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Fire-Retardant Properties of Exterior Insulation System in Cold Regions

Lv Chun, Li Jiamin, Liu Jie, Guo Guoliang

School of Architecture and Civil Engineering, Qiqihar University, Qiqihar, China

Email address

Lvchun8603@163.com (Lv Chun)

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Abstract

In order to study the external insulation system of high-rise building in severe cold regions, the author classified the external insulation wall by the difference of materials and technics, made a discussion especially on the EPS plates thin plaster system, the adhesive polystyrene thermal insulation mortar system, and the spot spraying of rigid polyurethane composite powder polystyrene particles such as exterior insulation system which were widely used at present, analyzed the combustion characteristics of different insulation materials and showed the exterior insulation system of high-rise building the key elements of security. The result show that the external insulation system of high-rise building of fire-retardant lies in materials and technics.

1. Introduction

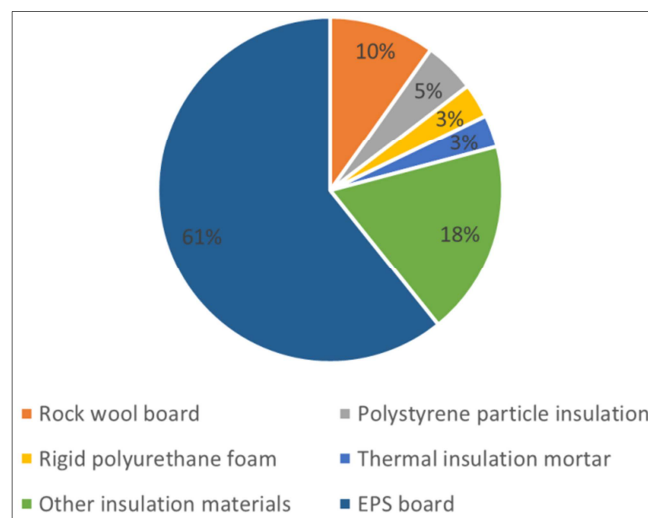


Figure 1. Statistics on the use of external wall insulation materials.

The external insulation technology has been used for 30 years in high-rise building in Europe [1-2]. It is the earliest region to carry on the technical certification, and the thin-plastered external insulation technology was mostly used. The Pilot project to use the external insulation of external wall technology was launched in mid-1980s in china. The polystyrene board compounded thin-plastered mortar external insulation system was the earliest used in high-rise building. In recent years, because of the needs of building energy conservation, the energy efficiency walls was adopted to the already Existing Building

and the new building in Energy-saving rebuilding project. The exterior wall external insulation which is the most widely used was the one of the energy efficiency walls. At the same time, the fire initiated by it was also becoming more and more, especially in high-rise building. According to my survey of Heilongjiang Province, the external wall insulation material varieties, as shown in Figure 1.

2. Exterior Wall External Insulation System

The exterior wall external insulation system is a group of nonbearing weight and heat preservation system which is applicable to install onto buildings' external surfaces. It consists of insulation layer, protective layer and fixing material. Basal layer is the exterior wall attached by external insulation system. The insulation layer is made of insulation material to insulate the temperature in insulation system. The protective layer is smeared on the insulation layer and filled with reinforcing net to protect the insulation layer and prevent the crack, the water and the percussive effect [3-5].

The exterior wall external insulation system is a widely used and relatively mature way of Energy-saving wall in high-rise civil building in severe cold region at present. In Terms of construction technology, it consists of the heat preservation boards (polystyrene boards, extruded boards, rock-wool boards and so on) system outside the wall using thin ash to paste external wall, the insulation boards system outside the wall using cast-in-place concrete, the insulation slurry system outside the wall using adhesive power polystyrene particle, the insulation system outside the wall using on-site spraying sclerotic latex polystyrene particulate composite polyurethane, the insulation boards system outside the wall using adhesive power polystyrene particle, the insulation boards system outside the wall using pre-cast composite cement and polystyrene and so on. As shown in Figure 2 to Figure 4. Among them, Figure 2 is a rock wool insulation material; Figure 3 and Figure 4, the use of EPS insulation board and polyurethane hard foam insulation board.



