The Modified Algorithm Study on Load Degree of Subway Station

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***Abstract*—On the basic of the research, this paper improves the algorithm of the station ticket gates load degree. First , the author improves the calculation method of the weight of the enter/exit ticket gates. We use the average passenger volume of each gate to calculate the weight instead of the total passenger volume. Second, the author adds unbalance coefficient to reflect the use unbalance of the ticket gates group. The result shows that the modified algorithm is more reasonable and scientific.**

***Index Terms*—subway station, urban rail transit safety, weight of ticket gates, load degree, unbalance coefficient**

I. INTRODUCTION

The ticket gates' load degree reflects the use of the gates. Using a reasonable method to calculate the load of the gates can reflect the real use of state of the gates. The reasonable ticket gates load degree can not only provide reliable management basis for the subway managers, but can also let the managers achieve the dynamic control of the passenger flow. So we can insure the station is safe.

The author of this paper proposed a method based on the volume of passenger flow getting in and out of the station to calculate the ticket gates load degree [1]. And the method is so easy that we didn't think about the average passenger flow of the gates group when we calculate the weight of the enter/exit gates, and we didn't think about the unbalance of the different gates group when we calculate the load degree of the enter gates group or the exit gates group. Feng Jiandong uses the Legion pedestrian simulation software to study the each gate's unbalance of the ticket gates group in literature [2]. He thinks that the gates should be dispersedly set at the station. But he didn't give out the algorithm of the ticket gates group. LI Sheng-li studies on evacuation efficiency of ticket gate and escalator under panic behavior [3]. In addition, there are few methods to calculate the load degree of the ticket gates group. So this paper mainly studies the algorithm of the gates' weight and unbalance under normal circumstances.

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II. THE ORIGINAL METHOD INTRODUCE

The research findings show that the method based on the volume of passenger flow getting in and out of the station is more reasonable in literature [1]. So we mainly study the modified algorithm based on this method. First of all, we introduce the method in literature [1] concisely.

A. The Load Degree of the Enter/Exit Gates

When calculate the load degree of the enter the ticket gates during the period of $(t, t+\Delta t)$, the paper uses the ratio of passenger flow volume getting in the station through one ticket gates group and passenger flow volume getting in the station through all enter ticket gates groups as the weight of this enter gates group. Then it sums the product of the enter gates weight in one group and the enter gates load degree in this group as the enter gates load degree of this station. And the paper gets the exit gates load degree of this station with the same method. The equations are as follows:

$$GU^{in/out}(s_{ij}) = \sum_{x=1}^{m} \lambda_x^{in/out}(s_{ij})\, gu_x^{in/out}(s_{ij}) \quad (1)$$

$$\lambda_x^{in/out}(s_{ij}) = \frac{c_x^{in/out}(s_{ij})}{\sum_{x=1}^{m} c_x^{in/out}(s_{ij})} \quad (2)$$

$$gu_x^{in/out}(s_{ij}) = \frac{c_x^{in/out}(s_{ij})}{afc_x^{in/out}(s_{ij}) \cdot \Delta t \cdot afc_e} \quad (3)$$

where: $GU^{in/out}(s_{ij})$ is the enter/exit ticket gates group load degree of the s_{ij} station during the period of $(t, t+\Delta t)$ (%); $\lambda_x^{in/out}(s_{ij})$ is the weight of the enter/exit gates of the xth ticket gates group at the s_{ij} station(%); $gu_x^{in/out}(s_{ij})$ is the load degree of the enter/exit gates of the x th ticket gates group at the s_{ij} station(%)[4], [5];

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$c_x^{in/out}\left(s_{ij}\right)$ is the volume of passenger flow getting in/out of the xth ticket gates group at the s_{ij} station during the period of $\left(t, t+\Delta t\right)$ (persons); $afc_x^{in/out}\left(s_{ij}\right)$ is the enter/exit ticket gates number of the xth ticket gates group at the s_{ij} station(unit); Δt is the test time(min); afc_e is the design capacity of each ticket gate(persons/min)[6]; xth is the order number of the ticket gates group, $x = 1 \cdots m$.

