Research on key points of smoke prevention and exhaust design for rail transit cover development

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Abstract. As one of the most important urban infrastructures, rail transit is the basic element of urban development and growth. In order to improve land utilization and economic benefits, the development of urban subways is the direction of development and construction of first- and second-tier cities with relatively developed economies in the future. Vehicle depots belong to industrial buildings, while garages, residences and supporting buildings belong to civil buildings, and different types of buildings are built together. At present, there is no guiding standard for the fire protection design of these buildings. At present, there are few successful cases in China for reference, and it is still in the exploratory stage. Based on the existing cases, the author conducts key research on its ventilation and smoke prevention and exhaust design, and compares and analyzes the controversial issues in the smoke prevention and exhaust design of the upper vehicle depot, and proposes a reasonable solution, hoping to provide the design of similar projects in the future. certain reference.

Keywords: Smoke Prevention and Exhaust Design; Rail Transit Cover Development;

1 Introduction

With the continuous development of my country's economy and the continuous expansion of urban scale, the issue of land intensification has been paid more and more attention. The subway vehicle base includes civil buildings such as comprehensive buildings, operation buildings, logistics buildings, training centers, and apartments for flight attendants and drivers, as well as industrial buildings such as application warehouses, joint garages, material warehouses, engineering garages, sewage treatment stations, washing garages, and substations [1]. It covers a large area, and the general parking lot is 10~20hm^2 and the vehicle base reaches 20~40hm^2. How to reuse the land of the vehicle base is an important issue to be considered in the construction of subways in various cities.

The development of the upper cover of the depot is to divide the depot into two vertically through a cover. The underside of the cover is used as a subway function, and the upper side of the cover is used as a civil building function, so as to achieve "two uses for one place" and "two birds with one stone" [2]. Effect. For this new type of building system, the relevant national engineering construction standards have not clearly stipulated the design principles for smoke prevention and exhaust [3]. Although there are many similar engineering cases in China, there is no unified approach. The notice of the Ministry of Land and Resources on the implementation

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of the "Notice of the State Council on Promoting Economical and Intensive Land Use" (Guotuzifa [2008] No. 16) proposed to vigorously improve the utilization efficiency of construction land and encourage the development and utilization of above-ground and underground space [4]. Taking this as an opportunity, the property development projects on top of stations combined with subway construction are developing rapidly in big cities. Such projects follow the requirements of "zero-distance" transfer and integrated construction and operation, focusing on convenient travel and convenient transfer [5]. The purpose is to take the rail transit stations as the core, scientifically arrange the entrances and exits, transfer facilities, pedestrian systems and urban life service facilities; An integrated construction project in which the transportation function and the urban comprehensive service function are organically connected.

As an indispensable part of building fire protection design, smoke prevention and exhaust system can create a safe environment for evacuation of people in the early stage of fire [6]. However, the rail transit parking lot is different from other places such as commercial office buildings and public areas of subway stations [7~9]. Its fire hazard level and personnel scale are relatively small, and the personnel in the parking lot are familiar with the working environment, whether it is self-rescue or waiting for fire rescue. better conditions. At present, there are no clear and unified regulations on the design principles of smoke prevention and exhaust systems for rail transit underground parking lots, and the fire performance evaluation method is generally used to evaluate the rationality of the design. Therefore, it is necessary to discuss the key points related to the design of smoke prevention and exhaust system for rail transit depots, so as to better carry out similar engineering design in the future.

1.1 Normative content

Article 8.2.7 of "Fire Protection Standards for Metro Design" (GB51298-2018) stipulates that the underground parking garages, train inspection garages, parking train inspection garages, application warehouses, joint maintenance warehouses, wheel warehouses, engineering garages, etc. The smoke exhaust system is set up. Based on this, the author gives two general layout plans for the base of the covered vehicle, as shown in Figures 1 and 2.

