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Analysis of project cost control in construction project based on the law of value analysis

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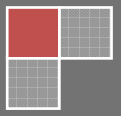
ABSTRACT

With the development of society, the internal situation of construction project has change a lot. The separation of technology and economy is becoming more and more obvious, which makes it difficult to control the project cost reasonably and effectively, resulting in the phenomenon of out of control. So, at present, the control of project cost is an important problem in construction project management. The theory of value engineering is a modern management technology produces along with the demand of society and it is an economic analysis method. The introduction of the value engineering theory into project can make the use of resources reasonably to achieve the maximum value. The value engineering theory introduced in the design stage of construction project can control the project cost and ensure the optimization of construction investment and resource utilization. This study introduces the basic theory of project cost management and value engineering and it analyzes the development situation of engineering project cost management at home and abroad as well as the research status of the application of value engineering in the design phase. For the problem that the investment to the construction project is out of control in China, the paper carries out the analysis of project cost controlled by construction project based on the value engineering. It compares the foundation engineering of a construction project to research on the value coefficient of the original foundation engineering scheme and the engineering scheme optimized by the value engineering. The result shows that the value coefficient of the engineering scheme optimized by the value engineering is much larger than the original scheme which illustrates that the optimized scheme realizes the same function with the original scheme with less project cost and improve the economic benefits of enterprises better than before.

KEYWORDS

Engineering construction; Theory of value engineering; Project cost; Economic benefits.



INTRODUCTION

Project cost is an important part of engineering construction, also it occupies a special position in engineering construction[1]. The whole process of engineering construction can be divided into six stages: the first one is the early decision stage; the second one is the design stage; the third is the project bidding stage; the fourth one is the construction implementation stage; fifth is the completion and acceptance stage and the sixth stage is the project settlement. For the design stage of construction project, because it is behind the decision stage, so when the decision stage once determined, it becomes a key stage that controls the project cost. The design stage is related to the design quality standards, the amount of expected investment of construction project, the detection after the completion of the project, the subscription whether meet the requirements as well as the whole process of construction project[2]. The technicians should participate in the design of the whole process of construction project with the cost engineer together. And when supervising technicians to carry on engineering design, it should be established on the basis of the economy and give full play to the effective combination of technology and economy. Started from the development situation of project cost management of construction project at home and abroad, this research analyzes the application of value engineering in the control of construction project cost. Also, it gives an example to analyze the project cost controlled by construction project based on the law of value analysis and understands the optimization of value engineering for the construction design, and the significant effect to the project cost control.

THE MANAGEMENT OF PROJECT COST AND THE BASIC THEORY OF VALUE ENGINEERING

The basic concept of project cost management

Project cost management refers to the cost management to the early plan and design scheme, which is the process to forecast, calculate and ensure the plan of project cost, as well as to supervise and control the project cost.

The management to the whole process of project cost

The whole process of project cost management refers to the implementation of project cost management in the whole process of construction project. The whole process includes project decision, project design, construction design, project implementation, project completion, project acceptance, project commissioning and operation. The construction project cost management is the management to the whole process of project. At present, the practice of project cost management in China emphasizes the management of design stage and makes a common management to the other stages for the whole process of project cost. According to the implementation schedule of the construction project, it carries out the dynamic management to the implementation of project cost of teach phase. The management flowchart of the whole process of project cost is shown in Figure 1, in which the solid arrow represents the work flow and the dotted arrow represents the control relation of project cost. In the design stage of construction project, the project cost control method and strategy is the compilation and review of rough calculation and budget to ensure the optimization of the design scheme, the quota design to design and to implement the design claim and design supervision system.

