

Fire Analysis for the Large Public Area at Zhongshan Square Station on Line 3 in Shijiazhuang City

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ABSTRACT

Zhongshan Square Station is a transfer station with an extremely large public area in the concourse level. Therefore, to ensure that the division of fire compartments for the platform and public concourse areas meets the overall fire safety requirements of the building, this project adopts methods such as optimization and redivision of fire compartments and verification of personnel evacuation scenarios to meet fire safety needs and proposes suggestions for reference in subsequent projects.

KEYWORDS

Fire Protection; Super Large Public Area; Fire Compartmentation; Safe Evacuation

1 Introduction

Zhongshan Square Station is a transfer station for Shijiazhuang Metro Line 1 and Line 3, located at the intersection of Zhonghua Street and Zhongshan Road. The Line 1 Zhongshan Square Station is set along the direction of Zhongshan Road, while the Line 3 station is set along the direction of Zhonghua Street. Single crossover lines are provided after both Line 1 and Line 3 stations, and connection lines are set up between Line 1 and Line 3 here.

Two-line stations are considered to be constructed simultaneously. The Zhongshan Square Station of Line 1 is an underground two-story island platform station, with the total length of the structural outer wall being 280.38m and the standard width being 23.1m. The Zhongshan Square Station of Line 3 is an underground three-story island platform station, with the total length of the structural outer wall (including part of the single crossover line) being 261.59m and the standard width being 23.5m. Line 3 is set below Line 1. The underground first floor serves as the concourse level for both Line 1 and Line 3, the underground second floor serves as the platform level for Line 1 and the equipment level for Line 3, and the underground third floor serves as the platform level for Line 3. A transfer staircase is provided between the two platform levels to connect them, forming an island-island "T" shaped transfer.

Fire compartments are divided according to the nature of station use and area size. The public areas of platforms and concourses for Lines 1 and 3 are divided into one fire compartment; equipment management rooms are divided into fire compartments with an area less than 1500m², separated into no-passenger area and passenger area. This station is divided into twenty fire compartments.

The public areas of platforms and concourses for Lines 1 and 3 are divided into one fire compartment, with five direct ground-level exits; the equipment management rooms at both ends of the platform level public areas for Lines 1 and 3 are each divided into one fire compartment, and the fire compartments where the number of people frequently staying is less than three people.

The equipment rooms at the large mileage end of Line 3 in the underground first floor are divided into two fire compartments, which are unattended areas with an area of 231 m² and 1473 m² respectively. The equipment rooms at the large mileage end of Line 1 are also divided into two fire compartments, with the fire compartment closer to the public area having an area of 1490 m², where a fire lane directly connects to the ground; the fire compartment farther from the public area has an area of 1488 m², which is an unattended area. The equipment management rooms at the small mileage end of Line 1 are divided into three fire compartments, with the one closer to the public area having an area of 606 m², which is an attended area, and this area has a fire lane directly connecting to the ground; the remaining two fire compartments have areas of 682 m² and 1234 m² respectively, which are unattended areas.

The underground level two area for the equipment rooms of Line 3 is divided into seven fire compartments, each with an area not exceeding 1500 m², and all belong to unattended areas.

The backup space is divided into six fire compartments, each with an area not exceeding 2000 m². Each fire compartment is equipped with an exit directly to the ground. Fire compartments two, three, four, and five use sunken plazas for evacuation.

The firewalls between fire compartments are separated by masonry walls with a fire resistance rating of no less than 3 hours. The doors on the firewalls are Class A fire doors, and the windows are Class A fire windows (using Type C Class A fire-resistant glass). The doors on the firewall between the ducts and other fire compartments are Class A airtight fire doors.

Analysis of Fire Safety Issues in Super Large Public Areas The provisions of Article 28.2.2 of the 《Metro Design Coden》 (GB50157-2013) stipulate that the division of fire compartments shall comply with the following regulations

The platform and public area of the concourse in underground stations should be divided into one fire compartment, and the maximum allowable floor area for each fire compartment in the equipment and management rooms should not exceed 1500 m².

When the underground transfer station shares a concourse, the area of the public concourse zone should not exceed 5000 m².

