

Difficulties and Countermeasures on Fire Protection Design of Large Commercial Building

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ABSTRACT Large commercial building has gradually become the main trend in commercial buildings recently. In current national fire protection design specification, the lacking of targeted measures for the fire protection design on such building will bring obsession to building designers during the specific engineering design, and it can easily lead to non-compliance with national specification. Therefore, we propose relevant state departments to publish state technical standard on fire control against fire protection design of large commercial building. Based on the collected information, data and conducted experiments, standardize the fire protection design of such buildings, will effectively avoiding formation of major fire potential.

KEYWORDS

Large commercial building
Fire protection design
Countermeasures

1. Introduction

In recent years, with the rapid development of China's economy and prosperity of market economy, commercial buildings of major cities have mushroomed. In order to meet the development needs of new business, traditional commercial buildings had undergone tremendous changes in function and form. They have not only multiple functions and forms, but also large building area, intensive personnel, complex functions, more flammable decoration materials and other features. Hence, if a fire occurs, it easily lead to rapid spreading, difficulties in evacuation and firefighting process and other consequences.

2. Difficulties on fire protection design of large commercial building

The former fire protection design was unable to meet the rapid development of modern commercial buildings, hence there is an urgent need for advancing fire protection design. Refer from the fire protection design situation for large commercial buildings of recent years, we should focus on the designs of fire protection district separation,

personal evacuation, firefighting and rescue activities, setting up commercial space and other issues, the following detailed analysis is made on these issues [1].

2.1. Issue of fire protection district separation

From past experience, water supply and discharge of water curtain in large commercial buildings are the engineering problems that difficult to solve. The use of fire shutter with large area often has a lot of problems, such as the gap of shutter boxes, the deformation of the guide rail, lower portion of roller blinds due to heat, fire shutter bulges to fire side due to flame effect, and loss of smoke fire retardant effect. These problems have a significant impediment on fire shutter function.

2.2. Issue of personal evacuation

Since large commercial buildings have intensive population, once fire occurs, people will have the difficulty in controlling emotions; and due to the impact of comprehensive factors such as health status and others, the evacuation eventually become more difficult to control, which posing a great threat on fire safety. If the original unobstructed public walkways and open atrium space was separated by a large number of shutter, it will cause difficulties to the evacuation and bring people's psychological insecurity.

2.3. The effective setting of commercial space

The commercial function is the main function of large commercial buildings, since the large commercial buildings are a multifunctional complex, there will be more

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types of business. Different businesses had different requirements for stores, some commodity with relatively strong artistry had special requirements for space, if the fire protection design was only made in accordance with the general requirements for fire protection, then it will failed to play the business functions in large business. Under normal circumstances, personnel security evacuation is conducted by stairs, but according to specification requirements of commercial fire protection evacuation width, the size of fire protection evacuation is large, e.g. the width of evacuation stairwell is correspondingly large, which will greatly reduce the commercial space, affect the fluency of procurement streamline organization.

2.4. Exhaust problems

Smoke is the culprit that caused death during fire. Among the people being burned to death, the majority also stifles to death by inhalation of sulfur dioxide, carbon monoxide and other toxic gases. Obviously, the fire occurs in the underground commercial street, if we can effectively discharge the smoke, the fire spread can be curbed, and people will be able to get a good evacuation. While the discharge of smoke can also reduce fire site temperatures, thereby effectively slowing the spread of fire and being more conducive to firefighters to rescue inside underground commercial space.

3. Key points and countermeasures of large commercial building fire protection design

3.1. The general layout

Large commercial buildings should be consistent with the requirements of urban planning during the siting and general layout design. The length of section along the street of large commercial buildings is greater than 150 m, or the total length is more than 220 m, provide fire road through the large commercial building: When it is really difficult, we should set a circular fire road. The fire separation distance between large commercial building and the surrounding buildings as well as between each single inside the buildings should meet the requirement.

3.2. Partition of fire protection district

The partition of fire protection district is an important part of building fire protection design. The area is mainly based on the nature, type, fire rating, fire separation structure of building and others. It is conducted according to the fire protection specification of architectural design (GB50016-2006) and the fire protection specification of high-rise public building design (GB50045-95). The fire protection districts should be separated by a firewall. When there is a difficulty for the application of firewall, fire shutter and other fire separation facilities may be used. When the public space is larger and irregular, we may draw a safety area inside the building. Within the range of which, we can prevent fire and smoke from invading through controlling

the internal combustibles and making strict fire protection separation between neighboring regions. Provide temporary transition space for evacuation escape and temporary safety place for the reconnaissance and firefighting process [2].

