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Analysis of Factors Influencing Labor Cost Changes of Transmission Lines Based on ISM Model

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Abstract: In the process of transmission line construction, project cost control is the key to ensure the project economy. In recent years, labor cost overruns have intensified, which has severely affected the cost of transmission line projects. As an important part of engineering cost, effective control of labor cost is crucial to lean management of engineering cost. In order to solve a series of problems caused by labor cost changes in transmission line engineering, this paper starts from looking for the influencing factors of labor cost changes, establishes a model, and accurately finds out the key influencing factors of labor cost changes. This research can provide a reference for the management and control of transmission line labor costs, and provide a path to realize the economic benefit of transmission line engineering.

Keywords: Engineering cost, Lean management, Labor cost changes, Key influencing factors

INTRODUCTION

The electric power industry is the pillar industry of our national economy, which is indispensable in social production and life. In the development of the power industry, transmission line construction has gradually become the focus and focus of the issue. This is because with the increase of the power consumption of the whole society, the complexity and vastness of the scope, scale and structure of the power grid have highlighted the reasonable cost of transmission lines.

For a long time, the labor cost does not account for a large proportion of the direct cost of the project and the oversupply of a large number of cheap labor forces has caused power construction companies to neglect the management of labor costs, so that when the labor cost rises just in power infrastructure projects, Many engineering companies don't realize the importance and severity of the problem. However, with the rising of labor cost, the advantages of cheap labor are gradually lost, and the proportion of labor costs in direct costs has increased, which makes the labor cost of transmission line project exceed the expenditure seriously,, and has certain influence on the construction of transmission line project. Until now, the development of electric power enterprises and construction enterprises in China is still limited by the change of labor cost.

Therefore, from the fundamental point of view, to explore the key factors that cause the change of labor cost can effectively realize the cost control of transmission line engineering and lean management of construction cost, and provide certain help for the future cost management of China's transmission line engineering.

Related literature review

Labor cost control is an important link of cost management. It is of great significance to identify the important factors that influence labor cost to effectively control labor cost. Starting from different dimensions, (Yuqian Wu.etc. 2018), analyzed a number of key factors influencing labor costs from different dimensions, including per capita GDP, CPI, social average wages, labor productivity and fixed asset investment.

Yi Liu. believe that labor costs are mainly influenced by two factors: daily consumption and daily wage unit price. From the perspective of economics.Fei Wang.etc. studies the heterogeneous response of manufacturing enterprises to the rising labor cost, and finds that the specific labor intensity of enterprises is the key factor that determines enterprises to cope with the rising labor cost. Iwona Rybka.etc. believe that due to the complexity and uniqueness of construction projects, construction projects are faced with high risks, and the interference of natural environment, dependence on weather, ground conditions and terrain have a great impact on increasing labor cost risks.

It can be seen that there are many factors affecting labor cost, so it is particularly important to make reasonable adjustment to the project cost based on the influencing factors. Li Zhou. pointed out that in the case of frequent fluctuations in market supply and demand and price levels, labor costs of engineering costs are also constantly changing, and local labor costs should be specifically adjusted in accordance

with the characteristics of labor market prices. Caihao Ye. establish the theoretical model of labor cost adjustment by analyzing the component factors of labor cost. Mingming Qian. etc. elaborated the principle, scope and method of labor cost adjustment under the market economy. Yang Li.etc. focuses on analyzing the main reasons for the current rise in labor prices, and draws a labor cost adjustment model based on various influencing factors. Jingjing Yin.etc. finally confirm that labor costs are controlled by adjusting the unit price of a fixed labor day by analyzing the differences between the elements that constitute the salary and the elements contained in the labor price in the market

