Research on the Construction Schedule and Cost Optimization of Grid Structure based on BIM and Genetic Algorithm

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Abstract. Grid structure architecture has grown to be one of the most significant infrastructure projects in the electric power sector as a result of China's rapid expansion of power engineering. Grid engineering in the construction management process is particularly tough due to the grid structure's several challenges, including sophisticated modelling, many members, and others. Yet, there are numerous issues with the conventional grid construction management, including low production efficiency, an increase in surplus materials, and an increase in installation component collisions, all of which raise the cost of both construction management and the project as a whole. The most significant project management technology for construction is BIM, which can directly manage the construction by creating a BIM model. The construction unit can achieve three-dimensional visualisation and process controllability of on-site construction with BIM software. The construction unit can address the construction management issues of complicated grid structure engineering by using intelligent member construction. Rush events will occur during construction, which may cause issues with the construction timeline and cost optimization. This study develops a construction schedule and cost optimization model using a genetic algorithm, which will help achieve cost optimization more effectively.

Keywords: BIM, Genetic Algorithm, Grid Engineering, Construction Schedule, Cost Optimization

1. Introduction

The design institute has developed numerous outstanding grid projects in recent years as China's grid technology has advanced. One type of long-span space structure that has good mechanical performance, stiffness, and integrity is the grid structure. Grid technology can successfully support a range of loads, making structural manufacturing and installation simple[1]. The seamless execution of the entire power transmission and transformation project would be impacted by schedule control and cost control, which are among the most crucial project management considerations[2].

In the actual grid engineering project management, the project economy mostly adopts the schedule cost optimization method to manage the objectives. For example, reducing the progress of project activities by increasing the cost will meet the requirement of shortening the project schedule with the least cost increase. With the progress of society, the traditional schedule optimization method has been unable to meet the needs of the greatest interests of all parties in the project construction, which leads to the construction schedule cost optimization has become an important research topic of project management[3]. In practical engineering application, schedule control is to compare the deviation between the actual progress and the planned progress. By taking corresponding measures, we can minimize the cost of compression. At present, BIM has become the most widely used schedule control tool in the progress management and control of grid engineering projects. Through BIM, we can broaden our thinking, which can make the project manager pay more attention to the progress control and monitoring. Through the control of the key chain technology, the control of the grid project progress can not only be integrated into the whole task, but also can truly determine the time required for the project. Through a systematic and holistic perspective, we can better carry out schedule management and cost optimization[4].

2. Related concepts

Software sharing in BIM Era

BIM system can form a working platform through a server, which can work together with various disciplines. By making the workflow orderly and concise, all kinds of information will be shared, which can achieve the consistency of design results and actual products. In recent years, BIM Technology has been developed rapidly, which has produced a lot of BIM software. Through BIM integrated database, we can carry out correlation and parameterization, which can realize the working platform of different professional cooperation[5]. Through BIM, we can achieve accurate transmission and timely sharing of information between different disciplines, as shown in Figure 1.


Figure 1. Software sharing in BIM Era.

Genetic algorithm

Genetic algorithm is a search optimization method based on the theory of biological evolution and molecular genetics, which is an adaptive global optimization probability search algorithm. Through the group search strategy and information exchange between individuals in the group, GA search does not rely on gradient information, which will have a strong macro search ability[6]. Genetic algorithm simulates reproduction, mating and mutation in natural selection and genetics. Through random selection, crossover and mutation, we can generate a new group of individuals that are more adaptableto the environment, which can make the population evolve to better and better areas in the search space. Genetic algorithm is a new global optimization algorithm, which has been widely used in function optimization, combinatorial optimization, production scheduling and other fields[7].

Basic steps of genetic algorithm

Genetic algorithm can be divided into two kinds of operation process: genetic operation and evolutionary operation. Genetic operation is used to simulate the population replacement mechanism in natural evolution. By generating new species, the algorithm can search the global optimal solution. Among them, evolutionary operation is a process of constantly updating population through competition mechanism. The basic steps of genetic algorithm are as follows. First, the initial population pop (k) is generated randomly. Secondly, based on fitness function, we can evaluate chromosomes. Thirdly, we can select chromosomes to form new pop (k) based on the fitness value. Fourth, through crossover and mutation, we can produce a new chromosome, namely offspring. Fifthly, by iterating over and over again, we can get to a predetermined evolutionary algebra. The
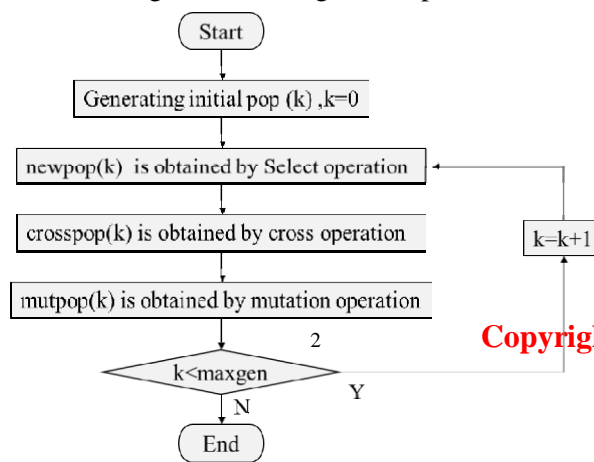
iterative flow chart of genetic algorithm is shown in Figure 2.

