Journal of World Architecture, 2025, Volume 9, Issue 2
https://ojs.bbwpublisher.com/index.php/JWA
Online ISSN: 2208-3499
Print ISSN: 2208-3480

Fire Protection Design and Case Analysis of Renovated and Expanded Student Apartments in Universities

Xinmiao Wang*

China University of Geosciences (Beijing), Beijing 100083, China

**Author to whom correspondence should be addressed.*

Abstract: With the continuous enrollment expansion of universities and the increase in the number of international students, student apartments are becoming increasingly in short supply, inevitably leading to renovation and expansion projects of apartments. New requirements have emerged for fire protection design in the renovation of student apartments. This case mainly involves new approaches and methods of fire protection design in the renovation of old buildings. An indoor fire hydrant system is newly added to the water supply part of the apartment building, and the main measures include drawing water from a nearby source and establishing a fire protection linkage control system.

Keywords: Renovation and expansion; Universities; Student apartments; Fire protection design

Online publication: April 28, 2025

1. Introduction

In recent years, with the expansion of the enrollment scale in universities, the construction of student apartments cannot meet the enrollment demand. As a result, the existing student apartments generally accommodate 8 or 10 people per room, which does not meet the construction standards specified in the "Guiding Opinions of the National Development and Reform Commission and Other Departments on Strengthening the Construction of Student Dormitories in Universities": 4 undergraduate students per room, 2 postgraduate students per room, and 1 doctoral student per room. With a large population density, in case of a fire, the consequences would be disastrous. Therefore, the fire protection construction of student apartments in universities is of utmost importance for ensuring the safety of the campus. Many universities are gradually renovating and expanding their existing apartments. The original buildings did not meet the area requirements for the mandatory configuration of fire hydrants, and after the expansion, the construction of the fire protection system needs to be added [1].

2. Existing problems

Firstly, the issues of fire protection water sources and power supplies need to be considered. When the old apartments in universities were initially designed, the building volume was not so large, so there was no corresponding quota for the system water source. Correspondingly, the electrical load will also increase. Therefore, it is necessary to consider providing a normal water supply and electrical capacity expansion projects to meet the daily needs of the renovated and expanded apartments.

Furthermore, the risks of cross operations during the construction process need to be considered. During the renovation of old buildings, problems such as pipeline conflicts and the collapse of old pipelines are inevitable. It is necessary to consider the damage to the original fire protection system in the building or the system caused unintentionally.

In addition, there are issues such as whether the fire protection design of student apartments should be carried out according to the standards for residential buildings or public buildings. The student apartments in universities can be designed and constructed according to the two standards of civil buildings and public buildings. Judging from the nature of the building itself, the student apartment buildings in universities should be determined as public buildings. According to relevant codes and laws, "buildings exceeding 24 meters should be classified as high-rise buildings, and apartment buildings exceeding 50 meters or with an area of more than 1,500 square meters per floor should be classified as first-class high-rise buildings". Although currently in the fire protection design of universities, both standards are legally valid. Only by strictly classifying the student apartment buildings in universities and then carrying out the design and construction of the overall fire protection layout, fire protection water supply, automatic fire protection facilities, fire protection power supply, etc. according to the provisions of the current "Code for Fire Protection Design of Buildings" and "Code for Fire Protection Design of High-rise Civil Buildings" can the congenital fire hazards be minimized to the greatest extent [2].

3. Design ideas

On the premise of fully meeting the fire protection requirements, the characteristics of fire protection for the special building group of the renovation and expansion of student apartments in universities are reflected, that is, drawing the fire protection water source nearby and connecting to the existing fire protection linkage system.

3.1. Drawing the fire protection water source nearby

According to the provisions of the "Code for Fire Protection Design of Buildings" (GB50016-2006) in China, "For other civil buildings such as office buildings, teaching buildings, and non-residential buildings that exceed 5 floors or have a volume greater than 10,000 m^3, indoor fire hydrants with a diameter of DN65 should be installed.". In this case, after the completion of the third-phase project of Building No. 14, the building volume has exceeded 10,000 m^3, so indoor fire hydrants need to be installed. However, the outdoor water source in the design is far away, and it is difficult to directly connect to the municipal pipeline network. To save resources and meet the requirements of the indoor fire hydrant system, that is, to ensure that the indoor fire hydrant system has sufficient water quantity and water pressure, the water source of the nearby high-rise apartment is selected to meet the fire protection requirements.

