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Study of the Construction Cost Management in Building Structure Design

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ABSTRACT Cost reduction is the goal of building engineering cost control and the main way to effectively increase corporate profit gains. In this paper, a brief discussion on the contents of engineering cost control in the building structure design is presented. It aims to make enterprises truly recognize the important role of engineering cost control through preliminary analysis and discussion and improve overall strength by a series of improvement measures.

KEYWORDS
Cost control
Building engineering
Improvement measures

1. Introduction

Engineering cost refers to the construction price of engineering, which is the total cost of the engineering project in project decision-making, project design, project implementation and other links. Engineering cost control is applied throughout the entire engineering construction process, but the proportion is different at different stages. According to statistical analysis, the impact of design phase on the entire project cost is about 35% to 75% [1]. So, design phase is an important stage in controlling engineering cost. In each professional design of the entire building project, the impact of structural design on the entire building engineering cost is the most significant, which is the key link of engineering cost control. The goal of structural design is the full realization of architectural design plan, strict compliance with design specifications that can ensure structural safety and implement the architect's blueprint. Structural design is the key of processing technology and engineering cost and is an important stage in determining and controlling the engineering cost.

2. Cost control principles which should be followed

2.1. Grasp the key control of cost in design control stage

Although engineering cost control is applied throughout the whole project construction process, effective cost control begins from the design stage after completion of the investment control. The subsequent cost control are adjusted on the basis of the budget of the construction drawings. In order to establish a solid foundation for the overall engineering cost control, we must do well at the first pass of engineering cost management before implementing the design drawings. Once there is delay until construction phase, there will be more trouble and increased loss for changing. Therefore, the engineering cost control efforts at design stage are not only necessary but are also very important and it can only be strengthened but not weakened.

2.2. Implementation of active control at each stage

For a long time, the control understood by people is to compare the target value with the actual value. Once the actual value deviates from the target value, immediately analyze the reasons for deviation and determine the next countermeasure on this basis. For the whole process of the engineering construction, it is very effective to carry out such engineering cost control. However, this control is still a passive control. In essence, this control can only figure out the problem but it is unable to prevent the problem from occurring. Therefore, in order to obtain optimal results of engineering cost control, we should implement the active control in all stages of engineering construction by minimizing or even avoiding the deviation between target value and the actual value [2].

2.3. Engineering cost control measures with the integration of technology and economy

Infiltrate the concept of engineering cost control into each design and construction technical measures and properly handle the relationship of unity of opposites between the advanced technology and economic strength. Carry out fur-

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ther various technical comparison, economic analysis and effect evaluation on a project, in pursuit of higher goals.

3. Cost control measures of architectural engineering design stage

3.1. Emphasis on the engineering cost control of design phase, organic combination of the technology and economy

On one hand, enhance the economic concept of the designer, keep close contact with the person who participates in economy construction in various stages of design. Avoid the phenomena whereby the designers just draw and building economic participants just count the money, the cost is unrelated to designers. Designers should pay attention to the program selection in the preliminary design phase and strictly budget the construction drawing. Control the cost within the approved budget, at the same time, enhance design change management and establish dynamic management awareness. On the other hand, building economic participants should be a good economic adviser of design staff by actively collecting relevant information, providing economic indicators for the designers in a timely manner, accurately measuring and calculating the safest technical solutions. As the guide for designers for economic comparisons and the pioneer of design, make increasingly accurate and reasonable investment budget in order to control engineering investment. Building economic professionals will participate in the management of design stages, intervene in the unnecessary waste in design from an economic point of view, make full evaluation of the programs on the economy, and integrate all the profession and manipulate the overall project, in order to control the investment and optimize design.

3.2. Vigorously push design bidding system and introduce the competition mechanism of survival of the fittest

In the design bidding, not only the design phase is completed through bidding, but the technical design or construction design also needs to introduce competition mechanism, so that each design stage is completed through the competition. Therefore, design units must complete every detail earnestly. If not, there is the possibility of losing. During bid assessment, the flexibility and novelty of design concept, engineering quality, economic rationality of investment estimation will be evaluated mainly. Through technical comparison, economic analysis and effect evaluation, strive to choose reasonable economy under advanced technology condition. Ensure that the advanced technology is under the reasonable economy conditions and pay attention to the attractive appearance while meeting the use function, so that the design bidders who use minimal investment to create the most cost-effective benefit would become the winning bidder.

3.3. Establish appropriate reward system, promote meticulous design

Implement design responsibility risk and reward system, change the real time reimbursement method of engineering design and actively implement the limited design. Under the premise of ensuring use function, integrate technology and economy by optimizing the design. Construction unit and design unit shall sign a design contract and specify the rights and obligations of both parts. As for the engineering waste resulting from design, schedule delays and exceeded loss of investment limit. The designer should be held accountable and should compensate: For scientific and rational, economical design plan, conduct comparison according to cost limit and design cost and the saved part will be given to designers as reward.

