Study on Basic Properties of Inorganic Isolation Partitioned Polystyrene Insulation Board

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Abstract. In order to ensure the safety of the inorganic isolation partitioned polystyrene insulation board in applying, this paper studied its heat retention, flame retardancy, water absorption, fatigue performance, and microscopic analysis. The test results showed that the apparent density of the board is about 120kg/m³ would meet the demands of great flame retardancy and good thermal insulation; the volume water absorption rate is curve growing in the early stage, it drops slightly and keeping stable after reach the maximum, the maximum is less than 8%; after 1500 times 12.1KN/m² impact on the board, the internal inorganic material is destroyed basically and remain unchanged in the substrate level; x-ray diffraction analysis result showed that there were Mg(OH)2 and hydrated magnesium sulfate in the solidified inorganic material.

Key words. Inorganic isolation partitioned polystyrene insulation board; Heat retention; Flame retardancy; Water absorption; Fatigue

1. Introduction

Inorganic isolation partitioned polystyrene insulation board (shorter form TEPS) is a composite insulating board, which is made up of mixed inorganic cementitious materials slurry and the base plate through impregnation and vacuum adsorption processes. It has good thermal insulation, chemical corrosion resistance and excellent mechanical strength. TEPS not only retains the good physical properties of the traditional benzol board, but also significantly improves the flame retardancy of the benzol board.

In order to improve the flame retardancy of EPS, Ruijuan Liu and Zhensen Liu¹ made a flame-retarded, economical and light composite polystyrene insulation board by painting the surface of mature benzol board and steaming curing slurry (mainly consisting of fast-hardening cement and modified resin). Hongyi Jiang and Zhonghai Yin² compacted silicate fibers, expanded perlite and polystyrene particles to prepare inorganic rubber powder polystyrene particles thermal insulation materials. This material has low self-weight, low thermal conductivity and recycled waste fly ash and polystyrene board. Miao Zhang³ used EPS as substrate, EG as flame retardant and PF as coating agent to prepare a new thermosetting insulation board, which improved the compressive strength and flame retardancy of the insulation board. However, previous studies focused on the flame retardant performance of thermal insulation panels, and less on the performances of modified materials in application.

TEPS is a new type of modified flame retardant thermal insulation material. Firstly there is a contradiction between flame retardant and thermal insulation. Secondly, water absorption is one of the
important properties to measure the durability of thermal insulation materials that has not been clearly studied at present. Thirdly, the modified insulation board is brittle, and its ability to withstand negative wind pressure has not been studied. Therefore, this paper studied the thermal insulation, flame retardancy, homogeneity and water absorption of TEPS, also studied the fatigue resistance of its mechanical properties by simulating the effect of wind pressure. The related problems are explored by micro-means.

2 Raw materials and measures

2.1 Raw materials

The base plate, EPS, TEPS made in Liaoning super insulation technology Co. Ltd; sizes are 1000mm × 600mm × 100mm. The segregated material is magnesium oxysulfide-based inorganic materials. The main components of the plastering mortar for exterior wall insulation materials are cement, fine sand, crack resistant fibers and polymer additives.

2.2 Measures

2.2.1 Thermal Conductivity and Combustion Calorific Value Test

According to GB/T 10295-2008 and GB/T 14402-2007, TEPS with apparent densities of 80 kg/m\(^3\), 100 kg/m\(^3\), 120 kg/m\(^3\), 140 kg/m\(^3\) and 160 kg/m\(^3\) were selected for thermal conductivity test and combustion calorific value test.

2.2.2 Mechanical Water Absorption Test

According to GB/T 8810-2005, four TEPS specimens were immersed below 5 mm of water level. Begin to measure the weight of specimens every hour, after 5 hours weigh the specimens every 2 hours, and then weigh the specimens every 3 hours…… With the prolongation of soaking time, the weighing interval time is adjusted accordingly until the weight does not change. Responding the water absorption character of TEPS by testing volume water absorption of difference time point.

2.2.3 Fatigue test design

Wind loading is the main external force acting on insulation board. By consulting relevant data[4], the maximum negative wind pressure in China is 12.1kN/㎡.Wind force is 121N equals wind pressure multiplied by specimen area. Using 121N force to impact the specimen 0 times, 500 times, 1000 times and 1500 times respectively. Then do pull-out test to measure the tensile strength.

2.2.4 X-ray diffraction analysis

In order to explore the solidified phase of inorganic materials,grinding inorganic materials and testing in D8 X-ray diffractometer to determine the phase composition of inorganic materials.

