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BIM CONTROL METHOD FOR HIDDEN QUALITY COST OF PREFABRICATED BUILDING CONSTRUCTION PROJECT

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ABSTRACT

At present, the hidden quality cost in the construction process of prefabricated building projects in China is too high. If it is not controlled, there will inevitably be a "benefit funnel". Based on the construction of cost BIM control model, the information integration platform of prefabricated construction project is designed. Utilizing the details provided regarding the model and platform, the technique of constrained machine learning is employed for managing the concealed expenses related to quality in prefabricated construction ventures. By optimizing cost control, the ultimate objective of managing expenses is achieved. The outcomes of experiments illustrate that this approach has the capability to proficiently govern the covert quality expenses linked with prefabricated construction projects. It significantly enhances the focused and efficient management of comprehensive and evolving oversight of quality-related expenses throughout the construction process.

KEYWORDS

Prefabricated building, Hidden quality cost, BIM Technology, cost control

INTRODUCTION

In recent years, with the deepening of globalization and the sustained growth of economies in various countries, the construction industry has become an important pillar in promoting world economic prosperity. However, at the same time, engineering quality accidents are also on the rise globally, which not only poses a serious threat to people's life and property safety, but also brings a heavy burden to the economies of various countries. More seriously, some projects have clearly failed to meet the mandatory international quality standards, which reflects that negligence and inadequate quality control have become an urgent problem to be solved in the global construction process. Governments, construction industries, and relevant regulatory agencies around the world are actively seeking effective solutions to strengthen quality control and ensure the safety and reliability of construction projects [1]. In this scenario, if left unchecked, these costs are bound to create a "benefit funnel," which hampers the comprehensive oversight of project expenses.

Reference [2] is to effectively control the production cost of prefabricated components and thus reduce the total construction cost of prefabricated buildings. This method analyzes the production characteristics of prefabricated components, and establishes the production scheduling optimization model of prefabricated components aiming at minimizing the production cost. An improved differential evolution algorithm is designed to solve the model. Reference [3] design the cost control scheme of prefabricated building construction regarding BIM Technology. This method discusses the collection and collection mode of assembly construction cost under BIM platform, combines BIM with earned value method, analyzes the deviation of cost, and puts forward corrective measures. Reference [4] sorted out 13 representative influencing factors, constructed an

Interpretative Structural Modeling (ISM) based impact index system for prefabricated construction cost, analyzed the relationship between factors, and obtained the weight of each influencing factor by combining Analytic Hierarchy Process (AHP) and entropy method. The analysis shows that component price, integrity of industrial chain, prefabrication rate and assembly rate, project management experience and system have great influence on the cost of prefabricated buildings. Based on the research results, reasonable cost control measures and suggestions are put forward to provide reference for the development of prefabricated buildings. These studies mainly focus on the establishment of qualitative control measures, and the quantitative data analysis is obviously insufficient.

Prefabricated building (also known as prefabricated building) is a method of constructing buildings by prefabricating components in a factory and assembling them on the construction site. This construction method has many advantages, such as high construction efficiency, controllable quality, and minimal environmental impact. In order to achieve dynamic and holistic control of implicit quality costs in construction projects, this article proposes a method for controlling implicit quality costs in construction projects based on the characteristics of multiple influencing factors and high uncertainty, combined with BIM technology. The research includes establishing cost analysis models, project cost models, and BIM based information integration platforms, while using extreme learning machine methods to optimize and control implicit quality costs. The novelty of the research lies in the combination of BIM technology and cost management, which improves the accuracy and real-time performance of cost analysis. At the same time, a BIM based information integration platform is used to achieve collaborative work and data sharing between different units. In addition, using extreme learning machine methods to process complex nonlinear data helps optimize the cost control process, improve the effectiveness and accuracy of cost control. Through these innovative methods and technologies, this study aims to solve the problem of implicit quality cost in prefabricated building construction projects and improve the efficiency and quality of the projects.

BIM COST CONTROL MODEL

Cost analysis

Firstly, the cost analysis of prefabricated buildings [5, 6] is carried out based on BIM Technology. Implement virtual construction of buildings through BIM Technology. Building BIM model is built, and cost analysis of each stage is implemented in the cycle construction process of the model.

(1) Theoretical basis

BIM, as a technology covering the whole life cycle of buildings [7, 8], will also keep BIM modeling until the building is completed. Therefore, it is necessary to build the most appropriate BIM modeling according to the life cycle of the building, rather than building the BIM model in a hurry. The specific steps are as follows:

Step 1: establish network and floor line

When architects create architectural and construction drawings, the layout of networks and floors serves as a crucial foundation. Accurate placement and positioning of columns depend on reference grids, facilitating on-site construction teams in locating precise points on the foundation. The floor line is essential for indicating floor heights and delineating the placements of beams, columns, wall heights, and floor positions. Typically, architects design floors and beams situated below the floor line, while walls are positioned beneath the beams or floors.

