Commercial Concrete Distribution Center Site Selection Strategy Study Based on Center of Gravity Method

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Abstract. Commercial concrete is an important construction material. The physical properties of commercial concrete and the variability of personnel, equipment, weather, geography, traffic, and other conditions at the construction site make the delivery of commercial concrete extremely challenging. Following the intensification of market competition, the efficiency, cost, quality, and timeliness of concrete commercial distribution affect the market competitiveness of enterprises. The location of the distribution center plays a fundamental role in the operation of the logistics system. In this paper, a detailed analysis of distribution center location optimization is carried out, and a model of commercial concrete distribution center location is established and demonstrated in a real case. It aims to help concrete commercial enterprises seize opportunities, optimize distribution, enhance their competitiveness, reduce wasted production capacity, improve the level of expertise in the construction industry, and provide important guidance for regional industrial layout and logistics planning.

Keywords: commercial concrete · distribution optimization · the center of gravity method

1 Introduction

The geographical environment and traffic conditions of Chongqing are extremely special, which has caused great challenges to the transportation of commercial concrete in Chongqing. The market competition of commercial concrete industry is becoming more and more heated. Some enterprises often have problems with distribution, such as inefficiency, high operating costs, and low service quality. This phenomenon not only affects the company's own core competitiveness, but also wastes social resources. The proportion of the total cost of goods and concrete distribution is the key link in the distribution of concrete enterprises, and the quality of distribution is directly related to the user's satisfaction. Commercial concrete, also known as ready-mixed concrete, is concrete that can be sold or purchased for commercial use. At this stage, commercial concrete is the most used material in the construction industry in China, and it is also the most widely used construction material in the world today. Since the reform and opening up, with

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the continuous urbanization process in China, a large number of infrastructure and various types of properties have been put into development and construction, and roads, bridges, dams, tunnels, housing, office buildings, public facilities, and other buildings have appeared rapidly. The continuous promotion of urbanization brings the demand for commercial concrete is rising. It is understood that from 2000 until now, the production of commercial concrete in China has soared from an annual output of more than 70 million cubic meters to about 2.8 billion cubic meters in 2020 and is still climbing.

At present, domestic concrete enterprises have formed a consensus on the road to green production. The industry will also develop towards industrial intelligence and digital transformation in the future. Big data, cloud computing, artificial intelligence, industrial Internet, and other digital technologies will be deeply integrated with the concrete industry. Intelligent manufacturing + Internet + green manufacturing of smart factories will certainly be the road of development of the concrete industry chain. In July 2020, the "Green Building Creation Action Plan" was released. The program clearly accelerates the evaluation and certification of green building materials and the promotion of their application, promotes the quality of building materials, and creates a number of green building materials application demonstration projects. The study of commercial concrete distribution optimization strategy can reduce logistics cost improve logistics efficiency and service quality, which is of great practical significance to promote the green development of concrete enterprises. In particular, the site selection study of a commercial concrete distribution center can save the cost of enterprise expenses, shorten the production cycle, improve the efficiency of vehicle utilization, and also ensure the construction quality and progress of the project, and improve the service level of transportation enterprises.

In the current research on the distribution optimization strategy, researchers mostly focus on the logistics distribution of general goods, including transportation vehicle route planning and scientific time arrangement. These methods are generally applicable to most logistics enterprises.

The research on logistics location has been more in-depth at home and abroad [9]. When determining the logistics distribution center, the center of gravity method is used for simulation, and combined with the analysis of social and economic factors, a scientific distribution center location model is obtained [1]. After analyzing the influencing factors of distribution center location, the model of logistics distribution center in disaster area is established by using the method of fuzzy analytic hierarchy process, The feasibility of the model is verified by applying the model to Istanbul.Domestic research started later than abroad, but after the efforts of many domestic researchers, the establishment of China's logistics system has been gradually improved, and there has been no small breakthrough in the location model of logistics center. [5] simplified the complexity of logistics location through network analytic hierarchy process, and verified its simplification effect by SD Simulation Experiment [8] analyzed the advantages and disadvantages of BP algorithm when establishing the location model, and optimized the model through the characteristics of strong regional search ability of annealing algorithm and the advantages of perfect search process of BP algorithm. Its disadvantage is that it ignores the influence of external factors on the location model. [3] comprehensively analyzed the influencing factors of the site selection of commercial concrete mixing

plant and made key research in the form of questionnaire. The results of the questionnaire were analyzed by SPSS 18.0 to analyze the importance of each influencing factor, and the analysis results were sorted. Finally, multiple effective influence inheritance were selected to achieve the purpose of comprehensive evaluation of the site selection of commercial concrete mixing plant.

Because the distribution and transportation of commercial concrete has its unique timeliness, if we do not combine the characteristics of commercial concrete and blindly select the research results of general logistics commodity distribution, there will often be an embarrassing situation that can not solve the practical problems. Therefore, according to the actual use characteristics of concrete, the distribution optimization scheme suitable for commercial concrete can be designed.

