Research on Engineering Cost Management in the Context of Intelligent Construction

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Abstract. In the transformation and upgrading of industrial structure today, intelligent construction can, to a large extent, solve the problems existing in the traditional construction industry, such as the separation of design and construction, high labor cost and the lack of overall management of the whole process system. As a result, it has become an important trend of the future development of the construction industry. This paper makes an in-depth discussion on the cost management of intelligent construction, analyzes the significance of intelligent construction to the whole process of project cost management, and summarizes the specific application of intelligent construction in engineering design, bidding, construction, operation and maintenance. However, while intelligent construction has become the future trend beyond traditional construction, it also poses many challenges to the existing mode of engineering cost management. This paper aims at forward some optimization ideas for your reference, hoping that intelligent construction will develop vigorously in the direction of efficiency, accuracy and system in the future.

Keywords: Intelligent Construction · Smart · Architecture · Engineering cost · BIM technology

1 Introduction

The construction industry is the pillar industry of the national economy, and it has great effect on the economic development of our country. However, the traditional construction industry has many problems, such as low management level, waste of resources and serious pollution. Intelligent construction can solve these problems to the greatest extent. At present, China is moving from traditional construction to smart construction with information modeling and design improvement, that is, through the in-depth combination of construction technology and information technology, with digital technology as the guide and industrialization as the core, we will build diversified, comprehensive and high-quality buildings. Smart construction relies on manual operation for control, while the later stage, intelligent construction, can replace manual operation on a certain basis. Intelligent construction utilizes digital information technology such as big data, Building

Information Model (BIM), Geographic Information System (GIS), Internet of Things and other digital information technologies to deal with cost, schedule, quality, safety and other aspects in the whole process of project construction, and realize self-regulate and intelligent management, which could reduce the cost of construction while improving the efficiency and quality of project construction. Therefore, intelligent construction will become the development trend of the construction industry [1].

2 The Function of Intelligent Construction in Engineering Cost Management

2.1 Design Stage

At present, intelligent construction is mainly based on BIM technology. Through the transformation of two-dimensional to three-dimensional building model, link the information of each link, obtain the reference data of architectural design, performance, cost and so on, and build an all-round comprehensive information database to promote the development of the whole process of construction in the direction of intelligence, systematization and informatization. In the future of intelligent construction, the preliminary and design stage is still the focus of cost control. In the design stage, designers check pipeline collision, missing items and legality of the BIM model built, constantly optimize the design drawings accordingly, reduce the waste of resources caused by drawing errors during construction, and fundamentally reduce the cost loss. For example, in the Pingdingshan First Hospital project, 366 design drawing problems were identified during the model construction and comprehensive adjustment phase, 27 drawing reviews and visualisation handovers were conducted, 79 key deepening areas were identified, missing design drawing parts were modelled and analysed using 3D3S software to deepen the model design, saving 5d in construction time.

In order to make the structure more scientific and reasonable, 3D printing technology can be used to assist designers in design, and Virtual Reality (VR) technology can be used to simulate indoor and outdoor layout, so as to achieve a more refined design depth [2]. Digital information technology can also be incorporated into the design to reduce the design error rate, so that the building is more in line with the mechanical characteristics of the structure, the design is more reasonable, conducive to the cost management of the building.

2.2 Tender and Bidding Stage

The bidding stage of construction project is also one of the key points of cost control, the accuracy of the tender offer directly affects whether the enterprise wins the bid or not. The inviting party can check the bill of quantities through the quantities obtained from the BIM model to avoid missing items and improve the accuracy and integrity of the bidding documents. In combination with BIM technology and GIS technology, the bidder simulates the construction scene of the building in the corresponding geographical environment under the three-dimensional technology, carries out the three-dimensional site layout reasonably, and develops the corresponding construction plan according to

different terrain characteristics, so as to improve the accuracy of the tender offer, and finally increase the probability of winning the bid.

In addition, Unmanned Aerial Vehicle (UAV) is used to investigate the construction site environment at this stage to obtain images and topographic mapping data of the surrounding environment, reasonably evaluate the design scheme [3], and make adjustments according to the specific environment, which is conducive to improving resource utilization and construction efficiency, reasonably and effectively shortening the construction period.

2.3 Construction Stage

In the construction process, there are many personnel and large machinery, which may lead to great difficulties in management coordination, responsibility determination, safety prevention and other aspects. In this regard, take this hospital project as an example, all parties can build BIM 5D cloud platform through the technology combining BIM model and Internet of Things, and manage construction safety, schedule, cost, contract, quality and other aspects through multi-dimensional correlation model. Connecting owners, designers, contractors and supervisors through the hub of cloud platform can effectively solve the problem of lack of communication between all parties in the traditional construction industry, which is conducive to timely discovery and solution of problems and the perfection of contract management.

