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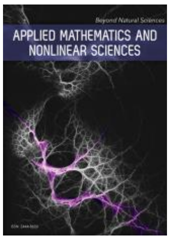

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Exploring the construction of an all-round cost management system for investment control in university engineering construction

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Abstract

In recent years, the investment amount of university engineering construction has been increasing significantly, and the establishment of scientific and reasonable cost management system has become particularly important in the investment control of engineering construction. This paper explores the investment control of university engineering construction and designs the basic framework based on three parts: whole process cost control, full caliber cost audit and full gradient grading management. With the help of BIM, we build a cost management system, which is divided into the planning stage, bidding stage, mid-construction, until the completion of the collation of cost data, extraction and preservation of cost indicators. After establishing a full range of cost management systems, the adjacency matrix X algorithm and functions are used to calculate. The experiment proves that: the investment estimate before the project construction affects more than 75% of the overall investment, and the all-round cost management system built based on BIM can make the investment estimate accurate and stable at 75%, and the negotiation change rule based on this is to save nearly 25% of the investment funds. The comprehensive cost management system has a comprehensive and detailed grasp of the cost process of specific construction projects and specific issues during construction, fully protecting the university's investment interests.

Keywords: University engineering construction; Investment control; All-round cost management; BIM technology; Investment estimation
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1 Introduction

Education is the key to a hundred-year plan. Education is an important cornerstone for national revitalization and promoting social innovation [1]. It is the fundamental way to improve the quality of the nation and promote the all-round development of human beings. Education carries the expectation of hundreds of millions of families for a better life and the hope of great national rejuvenation [2-3].Neither artistic nor disciplinary education is superior or inferior, as they both have a very profound impact on a person's life [4].But whatever education takes place requires a certain place, and the school is the best vehicle to carry out the act of education.

People are becoming more and more demanding on the material and spiritual levels. Therefore, it is urgent to upgrade the level of school operation and improve the conditions of school operation. The most basic requirement for colleges and universities to enhance the level of schooling and improve schooling conditions is to improve infrastructure construction. Relying on the development of economy and science and technology [5-6], the construction industry has been explored more [7]. However, the cost of college construction is limited, and new and repair college projects cost a lot of financial resources, light tens of millions and hundreds of millions of dollars. Construction project investment control is particularly important at this point, especially the investment estimation part at the beginning of the project [8-10], because it will largely affect the economic efficiency of the project. To reduce the burden of college engineering construction, we must strictly and reasonably control the project cost and build a comprehensive cost management system.

The literature [11] proves that large projects are risky in terms of cost and time, so we have to find the right method or system to avoid the risk. The literature [12] analyzes that in economic behavior, investments should be able to make reliable forecasts in advance in addition to considering the market offer to ensure high returns while reducing risk. This is reminiscent of other industries where investment forecasts and estimates are required to protect interests. The literature [13] concludes by discussing some practical aspects of implementing experimental uncertainty analysis in engineering tests, which shows the importance of optimizing the construction plan for engineering construction. The literature [14] presents one of the largest projects to demonstrate the management process of a large project: it consists of an initial and feasibility study, an urban and architectural design and an associated competition. Among them, architectural design is a very important part, if the design scheme is not in place, the subsequent construction will encounter many problems. The literature [15] suggests that architectural design has also undergone a dramatic transformation in the last 40 years based on the development of computer technology, and architects are faced with digital challenges, which include the implementation of parametric modeling tools. Therefore, relying on BIM for 3D modeling of architectural design is a major development trend, which provides relevance for the study of this paper. The literature [16] explores that the extensive benefits of BIM for building information modeling are not fully exploited by industry stakeholders. It provides theoretical support for researchers to integrate BIM technology into a full range of cost management systems. The literature [17-21] demonstrates to people through examples that BIM technology can make a difference in the construction industry. In summary, there are still more studies using BIM technology to solve the problems encountered in the construction process, but these studies summarize BIM technology simply as information integration, a static physical model. And these studies are more theoretical and lack the support of practice and data.

The purpose of this paper is to control the investment in university engineering construction by constructing an all-round cost management system with full process cost control, full-caliber cost audit and full-gradient hierarchical management. In order to better control the funds as a whole, BIM technology, which is currently widely used in the construction industry, is invoked in the construction of a comprehensive cost management system. The correlation coefficient is calculated by the mean value and difference series, and the gray correlation between the construction of all-round cost management system and the investment control of university engineering construction is obtained, which proves that the construction of all-round management system can realize the accurate investment estimation of project engineering, optimize the design and construction plan and solve the phenomenon of negotiation change easily in the construction process, so as to realize the investment control of university engineering construction. To provide a more comprehensive cost management system for future investment control in university construction.