B. The Comprehensive Load Degree of the Ticket Gates at the Station

When calculate the comprehensive load degree of the station, the paper uses the ratio of the volume of passenger flow getting in the station and the volume of the passenger flow getting in and out of the station as the weight of the enter gates group. At the same time, it uses the ratio of the volume of passenger flow getting out of the station and the volume of the passenger flow getting in and out of the station as the weight of the enter gates group. At last, it sums the product of the enter/exit gates weight and the enter/exit gates load degree of the station as the comprehensive load degree of this station. The equations are as follows:

$$GU_{(t+\Delta t)}\left(s_{ij}\right) = k^{in}\left(s_{ij}\right)GU^{in}\left(s_{ij}\right) + k^{out}\left(s_{ij}\right)GU^{out}\left(s_{ij}\right) \tag{4}$$

$$k^{in/out}\left(s_{ij}\right) = \frac{\sum_{x=1}^{m} c_x^{in/out}\left(s_{ij}\right)}{\sum_{x=1}^{m} c_x^{in}\left(s_{ij}\right) + \sum_{x=1}^{m} c_x^{out}\left(s_{ij}\right)} \tag{5}$$

where: $GU_{(t+\Delta t)}\left(s_{ij}\right)$ is the comprehensive load degree of the ticket gates at the s_{ij} station(%); $k^{in/out}\left(s_{ij}\right)$ is the weight of enter/exit gates group at the s_{ij} station(%); $GU^{in/out}\left(s_{ij}\right)$ is the enter/exit ticket gates group load degree of the s_{ij} station during the period of $\left(t, t+\Delta t\right)$ (%); $c_x^{in/out}\left(s_{ij}\right)$ is the volume of passenger flow getting in/out of the xth ticket gates group at the s_{ij} station during the period of $\left(t, t+\Delta t\right)$ (persons); xth is the order number of the ticket gates group, $x = 1 \cdots m$.

III. IMPROVED ALGORITHM

A. The Improved Algorithm of the Ticket Gates' Weight

There are some defects in the calculation method above. When calculates the weight of the enter/exit ticket gates, the author does not think about the average passenger volume of each ticket gate. For example, there are 500 persons getting through a gates group of 5 gates in 15 minutes, while there are 400 persons getting through a gates group of 3 gates in 15 minutes. According to the calculation method in literature [1], the weight of the 5 gates group $= 500/(500+400) = 55.6\%$, while the weight of the 3 gates group is 44.4%. But in fact, the 3 gates group bears a greater load. They should occupy a greater weight when we calculate the enter/exit gates group load degree. So considering the average passenger volume of each gate, we think the weight should be calculated as follows:

$$\lambda_x^{in/out}\left(s_{ij}\right) = \frac{c_x^{in/out}\left(s_{ij}\right) \Big/ afc_x^{in/out}\left(s_{ij}\right)}{c_x^{in}\left(s_{ij}\right) \Big/ afc_x^{in}\left(s_{ij}\right) + c_x^{out}\left(s_{ij}\right) \Big/ afc_x^{out}\left(s_{ij}\right)} \tag{6}$$

where: $\lambda_x^{in/out}\left(s_{ij}\right)$ is the weight of the enter/exit gates of the x th ticket gates group at the s_{ij} station(%)[7]; $c_x^{in/out}\left(s_{ij}\right)$ is the volume of passenger flow getting in/out of the xth ticket gates group at the s_{ij} station during the period of $\left(t, t+\Delta t\right)$ (persons); $afc_x^{in/out}\left(s_{ij}\right)$ is the enter/exit gates number of the xth ticket gates group at the s_{ij} station(unit); x is the order number of the ticket gates group, $x = 1 \cdots m$.

We can obtain the weight of the gates group by new algorithm with the data above: the weight of the 5 gates is $(500/5)/(500/5+400/3) = 42.9\%$, and the weight of the 3 gates is 57.1%. So this weight is more realistic.

B. The Calculation Method of the Unbalance Coefficient

Under normal circumstances, there are several ticket gates groups. And a gates group may correspond to one or more entrances. When planning the subway station, the planners maybe don't fully consider the land use function of the entrances. So it may result the unbalance use of the ticket gates. There is big volume of the passenger flow at some entrance during the peak in the entrances of commercial district, residential areas and transportation hub. However, there is smaller volume of the passenger flow at some entrance during the peak in the entrances of industrial area and administrative area. If use the method in literature [1], we will average the big load degree of ticket gates which have a heavy load. And the final load degree of the station ticket gates does not reflect the real situation.

We investigate a station. There are 4 gates groups at a station, and the sequence number is 1,2,3,4. The survey data is as shown in the Table I. The station load degree is 65.43% using the method in literature [1]. But the NO.1 group's load degree is 110%. It is in overload operation. But the final load degree of the station does not reflect this problem.

In order to solve this problem, we should consider the unbalance of the ticket gates group when calculate the load degree of the station ticket gates. So the author adds an unbalance coefficient.

