Cost Optimization Technology of Construction Engineering Based on Genetic Algorithm

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Abstract. In recent years, with the rapid development of computer information engineering technology and the continuous improvement of the management level of construction projects, it is possible to achieve multi-objective quantitative optimization of construction projects. The main content of project objective quantitative management is the comprehensive optimization of construction period and cost. Relatively reasonable determination of construction period can bring benefits to the project to a certain extent. This study is based on the genetic algorithm of construction cost optimization technology. The purpose of this study is to find out whether genetic algorithm can be used to design the optimal structure and solve the construction engineering problems. The main purpose of this paper is to study the possibility of using genetic algorithm to optimize the cost, time and labor of construction projects. It also aims to find out whether there are other methods to replace the use of genetic algorithms, so as to not only reduce but also minimize the cost, time and labor involved in the construction project. In addition, this work will attempt to.

Keywords: architectural engineering · Genetic algorithm · Cost optimization

1 Introduction

The construction industry has a large volume and a pillar position in the national economy. It is an important carrier and material production department for the development of the national economy. According to incomplete statistics, the total output value of the construction industry in 2015 exceeded 18 trillion yuan, and its added value reached 4.6 trillion yuan, accounting for nearly the proportion of the secondary industry. On the other hand, the construction industry is closely connected with other industries, which can drive the development of more than 50 related industries such as building materials, metallurgy, petroleum, forestry and machinery. The development of the construction industry has important strategic significance in expanding domestic demand, promoting employment and stimulating economic growth [1].

Usually, project management has three major objectives, namely, cost, construction period and quality. However, in fact, most of them use construction period and cost as the main objectives for management. On the premise of ensuring quality, reducing construction period and cost means more economic benefits. Therefore, when people choose

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bidding documents or construction schemes, the design with short project duration and lower cost will often be given priority. In fact, the relationship between construction period and cost is a unity of opposites, and there is no feasible solution [2]. It can achieve the two goals of short time and low cost at the same time. Reducing the cost will inevitably lead to the extension of construction period, and compressing the construction period to a certain extent will increase the cost input. In order to solve this problem, the time cost tradeoff method is proposed, which is also the main method to solve the time cost multi-objective optimization problem [3].

After many years of research, the multi-objective optimization problem of construction period cost has made great progress in theoretical research. However, due to the development of science and technology, the expansion of project scale and other reasons, the traditional optimization model of construction period cost can not meet the actual needs. In recent years, with the further improvement of modern computer technology, computer-aided computing has become the mainstream, and more and more artificial intelligence search algorithms have been applied to the optimization field, which provides a new direction for the development of duration cost optimization.

2 Related Work

2.1 Principle of Duration Cost Optimization

By analyzing previous research documents, it is not difficult to find that many documents seldom consider the time value of funds when studying the relationship between the duration and the cost of construction projects, and only analyze the relationship between the direct cost and the duration of the project, ignoring the relationship between the indirect cost and the duration of the project. Moreover, most studies assume that the direct cost and the duration of the project are linear, However, this assumption is not consistent with the specific project implementation process. With the shortening of the activity duration, the comprehensive cost of each project activity and its duration show a non monotonic nonlinear function relationship. For example, the shorter the construction period of the project, the greater the labor intensity of the project [4]. The exchange of resources for time will inevitably consume a lot of human and material resources. The direct cost increases, but the indirect cost decreases. Therefore, the duration and the comprehensive cost are not simple linear relations. To sum up, from the perspective of the contractor, the shorter the time to complete the project, the faster the funds will be withdrawn. Considering the time value of the funds, the faster the loan will be returned to the bank, the lower the interest, and the higher the income will be obtained. Therefore, it can more accurately reflect the real income of the contractor in the project construction, and is more conducive to the contractor to control its construction period and cost [5].

The total cost of construction projects is mainly composed of direct costs and indirect costs. The direct cost is calculated according to each work in the project. The shorter the execution time of each work, the more the direct cost of the work increases.

Indirect costs are apportioned comprehensively according to the whole project, that is, the shorter the construction period, the less the cost. Since the direct cost is inversely proportional to the construction period, and the indirect cost is directly proportional to the construction period, the total cost including the two must have a lowest point, which

is the best point for time cost optimization. As shown in Fig. 1, the X point in the figure is the best point.