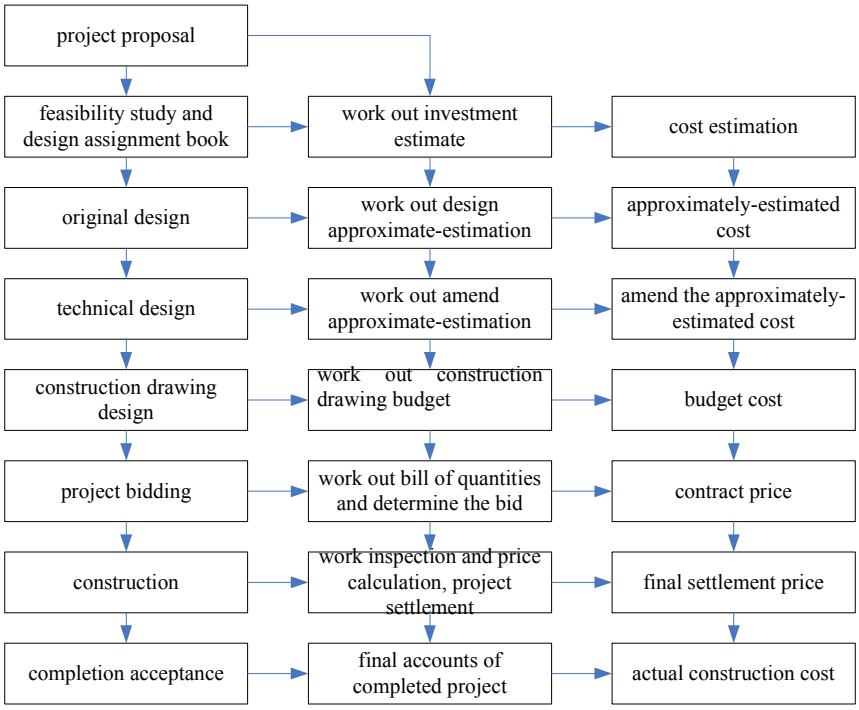


Figure 1 : The management flowchart of the whole process of project cost

Value engineering

Value engineering refers to the analysis and research to the product's function. By handling the relationship between the function of product and cost of product correctly, it can achieve the aim of resources conservation and cost reduction. Taking advantage of combination of technology and economy, value engineering analyzes the product's function and makes it operation in the best state to make the structure of the product more scientific and reasonable and to improve the economic benefits of enterprises. The main purpose of value engineering is to use the least cost to exchange for the desired function.

THE DEVELOPMENT STATUS OF THE PROJECT COST MANAGEMENT AT HOME AND ABROAD

The control and management of project cost at abroad

In the 19th century, Europe began to make the project cost management. But, at that time, the project cost management calculated the amount of investment of the project before the project decision was determined[3]. In the 1930s to 1940s, the theory of project cost management got constant development, but also it was widely used in the field of project cost management[4]. More and more people realized the importance of the investment benefits and economic and financial evaluation of project. the developed countries have established the more scientific and reasonable project cost management system and the project management began to develop towards normalization and scientization. In the 1950s to 1960s, more and more countries payed much attention to the project cost management and established the special project cost management association. Many experts and scholars researches and developed the project cost management. At that time, the project cost management made certain progress. In the 1970s to 1980s, the project cost management got comprehensive development. In 1976, the International Cost Engineering Council (ICEC) was established and the cost engineers all over the world were joined up. This promoted the development of the theories and schemes of project cost management and made them be widely used.

The research and application of value engineering at abroad

In the 1940s, during the purchase of raw materials, Lawrence D. Miles, the electronics engineer of American General Corporation found the relationship between function and cost of materials and proposed the analysis method about the function and cost of materials. Value engineering was established initially at that time. In the 1950s, value analysis theory was recognized and named as value engineering officially. It was used in military industry and shipbuilding industry and in 1959 the value engineering even has been applied to the Apollo project. Also, the United States set up special Value Engineering Society for value engineering. In the 1960s, value engineering was widely used in the United States. Japan recognized the significance of the value of engineering too and set up the Japanese Value Engineering Society and value engineering gained popularity in Japan. At the same time, European countries also recognized the significant role of value engineering and they introduced the management techniques of value engineering consecutively. In the 1970s, value engineering has spread to all sectors of the US market, bringing significant economic benefits for US companies. The former Soviet Union and part of the Eastern European countries also began to promote value engineering and it was applied to many industries in these countries. With the growing number of the application of value engineering in different industries of different countries, the whole world payed much attention to the value engineering and applied it to different industries in their countries to improve the economic benefits.

