Research on Hidden Cost Control Model of Construction Resources Based on BIM and GA

Peng Zang

Civil Engineering Department, Wenzhou Vocational & Technical College, Wenzhou 325035, China

18657716677@163.com

Abstract

To improve the hidden cost control ability and profitability of construction enterprise，based on analyzing the composition of the construction resources hidden cost and identifying the control elements, in view of the character of complexity and imperceptibility of controlling construction resources hidden cost, a model is established to optimize the construction resources and control the cost based on BIM and GA. Dynamic management of construction resources and effective control of hidden cost were both achieved by applying GA to the resource balance optimization. An engineering application case was presented to verify the availability and effectiveness.

Keywords

BIM; Hidden cost; Construction resources; Optimization.

1. Introduction

Compared with the dominant cost control of construction projects, the latent cost control is often limited by its concealment and difficult to quantify, but ignoring the control of the latent cost will directly affect the total cost and profit of construction projects. The rational and balanced allocation of construction resources is the main factor affecting the cost composition, and also the main aspect leading to potential hidden costs. However, due to the low degree of information, asymmetric information exchange between departments and links, untimely and inadequate management methods, there are many hidden costs in the process of construction resources allocation [1].

In view of BIM's research on multi-dimensional management of construction projects, foreign scholars Srinath S Kumarh and others have established the framework of BIM-based automatic planning system for construction sites in order to reduce the cost of construction site resources [2]. Zhang Jianping, a researcher in BIM team of Tsinghua University, has developed 4DBIM related systems, including construction resource simulation, 4DBIM construction schedule, construction site and cost monitoring, etc. [3-4]. Through the analysis of Engineering examples, Yao Fahai and others constructed a construction material management system based on BIM, thus realizing the timely monitoring of materials and effectively improving the level of resource management [5]. Wang Yankui et al. realized the optimal temporary storage allocation of construction site materials through interactive sequential goal programming algorithm on the basis of relevant information provided by BIM in order to reduce the cost of resource management [6]. At present, many optimization algorithms and models have been put forward by scholars at home and abroad for the optimal allocation of construction resources from different angles, among which genetic algorithm is widely used in the optimal allocation of construction resources [7-9] because of its multi-objective global search performance. At present, BIM research is mainly applied to the integration and sharing of static information, lacking of dynamic processing of information. The construction stage of a project is a dynamic change period. It is necessary to make predictions and adjustments according to the information in time and make the next work plan. Therefore, it has a good theoretical basis and practical value to use the construction resource equilibrium optimization model and BIM model together to solve the problem of information processing of construction resources in time and effectively control the hidden cost of construction resources.

2. Analysis on the Constitution and Controlling Elements of the Implicit Cost of Construction Resources

At present, scholars at home and abroad have made a preliminary study on the implicit cost of project duration, quality and contract, and put forward that the implicit cost of construction project is the opportunity cost of the enterprise's own resources and the current project management mode. From the perspective of construction resources allocation, the hidden cost of construction resources is defined as the additional cost caused by unreasonable allocation of construction resources (manpower, materials, machinery and equipment). In a broad sense, it is shown as the cost difference compared with the lowest cost of construction resources consumption.

2.1 Analysis on the Constitution of Implicit Cost of Construction Resources

The influence of construction resources on the cost of construction projects is mainly manifested in the explicit cost of resources, that is, the actual price and the hidden cost caused by the shortage or idleness of resources. Therefore, the rational allocation of construction resources is very important. The allocation of construction resources is to distribute all kinds of resources in the construction process to each working procedure in the construction stage in a balanced and reasonable manner, to ensure that the maximum efficiency of resources can be exerted and the hidden cost control of construction resources can be realized on the premise of completing the construction period and quality of the project on time. Based on the analysis of the characteristics of various construction resources and the study of the construction status quo, the hidden cost of construction resources allocation is classified into three categories by analyzing the causes of the hidden cost of various construction resources. Its subject composition is shown in Table 1.

Table 1 Construction resources hidden cost

First level subjects	Second level subjects	Third level subjects
	Hidden cost of human resources	Food and lodging expenses for staff Management fees for staff and workers Negative idle cost
Construction resources hidden cost	Hidden cost of construction material	Material storage fee Unreasonable cost of materials Material loss in lnventory Material shortage cost Reprocessing cost of understanding failure Economic loss of price difference
	Hidden cost of machinery and equipment	Idle cost of machinery Maintenance cost of machinery The Cost of Machinery Equipment Not Entering in Time Advance scrap cost of machinery Additional temporary facility costs

2.2 Analysis of the Implicit Cost Control Elements of Construction Resources

By analyzing the composition of hidden cost of construction resources, it can be seen that the hidden cost of construction resources mostly occurs in the actual construction process. Therefore, its control should be divided into three stages: pre-control, in-process control and post-control.

