Optimal design of open-air parking lot parking

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Abstract: This paper deals with the problems related to the planning and arrangement of parking lots, which is to make suitable parking arrangements without affecting the regular use of parking lots, so that the number of cars in the parking lot is the largest. According to the turning radius of the car and the basic parameters of the parking space, the functional relationship between the inclination angle of the parking space and the length of the parking space perpendicular to the channel direction, the width of the parking space parallel to the channel direction and the distance between the width of the channel and the end of the parking space is established. We set the number of parking rows and the number of passages, establish the target equation by determining the length and width of the parking lot and use Matlab to obtain the extreme value of the number of the target rows. The optimal design plan is obtained when the optimal location of the parking lot is tilted, the number of channels, and the number of parking spaces.

Keywords*:* parking space optimization; MATLAB; entrance and exit design; multi-block analysis; the optimal solution

1. Introduction

Since the 21st century, with the rapid development of social economy [10], household cars have entered ordinary households at an alarming rate and entered a period of rapid growth. This has caused a series of problems, among which parking problem is one of the more and more prominent problems. The parking problem is becoming more and more prominent [7], and gradually becomes one of the common problems faced by cities in China [4]. Parking spaces are limited by site conditions, providing only limited parking spaces, and planning for parking lots while ensuring free entry and exit of vehicles. Parking planning refers to considering factors such as the shared parking area, the difficulty of vehicle entry and exit [5], and the degree of smooth traffic in the parking lot within the limited space area, to design the parking space layout and maximize the space efficiency and time efficiency. How to design parking spaces for parking lots in all aspects, so that it can get a larger parking capacity is Car parking width [6].

1.1. Data Enumeration

Table 1. Parking dimension style

Household car parking size parameters		
Car parking length		4.2m
Car parking width		2.2m
Car turn radius		5.5m

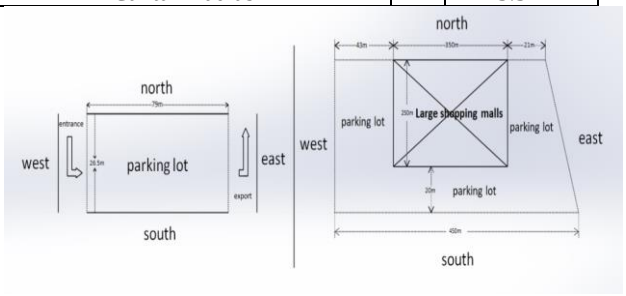

Figure 1. Parking lot design

2. Problem analysis

In the parking lot with a length of 79 meters and a width of 26.5 meters, the parking lot optimization model [1] is designed, which requires the driver to have enough space to park, and the parking lot has the most significant number of parking. We adopt three kinds of arrangement, parallel, oblique and vertical. The maximum number of parking spaces is analyzed [8].

We know that the turning radius of the family car is 5.5 meters. When parking vertically, we need a position of 5.5 meters in length and 2.5 meters in width. We design a single-row parking space and access passage. Because it is the minimum turning radius is 5.5 meters, the minimum width of the passage is:

$$R = 5.5 - 2.4\cos\theta \tag{1}$$

The angle θ between the long side of the parking space and the lane changes from 0 to 90 degrees, and the parking space width W:

$$w = \frac{2.5}{\sin\theta} \tag{2}$$

Length of parking space perpendicular to the passage direction L:

$$L = 5.5\sin\theta + 2.5\cos\theta \tag{3}$$

Distance from the end of each parking space L_d :

$$L_d = 5.5\cos\theta + 2.5\cot\theta\cos\theta \tag{4}$$

For the three arrangements, we have three design arrangements. It is a parallel-type double-row arrangement, vertical arrangement double-row, column-ramp arrangement. Parking arrangement establishing and optimizing model arrangement [2]. We assume:

$$x_i = \frac{2(a - L_d - 2c)}{w} \tag{5}$$

Formula wherein xi is the i -th number of the parking zone.

We do deal with optimization model for both parking spaces and channel arrangement:

Case 1: When m=2n, i.e., every two rows of parking space is equipped with a parking channel.

Case 2: when m=2n-1, i.e. n-th channel has no parking side. All channels on both sides in front of the parking space is provided.

By comparing the calculation to find the optimal design.