Project cost management and research status at home

At the beginning of the foundation of China, project cost management has been introduced to China. It mainly drawn lessons from the budget system management basic construction of the former Soviet Union to carry out the design. After the reform and opening up, China's project cost management got great development and China Construction Project Cost Management Association was set up as well as the certified cost engineers system was implemented, which promoted the effective development of project cost management in China. In 2003, China promulgated the valuation standard special for the bill of quantities of construction. From then on, the development direction of project cost management in China has changed from static management to dynamic management and the competition mechanism has been introduced to the project cost management system gradually.

The analysis of the application and research status of value engineering at home

With the development of value engineering theory and continuous improvement of project cost management, more and more experts and scholars carry out research on project cost management based on value engineering. The main research part is the design stage of construction project. There are many researches on project cost control and management of the design stage of construction project based on value engineering[5-9]. The main content of the researches includes the following aspects: (1) The introduction of value engineering in the design process makes the value engineering to analyze the function and cost of the materials in construction project, so as to achieve the purpose of optimization and control of project cost. (2) To carry out quota design in the design stage of construction project and control the investment in the design process, so as to achieve the purpose of quota. (3) Adopting the standard design at the design stage of project can reduce the waste of human and financial resources caused by some non-standard designs, which can well reduce the project cost. (4) Introduce the competition system during the design stage of construction project and use the design tender to control project investment. (5) To implement the whole management system of the project which focus on the design stage and carry on project cost

management in the whole process of the construction project, so as to improve the economic efficiency of enterprises in every aspect effectively.4 The application of value engineering in construction cost control in design stage

Design stage is an important stage in managing the whole process of project cost, as well as an important part of controlling the construction project cost. And the t control of project cost can guarantee the combination of technology and economy at the stage design.

The process of engineering cost in design stage includes three parts: the preliminary design stage, technology design stage, construction design stage and the process is shown in Figure 2, where the arrow represents the work flow, and the dotted arrow represents the relation of engineering cost control. It can be seen from Figure 2 that the control target and the focus of each stage is different, but the overall aim is to control the expenditure through the controlling management of project cost.

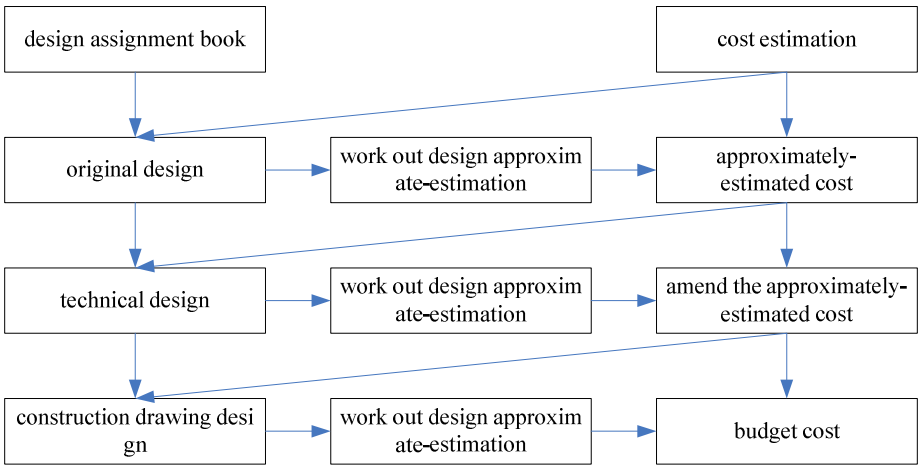


Figure 2 : The management process of project cost at design stage

The application of value engineering in project cost management includes many contents, such as being applied to the optimization of the overall scheme, quota allocation in quota design, optimization of the structure scheme, evaluation and selection of the design scheme. The present study main analyzes the application of value engineering in evaluation and selection of the design scheme.

The application of value engineering in evaluation and selection of the design scheme is not used to maximize the value, only searching for the lowest cost of the design scheme of, but to choose the comprehensive considerate design scheme that meet user requirements of the product function and cost. The design alternatives can be evaluated by using the value coefficient method. Then using the calculated function coefficient and cost coefficient scheme to get the value coefficients, according to which to determine the quality of scheme, the greater the better.

