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Influence of EPS filling methods and filling rates on thermal insulation performance of composite self-insulating blocks

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Abstract. Energy and the environment have the very close relationship. Many environmental problems depend on energy and economic development to solve step by step. One of the important measures to solve the problem of energy shortage is saving energy, economic development to relying more on energy saving of energy needed to solve, so building energy conservation has become the social issues of concern, and the key point of energy saving is on the retaining structure of the heating and cooling energy consumption. In this way, the thermal insulation and energy saving system of building envelope is increasingly strengthened.

In this study, the internal surface temperature and heat flow of each composite self-insulated block of the simulated wall were measured by the field detector of heat transfer coefficient of the building envelope of JTNT -a type, and the thermal properties of the six composite self-insulated blocks were compared and analyzed. The thermal insulation effects of the composite self-insulated blocks with different filling methods and filling rates were obtained. The following conclusions are obtained: The composite insulation wall with EPS has significantly better insulation effect than the wall without EPS, which is beneficial to the thermal protection of building envelope, reduces the heat loss from indoor to outdoor and energy consumption, and is of great significance. At the same filling rate, EPS should be filled as close as possible to the inside of the wall, which is more conducive to insulation effect.

1. Introduction

As more than 40% of social energy consumption becomes the largest part of energy consumption terminal ^[1], building energy conservation is of great significance for energy crisis mitigation and environmental protection ^[2]. The heat transfer loss of the wall as the enclosure structure accounts for 60%-80% of the total energy loss ^[3]. Through improving the insulation performance of the enclosure structure, especially the thermal performance of the wall, it is essential to create a building with high comfort and reduce the building energy consumption. The existing wall insulation method is mainly to increase the insulation layer on the outside of the wall. And the detailed studies were researched by Kaynakli^[4], Sadineni et al. ^[5] and Shekarchian et al^[6]. This method not only requires the secondary construction of the insulation layer, but also increases the construction cost due to multiple maintenance during its service life. In order to overcome the disadvantages of the above two structures, this study proposed to replace a single insulating layer with a composite self-insulating block filled with EPS in the cavity of sintered hollow brick, so as to achieve the purpose of energy saving. Sintered hollow brick has always been the core material in China's construction material market. The core research on its thermal performance mainly focuses on the distribution and heat transfer of the cavity.



At the same time, many studies are also carried out on the thermal insulation performance of composite self-insulated block and its influence on the building.

J.J del Coz Díaz, P.J. García Nieto^[7] have used the finite element method (FEM) theory, et al. calculated the heat conduction of five different block concrete hollow block walls, and analyzed the influence factors of block structure change on the heat conduction performance of masonry by using the mathematical nonlinear method. Yang Shu^[8] et al. discussed the block type design and thermal performance of the original composite self-insulation block, and improved the original composite insulation block by extending heat transfer path and increasing the volume of organic insulation material. Yan Lei^[9] et al. selected the composite self-insulated block composed of lightweight aggregate concrete small hollow block and thermal insulation material group as the research object, and obtained the influence of thermal insulation material thickness and thermal properties on the thermal properties of the block. Wei Mao, Liu^[10] and other people think, in the shale hollow brick hole filled with EPS (block), compared with the equivalent coefficient of thermal conductivity than before optimization to a difference of 0.15-0.16 W/(m²·K), the corresponding wall heat transfer coefficient is 0.44-0.46 W/(m²·K), the annual energy rate was 52.85%. Václav Kočí, Zdeňka Bažantová^[11] and others have used new composite insulation components for masonry family homes to calculate and analyze the overall thermal performance. The results show that if using the new composite heat insulation block, instead of the traditional brick or an old hollow brick with only a few big holes, can reduce the insulation thickness by several times; Jiancheng Li^[12] made the researches on influence of the hole shape of concrete hollow block on its heat insulation performance. Chaoping Hou^[13] and Jing Li^[14] simulated the performance of the 20-hole brick and got the corresponding thermal insulation data. Guoyong Zhang^[15] made an analysis of the influencing factors of the self-insulated wall. Xiaotian Li^[16] conducted a survey on the self-insulated wall in residential buildings in Chengdu. In addition to these, the research on the thermal insulation performance of different self-insulated hollow bricks still needs to be continued.

Based on the above problems, although the composite self-insulated block has been studied, it is still in the exploration stage. Due to different factors such as energy saving demand, thermal insulation demand and manufacturing cost, it is necessary to study the influence of filling position and filling rate of thermal insulation material on thermal insulation performance of composite self-insulated blocks.