3. Problem solving

3.1 The necessary arrangement of the three kinds

We know the minimum width of the channel R, stop bit width W, perpendicular to the channel length direction of the parking space L, parking end of each row distance Ld.

$$n(5.5-2.4\cos\theta) + m(5.5\sin\theta + 2.5\cos\theta) = 14$$

$$\begin{cases} R = 5.5 - 2.4\cos\theta \\ L = 5.5\sin\theta + 2.5\cos\theta \\ w = \dfrac{2.5}{\sin\theta} \\ L_d = 5.5\cos\theta + 2.5\cot\theta\cos\theta \\ X = \dfrac{a - L_d}{W} \end{cases}$$

$$x_2 = \frac{2(362\text{-}5.5\cos\theta\text{-}2.5\cot\theta\cos\theta)}{\dfrac{2.5}{\sin\theta}}$$

$$s' = \frac{2.5}{\sin\theta}(5.5\text{-}2.4\cos\theta + 5.5\sin\theta + 2.5\cos\theta)$$

$$x_3 = \frac{\dfrac{1}{2}(15+50)\times 264}{\dfrac{2.5}{\sin\theta}(5.5\text{-}2.4\cos\theta + 5.5\sin\theta + 2.5\cos\theta)}$$

$$s = \frac{1}{2}(15+51)\times 264$$

$$z = \max\sum_{i=1}^{3} x_i\theta \tag{6}$$

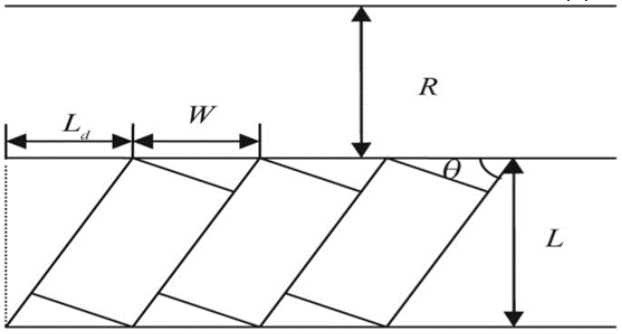

Figure 2. Oblique arrangement

When we use the vertical arrangement of the discharge, the discharge of each vertical parking in a row, this time with the channel angle parking α=90, vertical parking width W1 =2.5m, vertical parking spaces perpendicular to the longitudinal direction of the channel bit length L1 =5.5m, vertical channel width:

$$R\ 1 = 5.5\text{-}2.4\cos 90 = 5.5\text{m} \tag{7}$$

Vertical alignment can be drawn stop bits and the desired width of each row:

$$X = \left[\frac{a}{W_2}\right] \tag{8}$$

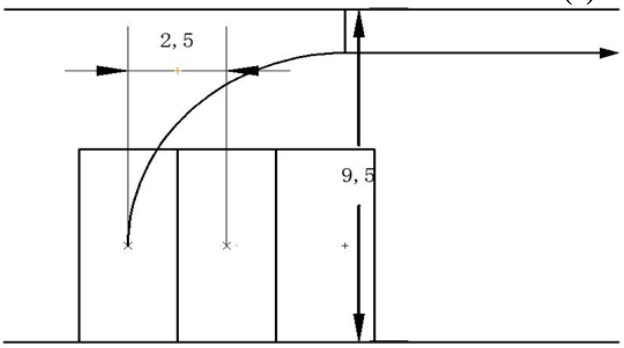

Figure 3. Vertical arrangement

When we use a parallel type arrangement, the respective parking spaces in a row parallel to the discharge, so the angle of the parking space with the channel α =0, the bit width of the parallel parking W2=5.5m, parking is parallel to the length perpendicular to the channel direction of formula L2 =2.5m, parallel to the channel width of formula:

$$R\ 2 = 5.5\text{-}2.4\cos 0 = 3.1\text{m} \tag{9}$$

Type arrangement can be drawn parallel parking digits and the desired width of each row:

$$X = \left[\frac{a}{W_2}\right] \tag{10}$$

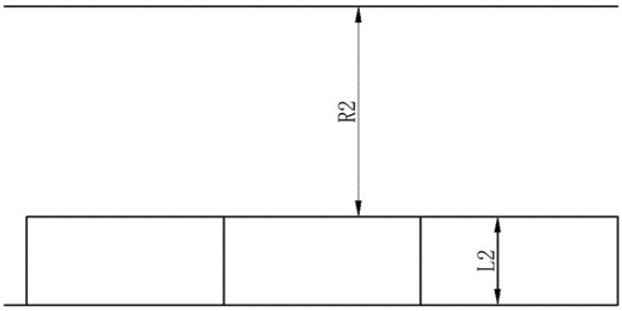

Figure 4. Parallel Arrangement

3.2 Parking and optimization analysis model channel arrangement

Case 1: when n = 2m, two rows of parking spaces per parking provided with a channel.

Case 2: when n = 2 m -1, i.e. n-th channel has no parking side. All channels on both sides in front of the parking space is provided with [3].