The method of calculating value coefficient is shown as follows.

Calculation of technical coefficients in design scheme

The calculation formula of technical coefficient is equation (1):

$$F_i = f_i / \sum_{i=1}^{m} f_i (i = 1, 2, ..., m) \quad \textbf{(1)}$$

In equation (1), Fi represents the technical coefficients of No. i evaluated object; fi represents the technical score of the No.i evaluated object; i is order number of the evaluated object; m represents the total number of objects in the design scheme.

(2) Calculation of economic coefficient in the design scheme

The calculation formula of economic coefficient is equation (2):

$$C_i = c_i / \sum_{i=1}^{m} c_i (i = 1, 2, ..., m) \quad \textbf{(2)}$$

In equation (2), Ci represents the economic coefficient of No. i evaluated object; ci represents the technical score of the No.i evaluated object; i is order number of the evaluated object; m represents the total number of objects in the design scheme.

The calculation of the value coefficient of each design scheme

The calculation formula of value coefficient is equation (3):

$$V_i = F_i / C_i \quad (3)$$

THE EVALUATION CASE ANALYSIS OF VALUE ENGINEERING IN THE PROJECT COST MANAGEMENT AT THE DESIGN STAGE

In construction project, foundation engineering is the most basic part of the housing construction project, and the invest which this part needs accounts for a large proportion in the total investment. The of this case analyzes the design of using the value engineering to optimize design foundation engineering in construction project to understand of function of applying value engineering into project cost control.

Scheme optimization

The case is the high-rise office building projects, with total construction area 42000 square meters, covering area about 12.74 acres, 28 floors (including 2-layer basement), and total height of 82.5 meters. The original design of foundation engineering scheme is shown in TABLE 1 which is too conservative, and many problems existed in the pile length and pile materials. The original plan is optimized using value engineering and the result is shown in TABLE 2. Compare the two schemes. The original scheme uses 207 piles of 20 meters, while the optimized scheme uses 148 piles of13.5 meters, which greatly reduces the number and length of piles, reducing the cost of foundation engineering. Through calculation, the cost of foundation engineering of the original design is1, 357,500 Yuan, while that of the optimized scheme is 758,600 Yuan, making the total control reduce 598,900 Yuan. The original design scheme of the foundation engineering is shown as TABLE 1. The design scheme of foundation engineering optimized by value engineering is shown as TABLE 2.

TABLE 1 : The original design scheme of the foundation engineering

Names	Contents	Remarks
The basic types of piles	bored piles	Pile length is 20 cm; embedded depth in middle-weathered rock is 3-4m (rock-embedded pillar); pile space of the core tube is 2.4 times of the pile diameter; around pile space is 3 times of the pile diameter
The basic types of main buildings	pile-group-raft-foundation	Raft thickness:70cm
The basic types of podium building	natural foundation, the independent foundation under pillar, the bearing layer in the fourth layer of clay	Use 50 cm concrete slab to make beam to connect it into a whole set.
The design value of total load of main buildings	656497KN	
Illustrations:		
1. The designed number of bored piles is 207, bearing all loads. Rock-embedded pile only has compression deformation, and almost no sedimentation.		
2. The original design makes three calculations and comparisons of the raft of the natural foundation: equal thickness of main building and the podium building, not equal one, and setting sedimentation joint. And the calculation result is that the bearing capacity of the foundation can meet the requirements, but the ratio between sedimentation of adjacent concrete pillars on the floor and the distance of the pillars is inconsistent with The basic design requirements of building foundation. And the pile foundation must be used to reduce the foundation sedimentation.		

Evaluation of the scheme

According to the steps of evaluation of value engineering, make evaluation and analysis of the original design scheme foundation engineering and optimized design scheme by value engineering.

The technical scores of the two schemes

Divide the construction project participants into three groups, respectively, designers, the cost staff, and the constructor. And the importance of the three groups in the constructing projects were: 0.45, 0.35,and 0.2. Calculate relative important coefficient according to the two evaluation index and obtain the technical scores. Use the 10 point system for scoring, and the results are shown in TABLE3. Through the formula 1 and 2, it can be calculated the technical and economical coefficient of the two schemes, shown in TABLE 4 and TABLE 5. Through the formula 3, it can be calculated the value coefficient of the two schemes, shown in TABLE 6.