2 Build a comprehensive cost management system with the help of BIM technology

2.1 Basic composition

The all-round cost management system is composed of three parts. The first part is the whole process cost control; the second part is the full-caliber cost audit; the third part is the full gradient grading management. Between these three parts, the construction cost is monitored and managed from the perspective of no technical means and management, but the investment in every aspect of the whole project is managed precisely.

2.1.1 Whole process cost control

The whole process cost control refers to the cost management mode of tracking the project estimation, design estimate, construction drawing budget, bidding control price, construction process cost audit and project settlement with the help of professional cost technology and relying on professional cost personnel for the projects to be built by universities. It includes the pre-construction preparation stage, the construction process and the project settlement stage.

2.1.2 Full-caliber cost audit

There are blind areas of investment management in the process of project costing, and the full-caliber cost audit aims to eliminate the blind areas of investment management. Only when all project investment is included in the scope of settlement audit, can the investment interests of the school be fully protected.

2.1.3 Full-gradient grading management

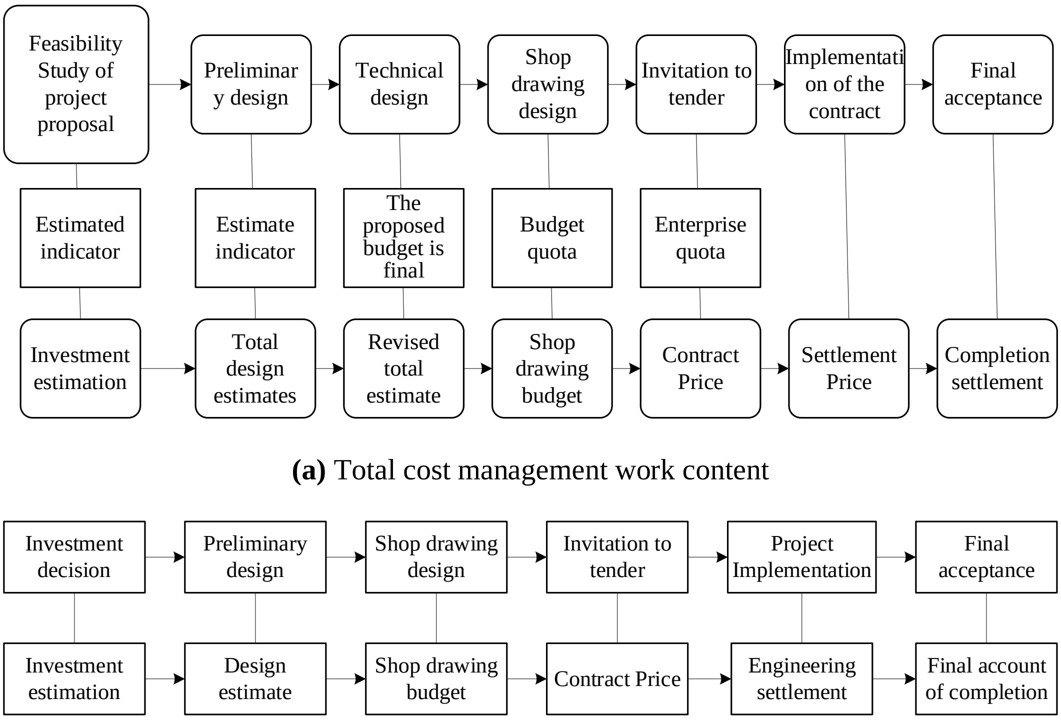
Due to the degree of design perfection, the degree of user demand clarity and the complexity of construction site conditions and environment, a large number of negotiation changes will occur during the implementation of college engineering construction. Full-gradient graded management is predictive, and timely negotiation change approval is carried out during the project construction process to control investment in real time.

2.2 Construction of all-round cost management system

All-round cost management should run through the implementation stages of project planning, design, transaction and construction, and all-round cost management should include the following work contents, as shown in Figure 1(a). However, with the rapid development of economic technology and the construction industry, the scale and area of buildings are getting larger and larger. There is an urgent need to seek a new technology to make the whole engineering and construction process and all aspects of engineering and construction presented in one system. In this context, it is found that

BIM can help to realize the integration of building information, from the design, construction, and operation of a building to the end of the building's whole life cycle, with all kinds of information always integrated in a 3D model information database. Design teams, construction units, facility operation departments and owners can work collaboratively based on BIM, which can effectively improve efficiency, save resources and reduce costs to achieve sustainable development.