2. Physical model and theoretical description

2.1 The physical model

In order to further explore the thermal insulation performance and parameters of composite self-insulated bricks, this study filled EPS thermal insulation material in the cavity of sintered porous bricks in a certain order and method to make composite self-insulated bricks, in which the variable was the position and filling rate of EPS. Figure 1 shows 6 filling methods in this study, with EPS filling rates of 0%, 25%, 50% and 100%, respectively. In order to account for the thermal insulation effect of composite self-insulated blocks with different filling rates, we simulated the construction of building walls. Figure 2 shows in the wall part of the composite self-insulated block. Figure 3 shows the building wall in this study. The size of sintered porous brick used throughout this study is 230*190*110 (unit is mm), and the pore size is 35*40 (unit is mm).

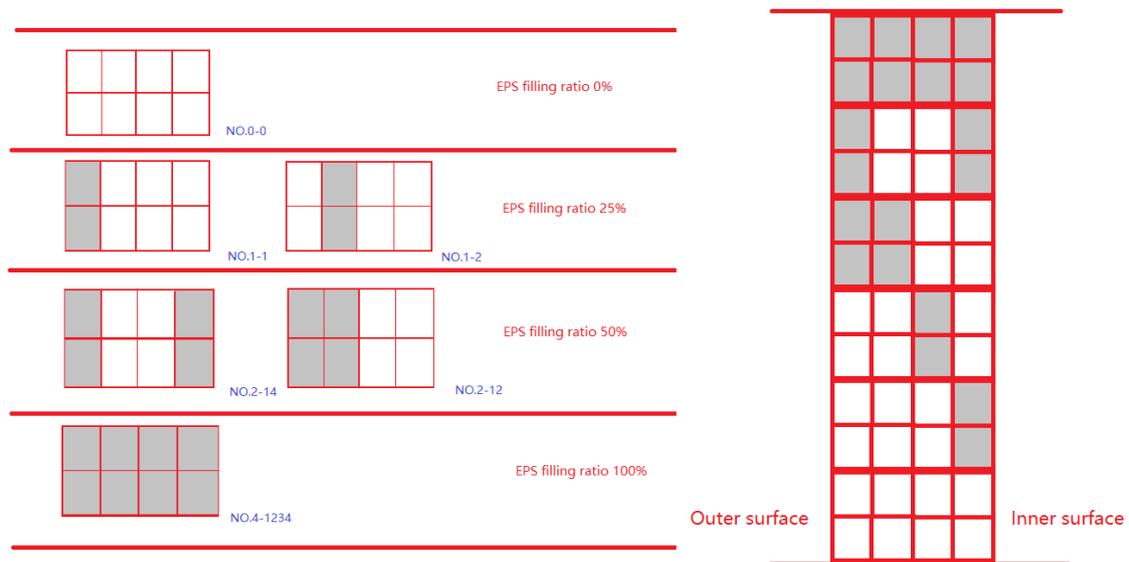


Figure 1. Experimental block types and the experimental wall

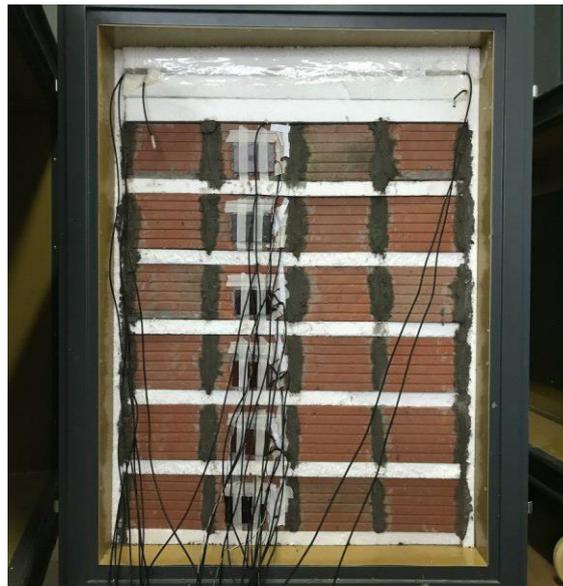


Figure 2. Schematic diagram of experimental building wall

2.2 Theoretical description and experimental method

Building envelope is always subjected to the indoor and outdoor thermal effect. At any time there will be heat transmitted to the indoor and outdoor through the envelope. In winter, the indoor temperature is greater than outside, and the heat is transferred from inside to outside. In winter, heat preservation design of the building envelope is usually calculated according to the stable heat transfer. The whole space is closed, and the small influencing factors can be ignored, so the heat transfer method is stable heat transfer, that is, there is a temperature difference between the two sides of the structure (indoor and outdoor), and the temperature difference between the indoor and outdoor does not change with time. Therefore, the temperature on both sides of the wall can be controlled as an index to measure its insulation capacity. The temperature inside the wall is set to 25 °C with continuous heating. The temperature outside the wall is set to 0°C; And the data are recorded every ten minutes.

