Analysis of enterprise quota compilation method under bill of quantities model

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Abstract. Since Specification of Quantity Billing in Construction Projects has been carried out and brought new requirements to construction enterprises, enterprises need to have a set of the enterprise quotas which are consistent with the enterprise's technological level, management ability and economic level to adapt the construction market. The enterprise must continuously accumulate project cost data to enrich and perfect the enterprise quota.

1. Introduction

With the rapid development of the national economy, the living standards of consumers have been further improved. As far as housing is concerned, people's demand for housing has entered the "high-quality residential era" from the "stable residence era" of the past. High-quality housing means quality, quantity, environment, prospects, etc., especially in terms of quality. Because it is not only related to the life and safety of the occupants, their settlement and work, but also the value-added of the future of the property. As a result, the quality of the project has become a hot topic in the country in recent years. In recent years, China's performance in terms of project quality has not been satisfactory. Due to China's vigorous development of infrastructure, the industry's management power is relatively weak, and the management system is imperfect. Therefore, some problems have appeared in the project, which have aroused great repercussions from the masses, and have become one of the key issues of people’s discussion and media’s criticism, such as the appearance of “crunchy building” and “cracky brittle”. Through a lot of research, the author discovered that the reasons for the quality problems are multiaarious, but in the end, it is driven by the interests. In response to media reports, "construction companies cut corners", why should construction companies cut corners? Because they are chasing after higher profits. The profit rate of the project is generally between 6% and 30% (depending on each industry). According to such profit rate, the annual income of the construction enterprise is considerable, but the reality proves that the construction company has not obtained it. There are two reasons why the construction company has not obtained the due profit: 1. In the bidding stage, the enterprise proposed quota that does not meet the strength of the enterprise and the construction cost cannot be accurately calculated, that is, the bid price is not commensurate with its own strength; 2. The construction companies delayed the payment of the construction cost, resulting in an increase in the amount of interest. Combining the theory and practical experience, this paper finds the intersection of management discipline, economic discipline and engineering technology discipline, and combines the basic national conditions to explain the measures and suggestions for stopping illegal behavior in project bidding. The paper has a relatively large practical significance and reference value.

Taking the implementation of the “Construction Engineering Quantity List Valuation Specification” (GB50500-2013) as the starting point, the project quantity list bidding pricing model has been...
implemented for ten years. In other words, the state has advocated the idea of “unified calculation rules, effective control of consumption, thorough liberalization of prices, correct guidance of independent quotations, and orderly competition in the market to form prices”. The reason why it advocates participating in market competition with enterprise quota is to improve the comprehensive strength of construction enterprises in China, enhance the competitiveness of construction enterprises in the domestic and foreign construction market, further improve the level of social productivity, reduce the consumption of social resources, save labor and improve production efficiency, and to promote the continuous improvement of the scientific management of enterprises and so on. In the past ten years, how do construction companies formulate corporate quotas? What is the future position of the construction company? How do construction companies face market competition correctly? Does China still need more thorough research on the control, management and reform of engineering cost? These problems are worth exploring and recollecting, and have achieved the desired goals.

2. Application status and problems of enterprise quota
In the current process of deepening the reform of the civil engineering cost management model, under the engineering quantity list pricing model, since most construction enterprises in China have not yet compiled an implementation quota suitable for the technical level and management level of the enterprise, the application status of the enterprise quota is reflected in the following: the consumption of human, timber and machine consumption standards borrowed from the quota of budget; the cost extraction standard borrows the quota documents promulgated by the provincial construction engineering authorities. There are serious problems in the current state of application of enterprise quotas. The budget quota is different from the establishment level of the enterprise quota. The budget quota represents the social average level, while the enterprise quota represents the average advanced level of the enterprise. If the civil engineering construction enterprise borrows budget quotas, it shall artificially calculate the budgeted labor days, material and construction machinery consumption standard according to the construction plan of the project and the actual use of the enterprise labor, materials and construction machinery. At the same time, according to the list of engineering quantities provided by the bidding companies, those companies combine the specific conditions of the project, the economic strength of the enterprise and the market price information, fully consider various risk factors and cooperate with the artificial adjustment to determine the labor, material and machinery fees. Then they use the comprehensive unit price valuation method to quote the price. In the above-mentioned artificial adjustment work, although the operator has a high sense of work responsibility and rich construction experience, there is inevitably a large degree of randomness, which will greatly reduce the efficiency and quality of bidding and construction management.