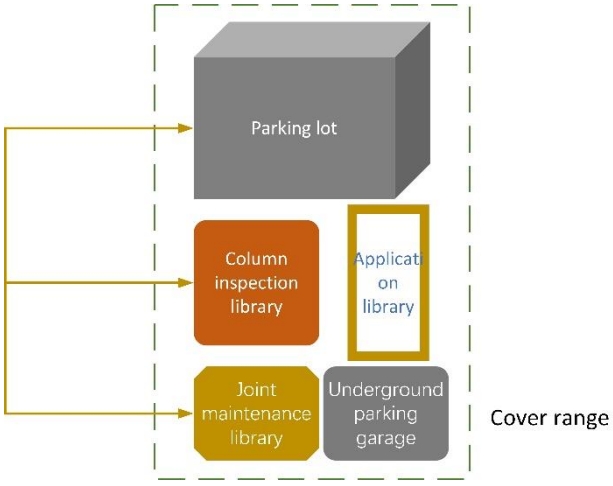

Fig. 1. General Plan 1 of the Overhead Vehicle Base

As shown in Figure 1, the comprehensive building is located under the cover, close to the edge of the cover, and close to the main production buildings such as the maintenance warehouse and the parking train inspection warehouse.

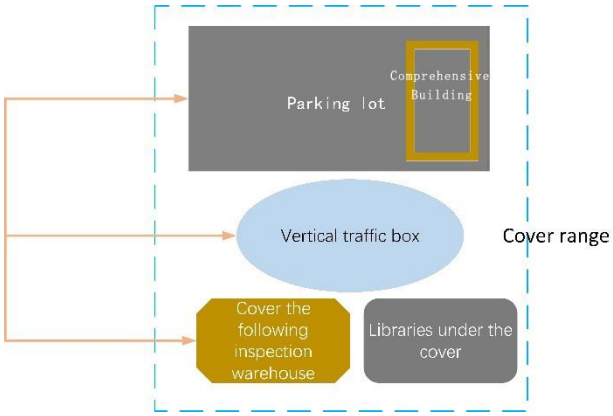

Fig. 2. General Plan 2 of the Covered Vehicle Base

As shown in Figure 3, the comprehensive building is set on the cover, and vertical traffic boxes are set up near the main production houses such as the maintenance warehouse, parking and train inspection warehouse.

The interpretation of the provisions of the Fire Protection Standard for Subway Design states that the traffic areas outside the warehouse, mainly the rail area, are basically free of combustibles, and are not long-term residence places for personnel, and the space is high, so no smoke exhaust facilities are required.

Article 8.3.1 of Beijing's local standard "Fire Protection Standard for Comprehensive Utilization Engineering of Urban Rail Transit Vehicle Bases" (DB11/1762-2020) stipulates that when a smoke exhaust system is responsible for the exhaust of multiple smoke prevention zones, its system smoke exhaust volume shall be calculated according to the smoke exhaust volume of the largest smoke prevention partition, and the smoke prevention partitions borne by one smoke exhaust system shall not be more than 3. Article 8.3.3 stipulates that the throat area should be equipped with smoke exhaust facilities; when the throat area is open on both sides and the lateral width is not greater than 300m, the smoke exhaust system may not be installed; when the lateral width is greater than or equal to 300m, the smoke exhaust system should be installed.

Article 8.5.4 of Shanghai's local standard "Design Standard for Urban Rail Transit Superstructure" (DG/TJ 08-2263-2018) stipulates that the space under the floor with a clear height greater than 9m may not be divided into smoke prevention zones, but should be divided into rows Smoke partition, and meet the following requirements:

1) The area of a single smoke exhaust zone should not be larger than 5000㎡.

2) The amount of smoke exhaust is calculated based on the ventilation volume of each exhaust smoke being turned over not less than 4 times/h. The space for storing the train should also be checked according to the scale of the train fire, and the amount of smoke exhaust should take the larger value.

3) When the space is divided into multiple smoke exhaust zones, the smoke exhaust system should meet the ability of two or more adjacent smoke exhaust zones to simultaneously exhaust smoke.

1.2 Normative analysis

It can be seen from the normative clauses and clause explanations in the Fire Protection Standards for Metro Design that the main idea is to consider that the underground parking garages and other monomers have large areas, do not have natural ventilation conditions, have long-term maintenance and train parking, and have certain fire hazards. There are hidden dangers, so consider setting up smoke exhaust facilities. However, the base layer of the vehicle under the cover is relatively high, and there are certain natural ventilation conditions when the two sides are open.

