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Application of Fuzzy analytical hierarchy method and BIM in quota design of EPC project

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Abstract. For an EPC project, the design of quotas is critical. BIM technology visibility, simulation, optimization and coordination, etc, as a transformative production tool have a profound effect on construction project cost accounting process. BIM can effectively improve the reliability of construction production process cost calculation. Fuzzy analytical hierarchy method is a quantitative weight calculation method, which can effectively reduce the subjective deviation. Besides, this method can quantify the thinking and experience of experts, and have high computational accuracy. In this paper, Fuzzy analytical hierarchy method and the BIM was combined. The various professional design target was determined by FAHP method. Based on BIM, the professional design scheme of each stage was analyzed to meet the design quota target.

1. Introduction

In the current situation of increasingly fierce competition in the construction market, it gradually becomes a mainstream trend that the design institute has been involved in the general contract EPC construction with professional advantages. Engineering Procurement Construction mode is design, procurement, construction integration mode. Compared with procurement and construction, design is the leading role and control the construction project investment and construction period from the source. The status of budget estimation outrunning estimation, budget outrunning budget estimation and final accounts outrunning budget has been bothering the bosses of state-owned metallurgical enterprises[1-2]. There are many reasons, but the inevitable reason is that the design profession has not strictly implemented the quota design. For the EPC project with fixed total price contract, the enterprise wants to stand in the fierce market competition. It is necessary to carry on project investment control effectively, strengthen design management and carry out quota design energetically.

2. Study on current cost control of quota design

Quota design, that is, carry out corresponding design work according to the quota of cost to ensure the design can effectively accord with the requirement of cost control. At present, qualitative methods
mainly include empirical method, Delphi method, etc. Quantitative methods mainly include IUR calculation methods, multiple weighting methods, fuzzy ahp and tomographic analysis methods\[3\].

Fuzzy analytic hierarchy process is an analytical calculation method based on fuzzy analytic method. It provides scientific basis for and is widely used, but rarely used in the field of civil engineering cost. At the same time, the accuracy of weight analysis is relatively high.

3. Application of BIM in design and cost control

In this paper, the fuzzy tomographic analysis method (FAHP) is combined with BIM. FAHP method is used to determine the quota design target value of each specialty in each stage. Based on BIM analysis, the design scheme of each specialty in each stage is calculated to meet the design quota. The Project investment of the whole project was effectively controlled to ensure the total investment was not broken through.

4. Quota design method based on BIM and fuzzy tomographic analysis method

4.1 Basic theory of fuzzy hierarchical analysis method

The basic principle is the synthesis of fuzzy relations. The FAHP method not only has clear results, but also is systematic and can deal with the problems difficult to be quantified well.

4.2 Basic steps of fuzzy hierarchical analysis method

(1) Build hierarchy model

First, the basic target layer of fuzzy hierarchical analysis structure\[3\] is built. As the highest level in the hierarchy, the goal of solving problems can be defined by the target layer, and it is also the basic goal of FAHP. The purpose of making the decision is how to deal with EPC construction project quota design, which is to find out the main factors of EPC construction project quota design. Secondly, the criterion layer of FAHP model is determined. The requirement of "EPC project design" is to achieve "high reliability of structure, reasonable cost and good environment". The components of the criterion layer based on these requirements are: safety, applicability and durability. Finally, the solution layer of the model is determined, as shown in figure 1.
(2) Constructing the fuzzy complementary judgment matrix

After establishing the model, the importance of two factors of each level was compared, and a fuzzy complementary judgment matrix was established. The importance of each factor through research or the hiring of experts was compared. Before the comparison of various factors, the significance of each element was evaluated with the scale method of 0.1~0.9, as shown as Table 1.

