Safety Performance of Exterior Wall Insulation Material Based on Large Security Concept

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Abstract. In order to evaluate the fire spread characteristics of building insulation materials under corner fire, an experiment is carried out with small-scale fire spread test system. The change rule of the parameters such as the average height of the flame, the average temperature of the flame and the shape of the flame are analyzed. The variations of the fire spread characteristic parameters of the building insulation materials are investigated. The results show that the average temperature of Expanded Polystyrene (EPS) board, with different thickness, decrease - rise - decrease - increase. During the combustion process, the fire of 4cm thick plate spreads faster.

1. Introduction

Hard closed-cell polystyrene foam (EPS) color steel sandwich panel is the current international, especially in the domestic market, a very common use of lightweight new building materials insulation materials\textsuperscript{1-3}. With the increasing construction of domestic buildings in recent years, the use of polystyrene (EPS) and other cost-effective materials as decorative materials and insulation materials has been widely used in the decoration of exterior walls. This has attracted the attention of many scholars\textsuperscript{4-5}. Edith et al. \textsuperscript{6} have studied the critical thickness of the material during the process of fire propagation in a microgravity environment. Eskimo koala et al. \textsuperscript{7} have experimented with the rapid propagation of PMMA flakes with different thicknesses. As the EPS fire spreads more complicated, the influence of the thickness on the fire propagation characteristics of the insulation material is relatively small, so it is necessary to study the fire spread characteristics of different thickness insulation materials in the vertical up case.

Based on this, the small-scale combustion experiment on insulation materials EPS is carried out in the laboratory. The thickness of the material is 2cm and 4cm. The size of the material is 25cm $\times$ 25cm. The thermal conductivity is 0.032 W / m $\cdot$ k. The compressive strength is 75 KPA and the density is 19 Kg / m$^3$. All of the values meet the relevant standards. The standard parameters are summarized in Table
1. In the laboratory, the propagation regularity of the flame is analyzed from three aspects of the average temperature of the flame, the average temperature of the flame and the thickness of the flame in the combustion process.

2. Experimental method and system

The experiment is carried out on a small-scale fire spread test. The experimental platform is constructed by the incombustible materials quartz. It is can be shown from the figure 1. Based on the small size experiments related to large-scale fire experiments, it is very important to predict and control the material fire at the present stage based on the parameters to predict the material fire propagation characteristics. Samples of insulation materials are from Hebei Langfang Xinda insulation plant. Before the experiment, the sample is processed. The scale is drawn every 3 cm on the surface to facilitate the high-speed camera to take pictures of the flame height at different times. And it is facilitated to measure the height of the flame height at different times. A relatively confined environment is built that there is plenty of air to support the burning of the combustion chamber. The experimental material is placed vertically to simulate the insulation material in the external wall burning scene. To avoid the interference of the outside world on the experimental system, the uniformity of the experimental environment is maintained during experiment. The sample placed vertically is kept by the use of blade system during the whole process of the experiment. The ignition device is used to ignite. The infrared thermometer is arranged 5 groups. It is layout straightly from the lowest end to the most high-end of the sample. The spacing is kept 5cm each infrared thermometer to measure the flame temperature.

![Figure 1. Schematic diagram of the experimental system](image)

1.EPS insulation material 2. Blade system 3. High-speed camera 4. Height measuring instrument 5. Infrared thermometer

| Table 1. EPS standard summary of the parameters |
|-----------------------------------------------|
| Project                        | Unit         | EPS       |
|---------------------------------|--------------|-----------|
| Thermal Conductivity           | W/m • k      | ≤0.042    |
| Compressive strength           | KPA          | ≥69       |
| Water absorption               | %            | <2.0      |
| Temperature (max)              | °C           | 70        |
| Flammability degree            |              | Ignited spontaneous |
### 3. Results and discussions

During the experiment, the room temperature is 18.2 °C, the humidity is 22% RH and the wind speed is 1 m/s. The combustion experiments of EPS with two kinds of thicknesses are carried out respectively. And the variation rules of mean maximum flame height, flame characteristic and flame mean temperature are obtained.

#### 3.1 The flame characteristics of EPS under different thickness.

Figure 2 is the thickness of 4 cm and 2 cm flame traces. They are at the beginning of combustion, burning to the material 1/4 position, burning to the material 1/2 position and the end of combustion respectively. The start time $t = 0$ s is defined as the moment when the flame appears before pyrolysis. It can be seen from Figure 2, the 4 cm thick average maximum flame height is greater than 2 cm thick for different thickness EPS in the combustion process. And the fire spread is faster. It mainly because the EPS board of 4 cm thick can provide more adequate fuel. It can be seen from the experiment that the combustion speed and intensity is also increasing with the increase the thickness of polystyrene (EPS) material. It can be also found that the smoke is generated during the polystyrene (EPS) combustion, and the irritating smell is accompanied. But 2 cm thick is burnt more fully from the burning traces. The EPS board of 4 cm thick is better between them from the perspective of insulation and fire.

![Figure 2: Flame characteristics at different locations with different thicknesses](image)

3.2 The average temperature of the flame of EPS under different thickness.

| Burn level   | B2                                      |
|--------------|-----------------------------------------|
| density      | KG/m²                                   |
| 18-20        |                                        |
| Convection heat transfer | Yes                                    |
| Bonding strength | MPA                                   |
|               | >0.1                                    |
3.3 The maximum flame height of EPS under different thickness.

Table 2. Flame average height and burning time of EPS

| Thickness/cm | Maximum height of flame /cm | Burning time/s |
|--------------|----------------------------|----------------|
| 4            | 11                         | 152            |
| 2            | 6.1                        | 162            |

It can be seen from Table 2, the average height of the flame changes relatively large with the increasing in thickness. It is indicated that the thickness has a greater impact on the average height of the flame.

Comparing to the burning time and the average height of the flame, it can be seen that the average height of the flame is up to 11cm in 152s for the thickness of 4cm EPS board, while maximum flame height is only 6.1cm for thickness of 2cm EPS board in 162s. This indicates that the burning of 2 cm thick polystyrene (EPS) is not sufficient. It is mainly because the EPS board can not provide sufficient fuel to maintain combustion.

4. Summary

Through the combustion experiments of EPS plates with different thicknesses, the variation rules of the mean maximum flame height, average flame temperature and flame characteristics during the vertical placement are analyzed.

(1) The fire of 4cm thick board is spread faster for different thickness EPS in the combustion process. It is mainly because the EPS board of 4 cm thick can provide more adequate fuel. The 2cm thick is burnt more fully from the burning traces of view. It is shown that the thickness of materials should be pay attention to in the selection of the external wall insulation materials. It is ensured its insulation characteristics at the same time to minimize the building fire impact.
(2) The average temperature of different thicknesses exhibits a decrease - rise - decrease - increase in the law when the EPS plates are combusted. This indicates that the flame in the vertical direction exhibits a cycle Sexual shock phenomenon.

(3) Comparing to the burning time and the average height of the flame, the maximum height of the thickness of 4cm EPS board is up to 11cm in the 152s time, while the maximum flame height of the thickness of 2cm EPS board is only 6.1cm in 162s. it is indicated that the burning of 2 cm thick polystyrene (EPS) is not sufficient.

5. Acknowledgments

This work was supported by Henan province key research projects of higher education (16B620001), Henan province key research projects of higher education (17A620001), Henan province key research projects of higher education (18B620001) and Henan Province Science and Technology Development Plans (172102310351)

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