Step 2: import CAD documents

Importing CAD files into BIM software [9, 10] can make it convenient to directly select the drawing surface or draw according to the drawing when building column beam slab wall in the next step. When importing CAD, pay attention to whether the unit and grid line are consistent with the CAD drawing.

Step 3: establish column beam slab

Position columns, beams, plates, walls, and other elements within the model in accordance with the drawing's surface. Choose suitable shapes corresponding to the distinct characteristics of each component for accurate representation.

Step 4: color display

Color rendering is an important tool for visual communication. When the architect discusses the design with the owner, the three-dimensional model can be used to discuss the building shape, spatial image and whether the architect's design meets the owner's requirements.

Step 5: output to CAD drawing and detail table

In BIM modeling, it is not necessary to build all the contents in one step, but to continuously improve the accuracy of the model according to the steps. From conceptual design to a built design, Level of Detail (LOD) is defined as five levels, namely lod100 to lod500. LOD 100 – conceptual conceptualization. At this stage, referred to as the conceptual design phase, the model represents the building's overall form and structure. Typically, it portrays the building's volume and provides an analysis of various aspects such as volume itself, building orientation, and cost per square meter. At LOD 200, which entails an approximate geometric representation of components, the model reflects both schematic and expanded design elements. This level of detail is comparable to the conceptual and expanded design stages. The model at this stage contains the approximate quantity, size, shape, position, direction and other information included in the universal system. LOD 300 – precise geometry precise component (construction drawing and detailed construction drawing). This level corresponds to the traditional construction drawing stage and the further detailed construction drawing phase. The model at this point should encompass details like component properties and parameters outlined by the owner in the BIM submission standard. It has proven highly effective for tasks such as accurate cost estimation and facilitating construction coordination, which encompasses collision inspections, construction scheduling, and visual representation. LOD 400 – fabrication processing. The model at this stage can be used for the processing and installation of model units, such as the processing and manufacturing of project components by specialized contractors and manufacturers. LOD 500 – as built. The model at this stage represents the completion of the project. The model will contain the complete component parameters and properties specified in the owner's BIM submission instructions. The model will be integrated into the building operation and maintenance system as a central database.

Based on the above analysis, this paper analyzes the hidden cost of lod100 in BIM.

(2) Cost analysis results

The concealed quality cost pertains to the potential loss arising from subpar quality in the delivered products or services. This type of cost isn't captured in financial records and is only assessable through estimation methods [11]. It represents an actual loss that does not find expression in financial accounting, and its worth remains uncompensated. It's an intangible and latent form of loss.

In the categorization of quality expenses, hidden quality costs emerge within the consumer phase of the product's lifecycle expenditure. These costs share the common trait of detaching from the internal value chain of the enterprise. If the enterprise allows certain quality defects out of the consideration of cost saving, the image of the product trademark will be damaged due to the flow of defective products into the market, which will further affect the future market share and reduce the sales income. This possibility not only exists, but will continue for a long time, and the loss amount is difficult to estimate. Some scholars call the loss caused by such quality problems exposed in the process of consumer use "hidden quality cost". On the surface, the hidden quality cost is the manifestation of the external loss cost of the manufacturer, but in fact, it is caused by insufficient investment in prevention and identification, which is manifested as the sum of various quality costs that violate the "applicability". It may not only mean the costs borne by manufacturers, but some costs that consumers have to bear temporarily will eventually bring incalculable losses to enterprises. Although the hidden cost is not actually paid, it is virtually equivalent to increasing the product cost after it occurs. Therefore, attaching importance to and controlling the occurrence of hidden quality costs will fundamentally improve the economic benefits of enterprises. This aspect is more and more important in the modern industrial society with "user satisfaction" as the leading and restricting factor.

Hidden quality costs mainly include meeting costs, procurement costs [12], talent flow costs, and other costs. See Table 1 for details.

