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The Impact of Short Routing on the Line Capacity of Urban Rail Transit

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Keywords: Short routing firstly, the findings were as follows.

Abstract. This paper established the composition of minimum interval of single crossover reentry station and double turn-back line station in different proportion of trains on long routing and short routing firstly. Moreover, the paper examined various factors which influence line capacity using quantitative analysis. The findings were as follows: When the dwell time decreased, the line capacity of short routing improved by 1.2 pairs/h and 1.8 pairs/h respectively. Technical operation time being compressed by 5 seconds, the line capacity increased by 1.2 pairs/h and 1.6 pairs/h. As for double turn-back line station, when the proportion of trains were 1:1, 2:1 and 1:2 respectively, the line capacity improved by 1 pair/h, 0.7 pair/h and 1.2 pairs/h with the turnout switching from No.9 to No.12.

1. Introduction

We can use multi-routing to improve the trains' full-load ratio in the section that the transportation demand is relatively small, making the trains turnover more rapid, reducing the number of launch vehicle, saving the operating costs, making full use of transport resources [1], which is the research practical significance of multi-routing study. Domestic and foreign multi-routing study mainly included from calculation method [2-3], the capacity loss calculation method [4], the alternative routing selection [5] and the station and the platform line layout, but the impact of short routing on line capacity of capacity tension section is not fully studied, and this is what this essay wants to focus on.

2. The Calculation Method of Line Capacity in Short Routing

Two intermediate reentry stations A and B with different layout are given. The operation processes of trains at two stations are analyzed when the proportion of trains on long routing and short routing is 1:1, 2:1 and 1:2 respectively, so as to get the minimum interval time of trains and the line capacity.

2.1 Reentry Model in Front of the Station

Station A is the turning station of the short routing. The layout of the single crossing line is adopted. The platform length (EC and FD) is 158m, and Point C and D are the

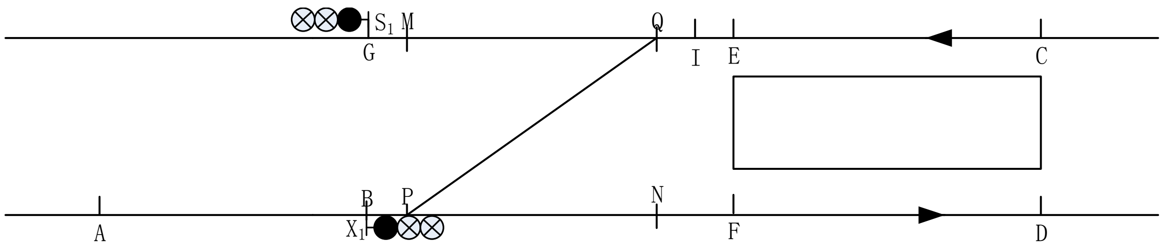

Figure 1. The layout of Station A

Stop position. The width of the platform is 11m and the line spacing is 14m. The station takes No. 12 turnout for vehicle reentry. The layout of Station A is shown in Figure 1.

Taking the train proportion on long routing and short routing of 1:1 for granted, the trains' operation process at Station A is as followed: Considering the critical situation, when the short routing train 1101 just leaves the cut-off point of the track circuit (Point G), reentrant train is 1102, and the down long shorting train just arrives at Point A and it can pull in directly. At the same time, the up long shorting train 1104 also reaches the station. When 1103 just clears the track circuit of the station, train 1104 also comes out at the same time. At this time, the short routing train 1105 reaches the location of the arrival. After reentry, it is recorded as 1106 of the train trips.

Changing the proportion of trains on long routing and short routing, we can see that in reentry model in front of the station, when the proportion of trains on long routing and short routing is x:y(x:y=1:1 or 2:1 or 1:2), the expression of the minimum interval time of the trains on short routing section is as follows:

$$I_{x:y}=t_1+t_2+t_3+t_4+\frac{x\cdot t_5+y\cdot t_6}{x+y} \quad (1)$$

The line capacity of small shorting is:

$$n_{x:y}=3600/I_{x:y} \quad (2)$$

In the formula, t_1 indicates the time of the train going out of the station straightly; t_2 indicates the time of departure processing; t_3 indicates the reaction time; t_4 indicates the station dwell time, t_5 indicates the time for the train to go straight to the station, t_6 indicates the time of the train's lateral entry.

