Fire prevention structure design of exterior walls of existing residential buildings

Yansheng Song *, Longwei Dong

School of civil engineering, Shenyang Jianzhu University, Shenyang, China

* Corresponding author: ceyssong@sjzu.edu.cn

Abstract. In this paper, taking the thermal insulation of the exterior wall after the renovation of multi-storey old residential quarters as the object Pyrosis is used to simulate the fire, and the prevention and control effects of different fire isolation belts and the combination of fire isolation belts and fire isolation layers on the longitudinal spread of the exterior wall fire are simulated. The results show that the arrangement of one fire isolation layer and each fire isolation layer in five groups of working conditions can effectively delay the longitudinal spread of external wall fire caused by window fire. The research results can provide reference for outdoor fire prevention and control measures of multi-storey buildings, and gain valuable rescue time for firefighting.

Keywords: Fire, isolation belt, fire propagation.

1. Introduction

At present, more than 90% of China's construction projects use organic exterior wall insulation materials, including molded polystyrene foam (EPS), extruded polystyrene foam (XPS) and so on. I.Asensio-Sevilla [1], Jorge R. Raposo [2] etc. have established the combustible flame spread model; Virginie [3] et al. studied the fire behavior of decorative materials. In this paper, taking the fire of an old residential building as the background, different combinations of fire isolation belts are set on the external wall of the building, and combined with the fire isolation layer, they are used as a "barrier" to block the fire from spreading longitudinally, so as to prevent the flame from forming a penetration on the external wall. Pyrosim software is used to simulate and analyze the fire of multi-storey buildings.

2. Establish a numerical simulation model

2.1. Project overview and meshing

The model is constructed as a seven-storey frame residential building in a residential area with a total height of 21m. The area of the fire source is set to $1m^2$, the power of the fire source is 3MW, the growth of the fire source is t^2 type, and the growth of the fire source is α 0.04689; the ambient temperature is 20 °C, the ambient pressure is 1.01325×10^5pa in Figure 1, Figure 2,

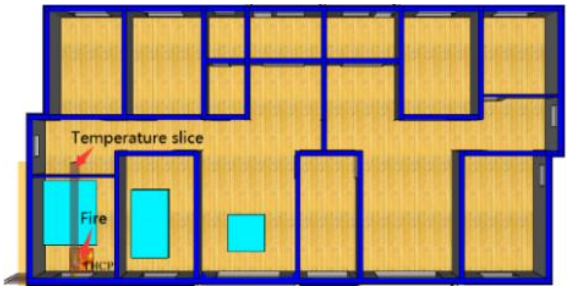

Figure 1. Model construction plan.

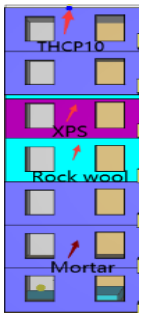

Figure 2. Diagramof external wall insulation construction

2.2. Simulation parameter setting

The external wall insulation system of the building model is strictly constructed in accordance with the "Code for Fire Protection of Building Design". The inner layer is the insulation material extruded polystyrene board (XPS) and the flame-retardant material rock wool, XPS is used as the insulation material, and the rock wool material is used as the "fireproof isolation layer" and the fireproof isolation belt. The height of the fireproof isolation belt is 300mm. The thickness of XPS and rock wool is set to 80mm, and the thickness of the first layer of the outer mortar is set to 15 mm, and the remaining thickness is 10mm. The heat release rat of the insulation extruded polystyrene sheet is set to 300 kW/m^2 [4] and the flash point is set to 360°C [5] in Table 1.

Table 1. Thermophysical properties of building energy-saving materials table

Material name	Density kg/m^3	Thermal conductivity $W/(m \cdot k)$.	Specific heat capacity $J (kg \cdot K)$.
XPS	25	0.03	5346.4
Rock wool board	150	0.04	750
mortar	1600	0.81	1050

3. Simulation results and analysis

3.1. Working condition setting

This paper takes the small and large, step-by-step order to gradually increase, in order to achieve the best barrier effect with the least amount of rock wool material, and the simulation of this group sets a total of 6 working conditions for comparative analysis in Table 2.

Table 2. Fire protection measures settings

The scene number	Exterior wall insulation	Fire prevention measures
Working condition 1	XPS	No barriers
Working condition 2	XPS	The compartment is equipped with an isolation belt
Working condition 3	XPS	Isolation zones are provided on each floor
Working condition 4	XPS	Isolation belt on each floor the fourth floor has a half-layer isolation layer
Working condition 5	XPS	Isolation belt on each floor the fourth layer has an isolation layer

3.2. Analysis of the results of each working condition

3.2.1. Working condition 1

The longitudinal direction represents the floor height direction (unit: m), and the horizontal direction of the floor (unit: m) is represented.

In the scene of indoor fire ignition, after about 300s of fire erupting from the window, the XPS insulation material is ignited and begins to spread, and the flame spreads from the temperature map to begin to appear in an inverted "V" shape, and the flame striker spreads to the roof at about 900 s and begins to expand to both sides. The temperature curve in the figure is getting denser and denser over time, and the temperature is also increasing, and it takes about 600s for the flame to reach the roof in Figure 3.

