Research on Multi Objective Decision Model of Railway Construction Project

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Abstract — Objective: Construction period, cost and quality are the three major objectives of construction projects. The purpose of this paper is to take the three factors into consideration to obtain the optimal management decision model. Methods: In this paper, a multi-objective decision matrix model is constructed to study the multi objective management of the project. Process: In this paper, we establish a matrix of multiple factors affecting the project, and determine the weight of the factors according to the expert's vote, and then study the optimal decision of multi objectives according to the probability of occurrence. Conclusion: In this paper, we establish a matrix of multiple factors affecting the project, and determine the weight of the factors according to the expert's vote, and then study the optimal decision of multi objectives according to the probability of occurrence.

Keywords - Multi objective decision making model; Decision matrix; Influence factors; Occurrence probability

I. INTRODUCTION

At present, high-speed railway is entering an unprecedented large-scale construction period. The design standards, construction method, equipment investment, external environment, construction management and investment and financing mode of the high speed railway have been deeply changed [1]. The new problems and challenges cannot be solved by the traditional construction organization design work. Construction plan is to implement the project management, project investment, quality and progress of the important work content control, directly determine the success or failure of the project. Therefore, it is necessary to study the selection and optimization of construction scheme of high speed railway.

Railway engineering construction project management is the target management, which is based on the project manager responsibility system. It is an effective scheme, organization, coordination and control of the whole process of project construction [2]. It is a vital aspect in the process of railway engineering construction, which is related to the success or failure of the project. Among them, the optimization of the control objective of the railway engineering project in the planning work is the basis and premise of the whole process of the engineering project control the organization, coordination and control. In the project period, the cost and the quality of the reasonable constraints, to the three of the multi objective dynamic equilibrium, rather than one-sided emphasis on one aspect but neglect other aspects. In the process of project management, there are various uncertainties, which pose a risk to the project objectives [3]. In the modern railway construction project management, it is necessary to carry out the dynamic process control effectively, and realize the dynamic control of the implementation process.

II. PROBLEMS EXISTING IN RAILWAY CONSTRUCTION PROJECT MANAGEMENT.

With the continuous development and expansion of China's opening up, domestic and foreign advanced management level and technical impact, in recent years, China's domestic engineering project construction enterprises continue to forge ahead, the enterprise management level continues to improve, management methods and means of continuous innovation [4]. In some large-scale infrastructure construction, noncommittal, the railroad industry as a whole, the project management level and economic benefits than planned economy era have been greatly improved, whether in theory or in practice experience have all made the satisfactory results. However, from the reflection of the economic benefits of total assets, profit margins and total turnover of the two indicators are less than half of the western countries. From this, we can clearly see that the huge gap between the domestic railway construction project management and the western countries, reflected in the vast majority of railway construction enterprise project management level is low, the project economic benefits are not ideal.

China's construction industry to go out of the country, the implementation of the "going out" open policy has been more than 20 years of history. In this more than 20 years, our construction enterprises not only to the foreign counterparts learned advanced construction technology and process, but also the introduction of advanced project management experience and scientific management methods, our country some construction enterprises but also to squeeze into the ranks of the international well-known large enterprises. But on the other hand, the overall level of China's construction industry [5] is still unsatisfactory, and there is a certain gap between the developed countries and the construction industry. The industrial organization structure is unreasonable, the equipment and the technology
Network and case based reasoning, the comprehensive objective optimization based on stochastic analysis, neural programming model with three points to optimize the time, meet its multi-objective comprehensive consideration, so may not reach the entire project benefit, and therefore to who consider the one or two objective optimization, but are often powerless. Therefore, the majority of scholars are techniques in the problem of complex and nonlinear cases engineering applications, the traditional optimization problem.

