technology will create more values to the construction enterprise. Therefore, the impetus for the construction unit in improving the profit rate and manufacturing efficiency through importing new methods and new technologies is much higher than that of the designer and developer. Conduct engineering measuring and project completion payment management, carry out the dynamic monitoring of the engineering cost, process the engineering amendment and claim, compile and audit the engineering settlement, completion settlement, process the project warranty expense and so on. Specifically, it is reflected that some construction projects have frequent design changes in the construction stage and the construction process, and many units participate in the construction. How to convey the latest design requirements to every technician rapidly and conveniently, so as to adjust the construction scheme and make technical disclosure timely, thus ensuring no deviation of the construction? In order to solve the problem, such as the installation company of CSCEC, the BIM group of the company introduces the distributed cloud platform technology, establishes the cloud platform work unit. The manager updates the data according to the design change condition. Once the worker turns on ipad in the environment with wifi, it can receive the model updating information, realize the no-barrier communication of the information, improve the work efficiency and ensure the construction quality. Meanwhile, the technicians of the engineering project can realize the correspondence between the model component and on-site component through the cloud platform technology and establish the partition petrol viewing management system through the cloud platform. The members of the cloud platform open the viewing angle of the corresponding space, find the corresponding component and obtain the component information through the gyroscope and joystick of the ipad, thus fundamentally realizing the visible information management of the ultrahigh and hidden component[7].

Settlement mainly means that the construction unit obtains the project fund according to the construction contract signed with the development unit, the drawings and the amended documents. The construction unit proposes the calculated project amount and price, while the development unit audits to grant the project fund to the construction unit or not. Engineering settlement requires both the development unit and construction unit to compile the engineering settlement document, namely, prepare the engineering settlement price. The settlement document has two compilation methods, namely, the contract budget has no adjustment, but only the settlement of the changed and discussed parts; only the changed part is regulated on the basis of the contract budget, with the discussed part being made separately. The traditional approach is that the two contracting parties make measurement and calculation by using the same drawing, and the budget engineers of the two parties carry out manual reconciliation combined with the amendments and visas occurred in the practical project. Generally, one project has at least 200-300 signing bills, which require the two parties to audit one by one. In this way, Manual verification is not only a heavy workload, but also a great deal of controversy over the amount of work due to differences in models between the two parties. In case of any amendment or change existing in the project, there is also a dispute over whether the change and visa
will result in double calculation and the final determination of the change price. If the BIM amount verification software is used to verify the settlement document, both the construction unit and development unit calculate with the same model, so the project amount is the same and the two parties have no controversy.

The application of BIM technology is effective in With the pushing forward of China construction information technology, BIM technology will be better applied in engineering cost management.

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