2.2 Reentry Model after the Station

Station B is the reentry station of the short routing, with the layout of the double reentry line after the station. The width and the length of the platform is 14m and 144m respectively and the line spacing is 17m. The train returns on the reentry line I in this station, and the effective length (EF) of the reentry line is 155m [9]. The station layout of Station B is shown in Figure 2.

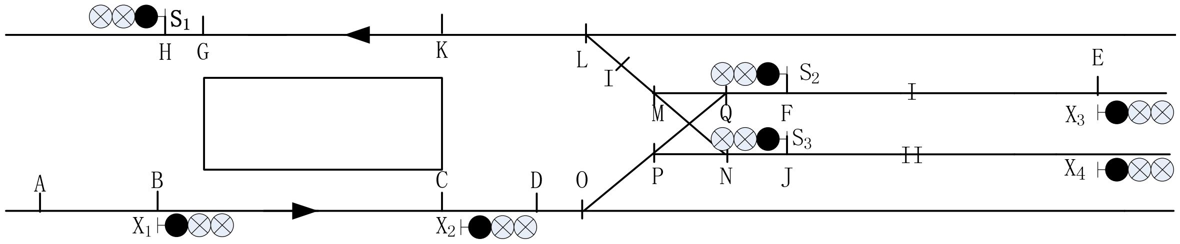

Figure 2. The layout of Station B

Changing the proportion of trains on long routing and short routing, we can see that in reentry model after the station, the expression of the minimum interval time of the trains on short routing section is as follows:

$$I'_{x:y}=t_2+t_3+t_4+t_6+\frac{x\cdot t_7+y\cdot t_8}{x+y} \quad (3)$$

The line capacity of small shorting is:

$$n'_{x:y}=3600/I'_{x:y} \quad (4)$$

In the formula, t_6 indicates the time for the train to go to the station; t_7 indicates the time of the train going out of the station; t_8 indicates the time for the train from Point C to Point F.

3. Quantitative Analysis of the Impact of Short Routing on Line Capacity

Based on Station A and B with different reentry modes, this paper selects three factors, such as the dwell time, the type of turnouts and the time of technical operation. Dwell time is set as 30s. The reaction time is set as 3s. The operation time is set as 13s. According to the formula given in this paper, the value of train interval time and line capacity can be obtained by MATLAB programming.

3.1 The Impact of Dwell Time on Line Capacity

Dwell time is an important part of the interval time of the train. The dwell time of this paper is analyzed with 20s, 25s, 30s, 40s and 50s respectively and the other parameters remain unchanged. The results are shown in Table 1.

Table 1. Calculation results of minimum interval time and line capacity of trains under different dwell time

Intermediate reentry station(Reentry mode)	Train interval time and line capacity	The proportion of trains on long routing and short routing	Dwell time(s)				
			50	40	30	25	20
Station A(single crossover reentry station)	Train interval time(s)	1:1	146.0	136.0	126.0	121.0	116.0
		2:1	144.7	134.7	124.7	119.7	114.7
		1:2	147.4	137.4	127.4	122.4	117.4
	Line capacity(pairs/h)	1:1	24.7	26.5	28.6	29.7	31.0
		2:1	24.9	26.7	28.9	30.1	31.4
		1:2	24.4	26.2	28.3	29.4	30.7
Station B(double turn-back line station)	Train interval time(s)	1:1	125.4	115.4	105.4	100.4	95.4
		2:1	122.8	112.8	102.8	97.8	92.8
		1:2	128.0	118.0	108.0	103.0	98.4
	Line capacity(pairs/h)	1:1	28.7	31.2	34.2	35.9	37.7
		2:1	29.3	31.9	35.0	36.8	38.8
		1:2	28.1	30.5	33.3	35	36.6

It can be seen from Table I that if the intermediate station adopts single crossover layout, line capacity of short routing section increases with the station dwell time decreasing. From the point of view of degree of change, with the dwell time of each compression 5 seconds, the line capacity increases by 1.2 pairs/h. If the intermediate station adopts double turn-back line layout, with the dwell time of each compression 5 seconds, the line capacity increases by 1.8 pairs/h.

