Energy Conservation Analysis of Three-Row-Hole Hollow Blocks

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Abstract: In recent years, solid clay blocks have been forbidden in large and middle cities with the wall reformation policy issued in China. Many kinds of new wall materials have appeared in the market, but little research has been done on these new materials' energy conserving effects. The government of China adopted forcible energy conserving measures in the building industry in 2005. Because of this, more attention is being paid to the energy-conserving ability of the wall material. In this paper, we investigate the thermal properties of two different kinds of three-row-hole blocks through experiments, analyze their energy conserving index, and suggest ways to save energy based on the results of the investigation.

Keywords: hollow block**;** wall material; detection; energy conservation

1. PREFACE

The over use of energy and the energy supplying shortage have caused all countries' attention. The whole world is taking certain measures to saving energy. The building energy consumption takes a large proportion of a county's total energy consumption. China always pays great attention to the energy conserving ability of the walls. The relevant departments have issued several documents to require the building industry to innovate the wall material and forbid the use of solid clay blocks gradually, but the situation that clay block and non-energy conserving materials are mainly used in building industry has not changed a lot. In order to change this situation, the General Office of the State Council launched the document 33—"the document on promoting the innovation of the wall materials and popularizing the energy conserving buildings". Many kind of new wall materials appeared in the market after the document being issued. The three-row-hole hollow block is one of them. The thermal property quality of the wall material decides how much the building energy consumption will be directly.

2. THE STUDY OBJECT AND THE BACKGROUND

At present, various load-bearing hollow blocks have been invented. Some of the blocks are used to build wall directly, and some are used for outer and inner heat-preservation after the walls being built. It is rare to see that putting heat-preserving materials and concrete together to make blocks [1]. Two kinds of studying objects are in this thesis: one kind of the hollow block is made of urban waste and concrete; the other kind of hollow block is made by adding expanded perlite or haydite to the former in certain proportion. Figure. 1 shows the structure of them.

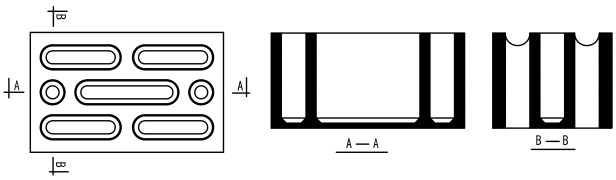

Fig •1 Structure of the three-row-hole hollow block

This hollow block is a new type load-bearing wall material with two practical patent technologies. (The patent number: 200520051504.2; 200520052295.3) Its contour dimension is: 390×190×240mm. The thesis focuses on the heat-transfer coefficient *K* and thermal resistance *R* of the wall built by this new kind of hollow block, and then figure out the specific energy conserving index by comparing it with the traditional solid clay blocks.

3. THEORY EVIDENCE

According to Fourier J. thermal basic law [2], there is:

$$q = -\lambda grandt \quad \text{W/m}^2 \qquad (1)$$

After the block being built into a wall, there is no heat source inside the wall, so the heat conduction coefficient λ of the whole wall can be regarded as a constant. The temperature of the wall's both side can be preserved homogeneous and stable; and the height value of the wall is much high than its thickness value, so the temperature changing rate along the height and wideness can be approximately regard as zero; the temperature only change along the thickness. So, the method of one-dimensional steady heat conduction can be adopted.

Assuming the temperature of the warm side is t_1, and the temperature of the cold side is t_2, we can get:

$$\frac{d^2t}{dx^2}=0 \qquad (2)$$

The boundary condition of the two sides is:

$t\ /_{x=0}= t_1$, $t\ /_{x=\delta} = t_2$,.

Combining this with Fourier J. Law, there is:

$$q=-\lambda\frac{dt}{dx}=\lambda\frac{t_1-t_2}{\delta} \qquad W/m^2$$

$$\lambda=\frac{q\bullet\delta}{t_1-t_2} \qquad W/(m\cdot K) \qquad (3)$$

And

$$R=\frac{\delta}{\lambda}\quad (m^2\cdot K)/W \qquad K=\frac{1}{R}=\frac{\lambda}{\delta}\quad W/(m^2\cdot K) \qquad (4)$$

4. EXPERIMENT TESTING

The method of experiment is adopted in the research of the three-row-hole hollow blocks. By detectiving the value of the tasting points, we can calculate the average heat-transfer coefficient *K* and the thermal resistance *R*.

