Case study of engineering cost project management based on BIM software system

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Abstract: In view of the traditional cost design budget quality is not high, limit design index decomposition is difficult to achieve, cost management efficiency is poor, excessive expenses and other problems. According to the whole process cost management theory and lean construction theory, BIM technology is applied to the whole process cost management of the project. The advantages of BIM cost management in the design stage, contracting stage and construction stage of construction engineering are analyzed, and it is proposed that the application of BIM technology in the cost management of underground integrated pipe gallery project is more efficient, more accurate and more objective, which provides a reference for the integrated application of BIM technology in the cost management of municipal engineering.

1. Introduction

Engineering cost management determines the cost and investment efficiency of engineering projects. Traditional cost efficiency is low, imprecise, extrabudgetary changes, budget overruns, for complex geological environment, large amount of engineering, long period of the project, such as the municipal underground integrated pipe corridor project, may be due to improper budget management, seriously affect the quality of the project. It is necessary to study the application of BIM technology to improve the whole life cycle management level of cost informatization.

BIM (USA 2006) is defined as "a digital representation of the physical and functional characteristics of a construction project, as a shared information resource for a construction project, which can provide a reliable basis for decision-making throughout the project life cycle, and is a shared digital representation based on open standards of interoperability". BIM is an important digital technology, and its application in the whole process management of project cost is an inevitable trend in the development of the industry [1]. It has played an important role in ensuring project progress, improving project quality and preventing corruption in the field of project construction [2]. The application in various stages of municipal engineering has achieved more innovative results, which has greatly improved the intelligent level of municipal engineering construction process and brought new vitality and vitality to the entire municipal industry [3].

However, due to the short introduction time, BIM technology inevitably has some problems in the application of municipal engineering cost management, such as insufficient application degree in the project scheme and design stage, and the application effect needs to be further improved [4][5].

Therefore, this paper follows the concept of digital construction of future municipal engineering, takes the whole life cycle of construction projects as the main line, and analyzes the application of BIM technology in the whole process cost management of municipal engineering combined with the real case data of a representative urban underground integrated pipe gallery project.

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2. Concept Definition

2.1 Engineering cost

Project cost refers to the construction price of the construction project. From the perspective of investors and market transactions, the project cost can be understood as the meaning of project investment and project contract price. Project investment refers to the total investment cost of fixed assets expected or actually spent by the investor on the project construction. From the perspective of the investor, the project cost is the total investment in fixed assets of the construction project. The contract price of a project refers to the total price paid to the contractor by the contractor of a certain project according to the contract. It is a typical form of project cost and the price recognized by both the supply and demand parties in the construction market. According to the different implementation stages of construction projects, the project cost can be generally divided into estimated cost, estimated cost, budget cost, completion settlement cost and completion final accounting cost.

Municipal engineering refers to municipal roads, Bridges, squares, parking lots, tunnels, pipelines, sewage treatment, household garbage treatment, street lights and other public utility projects. Specifically, it includes road traffic engineering, river and lake water system engineering, underground pipeline engineering and overhead pole and line engineering. It has the characteristics of wide coverage, large construction scale, large engineering amount, high design difficulty, high technical content, great impact on the environment, long construction cycle, etc., and is an essential livelihood infrastructure for urban survival and development.

2.2 Engineering cost management

Engineering cost management refers to the process of forecasting, planning, control, accounting, analysis and evaluation of engineering cost by comprehensively applying the knowledge and skills of management, economics and engineering technology. Project cost management includes both the management of project investment and the management of project contract price. It involves the macro-control of the project cost by the national construction administrative department using legal, economic and administrative means (called the macro-management of the project cost), and also involves the specific management of the project cost by the project participation subject according to the project valuation basis and market information (called the micro-management of the project cost).

Project cost management follows the three basic principles of "the whole process cost management focusing on the design stage", "the combination of active control and passive control of project cost", and "the combination of technology and economy to control project cost". In different stages of project construction (see whole process cost management), its work content is different.

2.3 Whole process cost management theory

In order to ensure the investment benefits of construction projects, the whole process of project cost management refers to the whole process of project cost management from the project cost prediction in the feasibility study stage, through the project cost pre-control, economic demonstration, contract price determination, the use of funds during the construction period, the actual project cost determination to the economic post-evaluation. Its core idea lies in the determination and control of construction project cost based on activity method.