3 Test results and analysis

3.1 Thermal conductivity and combustion calorific value

The thermal conductivity and combustion calorific value corresponding to different apparent densities of TEPS obtained by the above test method are shown in Fig.1.
Fig. 1 The thermal conductivity and calorific value corresponding of different density TEPS
As can be seen from Fig. 1, with the increase of apparent density, the thermal conductivity of TEPS increases and the combustion calorific value decreases. This is because the higher the apparent density of TEPS is, the more inorganic materials are added, which results in the increase of thermal conductivity and the decrease of calorific value. When the apparent density of TEPS is 120 kg/m³, its thermal conductivity is 0.56 W/(m·K) and its calorific value is 2.6 MJ/kg. To meet the engineering requirements for thermal insulation and flame retardancy. Therefore, it is suggested that TEPS with density of 120 kg/m³ be used in actual construction.

3.2 Water absorbency
The volumetric water absorption of TEPS at different time points measured by the above test method is shown in Fig. 2.

As can be seen from Figure 2, the volumetric water absorption increased dramatically in the first 1 h. Volume water absorption rate of 1-400 h increases first by curve and then by wave to maximum value. The maximum volume water absorption rate of insulation board at 400 h, then wave reduced to steady, add up to 900 h.

Fig. 2 The curve of volume water absorption with time
The specimen dried in the first hour absorbed water rapidly and abundantly. 1-400h specimen still absorbs water mainly but speed slows down. Water immersion the benzene particle gaps that without inorganic filling dense. At the same time, MgO hydration into Mg(OH)₂, MgSO₄ soaking up become hydrated magnesium sulfate may increase the quality of specimens. To ensure the accuracy of test data, When weighing the quality of specimens would wipe the surface moisture of specimens with wet towels according to the specifications. This process may remove Mg(OH)₂ that generated and wrapped on the surface. Additionally, partially soluble crystals may dissolve with the prolongation of immersion time. These lead to the fluctuation of sample quality after immersion.

The maximum volume water absorption rate of individual TEPS samples is about 8% at 400 h. After test verification and according to relevant standards, the board is suitable for external insulation materials.

3.3 Fatigue property
Obtaining the tensile strength of TEPS, benzol board, substrates immersed in water and placed naturally after different impact times by the above test method, the test results are shown in Fig. 3. As can be seen from the TEPS natural polyline in Figure 3, the initial strength of the plate is fully specified in the requirement that the tensile strength perpendicular to the plate surface should not be less than 0.1MPa. The tensile strength decreases continuously with the increase of impact times. After one thousand and five hundred times shock, the strength reaches 0.07 MPa. From soaking TEPS line diagram, it can be seen that immersion has an obvious effect on the strength of the board, after one thousand times of impact strength, the immersed board has basically reached 0.07 MPa.

Fig. 3 The tensile strength

The overall tensile strength of TEPS is between the substrate and EPS. Naturally TEPS and EPS polylines are almost parallel, intersect with the base plate broken line finally. The tensile strength of immersed TEPS decreased to the level of substrate ahead of time. This phenomenon shows that the inorganic materials inside the TEPS plate are destroyed continuously during the impact process, inorganic materials destroyed basically by one thousand and five hundred times shock, and immersion accelerated fatigue of TEPS. From the strength broken line of the substrate, it can be seen that the impact of the substrate is not significant. Therefore, it can be inferred that the tensile strength of TEPS can be maintained at 0.07 MPa whether undergoes how many times shock. If the construction operation is standardized, the board is safe in use, there will be no internal fracture of insulation board.

3.4 X-ray diffraction analysis

The XRD diffraction pattern is shown in Fig. 4.

As shown in Figure 4, the main components of inorganic materials are MgO, Mg(OH)₂, SiO₂, (Mg,Fe)CO₃, hydrated magnesium sulfate, basic magnesium sulfate and so on. It is proved that Mg(OH)₂, hydrated magnesium sulfate, basic magnesium sulfate and other substances are formed after the reaction of inorganic materials.

4 Conclusion

(1) When the apparent density of TEPS is about 120 kg/m³, it can meet the requirements of class A flame retardant and good heat preservation performance at the same time.

(2) The volume water absorption of TEPS increased by a curve in the early stage, then the wave decreased and remained stable after the wave reached its maximum value. The maximum volumetric water absorption does not exceed 8%, it is suitable for use in cold areas.
(3) The inorganic materials in TEPS were basically destroyed after 1500 shocks of 12.1kN/strength, keeping around 0.07 MPa. It is safe in application.

(4) The reaction of inorganic material components produces Mg(OH)$_2$, hydrated magnesium sulfate, basic magnesium sulfate, which may cause fluctuation of water absorption quality.

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