

# Numerical Simulation of Thermal Theory of Sintered Coal Gangue Self-Insulation Block and Wall

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**Abstract:** As a new building material, sintered coal gangue self-insulation block can not only make efficient use of industrial waste but also have a stronger heat preservation effect. In this paper, we use sintered coal gangue self-insulation block with staggered rectangle holes and wall as objects which can be seen commonly in the Anhui market. Through studying block type, wall thickness and masonry mortar type's effects on the heat preservation of the wall based on ANSYS numerical modeling, it proves that with special masonry mortar, sintered coal gangue self-insulation block can reach the best energy-saving effect, which meets the need of green building and sustainable building .

## 1 Introduction

With the increase of national requirements in energy saving and emission reduction, the development of building insulation material and the study in thermal performance are attached great importance. Gangue is one of the salvaged materials in coal mining in our country, which is regarded as cost-effective material not only for it can be used as both raw material and fuel in producing building materials but also for it can keep active after burning. By using the gangue as raw material to produce sintered self-insulation hollow block can improve the whole capability of block.

Li Ping gained the conclusion that the sintered coal gangue masonry wall meet the national energy conservation requirement of saving 65% resource from the thermal performance testing in sintered coal gangue self-insulation block [1]. Li Donghong points out that saving building energy consumption can be started from the study of exterior wall structure-sintered insulation hollow block. Reducing the thermal conductivity of sintered insulated hollow block, thus improving the thermal insulation ability of wall[2]. Ammar Bouchair established a theoretical model for simulating the thermal performance of the hollow brick, and he carried out the steady-state thermal analysis of the sintered hollow brick wall; The study shows that increase the hole length of the sintered hollow brick, add adiabatic insulation material in the slot, and reduce the radiation rate on the surface of the hole can improve the thermal performance of brick. [3].

In this paper, we discuss the most energy-saving thermal insulation material collocation method through the numerical simulation and comparison of the insulation effect of sintered coal gangue self-insulation

block and ordinary clay block as well as walls with different masonry mortar or different thickness.

## 2 Block Selection and Determination of Parameters

### 2.1 Selection of Block

Normally, the holes of hollow block are different. Li Jiancheng from South China University of Technology Subtropical Building Research Office, proved that in the same hole rate, under the condition that the outer wall and inner wall thickness of the hollow block are the same, the rectangular hole heat transfer coefficient is the smallest, the diamond is second, the circle is the largest whether considers the radiation of the inner surface of the hollow block or not[5] By calculating the average thermal resistance of block with different holes , Western studies have found that the best arrangement of sintered block holes is staggered, so this paper studied the coal sintered gangue self-insulation block with staggered and rectangular holes, which is commonly used in the Anhui market. The block sizes are 240mm×200mm×190mm and 240mm×240mm×19mm.

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**Figure.1.** Picture of Real Sintered Coal Gangue Self-insulation Block

### 2.2 Determination of material parameters

By referring to the code of design for civil building thermal engineering gb50716-1993, the thermal conductivity of the selected block and mortar can be obtained which are Shown in Table.1.

**Table.1.** Thermal conductivity of related materials.

Name of the Material	Heat Conductivity Coefficient
Clay Brick	0.76
Colliery Wastes Brick	0.57
Air	0.087
Common Cement Mortar	0.93
Special Cement Mortar	0.30

### 2.3 Determination of environmental parameters

Referred to “indoor air quality standard” GB t1883-2002 and the main meteorological parameters of Anhui Province, we assume that the summer outdoor temperature is 28.1 °C and indoor is 25 °C , winter outdoor temperature is 2.6 °C and indoor is 20 °C . Above all, the outdoor and indoor limited simulation values are 2.6 °C and 20 °C respectively.(The outdoor and indoor surface convection heat transfer coefficients are 25 w/m<sup>2</sup> \* k. and 9.1 w/m<sup>2</sup> \* k respectively.)