The whole process of cost management is usually divided into five stages: project decision, project design, project contracting, project construction and project completion. Project decision-making stage involves project planning, investment estimation, project economic evaluation and project financing plan analysis and other activities. The key control points of project cost in this stage are feasibility study report and investment estimation. The project design stage can be subdivided into preliminary design stage, expanded preliminary design stage and construction drawing design stage. The key control point of the project cost in this stage is the allocation of investment quota and the setting of design parameters, the optimization and optimization of design scheme, the preparation and review of design budget estimate and construction drawing budget. The project contracting stage is also known as the project transaction stage or bidding stage. The main activities involve the division of bid sections, the selection of contracting mode and contract form,

and the preparation of bidding control price or tender base. The key control points of the project cost in this stage are engineering change, on-site visa, engineering claim, project advance payment, project progress payment, control equipment and material costs. The activities of the project completion stage are mainly the settlement and final accounting of the project, and the key control points of the project cost in this stage are the adjustment of the material price difference, the review and audit of the settlement, the preparation of the final accounting report and the determination of the value of the new assets.

2.4 Lean construction theory

Lean construction is a new method of delivering construction projects, and its concept was first proposed by Danish scholar Lauris Koskela in 1992, when it was described as "a method of designing a production system to reduce the consumption of materials, time and labor, so as to maximize the value". The American Architectural Association defines Lean construction as "a continuous process of excellence in project execution that eliminates waste, meets or exceeds all customer needs, and centers on the overall value stream." China's Lean construction Technology center defines it as "integrated production management theory, construction management theory and the particularity of the architect's constant production, oriented to the whole life cycle of building products, continuously reduce and eliminate waste, and maximize the systematic method to meet customer requirements." To sum up, the core idea of lean construction is to increase the value of the project by transferring additional worthless tasks, so as to maximize the benefits and minimize the waste, and to meet customer requirements to the greatest extent.

3. The technical realization of BIM technology

3.1 BIM technology concept

Building Information Modeling (BIM) is a revolutionary digital approach to creating and managing full lifecycle information for construction projects. By converting 2D drawings into 3D models, it not only visually displays the exterior and internal structure of the building, but also integrates many non-geometric information such as building materials, costs, construction resources, etc., providing a new way of working for the design, construction and operation management of construction projects.

BIM is a multi-dimensional model information integration technology that enables all participants of a construction project to carry out engineering and management such as planning, design, construction, operation and maintenance during the whole life cycle of the project. It integrates structured and multi-domain data to manage the life cycle of the built environment, fundamentally changing the way employees rely on symbolized text drawings for project construction and operation management, improving work efficiency and quality, and reducing errors and risks in the whole life cycle of construction projects. It is also the foundation for the digital transformation of the architecture, engineering and construction industries.

3.2 BIM technical characteristics

Visualization. Visualization requires the visual presentation of buildings and components as well as the surrounding environmental conditions in a three-dimensional manner, including the virtual building and its construction process. The modeling and design process of BIM technology is based on the three-dimensional state. Each component can present a three-dimensional physical map through the X, Y and Z coordinate axes in the space, and a series of work such as project design, construction and operation can be clearly carried out in the visual state, so as to realize the technical visualization of design, construction organization and complex structure nodes.

Coordination. Coordination is an important content and difficulty of the whole process of construction management, involving the coordination of the project participants within the project, among the participants, project data standards and among professions.

Simulation. Simulation means that the engineering project realizes various simulation through

virtual construction to play different roles in different project management stages. BIM technology can not only simulate the actual situation of engineering project planning in advance and determine its rationality, but also provide the required engineering quantity data for cost management based on the simulation results, so as to realize timely adjustment and update of the data and effective control of the project cost.

Optimality. Optimization is an indispensable part of the whole process management of engineering projects. Only through continuous optimization can the project plan better meet the needs of relevant parties. The optimization of BIM technology is mainly reflected in the combination of project design and investment return analysis, real-time calculation of the impact of changes in the former on the latter, to provide owners with the best design scheme to meet their needs.