Tab. 1 - Hidden quality cost

Cost type	Influence factor
Meeting costs	Unscientific construction organization design
	Catch up with the construction period and neglect the quality problem
	Backward process method
	The quality inspection is not conducted carefully
	Defective design documents
	Blindly reduce costs and sacrifice quality
	Quality standards lag
Procurement costs	The quality of building materials is not up to standard
	Material and equipment factors: Equipment maintenance is not in place [13, 14]
	Material degradation
Talent flow costs	The owner is not responsible
	Dereliction of duty by supervisors
	Lack of training for labor personnel
	Low quality of construction management personnel
Other costs	Restriction of natural conditions
	Environmental factors (force majeure)
	Operation environment impact
	Market and policy impact

Project cost model

In the cost management of construction projects, quality cost is an important part that cannot be ignored. It is divided into two levels: explicit quality cost and implicit quality cost. Explicit quality costs refer to costs that can be directly recorded in accounting accounts, such as repair costs and compensation costs incurred due to quality issues. These costs are relatively transparent and easy to calculate and calculate. However, the implicit quality cost is not the case, as it often drifts away from accounting accounts and is difficult to quantify directly, making it easy for people to overlook. Implicit quality costs include indirect costs such as reputation loss, customer loss, and project delays caused by quality issues. Although these costs are not directly reflected in the financial statements, their existence and impact are tangible. If not controlled, the implicit quality cost can easily form a "benefit funnel", meaning that as the project progresses, quality problems accumulate, ultimately leading to a decline in overall project benefits. This not only hinders the comprehensive management of project costs, but may also have a serious impact on the long-term development of the enterprise. Therefore, in order to ensure real-time and dependable access to project information for Party A throughout the project construction journey, a hidden quality cost control framework for prefabricated construction projects is established, drawing on BIM [15–17]. This framework is designed to effectively manage the concealed quality costs associated with the project. The structure of this model is depicted in Figure 1.

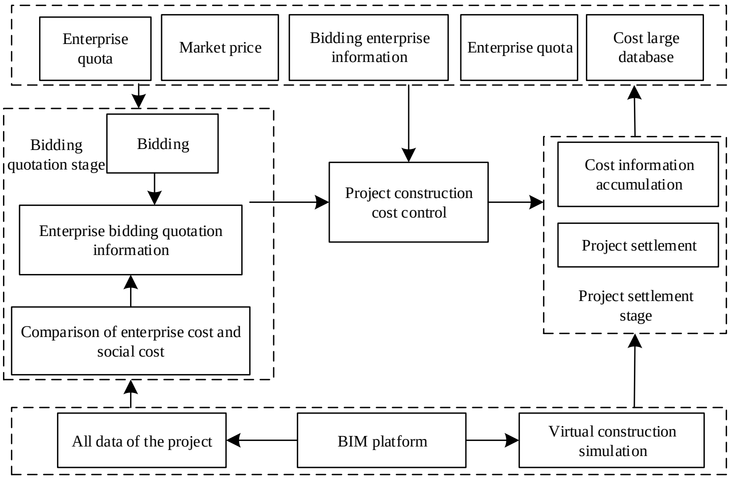

Fig. 1 – Hidden quality cost control model of prefabricated building construction project based on BIM

The model shown in Figure 1 is implemented in combination with BIM. In the model, the cost big data includes data information of multiple entities and levels. Party A integrates all information for the whole project from construction to completion. Cost big data has obvious hierarchical characteristics, and this kind of data is selective in the updating process, which can realize efficient information updating. Using BIM, Party A can carry out a virtual construction simulation of the project. This simulation encompasses the construction advancement and expenses for each construction phase of the project. It compiles the expense outcomes for each construction element, leading to more precise cost data compilation.

BIM based prefabricated building construction project information integration platform

The core of BIM is information, and the efficient mutual use of information is the core value of BIM. The prefabricated building construction project is an industry involving many parties and a large number of associations, and the construction period is relatively long. Therefore, in the whole life cycle, it generates a huge amount of information. In order to make this information fully, quickly and reliably used and play its value, Party A takes the leading position to complete the information integration of the prefabricated building construction project [18–20], According to the integrated information, the construction conditions of the prefabricated building construction project are simulated to provide reliable data basis for cost control. The architecture of BIM based information integration platform for prefabricated construction projects is shown in Figure 2.

