Analysis of design points of water supply, drainage and fire extinguishing system of Taihe East Station on Shanghe Railway

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Abstract. As the most representative building along the railway, the high-speed railway station has become the key project of each line. The water supply, drainage and fire extinguishing systems are important parts of railway stations, including such functional contents as production and living water supply, sewage and wastewater, rainwater, fire protection of station houses, platforms, exit channels, drop-off platforms, parking yards, auxiliary houses, etc. Taking Taihe East Station as an example, this paper introduces the content of the water supply, drainage and fire extinguishing system of the high-speed railway station and analyzes the design points to provide a case reference in this aspect.

1. Introduction
In recent years, the reform and development of railways have achieved world-renowned achievements, and high-speed railways have become a bright national business card. According to the data from China National Railway Group Co., Ltd. (http://www.china-railway.com.cn/), by the end of 2018, the total mileage of railway operations nationwide had reached more than 131,000 kilometers, and the total mileage of high-speed railway operations exceeded 29,000 kilometers. The operating mileage of high-speed rail exceeds 2/3 of the total high-speed rail in the world, ranking first in the world.

The Beijing-Hong Kong high-speed railway Shanghe section starts from Shangqiu City and ended in Hefei City. The line has a total length of 378 kilometers. It has 14 stations with the initial operating speed of 300 kilometers per hour and a design speed of 350 kilometers per hour. The design of the station building started in 2016 and officially opened for operation on December 1, 2019. The Beijing-Hong Kong high-speed rail is an important "one vertical" in China's "eight vertical and eight horizontal" high-speed railway network. The completion of the Shanghe section will further improve the high-speed railway network in the central region, which is of great significance for the implementation of the national strategy for the rising central China.
2. **Project overview**
Taihe East Railway Station is located in Taihe County, Fuyang City, northwest of Anhui Province. The station is about 10.0 kilometers away from Taihe County and is one of the stations in the Shanghe section. The mileage of the station center is DK149+245, and the station type is a line-side flat station type with an overhead floor [1]. The scale of the station is 2 platforms of 4 lines (including 2 main lines), with one basic platform and one intermediate platform (all dimensions are 450 m×9 m×1.25 m). One passenger tunnel with a net width of 8 m and one passenger overpass with a net width of 8 m are settled at the station.

This station is a small railway passenger station [2]. The peak hour departing quantum is 165 people per hour (2025), with a maximum 300 passengers in waiting room. The building area of the station is 21019 m², including the development area of the overhead floor is 6021 m², and the platform canopy is 8371.9 m². This station mainly includes the underground outbound/overhead layer (-6.30 m), ground inbound layer (+0.00 m), overpass layer (8.40 m) and air-conditioning room mezzanine (4.20 m), with a roof top of 25.20 m. The fire resistance level of the main body of the station is level 2, and the seismic fortification intensity is 6 degrees.

3. **Design contents and interface**

3.1. **Design contents**
The professional design of water supply and drainage of this station includes: water supply and drainage system, hydrant system, sprinkler system, fixed fire monitor extinguishing system, platform canopy drainage system, gas fire extinguishing system, fire extinguisher configuration, etc.

3.2. **Design interface**
Taking the using land red line of the station as the boundary, the water supply and drainage and fire extinguishing pipelines, valve wells and inspection wells within the boundary are the design scope of us.
4. Overview of key systems

Table 1 outlines the main water supply and drainage systems of Taihe East Station, and Table 2 covers the main fire extinguishing systems.