The specific work of the full range of cost management work designed using BIM software is shown in Figure 1 (b): in the planning stage to carry out the total project investment estimate design stage mainly for the preparation of the budget estimate. In the bidding stage to carry out the bidding control price or the preparation of the intercept price. In the construction mid-term settlement, quantity calculation and engineering change control are carried out, and the statistical quantity and claim management are carried out in the completion settlement. Finally, we finish the collation of cost data, cost index extraction and preservation.



(a) Total cost management work content

(b) The work content of all-round cost management designed by using BIM-related software

Figure 1. All-round cost management system

A complete BIM model of engineering project can be built from the following four levels, as shown in Table 1. Each level should contain the following elements: sub-model contains the information of basic components, such as frame columns and structural beams in construction, and the size, length and structural form of steel in steel structure, which is more like the itemized works in the construction bill of quantities. The professional component layer should contain all components covered by each profession, for example, foundation components in structural profession, piping components in water supply and drainage profession, etc., which is more like the divisional works in the bill of quantities. The basic model expresses the basic information of single project, the related relationship between each sub-model and professional components, such as site, floor, related properties, related process, related relationship, etc. This corresponds to the unit project in the list specification. The project is in different stages, and each participant needs to achieve different functions, all need to have their own models, such as the site model built by the planner, the structural model built by the designer, the construction model built by the contractor, the as-built model built by the owner, etc.

Table 1. Standard BIM model hierarchy

Model Level	Content included	Corresponding inventory level
Submodels	Foundation construction information: frame column, frame beam	Sub-projects
Professional Construction	Building components: building foundations, plumbing and electrical piping	Divisional Engineering
Basic Model	Basic information on individual projects: venue, floor	Unit works
Data Information	Participants' own models: structural model, construction model, as-built model	Single project

3 All-round cost calculation

3.1 Investment estimation

Project estimation is an indispensable preparation for cost management in the pre-construction stage of college engineering. This stage is less costly, but the accuracy will have a significant impact on the following work. If the budget calculation result at this stage is not accurate, it is easy to cause the consequences of serious shortage of funds later. The accuracy of the calculation plays a pioneering role in the whole college engineering construction cost. The costing process cannot be ignored because the design cost accounts for a small proportion of the total cost of the construction project. According to the relevant research and survey, the rationality, feasibility and accuracy of the design scheme can affect 75% or even 90% of the whole project costing work. This shows that the use of the optimal cost program can make the entire cost of a million dollars impact. Construction process cost audit management is an important part of the entire construction cost. This link should discuss the feasibility, economy, efficiency and environmental protection of the construction technology plan of the whole project construction. A reasonable and efficient construction process audit can predict in advance whether the investment amount will change, so that the whole project construction has controllability. Project settlement is the closing stage of the entire construction is also the core work of engineering cost management, is one of the core links to determine the total cost of investment and the total cost of the project, and plays a decisive role in the scientific and standardized project management and the effectiveness of engineering cost audit.

BIM has the function of cost estimation [22-25], which can import 2D drawings into the software of BIM technology according to the available data, create 3D models, and use the powerful information statistics function of BIM to make investment estimation. The precision requirements and accuracy are shown in Table 2.

Table 2. Investment estimation accuracy requirements and BIM seeking accuracy

Investment estimation stage	Accuracy requirements	Accuracy
Investment Decision	Greater than 30%	75%
Project Proposa	Within 30%	23%
Preliminary feasibility study	Within 20%	15%
Detailed feasibility study	Within 10%	7%

In general, the investment in the construction of university projects can be defined as the following problem.

Objective function.

$$\min J = \int_{t_o}^{t_f} L\left(x(t),u(t),t\right)dt \tag{1}$$

Equation of state.

For continuous time systems.

$$x(t) = f\left[x(t),u(t),t\right] \tag{2}$$

For discrete-time systems.

$$x(k+1) = f\left[x(k),u(k),k\right] \tag{3}$$

Control scope.

$u(t)$ Constraints to be satisfied.

$$u(x,u) \le 0 \quad j = 1,2,\cdots,m(m \le r) \tag{4}$$

Control set.

$$U = \left\{u(t)\middle|\varphi_j(x,u) \le 0\right\} \tag{5}$$

Allowable control.

$$u(t) \in U \tag{6}$$

The end conditions are the same as the beginning conditions: a set of constraints that can be given by the project sponsor or institution and a set of constraints of the social and natural environment.