| Fuzzy scale | its meaning |
|-------------|-------------|
| 0.1         | For comparing the importance of elements A and B, B is extreme important. |
| 0.3         | For comparing the importance of elements A and B, B is obviously important. |
| 0.5         | For comparing the importance of elements A and B, B is equally important. |
| 0.7         | For comparing the importance of elements A and B, A is obviously important. |
| 0.9         | For comparing the importance of elements A and B, A is extreme important. |

(3) the weights of the elements

The single hierarchy is to calculate the relative weight of each element of the same hierarchy, that is, to determine the weight vector. The weight of each element is calculated by the formula (1).

$$\omega_i = \frac{1}{n} \left( \sum_{j=1}^{n} a_{ij} + 1 - \frac{n}{2} \right) \quad (i=1,2, \ldots, n)$$  \hspace{1cm} (1)
4.3 The steps of quota design by using fuzzy hierarchical analysis method and BIM technology

The control process of quota design was to reasonably determine the investment quota of the project and scientifically decompose the investment target. And then phased quota design target cost control for each specialty was carried out. Control process of total investment quota -- target value of each specialty design quota-cost estimation value of BIM specialty was formed.

1) Determine the feasible Cost of construction and installation of EPC project

The general contract price mode was adopted in EPC construction project, the general contract price usually refers to the construction and installation fee. According to the professional classification, the construction and installation fee include civil cost, decoration cost, water supply and drainage cost, fire control, electrical engineering costs. All the other expenses in the total investment except the construction and installation fee are based on the construction and installation fee. The quota design is mainly aimed at the construction and installation fee.

2) Determine the weight and quota of each specialty in each stage

Value engineering is restricted by the interaction between function and cost. The maximization and numerical value of cost and function indexes in the value engineering of engineering construction projects was studied and analyzed. The model of fuzzy hierarchical analysis is established to determine the weight of each part of each specialty. By applying this method, the cost ratio of each professional component and the corresponding functional proportion are obtained. According to the construction and installation fee and the weight of each part of each specialty, the quota design target value of each professional stage ($M_0$) can be obtained. For investment estimate > design budget estimation > diagram budget, the design budget estimation and diagram budget is set as 0.95 and 0.90 times of estimated quota respectively in this paper.

3) Scheme design based on BIM and quota design

Based on the automatic and rapid calculation characteristics of BIM technology[6-7], quantity of each professional project and estimate cost value and communicate to designer in time was calculated. And the corresponding quota design target value of each profession carries on the comparison was analyzed. If the requirements are met, the design plan shall be determined; otherwise, the design shall be optimized.

4) Primary design

At the preliminary design stage, the chief designer should assign the design task and the limited design target value to the corresponding professional design department, which to give full play to technical expertise and control cost. BIM technology was used to obtain various information parameters and engineering quantities of various design schemes. And according to the index database or the estimate database, each profession estimate index value was calculated. Furthermore, it was determined whether it meets the design requirements of the budget estimate limit and the preliminary design scheme was determined.

5) Construction drawing design

During this design stage, the construction drawings are modeled using BIM technology. According to the results of the model, the cost of project was budgetted. Based on the quantity of project and the price of talent machine, the budget target of each specialty was calculated. If the budget indicators meet the design requirements of the budget limit and the design specifications, the design plan was determined. Otherwise, the design was optimized.

5. Conclusion

Under the general contract management mode, the influence of design stage on the total project cost is
70% to 85%. Therefore, the design of quota is a fundamental control of the total project cost, and it plays an important role in the project cost control. In the EPC project general contracting project, BIM technology and fuzzy hierarchical analysis method was used to promote the limited design. The total investment of the project was effectively controlled to maximize the capital value.

As a powerful means to control the cost of the overall contract management project, the difficulty is to reasonably decompose the total contract price and determine the design target value of quota for each professional stage. In this paper, the weight value of each specialty was calculated by establishing the fuzzy hierarchical analysis model. The advantages of BIM technology, such as visualization, parametric design, collision detection, collaborative work and rapid calculation of engineering quantity was used.

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