In order to measure the required temperature of the experiment, we set temperature probes on both sides of the wall and hung two temperature probes on the inside and outside of the wall to measure the

temperature value of the air on both sides, and recorded the measured temperature data with a temperature tester.

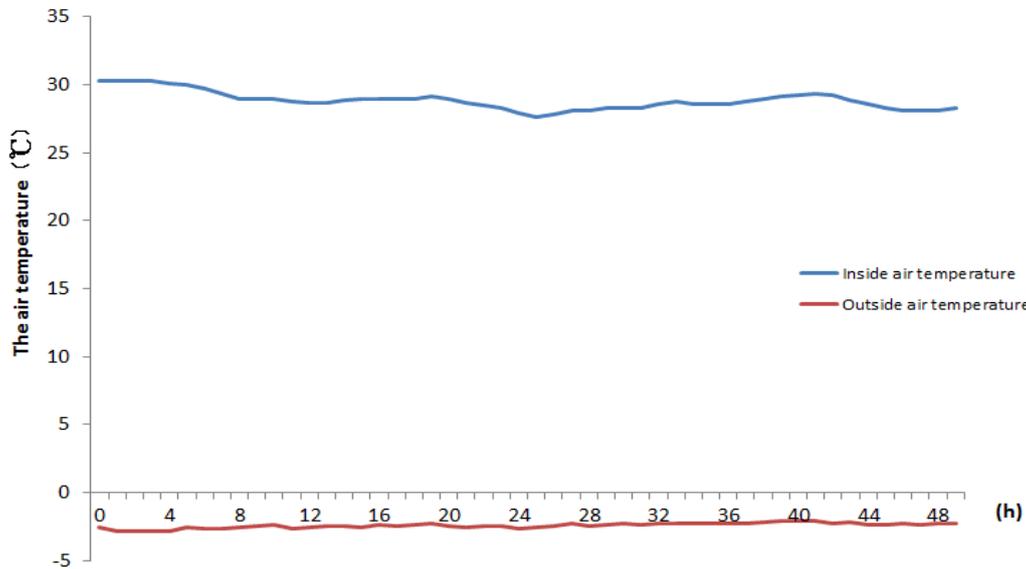


Figure 3. Average air temperature on both sides of the experiment

The equation is used to calculating thermal resistance. Through the temperature of the outer and inner surface, the thermal resistance can be expressed as shown in equation (1)

$$R = \frac{T_2 - T_1}{P} \quad (1)$$

- R - thermal resistance of the measured object;
- T_1 - cold end temperature, °C;
- T_2 - hot end temperature, °C;
- R- the power of the heating source

3. Comparison of internal surface temperature of self-insulated wall

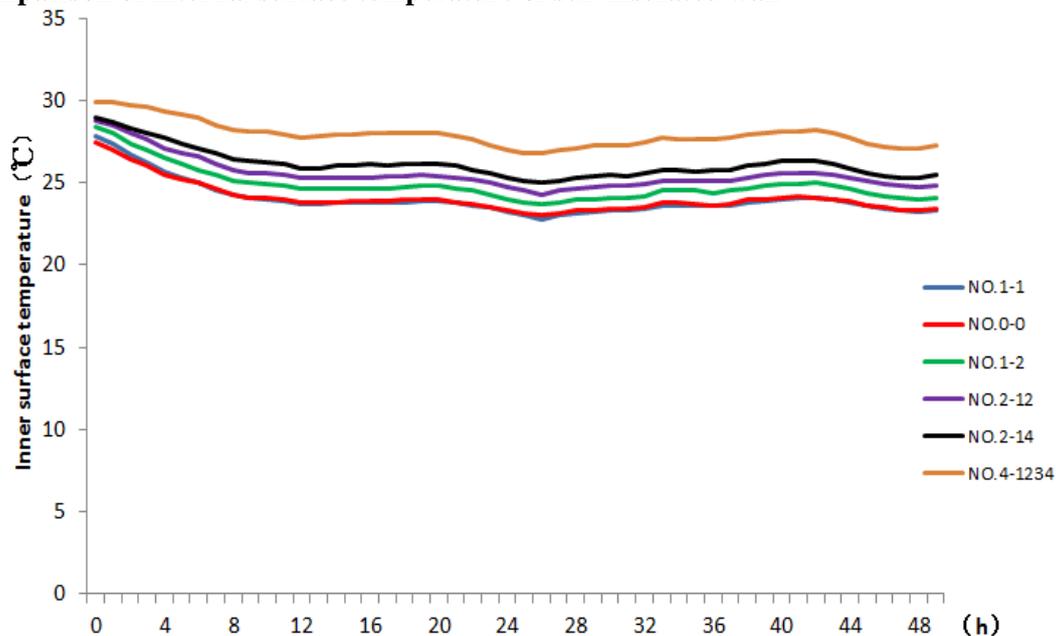


Figure 4. Variation of internal surface temperature over time for 6 different self-insulating blocks.