3.3 Overview of underground integrated pipe gallery

The integrated pipeline corridor is a modern, scientific and intensive new urban municipal infrastructure formed by centralized installation of more than two kinds of pipelines such as power, communication, water supply, heating, cooling, water, gas, and garbage vacuum tubes into the same underground space below the road. The construction of underground integrated pipeline corridor is conducive to the development and utilization of urban underground space and intensive development, and improve the comprehensive carrying capacity of the city. It should be noted that the construction should be based on the comprehensive pipeline corridor project planning, and pay attention to the connection and coordination with the underground space, environmental landscape and other related urban infrastructure. In essence, the underground integrated pipeline corridor still belongs to the road municipal comprehensive supporting project.

According to the different types of pipelines included in the integrated pipe corridor, it can be divided into three kinds: trunk integrated pipe corridor, branch integrated pipe corridor and cable integrated pipe corridor. The main integrated pipeline corridor is usually set in the motor vehicle road or road green belt, the main purpose is to accommodate the main urban engineering pipeline, the construction of independent subdivision, its section shape is mostly circular or multi-cell box type. The branch integrated management is usually set under the sidewalk, non-motorized lane or road green belt, the main purpose is to accommodate the urban distribution project pipeline, using single or double cabin construction, its section shape is mostly rectangular. Cable integrated pipe corridor is usually set under the sidewalk, the main purpose is to accommodate power cables and communication cables, generally using shallow buried trench construction, its section shape is mainly rectangular.

3.4 Application development of BIM technology

BIM technology (Building information model) application development direction:

life cycle management : The traditional application of BIM mainly focuses on the construction stage of a project, but in the future, BIM technology will be more applied to the whole life cycle management of a building, including design, construction, operation and maintenance and other stages. Through BIM model, the whole process management from planning to demolition can be realized, and the overall efficiency and benefit of the project can be improved.

integration with big data: with the development of big data technology, BIM technology will be combined with big data to realize data collection, analysis and application in all aspects of construction projects. Through big data analysis, the potential risks and challenges in the project can be predicted, and countermeasures can be formulated in advance to improve the efficiency and quality of project management.

The integration of BIM and cloud computing: The integrated application of BIM and cloud computing can convert BIM application into BIM cloud service, improve computing efficiency by utilizing the powerful computing power of cloud computing, and store and manage BIM model and related data through the cloud to realize access and sharing anytime and anywhere.

integration with the Internet of Things: The integrated application of BIM and the Internet of Things can realize the integration and fusion of the whole process of building information, perceive, collect, transmit and monitor various information of the building through the Internet of Things

technology, and realize the closed loop of information flow between virtual information management and physical environment hardware.

combination with artificial intelligence: The combination of BIM technology and artificial intelligence can realize automated building design and analysis, improve design efficiency and accuracy. At the same time, intelligent algorithms can be used to optimize building energy and energy-saving design, further improving the operational efficiency and sustainability of buildings.

integration with other technologies: BIM technology can also be integrated with VR/AR, digital twin, robot and other technologies, bringing revolutionary changes to architectural design, construction and operation and maintenance. For example, VR and AR technology can be used for virtual demonstration rooms and construction simulation to improve the accuracy and efficiency of design and construction.

4. BIM technology application advantages analysis

4.1 Early stage of project

The advantages of BIM technology in the cost management of the project decision-making stage are mainly reflected in that, through its data storage and analysis functions, it provides investment decision guidance for the economic indicators and parameters of the project, and improves the accuracy of investment estimation. Information integration and virtual visualization based on BIM technology can effectively solve the above problems.

The application of BIM technology in the design stage improves the accuracy and efficiency of engineering cost calculation, and realizes the mutual sharing of data and information between projects. It not only allows designers to meet the project functions and project technologies at the same time, but also takes into account the cost of engineering projects and creates more economic profits. The modeling design under BIM technology is based on three-dimensional visualization and displays the three-dimensional model of the distribution information of the underground integrated pipe corridor in a three-dimensional form, which provides convenience for the conceptual design and scheme design of buildings. Virtual roaming is used to effectively simulate the work scene, which can fully check whether the design net height and net width meet the requirements of later operation and maintenance, and ensure that the actual scheme conforms to the actual construction and maintenance operation standards. At the same time, it provides a powerful tool for the design of spatial architecture, so that the spatial position of each component of the building can be accurately positioned and reproduced, so that it can meet the requirements of the code.