3. The formulation of enterprise quota
By combining years of budgetary experience, the author sums up the idea of the establishment of enterprise quotas: the budget quota is the result of the hard work of the predecessors, and it is the crystallization of science, wisdom and practice. It reflects the quantitative standards of living labor and materialized labor, and still has an important reference role in the bidding and quotation activities of civil engineering construction enterprises. When formulating enterprise quotas, enterprises can use budget quota as an important reference, so that budget quotas can be used as a reference scale for enterprises, avoiding the blind reduction of enterprise quotas or expanding the consumption standards of labor, materials and construction machinery, so that the enterprise quota can be accurate. The enterprise quota can truly reflect the modern construction management level that represents the average advanced level of the enterprise. At the same time, the consumption of new materials, new processes, new technologies and new equipment is reflected correctly in time. The engineering cost reform under the engineering quantity list pricing model is mainly reflected in the separation of workload and price. Instead of emphasizing the unified implementation of government pricing, the company will quotation by itself. In the preparation of enterprise quotas, the company should, under the effective guidance of the budget quota specification, take the advanced construction organization
design and construction acceptance specifications as the important basis under the effective control of the budget quota, and reasonably determine the matching of different types of workers in the same project and the matching of different technical grades of workers of the same type; The company should also reasonably determine the actual consumption and loss of materials. Reasonably determine the matching of construction machinery with different types and different powers of the same project or the combination of construction machinery and manual operation; independently and flexibly determine the innovative and stimulating standard of enterprise consumption. According to the actual situation of the company's personnel, technology, equipment, management, etc., considering the competitive price of the market, the enterprise's fixed cost standard is determined autonomously and flexibly [2].

4. Research on the method of compiling enterprise quota

The author combines mathematics, statistics, economics and other related subject knowledge, and summarizes the following four methods for the establishment of enterprise quotas for reference to construction companies.

4.1 Empirical estimation method

The experience estimation method is a combination of engineering economics personnel, engineering and technical personnel and engineering management personnel. According to the individual or collective practical experience, through the analysis of drawings and on-site observation, understand the construction process, analyze the production technology organization conditions and operation of the construction (production), and also analyze the difficulty of the operation method, etc. Then a discussion is conducted to develop a quota method.

Using the empirical estimation method to establish the quota, the process (or individual product) should be divided into operations (or actions), which are respectively used as the basic working time of the operation (action), and then the auxiliary working time, preparation time, end time and rest time are considered. After comprehensively sorting and optimizing the finishing results, the quota data of the process (or product) is obtained.

The advantage of this method is that it is simple and fast. The shortcoming is that it is easily affected by the subjective factors and limitations of the participants, and it is the phenomenon that the designed quotas are higher or lower. Therefore, the empirical estimation method is only applicable within the enterprise as a supplementary quota for some partial projects.

In order to improve the accuracy of the empirical estimation method and make the appropriate quota level, the probability can be used to estimate the quota. This method is to ask experienced personnel to estimate the product and construction process of a certain unit, and then draw three values of working hours: advanced (optimistic estimate) is a, general (maximum possible) is m, conservative (pessimistic estimate) is b, thus finding their average value \( \bar{t} \).

\[
\bar{t} = \frac{a + 4m + b}{6}
\]

(1)

The mean variance is

\[
\sigma = \left| \frac{a - b}{6} \right|
\]

(2)

According to the formula of the normal distribution, the adjusted working hour quota is:

\[
t = \bar{t} + \lambda \sigma
\]