It can be seen that the high-speed railway construction scheme is not there at the same time. This is a multi-objective optimization model of T, Q, C (duration, quality and cost) is put forward by Wang Yu, [7] and the "two optimization" is put forward. According to the idea of integrated management, the quality of the system is sensitive to quality and duration and cost. Based on the optimization of the project and the cost, the cost and quality of the project are analyzed. Tang Ming [8] put forward a kind of enterprise economic benefits as the goal, taking into account the time, cost and resources of the 3 indicators, using double - Code decision-making network, the overall perspective to seek the best economic benefits of integrated optimization method.

Chen Jian Hua [9] proposed the process management based on the multi objective synthesis of engineering projects and the key control points on the key line. The control target is real-time monitoring and controlling the multi objective comprehensive dynamic control model and the corresponding control mechanism. All of the above have considered the construction period, cost, quality and resources in the optimization of the three, in the construction of the project has played a very positive role. But in the increasingly fierce competition in the industry, time, cost, quality and resources at the same time to consider the optimization of the best combination is the pursuit of the direction of the scholars. Such as Zhou Shula from the traditional single goal to start, respectively, the construction period, quality, cost and resource balance of the four models, and then these four models into a multi-objective programming model.

It can be seen that the main factors in the optimization of engineering projects are time, cost, quality and resources. In the optimization, the main aim is to optimize the target and establish the target model. Finally, the two step optimization of the two step optimization is carried out. This idea is easy to realize the optimization of the different goals, but the whole project benefit is not necessarily achieved by optimization. In the construction process of complex scale engineering projects, the diversity of the construction objective must take all the key factors in the decision making process.

### A. The intrinsic relationship between the project objectives

The implementation of target management and strengthening project planning is an important means to improve the management level of railway construction and promote the standardization management. The target of railway engineering construction is to control the investment (cost), progress, quality, safety and environment [10]. Therefore, we should use multi objective decision support method. Through improving the integration of various management object and resource elements, optimizing and increasing the order of management object, and promoting the mutual complement and matching between the management object and resource elements, to realize the comprehensive optimization effectively. In order to realize the multi-objective decision support, we must clarify the relationship between the multiple objectives, make the project resources rational allocation, management elements

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of the integration, and realize the integrated optimization management.

Investment, progress, quality, safety, environmental protection between the five major objectives, taking into account the quality, safety and environmental protection of the target attributes similar to their investment, progress and the existence of a similar contradiction between the unified relationship, so they are considered as the same kind of target [11]. Figure 1 shows the contradiction between multiple objectives.

![Figure 1. Contradiction between target controls](image1)

Although there is a certain contradiction between the multi objectives, but the further analysis, the relationship between the multiple objectives and the existence of a promotion [12], as shown in figure 2.

![Figure 2. Consistent relationship between target controls](image2)

It can be seen that the relationship between the numbers of targets is the unity of opposites, and the change of one object can affect other targets, but also other targets. The relationship of the unity of opposites, tells us that we can not only emphasize the unilateral goal, regardless of other aspects of the goal, of course, the pursuit of absolute best is not realistic. Therefore, through scientific planning and decision making, using multi objective decision support method, and make full use of the goal, to avoid their contradictory side, to set up the target system, and to improve the integration of management object and resource.

B. Characteristics of multi objective decision making problem

In multi-objective decision making problems, the concept of optimality is generally no longer applicable. This is because there is a contradiction between multiple objectives, a solution to achieve the optimal and cannot make the other all the properties of the optimal, so the introduction of non-inferior solution (that is, PARETO optimal solution) [13]. Setting a traffic construction project selection decision problem \( Q = \{A, C, Y, P\} \), and \( A = \{a_i, i = 1, 2, \ldots, m\} \). Express the Optional scheme set, \( C = \{c_j, j = 1, 2, \ldots, n\} \) is the decision index set, \( Y = \{y_{ij}\}_{m \times n} \) is the decision matrix, \( y_{ij} \) represents the evaluation of the \( j \) index of the \( i \) scheme, \( P = \{P_1, P_2, \ldots, P_l\} \) Represents a preference structure for a decision maker, \( l \) is a number of decision makers, \( Q \) has the following characteristics: (1) the alternatives are composed of discrete, finite and non-inferiority schemes. These schemes are designed to be screened out by the paper or after the site investigation, which have strong comparability and the characteristics. (2) The value is large; (3) the value preference of decision makers is clear; (4) the evaluation of the scheme is based on the criteria. According to the characteristics of the problem, it is a more reliable method to eliminate and choose the method of multi criteria decision making method. The most important advantage is that it can be used in the decision matrix and the value preference of decision matrix.