4.2 Project implementation phase

The realization of virtual construction with three-dimensional model as the carrier can realize the professional deepening design and comprehensive deepening design of construction drawings in the construction preparation stage, so that the practical operation of construction drawings is enhanced, and the professional social design is highly integrated. At the same time, the analysis and optimization of construction schemes and the layout optimization of construction sites are realized through three-dimensional site and virtual construction. The construction of underground integrated pipeline corridor project involves a wide area, and in the process of construction, it is often necessary to coordinate with the surrounding environment, such as pipeline relocation and traffic dredging. Before the construction of the project, the feasibility of the construction bill and the impact on the surrounding environment can be dynamically simulated according to the real situation of the surrounding environment, so as to determine the optimal construction scheme and reduce the cost of pipeline relocation in the later stage.

The digital manufacturing of prefabricated components has greatly improved the precision of construction technology of construction enterprises. There are many types of prefabricated components involved in the construction of underground integrated pipe corridor. In the construction phase, through the digital manufacturing of prefabricated construction and the simulation of key construction processes of various specialties, the production of prefabricated components is accurate

and efficient and the construction process is optimized. In the completion stage, assist in the production of as-built drawings, make the drawings more accurate and rapid, and assist in the completion of digital payment.

The application of BIM technology in the completion and settlement stage of engineering projects can improve the integrity and standardization of the storage of engineering volume settlement data by virtue of its powerful data storage function, provide strong support for the work of engineering auditors, quickly retrieve the cost data of the whole process of the project and verify and compare the actual construction situation. It also brings great convenience to the settlement of progress payment, which is conducive to the shortening of the audit cycle of project settlement and the improvement of settlement efficiency and settlement quality, and can further enhance the transparency of project cost audit.

4.3 Application of BIM technology in engineering cost management

Improve the accuracy and efficiency of engineering quantity calculation. BIM technology can realize the accurate calculation of engineering quantity by establishing 3D model, reduce human error, and improve calculation efficiency and accuracy.

Realize the cost estimation of the whole process. BIM technology can better display engineering data, help to estimate the overall cost and identify the project cost, so as to control the overall cost of the whole project conveniently and quickly.

The whole process cost control. BIM technology can be used to control the cost at all stages of project decision-making, design and construction, so as to avoid design changes and rework and reduce construction costs.

To optimize design, BIM technology can help designers optimize design schemes, reduce design errors, and improve construction efficiency and quality through simulation.

Material management, BIM technology can accurately calculate the usage of construction materials, manage the use of construction materials, timely update material price changes, and effectively control material costs.

Progress monitoring, BIM technology can feedback the construction status in real time, solve faults in time, improve the construction quality and efficiency, and help control the construction progress.

Historical data accumulation and sharing. BIM technology can integrate the historical data of a construction project into a model, facilitating the accumulation and sharing of historical data, and providing reference for similar projects.

5. The construction of ecological aesthetic orde

5.1 Project investment decision stage

The main factors affecting the investment decision in the underground integrated pipeline corridor project are: determining the construction scale of the project; Selection of site for underground integrated pipe corridor project; Technical plan for underground coordinated construction. When determining the scale of the project, natural factors such as geology, hydrology, vegetation, soil layer should be fully taken into account, and social objective factors such as surrounding roads and communities should be taken into account. Different geological conditions and surrounding buildings will affect the cost of the foundation pit support and foundation treatment of the pipe corridor. The section size and the number of cabins of the integrated pipe corridor determine the construction scale of the pipe corridor, but also related to the difficulty of construction. As an underground public tunnel, the underground integrated pipeline corridor can coordinate with the related corridor departments through the information sharing platform of BIM technology during construction, and select the address that meets the economic value and social benefits.