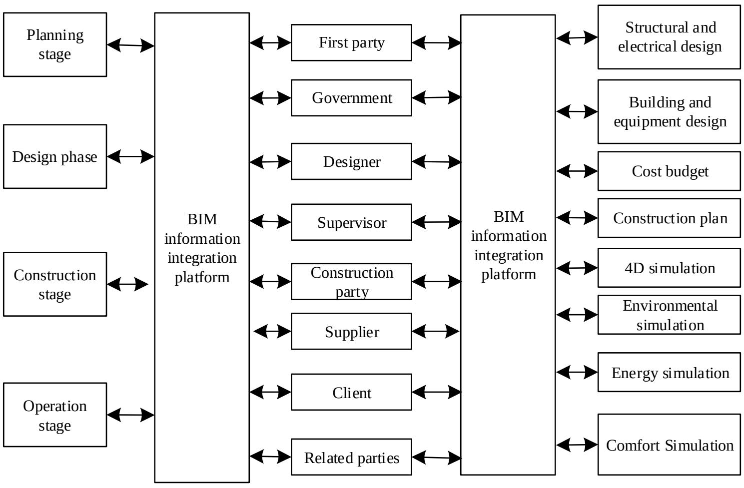

Fig. 2 – BIM based information integration platform architecture of prefabricated building construction project

BIM has a good integration function. The processing of various information of the project can be completed through information loading source and conversion standard. The former is in multi-interface state and the latter is a unified standard. It also supports the management and sharing of comprehensive and dynamic information of the project.

PROJECT HIDDEN QUALITY COST CONTROL METHOD

In construction projects, there is usually an initial budget or bid, which is estimated based on factors such as project design, scale, material costs, labor costs, etc. However, in the actual execution process of the project, due to various reasons (such as design changes, market fluctuations, changes in construction conditions, etc.), the actual cost may deviate from the budget. Therefore, the goal of the engineering cost control method in this article is to make the actual cost as close to or within the budget as possible through reasonable management and strategic adjustments during the project execution process. On the basis of building the above cost control model, this paper uses the typical technology of big data analysis, namely Extreme Learning Machine (ELM) [21, 22], to complete the hidden quality cost control of prefabricated construction projects.

Theoretical basis of limited learning machine

ELM represents a feedforward neural network characterized by a single hidden layer. It has significant advantages in operation efficiency and can ensure the reliability of cost control results. The implicit quality cost data of prefabricated building construction project is expressed by (x_i, t_i), and its quantity is N, which is taken as the input of elm, where $x_i = [x_{i1}, x_{i2}, \dots, x_{in}]^T \in R^n$ and $t_i = [t_{i1}, t_{i2}, \dots, t_{im}]^T \in R^m$. $\overline{N}$ represents the number of nodes in the hidden layer, $g(x)$ represents the activation function, then the elm control model is:

$$t_j = \sum_{i=1}^{\overline{N}} \beta_i g\left(w_i \cdot x_j + b_i\right) \tag{1}$$

Where: $j = 1,2,\dots,N$; β_i and w_i denotes the weight. The former belongs to the node between the hidden layer and the input layer, and the latter belongs to the node between the hidden layer and the output layer; b_i represents the offset value [23, 24], belonging to the node and located in the hidden layer.

During the learning and training of the model, in order to achieve the maximum approximation of the model to (x_i, t_i) with the number of N, it is necessary to ensure that formula (2) is established, which is:

$$\sum_{i=1}^{\overline{N}} \beta_i g\left(w_i \cdot x_j + b_i\right) = t_j \tag{2}$$

At this time, formula (2) is the output result of cost control. If $x_1, x_2, \ldots, x_N$ is the input, under its influence, the output of the i-th node in the hidden layer can be represented by the i-th column in the matrix. To complete the training of the model:

$$E = \sum_{j=1}^{N} \left(\sum_{i=1}^{\overline{N}} \beta_i g\left(w_i \cdot x_j + b_i\right) - t_j \right)^2 \tag{3}$$

When $g(x)$ is infinitely differentiable, w_i and b_i can be randomly allocated. At this time, the formula (1) is trained, and the training result can be regarded as the solution of the least square solution of formula (3). The formula is:

$$\hat{\beta} = H^{+}T \tag{4}$$

Where: H^{+} represents the generalized inverse matrix, belonging to H. Thereby completing BIM control.

BIM based cost control

Take the control results output by the model as the basis for BIM based cost control. To ascertain the interrelation and comparative significance of diverse indicators concerning the concealed quality expenses in prefabricated construction projects, separate hidden quality cost models for these projects are established utilizing the rough set theory. In order to obtain the Rule Association between the sub cost and the total cost, the association between each indicator is arranged; Formulate cost control strategies according to the obtained rules association results, complete cost control through the transfer of cost models, and provide cost control results to Party A.

The cost dynamics is generated by the construction activities of the prefabricated building construction project. The dynamic model of the hidden quality cost control of the prefabricated building construction project is constructed in combination with BIM. The model formula is:

$$s = (U, A, V, f) \tag{5}$$

Where: the cost information expression system is represented by U; Information sets and functions are represented by A and f respectively, and the former cannot be empty and finite; The total attribute is represented by V. $(x_1, x_2, \ldots, x_n)$ represents the universe; Each attribute is represented by a_m; The attribute is represented by a_j and its value range is represented by V_{a_j}. If $A \in C \in D$ is the condition that U needs to meet, and in f, C and D represent attributes, the former corresponds to the condition, and the latter corresponds to the decision.