Figure 2. Rock wool board.



Figure 3. Construction of polystyrene (EPS) board.

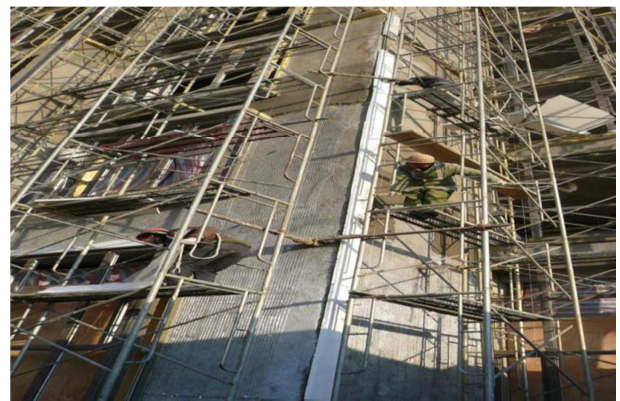


Figure 4. Paste the alkali fiberglass mesh cloth.

2.1. Thin-Plastered Insulation Boards System

The thin-plastered insulation boards system consists of polymer mortar adhesive, surface mortar, insulation boards, alkali resistance fiber glass mesh, and surface decorative material and so on. The exterior wall external thin-plastered insulation boards system is based on the key technology of cement-based polymer-modified mortar, and made up of an insulation system with the insulation boards, and the fiberglass mesh. By heat insulation outside of the building, it can act a series of noticeable building energy conservation, such as reducing the consumed cost in construction, improving the living environment, and reducing greenhouse gas emissions and so on. The thin-plastered insulation boards system consists of the thin-plastered insulation boards system outside the wall using polystyrene and mesh, the thin-plastered insulation boards system outside the wall using extruded boards, and the thin-plastered insulation boards system outside the wall using rock-wool boards and so on. As shown in Figure 2 to Figure 4.

2.2. Insulation Boards System Outside the Wall Using Cast-in-Place Concrete

The technology consists of having net system and none net system. The none net insulation boards system outside the wall using cast-in-place concrete should set the insulation

boards into the building template in concrete frame and shear system, and should be fixed on the outside of the wall that will be irrigated immediately, and then irrigate concrete, lastly the concrete and the insulation boards are irrigated one-time-formed and made up of the complex wall.

2.3. Insulation Slurry System Outside the Wall Using Adhesive Power Polystyrene Particle

The adhesive power polystyrene particle insulation material is suit for kinds of outside insulation projects. The material consists of insulation layer, anti-cracking protection layer and so on. According to the application of the insulation, we confirm the each layer's combination of material. The polymer dry mixed mortar and the polystyrene particle and water are mixed on-site by mortar mixer mortar mill, and then spread on the wall, so the insulation layer is formed. The insulation layer has the character of steady thermal conductivity, high heat storage capacity, insulation, excellent fire-safe, high strength, water resistant, strong deviation rectification to wall, no pollution to environment, and good effect of anti-crack using on the outside wall. Compare with the dry operation, the construction quality is easily to controlled. So it is an ideal exterior wall external insulation system. As shown in Figure 5 and Figure 6.



Figure 5. Rigid polyurethane foam and Polystyrene Granule Insulating Slurry.



Figure 6. Polystyrene Granule Insulating Slurry.

2.4. Insulation System Outside the Wall Using on-Site Spraying Sclerotic Latex Polystyrene Particulate Composite Polyurethane

The insulation system outside the wall using on-site spraying sclerotic latex polystyrene particulate composite polyurethane carry on the subjectively insulation by hard foamed polyurethane spot-sprayed, and carry on the leveling and complementary insulation by insulation mortar consisting of gelatinous powder and expanded polystyrene pellets. It makes the most of the good heat-retaining properties of the polyurethane and has strong strength because of sticking with wall inside and insulation latex using polystyrene particulate outside [1]. Besides, the exterior wall external insulation system sticking insulation board using latex polystyrene particulate composite polyurethane is similarity to the insulation system outside the wall using on-site spraying sclerotic latex polystyrene particulate composite polyurethane. As shown in Figure 7 to Figure 9.