3.2 The Impact of Turnout Type on Line Capacity

Turnouts will affect the capacity of intermediate reentry stations. When the station's turnout switches No. 9 to No.12 and the other parameters remain unchanged, the calculation results are shown in Table 2.

It can be seen from Table II that if the intermediate station adopts single crossover layout, with the turnout switching from No.9 to No.12, when the proportion of trains on long routing and short routing is 1:1, the line capacity only increases by 0.2 pair/h; when the proportion of trains is 1:2, the line capacity increased by 0.6 pairs /h. When the intermediate station adopts double reentrant line layout, with the turnout switching from No.9 to No.12, the line capacity increased by 1 pair /h, 0.7 pair/h and 1.2 pairs/h respectively with the proportion of trains 1:1,2:1 and 1:2.

3.3 The Impact of Technical Operation Time on Line Capacity

The technical operation time of this paper is analyzed with 20s, 25s, 30s, 40s and 50s respectively and the other parameters remain unchanged. The results are shown in Table 3.

It can be seen from Table 3 that if the intermediate station adopts single crossover layout, with technical operation time of each compression 5 seconds, the line capacity increases by 1.2 pairs/h. If the intermediate station adopts double turn-back line layout, with the technical operation time of each compression 5 seconds, the line capacity increases by 1.6 pairs/h.

Table 2. Calculation results of minimum interval time and line capacity of trains under different turnout type

Intermediate reentry station(Reentry mode)	Train interval time and line capacity	The proportion of trains on long routing and short routing	Turnout type	
			No.9	No.12
Station A(single crossover reentry station)	Train interval time(s)	1:1	126.9	126.0
		2:1	123.7	124.7
		1:2	130.1	127.4
	Line capacity(pairs/h)	1:1	28.4	28.6
		2:1	29.1	28.9
		1:2	27.7	28.3
Station B(double turn-back line station)	Train interval time(s)	1:1	105.4	102.5
		2:1	102.8	100.8
		1:2	108.0	104.1
	Line capacity(pairs/h)	1:1	34.1	35.1
		2:1	35.0	35.7
		1:2	33.3	34.6

Table 3. Calculation results of minimum interval time and line capacity of trains under different technical operation time

Intermediate reentry station(Reentry mode)	Train interval time and line capacity	The proportion of trains on long routing and short routing	technical operation time (s)				
			26	21	16	11	6
Station A(single crossover reentry station)	Train interval time(s)	1:1	136.0	131.0	126.0	121.0	116.0
		2:1	134.7	129.7	124.7	119.7	114.7
		1:2	137.4	132.4	127.4	122.4	117.4
	Line capacity(pairs/h)	1:1	26.5	27.5	28.6	29.7	31.0
		2:1	26.7	27.8	28.9	30.1	31.4
		1:2	26.2	27.2	28.3	29.4	30.7
Station B(double turn-back line station)	Train interval time(s)	1:1	115.4	110.4	105.4	100.4	95.4
		2:1	112.8	107.8	102.8	97.8	92.8
		1:2	118.1	113.0	108.0	103.0	98.4
	Line capacity(pairs/h)	1:1	31.2	32.6	34.2	35.9	37.8
		2:1	31.9	33.4	35.0	36.8	38.8
		1:2	30.5	31.9	33.3	35.0	36.6

4. Conclusion

In this paper, the influence degree of each factor on the capacity of short shorting is analyzed. The main conclusions are as follows: When the dwell time decreases, the line capacity of short routing improves by 1.2 pairs/h and 1.8 pairs/h respectively. With technical operation time of each compression 5 seconds, the line capacity increases by 1.2 pairs/h and 1.6 pairs/h. For double turn-back line station, when the proportion of trains is 1:1, 2:1 and 1:2 respectively, the line capacity improves by 1 pair/h, 0.7 pair/h and 1.2 pairs/h with the turnout switching from No.9 to No.12.

In this paper, the dynamic simulation of train operation is not based on basic vehicle data, combined with interval lines, stations, signal control and so on, which will be the focus of next research.

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