The growth of the total set shall be based on the premise of controlling the growth of the subset cost. The discernible matrix is represented by $M = n \times n$, which is used to describe the quantification of the cost deviation. If it is input into formula (5), the elements in $M = n \times n$ are described by formula (6):

$$m_{ij} = \begin{cases} c \in C & c(x_i) \neq c(x_j), d(x_i) \neq d(x_j) \\ 0 & d(x_i) = d(x_j) \end{cases} \tag{6}$$

Where: x_i represents cost data, and its value on c is represented by $c(x_i)$; The value of D after solution is expressed by $d(x_i)$. The higher the frequency of attributes in the matrix, the better the representation effect; The more attributes exist, the more important they are. Attribute is the core element of cost control. Formula (7) is used to measure the relative importance of cost indicators:

$$sig(c) = \sum_{i=1}^{n}\sum_{j=1}^{n}\frac{\lambda_{ij}}{|m_{ij}|} \quad (7)$$

Where: the relative importance of each indicator of cost is expressed by $sig(c)$; The number of attributes is represented by $|m_{ij}|$; The global effect of attributes is represented by $\sum_{j=1}^{n}$; Quantitative attribute benefit is expressed by λ_{ij}. After the normalization is applied to the formula (7), the corresponding factor importance can be obtained. The formula is:

$$W = (w_1, w_2, \ldots, w_n) \quad (8)$$

Where: $w_1, w_2, \ldots, w_n$ represents cost factor.

Simplify the cost attribute and remove redundant information. Rough sets contain upper and lower similar sets, respectively corresponding to the primary merge set of X and the intersection set of X, and all elements in the two sets belong to X. H denotes a non-empty set, which is given, and its equivalence relation is represented by R, and $X \in U$; The similarity space is represented by K, and $K = \{U, R\}$, the association between elements is obtained according to formula (8), and in each index element belonging to the cost, the formula is:

$$R(X) = \{X \in U: [X]_R \subseteq X\} \quad (9)$$

$$(X) = \{X \in U: [X]_R \cap X\varphi\} \quad (10)$$

The above two formulas respectively represent the lower and upper similarity sets, which belong to R and are located in X; $[X]_R$ represents a set, which is composed of X and its equivalent relationship. Formula (11) ~ (13) for the edge domain, positive domain and negative domain respectively:

$$B_{nR}(X) = R^{-}(X) - R_{-}(X) \quad (11)$$

$$P_{POS_R}(X) = R_{-}(X) \quad (12)$$

$$N_{Neg_R}(X) = U - R_{-}(X) \quad (13)$$

Where: the former belongs to X , and the latter two belong to R and are located in X .

According to the association between each indicator of cost, the ranking is implemented. Based on the rough set theory, the cost control decision-making and probability rules are obtained, which are located in the order structure. The rules between costs are related, and the acquisition is simplified according to the attributes. The cost control is completed according to the Rule Association, as shown in formula (14):

$$P_{POS_{R-C}}(D) = \frac{\lambda_{ij}\sum_{i=1}^{n}P_{POS_R}(D)}{N_{Neg_R}(X)} \quad (14)$$

Where: $P_{POS_{R-C}}$ represents the negative field and belongs to the total cost set.

Optimization of hidden quality cost control of prefabricated building construction project

The statistical analysis model for the hidden quality expenses in prefabricated construction projects is formulated, and the characteristic attributes of the association rule pertaining to the hidden quality cost within these projects are derived as follows:

$$S_{i,j}(t) = p_{i,j}(t) - \lambda_{ij} p_{i,j}(t) \tag{15}$$

In the provided expressions, $p_{i,j}(t)$ denotes the fuzzy evaluation feature of the hidden quality cost in the context of prefabricated building construction projects, while $T_{i,j}(t)$stands for the feature set encompassing the operations related to the hidden quality cost within these projects, presented as:

$$T_{i,j}(t) = \frac{\left|p_{i,j}(t) - \Delta p(t)\right|}{P_{POS_{R-C}}(D)} \tag{16}$$

In this context: $\Delta p(t)$ represents the gain coefficient. The approach of multiple regression analysis is employed to actively uncover the hidden quality cost dynamics within prefabricated construction projects. The outcome is the acquisition of the quantitative characteristic distribution function for the hidden quality cost within these prefabricated construction ventures, illustrated as follows:

$$U_{i,j}(t) = \exp\left(-T_{i,j}(t) z_i(t)\right) \tag{17}$$

Where $z_i(t)$ signifies the ambiguity function associated with the hidden quality cost of the prefabricated construction project [25].