**Table 1.** Overview of water supply and drainage systems of station house.

| Subitem           | Pattern                                                                 |
|-------------------|-------------------------------------------------------------------------|
| Domestic water supply | Direct supply from water supply network                               |
| Domestic sewage   | Discharged into the outdoor sewage inspection well                      |
| Domestic wastewater | Discharged into the outdoor wastewater inspection well                  |
| Kitchen oil wastewater | Discharged into the outdoor sewage inspection well after being treated by the grease tank |
| Rainwater         |                                                                        |
| Roof              | Half-pressure flow                                                      |
| Canopy            | Half-pressure flow                                                      |
| Passenger platform | Half-pressure flow                                                      |
| Outdoor           | Gravity storm system                                                   |

**Table 2.** Overview of fire extinguishing systems of station house.

| Subitem                  | Fire water | Water supply facilities                                           | Water supply system |
|--------------------------|------------|------------------------------------------------------------------|---------------------|
| Hydrant systems          | Inside station house | Fire reservoir, Fire pumps, pressure stabilizers, gravity fire tank, pump adapters | Temporary high pressure system |
|                          | Outside station house | Fire pumps, pressure stabilizers                                 |                      |
| Sprinkler systems        | Inside station house | Fire reservoir, Fire pumps, pressure stabilizers, gravity fire tank, pump adapters | Temporary high pressure system |
|                          | Waiting hall | Fire reservoir, Fire pumps, pressure stabilizers, gravity fire tank, pump adapters | Temporary high pressure system |
| Fixed fire monitor extinguishing systems | | | |
|                          | Specific electrical rooms | Pre-engineered systems | |

5. Design essentials

5.1. Design basis and parameters of fire extinguishing system

Table 3 lists the design parameters of each fire extinguishing system in the station building of Taihe East Station.

**Table 3.** Parameters of fire extinguishing systems of station house.

| Subitem                  | Design peak flow (L/s) | Pressure of the worst adverse point (MPa) | Fire extinguishing time (h) |
|--------------------------|------------------------|------------------------------------------|-----------------------------|
| Hydrant systems [3]      | Inside station house   | 20                                       | 0.35                        | 2                           |
|                          | Outside station house  | 40                                       | 0.14                        | 2                           |
| Sprinkler systems [4]    | Waiting hall (±0.00 m) | 41.6                                     | 0.1                         | 1                           |
|                          | Underground outbound layer | 36.1                                    | 0.1                         | 1                           |
|                          | Others                  | 27.0                                     | 0.1                         | 1                           |
| Fixed fire monitor extinguishing systems [5][6] | Waiting hall (8.40 m) | 40                                       | 0.8                         | 1                           |

5.2. Fixed fire monitor extinguishing systems
5.2.1. Location. The fire monitor extinguishing system is set above the station to protect entrance hall and overpass layer waiting hall.

5.2.2. Design parameters. The fire monitor, equipped with an atomization device with its own infrared detection device, has a single gun flow rate of 20 L/s, a range of 50 meters, the most unfavorable point outlet water pressure of 0.80 MPa, and a locating time of less than 120 s. The water jets of two fire monitors in any part of the protection area are simultaneously arriving with the design flow of 40 L/s and the fire duration of 1 hour.

5.2.3. System. The station fire monitor system adopted a Temporary high pressure system. The fire reservoir, fire pump, and gravity fire tank jointly supplied water, and the pipes were arranged in a ring. Because the elevation of the ceiling above the station waiting hall is higher than the minimum water level of the gravity fire tank, the system's annular water supply pipe is set in the ceiling of the underground outbound layer, and the fire monitor extend from each branch pipe to the space of the waiting hall. The fire monitors and valve components should be in accordance with the specification requires setting [6]. At this point, the central elevation of the water supply pipe of the system and the elevation of the fire monitor are lower than the minimum water level of the gravity fire tank to make the effective volume of the tank fully utilized. The schematic diagram of fixed fire monitor extinguishing system is shown in Figure 3.

Figure 3. Schematic diagram of fixed fire monitor extinguishing system.

5.2.4. Pump Adapter
There are 3 sets of fire pump adapters (DN150) outdoor, with a single flow rate of 15 L/s, and an outdoor fire hydrant within 15~40 meters.