4. The reasonable control of the member section size and reinforcement consumption

4.1. Reasonable choice of member cross-sectional dimension

The selection of building component cross-sectional dimension includes a reasonable selection of cross-sectional dimension of beam and columns, thickness of concrete walls and plate, etc. In general, for components with the same structure, when the cross-sectional size decreases, the reinforcement ratio and consumption are increased; on the contrary, when the cross-sectional size increases, the reinforcement of component can be appropriately reduced, but the amount of concrete needed increases, thereby increasing the total load of the building. Hence, the sectional dimension of component and its reinforcement ratio is conflicting within a certain range. When designing structural component, the structural engineers shall chose a reasonable cross-sectional dimension, enable the total cost of concrete and reinforcement of component to be the lowest, thus this cross-section is the reasonable cross-section of component. Reasonable structure design requires structural design staff to determine the reasonable cross-sectional dimension of each component through multiple calculations, comparison and analysis. In order to achieve the balance of cross-sectional dimension of component and amount of reinforcement, thus reasonably controlling the engineering cost. During structural design practice, under the premise of meeting aesthetics, headroom of building, structural designers usually take a cross-sectional dimension for each component based on past experience to calculate, and then analyze the results of component. For the common structural member, when its reinforcement ratio is in a reasonable range (referred to economic reinforcement ratio), it is generally considered that the cross-sectional dimension of the member is reasonable. Otherwise, we need to reselect sectional dimensions to calculate until obtaining the most reasonable member cross-sectional dimension, in order to achieve the balance between section size of structural member and reinforcement, thus effectively controlling engineering cost. In the present stage, due to the relatively low concrete price and high steel price, the content of reinforcement in component has a greater impact on the cost, so, in general, the reasonable

Table 1. The reinforcement calculation of basement floor of three kinds of reinforcement.

Category	Strength of concrete	Thickness of plate (mm)	Minimum reinforcement ratio (%) $\rho_{min} = \mathrm{Max}\{0.20\%, 0.45 f_t / f_y\}$	Reinforcement calculation per meter (mm2)
HPB235	C30	250	0.306	765
HRB335	C30	250	0.215	538
HRB400	C30	250	0.20	500

economic reinforcement ratio of reinforced concrete beam is controlled within 0.6% during structural design practice. The reinforcement ratio of column and wall design can be controlled through the corresponding axial compression ratio and the reinforcement ratio of plate should be slightly larger than the minimum reinforcement rate [3].

4.2. Adopting high-strength reinforcement to reduce steel ratio

Control of reinforcement consumption in the structure design phase is the most effective way to reduce engineering cost. During structural design, compared with low-strength reinforcement, adopting high-strength reinforcement can reduce the reinforcement consumption, thereby reducing the cost. Under the condition of ensuring the limit states of ultimate bearing capacity and limit states of serviceability of a construction, widely adopt HRB400 rebar, change the traditional practices that fully adopting HRB335 grade rebar as main reinforcement and HPB235 grade rebar as stirrup and plate reinforcement regardless of the actual situation. Actually, m 400 rebar is much better than HPB235, HRB335 grade rebar in terms of strength, ductility and price. In general, for the plate with small span and large thickness, the reinforcement is usually controlled by the minimum reinforcement ratio. In accordance with the design specification of concrete structures, the minimum reinforcement percentage of longitudinal reinforcement of bending members is the larger one among 0.20 and 45 ffy. Obviously, the minimum reinforcement ratio is directly related to steel grade, under the condition of same strength grade of concrete, the minimum reinforcement ratio reduces with the increase of rebar strength design value. In this case, the HRB400 rebar plate with lower amount of steel is adopted. Especially when the concrete strength is higher and the thickness of plate is larger, the superiority of HRB400 Reinforcement is more obvious. Such as in a basement floor design, in order to meet the requirements of underground waterproof technical regulations, the thickness of the plate must be not less than 250 mmtsj. When the water table is low without considering the anti-floating design, usually the plate reinforcements are constructed according to the minimum reinforcement ratio. Here, we will calculate the reinforcement of base plate in basement according to three kinds of rebar, the results are shown in Table 1.

As it can be seen from Table 1, when the reinforcement of plate is constructed according to the minimum reinforcement ratio, the use of HRB400 rebar can minimize the amount of rebar. Ccompared to HPB235 grade rebar, the use of HRB400 rebar can save about (765 - 500) / 765 ~ 100% = 35% of rebar. While the price of HRB400 grade rebar is only about 5% higher than HPB235 rebar per ton. Therefore, the reasonable use of HRB400 rebar in structural design may effectively control engineering cost.

5. Using the appropriate basis form

Foundation is an important part of building, in which its cost accounts for 10% to 20% of the total engineering cost. Hence, the choice of a suitable foundation form in structural design is critical to engineering cost control. During foundation design, structural design personnel should make comprehensive consideration about the force characteristics of the superstructure of building, engineering geological conditions of the construction site, hydrogeological conditions and local experience in construction, etc. In general, the natural foundation cost is about 20% to 60% of pile foundation cost. Therefore, under the premise of meeting the design requirements, we should use natural foundation as far as possible but not use pile foundation and other deep foundation. There may be more than one kind of foundation form for general building structure and the structural designer should choose the most suitable foundation form through technical and economic comparison of different foundation plan, so as to achieve the engineering cost control.

6. Conclusion

Engineering cost is the core indicator of investment and construction of engineering project as the amount of engineering cost directly determine the investor's investment income. Therefore, the cost managers should uptake rigorous, dedicated work attitude, and advanced scientific methods of work, in order to manage and control engineering cost well from the professional point of view of each link.

Conflicts of interest

These authors have no conflicts of interest to declare.

Authors' contributions

These authors contributed equally to this work

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