(1)The improvement of visualization belongs to the category of prior control. The traditional project management method based on two-dimensional drawings has a low degree of visualization, and it is difficult to visualize the relationship between construction resources and entities. Therefore, the purpose of improving the degree of visualization is to obtain a detailed plan for the use of construction resources through the construction of multi-dimensional models.

(2)Scheme optimization belongs to the category of prior control. The aim is to get feasible and effective construction resource optimization scheme through advanced management means.

(3)The dynamic control of construction wage source based on BIM and the real-time cost monitoring belong to the same control category. In the process of project execution, construction progress, resources and cost information are changing. Dynamic resource control and real-time cost monitoring aims at timely feedback of resources and cost changes according to project progress, realizing deviation early warning, and strictly controlling hidden costs caused by untimely processing due to information lag.

(4)Cost analysis is the control factor after the event. The purpose is to trace and analyze the causes of construction resource consumption and cost deviation, explore the causes of hidden cost, and provide reference for subsequent project cost control.

3. Construction of Construction Wage Source Optimization and Dynamic Control Model Based on BIM and GA

Based on the analysis of the components and control elements of hidden cost of construction resources in construction projects, the optimization and dynamic control model of construction resources based on BIM and genetic algorithm is constructed, as shown in Figure 2.

3.1 Building Information Model

BIM information model mainly solves the problem of low degree of visualization in the current construction stage, which is the basis of the whole model. It consists of three parts: the first part is to build a three-dimensional BIM model by using Autodesk Revit software; the second part is to import the three-dimensional BIM model into Guanglian Valuation Software, and associate the BIM model with various lists to obtain the contract budget and cost budget directly. Thirdly, the three-dimensional BIM model, construction schedule project file and budget file are imported into BIM5D platform to realize the integration of project information. The third part is to obtain accurate data of project construction progress, cost and construction resource requirement from BIM5D information integration platform, to realize dynamic query, and to provide basis for subsequent construction resource balancing and optimization.

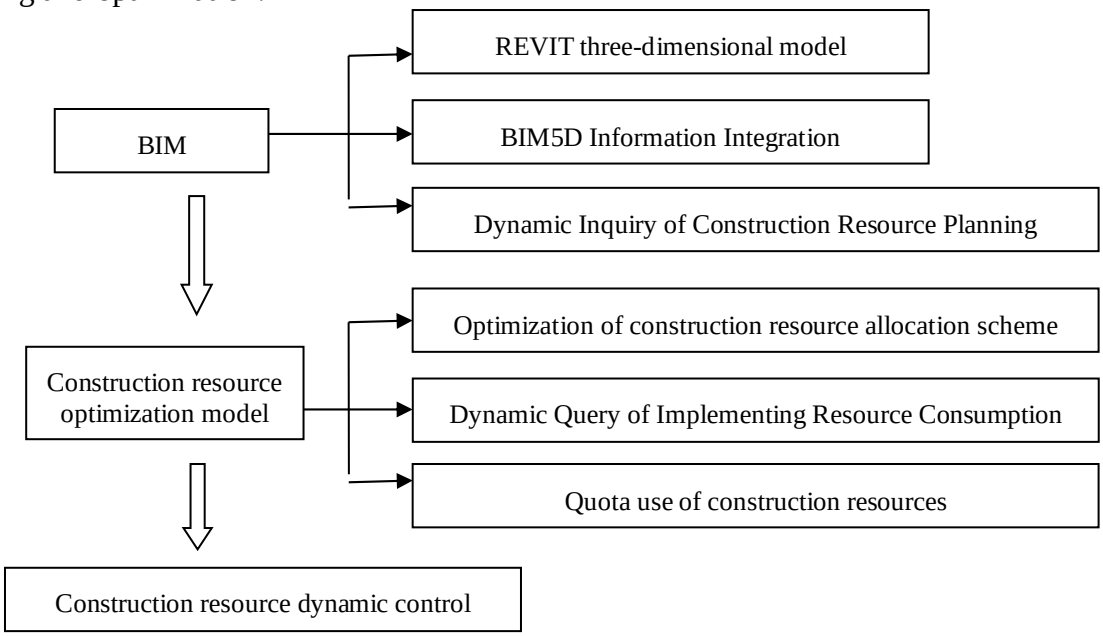

Fig.2 Construction resources optimization and dynamic control model based on BIM and GA