Where: J cost, for each control function there is a value corresponding to it; L cost function, which is a function of vectors $x(t)$ and $u(t)$; $x(t) - n$ dimensional state vector; $k -$discrete fragment k corresponding to a time point; $u(t) - r$ dimensional control vector; $f - n$ dimensional vector function; $\varphi_j - x,u$ boundary function of the action domain.

According to a report of Royal Academy of Engineering, for example, the ratio between construction cost, maintenance cost and operation cost is 1:6:190. This shows that the operation and maintenance cost of many projects is much larger than the construction cost, which shows that the investment in college projects is not well controlled. However, at present, most of the decision makers' eyes and control means are only betting on the construction stage of project cost management, while a far-sighted decision should be a comprehensive view of the whole situation, so cost management should be carried out from all aspects of the project. The core idea of all-round cost management theory is to consider the preliminary planning and design costs, construction period costs, post-delivery operation costs and maintenance costs as a whole in the project decision-making stage. The starting point is to maximize the value of the whole project by balancing the construction and operation costs, i.e., the total cost is minimized and the total value is maximized. However, to achieve this goal, the costs of the whole construction process must be accurately estimated.

3.2 Design and construction

To calculate the floor area, the construction unit or its commissioned BIM consulting unit needs to establish a simulation of the three-dimensional model, and use the model to import into the relevant calculation software to quickly calculate the volume of work.

$$S = (A+4)\times(B+4) = Send + 2Loutside + 16 \tag{7}$$

Where: S is the amount of leveling site works; A is the length of the exterior wall edge in the length direction of the building; B is the length of the exterior wall edge in the width direction of the building; $Send$ is the floor area of the ground floor of the building; $Loutside$ is the perimeter of the exterior wall edge of the building.

Calculate investment estimates using historical project technical indicators of the same structural form, use and technical standards as those of the proposed project. Three-dimensional modeling at the investment decision stage and rapid calculation of quantities based on this model will produce fast and accurate investment estimating documents, which will substantially improve the accuracy of the estimates and provide accurate data sources for subsequent cost management work. The technical estimation indexes of each specialty utilized often require cost staff to collect, analyze and store the estimation indexes by themselves or query similar engineering cost information and calculate the existing cost data. The unit accumulated three-dimensional model of each project calculated by the volume of work, project prices and other cost data, in the preparation of the next project estimate will have the actual, detailed estimating information available for query.

Carry out the design work. The three-step process of design work is preliminary design, schematic design, and construction drawing design. In the preliminary design stage, since there are no detailed construction drawings, it is impossible to calculate the exact amount of works, and the method of determining the project cost at this time is still to use the floor area and building index for calculation, which is similar to the investment estimate, so it is not repeated. The program design stage is mainly to do some deepening of the technically difficult parts. In the construction design stage, according to the design of the construction drawings to calculate the exact amount of work, the use of the current list of pricing norms and the local fixed rate of labor, materials, machinery consumption standards and cost standards to calculate the amount of sub-item works and calculate the list of unit prices, and then take the cost, summary calculation of the cost of the project, construction budget relative to the investment estimate and the preliminary design estimate to derive the project Price is more accurate, of course, the calculation process will also be more complex.

In the design stage can also use BIM software to carry out some direct conflict checks of various professions, for example, the drainage pipes to go to collision check, you can see whether the engineering pipes collide with the frame beam; between each of our views, such as structural drawings and architectural drawings there is no inconsistency. In the design stage, we try to modify the drawing errors, so as to avoid the occurrence of rework and changes in the later construction, thus avoiding the increase of project cost.

In the bidding stage, the main use of BIM software to establish the quantity model for fast and accurate calculation, the use of pricing software and list specifications combined with a list of items and calculate its comprehensive unit price, and finally calculate the cost of the project as a tender control price or bid price.

After the new project is constructed, the corresponding calculation rules are selected and floors are established for vertical space division. Identify the axis network for horizontal positioning. Identify columns, calculate column concrete volume, formwork volume, reinforcement volume, etc., identify beams, calculate frame beam concrete volume, formwork volume, reinforcement volume inside beams, etc., identify slabs, calculate cast-in-place slab slab concrete volume, slab bottom mold volume, reinforcement volume inside slabs, etc., identify walls, door and window openings, identify rooms, calculate decoration volume, identify foundations, automatically generate pads and earthwork. Finally, according to the calculation results go to the preparation of tender quotation.