2 Commercial Concrete Distribution Center Site Selection Analysis

2.1 Distribution Center Site Selection

Distribution center site selection is the process of selecting one or several addresses to plan and build a distribution center in an area with several demand points through the analysis of external and internal factors. The correct location of the distribution center will directly affect the distribution efficiency and cost of the enterprise. A proper distribution center solution can greatly improve the distribution efficiency and service quality of the enterprise, thus bringing more profit to the enterprise.

2.2 Commercial Concrete Distribution Process

In order to solve the challenge of commercial concrete distribution problems, the concept of a distribution center was brought into commercial concrete logistics. A transportation mode aimed at integrating enterprise resources and efficient distribution. It is a mainstream practice in the modern logistics industry and the development direction of the commercial logistics industry. The centralized distribution function of the distribution center is used to solve the problems that arise, such as misallocation of orders, unreasonable personnel deployment of vehicles, and idle or insufficient ready-mix trucks.

3 Construction of a Distribution Center Location Model Based on the Center of Gravity Method

3.1 The Center of Gravity Method

The center of gravity method is used to construct a distribution center site selection model that draws on the widespread use of this method in general logistics center site selection, which is a method that allows static or continuous site selection for a single target. Its modeling method is derived from the Cartesian coordinates in geometry. In its use in commercial concrete delivery, the commercial concrete distribution center and the different sites can be viewed as points on a plane. After the site coordinates are given, the

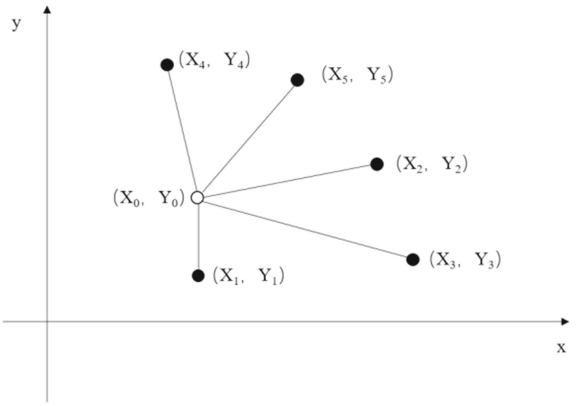

Fig. 1. The center of gravity distribution diagram.

center of gravity of these points is solved by considering the supply and transportation costs as weights and the total transportation costs as the final destination (Fig. 1).

The center of gravity method functional relationship is given in (1)

$$TC_{min} = \sum_{i} ViRiDi \tag{1}$$

where TC denotes the transportation cost pool, Vi denotes the supply at point i, Ri denotes the distribution freight rate at point i, and Di the distance of the distribution center from point i.

$$Di = \sqrt{(Xi - X)^2 + (Yi - Y)^2} \tag{2}$$

In Eq. (2), (X, Y) is the coordinates of the distribution center, and (Xi, Yi) the coordinates of the place where the commodity is supplied.

In Eq. (2), (X, Y) is the coordinates of the distribution center, and (Xi, Yi) the coordinates of the place where the goods are supplied.

3.2 Distribution Center Site Selection Modeling

According to the basic equation of the center of gravity method, the following equation can be established:

$$X = \frac{\sum_{i=1}^{n} a_i x_i n}{\sum_{i=1}^{n} a_i n} \qquad Y = \frac{\sum_{i=1}^{n} a_i y_i n}{\sum_{i=1}^{n} a_i n} \tag{3}$$

After the initial solution is obtained by the formula, a more accurate solution is finally obtained by the least squares method, which minimizes the distribution cost. The optimization process is as follows:

$$F(x) = \sum_{i=1}^{n} a_i n d_i \tag{4}$$

$$\frac{\partial F}{\partial X} = \sum a_i(X - X_i)n/d_i = 0 \tag{5}$$

$$\frac{\partial F}{\partial Y} = \sum a_i(Y - Y_i)n/d_i = 0 \tag{6}$$

The resulting X and Y are the optimal solutions obtained in the first iteration. So the new equation for the exact center of gravity method is:

$$Xt = \frac{\sum_{i=1}^{n} a_i x_i n/d_i}{\sum_{i=1}^{n} a_i n/d_i} \qquad Yt = \frac{\sum_{i=1}^{n} a_i y_i n/d_i}{\sum_{i=1}^{n} a_i n/d_i} \tag{7}$$

F in the formula is the shipping cost from the distribution center to each site, di is the distance from the distribution center to each site, because (X, Y) and (Xi, Yi) in the same plane, $di = \sqrt{(X - Xi)^2 + (Y - Yi)^2} \cdot 1.41$ is the solution of t iterations, t = 1, 2, 3 … n; where The precise process steps are as follows:

The distance from the distribution center to each site is obtained by bringing the original solution (X, Y) into the di equation. TThe freight rate of distribution to each site is obtained by Fi = aindi, the original solution of the freight rate F is obtained according to 3.2, and the original solution is brought in to obtain the solution of the first iteration. Repeat the first and second steps to calculate the new value F1 (X1, Y1). Compare F1 and F. If F1 is smaller than F, continue iterating. Until Ft is equal to the result of Ft-1 iterations, the final (Xt − 1, Yt −1) is the optimal solution. After finding the theoretical optimal solution, an area is obtained with a certain length as the radius, after which several coordinates that meet the construction requirements are selected as backups within this area. Then the influencing factors of the concrete distribution center site selection analysis are analyzed. The scoring method is used to conduct a comprehensive analysis of the backup coordinates to find the best construction location.