## 3 Modeling and Computing

### 3.1 Model Building

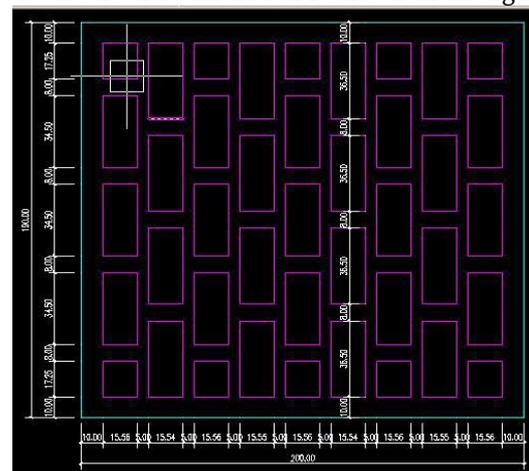
This paper selects sintered coat gangue self-insulation block and ordinary clay brick block with the same hole rate (39.6%) and the same size (240mm\*200mm\*190mm), using the ANSYS software

to simulated the thermal performance of two blocks. Steps are as follow.

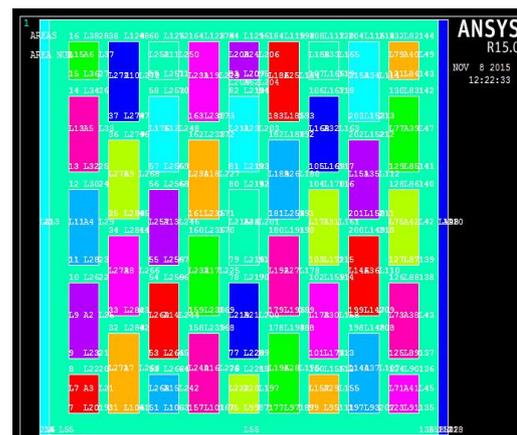
- Define the job file name
- Define the material attribute value
- Define the section size type
- Set up the geometric model (point, line, surface)
- Mapped Meshing
- Impose constraints and loads
- Solve and get the result

### 3.2 The Numerical Modeling of Block

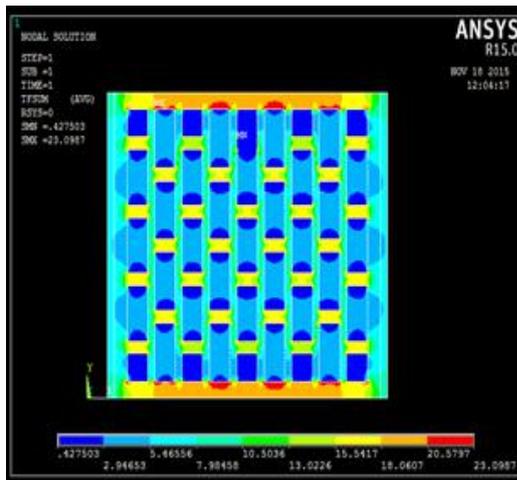
The result of value simulation is shown in the figure:



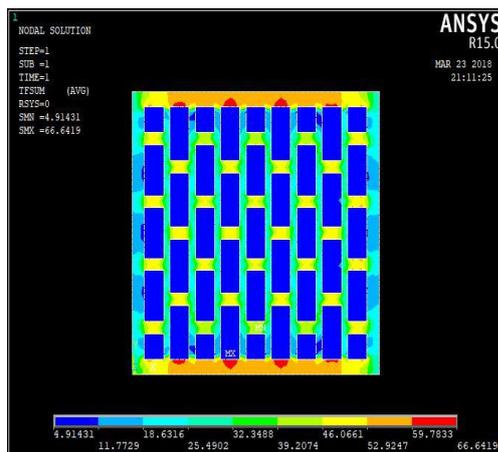
**Figure.2.** Set up brick model



**Figure.3.** Meshing



**Figure.4.** Heat Flux distribution diagram of sintered coal gangue self-insulation block



**Figure.5.** Heat Flux Distribution diagram of ordinary clay block

### 3.3 Discussion

This paper uses the heat transfer coefficient as the index to evaluate the thermal performance of the block. The calculation formula is  $q = K(T_1 - T_2)$ , where  $K$  is heat transfer,  $q$  is average heat flow;  $T_1$  and  $T_2$  are the average temperature on each side of the block value.

Under the same condition, the maximum heat flow of sintered coal gangue self-insulation block is  $q = \frac{23.48w}{m^2 \times C}$ , calculation result is  $K = 1.327 < 1.5$ , which meets the design standards for energy efficiency of residential buildings in Anhui province. While the maximum heat flow 1, 5of ordinary clay blocks is  $q = \frac{66.64w}{m^2 \times C}$ ,  $K = 3.76 > 1.5$ , obviously beyond the standard that regulated in the design standards for energy efficiency of residential buildings in Anhui province

Under the same conditions, the thermal insulation resistance of sintered coal gangue self-insulation block is better than the ordinary clay blocks, which meets

the requirement of energy conservation and environmental protection better.