The three-dimensional technology of BIM technology can directly express the relationship between the construction scheme and the surrounding buildings, and fully consider the coordination of the surrounding buildings, so as to reduce the cost of secondary excavation of the foundation pit,

independent support and the cost of excavation and restoration of the original road surface to the greatest extent. The application of BIM technology in the investment decision-making stage of underground integrated pipe corridor project improves the accuracy of investment estimation by building BIM technology information platform, so that project decision-makers can obtain the best investment plan.

5.2 Design phase

The underground integrated pipe corridor project has the following characteristics in the design stage: the whole project is a linear project; In the specific node, the node work characteristics; According to the specific requirements of the corridor pipeline in different sections, the cross section of the corridor is varied. There are changes in the general tunnel route and height of pipeline corridor line. Various types of nodes are arranged at a certain distance. The BIM model can comprehensively coordinate the contradictions between various specialties in the pipeline corridor project, optimize the pipeline layout at the complex location of the pipeline corridor node, and avoid unnecessary backwork and material waste.

BIM software is used to visually display the architectural performance, functional zoning, and surrounding environment through three-dimensional visualization, roaming and other ways, and the corresponding technical indicators are calculated. Secondly, through simulation calculation, the limit energy consumption index of each scheme is analyzed and calculated. Finally, on the basis of the budget estimates of each program, the corresponding economic indicators are analyzed and calculated to reasonably determine the cost limits of different processes. Compared with the two-dimensional design, the bending design of complex, multi-layer and multi-type complex pipelines is completed.

5.3 Education of aestheticizing social orde

Modeling analysis usually requires the combination of BIM technology software with the corresponding calculation and pricing software. First of all, after automatically obtaining each project quantity of the pipeline corridor project, the project quantity list is generated; Then the model is imported into the pricing software, after obtaining the fixed unit price, the group pricing is carried out, the required cost of the project is quickly calculated, and more detailed reports are generated.

By using BIM technology software, the cost personnel can simulate the situation on site by importing the collected information into the project model according to the characteristics and specific conditions of the corridor project. After determining the bidding conditions and bidding methods, the system will give the general bidding plan and automatically give the specific time of each work. BIM technology software can be used to accurately calculate the amount of people, materials and machines for the engineering quantity list of the underground integrated pipe gallery, and then quickly find a solution according to the construction environment, construction difficulties and the comprehensive capacity of the construction unit. At the same time, the application of BIM technology in the preparation of business standards is conducive to helping cost personnel more conveniently obtain the component information required for cost preparation, and can also give full play to the role of the stored information to help cost personnel make a comparative analysis of people, materials, machines, etc., and obtain a more reasonable quotation.

5.4 Construction phase

BIM model relies on a powerful engineering information database to realize the effective integration and linkage changes of 3D model, material module and cost module, so that design changes and material price changes can be updated in real-time in the BIM model, and the model establishment, construction organization plan, cost and manufacturing are integrated to achieve real-time cost simulation and accounting. Timely and accurate presentation of data to all project participants.

The multidimensional query function of BIM can extract the required engineering quantity according to the time node, schedule node, position node and subcontract, and carry out resource planning and control analysis at different levels and in different Spaces based on relevant data

analysis technology, so as to achieve strict control and fine management of resource consumption.

6. BIM technology application and promotion suggestions

6.1 Establish the construction cost management information standard system

We need to formulate the construction cost standard of the underground comprehensive pipe corridor, establish the national engineering cost database of the underground comprehensive pipe corridor, do a good job in cost calculation and release, carry out construction cost data accumulation, and improve the public service ability of the project cost. At the same time, the project cost data exchange standard is compiled to break the information island and lay the foundation for the project cost information and data sharing.

We need to speed up the informatization reform of the engineering cost industry, guide the engineering cost industry to establish a scientific and reasonable informatization standard system, promote the implementation of the informatization standard of engineering cost, and let the future digital construction return to the essence of cost.

6.2 Promote the reform of project cost management

We need to establish a diversified project cost information service model, clarify the service boundary between the government and the market, clarify the list of project cost information services provided by the government, and encourage social forces to carry out project cost information services.

We should strengthen digital cost management, dig deep into big data, constantly improve the cost database, open up the whole process of project cost management, improve the resource sharing and effective utilization level of construction project cost information, integrate all elements of project cost management, build a complete cost big data technology system, and connect all participants in project cost management. Build an open and shared digital ecosystem.