C. Decision matrix of multi objective decision making model for railway construction projects

If the construction of high-speed railway in our country has \( m \) target \( V = \{v_1, v_2, \ldots, v_m\} \). The weight of each target is \( W_j \), satisfied \( 0 \leq W_j \leq 1 \). And \( \sum_{j=1}^{m} W_j = 1 \). For a high speed railway using different construction organization to draw \( n \) construction scheme, the decision set of the multi objective problem is \( P = \{P_1, P_2, \ldots, P_n\} \). The property of the target \( P_i \) is denoted by \( V_j \), which is \( U_{ij} = \{i = 1, 2, \ldots, n; j = 1, 2, \ldots, m\} \). Usually in the construction of high-speed railway construction, the completion probability is more better, the investment cost is fewer is better, the higher the better construction quality, construction is the better safety and environmental protection more perfect and better and so on, constitutes a decision matrix:

\[
U = (u_{ij})_{n \times m} = \begin{bmatrix}
    u_{11} & \cdots & u_{1m} \\
    \vdots & \ddots & \vdots \\
    u_{n1} & \cdots & u_{nm}
\end{bmatrix}
\]

The optimization decision of construction scheme of high speed railway construction is based on the weight of decision matrix and different target [14], and the overall
optimization construction scheme which can meet the requirements of multi objectives is selected in a feasible construction scheme.

**Weight determination**

Weight is the position in the decision-making process, which is reflected in the decision-making process, and it is the important factor to reflect the importance of each index in the decision-making process [15]. Therefore, the weight of the decision to become important decision-making activities, the actual use of accurate figures to indicate the weight of the index is not accurate, because the important degree of each indicator in the activity is not as accurate as the specific figures. In order to truly reflect the process of weight determination, in order to determine the importance of the index to a range to replace the specific score. That is,

with the integer value of 0 ∼100, in a given score, the total score of 100 in the n factor in the appropriate allocation, so that the center of the n range of play and close to 100. For example, to the index i , the Wj = [Wj, Vj], number of s interval numbers can be obtained by a given score of s . In which, j = 1, 2, ..., s And, 0 ≤ Wj ≤ Vj ≤100 , ∑i=1n Wj ≤100 , ∑i=1n Vj ≥ 100 .Index i weight of the s interval number Wj = [Wj, Vj], determined, the s number of the interval number is accumulated, so that the value of the weight distribution, and then according to the distribution of random values to carry out multiple objectives decision-making, that is, the random weight. The steps of determining the weights of the index i Wj (j = 1, 2, ..., m) are as follows:

1. Step 1: as for the index i , firstly, we should find s interval number Wj = [Wj, Vj], and then find out the minimum value Wj,min = {(Wj)} the maximum value Wj,max = {(Wj)} .

2. Step 2: If τ = Vj,max − Wj,min + 1.Then we should count sectionWj,min, Vj,max , so as to find out the frequency Pk,i of each integer value Wk,i in the s interval and the cumulative probability Pk,i . Among this k = 1, 2, ..., t .

3. Step 3: Pk,i = 0, Pk,i = 0,k = 1, 2, ..., t

4. Step 4: k = 1 , for all the j = 1, 2, ..., s , if(Wj) j ≤ Wk,i (Wj) j , so Pk,i = Pk,i + 1

5. Step 5: Pk,i = Pk−1,i + Pk,i

6. Step6: If k = 2, ..., t , Repeat second and third steps, and find all the frequency Pk,i and the cumulative probability Pk,i .