ANALYSIS OF INFLUENCING FACTORS OF LABOR COST CHANGES

Identification of Influencing Factors of Labor Cost Changes

Changes in labor costs for transmission line engineering are affected by a variety of factors, directly affected by the difference between the labor market price and the fixed labor unit price, and indirectly affected by the climate, environment, and construction management. In order to accurately identify the influencing factors of labor cost changes in transmission lines, this article first sorts out the influencing factors of labor cost changes in transmission lines in different countries and regions, then combines the background of the Chinese transmission line market, and finally the causal analysis chart is used to determine the influencing factors of the labor cost changes of the transmission line from the economic, social, environmental, engineering characteristics, and labor market conditions. The analysis results are shown in the following figure:

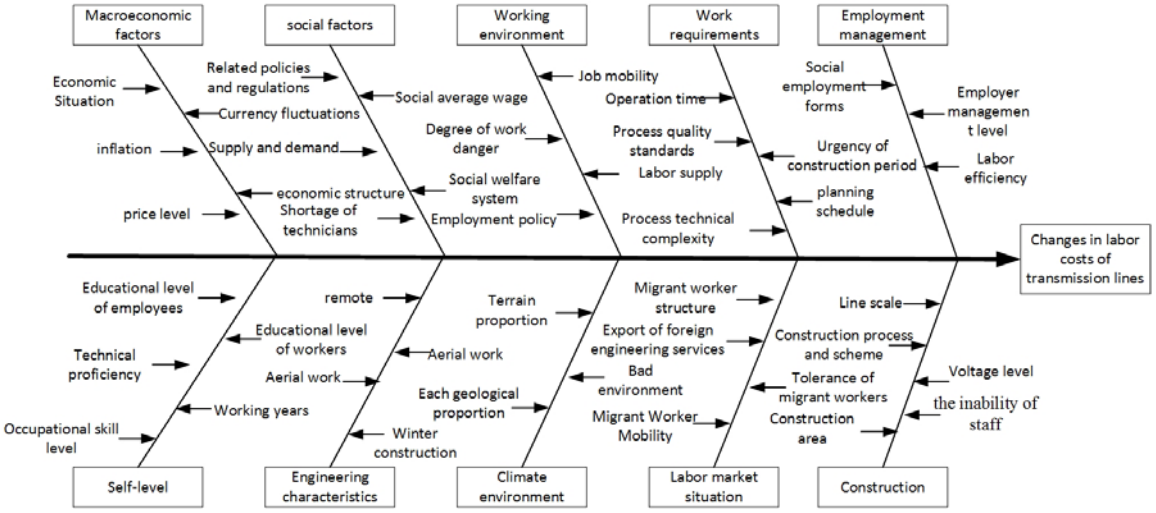

Fig. 1. Fishbone diagram of labor cost changes of transmission lines

According to the fishbone diagram analysis, these factors either directly affect the transmission line labor cost, or indirectly affect the transmission line labor cost through other influencing factors, and the impact of these factors on the transmission line labor cost is uncertain. However, when evaluating the labor cost of transmission lines, it is necessary to consider the key factors, distinguish the priority and make the structure clear. Therefore, it is necessary to conduct structural analysis on these factors. The following is the ISM structural interpretation model for factor analysis.

Analysis of Labor Cost Changes Based on ISM Model

System element analysis

According to the fishbone diagram above, select the important factors that affect the labor costs of the transmission line, and record the i-th influencing factor as S_i, That is: the unit price of market labor costs S_1, actual consumption S_2, inflation S_3,Supply and demand S_4, price level S_5, Educational level of employees S_6,recruitment policy S_7, migrant worker structure S_8, labor supply S_9,export of foreign engineering services S_{10},urgency of construction period S_{11}, Labor efficiency S_{12},construction process and scheme S_{13}, degree of danger S_{14}, topography S_{15}, climate environment S_{16}, social average wage S_{17}, the inability of staff S_{18}, line scale S_{19}.

There may be a causal relationship between these factors. We compare each factor S_i with other factors respectively. The AHP method can be used to establish the logical relationship between the factors. If there is a direct causal relationship, it is indicated by an arrow line in the factor relationship diagram, as shown in the following table.