TABLE 2 : The design scheme of foundation engineering optimized by value engineering

Names	Contents	Remarks
The basic types of piles	bored piles	Pile length is 13.5 cm; embedded in strong-weathered rock (non-rock-embedded pillar); pile space inside the core tube is 2.9 times of the pile diameter; pile space out of the core tube is 5 times of the pile diameter. The sides and bottom parts of the bored pile are processed with post grouting treatment.
The basic types of main buildings	pile-group-raft-foundation	Raft thickness:80cm
The basic types of podium building	natural foundation, the independent foundation under pillar, the bearing layer in the fourth layer of clay	Use 50 cm concrete slab to make beam to connect it into a whole set.
The design value of total load of main buildings	656497KN	
Illustrations: 1. In order to reduce the foundation load of main building, in setting piles and the calculation, expand the main building to the outer space with one step. And the main building pile foundation is divided into inside core tube and outside core tube. Through calculation, pile number outside the core tube is 70, while inside one is 78. 2. Through the calculation, in the compound method of setting pile, the ultimate bearing capacity of single pile is 4750KN, and because of the improvement of bored pile construction technology, the coefficient of bearing capacity of single pile is increased by 1.5, increasing ultimate bearing capacity to 7125KN. The bearing capacity of pile foundation outside the core tube is 490850KN, and inside one is 185725KN. So the bearing capacity of the pile foundation of main building is 676475KN > 656497KN (designed total load value of the main building), where the soil between the piles bear a load of about 50%, playing a significant role in it. 3. In calculation, the stiffness of upper structure is considered. The maximum sedimentation value of core tube is 30mm, and the total differential of basic sedimentation value is 12mm, reaching the requirements of the standard. 4. Due to usage of t non-rock-embedded pillar, the punching force of raft is changed, and is calculated to be 117525KN, so the thickness 80cm can meet the requirements.		

TABLE 3 : Technology scores of the two schemes

Evaluation index	The score to designers ①	The score to cost staff ②	The score to constructor③	The coefficient of relative importance(0.45①+0.35②+0.2③)/10	The score to design scheme	Original design scheme	Created scheme
To improve the bearing capacity of foundation	7	5	6	0.61		6	5
To reduce the foundation settlement	3	5	4	0.39	score	4	5
total	10	10	10	1			
Technology weighted score					□	5.22	5.00

TABLE 4 : The technical coefficient of the two schemes

The name of scheme	Technology weighted score	Technical coefficient
Original design scheme	5.22	0.51
Created scheme	5.00	0.49

TABLE 5 : The economical coefficient of the two schemes

The name of scheme	Project cost (ten thousand)	Economical coefficient
Original design scheme	135.75	0.64
Created scheme	75.86	0.36

TABLE 6 : The value coefficient of the two schemes

The name of scheme	Technical coefficient	Economical coefficient	Value coefficient
Original design scheme	0.51	0.64	0.79
Created scheme	0.49	0.36	1.36

The calculation shows that the value of coefficient of original foundation engineering scheme is 0.79, while the value coefficient of optimized foundation engineering scheme is 1.36, which means that the optimized scheme is better than the original construction scheme, and also shows that the optimized construction scheme cost less than the original scheme to realize the same function. It has a good effect on the control of engineering cost.

CONCLUSIONS

Value engineering project has obvious effect on cost control of engineering projects. The presented study introduces the importance of the design stage in construction project, analyzes the present situation of the engineering cost management in and outside China, and application status of value engineering in and out China. Also the engineering cost control of value engineering at design stage is studied. Aiming at the problem of existing investment being out of control in engineering cost, the value engineering is introduced in the engineering cost management of construction project, and makes the design scheme of foundation engineering on the construction project. Through comparing the original design scheme and the new scheme optimized by value engineering, make evaluation and analysis of value engineering. And it can be realized that the optimized scheme is better than the original foundation engineering scheme, and more conducive to improving the economic efficiency of enterprises.

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