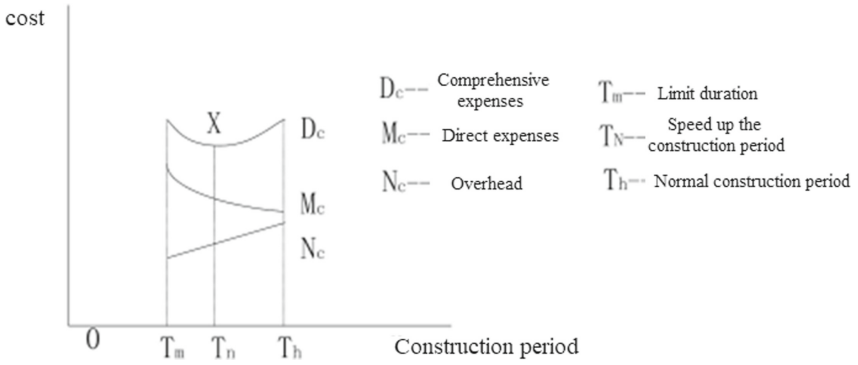

Fig. 1. Construction cost relationship

2.2 Cost Optimization Principle

The optimization principle of duration cost optimization is to minimize the project duration while reducing the project cost to the maximum extent, and improve or not affect the project quality. It is to sacrifice a certain number of certain objectives to achieve the overall gain or meet a specific demand. In short, the owner or the contractor can obtain the best arrangement and combination of the project subprojects by reasonably allocating the duration, construction cost or changing the construction sequence of the subprojects within a reasonable time and cost range through some optimization method. Under the same construction period, the total cost of any other sub project arrangement is higher than the optimization result, or under the same cost, the total construction period of any other sub project arrangement is longer than the optimization result [6].

From many research results of multi-objective optimization, we can see that there are many methods that can be used to solve the problem of multi-objective optimization. However, for the construction period cost optimization problem of building engineering construction, the most common method is to simplify the complexity and combine the multi-objective problems through certain variables or existing relationships, such as linear combination and objective weight ranking, so that the mathematical method can be used to solve the problem, that is, the optimization can be realized by solving the objective function. Therefore, the design of objective function is the basic premise of the whole optimization process [7].

The process of optimizing the objective function is the process that the duration cost optimization scheme gradually approaches the best scheme with shorter duration and lower cost. Under certain constraints, to select the best scheme from multiple schemes, it is necessary to use the optimization principle to continuously improve the original scheme according to the target until the most satisfactory scheme is found by the owner

and the contractor. The duration cost optimization is to find a satisfactory solution according to the above steps [8]. After the operation, a group of non mainstream solutions will be obtained: under the same constraint conditions, this group of solutions has obvious advantages over other solutions, that is, Pareto front (solution set composed of all Pareto solutions).

3 Construction Cost Optimization Technology Based on Genetic Algorithm

3.1 Genetic Algorithm

The genetic algorithm does not depend on the domain and type of problems, and provides a general framework for complex system optimization problems (the greatest advantage of the genetic algorithm is that it is not constrained by the domain and type of problems, and provides a general framework for complex system optimization problems)[9]. The calculation steps are as follows:

(1) First, the individual expression m and the solution space are given, that is, the decision variables and various constraints are determined.
(2) Define the type of objective function and describe or quantify it in mathematical form.
(3) The individual gene set M and the search space, i.e., the coding gene of the chromosome representing the feasible solution, are defined.
(4) To clarify the decoding method, that is, to clarify the conversion relationship and method from individual genotype m to individual phenotype M.
(5) The quantitative evaluation method of individual fitness was defined and the regenerated individuals were selected.
(6) The specific operation methods of selection operation and crossover operation are specified. In this paper, the crossover probability is determined according to the following formula, and new individuals are generated through crossover.
(7) To clarify the specific operation method of mutation operation, this paper determines the mutation probability according to the following formula, and generates new individuals through mutation.

$$\begin{cases} \max, f(X) \\ s.t. X \in R \\ R \subseteq U \end{cases} \tag{1}$$

(8) Specify the relevant operating parameters of the genetic algorithm, and generate a new generation of population through crossover and mutation, and return to step 2. See Fig. 2 for the specific algorithm diagram.