We set before (m-1)-th traffic channel width of R1, m-th traffic channel width R2, before parking the length and width of the m-1 region is L1, W1, m-Parking bit length and a width L2, W2. M -1 distance between the front end of the parking area is LdI, Ld2 m-th region from the end of the parking, the angle between the two cases, respectively θ1, θ2.

3.3 Program Setting

Scheme 1: n = 2m, which can accommodate the maximum number of parking spaces:

$$Z = \max \sum_{i=1}^{n} x_i$$

$$x_i = \frac{2(a - L_d - 2c)}{w}$$

st.nR+mL=b

$$\text{n=2m,m,n} \in \text{Z}^{+} \tag{11}$$

Scheme 2: n = 2m-1, which can accommodate the maximum number of parking spaces:

$$Z = \begin{cases} \max(\sum_{i=1}^{n-1} x_i + x_n) \\ \max(\sum_{i=1}^{n-1} x_i + x_n) + x_0 - x_n \end{cases}$$

$$st.(n-1)R_1 + R_2 + (m-1)L_1 + L_2 = B$$

$$x_i = 2(A - Ld_1 - 2c)/W_1$$

$$x_n = (A - Ld_2 - 2c)/W_2$$

$$R_1 = 5.5 - 2.4\cos\theta_1$$

$$R_2 \geq 5.5 - 2.4\cos\theta_2$$

$$L_1 = 5.5\sin\theta_1 + 2.5\cos\theta_1$$

$$L_2 = 5.5\sin\theta_2 + 2.5\cos\theta_2$$

$$Ld_1 = 5.5\cos\theta_1 + 2.5\cot\theta_1\cos\theta_1$$

$$w_1 = \frac{2.5}{\sin\theta_1}$$

$$Ld_2 = 5.5\cos\theta_2 + 2.5\cot\theta_2\cos\theta_2$$

$$w_2 = \frac{2.5}{\sin\theta_2}$$

$$\text{n=2m-1,m,n} \in \text{Z}^{+} \tag{12}$$

3.4 Results

Scheme 1: n=2m

$$st.nR + \text{mL} = \text{n}(5.5 - 2.4\cos\theta) + \text{m}(5.5\sin\theta + 2.5\cos\theta) = 26.5 \tag{13}$$

$$x_i = 2(A - Ld_1 - 2c)/W_1 \tag{14}$$

The largest number of parking spaces:

$$Z = \max \sum_{i=1}^{n} x_i \tag{15}$$

Scheme 2: n=2m-1

$$st.(n-1)R_1 + R_2 + (m-1)L_1 + L_2 = (n-1)5.5 - 2.4\cos\theta_1 + 5.5 - 2.4\cos\theta_2$$
$$+(m-1)5.5\sin\theta_1 + 2.5\cos\theta_1 + 5.5\sin\theta_2 + 2.5\cos\theta_2 \tag{16}$$

$$x_i = 2\left(79\text{-}5.5\cos\theta_1 + 2.5\cot\theta_1\cos\theta_1\text{-}12\right)/\frac{2.5}{\sin\theta_1} \tag{17}$$

$$x_n = 2\left(79\text{-}5.5\cos\theta_2 + 2.5\cot\theta_2\cos\theta_2\text{-}12\right)/\frac{2.5}{\sin\theta_2} \tag{18}$$

The largest number of parking spaces:

$$Z = \begin{cases} \max(\sum_{i=1}^{n-1} x_i + x_n) \\ \max(\sum_{i=1}^{n-1} x_i + x_n) + x_0 - x_n \end{cases} \tag{19}$$

Matlab using software programs are one hundred twenty-two processing program can be drawn to a total number of parking 138, two solutions for the total number of parking 117. You can obtain a better scheme Scheme II.

3.5 Analysis of results

After solving the model, we know that a program is better than Scheme II, so we use two rows of parking spaces per parking provided with a passage for the intermediate parking inclination angle a = 45. Design drawings as follows:

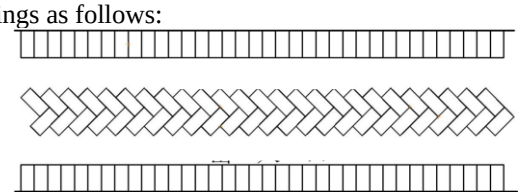

Figure 5. Schematic diagram

4. Conclusion

This model is a rigorous mathematical model based on the basic parameters of the optimal layout of parking lots and traffic lanes. Matlab is used to calculate the optimal solution. The model is designed for the parking lot of a large shopping mall and has strong practicability. The ideas, methods, and results of the design also have a high reference value for the optimization design of other large parking lots, which can be extended to any parking lot and has better economic benefits and practical significance. To promote real life, we can also set up a display at the entrance of the parking lot, prompting drivers to park their positions at any time, which can reduce traffic congestion and ensure better parking order and efficiency.

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