Use smart construction site system to manage labor, materials, large machinery and working environment with information; Through face recognition technology, to achieve the construction workers real-name system management, effectively avoid the foreign irrelevant personnel at random access to the construction site brought security risks; Use the material management system of the cloud platform for material management[4], reducing the loss caused by non-standard material storage, and guaranteeing the project implementation progress; When the project scale is large, the site cannot achieve closed management, and the statistics of mechanical stations and shifts are difficult, monitoring and UAV patrol can be used to make real-time statistics and check the number of mechanical stations and shifts, which can ensure the efficient and safe construction of the project and reasonably control the cost. The data analysis of the relevant engineering examples lead to the implementation effect of the intelligent construction project, as shown in Table 1.

2.4 Operation and Maintenance Stage

Good operation and maintenance can give full play to the function of the construction project, which could improve the quality of the project and extend the life of the building. Based on BIM technology and big data monitoring and analysis of the use status of buildings, a dynamic digital model can be established to realize visual management. Through the analysis and comparison of building reliability, economy and energy consumption, the management and supervision mode of construction equipment operation is summarized to promote the wisdom of daily operation and maintenance [5], so as to reduce operation and maintenance costs. The establishment of the late operation and

Table 1. Implementation effect of intelligent construction

Project Name	Technology	Material Saving	Time Saving	Economic Efficiency
60m precast box girder	BIM automated steel processing	3%	1.5–2d per beam	Savings of 10,202 yuan per piece
Line 6 subway station	Virtual simulation analysis of the process	Steel 800t Wood 800m^3	4–6 months (about 20%–30%)	84% reduction in peak staffing
A group headquarter	UAV + BIM technology	Pipe more than 10%	15d	Saving cost 650000 yuan
Jingdezhen Imperial Kiln Museum	Lay line robot	Template reduction of 312,000 yuan	15d	40% reduction in cost

maintenance system is conducive to improving the management mode and promoting the benign competition in the market.

3 The Challenge of Intelligent Construction to Engineering Cost Management

Intelligent construction has many advantages over the traditional construction method, but due to the intelligent construction in our country is still in the initial stage, Relevant case studies are relatively few, and there are still many deficiencies. Compared with other industries, the construction site of the construction industry is complex and types of work are various, the application of digital technology is difficult, and the research and development cost is high, which brings great challenges to the engineering cost. At present, intelligent construction is mostly used in pilot projects, which are characterized by particularity and with low universality. There are relatively few case studies. Moreover, intelligent construction is great difficulty in design. High operation and maintenance costs, and high total project investment, making it difficult for small and medium-sized enterprises to bear. In this regard, the main reasons for the obstacles in the implementation of smart construction to the owners and other participants are analyzed through consulting data and investigation, as shown in Fig. 1, which will be explained step by step below.

First of all, there are so many enterprises developing BIM related softwares which leads to design, bidding, construction, operation and maintenance stage respectively use different software technology [6]. So they cannot achieve information and data interoperability and lack of a management platform to integrate and unify all resources. At the same time, partial construction personnel lack of innovative consciousness and degree of cooperation, resulting in the construction delay, the construction period is delayed, thus affecting the cost of the project.

Secondly, the number of general contractors who can complete the construction general contract (EPC) under intelligent construction is small, and it is difficult for the
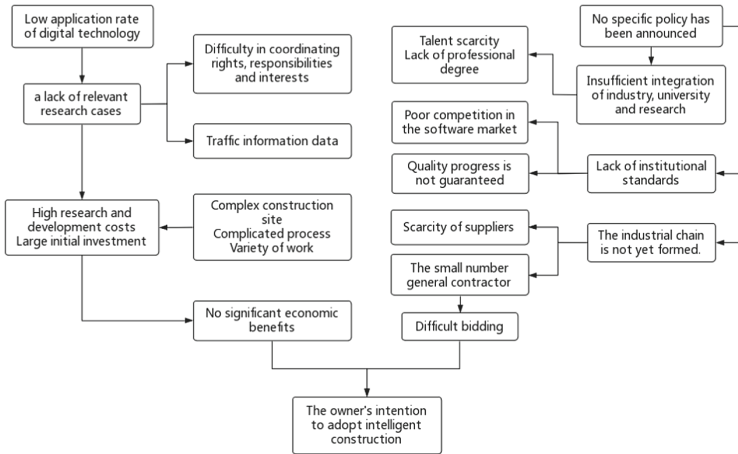
Fig. 1. Main factors influencing the adoption of intelligent construction by owners and other participants

owners to bid, which is not conducive to promoting the owners to adopt the construction scheme of intelligent construction. In addition, the intelligent degree of equipment and materials applied in intelligent construction is relatively high, and the number of suppliers is small, which is not conducive to price negotiation and difficult to control procurement cost. In the construction process, due to the uncertainty of time and space, intelligent construction equipment has the risk of damage. Compared with traditional construction equipment, the maintenance cost of intelligent construction equipment is higher, which is not conducive to the cost control.