Figure 7. Spraying polyurethane rigid foam.

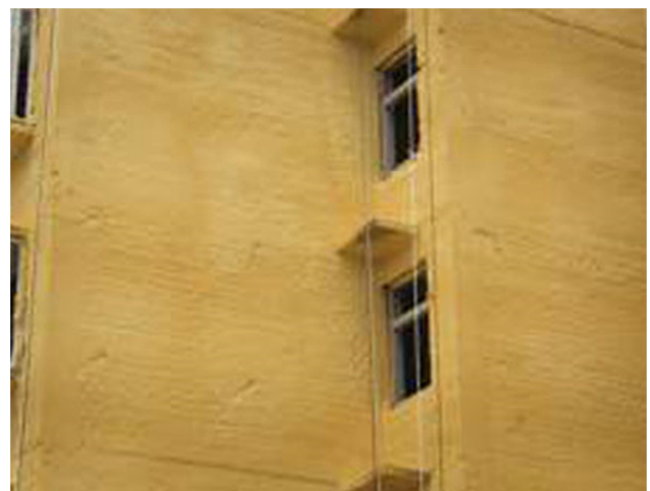


Figure 8. Polyurethane hard foam insulation wall.



Figure 9. Rigid polyurethane foam composite polystyrene particle insulation slurry wall.

3. Fireproofing Performance of Heat Preservation Material

The exterior wall external insulation system in the high-rise building adopt the insulation material as the main body, its core function material is insulation board, which is 80% percent of the system volume. According to the type of the material, the insulation material consist of organic thermal insulation material of walls, inorganic thermal insulation material of walls and composite thermal insulation material of walls.

The organic insulation material is considered having flammability commonly, which mainly consists of polystyrene board (thermoplasticity), polyurethane (thermosets) and phenolics. The organic insulation material is having low density, small thermal conductivity, low water absorption rate, superb sound insulating performance, strong mechanical strength and equality frame. Now the organic insulation material on the exterior wall is polystyrene board which having numberless closed little holes after sparkling styrene by vesicant.

The inorganic insulation material that mainly consist of mineral wool and glass wool is regarded as non-combustibility material, such as perlite floor slab, bubble floor slab, complexed silicate, rockwool, bubble glass and so on. The rockwool and glass wool sometimes are called mineral wool, they are inorganic material. The rockwool does not burn, and its price is lower, has some sound insulating performance. But the quality of the rockwool differs greatly, insulation is good but the density is low, the intensity of tension tensile strength is low, and the durability is poor. The glass wool has better handle than rockwool, it can improve the labor condition, but its price is higher than rockwool.

The rockwool has the characters of not burning and lower prices, in addition to meeting the thermal insulation properties can also have certain sound effects. The quality of the rockwool is different greatly, good heat preservation performance but low tensile strength and poor durability. The glass wool feels better than the rockwool, so can improve the worker's working conditions, but its prices is higher.

One kind of the composite insulation materials of wall is the organic-inorganic composite thermal insulation material mainly using adhesive power polystyrene particle insulation material, which is cognized generally difficult burning material; and the other is decorative plate having both decoration and insulation performance, covered by metals or organic materials, such as metals sandwich boards, vacuum insulation panels and so on.

The exterior wall external insulation system almost has no fire safety problems when using no burning of difficult burning material. But under the current technical conditions in China, the combustible materials such as polystyrene foam and rigid foam polyurethane is used widely in exterior wall external insulation system, so the issue of fire safety appeared, but with the gradual increase of the energy saving standard, the issue will be more prominent. So, with the wide application of these combustible organic insulation materials and the gradual increase of the thickness, we must pay sufficient attention to fire of the outside wall. In the last few years, the external wall thermal insulation material has caused many fires. See Figure 10 and Figure 11.