Figure 2. Iterative flow chart of genetic algorithm.

3. Establishment of construction schedule cost optimization model of Wangjia project

Establish optimization model

This paper takes into account the owner's payment for a certain work in the project, which is carried out periodically during its implementation. Assuming that the one-time payment in the middle of work is simplified, the relationship between jobs is compiled according to the single code network. At the same time, this paper considers the objective existence of the time value of funds. In this paper, the optimization model can be established, as shown in Formula 1. M

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$- s\ )\rceil (P/F, I\ , S$
$+_j + \Delta C^{ID}(P$

$.t.$

$j=1$

$t_j, d_j \geq 0$

$s_{tj} \leq t_j \leq n_{tj}$

$\lfloor\ _{cj}\quad _j\quad _j\quad _{tj}\ \rfloor$

$\quad\quad _0\quad _j\quad 2\quad\quad\quad A\ ^0$

(1)

$$n_{cj} \leq d_j \leq s_{cj}$$

$$TC = \max\{s_j + t_j$$

$j = 1, 2, ..., m\}$

$$s_j = \max\{s_h + d_h\},\ h\ is\ the\ set\ of\ jobs\ j\ before\ jobs$$

Among them, m is the number of jobs,

ΔC^{ID}

is the indirect cost rate of the project, which is

usually a constant; TC is the construction period of the project; s_j is the start time of work j; i_0 is

the benchmark discount rate; $P/F, I_0, S_j + {t_j}/{2}$ is the present value coefficient of one-time payment;

$P/A, I_0, TC$ is the present value coefficient of equal payment.

Process design of construction schedule cost optimization

Based on genetic algorithm, this paper establishes the resource balance optimization process of construction system, as shown in Figure 3.
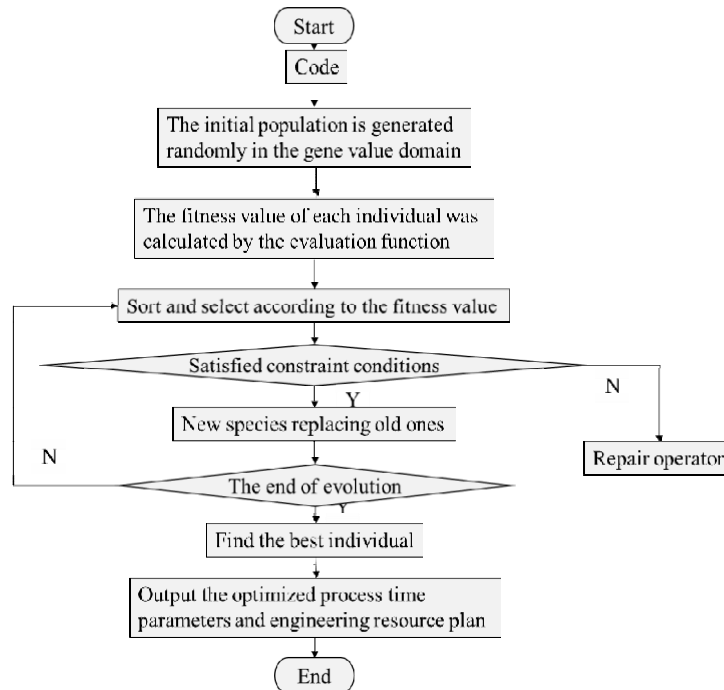
Figure 3. Process design of construction schedule cost optimization.

4. Conclusion

Based on BIM, we can establish the overall model framework of grid engineering, which can make the original geometric information more intelligent. Through BIM, we can import all the information such as grid member, welding ball node connection and splicing weld into the whole model through 3D solid modeling. Combined with bar code technology, we can directly present the information as bar code, which will facilitate the site construction personnel to accurately and quickly find the bar. Through the network planning schedule and cost optimization method, this paper calculates the schedule and cost optimization method based on genetic algorithm, which can more accurately consider the direct cost and schedule of grid engineering.

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