Finally, policy is also one of the important factors affecting the cost. At present, our country has not promulgated the law on the scope of application of intelligent construction projects. In addition, China lacks relevant system and standards for intelligent construction projects [7], and the inspection and acceptance processes all follow the smart construction standards, lacking the whole process of intelligent awareness, and failing to fully guarantee project quality and construction safety. The lack of standards is not conducive to the formation of the industrial chain, will cause the increase of project costs, bring difficulties to the cost management. In addition, the design, construction and other technical personnel lack of operational experience, the shortage of professional personnel due to the few application cases of intelligent construction, will affect the practical effect of digital technology, so that the actual construction progress and effect can not reach the expected plan, reduce the quality of the project.

4 Optimization Ideas

4.1 Increase Pilot Projects by PPP Model

Through the adoption of Public-Private Partnership (PPP) model, the government provides financial subsidies or promises to operate the duration of the way to attract private capital to invest in the use of wisdom to build technology infrastructure projects pilot

projects. In the bidding stage, the intelligent construction scheme should be included in one of the bid evaluation criteria to encourage the intelligent construction of bidding enterprises. In the construction stage, the PPP mode of government enterprises is beneficial to share the investment risk of private capital and improve the enthusiasm of enterprises to use digital technology. On the other hand, it reduces the financial burden of the government [8], increases the demonstration cases of intelligent construction projects, and brings certain reference to the follow-up projects.

4.2 Set up the Whole Process Cost Management Platform

At present, there are too many intelligent software platforms and most of them are only for a certain stage of research and development. If the software platform is used in the whole process of construction project, it will greatly increase the acquisition cost, improve the upfront investment and reduce the communication efficiency of various departments. Therefore, the establishment of a unified management platform in the whole process is very important. It is the development direction of intelligent building in the future to integrate the technology and data used in decision-making, design, bidding, construction, operation and maintenance, and to use big data to control the cost of the whole process, and optimize and control the cost under the premise of ensuring quality and quantity. At the same time, the establishment of engineering cost index database is also the development trend in the future [9].Through the database, we can effectively reduce the dependence on budget quota, draw lessons from typical cases to accurately control the cost, and realize the integration, dynamic and intelligent construction of the project.

4.3 Cultivate Professionals in Intelligent Construction

The intelligent development trend of the construction industry has put forward higher requirements for the cultivation of talents, and a number of high-level intelligent construction professionals are in urgent need [10]. At present, there are few schools offering relevant courses in our country and lack of training standards, which is not conducive to the training of professionals. Therefore, we should formulate the talent training standard as soon as possible, and determine the talent training plan according to this standard, train the applied professional talents through the combination of theoretical teaching and curriculum practice, and solve the problem of talent shortage. In addition, we should pay attention to reverse the concept of some construction personnel, popularize the advantages of intelligent construction, carry out induction training, constantly improve the professionalism of personnel, and improve construction efficiency.

4.4 Formulate and Perfect Standards and Specifications

The healthy development of the industry needs to be standardized by perfect institutional standards. Further improve the intelligent construction specifications on the basis of the existing smart construction specifications, formulate the intelligent construction project delivery and acceptance standards, is conducive to construction safety management,

could ensure the quality of the project, and achieve green construction. For example, further standardizing the qualification examination of suppliers, examining the quality of materials and equipment, and guiding the price range in a reasonable range can avoid the behavior of suppliers damaging the market due to malicious competition, so that the intelligent construction market system is perfect, the quality is qualified, the price is reasonable, and the profession is guaranteed. At the same time, compared with the traditional construction mode, the contractor of intelligent construction mode needs to have higher technology and management level, stronger ability to resist risks and more professional talents. Strengthening qualification audit is conducive to reducing waste of resources, ensuring project quality, standardizing market behavior, and safeguarding the legitimate rights and interests of all parties involved.

5   Conclusion

As the development trend of the construction industry, intelligent construction solves the problems of the traditional construction industry in resources, efficiency, environmental protection and other aspects, and injects new impetus for the high-quality development of the construction industry. At present, the application of intelligent construction mainly takes BIM technology as the center, supplemented by GIS, big data, Internet of Things and other technologies. It is applied in the design, bidding, construction, operation and maintenance of construction projects, which effectively reduces the construction cost, ensures the quality of the project and improves the efficiency of engineering cost management. However, the application of intelligent construction poses many challenges to the existing model of engineering cost management. These factors affect the popularization of intelligent construction. In order to cope with the challenges and promote the development of the intelligent construction mode, this paper puts forward several optimization ideas. It is believed that the future construction industry can develop towards a more intelligent, digital and systematic direction.

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