TABLE I. THE RESULT OF LOAD DEGREE BY THE METHOD IN LITERATURE [1]

x	afc_e	Δt	The enter ticket gates						The exit ticket gates						GU
			c_x^{in}	afc_x^{in}	gu_x^{in}	λ_x^{in}	GU^{in}	k^{in}	c_x^{out}	afc_x^{out}	gu_x^{out}	λ_x^{out}	GU^{out}	k^{out}	
1	35	15	2891	5	110.0	53.4	85.0	56.1	1834	6	58.0	43.4	40.4	43.9	65.43
2	35	15	1900	5	72.0	35.1			1157	6	37.0	27.4			
3	35	15	301	7	8.0	5.6			894	8	21.0	21.1			
4	35	15	321	7	9.0	5.9			343	8	8.0	8.1			

In this paper, the definition of the unbalance coefficient is the ratio of the load degree of one gates group in one direction and the average load degree of all the gates groups in this direction. The equation is as follows:

$$\theta_x^{in/out}\left(s_{ij}\right)=\frac{gu_x^{in/out}\left(s_{ij}\right)}{\sum_{x=1}^{m} gu_x^{in/out}\left(s_{ij}\right)\Big/ m} \tag{7}$$

where: $\theta_x^{in/out}\left(s_{ij}\right)$ is the unbalance coefficient of the enter/exit gates group of the x th ticket gates group at the s_{ij} station(%); $gu_x^{in/out}\left(s_{ij}\right)$ is the load degree of the enter/exit gates of the x th ticket gates group at the s_{ij} station(%); x th is the order number of the ticket gates group, $x=1\cdots m$.

C. The Station Gates Saturated Improved Algorithm

We can get the new algorithm by improving the calculation method of the ticket gates group. And the equation is as follows:

$$GU^{in/out}\left(s_{ij}\right)=\sum_{x=1}^{m}\lambda_x^{in/out}\left(s_{ij}\right)\theta_x^{in/out}\left(s_{ij}\right)gu_x^{in/out}\left(s_{ij}\right) \tag{8}$$

where: $GU^{in/out}\left(s_{ij}\right)$ is the enter/exit ticket gates group load degree of the s_{ij} station during the period of $\left(t,t+\Delta t\right)$ (%); $\lambda_x^{in/out}\left(s_{ij}\right)$ is the weight of the enter/exit gates of the x th ticket gates group at the s_{ij} station(%); $\theta_x^{in/out}\left(s_{ij}\right)$ is the unbalance coefficient of the enter/exit gates group of the x th ticket gates group at the s_{ij} station(%); $gu_x^{in/out}\left(s_{ij}\right)$ is the load degree of the enter/exit gates of the x th ticket gates group at the s_{ij} station(%).

And the calculation method of the final station load degree is the same as equation (4) and (5).

IV. EXAMPLE

Based on the survey data, we can calculate the load degree of the station we investigated by the improved algorithm. And the result is as shown in the Table II.

TABLE II. THE RESULT OF LOAD DEGREE BY THE IMPROVED ALGORITHM

x	afc_e	Δt	The enter ticket gates					The exit ticket gates					GU
			c_x^{in}	afc_x^{in}	gu_x^{in}	λ_x^{in}	θ_x^{in}	c_x^{out}	afc_x^{out}	gu_x^{out}	λ_x^{out}	θ_x^{out}	
1	35	15	2891	5	110.0	53.41	2.21	1834	6	58.0	43.38	1.87	120.88
2	35	15	1900	5	72.0	35.10	1.45	1157	6	37.0	27.37	1.19	
3	35	15	301	7	8.0	5.56	0.16	894	8	21.0	21.14	0.68	
4	35	15	321	7	9.0	5.93	0.18	343	8	8.0	8.11	0.26	
$GU^{in/out}$			166.65					62.28					
$k^{in/out}$			56.15					43.85					

From the Table II, we can know that the final station load degree is 120.88%. This result is more reasonable than the one which is calculated by the method in literature [1].

V. CONCLUSION

Through the study of this paper, we can get the conclusion as follows:

A. Improved the Calculation Method of the Weight

We improve the calculation method of the weight of the enter/exit ticket gates group. When calculate the weight of the enter/exit gates group, we use the average passenger volume of each gate instead of the total passenger getting through the gates. And the result shows that the improved algorithm is more scientific.

B. Added the Unbalance Coefficient

When calculate the load degree of the enter/exit gates group, we add the unbalance coefficient to expand the affect of the big load degree. And the result is more reasonable than the algorithm in literature [1]

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