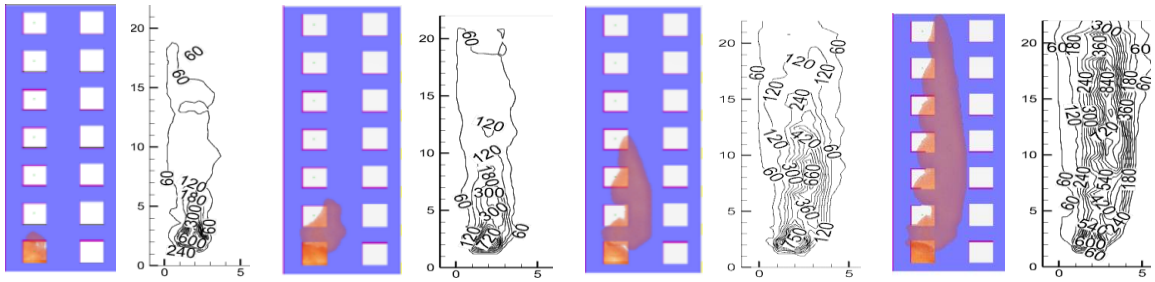

Figure 3. Temperature diagram and spread diagram of working condition 1 at different times

3.2.2. Working conditions 2

Compared with condition 1, the spread of fire is almost the same, and the speed of spread is slowed down, indicating that the ability to increase the barrier to the spread of fire by adding the barrier belt has been enhanced. From the spread map, it is known that the initial spread is mainly upward, and when it reaches the roof, it is mainly horizontal spread, and eventually it will develop into a situation where the entire external surface of the building is fully involved in. Around the 1320s, it took about 1020s for the Flame Striker to erupt and spread to the roof, a 47% delay compared to Condition One. It can be seen that the isolation belt arrangement can slow down the spread of external wall fire in Figure 4.

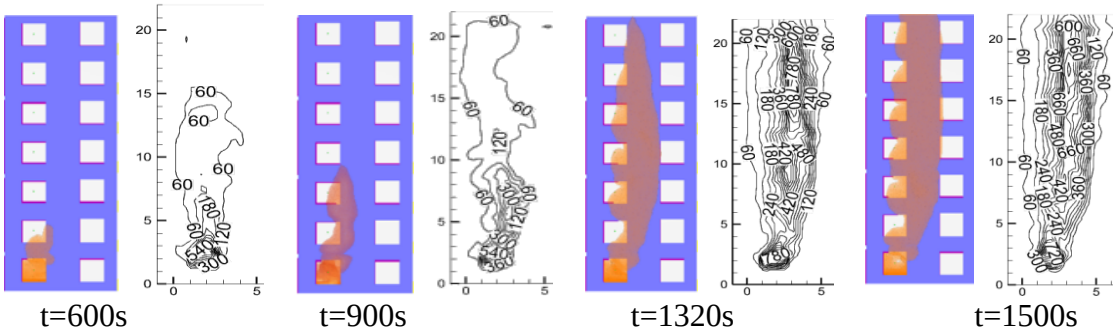

Figure 4. Temperature diagram and spread diagram of working condition 2 at different times

3.2.3. Working conditions 3

Under this condition, the flame striker spread to the roof at 1560s, and it took 1260s to spread from the window to the roof, which was delayed by 73% compared with the working condition 1, indicating that the spread rate of the fire in the isolation belt was more obvious in Figure 5.

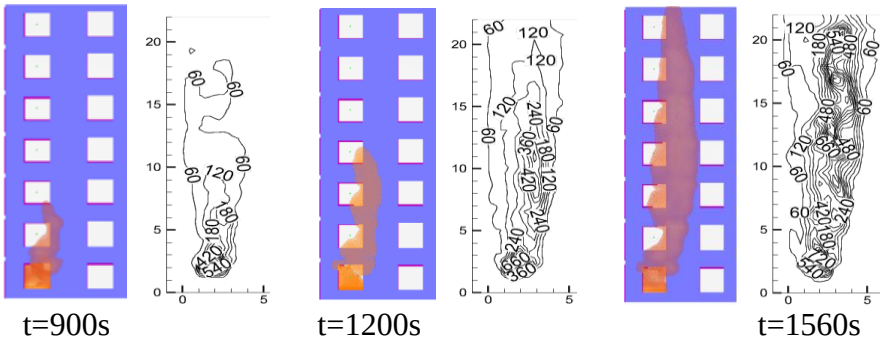

Figure 5. Temperature diagram and spread diagram of working condition 3 at different times

3.2.4. Working conditions 4

The flame is blocked by the isolation layer and the layers of the isolation belt in the process of spreading, which "cuts" the original insulation system into multiple areas as a whole, interrupting the continuity of the insulation material. This condition flame striker spread to the roof at 1920s, and the

spray from the window spread to the roof in 1620s, which is 113% longer than condition 1, which indicates the use of isolation layers and isolation belts is better in Figure 6.