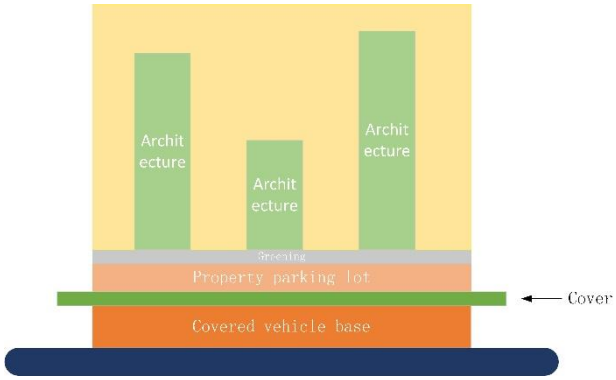

Fig. 3. Basic composition of rail transit superstructure development

It can be seen from the "Fire Protection Standards for Comprehensive Utilization Engineering Design of Urban Rail Transit Vehicle Bases" that the idea of setting the smoke exhaust system is that a system only needs to exclude the smoke volume of the largest smoke prevention zone. The requirements in the Technical Standard for Smoke Exhaust System are the same, and the situation of smoke in adjacent smoke prevention zones is not considered. However, it limits the number of smoke prevention zones that a smoke exhaust system is responsible for, and the "Technical Standards for Building Smoke Prevention and Smoke Exhaust Systems" also limits the area of smoke prevention zones. The single-unit smoke exhaust system of buildings with a construction area of more than 10,000 square meters such as under-cover application warehouses and combined garages is too divided, which increases the cost and complexity of the system. Beijing's local standards also put forward higher requirements for the lower throat area. Other specifications point out that the throat area is relatively high, there is no combustible material and no long-term resident personnel, and there is no need to set up smoke exhaust facilities, which simplifies the system and reduces engineering investment. However, local standards in Beijing require that a smoke exhaust system should be installed when the throat area is greater than or equal to 300m. It can be seen from the "Design Standards for Urban Rail Transit Overhead Buildings" that the Shanghai local standards for spaces larger than 9m are lower than those specified in the "Technical Standards for Building Smoke Prevention and Exhaust Systems". To meet the long side length requirements of the smoke prevention zone, the

setting of the smoke exhaust system can be simplified. The local standard of Shanghai also proposes the concept of smoke exhaust zone, which is the area undertaken by a single smoke exhaust system in the space with a clear height greater than 9m and no smoke prevention zone.

2 Case Analysis

While some cities have local codes as guidelines, the standard requirements are not uniform across regions. More than ten sections including Jiaxing Line T1, Guangzhou Line 6, Guangzhou Line 22, Suzhou Line 2, Wuxi Line 1, etc., the opening rate of the building facade or the natural ventilation openings of the cover plate under the vehicle base. Smoke prevention and exhaust practices are not the same, the statistics are shown in Tables 1-2.

Table 1. Statistical table of facade opening rate of buildings under different urban rail transit

Serial number	Line	Overhead vehicle depot name	Facade openness or cover panel natural ventilation
1	Jiaxing T1 line	Jiaxing Line T1 Tram Qingfeng Road Parking Lot	When there is a real difficulty, the open area of the outer wall shall not be less than 25% of the area of the facade
2	Guangzhou Line 6	Luogang Depot	Class D and E workshops with a construction area of more than 5,000 square meters, such as maintenance warehouses, parking and train inspection warehouses, machine adjustment and engineering garages, are equipped with mechanical smoke exhaust, and the rest are considered as natural smoke exhaust.
3	Guangzhou Line 22	Chentougang parking lot	If the fire lane is located under the cover, there shall be natural ventilation openings on the top cover, and the effective area of the natural ventilation shall not be less than 25% of the ground area of the fire lane, and the nearest horizontal distance between the edges of the natural ventilation shall not be greater than 60m.

4	Shanghai Line 17	Xujing North City Car Parking Lot	Since the cover of the mezzanine garage is surrounded by open or perforated aluminum plate decoration, it is basically fully open.
5	Chengdu Line 2	Chengdu West Railway Station Parking Lot	Except for the wall on the side of the complex building, the rest are open

Table 2. Statistical table of smoke prevention and exhaust practices in the throat area under different urban rail transit covers

Serial number	Line	Subunit extra-pharyngeal area	Standard $m^3/(h \cdot m^2)$
1	Jiaxing T1 line	Natural smoke extraction	⩾60
2	Guangzhou Line 22	Mechanical fume extraction	——
3	Shanghai Line 17	Mechanical fume extraction	——
4	Suzhou Line 2	Mechanical fume extraction	60
5	Wuhan Line 2	Mechanical fume extraction	60
6	Shenzhen Line 11	Mechanical exhaust with jet fan	60

The main monomers of the vehicle base under the comprehensive development cover are the application warehouse, the maintenance warehouse, the parking garage, the engineering garage, the substation, and the washing garage. According to the analysis of the above table, there are three main problems in the smoke prevention and exhaust design at this stage:

1) Design of smoke prevention and exhaust system in production supporting area.