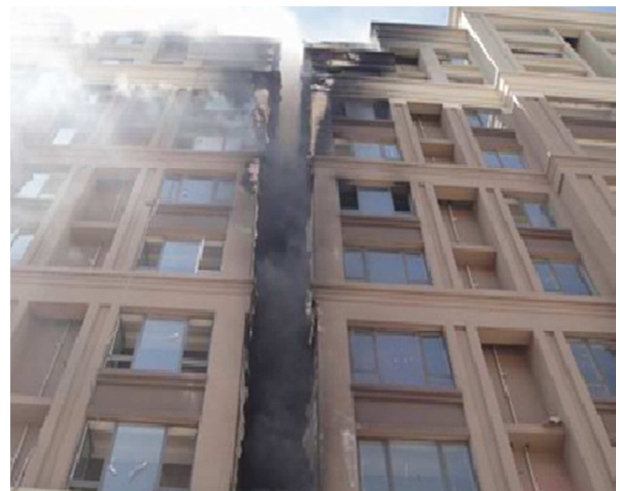


Figure 10. Exterior insulation material cause fire.



Figure 11. Exterior insulation material cause fire.

3.1. Fire Prevention Performance of Polystyrene Board

The polystyrene board is made of the thermoplastic polymer thermal insulation material. The polystyrene will produce hot deformation, softening and melting phenomena when its temperature high to 70°C~98°C, and will produce vitrification when the temperature high to 100°C. Because made of carbon hydrogen essentially, the polystyrene board is highly combustible. So if without any fire-retardant treatment, it will burn intensely.

3.2. Fire Prevention Performance of the Polyurethane

The polyurethane is made of the thermal insulation material with a thermosetting polymer. It is the best in all organic insulation material of external wall. It will not decompose below 200°C. The thermosetting materials will factor out the flammable gases usually when heated, and it will form the charring layer when fire. The polyurethane foam is highly inflammable material essentially, its oxygen index is only 16.5°C without fire retardant treatment. By determining the ignition temperature of the polyurethane foam is 310°C, the autoignition temperature is 415°C. The products of the thermal decomposition and combustion are mainly hydrogen cyanide, carbon monoxide, isocyanates and so on, so the research of it is more. The polyurethane can prevent burning by producing cover to isolate air and absorbing the heat using phosphorus and halogen [6].

3.3. Fire Prevention Performance of the Alnovol

The alnovol is a high performance organic insulating materials. The insulation board made of the material burn difficultly in the event of fire. It will only produce burning or smoldering phenomenon when the temperature higher than 400°C. It may smolder for a period of time after leaving the source of fire, but the products are almost all carbon. [7] Although the research findings and the experimental data are little, but to be sure, compared to the other organic insulation materials, it is the best materials in flame retardancy of the effective organic insulation because of it producing less

volume of toxic smoke [8].

3.4. Fire Prevention Performance of the Adhesive Polystyrene Particulate

The adhesive polystyrene particulate is slurry which is stirred using polystyrene particulate, special rubber powder and water. The 80% of its volume components of the adhesive polystyrene particulate slurry is organic polystyrene particulate, the remaining 20% being shroud by inorganic powder, the rubber powder, after it formed by stirred. The slurry is a hypoelasticity having high weather stability. The major advantage of the adhesive polystyrene particulate is high fire resistance rating which combustion rating can achieve B1 level. It belongs to difficult burning materials and is a kind of inorganic compound thermal insulation materials [7]. The polystyrene particulate will soft and melts but will not burn when the adhesive polystyrene particulate was heated. Because stirred by inorganic materials, the adhesive polystyrene particulate will form the closed cavity after the polystyrene particulate melted, and the thermal conductivity will be lower, the heat will be more slowly. The volume of it remained stable and no significant change during heated, but its thermal conductivity is generally higher than the other organic thermal insulation materials.

3.5. Fire Prevention Performance of the Rock-Wool Board

The rock wool is inorganic thermal insulation materials, so it is considered to be non-combustible materials. When we require the higher fireproofing performance of the external wall, we usually recommend using this type of inorganic thermal insulation material as external wall thermal insulation material. The rock wool and the slag wool are inorganic non-combustible silicate fibers, but in the course of processing into products we need join the organic binder and other additives sometimes, which have the effect of the combustion performance on the fiber products. So the combustion performance of the rock wool and slag wool product depend on the variety and the amount of the combustible binder. The index as shown in Table 1.