The above regulations pointed out the subway underground platform and station hall are divided into a fire protection zone.《Design Code for Subway》stipulate,when underground transfer stations share a concourse, the concourse public area should not exceed 5000 m².

This project is a transfer station, with the hall public area covering 9640 m². Therefore, whether the division of fire compartments for the platform and hall public areas in this project can meet the overall building requirements. The requirements for fire safety need to be justified to confirm whether its fire safety performance can reach the equivalent level specified by the regulations.

2 Preliminary Solutions

The underground transfer hall mainly serves as an evacuation area with minimal fixed fire load. The transfer hall is only used as a transitional evacuation area. Therefore, it is not necessary to divide the fire compartments within the transfer hall. To ensure the above design concept is realized, the following fire protection measures need to be implemented:

This station should be designed for fire protection in accordance with the current national standard 《Technical Specifications for Urban Rail Transif》 (GB50490-2009) and 《Design Code for Subwayn 》(GB50157-2013) t; the reserved commercial areas should be designed according to the 《Fire Protection Code for Building Design》(GB50016-2014).

The office and ancillary equipment rooms within this station, the subway concourse public area, and the platform public areas should be divided into fire compartments according to their different

functions. Among these, the underground level one concourse public area, and the underground levels two and three platform public areas can be considered as one fire compartment.

The public areas of the platform and concourse in this station should not be equipped with any commercial facilities (including incidental commerce).

2.1 Fire compartmentation

The subway station and the adjacent commercial area should be separated into different fire compartments. The station and the commercial area should be divided by firewalls, fire shutters, and Class A fire doors. When using fire shutters, the total length of the fire shutters should not exceed 20m, and the length of a single span of fire shutters should not exceed 10 m.

The underground level one concourse public area, and the underground levels two and three platform public areas are divided into one fire compartment;

The fire compartment area of the Business Development Department does not exceed 2 000 m².

The area of fire compartments in non-public areas is no larger than 1 500 m².

The part connected to the sunken square is separated by fire-resistant walls or fire-resistant glass with a fire resistance limit of no less than 1.0 hour; the passage from the transfer hall to the sunken square on both sides is separated by solid walls or Class A fire-resistant glass with a fire resistance limit of not less than 2 hours.

Platform and concourse interior finishes should use non-combustible materials.

Platforms and public areas of concourses should be equipped with indoor fire hydrants and fire hose reels. In cases where no commercial facilities, newsstands, vending booths, or other small stalls are set up in the platforms and public areas of the concourse, an automatic sprinkler system may not be required.

To promptly and effectively extinguish or control the fire in its early stages, it is recommended to install one wheeled dry powder fire extinguisher at each end of the public area of the subway platform. Fire extinguishers should also be configured at the security check machine location, the concentrated area of automatic ticket vending machines, ticket counters, and other areas in the concourse level of the subway.

The connecting areas between the public zones of Line 1 platform and Line 3 platform transfer passage should be equipped with special-grade fire-resistant rolling shutters to separate the platforms of the two lines. After the fire detectors activate, it is advisable to use a two-step descent control method, and manual raise/lower buttons should be installed inside the passage.

The platform track area and public area should be separated by fire-resistant glass with a fire resistance limit of no less than 1.0 hour for the barrier door system, with the barrier door system height not less than 2.3m. The main frame of screen door system fire partition and automatic sensor door made of special fireproof steel.

Barrier-free elevators should be separated from public areas using fire-resistant partitions with a fire resistance limit of no less than 1.0 hour.

2.2 Smoke Prevention and Exhaust Ventilation

At the open stairwell openings where the underground platform level connects to the concourse level, smoke barriers or curtains should be installed ceiling screen and the smoken screen, the lower edge of the ceiling screen wall is not higher than the suspended ceiling of the platform floor.

A glass balustrade with a height of no less than 1.1m is installed at the upper part of the staircase entrance.

To enhance the smoke-holding capacity of the subway public area during a fire, it is

recommended that the suspended ceiling in the station platform and hall public areas adopt an open-ceiling design, and smoke control zones should preferably be divided with an area not exceeding 2000 m^2 , with the open-ceiling ratio not less than 30%, and smoke barriers should extend to the underside of the structural slab.