Employing the big data information fusion technique facilitates the operational management and statistical oversight of the hidden quality cost within prefabricated construction projects. This leads to the establishment of the training function $s_i = \{x_j : d(x_j, y_i) \le d(x_j, y_l)\}$ for controlling the hidden quality cost of such projects. Under the influence of fuzzy information, the quantitative measure of the fuzzy degree in relation to the control of hidden quality cost within prefabricated construction projects is achieved.

$$\min z_i(t) = \min\left\{U_{i,j}(t), N_{Neg_R}(X)\right\} \tag{18}$$

Using the limit learning machine, the weight vector μ_{ik} of the hidden quality cost control of the prefabricated construction project is obtained. Under the guidance of association rules, the optimization objective function of hidden quality cost control of prefabricated construction projects is obtained as follows:

$$J = \sum_{k=1}^{n} \sum_{i=1}^{c} \mu_{ik} \min z_i(t) \tag{19}$$

Solve formula (19) to complete the hidden quality cost control of the prefabricated building construction project:

$$V_i = x_k \sum_{k=1}^{m} \mu_{ik} \Big/ J \tag{20}$$

According to the above analysis, we can realize the hidden quality cost control of prefabricated construction project.

TEST ANALYSIS

Project overview

The prefabricated building in the experiment is a student apartment. The building structure of the apartment is a frame shear assembly structure. The project contracting mode is general contracting. The overall building area can reach 25000 square meters, and it is divided into two buildings. In the given context, Building A consists of seven above-ground floors and two below-ground floors, encompassing a combined area of 4200 square meters. On the other hand, Building B features eighteen above-ground floors and two below-ground floors, with a total area of 20800 square meters. The project is priced in the form of list, except for the following adjustments: adjustments allowed by the contract, various rewards and penalties, economic visas, design changes, changes in the manufacturer or brand of equipment and materials, risk adjustment in the price of commercial concrete and reinforcement, and provisional price adjustment of equipment and materials. No adjustment will be made due to rate changes, technical measures costs, machinery costs, material prices, labor costs and other reasons. In this paper, the prefabricated building construction project is selected as the case study object. According to the requirements of Party A, the cost control of the project is carried out through MATLAB software according to the cost control method proposed in this paper, and the overall application of this method is tested.

Result analysis

In the experiment, the running time and relative error data of the method are obtained, and the control effect is reflected by these two parameters. The calculation formula of relative error is as follows:

$$\partial = \frac{y_i - \hat{y}_i}{y_i} \tag{21}$$

Where: ∂ represents the relative error. The smaller the absolute value, the stronger the implicit quality cost control ability of the model. In the experiment, in order to enhance the contrast of the results and make the experimental data more abundant and detailed, the running time and relative error experimental data of the two methods are added as the comparative data in the experiment. These two methods are the implicit quality cost control method based on difference algorithm and ism. Firstly, the running time of the three experimental methods was tested.

For this method and the implicit quality cost control method based on difference algorithm and ism, the running time experimental data in cost control are shown in Table 2.

Tab. 2 - Operation time experimental data

Prefabricated building	Control iterations	Running time (s)		
		Methods in this paper	Method based on difference algorithm	Methods under ISM
Building A	5	1.42	1.84	2.13
	10	1.76	2.03	2.02
	15	1.74	1.92	2.07
	20	1.94	2.14	2.12
Building B	5	2.16	2.51	2.8
	10	2.15	2.58	2.84
	15	2.37	2.57	2.72
	20	1.97	2.88	3.1

The running time experimental data in Table 2 shows that, compared with the implicit quality cost control method based on the difference algorithm and ism, the design method takes less time to control the cost of building a or building B within the range of 5-20 control iterations, which proves that the designed implicit quality cost control method model has shorter running time than other methods.

The text method needs to control the project cost before controlling the cost. In this paper, elm is used to complete the cost control. During the control process, elm needs to determine the optimal number of hidden layer nodes, and take the time complexity of model training as the measurement standard to test the time complexity results of this method under different node numbers, as shown in Figure 3.