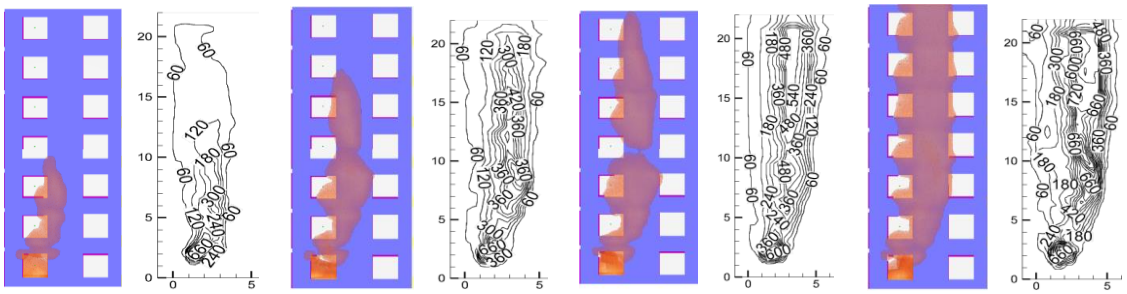

Figure 6. Temperature diagram and spread diagram of working conditions 5 at different times

4.2.5. Working conditions 5

The flames spread to the fourth floor, at which point the fire paused briefly and began to expand to the sides, reaching a certain point, the fire penetrated the isolation layer to ignite the insulation material on the upper floor, and when it reached the 1530s, the fire spread to the roof. Due to the appearance of the isolation layer, the fire is spaced, the spread trend of the fire is attenuated, and the time for the flame to spread to the roof is extended by 157% compared with the working condition 1, and the blocking effect is more significant in Figure 7.

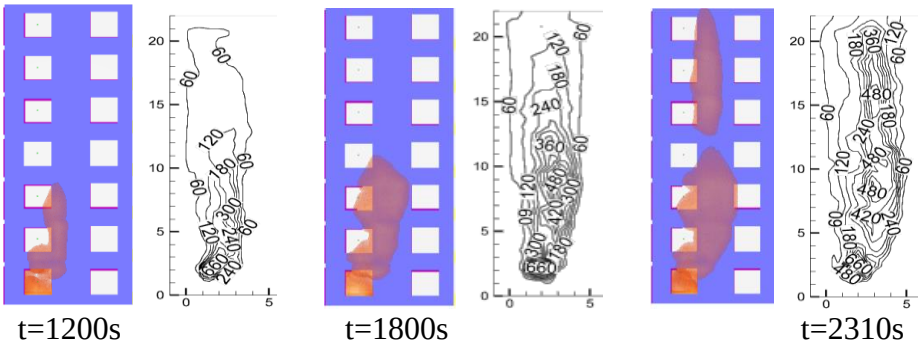

Figure 7. Temperature diagram and spread diagram of working condition 6 at different times

3.3. Temperature comparison analysis

Select the temperature value of a temperature measuring point (THCP10) at the top of the building under different working conditions, As can be seen from the figure, when the temperature reaches 360℃, the working conditions 2, 3, 5 and 6 are about 53%, 79%, 120% and 161% longer than the working condition 1, which is roughly the same as the time when the fire spreads to the roof under all working conditions, which indicates that the reasonable configuration of isolation layer and isolation belt can transfer the temperature in Figure 8.

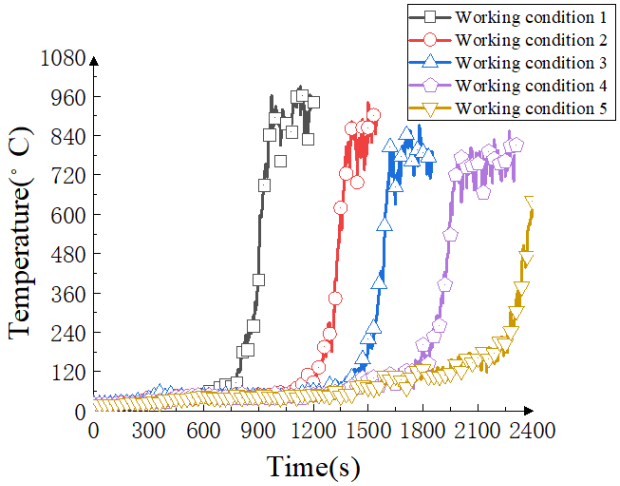

Figure 8. Temperature curve of measurement point 10 under different operating conditions

4. Conclusion

The initial flame spread is inverted V-shaped, and the angle of V-shaped gradually decreases in the vertical spread. In the process of fire development, the forms of fire spread include upward fire spread and horizontal fire spread. Before the flame spread to the top, upward fire spread dominates. In six groups of working conditions, with the increase of the area of flame-retardant materials, the flame spread speed decreases to some extent; Setting isolation layer alone has no obvious isolation effect, but when the flame passes through the isolation layer, it has an isolation effect. Reasonable configuration of isolation layer and isolation layer is adopted in working condition 5, and the isolation effect is the best.

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