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Safety Risk Analysis and Countermeasures Study on Regular Mass Passenger Flow of China's Urban Subway

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Abstract

In view of the normalization and complicate trends and current situations of China's mass urban passengers, this article determines the definition of "mass passenger flow" and its judgment standards, analyzes causes for mass passenger flow and safety problems it brings about, and concludes with suggestions on prevention and response measures on mass passenger flow phenomenon.

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Keywords: mass passenger flow; subway;safety risk analysis; countermeasure suggestions

1. Definition of Mass Passenger Flow and Current Situations

The so-called mass passenger flow refers to the case that during a certain operation period, the number of passengers waiting and staying at a rail transit station reaches the maximum passenger capacity, or the actual passenger capacity of trains exceeds the original design, and the passenger number continues to increase. According to the predictability, mass passenger flow can be divided into predictable mass passenger flow and sudden mass passenger flow. And according to its causes and characteristics, predictable mass passenger flow can be divided into workday mass passenger flow, holiday mass passenger flow, event mass passenger flow and bad weather mass passenger flow.

Currently, mass passenger flow phenomena at different degrees appear in Beijing, Shanghai, Guangzhou, Shenzhen and other big cities with large-scale rail transit network, and those phenomena tend to be regular and complicated. As for Shanghai, workday passenger flow of over 9.5 million passengers and over 10 million weekday passengers will become the new normal state. And the average daily passenger traffic intensity per kilometer of Guangzhou has reached 24,600 passengers/kilometer-day as the top in China, exceeding 19,700 passengers/kilometer-day of Beijing and 14,400 passengers/kilometer-day of Shanghai [1]. The rail transit capacity of Beijing and Shanghai has accounted for about 50% of the transport capacity of the whole city, close to transport capacity limit.

Aiming at mass passenger flow, subway operation units carry out flow-limiting and dispersion measures at platforms, halls and doorways. Beijing currently has 63 stations with regular flow-limiting measures, Shanghai has 34, and all transfer stations in Guangzhou carry out regular flow-limiting measures; all these have brought great challenges to the public safety of subway.

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2. Judgment Standards on Mass Passenger Flow

Currently, judgment standards on mass passenger flow of different cities are more or less alike. Take Beijing as an example. Its judgment standards are as follows:

(1) Centralized passenger flow reaches 70% capacity of doorway;

(2) Walking speed in passageways is below 0.75 meter/second and subsequent passenger flow continues enter passageways;

(3) More than 5 people in line waiting at ticket gates, and passenger flow continues to increase;

(4) After 2 subway trains in the same direction, 1/4 passengers remain on the island platform, 1/3 remain on the side platform;

(5) Segments with over 100% section load factor for trains departing;

(6) Segments with over 100% section load factor for trains departing of transfer lines.

3. Causes for Mass Passenger Flow

3.1. The deviation of predicted passenger flow results in transport capacity shortage

The predicted passenger flow is the most important basis for the design, construction and operation of subway lines. Currently, according to investigation and survey, the large error of this value is an important reason resulting in mass subway passenger flow. Take Beijing Subway Line 4 opened in 2009 for example. Its predicted average daily passenger volume in initial stage is 781,200 passengers; the predicted value for short-term passenger volume is 903,600, and long-term 1,090,800. As of this year, however, the actual daily passenger of this year reaches 1,132,000, exceeding the long-term forecast. Due to insufficient prediction, Shanghai Subway Line 6 and 8 adopted the C-train, causing transport capacity shortage and crowded passenger flow right after its opening. And Line 16 opened at the end of 2013 didn't learn a lesson from these two lines but adopted trains with 3 carriages. After its opening, almost all stations along the line need flow-limiting measures.

3.2. Planning changes bring passenger flow explosion around subway

At present, subway is an important driving force in the process of urban construction, playing a crucial role in population dispersion of city center and industrial transfer. In most cases, the development of a city goes together with its subway lines. Driven by economic interests, changes in urban planning become possible. In general, it takes at least 5 to 6 years from the planning to the completion of a subway line. Subway passenger flow is forecasted based on the overall urban planning and regulatory plan at the moment of planning. But after the subway construction plan is approved, driven by economic interests and the needs for urban development, large-scale residential districts, large business districts and other crowded areas which didn't exist in original overall planning will be constructed around subway stations, causing passenger flow explosion after the subway opens and increasing the subway operation risks.

3.3. Severe "tidal phenomenon" leads to concentrated passenger flows

Rail traffic network is featured with relatively concentrated morning and evening peak passenger flows. According to statistics, the daily morning and evening peaks (7:00-9:00, 17:00-19:00) account for approximately 30%-40% of total passenger flow, and this phenomenon is especially severe for suburban lines. As result, subway passenger flows are highly concentrated in short time and evacuation is extremely difficult.

3.4. Extreme passenger peak during important events triggers mass passenger flow

During various large-scale sports and cultural events, subway stations around venues play a major role in passenger transport. Especially after the end of the event, relevant stations will receive a wave of extreme passenger peak in a short time. Besides, the subway operation interval is longer than morning and evening peak hours, so it is more likely to trigger mass passenger flow.