Table 1: Factor association

Factor	Direct influence factor	Factor	Direct influence factor
0	-	10	5
1	4,5,6,7,8,9,10,11,12,13,15,16,17,18,20	11	7,8,10,13,14,15
2	7,8,12,13,14,15, 16,17,18,19	12	7,8,9,16,17,18,20
3	6	13	7,8,10,16,17,18,20
4	4,6,9,11,12,13,14,15,16,17,18,19,20	14	16,17
5	4	15	-
6	8,13,18	16	-
7	7,13,18	17	8,20
8	11	18	7,8,9,10,11,12,13,14, 15,16,17,18,19,20
9	-	19	7,18

Establish adjacency matrix and reachability matrix

The adjacency matrix shows the structural relationship between the two pairs of different influencing factors, and describes the reachability of each factor after the path of length 1. Assume that the element a_{ij} in the adjacency matrix A can be defined as follows:

$$A=\left[a_{ij}\right]=\begin{cases}1, \textit{ Indicates that } S_i \textit{and } S_j \textit{ are related}\\ 0, \textit{ Indicatesthat } S_i \textit{ and } S_j \textit{ are not directly related}\end{cases}$$

According to the determined factor set S= $(S_1, S_2, \ldots, S_n)$, the relationship between the factors is judged by using the factor relationship table, and the adjacency matrix A can be obtained.

$$A=\begin{bmatrix}
1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
1&1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
1&0&1&0&0&0&0&0&0&0&0&1&0&0&0&0&0&0&1&0\\
0&1&0&1&1&1&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&1&0&0&1&0&0&0&0&0&1&0&0&0&0&0&0&0&0&0\\
0&1&0&1&1&1&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&1&1&0&0&0&1&1&0&0&0&1&1&1&0&0&0&0&1&1\\
0&1&1&0&0&0&1&1&0&0&0&1&1&1&0&0&0&1&1&0\\
0&1&0&0&1&0&0&0&1&0&0&0&1&0&0&0&0&0&1&0\\
0&1&0&0&0&0&0&0&0&1&0&1&0&1&0&0&0&0&1&0\\
0&1&0&0&1&0&0&0&1&0&1&0&0&0&0&0&0&0&1&0\\
0&1&1&0&0&0&0&0&0&0&0&1&0&0&0&0&0&0&1&0\\
0&1&1&0&0&0&1&1&0&0&0&1&1&0&0&0&0&0&1&0\\
0&0&1&0&0&0&0&0&0&0&0&1&0&1&0&0&0&0&1&0\\
0&1&1&0&0&0&0&0&0&0&0&1&0&0&1&0&0&0&1&0\\
0&1&1&0&0&0&0&0&0&0&0&0&1&1&1&1&0&0&1&0\\
0&1&1&0&0&0&0&0&0&0&0&0&1&1&1&0&1&0&1&0\\
0&1&1&0&0&0&1&1&0&0&0&0&1&1&0&0&0&1&1&1\\
0&0&1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&1&0\\
0&1&0&0&0&0&0&0&0&0&0&0&1&1&0&0&0&1&1&1
\end{bmatrix}$$

Then the reachable matrix is established. The reachable matrix refers to the degree that can be reached by a certain length of path between the elements in the incidence matrix. The adjacency matrix A and the identity matrix I are used for power operation based on Boolean algebra until A satisfies the following formula:

$$\left(A+I\right)^{k-1}\neq\left(A+I\right)^{k}=\left(A+I\right)^{k+1}=M$$

The M matrix obtained at this time is the reachability matrix. In the actual operation, in order to simplify the operation, the reachable matrix M is obtained by programming with the MALTAB software, as shown below:

$$M=\begin{bmatrix}
1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
1&1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
1&1&1&0&0&0&0&0&0&0&0&1&0&0&0&0&0&0&1&0\\
1&1&1&1&1&1&1&1&1&0&1&1&1&1&0&0&0&1&1&1\\
1&1&1&0&1&0&1&1&1&0&1&1&1&1&0&0&0&1&1&1\\
1&1&1&1&1&1&1&1&1&0&1&1&1&1&0&0&0&1&1&1\\
1&1&1&0&0&0&1&1&0&0&0&1&1&1&0&0&0&1&1&1\\
1&1&1&0&0&0&1&1&0&0&0&1&1&1&0&0&0&1&1&1\\
1&1&1&0&1&0&1&1&1&0&1&1&1&1&0&0&0&1&1&1\\
1&1&1&0&0&0&0&0&0&1&0&1&0&1&0&0&0&0&1&0\\
1&1&1&0&1&0&1&1&1&0&1&1&1&1&0&0&0&1&1&1\\
1&1&1&0&0&0&0&0&0&0&0&1&0&0&0&0&0&0&1&0\\
1&1&1&0&0&0&1&1&0&0&0&1&1&1&0&0&0&1&1&1\\
1&1&1&0&0&0&0&0&0&0&0&1&0&1&0&0&0&0&1&0\\
1&1&1&0&0&0&0&0&0&0&0&1&0&0&1&0&0&0&1&0\\
1&1&1&0&0&0&1&1&0&0&0&1&1&1&1&1&0&1&1&1\\
1&1&1&0&0&0&1&1&0&0&0&1&1&1&1&0&1&1&1&1\\
1&1&1&0&0&0&1&1&0&0&0&1&1&1&0&0&0&1&1&1\\
1&1&1&0&0&0&0&0&0&0&0&1&0&0&0&0&0&0&1&0\\
1&1&1&0&0&0&1&1&0&0&0&1&1&1&0&0&0&1&1&1
\end{bmatrix}$$

Hierarchical analysis of influencing factors

According to the factor level allocation method, the factors that affect the transmission line labor costs are divided into the following 6 levels:

$$L_1=\{1\quad 2\}$$

$$L_2=\{11\quad 18\}$$

$$L_3=\{13\quad 14\}$$

$$L_4=\{6\quad 7\quad 9\quad 12\quad 17\quad 19\}$$

$$L_5=\{4\quad 8\quad 10\quad 15\quad 16\}$$

$$L_6 = \{3 \quad 5\}$$

The hierarchical structure is as shown in the figure:

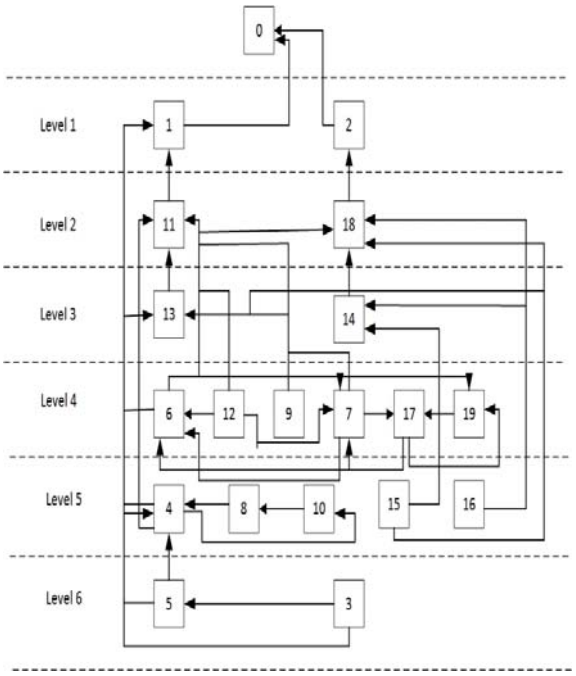

Figure 2. The hierarchical structure of influencing factors

It can be seen from the figure that the system of labor cost influencing factors of transmission lines is a six-level hierarchical structure model. The arrows from the bottom to the top indicate that the factors at the lower level affect the factors at the higher level.