5.2.5. Control and operation
1) Automatic control-mode
When the intelligent infrared detection component collects the fire signal, it starts the fire monitor transmission device to scan. After completing the positioning of the fire source, the electric valve is opened, and the signal is simultaneously transmitted to the fire control room (showing the location of the fire), start fire monitor booster pump, and give feedback signal to the fire control room. The fire pump can also be directly started by the pressure switch on the fire pump outlet pipe and the flow switch on the gravity fire tank outlet pipe.
2) Manual control-mode on the fire control room
In the fire control room, according to the screen display, the muzzle of the fire monitor can be turned by the joystick to point to the fire source, and the fire pump and electric valve can be manually started to implement fire extinguishment.
3) Manual control-mode on the spot
On-site staff found a fire, manually operated the buttons on the on-site manual control panel near the fire monitor, turned the muzzle of the fire monitor to point to the fire source, and manually activated the fire pump and electric valve to extinguish the fire.

5.3. Roof rainwater drainage system

5.3.1. Overview. The roofing project of Taihe East Railway Station is mainly divided into metal roofing and concrete roofing.

The outdoor roof of the equipment platform of the station building is a concrete roof, and the waterproof level is Class I. The elevation of the concrete roof structure is 14.100 m, with a 400 mm wide gutter on the top and 300 mm at the deepest point.

The main roof of the station is constructed with orthogonal steel truss and aluminum-magnesium-manganese metal composite panel roof. The design life of the waterproof layer is greater than or equal to 20 years. The roof elevation is 19.500~25.200 m. The metal roof is provided with a stainless steel drainage gutter with a width of 600 mm and a depth of 350 mm and a thickness of 3.0 mm. It is made into a groove shape and has the same material and surface treatment as the roof floor. Stainless steel gutters are provided with expansion joints, and the maximum length of each section should not be greater than 30 m.

5.3.2. Drainage system. The roof of Taihe East Railway Station is a roof rainwater drainage system of half-pressure using 87 roof outlet, and overflow facilities are set for 50 years recurrence interval. Rainwater is collected and discharged to the outdoor rainwater inspection well through the pipes. The floor plan of the station roof is shown in Figure 4, and the schematic diagram of the roof rainwater drainage system is shown in Figure 5.

![Figure 4](image4.png)
Figure 4. Plan graph of roof rainwater drainage system.

![Figure 5](image5.png)
Figure 5. Schematic diagram of roof rainwater drainage system.
Since overflow drainage is not allowed to endanger the safety of construction facilities and personnel, and considering the effect of the building facade, the rainwater overflow facility on the roof of the station adopts the "pipe system + overflow" approach.

The west side is the front elevation of the station building, and it is also the main passageway for passengers. Therefore, a pipe system overflow is adopted for the metal roof gutter in this direction. The overflow roof drain are 87 roof outlets, which is set 100 mm above the bottom of the gutter. When the overflow system is working, the rainwater is collected and discharged from the overflow roof drain through the downspout to the outdoor rainwater inspection well.

On the east side is the back elevation of the station building, and passenger traffic is limited to the projection area of the overpass, so the metal roof gutter in this direction is provided with an overflow gate. Each gutter overflow gate has a size of 600×100 mm, a total of 5 locations with the opening facing the east side of the station.

In addition, the concrete roof gutters on both the north and south sides of the station are provided with one 400×150 mm overflow gate (two in total), and the opening faces the east of the station.

5.3.3. Installation. The roof gutter 87 roof outlet is made of cast iron; the half-pressure flow rainwater pipe is made of high-density polyethylene drainage pipe (HDPE pipe), which is connected with the hot-melt connection. The rainwater downspout should be installed directly along the wall and column. If there are concealment requirements, it can be installed in the tube well in a concealed manner, and a check hole should be left [7]. Figure 6 shows the installation situation of gutter roof drain and overflow gate.

![Figure 6. Gutter roof drain and overflow gate.](image)

6. Conclusion
The railway is the major artery of the national economy, an important foundation of the country and a popular means of transportation. Higher requirements for the design of railway stations have been proposed due to the ever-expanding breadth and depth of our country's railway construction. The design of station water supply and drainage and fire protection involves many specifications and complicated interfaces. In the future design work, we should sum up and learn more to fully understand the design requirements and relevant information of each station to complete faster and more accurate design tasks.

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