Subway Station's Outburst Passenger Flow Organization after Large-scale Activity Based on Calculation and Simulation

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Abstract—After large-scale activity, the outburst passenger flow probably causes serious impact on stations surrounding the activity venue, at this time, stations should take corresponding organization measures to guarantee efficient and smooth running. This paper put forward the organization process of subway station's outburst passenger flow after large-scale activity according to the factors and methods of the organization. Then, this paper took Beijing Football League held in Beijing Workers' Stadium for an example and provided some suggestions for organization of Dongsishitiao station's outburst passenger flow according to the process based on calculation and simulation using historical AFC data. This paper aimed to provide a theoretical reference for future organization of stations after large-scale activity.

Keywords-large-scale activity;subway station;outburst passenger flow;organization; simulation.

I. INTRODUCTION

Large-scale activity is the activity which can cause a lot of traffic demand and have to develop a detailed traffic organization and management planning. After large-scale activity, the outburst passenger flow's summit period and start location is very concentrated, which can have a serious impact on start station. So, after an activity, the station should take corresponding organization measures quickly and efficiently to meet the needs of passengers travel demand and guarantee the efficient and smooth running of urban rail transit system. References [1, 2] studied some organization methods and models of road traffic under the condition of large-scale activity. References [3, 4, 5] studied subway station's outburst passenger flow organization of all events which initiate large passenger flow including large-scale activity. So, there are few special researches on subway station's outburst passenger flow organization after large-scale activity. And in this paper, organization methods and process specifically for subway station's outburst passenger flow after large-scale activity will be given based on calculation and simulation.

II. THE FACTORS OF THE ORGANIZATION

Station's outburst passenger flow organization after large-scale activity is mainly influenced by the characteristics of outburst passenger flow into the station and the station's evacuation capability which can be analyzed based on historical information and data of the activity and station. The characteristics include the distribution regulation with time, the continuing time, the maximum and its arriving time which can be analyzed based on the station's historical AFC data after the activity. Station's evacuation capability is divided into path capacity and space capacity. According to references [6,7], this paper selected path and space capacity limit as shown in Table 1 and Table 2 based on service level of station's facilities and areas. If passenger flow is above path capacity limit, there will be some flow bottlenecks at path facilities, and it proves that passenger flow is large but under the safe level. But if passenger density is above space capacity limit, it proves that passenger flow is so large that it is above the safe level.

TABLE I. STATION'S PATH CAPACITY LIMIT

Facilities	entrance path	automatic fare gate	stairs	escalator
Path capacity limit (per meter per minute)	50	17	32	71

TABLE II. STATION'S SPACE CAPACITY LIMIT

Area	station platform	station hall	train
Space capacity limit (per square meter)	passenger density		stranded passenger density
	2	2	2

III. THE METHODS OF THE ORGANIZATION

A. *Increase Station's Path Capacity*

If there are some flow bottlenecks at path facilities but the passenger flow is under the safe level, we should increase station's path capacity. This includes following aspects:

- Increase entrance path capacity by closing its exit function;
- Increase stairs or escalator path capacity by staff guiding or only letting passenger into the station;
- Increase automatic fare gate path capacity by increasing its into-station ones' opening number.

B. *Decrease Station's Passenger Density*

If the passenger flow is above the safe level, we should decrease station's passenger density to make the passenger flow down into the space capacity range. This method consists of three levels:

- The first level is decreasing station platform's passenger density by setting isolation fences or warning ribbons at the path or stairs (escalator) between the station platform and hall or changing the running direction of escalator to limit passengers into the platform.
- The second level is decreasing passenger density of station hall's paid area by properly decreasing the opening number of into-station automatic fare gates to limit passengers into the area.
- The third level is decreasing passenger density of station hall's non-paid area by setting curved isolation railings at the entrance or shutting down part of entrances to limit passengers into the area.