In this process, it should be noted that: foundation trench excavation and pit excavation do not belong to the same concept, the length of the exterior wall foundation trench and the length of the interior wall foundation trench are calculated as the net length of the interior wall, and the intersection rejoins out not with the deduction of.

$$V=\left(A+2C+K\times H\right)H\times L \tag{8}$$

Where: V is the volume of soil in the foundation trench; A is the width of the bottom of the trench; C is the width of the working surface; H is the depth of the foundation trench; L is the length of the foundation trench.

$$V=1/6\,H\left[A\times B+a\times b+\left(A+a\right)\times\left(B+b\right)+a\times b\right] \tag{9}$$

Where: V is the volume of pit; A is the length of the top of the pit; B is the width of the top of the pit; a is the length of the ground of the pit; b is the width of the bottom of the pit.

It should be noted that the construction project second class cost originally does not belong to internal audit, but the construction project second class cost has many types and large quantity, which accounts for about 10% of the project investment, as shown in Table 3. The full-caliber cost audit management mode makes the university engineering construction break the original engineering cost boundary, incorporates the construction engineering second-class fees which were not originally subject to internal audit into the scope of internal audit, comprehensively eliminates the blind spot of investment management, and at the same time provides the protection of school investment interests and scientific audit of engineering settlement.

Table 3. Types of construction works II and the proportion of costs in the project investment

Construction Engineering II	Category	Percentage of
	Design Fee	3%
	Supervision fee	1%
	Survey Fee	1.2%
	Bidding agency service fee	0.8%
	Project proposal preparation fee	2%
	Environmental Impact Assessment Fee	0.3%
	Foundation Pit Monitoring Consulting Fee	0.7%
	Foundation pit monitoring and testing fees	1%

3.3 Negotiation changes

Data show that more than 80% of construction projects will produce negotiation changes during the construction process. 10% of large negotiations account for 40% of the total cost, and 65% of the number of small negotiations will also account for 15% of the cost. If negotiation changes are not handled well, a significant additional expense will be added to the project investment.

Adjacency matrix X is used to indicate the interrelationship between factors affecting BIM application in project cost management affecting negotiation changes. 0 means there is no mutual influence, 1 means there is mutual influence. Let the time, amount, processing department, project manager, engineer, information clerk and budget clerk be 1-7 respectively, from which the adjacency matrix X can be obtained

$$X = \begin{bmatrix} 0\ 0\ 0\ 1\ 0\ 1\ 0 \\ 0\ 0\ 0\ 0\ 0\ 1\ 0 \\ 0\ 1\ 0\ 0\ 0\ 0\ 1 \\ 0\ 0\ 0\ 0\ 0\ 1\ 0 \\ 0\ 1\ 0\ 0\ 0\ 0\ 0 \\ 0\ 1\ 0\ 0\ 0\ 0\ 0 \\ 0\ 1\ 0\ 0\ 0\ 0\ 0 \end{bmatrix} \tag{10}$$

Adjacency matrix X plus unit matrix I yields matrix Y. Then Boolean operation is performed on Y until Yn-1 ≠ Yn=M, M is the final reachable matrix, which can represent the interrelationship between the factors of negotiation changes in BIM application in project cost management.

$$M=\begin{bmatrix} 1\,1\,0\,1\,0\,1\,0 \\ 0\,1\,0\,0\,0\,1\,0 \\ 0\,1\,1\,0\,0\,1\,1 \\ 0\,1\,0\,1\,0\,1\,0 \\ 0\,1\,0\,0\,1\,1\,0 \\ 0\,1\,0\,0\,0\,1\,0 \\ 0\,1\,0\,0\,0\,1\,1 \end{bmatrix} \tag{11}$$

Gray correlation is a quantitative analysis of the development process of a system by determining the degree of association between factors based on the degree of similarity between curves, and measuring the degree of proximity between factors based on the similarity of developmental dynamics between factors. The greater the correlation between factors, the more similar they are.

The gray correlation degree has the following properties:

1) Normality, i.e., the gray correlation degree takes values on (0, 1).

2) A set has an association degree of 1 in itself.