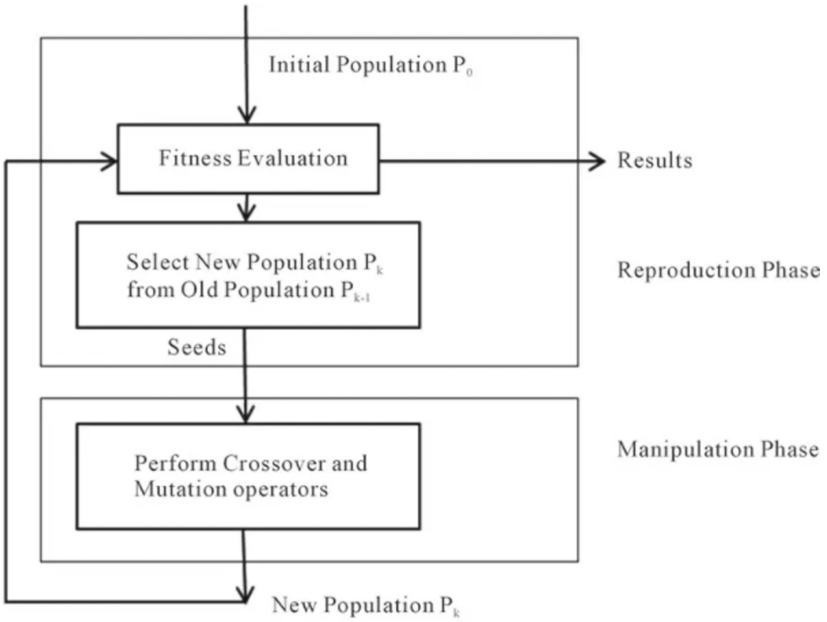

Fig. 2. Schematic diagram of genetic algorithm operation

3.2 Construction Cost Optimization Based on Genetic Algorithm

After the model is established, we need to solve it, that is, to find the optimal construction period and cost. In this paper, the genetic algorithm described above is used to solve the problem.

First, we need to set initial parameters, including genetic parameters and project parameters. Among them, genetic parameters include individual coding string length L, population size o, crossover probability p, mutation probability P and iteration algebra T. when binary coding is adopted, the selection of individual coding string length L is related to the accuracy of problem solving. When floating-point coding is used, it is the same as the number of decision variables and the population size O It refers to the number of individuals in the population. On the one hand, the value of Q should not be too large to reduce the operation efficiency of genetic algorithm; on the other hand, it should not be too small to reduce the diversity of the population. Therefore, the value range of Q is generally recommended to be 20 ~ 100. Project parameters: project duration T, cost C, project scale, logical relationship between processes, etc. [10].

Secondly, the initial population is randomly generated; The essence of genetic algorithm is the process of searching the optimal solution under the given solution set and the set constraints, so it needs to give an initial population. The individuals in the initial group shall be randomly generated by a random function according to the initial parameters, so as to obtain the initial group that does not contain any subjective intention of the decision maker. Therefore, the model needs to adopt the method of uniform sampling, and randomly generate n individuals in the problem solution set to form the initial set Q. through the following steps, the optimal resource allocation set of the process is finally

generated, which also forms the basis for the optimization of construction period and cost.

General process of individual fitness evaluation:

(1) Decoding the individual coding string to obtain the individual phenotype.
(2) Calculate the corresponding objective function value according to the individual phenotype.
(3) According to the objective function and the constraint conditions, the objective function value is converted according to the following formula to obtain the individual fitness.

4 Conclusion

The comprehensive optimization of construction project duration and cost is of great significance to effectively manage the project and ensure the smooth implementation of the project. Duration cost optimization is a kind of combinatorial optimization problem. The biggest problem faced by the combinatorial optimization problem is how to solve the combinatorial explosion. Although the swallow is small, it has everything. Even a very small and simple project usually has hundreds of processes. This situation makes the duration cost optimization of engineering projects extremely complex and difficult. For this reason, it has attracted the research enthusiasm of many scholars at home and abroad. At present, from the perspective of time cost optimization technology, although enumeration method can obtain the optimal solution or satisfactory solution, its modeling data is difficult to collect, modeling is difficult and the amount of calculation is huge, which restricts its application in time cost optimization of large-scale projects. Due to the lack of corresponding mathematical rigor, it is difficult to ensure that the solution obtained by heuristic algorithm is the optimal solution, so its application in engineering projects is also greatly limited.

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