7. Step 7: If k = 1, 2, ..., t , Calculate the probability and the cumulative probability of each weight score, Pk,i = Pk,i / Pk−1,i Pk,i = Pk,i / Pk−1,i .

Finally, when the decision making is the index I to generate a [0, 1] of the random number qj , then we can find out k , which can make Pk−1,i ≤ qj ≤ Pk,i , its corresponding value of Wk,i is also the weight, and all the weight values of all n indexes are obtained by the W = [w1, w2, ..., wn]T . Then the vector W = [w1, w2, ..., wn]T is normalized to get the standard weight vector. The weight of the weight is only one kind of the combination, in the decision-making, it is necessary to carry out a variety of combinations of the corresponding test, and ultimately determine the optimal solution.

IV. MULTI OBJECTIVE DECISION MAKING OF RAILWAY CONSTRUCTION PROJECTS

The four kinds of construction schemes of the bridge pile foundation of a high speed railway bridge are the kinds of construction schemes, and the index attribute values of each construction scheme [16] are shown in Table 1. In the decision from the completion probability p, investment cost C, pile foundation stability of Q and construction safety s and construction five indicators of environmental impact e consider. The cost of the unit, the stability of the pile foundation, construction safety, environmental protection three qualitative indicators by fuzzy evaluation method. Stability of pile foundation level = {0.80, 0.85, 0.90, 0.95}, qualified security level {security and medium security, good safety, good security}, the corresponding evaluation value = {0.6, 0.7, 0.8, 0.91}; environmental protection level {to meet the basic requirements of environmental protection and environmental medium, Mingling environmental protection, environmental protection and}, the corresponding evaluation value = {0.70, 0.75, 0.80, 0.85}.

<table>
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<tr>
<th>TABLE 1 CONSTRUCTION SCHEME INDEX</th>
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<td>Feasibility plan</td>
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In this section, a high speed railway bridge pile foundation engineering construction scheme is chosen as an example, using the above algorithm to solve the case, according to table 1, therefore, the decision-making matrix is:
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\[
U = \begin{bmatrix}
80% & 2.45 & 0.95 & 0.8 & 0.75 \\
95% & 2.50 & 0.90 & 0.9 & 0.80 \\
90% & 2.40 & 0.85 & 0.7 & 0.70 \\
97% & 2.65 & 0.80 & 0.6 & 0.85
\end{bmatrix}
\]

(2)

For each index, a weight region is given according to the score of each expert. Among them, the probability and the cumulative probability of the weight values of the index P are shown in Figure 3.

![Figure 3. Index P weight fraction cumulative distribution curve](image)

In the multi-objective decision making, we first produce a random number between 0 and 1, the corresponding figure 1 find its location, determine the corresponding score. According to random weighting method, the random number is 0.72, the corresponding weight value is 25. According to the same method, the weight values of the other four indicators are: 23, 25, 12, and 20. Then the weight vector \( w = [25, 23, 25, 20, 12] \).

For the final weighting can be obtained a set of optimal solutions, in the actual construction process can be achieved in the decision-making results in the impact of the combination of decision-making. For each index, a weight region is given according to the score of each expert. Among them, the probability and the cumulative probability of the weight values of the index P are shown in Figure 3.

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V. CONCLUSION

How scientific arrangement of construction schedule, reasonable allocation of funds and guarantee construction quality, timely grasp of the construction schedule, cost, quality and environmental information, do the project schedule, cost, consideration of quality and environment, proper arrangements is each railway construction and management of the Department. Construction units, and supervision units’ witch to be solved a key problem. Railway engineering construction project management is the goal of the project manager responsibility system, is to achieve the purpose of the owners of high efficiency, according to the inherent law of project construction and program of the whole process of project construction to carry out an effective plan.

REFERENCES