3.2. Fire protection linkage system

The fire protection linkage system is widely used in newly built buildings currently. That is, the changes in

environmental parameters such as smoke, light, and temperature during a fire are detected by corresponding detectors and then transmitted to the central processing host. Through the rapid analysis of the computer, it is determined whether there is a fire, and the fire situation is quickly reported. At the same time, the automatic fire extinguishing system is activated to suppress the fire; the emergency broadcast and crowd evacuation guidance systems are triggered to assist occupants in evacuating swiftly; the fireproof rolling shutter doors close to isolate the affected area; and the smoke exhaust system starts operating to remove toxic gases. These coordinated actions aim to control the fire, minimize casualties, and reduce property damage. In this case, the connected high-rise apartment is a newly built building equipped with automatic fire control and alarm devices. At the same time, the automatic control system can also start the outdoor fire hydrant water supply system to meet the requirements of water quantity and water pressure for fire protection. The outdoor fire hydrant water supply system is composed of the outdoor pipeline network, fire hydrants, fire pools, and water pumps, etc., ensuring water safety [3].

4. Case analysis

4.1. Project overview

Building No. 14 of a certain university's student apartment was completed in three phases. The building floor height is 3.2 meters, the number of floors is 5, the building height is 17.2 meters, and the fire resistance rating is Class II. The first phase was completed and put into use in the 1990s, with a usable area of approximately 2,900 m², which did not meet the area requirements for the mandatory configuration of fire hydrants at that time. A few years later, the second-phase project was constructed, and the project plan for the third-phase project was preliminarily formulated. However, the total area of the first and second phases still did not meet the area requirements for the mandatory configuration of fire hydrants.

At the beginning of the 21st century, to achieve teaching goals such as enrollment expansion and academic exchanges with foreign countries, the school decided to build the third-phase project of Building No. 14, which was built as an international student apartment and could meet the usage requirements of most international students in the school. Among them, a total of 84 rooms were put into use, including 76 international student dormitories, 1 duty room on the first floor, 1 hot water room on each of the second and fourth floors, 1 laundry room on each of the third and fifth floors, and 3 other equipment rooms. The original exterior windows, entrance doors, heating system, and radiators were all retained. This building is equipped with an access control system, an intercom system for the building, a telephone system, a wired and wireless network system, and the pipelines for the television and air conditioning systems are reserved. A solar energy system was newly added to the entire Building No. 14, and a one-card charging system is used for the hot water used by students.

After the completion of the third-phase project, the overall structure of Building No. 14 has met the configuration requirements of fire hydrants. According to the provisions of the "Code for Fire Protection Design of Buildings", except as specified in Article 8.3.4 of this code, the following buildings should be equipped with indoor fire hydrants with a diameter of DN65: For other civil buildings such as office buildings, teaching buildings, and non-residential buildings that exceed 5 floors or have a volume greater than 10,000 m³; For residential buildings exceeding 7 floors, an indoor fire hydrant system should be installed. When it is really difficult, only a dry fire standpipe and an indoor fire hydrant with a diameter of DN65 without a fire hydrant box can be installed. The diameter of the fire standpipe should not be less than DN65. Therefore, in this design, a fire hydrant system was added, and a fire protection linkage control system was also equipped.

4.2. Fire protection water source

(1) Fire Pool: In order to meet the fire protection water quantity requirements in the initial stage of a fire, a fire pool for storage was set up. This fire pool stores the fire protection water quantity for 10 minutes to ensure the water pressure of the pipeline network and the water consumption in the initial stage of a fire.