4.1 Disposition of the Testing Points

The inner structure of the three-row-hole hollow blocks is symmetrical along the central axis, and there are 5 different structural parts in each side. The size of each block is 390×190×240mm. The size of measuring head is 110×55mm. So, we can arrange 5 testing points in the block. The disposition of them is showed in figure 2.

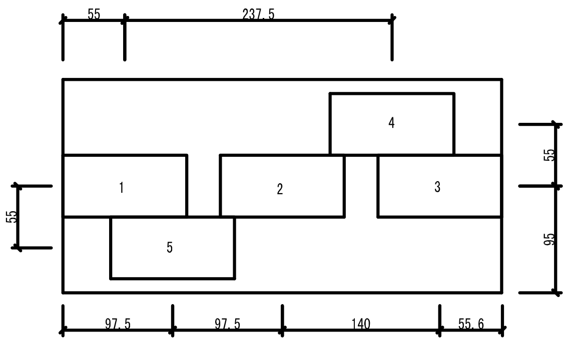

Fig • 2 The Disposition of the testing points

4.2 Detecting Environment and condition

The testing room is sited in a corner of a workshop. The two previous walls of the workshop are used as the outer wall, and the other two wall (wall one and wall two) are built with two kinds of hollow blocks which are made of different materials. The roof is covered by heat-preservation material. One week after the walls being built, drying the walls over heat and beginning to detective 2 days later. The block used to be tested is in the middle of the wall. At the beginning of the test, controlling the humidity and temperature at a stable value (eg. 30 , 45%) by the humidistat and the thermoregulatory. Each testing point has a groove and put the measuring head of the heat-flow meter in the groove. Butter is used to fix them.

The meteorological parameter outside the room during the testing process: temperature 13.7 , relative humidity 44.7%, air flow speed 0.02m/s.

4.3 Testing Instrument

The experimental instrument used in the test: Humidistats, thermeregulator, handle infrared radiation thermometer, air quality tester, digital heat flow meter /thermometer.

5. DATA TESTING AND ANALYZING

5.1 Data Testing and calculating

When testing the heat-flow density of each testing point, measuring the inner and outer temperature of a block. Measuring each point three times and getting three groups of data, then working out the heat conduction coefficient of each time according to formula (3). Pulsing the 3 heat conduction coefficients and working out the average value as the final heat conduction coefficient of the point. Then we can multiply the bulk proportion of each testing part by the average heat conduction coefficient of each point to get the heat conduction coefficient of the whole block. According to formula (4), we can work out the thermal resistance *R* and heat-transfer coefficient *K* of the hollow block.

Through the method above, we can calculate the value of the heat conduction coefficient λ, heat-transfer coefficient *K* and thermal resistance *R* of the blocks in wall one and wall two. The results are showed in table 1.

Table 1 λ, *K* and *R*

Block type	Heat conduction coefficient λ $W/(m \cdot k)$	Heat-transfer coefficient ***K*** $W/(m^2 \cdot k)$	thermal resistance ***R*** $(m^2 \cdot K)/W$
Block in wall One	0.294	1.25	0.816
Block in wall two	0.459	1.912	0.523

According to the dates above, comparing with the traditional solid clay block, the block one's energy saving rate is 63.7%, the block two's energy saving rate is 43.32%. Under the same using condition, the heat which transfers between the inside and outside of the house through the wall will reduce a lot in summer or winter by using these blocks. In this way, the energy-saving purpose can be achieved effectively.

5.2 Error of measurement Analysis

The block heat conduction coefficient is related with percentage of water content, material and internal hole arrangement situation itself. This test time from the beginning is short from being made; percentage of water content is higher. It has the certain influence on the measurement result; the hole inside water vapor content relative is also high when test begin, its heat preservation performance is weaken. In addition, the medium used to remain room temperature and humidity is air, the indoor air has the relative lower flow rate when test, it can accelerate convection heat exchange and has an influence on the test result

6. POSTSCRIPT

China has attached unprecedented importance on energy saving construction since 2005. A series of policies and measures were carried out by the departments concerned to popularize energy saving technologies. In June, the State Council issued documents on the purpose of innovating wall material and popularizing energy saving buildings. In July, the state council issued document on building a society of conservation, including saving energy 、water、land and materials. And also in July, T*he Design Standard of Public Energy Saving Building* was issued. At the end of the year, the 2008 Organizing Committee of Olympic Games examined the energy saving ability of 12 Olympics grounds. In the 11th Five-year plan of China, energy saving construction was listed. All these facts shows that the study and invention of new wall materials and the study of their energy saving ability will be an importance for tomorrows building industry; and it will play an important role in the building market as well.

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