Table 1. Advantages and disadvantages of insulation materials.

Material name	Thermal conductivity w/m·K	Insulation effect	fire-retardant	Other properties
Expanded polystyrene board	0.038-0.041	high performance	poor performance	Medium intensity
Extruded polystyrene board	0.028-0.03	high performance	poor performance	High strength
Rock wool board	0.041-0.045	Mediune	fire-retardant	High Hygroscopicity
Adhesive polystyrene granule insulating slurry	0.057-0.06	poor performance	fire-retardant	High constructability
Perlite slurry	0.07-0.09	poor performance	fire-retardant	High temperature resistance
Rigid polyurethane foam	0.025-0.028	high performance	highly flammabl	Good waterproof
Phenolic resin	0.025	high performance	fire-retardant	High temperature resistance

4. Fire Prevention Performance of the Exterior Wall External Insulation System

In general, the fire prevention performance of the exterior wall external insulation system depends on the fire prevention performance of the insulation material. After the organic flammable insulation materials reaching the relevant standard requirements we should stress the whole fire prevention performance of the system. The basics of affecting the fire prevention performance of the exterior wall external insulation system in high-rise building are the insulation material and the construction manners. The insulation materials are the basic conditions affecting the fire safety performance of the system. When we use the insulation materials as the insulation layer, the construction manners is the key of the fire prevention performance. The construction manner which affects the fire prevention performance of the system including: the thickness of the protection layer or surface layer, bond or fixed manner, fireproof construction of the warehouse [9]. When the system has the cavity structure, the spread of the fire is accelerated because of the free flow of the air in internal cavity, which provides the enough oxygen for organic insulation materials. It can prevent the fire spreading to other parts effectively by adopting the warehouse form or setting fire belt in the fireproof structure of the system. The thickness and the stability of the lateral protection of the insulation layer determine the fire prevention performance of the protective surface to the inner side of the organic insulation materials.

5. Conclusion

The thermal insulation and the fire retardant is a pair of contradictions, the organic materials has good heat preservation and energy-saving effect but low retardant relatively while the inorganic materials is the reverse [10]. The phenolic foam has good heat resistance and low smoke after combustion. The rock wool and glass wool are widely used internationally. The rock wool is heat resistant, its maximum used temperature can reach to 650°C, the glass wool also can reach to 300°C. So these inorganic thermal insulation materials should be strongly advocated in exterior wall external insulation system in high-rise building in the future. We should use non-combustible or fire retardant materials as the protection layer and should cover the thermal insulation materials completely when using organic flammable insulation materials as the protection layer. The thickness of the first protection layer should be not less than 6mm, and the other should be not less than 3mm. In this sense, the inorganic thermal insulation materials should be preferred such as rock wool board. The exterior wall external insulation system using rigid polyurethane composited adhesive polystyrene particulate field sprayed and the exterior wall external insulation system pasting polystyrene plate composited adhesive polystyrene particulate are also a

good choice. We should take fire construction safety measures strictly in the exterior wall external insulation system in high-rise building. The exterior wall external insulation system should have a certain degree of fire resistant performance to ensure that don't burst, don't fall off, don't spread, don't melt and don't flow in the fire. In the case of fire space, the system should not burst, fall off, and burn because of thermal radiation when adjacent building is firing. We should set the fire isolation structure to prevent the spread of the fire when using combustible materials to make the thermal insulation layer. The fire isolation structure should be mainly set on the window and extended above 200mm to the right and left. Generally, there should be differences between the insulation materials and the fire prevention performance of the system [11]. The combustion performance of insulation materials should meet the B2 level requirements, and the external insulation system should meet the B1 level requirements. Adopting the more thickness protection layer is more effective for fireproofing of the external insulation system. Setting the fire construction measures properly and setting fire belt have very great significance.

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