According to the space capacity limit in Table 2, this paper regarded passenger density exceeding 2 per square meter in corresponding area as the start condition of each level. And at the same time, if stranded passenger density on the platform is above the limit in Table 2, we should increase the train capacity by staff guiding or shortening the interval between trains.

IV. THE PROCESS OF THE ORGANIZATION

According to the factors and methods of station's outburst passenger flow organization after large-scale activity, this paper put forward the organization process as shown in Fig .1.

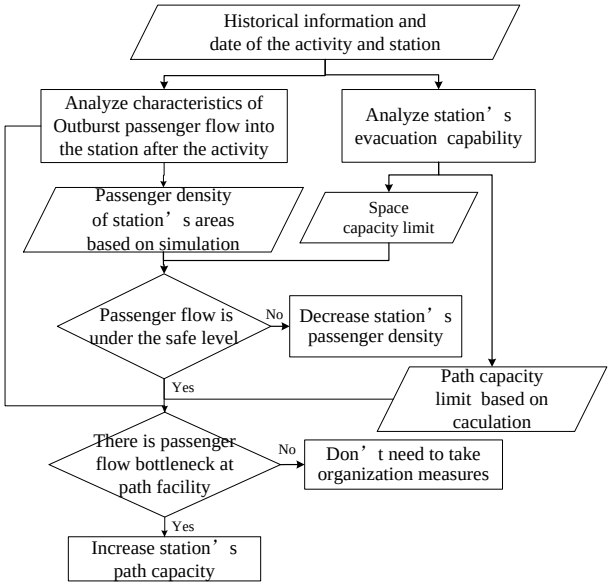

Figure 1. Organization process of station's outburst passenger flow after large-scale activity

This paper use SRAIL simulation system for the simulation. The system consider passengers' micro behavior and the interactive relationship between passengers, facilities and surrounding environment, and it can realize passengers' accumulation and dissipation in subway station conveniently.

An example will be listed in next section which can well descript the organization process.

V. THE EXAMPLE ANALYSIS

This paper takes the 2013 year's Beijing Football League (according with the study object of this paper) held in Beijing Workers' Stadium for an example, and studies the outburst passenger flow organization of Dongsishitiao station beside the stadium.

A. *Characteristics of Outburst Passenger Flow Analysis*

The football league usually ended at about 21:00. Fig .2 shows the contrast between passenger flow (per minute) into the station of three activity days and general days at 21:00-23:00 according to Dongsishitiao station's historical AFC data processing.

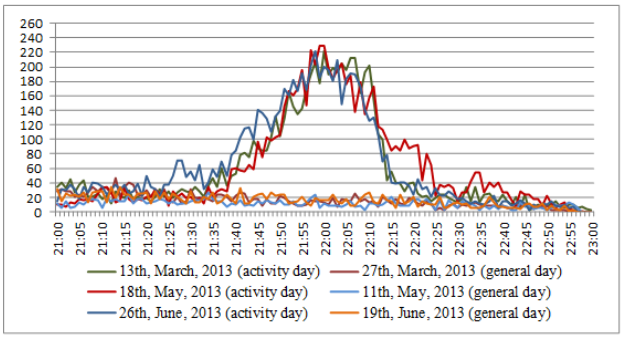

Figure 2. Organization process of station's outburst passenger flow after large-scale activity

Compared to general days' passenger flow, activity days' one has an obvious summit. Three activity days' passenger flow shows similar distribution with time, and outburst passenger flow is continuing between about 21:40—22:20, and reaches a maximum about 220 per minute at about 22:00. Because of the relatively stable audience origin and similar distribution regulation of the activity outburst passenger flow, this paper selected the average of the three activity days' historical data as the following calculation and simulation study object.

B. Station's Evacuation Capability Analysis

Dongsishitiao station is an intermediate station located on the subway line 2. Fig .3 shows the arrangement condition of the station drawn by SRAIL (map file).