Let $X_0=(X_0(1), X_0(2),\dots ,X_0(n))$ be a sequence of system features and

$$X_1=(X_1=(X_1(1),X_1(2),\dots ,X_1(n))$$

$$\dots\ \dots\ \dots\ \dots\ \dots\ \dots$$

$$X_i=(X_i=(X_i(1),X_i(2),\dots ,X_i(n))$$

$$\dots\ \dots\ \dots\ \dots\ \dots\ \dots$$

$$X_m=(X_m=(X_m(1),X_m(2),\dots ,X_m(n))$$

Is the sequence of correlated factors, then the correlation between factor Xi and indicator X0 is defined as

$$V_t=\frac{1}{n}\sum_{i=1}^{n} li\left(t\right) \tag{12}$$

$$li\left(t\right)=\frac{\Delta_{\min}+p^0\Delta_{\max}}{\Delta_i\left(t\right)+p^0\Delta_{\max}}\left(t=1,2,\cdots,n\right) \tag{13}$$

Where: $\Delta_i\left(t\right)=\left|x^i\left(t\right)-x^0\left(t\right)\right|$; $\Delta_{\min}=\min\limits_i\min\limits_t=\left|x^i\left(t\right)-x^0\left(t\right)\right|$; $\Delta_{\max}=\max\limits_i\max\limits_t=\left|x^i\left(t\right)-x^0\left(t\right)\right|$, 0 < p < 1 is the discriminant coefficient, and p = 1 is usually taken as the case.

According to the above, the following correlation equation is thus obtained.

The difference finding sequence is.

$$\Delta_i(t)=\left|x_i(t)-y(t)\right| \tag{14}$$

The correlation coefficient (resolution factor 1) is calculated as:

$$li(t)=\frac{\Delta_{\min}+0.5\Delta_{\max}}{\Delta_i(t)+0.5\Delta_{\max}} \tag{15}$$

Relevance calculation model.

$$V_i=\frac{1}{n}\sum_{t=1}^{n}li(t) \tag{16}$$

Through the above calculation strategy, the relevant cost indexes in engineering construction are obtained.

4 All-round cost result analysis

4.1 Achieve accurate investment estimation

Cost management needs to be implemented in the whole process of the project, and it also needs to be focused. Different stages have different degrees of influence on cost. The design stage has a relatively large impact on the cost, and the preliminary design stage has a 75% or more impact on the cost; the technical design stage has a 35%-75% impact on the cost; the construction drawing design stage has a 5%-35% impact on the cost; and the construction process has a 5% or less impact on the cost. Thus, it is extraordinarily important to achieve accurate investment estimation of the project. The all-round cost management can perfectly solve this problem by realizing accurate investment estimation with the help of BIM model. As shown in Figure 2.

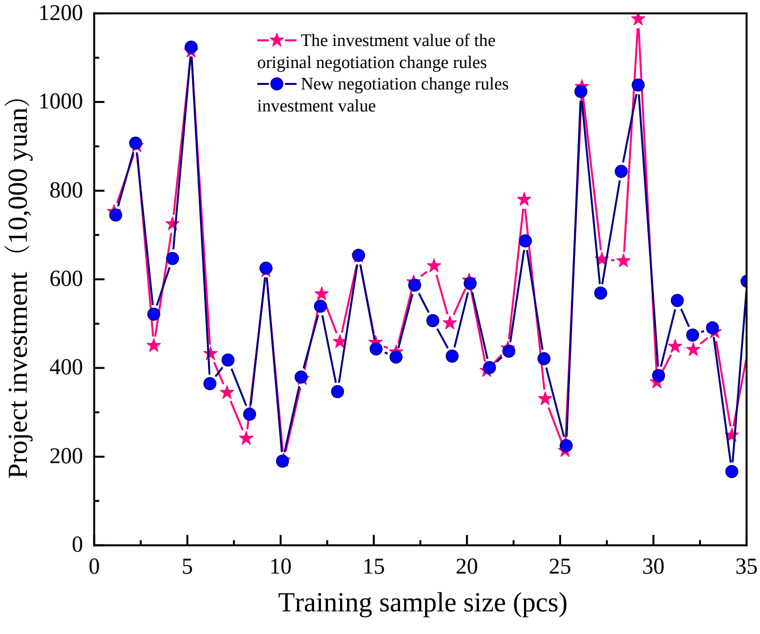


Figure 2. Investment estimation and real investment under BIM model

The selected 35 college engineering construction investments are used as training samples for the investment estimation of project engineering, and then the real investment of engineering construction samples are compared with the estimated investment to make the above figure.

Among these 35 college engineering construction investment statues, the error between the investment estimation of 25 samples and the real investment of project engineering is not more than 100,000 yuan, and the budget accuracy is as high as 71%, while the error between the investment estimation of the remaining 10 training samples and the actual investment of project engineering is not more than 500,000 yuan, which is not more than 10% of the actual investment of the project. These data and comparison graphs are sufficient to prove that all-round cost management can provide a good control of the overall project investment at the very beginning stage of the project engineering.