The smoke exhaust volume of the public area in the platform and concourse should not be less than $60\text{m}^3/(\text{m}^2 \text{ h})$; the designed smoke exhaust volume of the track top exhaust/smoke exhaust system (UPE) in the platform running area should not be less than $40 \text{ m}^3/\text{s}$, and the designed smoke exhaust volume of the tunnel ventilation/smoke exhaust system (TVF) should not be less than $100\text{m}^3/\text{s}$ (on both sides).

The exhaust/smoke exhaust system ensures that the air velocity from the transfer hall to the public area of the platform is no less than 1.5 m/s.

If a fire occurs in the public area of the platform or concourse level, the ventilation/smoke exhaust system responsible for that levels platform or concourse will operate in smoke exhaust mode and stop supply air. At the same time, the ventilation/smoke exhaust system of the adjacent level concourse or platform will operate in supply air mode and stop exhaust air, preventing smoke from spreading to the adjacent level, which is conducive to passenger evacuation.

When a train parked at the platform catches fire, the smoke should be exhausted using the upper exhaust air ducts of the track, while simultaneously activating the smoke exhaust outlets in the public area of the same level platform to assist in smoke exhaust, channeling the smoke from the track area of the platform to the ground through the ventilation shafts. The ventilation/smoke exhaust system on the concourse level adopts a supply air mode, stopping exhaust, to create a positive pressure downward from the stairs between the concourse and the platform, facilitating passenger evacuation against the new air flow.

Equipment areas and office areas shall be designed for smoke prevention and exhaust according to the code requirement.

3 Safety evacuation plan

For commercial development areas with a construction area greater than 1000 m^2 in fire compartments, there should be no fewer than 2 direct exits to the outside; for fire compartments with a construction area not exceeding 1000 m^2 , there should be no fewer than 1 direct exit to the outside; commercial development areas can use sunken squares for evacuation, and the sunken squares should meet the following requirements:

The horizontal distance between the nearest edges of openings leading to the sunken plaza from different areas should not be less than 13m. The net area of the outdoor open space used for evacuation should not be less than 169 m^2 ;

At least one evacuation staircase leading directly to the ground should be provided in the sunken square; the total width of the evacuation staircases can include the width of the evacuation staircases and 90% of the width of the escalators, with a minimum width of 10.2 m.

Part of the commercial development areas cannot have staircases that lead directly to the outdoors or may not be able to lead directly to the outdoors; in such cases, evacuation can be conducted using refuge corridors.

The distance from any point in the transfer hall to the nearest staircase entrance or passageway entrance shall not exceed 50 m.

Within the calculated length of the public area on the platform, the distance from any point to the nearest exit or passage opening should not exceed 50 m.

The number of safety exits in each fire compartment for equipment and management rooms

should also be no less than two, and there should be a fire exit leading to the other surface; when there are fewer than three people, a separate stairwell is not required, personnel can be evacuated outside through the platform public area.

4 Others

The public areas of the underground station platform and concourse level should be equipped with an automatic fire alarm system and emergency broadcast system, and luminous or photoluminescent evacuation indication signs that maintain visual continuity should be added on the ground of evacuation corridors and main evacuation routes.

Emergency lighting fixtures should ensure that the minimum horizontal illuminance on the floor of the evacuation walkway is not less than 5 Lx, and the continuous power supply time of its backup power source is not less than 180 minutes.

5 Recommendations

Fire safety is both relative and a reflection of the overall system performance. For this reason, the following suggestions for the fire safety design of this project are proposed for reference:

For the various functional areas within the station, attention should be paid to controlling combustible materials and electrical wiring faults, and strengthening the management of fire hazard sources.

The floors, walls, fixed furniture, seats, etc., in the underground public areas of the station should all use non combustible materials for decoration. For the decoration within the station, commercial operation areas, the use of flammable, combustible, or materials that produce large amounts of smoke is prohibited; the use of flame-retardant materials should be minimized as much as possible.

Strengthen the management of fire evacuation routes and safety exits to ensure they remain unobstructed and easily openable, ensuring all personnel can evacuate safely in case of a fire. Particularly, for the automatic escalators in underground public areas, they should be supplied with first-class load power and ensure they can reverse and move upward during a fire.

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