(3)

\( \lambda \) is the coefficient of \( \sigma \) in the formula. From the normal distribution table (Table 1), the probability \( P(\lambda) \) corresponding to the \( \lambda \) value can be found.

| \( \lambda \) | \( P(\lambda) \) | \( \lambda \) | \( P(\lambda) \) | \( \lambda \) | \( P(\lambda) \) | \( \lambda \) | \( P(\lambda) \) |
|---|---|---|---|---|---|---|---|
| -2.5 | 0.01 | -1.5 | 0.07 | -0.5 | 0.31 | 0.5 | 0.69 |
| -2.4 | 0.01 | -1.4 | 0.08 | -0.4 | 0.34 | 0.6 | 0.73 |
| -2.3 | 0.01 | -1.3 | 0.10 | -0.3 | 0.38 | 0.7 | 0.76 |
| -2.2 | 0.01 | -1.2 | 0.12 | -0.2 | 0.41 | 0.8 | 0.79 |
| -2.1 | 0.01 | -1.1 | 0.14 | -0.1 | 0.43 | 0.9 | 0.83 |
| -2.0 | 0.01 | -1.0 | 0.16 | 0.0 | 0.45 | 1.0 | 0.87 |

Table 1 From the normal distribution table
4.2 Statistical analysis

The statistical analysis method is to combine the statistical data of the work time consumption of similar projects or similar products in the past construction with the current production technology organizational conditions to analyze the factors to establish a quota method[5]. The steps are:

1. Rule our obviously unreasonable data in the statistics that are particularly high and low.
2. Calculate the average

\[ \bar{t} = \frac{t_1 + t_2 + \ldots + t_n}{n} = \frac{\sum_{i=1}^{n} t_i}{n} \]  

(4)

Where

\( n \) — the number of data.

Or

\[ \bar{t} = \frac{1}{\sum f} \sum ft \]

Where

\( f \) — the frequency, that is, the number of times a certain value appears in a sequence;

\[ \sum f \] — the sum of the occurrences of the different values in the series;

\[ \sum ft \] — the sum of the different values in the series multiplied by the number of occurrences, and then the sum of all the products.

3. Calculate the average advanced value

The average value is added to the average of the values smaller than the average value in the series (for time quota) or the average of the values larger than the average value (for the production quota), and then the average is obtained, that is, the second time average. This is the basis for determining the level of the company's quota.

For working hours quota:

\[ \bar{t}_0 = \frac{\bar{t} + \bar{t}_n}{2} \]  

(5)

Where

\( \bar{t}_0 \) — the average advanced value after the second average;

\( \bar{t} \) — the full average;

\( \bar{t}_n \) — the average of the individual values less than the full mean.

For production quota:

\[ \bar{P} = \frac{\bar{P} + \bar{P}_k}{2} \]  

(6)

Where

\( \bar{P}_0 \) — the average advanced value after the second average;

\( \bar{P} \) — the full average;

\( \bar{P}_k \) — the average of the individual values greater than the full mean.

The results obtained by statistical analysis are generally biased towards advanced, and most workers may not be able to achieve it, and the average advanced principle cannot be better reflected. A probability measurement algorithm has recently been proposed to determine how many percentages of workers can meet or exceed the quota as a basis for determining the level of the quota. This method is now described as follows.

The calculation steps for this method are:

1. Identify valid data
Sort and analyze several hours of consumption data of a certain production activity, and delete the data that is obviously high or low.