4.2 Optimize design and construction plan

The data stored in BIM technology model is much more comprehensive than two-dimensional drawings. It can not only express the basic matters such as structural information, architectural information, mechanical and electrical equipment information, but also automatically and accurately calculate the volume of works through the three-dimensional data of components, and classify statistics and issue reports.

Because the data of the building components composing the BIM model contains at least three-dimensional information (i.e. the length, width and height of the components) and thus occupies a certain spatial position, the type of the components can be identified and the volume of works can be calculated according to the attributes inputted by the components in the digital model; if the volume of works is to be counted, some BIM software or plug-ins can be used to form the corresponding reports, and the calculated volume of works is combined with the calculation rules and The calculated quantity is the accurate quantity of work which combines the calculation rules and the deduction relationship of 3D model.

When preparing the estimate and budget, the 3D model quickly calculates the quantity of works and design review, and in the construction stage, the managers use the previous 3D model to simulate the construction process; when making settlement, the simulated quantity model can quickly statistically show the amount of changes and list prices. So that the whole construction design and program formation are no longer separate individuals, but become an interlocking organic whole. Based on this BIM model transfer, the optimization of the construction plan and design of the whole project is realized. It can be seen that compared with the current construction industry's popular whole life cycle cost management and whole process cost management, the all-round cost management built with BIM is more advantageous, as shown in Table 4.

Table 4. Comparison of three cost management modes

Type	Total Life Cycle Cost Management	Total process cost management	Total Cost Management
Quantity estimation method	Drawings	Drawings	Three-dimensional data
Quantity estimation accuracy	82%	87%	95%
Project design time	55 days	60 days	45 days
Duration	14 months	18 Months	12 Months

The three cost management modes are able to make more accurate estimates of the project volume, but the accuracy of the volume estimation of all-round cost management is 13% and 8% higher than the other two cost management, although the difference is not very big from the data, but when combined to the project engineering, the coefficient in front of the percentage is magnified, tens of millions or even hundreds of millions of times, the volume of the project is unimaginable. With the help of BIM technology to optimize the design plan, improve the design quality, the highest in the design process can find more than 1000 errors in the drawings, significantly reduce the later design changes, reduce the design changes by nearly 60%. All-round cost management relies on BIM technology to make the project cost data automatically form electronic documents according to the locally prescribed cost document format and specifications, which can be passed, shared, modified and calculated indicators among different staffs, reducing the waste of time, shortening the construction period by nearly 6 months and increasing the construction efficiency by 15%-20%.

4.3 Change negotiation change rules

The matrix Y obtained by adjacency matrix X plus unit matrix I is subjected to Boolean operation, so that $Yn\text{-}1 \neq Yn = M$ can obtain matrix M, and the reachable geometry (N (i)) and prior set (X (i)) of each factor are obtained, as shown in Table 5.

Table 5. Reachable geometry (N(i)) and prior set (X(i))

Serial number	N(i)	X(i)	N(i)∩X(i)
1	1,2,5,6	2,4	2
2	2,3	1,2,3,5	2,3
3	2,3,5,7	3,6	3
4	2,3,7	1,2,6	2
5	3,4,6	4	4
6	3,5,6	3,5	3,5
7	2,3,4	2,7	2

From the adjacency matrix, it can be seen that the main factors affecting the construction project in the construction process negotiation changes are 2 and 3, respectively, the amount and handling department. The funds can be managed by controlling the amount and the sub-department during the negotiation changes.

Based on the objective function above, it can be calculated that 100,000 and 500,000 are the two major peaks that cause unnecessary capital expenditure in negotiation changes. Accordingly, combining the objective function and the adjacency matrix X impact level, the following rules negotiation change rules are formulated.

Negotiations of less than 100,000 are reviewed by the project department, changes in negotiations of more than 100,000 are collectively resolved and technically reviewed by the technical committee, and those exceeding 500,000 are approved by the divisional council. In this way, the all-round cost management minimizes the investment risk and makes the investment controllability greatly enhanced. As shown in Figure 3.