3.2 A genetic algorithm-based optimization model for the equilibrium of construction resources

The information integration platform based on BIM only achieves the goal of project management by summarizing project information. In order to control the hidden cost of construction resources more effectively, an optimization algorithm of construction resources is introduced to remedy the defects of BIM in information processing. In practical projects, unreasonable allocation of construction resources will lead to a large number of workers, waste of materials, idle machinery and equipment, resulting in additional hidden costs. Therefore, the balanced optimization of construction resources is the key way to control the hidden cost. Under the condition of relatively fixed construction period, the construction resource balanced optimization model is established according to the information of construction resource demand and solved by genetic algorithm. Finally, a reasonable and effective construction schedule plan is obtained, and the latest plan is updated to BIM5D information integration platform to generate an implementation resource utilization plan, which provides data basis for the realization of quota collection. Complete feedforward control of project cost in construction phase.Conclusion

Implicit cost is a kind of cost implicit in the total cost of the enterprise and free from the supervision of financial audit. It is a implicit future cost and transfer cost caused by the behavior of the enterprise or employee intentionally or unintentionally. It is the sum of the future tense and the cost form of the transfer of the cost, such as the huge cost increase brought by the management decision error, the inconsistency of the leadership failure, the information and the loss of instructions.

4. Case analysis

Taking a commercial project in Wenzhou as an example, the project has 11 stories, 3 stories underground and 8 stories above ground. It is a frame-shear wall structure with a building area of about 240,000 m 2. The construction enterprises of the project have applied advanced BIM technology in the construction stage and established a perfect building information model to guide the construction. The project starts on October 13, 2015 and is completed on January 16, 2017 with a total duration of 460 day.

4.1 Engineering application

Using 3D visualization technology in BIM5D software, different technical schemes of the project can be presented, so that the schemes and submissions can be visualized. For detailed resource utilization planning, BIM5D platform can directly export inventory resource statistics. During the construction of this project, the construction enterprise manages the construction resources scientifically through BIM5D, and finds out the causes of the progress deviation through the data collection of long-term on-site resource consumption and progress plan, the comparative analysis of three calculation of resources, and the amount of human resources and machinery engineering, and on this basis, forecasts the future progress plan. The project timely adjusts the site resource allocation plan according to the change of construction progress. At the same time, the actual progress information of construction site is uploaded to the 5D platform to compare with the planned construction period, so as to grasp the site construction progress in time. When early warning of advance and lag of construction period is found, the scheme should be adjusted in time to ensure that the project is completed on time and realize dynamic control of construction resources. In the aspect of cost management, BIM5D is used to check part of the project cost, measure cost and other items in the budget document, and carry out cost dynamic query and real-time tracking analysis, so as to realize the fine management of the project.

Through the use of BIM technology, the project ultimately saved more than 7 million yuan in cost, of which construction resources accounted for more than 80%, which fully reflects the advantages of BIM compared with traditional project management. In order to further verify the feasibility and validity of genetic algorithm applied to implicit cost control of construction resources, the genetic algorithm is used to calculate and analyze the balanced optimization of construction resources for this project. The commercial project has 46 processes, 34 of which are key processes. After collecting the

relevant data from BIM5D platform, the non-critical process information of the project is sorted out. The genetic algorithm is used to solve the equilibrium optimization model of construction resources. As mentioned above, the cost of required resources is used to represent the resource demand. The objective function is the sum of standard deviations of the daily resource demand cost in the construction period when the resource weight coefficient K is 1. The daily resource demand cost is the sum of all construction resource demand costs. According to the simulation results, the evolutionary algebra of genetic algorithm is 500, the population size is 100, the crossover probability is 0.7, and the mutation probability is 0.05.

5. Conclusion

The hidden cost control model based on BIM provides powerful information and data support for construction resource control in construction stage, and transforms the traditional ex post control into ex ante and in-process control. By introducing GA to optimize the resource balance, the optimal start time of each construction process can be calculated accurately, the optimal allocation of construction resources can be realized, and the unnecessary cost of manpower, materials and machinery can be saved. By combining BIM technology with genetic algorithm, the construction resource optimization and dynamic control model are constructed to make the hidden cost control of construction resources more scientific and reliable.

Acknowledgements

(1)General Research Projects of Wenzhou Vocational and Technical College in 2018 (No. WZY 2018024).

(2)Zhejiang Province “School-Enterprise Cooperation Project”in 2018(No. FG2018053).

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