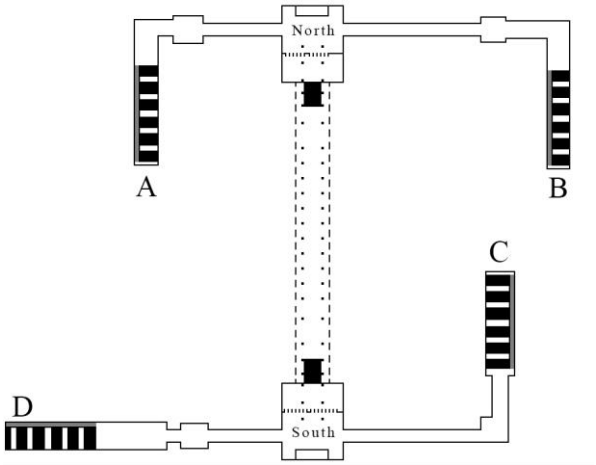

Figure 3. Organization process of station's outburst passenger flow after large-scale activity

According to on-spot investigation during the period after the activity, we know some information about the station:

- There are A,B,C,D four entrances in the station, and B,C entrances are closed to the stadium, so, there is larger passenger flow into the station via B,C entrances with about 42%, 54% than via A,D entrances with both about 2%.
- There are one stairs (called Stairs. 1 in the following) used for getting into the station and one escalator using for getting out of the station in each entrance path.
- The station halls include north hall and south hall which are connected with the station platform by stairs (called Stairs. 2 in the following) used for both getting into and out of the station.
- There are 10 automatic fare gates in the north hall (5 into and 5 out of the station) and 13 in the south hall (6 into and 7 out of the station).
- The station platform is an island one which can let trains arrive to the station in both up and down directions.
- Table 3 shows the path facilities' width; Table 4 shows the path capacity limit of the station provided by Table 1, Table 3 and some calculation.

TABLE III. PATH FACILITIES' WIDTH OF DONGSISHITIAO STATION

Facilities	entrance path	Stairs. 1	Stairs. 2	AFC facility
Width (m)	4.5	6	6	1

TABLE IV. PATH CAPACITY LIMIT OF DONGSISHITIAO STATION

Facilities	entrance path	stairs		AFC facility	
		Stairs. 1	Stairs. 2	north hall	south hall
Path capacity limit (per minute)	225	192	192	85	102

C. Passenger Density of Station's Areas Based on Simulation

According to the continuing time of the outburst passenger flow, the simulation time is set to 21:30 - 22:30. The specific simulation process is as follows: above all, prepare relevant documents including generation rules of passenger flow, timetable of trains, map file and path file to input the simulation system; then, set relevant simulation parameters and start the simulation; finally, after the simulation, output the passengers' density of station platform and hall. Fig .4 and Fig .5 respectively show the simulation interface before and after the train arriving at about 22:07 (red dots represents into-station passengers and yellow dots represents out-of-station ones). Fig .6 and Fig .7 show the change of the density (per square meter) with time after processing.