6.3 Promote the lightweight application of BIM technology

Reduce the application cost of BIM software. It is suggested to take municipal engineering as a pilot to promote the popularization and application of BIM technology software, and at the same time create a loose policy environment for the research and development, innovation and integration of BIM technology in the institutional management side, so as to promote the continuous maturity of BIM technology.

Promote the lightweight application of BIM software. Under the premise of meeting the information lossless, model accuracy and functional requirements, lightweight can realize the simplification, transformation and restoration of the model in the geometric entity with the help of the model entity repair technology, information cloud technology and logic simplification technology, and the process of carrying information and building logic. Lightweight technology is not only conducive to expanding the application scope and application scenarios of BIM, but also can reduce the difficulty of software application, so that BIM software in the general strength of the design and construction enterprises to improve the possibility of application.

6.4 Pay attention to the training of BIM engineering cost personnel

Our training objectives: Students should master the basic principles and operation methods of BIM technology, and be able to proficiently use BIM software for 3D modeling and information extraction. Students should be familiar with the relevant laws, regulations and standards of construction project cost management, and have the basic ability of project cost estimation, bill of quantities preparation and other work. Students should have the ability to combine BIM technology with cost work, and be able to independently complete the application of BIM technology in the field of engineering cost. Students should have teamwork and communication skills to meet the rapidly evolving and changing needs of the construction industry.

BIM talents should be interdisciplinary talents, with basic engineering professional ability, BIM practical operation skills, and multi-participation-based management collaboration ability. Through

the implementation of a series of preferential policies, the society should be guided to increase the training of BIM technical talents, especially to encourage enterprises to increase the training of existing engineering cost personnel. Emphasizing the professional characteristics of "BIM+ cost management", it aims to cultivate composite application-oriented senior engineering cost management talents with the ability of engineering project investment decision-making and whole process engineering cost management

To try to implement feasible talent training programs in the integration of industry and education and school-enterprise cooperation, students need to have a solid theoretical foundation and practical experience, master engineering cost calculation, cost management and other related skills, and enhance the application and operation ability of BIM technology.

6. Conclusion

Project cost management runs through the whole process of project construction, it not only involves the national macro investment management and micro project construction price management, but also relates to the transformation and upgrading of the construction field and high-quality development.

BIM technology can be applied in project engineering functions include model maintenance, site analysis, project planning, program demonstration, visual design, collaborative design, engineering volume statistics, pipeline synthesis, construction progress and construction organization simulation, digital construction, material tracking, construction site cooperation, completion model delivery, building system analysis and so on.The common problems in the application of BIM technology in the whole process cost management are: insufficient application depth, differences in calculation accuracy, lack of system system for the whole process cost control and management, and lack of high-quality professional technical management personnel.

In the process of cost management of various stages of municipal construction projects, we should not blindly pay attention to economic benefits and pursue low costs, but must focus on the balance between economic benefits and project quality. At present, the application of BIM technology in municipal engineering cost management still belongs to the data of engineering experience. It can optimize the design and reduce the workload of cost personnel, but it cannot replace the actual engineering cost practice.

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References

[1] Chen Anqi, GAO Tingting, Chen Jian. Application analysis of BIM technology in the whole process management of construction cost [J]. Educational Review, 2019, 12:145-149

[2] Pu Hongjuan. Application research of BIM Technology in Engineering cost management [D]. Zhengzhou University, 2017

[3] Chiao Yili. Application of BIM Technology in Municipal Engineering Construction [C]. Proceedings of the 2021 Industrial Building Academic Exchange Conference (Volume 1)

[4] Zhong Yi, Chen Xiaoqian. Application of BIM technology in the whole process management of municipal engineering cost [J]. Value Engineering, 2019, 38 (20) :255-257. (in Chinese

[5] HU Ke, Huang Xiangping, Hou Fei, Chi Hang. Discussion on the application of BIM technology in the preliminary work of municipal engineering [C]. The 9th International Conference on BIM Technology -- Proceedings of BIM Assisting New City Construction, 2022:484-489.