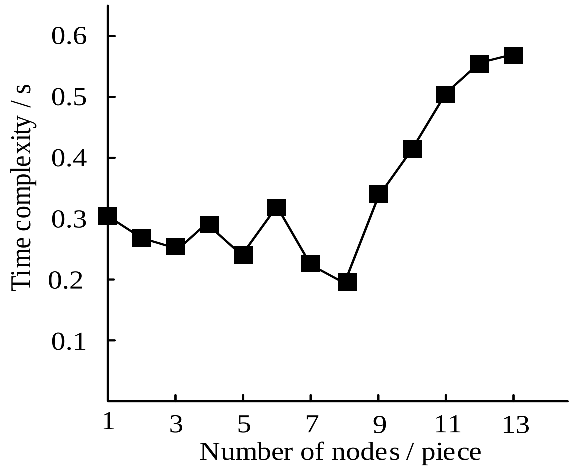

Fig. 3 – Test results of number and time complexity of hidden layer nodes

According to the test results in Figure 3, it can be seen that the model training time complexity fluctuates irregularly when the number of hidden layer nodes increases gradually, but the time complexity is the lowest when the number of nodes is 8. When the number of nodes exceeds 8, the time complexity increases significantly. This result is that the training time of the model will increase significantly due to the excessive number of nodes.

Then the relative error experimental results of the cost control results of the three experimental methods are obtained. The relative error between this method and the implicit quality cost control method based on difference algorithm and ISM is shown in Table 3.

Tab. 3 - Relative error test results

Prefabricated building	Control iterations	Relative error		
		Methods in this paper	Method based on difference algorithm	Methods under ISM
Building A	5	2.77	3.36	3.95
	10	2.65	3.65	3.01
	15	2.52	3.58	3.12
	20	3.45	3.9	3.52
Building B	5	2.45	3.52	3.05
	10	2.3	3.96	3.67
	15	2.85	3.48	3.41
	20	2.94	3.74	3.62

According to the relative error experimental results in Table 3, the relative error of the design method is smaller than the implicit quality cost control method based on the difference algorithm and ism, which proves that the design method has stronger implicit quality cost control ability.

The text method needs to control the project cost before controlling the cost. In this paper, elm is used to complete the cost control. During the control process, elm needs to determine the number of nodes in the best hidden layer, and take the root mean square error of model training as the measurement standard to test the root mean square error results of this method under different node numbers, as shown in Figure 4.

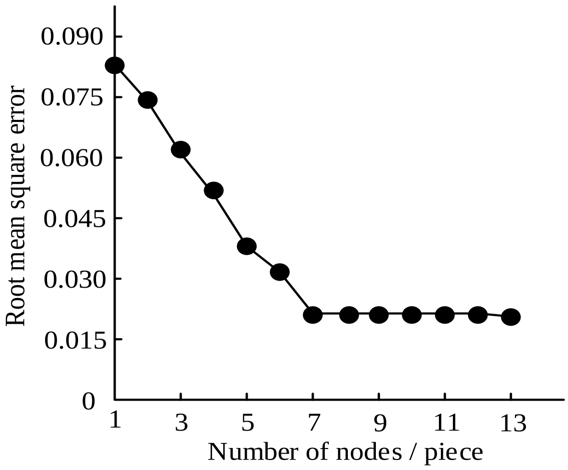

Fig. 4 – Root means square error test results of hidden layer nodes

According to the test results in Figure 4, with the gradual increase of the number of hidden layer nodes, the root mean square error shows a gradual downward trend. When the number of nodes is 7, the root mean square error is the smallest, which is 0.012. After the number of nodes exceeds 7, the root mean square error remains almost unchanged

Combined with the test results of time complexity (running time) and root mean square error (relative error), the number of hidden layer nodes is finally determined to be 8 and used in subsequent tests.

Test the change results of the model fitness function under different node numbers with the gradual increase of iteration times under the optimal number of hidden layer nodes to measure the convergence performance of this method. The results are shown in Figure 5.

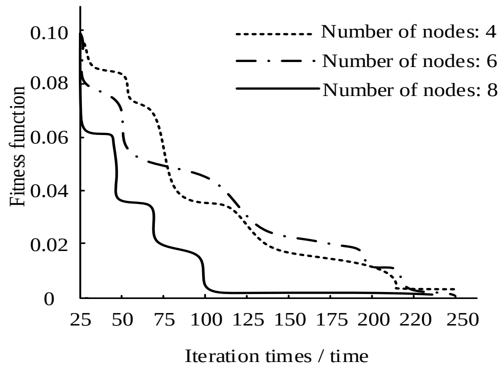

Fig. 5 – Convergence performance test results

As depicted in Figure 5, the test outcomes reveal that as the number of iterations increases gradually, the fitness function displays a consistent downward trajectory. Notably, when the node count is set at 4 and 6, the fitness function exhibits a gradual decline. Beyond 200 iterations, the fitness function reaches a state of stability without further fluctuations. Similarly, with 8 nodes and

100 iterations, the fitness function stabilizes. These findings underscore the method's commendable convergence capabilities, indirectly confirming the appropriateness of the 8-node configuration. In order to test the implicit quality cost control performance of the method in this paper, taking the seven project construction parts divided into the project as an example, the method in this paper is used to control each part and obtain the control results, as shown in Figure 6. Among them, the construction parts of 7 projects are represented by No. 1-7 construction respectively.