3.3. Emergency exits and evacuation staircases

The number of emergency exit in each fire protection district should be determined by calculation. Some requirement such as, no less than 2 exits; the clear width of entrance, security door of commercial business hall should be not less than 1.4 m; and the determination of number and total width of stairs is the key of building fire protection design, was also the main difficulty of current design. The reasonable setting of evacuation staircases is important, hence we should use natural ventilation and lighting as far as possible. When indeed requiring evacuation staircases in the middle of market due to insufficient evacuation distance, the staircases may be arranged in groups. The width should be not less than 1.4 m. Fully take advantage of the features that the storey of commercial building is generally greater than 5 m. Outdoor stairs should have good smoke prevention feature, and don't occupy the interior space of market. Scissor staircase may use in graphic design for relatively narrow space, it play the role of two staircases and solve the problems of insufficient total width of security evacuation. Scissor staircase requires to set a non-combustible wall between two ladder sections, its fire resistance is not less than 1.00 h, so that the two evacuation routes become independent space, scissors staircase should be designed as smoke prevention stairwell, and set a front room.

3.4. Exhaust system

In order to meet the skylight design at the top of atrium and maintain high permeability demands for top of atrium, its recommend the use of natural ventilation system, which locate smoke window at the top of atrium to discharge smoke. This may increase the reliability of exhaust system and does not need to install exhaust fans and piping and other equipment at a higher roof position or on the side walls, which reducing light transmission and aesthetics, and also destroying the original architectural concept.

3.5. Evacuation width and evacuation distance

The total width of each evacuation corridor, emergency exit, evacuation staircase and evacuation door of each room should be determined through calculation according to Article 5.3.17 of the building design fire protection specification (GB50016-2006). The number of evacuees in stores should be calculated through construction area of each layer of business hall multiplying by the area conversion value and conversion factors of the number of evacuation. The area conversion value of ground store should

be 50–70% that of underground store should be not less than 70%, the evacuation conversion factor may be determined by calculation. Evacuation distance is the main way to guarantee personnel to arrive at a safety place safely. The Relevant specifications have clearly definition for the safe evacuation distance of civil building. If it is multi-story building, the evacuation distance of business hall and other large space should be determined according to Note 1 of the building design fire protection specification (GB50016-2006), which the linear distance of any point inside to the nearest security exit should be not greater than 30 m (when fully setting sprinkler system inside the building, its safety distance is $30 \times 125\% = 37.5$ m). Whereas, high-rise building should be set according to article 6.1.7 of fire protection specification of high-rise civil building design (GB50045-95), which, its interior a straight line from any point to the nearest safe exit of not more than 30 m. Safety evacuation of personnel should be made by increasing the width and amount of channels, shortening evacuation time and other indicators, in order to achieve the safety evacuation [3].

3.6. Underground fire Quarantine and roof refuge Space

Roof refuge space from article 4.2.4 of Shop architectural design specification (JGJ48-88) presents the corresponding indication for large commercial buildings. In case of fire, indoor personnel should be able to arrive at roof refuge space in time, the evacuation stairwell must clearly defined, and the fire protection designer should strictly follow the regulations to reduce the damage during fire accidents.

3.7. Fire rescue window

Fire rescue window mainly ensure firefighter can carry out firefighting or rescue by special entrance. The window allows fire and rescue personnel to enter from outside wall of each layer, hence the net size of window shall be not less than $0.8 \text{ m} \times 1.0 \text{ m}$, the distance between lower edge of window and interior floor is not more than 1.2 m, the window spacing should not exceed 20 m, the glass of window should be easy to break, and clear signs which can be identified outside should be set.

3.8. Evacuation instruction

Since the large commercial buildings were crowded and the personals have different levels of quality, we should consider the acceptability and ability to identify of different people when indicating evacuation instructions. Try to make the evacuation instructions simple and clear, but also eye-catching, in order to ensure that all personnel can understand and clearly see it. Considering the dense fog during a fire, therefore, evacuation lights need to use special materials to ensure that personnel can correctly identify the direction in the smoke.

4. Conclusion

In summary, during the fire protection design of commercial buildings, the designer should consider the complexity of large commercial buildings. The fire protection design should be made by combination of related requirements of large building after field trips in the premise of complicating with the national laws and regulations. At the same time, we should ensure the practicality and aesthetics of large commercial buildings, the design should be conducted according to the related fire protection specification during large commercial building design to meet the requirements of fire specification and prevent many risks in future.

Conflicts of interest

These authors have no conflicts of interest to declare.

Authors' contributions

These authors contributed equally to this work.

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