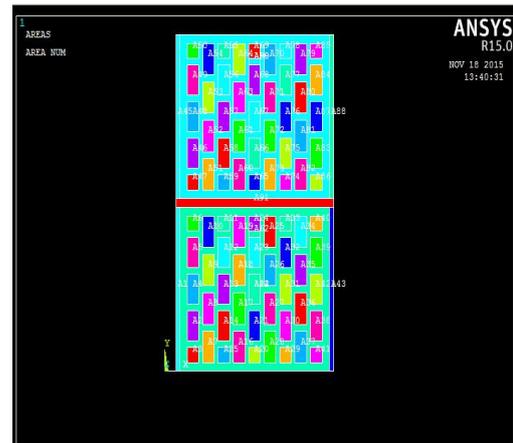
## 4 Numerical simulation of thermal performance of masonry walls

In the third part we draw a conclusion that sintered coal gangue self-insulation block has good thermal insulation effect by analysing single block rectangular block.

Next, this paper discusses the effect of mortar's type on the thermal performance of masonry wall under steady temperature through simulation and comparison of thermal performance of sintered coal gangue self-insulation block walls with two different kinds of masonry mortar (ordinary cement mortar(The heat conductivity coefficient is  $0.93w/m \times k$ ) and special cement mortar(The heat conductivity coefficient is  $0.30w/m \times k$ ) )and different thickness( 200mm and 240mm ).

### 4.1 Modeling Calculation

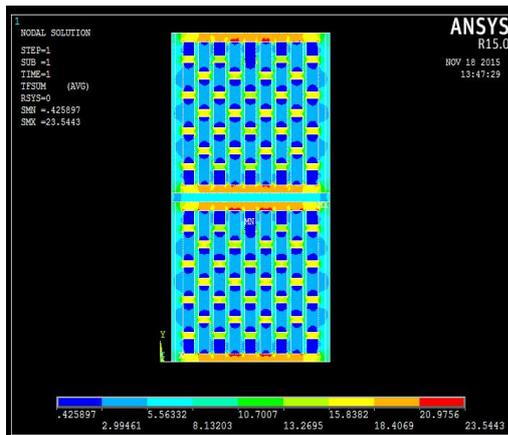
The process of wall modeling is similar to that of the third part. Its grid partitioning method is shown in the figure.



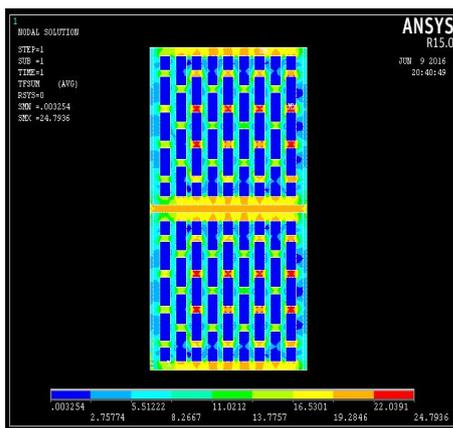
**Figure.6.** Picture of wall modeling grid partitioning method

### 4.2 The result of value simulation

Under steady temperature, the numerical simulation results of the thermal performance of two kinds of sintering coal gangue with two kinds of masonry mortar (ordinary cement mortar and special cement mortar) and different thickness (200 mm and 240 mm) are shown respectively in the figures.



**Figure.7.** Heat flux distribution diagram distribution diagram of ordinary cement mortar block



**Figure.8.** Heat flux distribution diagram distribution diagram of special cement mortar block

### 4.3 Results Analysis

By simulating values, we come to the conclusion that sintered coal gangue self-insulation block (thickness are both 200mm) with two different kinds of masonry mortar can meet the requirement of saving 50% energy. The heat transfer coefficient of wall with special masonry mortar is smaller than that with cement mortar, which states special masonry mortar can do better in wall energy saving. With 240mm thick masonry panel, using cement mortar can only save 50% energy, while using special masonry mortar can save 65% energy.

## 5 Conclusion

Compared to traditional clay brick blocks, sintered coal gangue self-insulation block can not only use industrial waste more efficiently, but also have better heat preservation and smaller heat transfer coefficient, which more accord with the requirements of green building and sustainable building. With special masonry mortar, the sintered coal gangue self-insulation block can gain better thermal performance.

This paper's conclusion provides support for the promotion of this environmental-friendly building material.

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