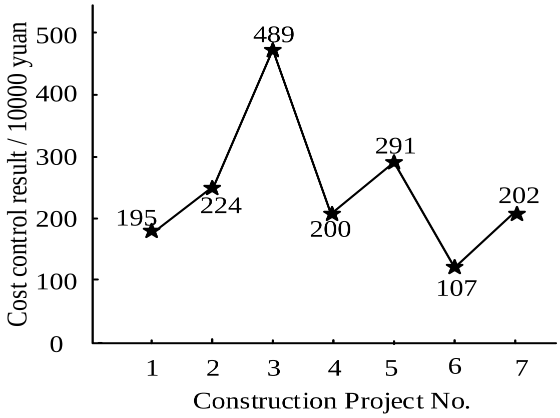

Fig. 6 – Cost control performance test results

According to the test results shown in Figure 6, this method can complete the hidden quality cost control of 7 project construction parts of the prefabricated building construction project, because BIM is used to control the cost of the project. BIM has information integration and virtual construction of the project, and can reliably grasp the progress of the project in different construction parts. Therefore, the construction cost of each part of the project can be controlled, good cost control performance of each project.

To evaluate the efficacy of this method in controlling hidden quality costs, a textual approach is employed to manage cost information post-control. This generates an overall assessment of cost control outcomes for the prefabricated building construction project. To ensure the impartiality of the control outcomes, the evaluation is conducted across three distinct scenarios.

The first scenario involves introducing 1dB noise to the cost information. The second scenario entails randomly selecting 5 × 104 data entries. In the third scenario, 20 × 104 erroneous data inputs are used. The resultant control outcomes for the overall cost of the prefabricated building construction project in these three conditions are contrasted against actual cost results. This comparison serves as a metric to gauge the effectiveness of the method's control capabilities. The outcomes of this analysis are presented in Figure 7.

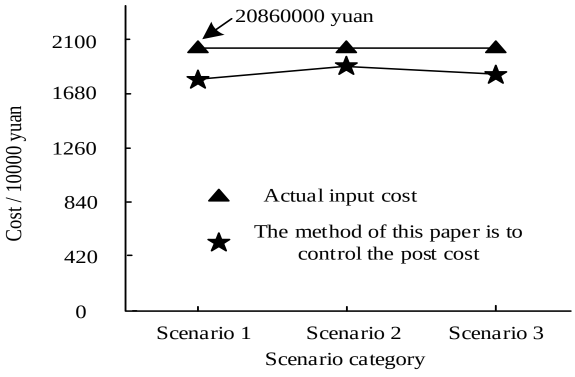

Fig.7 – Cost control results

According to the test results shown in Figure 7, under the three scenarios, the method in this paper can complete the cost control and control, and the cost after control is lower than the cost used in the actual construction. The results show that the method in this paper can more reasonably complete the total cost control of the prefabricated building construction project and realize the cost control under different scenarios. The reason is that BIM has the information integration function and can complete the integration and analysis of comprehensive information, and the method in this paper has a large cost database, which can provide reliable reference data for cost control. Therefore, even if there is a certain degree of missing or error in data information. The cost control can still be completed, and the control result is still better than the actual cost result, which can ensure that the cost of all links of the prefabricated building construction project is the most reasonable state and better than the actual input cost.

CONCLUSION

As the prefabricated building construction project mode is completed jointly by many parties, it is difficult for Party A to control the cost, and it is impossible to achieve information management and control. This paper analyzes the characteristics of a prefabricated building construction project, and puts forward the BIM control method of hidden quality cost of prefabricated building construction project to help party and complete the cost control of the project. This approach integrates BIM technology to effectively manage the cost aspects of prefabricated building construction projects. The conducted testing demonstrates that the method presented in this paper is capable of controlling costs within such projects. Additionally, it achieves the control of hidden quality costs across each construction facet within the entirety of the project. The application of BIM facilitates the consolidation of all pertinent project information, establishing a dependable foundation for Party A's cost control efforts and ensuring cost optimization.

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