(2) Ring pipeline network of the high-rise apartment: The water source is drawn from the ring pipeline network on the second underground floor of the nearby high-rise apartment. Both of the two access points meet the water quantity and water pressure requirements of Building No. 14. Inside Building No. 14, the requirement of simultaneous water supply also needs to be met, forming a loop water supply.

4.3. Fire protection water supply system

As a supplement to the water supply pipeline network, the fire protection water supply system can meet the requirements of water quantity and water pressure for fire protection. Both the water pressure and flow rate need to meet the fire extinguishing requirements at the most unfavorable point. There are fire pumps in the pump room. When a fire alarm is received, the fire protection water supply system is started, so that the pressure in the pipeline network quickly reaches the pressure requirements of the high-pressure water supply pipeline. The full water column of the water gun should not be less than 10 m to ensure that after the firefighters arrive at the fire scene, they can directly connect the water belt and water gun from the fire hydrant to ensure the safe and effective extinguishing of the fire.

(1) Fire protection water quantity

According to the specification requirements, outdoor fire hydrants should be installed in civil buildings, and the fire resistance rating is Class II, so a fire protection water supply should be set up. According to the specification, the number of fire incidents at the same time is set to 2 times. Regarding the indoor fire hydrant water consumption for one fire extinguishing, according to the characteristics of this building, since the maximum building volume is greater than 10,000 m^3, it is taken as 15 L/s. The fire duration for civil buildings is calculated as 2 hours, and the fire protection water consumption is taken as 15 L/s. The fire pool should be set to 108 m^3, and the data of the municipal water supply is 60 m^3/h, which can be replenished within 2 hours, meeting the requirements.

(2) Fire protection water pressure

The fire protection water pressure here mainly refers to the water pressure situation that the pump can provide to the system. According to the indoor water supply design specification, that is, the minimum effective head of the pump needs to meet:

$$H = Hxh + z + \Sigma h$$

H refers to the water pressure that the pump can provide to the system; *Hxh* refers to the water pressure at the most unfavorable fire hydrant outlet; *z* refers to the elevation difference from the water intake to the axis of the pump; *Σh* refers to the total head loss in the pipeline.

(3) Pipeline laying

New fire protection pipelines are rearranged to make the overall fire protection water supply pipeline form a system with the original fire protection pipeline of the high-rise apartment. Since the fire protection water quantity is 15 L/S, the fire protection pipeline is arranged in a branched shape, and the pipeline burial depth is 1.00 meter. At the same time, the following requirements are met:

$$S1 \leq 2$$

$$R = C \bullet Ld + h$$

S1 refers to the distance between fire hydrants, in m; *R* refers to the protection radius of the fire hydrant, in m; *C* refers to the bending reduction coefficient when the water belt is deployed, generally taken as 0.8–0.9; *Ld* refers to the length of the water belt, and the length of each water belt should not be greater than 25 m, in m; *h* refers to the horizontal projection length of the full water column of the water gun when it is inclined at 45°, in m, *h* = 0.71Hm, generally taken as h = 3 m; *Hm* refers to the length of the full water column of the water gun, in m; *b* refers to the maximum protection width of the fire hydrant, in m.

(4) Control of the fire protection water supply system

The control of the fire situation in the initial stage of a fire mainly lies in the start and control of the fire pump, which is also the most reliable guarantee for the operation of the water fire extinguishing system [3–5]. Therefore, in the control of the fire protection water supply system, the linkage control of the system fire pump is a crucial part. For the fire hydrant system, the start of the fire pump in the temporary high-pressure system is generally controlled by the fire control center and the button in the fire hydrant box. In this case, the start of the fire pump mainly relies on the cooperation of the linkage system. After receiving the alarm, the main machine of Building No. 14 starts first, and within 5 seconds, the control cabinet in the connected high-rise apartment starts the corresponding program to control the operation of the water pump, to achieve automatic control. In addition to setting up a fire pump, a standby fire pump should also be set up, and it should meet the requirements of automatic control and water quantity, and water pressure.