2) Whether to consider the facility to prevent smoke and exhaust when the throat area is covered.

3) Division of smoke-proof zones under the cover.

There are many disputes in the design of the above issues. According to local standards, customary practices and the communication of fire protection departments, the design is usually

carried out according to stricter measures, which may cause waste of resources and increase the complexity of the system. It is convenient for later operation and maintenance.

3 Analysis and discussion

With reference to relevant national and local standards and the practice of covered vehicle bases that have been opened to traffic in some cities, the following analysis can be made for the doubts existing in the design of the three covered vehicle bases proposed by the case analysis in this paper.

3.1 Design of smoke prevention and exhaust system in production supporting area

The production supporting area is divided into 20 fire compartments, all of which are located underground. It mainly includes weak current equipment, power transformation and distribution, conference room, maintenance team, driver's lounge, fire control room and other rooms. Its architectural features and room functions are similar to those of the underground station equipment area. However, except for the electrical room, all areas are equipped with automatic sprinkler systems, and the fire risk is lower than that of the station equipment area. Therefore, it is recommended to implement the smoke prevention and exhaust system in the area of production supporting buildings according to the requirements of GB 50157-2013 "Code for Metro Design" and GB 51298-2018 "Fire Protection Standard for Metro Design", and the unspecified part refers to GB 51251-2017 "Smoke Prevention and Exhaust in Buildings" Design according to relevant regulations of System Technical Standards.

The equipment area is divided into 25 smoke-proof zones. Mechanical smoke exhaust and natural air supply are adopted. The external smoke exhaust and air supply outlets are given priority to use the natural ventilation shaft of the annular fire lane. Due to the scattered layout of the rooms in the entire equipment area, in order to reduce the length of the air duct and avoid excessive pipeline crossing, the special equipment room for smoke exhaust should be arranged in the middle of the two fire compartments as much as possible.

3.2 Whether to consider whether the facility should be smoke-proof and exhausted under the throat area

Article 8.2.7 of GB 51298-2018 "Fire Protection Standards for Metro Design" stipulates that "underground parking garages, train inspection garages, parking garages, application garages, joint maintenance garages, wheel garages, engineering garages, etc. Set up a smoke exhaust system", it is not clear whether the throat area and the car wash line must be equipped with a smoke exhaust system. Combining the interpretation of the provisions, "except for large-area places such as parking garages and train inspection warehouses, other traffic areas outside the warehouses, mainly the rail area, are basically free of inflammables, and are not places for long-term residence of personnel, and the space is high, so there is no requirement to set Smoke extraction facilities". Considering that the throat area and the car washing line are not divided into fire zones, there are basically no combustibles and no people stay for a long time, and at the same time meet the requirements of tall space, from the perspective of economic construction, smoke exhaust systems may not be installed in this area.

3.3 The division of the smoke-proof zone under the cover

The large warehouse under the cover should be divided into smoke prevention zones according to the Technical Standard of Building Smoke Prevention and Exhaust System. The division of smoke prevention zones should be based on the principle of simplifying the system. When there are local standards that do not need to be divided into smoke-proof zones or when there are other restrictions on the division of smoke-proof zones, the design should be carried out according to local standards, and the equipment selection and smoke exhaust mode should also be set according to local standards.

4 Conclusions

The functions of the covered vehicle base are complex, and the fire protection design problem has not been thoroughly studied in the industry. The standard requirements vary from place to place. Many smoke prevention and exhaust design standards and schemes need to be summarized through practical experience. Through case analysis and normative analysis, this paper puts forward feasible solutions, discusses ideas and analysis conclusions, which can provide reference for the design of smoke prevention and exhaust systems for similar projects. It is suggested that the follow-up design fully understand the principles of the specification and the characteristics of building fire protection design, and proceed from the perspective of engineering economic construction to reasonably carry out the design of the smoke prevention and exhaust system.

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