(1) Figure 4 shows the changes of the internal surface temperature of the composite self-insulated wall with six different EPS filling methods over time. It can be seen that under different filling positions and filling rates. There are significant differences in the internal surface temperature of the composite self-insulated block.

(2) It can be found that there are four filling rates: 0%, 25%, 50% and 100%. With the increase of EPS filling rate, the corresponding internal surface temperature of sintered hollow brick was also higher, indicating that the insulation effect of composite insulation wall with EPS was better than that without EPS, which was beneficial to the thermal protection of building envelope and reduced heat loss and energy consumption.

(3) As shown in FIG. 4, when the filling rate is 25%, the measured temperature of no.1-2 is always higher than that of no.1.1. When the filling rate is 50%, the temperature of NO.2-14 is always higher than that of NO.2-12, indicating that the filling effect near the inside of the wall is much better than that near the outside of the wall at the same filling rate, which can further increase the insulation effect.

4. Comparison of heat flow from inside the insulation Wall

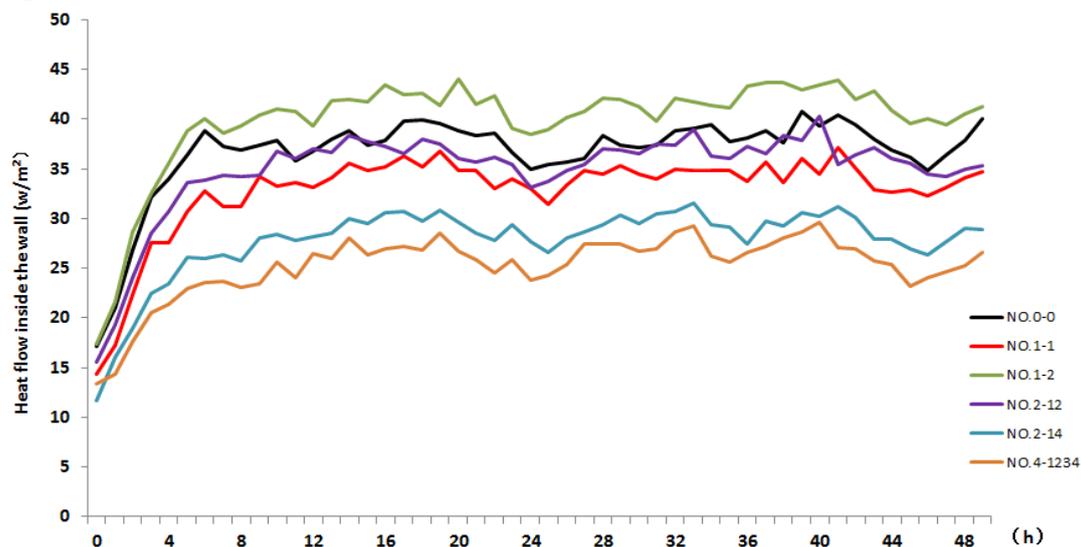


Figure 5. variation of heat flow from inside the insulation wall

It can be seen that the higher the filling rate of EPS, the lower the measured heat flow value, indicating the better insulation performance. The research results showed that under the same EPS filling rate, the self-insulation performance of cavity filling on both sides of the block was better than fresh filling positions. According to heat flow data, NO.1-2 holds the largest heat flow and the worst insulation performance. NO.4-1234 has the smallest heat flow and the best insulation performance.

5. Conclusions

In this study, sintered hollow brick in Chengdu weather was used as the research object to produce composite self-insulated block, the construction of wall enclosure structure, and study the influence of EPS thermal insulation filling on its thermal performance. The following conclusions are drawn:

(1) The composite insulation wall with EPS has significantly better insulation effect than the wall without EPS, which is beneficial to the thermal protection of the building envelope, reduces the heat loss from indoor to outdoor and energy consumption, and is of great significance.

(2) In the process of heat transfer, the insulation capacity of the composite self-insulated wall is not accumulated by adding separately, and the insulation performance is not positively proportional to the EPS filling rate, but depends on the filling mode and combination type of EPS.

(3) At the same filling rate, EPS should be filled as close as possible to the inside of the wall, which is more conducive to the insulation effect.

(4) NO.4-1234 has the smallest heat flow and the best insulation performance.

Acknowledgments

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