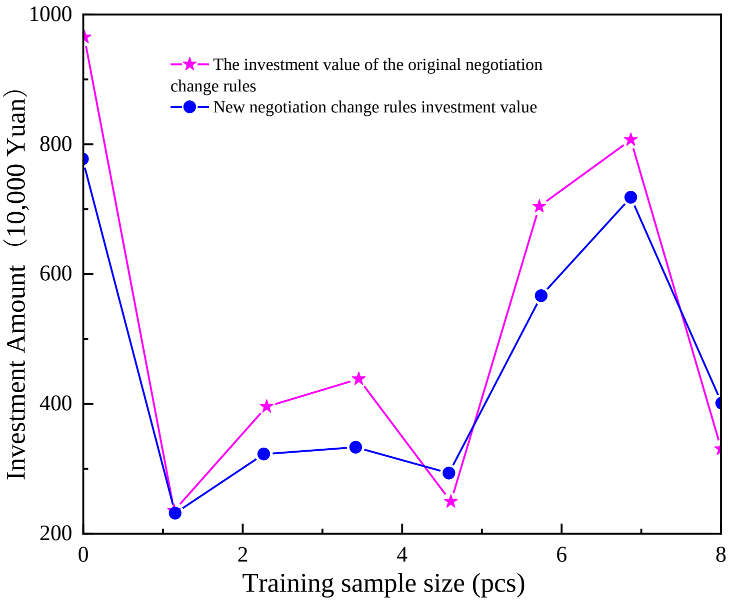


Figure 3. Impact of negotiation changes on investment

In Figure 3, we can clearly see that after changing the negotiation change rules, the investment in engineering projects is worthy of effective control. In the selected sample of engineering projects, 62.5% of the projects have reduced the investment range, saving nearly 25% of investment funds.

25% of the projects can even make the project investment reduced by 2 million.

Whether the all-round cost management system is feasible can be judged by analyzing the correlation degree between them, and the gray correlation analysis method can be used here to analyze their correlation degree.

Let the content sequence of constructing all-round cost management system for university engineering construction investment control be the reference sequence, and the content sequence of project proposal (feasibility study) and engineering construction investment control be the comparative sequence, respectively, X1 and X2.

The mean sequence is calculated as follows.

$$Y=(0.73,0.82,1.16,1.6,0.9,0.74,0.38,1.11,1.7,0.12,1.59,1.57,0.85,1.39).$$

$$X1=(0.73,0.75,1.07,1.66,0.9,0.88,0.65,1.4,1.13,0.6,1.33,1.2,0.85,1.24).$$

$$X2=(1.0,1.0,0.91,0.72,1.05,1.01,1,1.34,1.01,1.51,1.04,1.03,1.01,1.01).$$

The result of the difference is.

$$\Delta_1=(0.3,0.02,0.06,0.07,0.02,0.06,0.2,0.1,0.07,0.36,0.12,0.13,0.15,0.2).$$

$$\Delta_2=(0.23,0.26,0.22,0.72,0.11,0.25,0.36,0.14,0.06,0.81,0.35,0.33,0.15,0.27).$$

This leads to.

$$\Delta_{\min} = \min_i \min_t \Delta_i(t) = 0, \Delta_{\max} = \max_i \max_t \Delta_i(t) = 0.81.$$

$$l_1 = (0.87, 0.89, 0.82, 0.91, 0.89, 0.87, 0.67, 0.85, 0.87, 0.63, 0.72, 0.7, 1, 0.71).$$

$$l_2 = (0.61, 0.66, 0.62, 0.34, 0.8, 0.59, 0.44, 0.7, 0.87, 0.33, 0.54, 0.54, 0.72, 0.52).$$

The results of correlation degree are V1=0.87 and V2=0.62.

Through the correlation degree, it can be seen that the correlation degree between constructing all-round cost management system and university engineering investment control is great. The construction of all-round cost management system can effectively control the investment of university engineering construction and protect the rights and interests of universities.

5 Conclusion

In this paper, we firstly study and analyze the cost management system and explore the construction of all-round cost management system for college engineering construction investment control. By constructing all-round cost management system with the help of BIM technology, the results achieved are as follows.

1) Project investment estimation affects 75%-90% of the whole project investment, and the accuracy of all-round cost management system on project investment estimation with the help of BIM is as high as 75%, which is 45% higher than the standard. At the same time, the managers of the all-round cost management system are the whole team members of the project, 100% all-round management. The comprehensive cost management system is a new trend in cost management, and its theoretical completeness and management comprehensiveness are worthy of study, reference and application by cost managers.

2) Through calculation, we know that the correlation degree between constructing all-round cost management system and university engineering investment control is V1=0.87 and V2=0.62, thus, through the correlation degree, we can know that the correlation degree between constructing all-round cost management system and university engineering investment control is very large.

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