Levels 1 and 2 are the most direct influencing factors. Changes in market unit prices and actual consumption directly affect labor costs, while the urgency of the construction period and the inability of staff to work directly lead to changes in actual consumption, which in turn affects changes in costs.

Levels 3 and 4 are the intermediate power layer factors. In the third layer, the construction process and scheme and the degree of danger are the driving factors that affect the change of labor costs. The construction process and scheme are an important basis for ensuring the stable operation of the entire transmission line. As the transmission line project requires high-altitude operation, the danger level makes the manpower willing to engage in the project scarce, and the unit price of labor must rise. In addition, high-altitude operations will inevitably lead to a decrease in labor efficiency and further affect actual consumption, thereby increasing labor costs. In the fourth layer, the influencing factors are not only related to the social environment, but also related to the scale of the project and the construction workers themselves. Under the overall environment, the average wage level of the society rises, which drives the wage level of the employees to rise and the labor price to rise in the market. The education level of the workers affects the comprehensive quality of the workers, which in turn affects the labor efficiency, thus affecting the actual consumption and the labor cost. The influence of line size on labor cost change is mainly reflected in the fact that compared with the project with short erection line, the line length is long and the required time period is long, and there is more uncertainty, which has a certain influence on labor consumption and labor cost unit price, thus affecting labor cost.

Levels 5 and 6 are the most basic factors that affect the labor cost of transmission lines, and they have a guiding effect on the upper layers. In the course of economic development, inflation has caused prices to rise, purchasing power to fall, and labor market prices to rise. With the development of "One Belt And One Road" and the deepening of "going out" strategy, a large number of labor services are exported to foreign countries, which makes the labor market in short supply, resulting in a shortage of personnel, especially technical personnel, which leads to a substantial increase in the price of the labor market. The harsh environment of the transmission line project has reduced the number of workers engaged in the transmission line. The working environment directly affects the willingness of labor to enter the transmission line project, which further affects labor output and causes significant changes in costs.

PROPOSAL

With the deepening of the reform of the power system and the increasingly complex external environment, the cost of transmission and transformation projects will face a severe test, and the high labor cost of transmission lines is the focus of attention. In this paper, ISM analysis is applied from the perspectives of economy, society, environment, management and engineering characteristics, constructs an explanatory structure model of the influencing factors of transmission line labor cost, clarifies the correlation among the influencing factors, establishes the corresponding hierarchical structure, and finds out the most direct, dynamic and guiding influencing factors of transmission line labor cost. In view of this hierarchical analysis, the following Suggestions are proposed:

① Strengthen the dynamic management of construction cost, learn from the standards of construction project management in the new era, dynamically manage the implementation of transmission line engineering, and design feasible guidance schemes. Construction units can be required to design the construction cost management system based on the guidance, combined with its own construction characteristics, designed a scientific and reasonable engineering cost dynamic management system.

②Carefully analyze the impact of society and the environment on the construction, establish a risk

prevention and control mechanism, control the inconsistency between the plan and the actual operation during the construction process, avoid large changes in labor costs due to the construction quality and progress of the project, and strictly control the transmission lines Construction labor costs.

③It is beneficial to improve labor efficiency and save labor cost to pay attention to the training of professional talents and improve the skill level and comprehensive quality of employees.

CONCLUSIONS

The ISM model used in this article provides an analysis method for the influence factors of transmission line labor costs, but each factor only uses 0 or 1 to determine whether there is an associated impact. It cannot reflect the strength of the impact and determine whether each factor Influential and may have certain personal subjectivity and limitations. Therefore, how to improve this problem, so as to make the hierarchy more clear and deeper, will be the focus of the next research.

The labor cost of transmission line construction is directly or indirectly affected by many factors, causing severe overruns in the labor cost of transmission line construction. The identification and control of the factors affecting the labor cost of transmission line is particularly important for the implementation of refined cost management and cost control of the project.

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