(5) Others

After research by the design institute and the owner, the fire protection water source was determined. It was determined that the fire protection water source is drawn from the fire pump room of the nearby high-rise apartment. After on-site investigation and consultation of relevant drawings, the following specific suggestions are made:

(1) The water source is drawn from the ring pipeline network on the second underground floor of the nearby high-rise apartment. The two access points are located in the corridor on the west side of the second underground floor (**Figure 1**). It is connected to the ceiling of the storage room on the first underground floor through the storage room and goes out of the wall. The elevation of going out of the wall is -1.25 meters, and the practice refers to the construction requirements of the high-rise apartment.

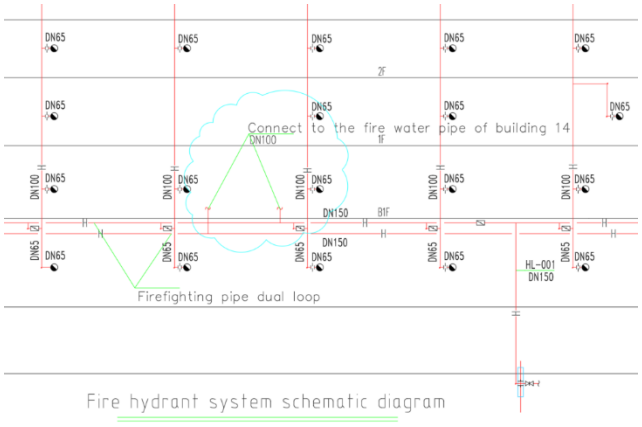

Figure 1. Schematic diagram of the access points

(2) The outdoor route must be surveyed clearly to check whether there are conflicts with other pipelines.

(3) The original designed fire hydrants in Building No. 14 need to select pressure-reducing and pressure-

stabilizing fire hydrants according to the pressure at the hydrant outlet.

(4) Requirements for weak current construction. The fire pump starting line of the fire hydrant is laid through a SC40 steel pipe along the outdoor fire water pipe (the horizontal clear distance between the fire pump starting line pipe and the fire water pipe is ≥ 0.5 m) to the first underground floor of the high-rise apartment building, and then connected to the fire pump starting line of the nearby fire hydrant button in the corridor. Waterproof treatment should be done at the place where the steel pipe enters the building. The steel pipes laid openly on the first underground floor of the high-rise apartment building should be painted with fireproof paint.

(5) In addition to meeting the requirements of relevant codes and regulations, the above construction also needs to meet the relevant requirements of the Party A, such as the settings of water meters and water wells.

(6) For the fire protection linkage control system, when a fire occurs in the building, the alarm device should first detect the fire signal, quickly transmit it to the main machine, start the alarm bell according to the set program, and quickly cut off all kinds of non-fire protection power supplies [4].

5. Conclusion

Due to the limitations of the existing scale of universities, there are many problems in the selection of water sources and the design of the linkage control of building fire protection facilities for renovation and expansion projects. This article only starts from the universities themselves and proposes several solutions to common situations from the perspective of energy conservation and full utilization of resources. When designing and constructing the selection of water sources and the linkage control of building fire protection facilities, it is necessary to comply with the relevant requirements of the current fire protection codes and also meet the principles of economy and practicality. These solutions are also important links in realizing the construction of a modern building system in universities [5].

Disclosure statement

The author declares no conflict of interest.

References

[1] Code for Fire Protection Design of Buildings, 2006, GB50016–2006. China Planning Press, China.

[2] Code for Design of Outdoor Water Supply, 2006, GB50013–2006. China Planning Press, China.

[3] Sun L, Wang H, 2014, Design of Automatic Fire Alarm System for Residential Buildings—Interpretation of the "Illustrated Design Code for Automatic Fire Alarm System". Building Electricity, 2014(9): 7–12.

[4] Tang Y, 2014, Discussion on the Design and Development Status of Automatic Fire Alarm Systems in High-Rise Buildings. China Science and Technology Information, 2014(1): 40–41.

[5] Jia B, Zhao H, 2012, Analysis of the Linkage Debugging of the Fire Protection System. Theoretical Research in Urban Construction (Electronic Edition), 2012(2): 2095–2104.