4 Case Studies of Site Selection Options

4.1 Solving Theoretical Site Selection Schemes Using Models

At commercial concrete Ltd., there are 9 construction sites in Chongqing that require transportation and distribution work, and their coverage area is medium-sized. In order to reduce the cost of distribution, it is requested to build a distribution center for centralized delivery and dispatch. Among them, the geographic coordinates of each construction site and the order quantity are presented in the following table. The coordinates of the distribution center (X, Y) were obtained by establishing an accurate center of gravity method model and inputting the actual data to optimize the site selection (Table 1):

① Using the previously established (3.1) by the center of gravity method to find the original solution, that is, the distribution center coordinates: according to the site coordinates in Table 7.2 and the order quantity of the site can find the original solution as (X = 4.6, Y = 6.1);

Table 1. The commercial concrete distribution situation of H company.

Construction site	Xi	Yi	n	a/ cubic meters
1	0.4	6.4	1.1	10.8
2	1.4	6.1	1.1	7.2
3	3.1	5.1	1.1	6.4
4	4.7	6.3	1.1	5.4
5	3.5	7.8	1.1	7.2
6	6.2	4.4	1.1	5.2
7	7.5	5.3	1.1	5.3
8	6.6	7.9	1.1	5.6
9	9.2	5.1	1.1	10.5

② According to the least-squares optimization idea of the exact center of gravity method, the model is calculated using an excel software tool. The known data such as the information in Table 7.2 and the calculated coordinate values of the original distribution center are input,

③ Enter the function in the excel software to find the distance from the distribution center to each site, and the transportation cost per trip and the total transportation cost F = 292.24 respectively.

④ Using the planning solution, i.e., the least-squares optimization process, the total freight cost is located in the target unit, and the minimum value of the total freight cost is obtained, and the variable unit is the coordinate unit of the distribution center. The final optimization solution of the center of gravity method is obtained by planning solution, and the coordinate point X = 4.65 and Y = 6.27 are selected for the final distribution center. The transportation cost is at least F = 291.63.

4.2 Comprehensive Evaluation of Site Selection Options

It may be found after solving the theoretical optimal distribution center construction coordinates using the model in the previous section. Still, in the actual construction process this theoretical optimal location cannot build the distribution center due to the interference of some factors. For example, there are already buildings in the area. Chongqing is a city with many mountains, rivers, and lakes. The influence of unsuitable terrain at the coordinate location may also lead to the inability to build the distribution center. A suboptimal solution can be made based on the (X, Y) coordinates, and a region is obtained by considering the (X, Y) coordinate point as the location of the center of a circle with a certain length as the radius. After that, several coordinates that meet the construction requirements in this area are selected as backups. After the alternate coordinates are selected, a comprehensive comparison of the alternative sites is then performed by the comprehensive scoring method to select the best site option for establishing the distribution center.

Table 2. Comprehensive analysis and evaluation table for JG site selection.

Considerations	Weight	Rating		
		PointA X = 4.65 Y = 6.27	Point B X = 4.3 Y = 5.8	Point C X = 5.1 Y = 6.7
Transportation costs	0.4	100	90	87
Land price	0.1	70	50	100
Transportation convenience	0.2	50	100	85
Environmental impact on surrounding residents	0.2	100	80	35
Urban planning	0.1	50	70	100
Weighted score		82	84	78.8

After analyzing the factors influencing the location of the concrete distribution center, the four influencing factors of land price, traffic convenience, environmental impact on the surrounding residents, and urban planning were added on the basis of transportation cost. The optimal and sub-optimal solutions were analyzed comprehensively by scoring method. The best location for the establishment of the distribution center was found to be point B (X = 4.3, Y = 5.8) by comparison, and the analysis process is detailed in Table 2.

5 Conclusions

Under the background of the rapid and healthy development of the commodity concrete market in Chongqing, the optimization strategy proposed in this paper is conducive to solve the problems of overcapacity, weak competitiveness and low service efficiency of commercial concrete enterprises in Chongqing; at the same time, it also contributes to the innovation and upgrading of the management and management of the commodity concrete industry in Chongqing.

The location of distribution centers is an important and urgent issue for both construction companies and distribution logistics companies. This paper establishes a systematic and scientific model for commercial concrete distribution center location optimization and adopts the center of gravity method to solve the problem. It is an important guideline for the selection of distribution centers of enterprises. However, when establishing the distribution model in the paper, there is a lack of diversity in vehicle models and concrete types. In actual distribution, the concrete grade affects the price of commercial concrete, while the vehicle model is about the efficiency of distribution, and often enterprises will choose different combinations for concrete distribution. Therefore, in future research, these two factors can be taken into account in the model building process to make the model more meaningful for practical guidance.

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