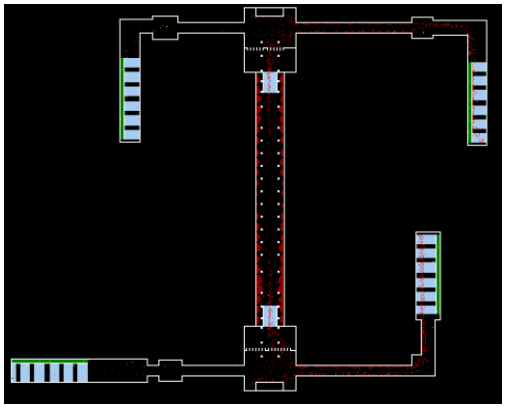

Figure 4. Simulation interface before the train arriving

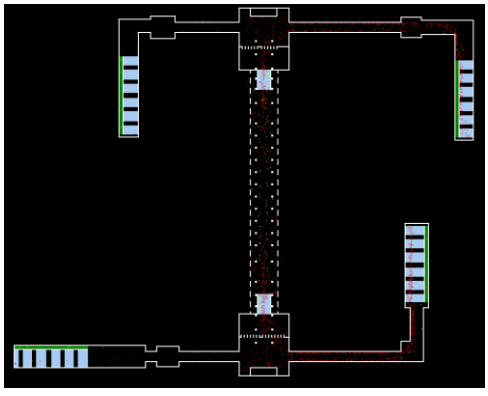

Figure 5. Simulation interface after the train arriving

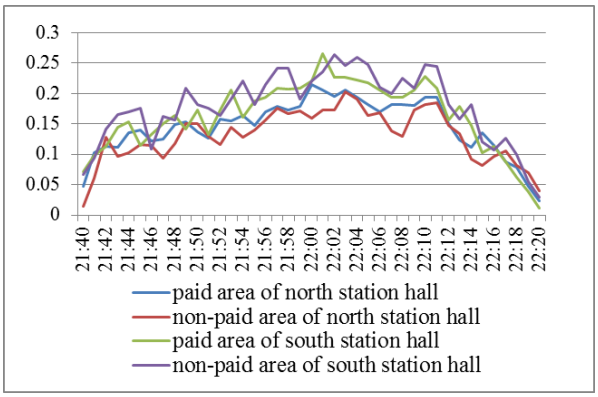

Figure 6. Passenger density of station hall

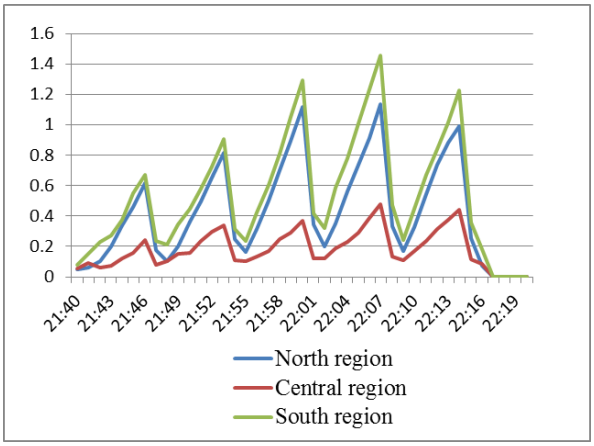

Figure 7. Passenger density of station platform

D. *Organization Measures Analysis*

According to the analysis, calculation and simulation above, we can draw some conclusions below:

- The passenger density of all areas is less than 2 per square meter, so, the station's space capacity can satisfy passenger flow demand and the passenger flow is under the safe level.
- The passengers' density of station platform presents obvious periodicity change with the trains' arriving, but the density distribution is not balanced.
- The stranded passengers' density of station platform at the end of each cycle maintains at about 0.2 per square meter, which proves that the train space capacity can satisfy passenger flow demand.
- Compare Table 4 and the maximum about 220 per minute of the outburst passenger flow and the percent of each entrance, we can conclude that the into-station automatic fare gates are station's passenger flow bottleneck.

Therefore, we should take some corresponding organization measures:

- Respectively increase the number of into-station automatic fare gates in north and south station hall to 8 and 10 according to the rate of the passenger flow into and out of station. By this way, passengers can arrive to the platform more quickly to accelerate evacuation and promote the utilization rate of the arriving train space capacity.
- Arrange staff to guide passengers out of the station via A and D entrance but not via B and C entrance. It can decrease cross interference of passenger flow at B and C entrance by this way.
- Arrange staff to guide passengers to the central region of platform to wait the train. It can balance the passengers' distribution on the platform.

VI. CONCLUSIONS

This paper put forward the organization process of subway station's outburst passenger flow after large-scale activity and studied organization measures for Dongsishitiao station after Beijing Football League according to the process. We can see that the key of the organization is judging whether the condition of station's existing facilities and organization can satisfy the outburst passenger flow's demand. In the future, we will further study the evaluation method of the organization and improve our organization system.

ACKNOWLEDGMENT

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