2. Calculate the average value of working hours $t$

3. Calculate the mean square error $S^2$ of the consumption data of working hours

$$S^2 = \frac{1}{n-1} \sum_{i=1}^{n} (x_i - \bar{t})^2$$

Or

$$S^2 = \sum_{f_i} \frac{1}{f_i} \sum (x_i - \bar{t})^2 f_i$$

4. Use a normal distribution to determine the level of the quota

The probability function of a normal distribution is:

$$P(x) = \frac{1}{\sqrt{2\pi\sigma}} \int_{-\infty}^{x} e^{-\frac{(t-x)^2}{2\sigma^2}} dx$$

If

$$\lambda = \frac{x - \bar{t}}{\sigma}$$

Then formula (10) is

$$\phi(\lambda) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\lambda} e^{-\frac{\lambda^2}{2}} d\lambda$$

When $x$ equals to $x_0$, $\lambda_0$ is the value of $\lambda$.

From formula (10):

$$x = \bar{t} + \lambda_0 \sigma$$

So, the relation between $x_0$ and $\lambda_0$ is

$$x_0 = \bar{t} + \lambda_0 \sigma$$

4.3 Comparative analogy

The comparative analogy method is also called the typical quota method. It is based on the quota level of typical quota items of products or processes of the same type or similar type. After analysis and comparison, the same set of methods for calibrating the quota level of each adjacent project is introduced.

This method is simple, and the workload is small. As long as the typical quota is properly selected, practical and representative, the quotas introduced by the class are generally reasonable. This method is suitable for construction (production) processes of the same type and small batch size. With the continuous improvement of construction mechanization, standardization and assembly, the scope of application of this method will gradually expand. In order to increase the accuracy of the quota level, the main item is usually used as a typical quota.

When adopting this method, special attention should be paid to mastering the similar characteristics of the process, product construction (production) process and labor organization, and carefully analyzing various influencing factors of the construction (production) process to prevent projects with large changes in factors. The comparative analogy method has two commonly used proportional number method and coordinate graphic method.

1. Proportional number method

The proportional number method is also called the proportional push algorithm. Based on certain labor quota projects (generally long execution time, more data, and stable quota levels), it is determined by technical measurement or by statistical data to obtain the proportional relationship or difference of adjacent projects or similar projects.

The proportional number method can be calculated by the following formula.

$$t = P \cdot t_0$$

(14)
Where
\[ t \] — the time quota to be calculated;
\[ t_0 \] — the time quota of adjacent typical quota items;
\[ P \] — The ratio that has been determined.

4.4 Technical measurement method [1]
The technical measurement method is based on advanced and reasonable production (construction) technology, operation technology, reasonable labor organization and normal production (construction) conditions. The working time consumption of the workers and machinery during the construction, the number of completed products and related influencing factors are recorded in detail. The results of the records are collated, and the influence of various factors on the working time consumption of the products is objectively analyzed. Based on this, trade-offs are made to obtain time-consuming data for each project, so as to establish a method of labor quota. This method has high accuracy and scientificalness and is the main method for formulating new quotas and typical quotas (the picture below).

5. Problems that should be paid attention to when formulating enterprise construction quotas [3]

5.1 Enterprise quotas involve the long-term development of enterprises. A reasonable level of enterprise quota can bring correct guidance to enterprises, enhance their competitive strength, and guide enterprises to improve economic and social benefits. Therefore, from the preparation to the implementation of the enterprise quota, it must be reviewed and discussed for several times before it can be used for enterprise bidding and economic accounting management.

5.2 With the development of production technology in the industry, new materials and new technologies will enter the market, some construction products will be eliminated, and some construction techniques will be eliminated by the market. Therefore, the enterprise quota must have a certain lag. Enterprises should set up a special theoretical research department to collect various market information and dynamic image factors in a timely manner, so that they can improve and adjust the enterprise quota to make it more practical and scientific. At the same time, improve the management level of all levels of work, and maintain the competitive advantage of enterprises in the construction market.

6. Conclusion
The implementation of the engineering quantity list pricing model has promoted fair competition and healthy development of the industry. The formation and development of enterprise quotas must go through a stage, integrate theory into practice, and then draw theory from practical experience. It is necessary to continuously explore, improve and strengthen internal management, improve the level of employees themselves, promote scientific and technological progress, establish an enterprise information network, and constantly improve corporate quotas.

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