

# FCB Composite Panel Thermal Insulation Performance of Finite Element Analysis

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**Abstract.** Through the study of the thermal insulation performance of FCB composite panel of finite element simulation, the wall heat transfer coefficient  $K$  is determined. By changing different keel spacing and the hole size, studies the influence of different parameters on the wall heat preservation performance. Finite element results show that the three kinds of structure forms of the heat transfer coefficients of FCB composite panel meet the cold (C) palisade structure wall of the heat transfer coefficient of the limit, which is required in the Design standards for energy efficiency residential building of Liaoning province.

## 1. Introduction

Due to composite panel has a green, energy-saving, light quality, economy, and the advantages of high strength, it is widely used in steel structure housing palisade structure. But as to meet the requirements of thermal insulation, energy saving, and fire in the cold region of the steel structure of composite panel applications are still limited. This paper proposes a new steel structure wall form, named FCB (Fiber Cement Board) composite panel.

FCB composite panel is mainly composed of dragon skeletons, cement fiber board and rock wool. Dragon skeletons and cement fiber board are fixed with tapping screw, cement fiber board and rock wool are connected with gelled material. Within the cavity is formed between inside and outside wall plate and keel filling rock wool to improve the insulation performance of composite panel. This article through to the insulation performance of the composite panel simulation, to explore whether such panel can be used in cold region in China or not.

## 2. Specimen design

By changing different keel spacing and the hole size, studies the influence of different parameters on the wall heat preservation performance. Design of the three kinds of FCB composite panel in table 1.

Table 1 Parameter design of FCB composite panel

The type of panel	Panel size (mm)	Keel spacing (mm)	Hole size (mm)
FCB-600	2800×2400×140	600mm	null
FCB-800	2800×2400×140	800mm	null
FCB-hole	2800×2400×140	600mm	1200×1500

The top and bottom of FCB composite panel is cement fiber board, which thickness is 10 mm. Internal area layout section height of 120 mm steel keel as the main stress components, In order to ensure the panel has enough stiffness, decorate a certain number of sheet steel in the keel internal. Arrangement the left edge and the upper edge of the keel protruding, arrangement the right edge and the lower edge of the keel indenting, arrangement vertical keel in the central dragon framework, which height is 80 mm. The cross section form of three kinds of FCB composite panel as shown in Fig.1. For the study of panel internal temperature change along the section height direction, several points were set up inside the panel. The location of the point as shown in Fig. 2.

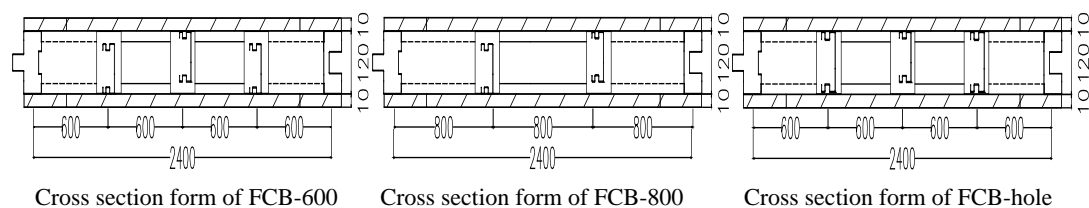


Fig. 1 The cross section form of three kinds of FCB composite panel

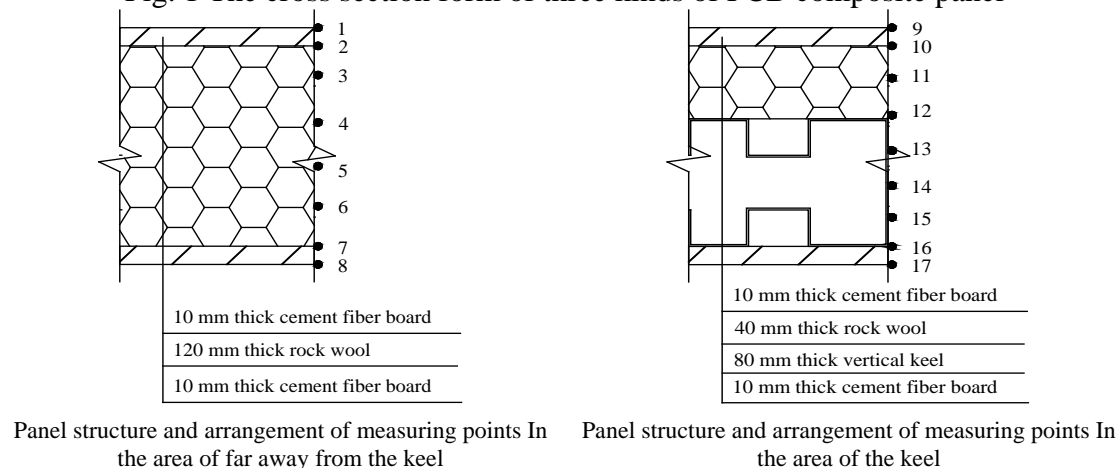


Fig. 2 The location of the measuring points

### 3.The finite element analysis

#### 3.1 Summary of the finite element.

This article selects the ABAQUS finite element software to simulate the heat transfer process of FCB composite panel, By measuring the temperature and heat flux of the panel, according to the basic principles of heat transfer, calculate the panel heat transfer coefficient approximately. By changing the thermal insulation material, keel spacing, hole size, and a series of parameters, further summarizes the main factors influencing the heat transfer performance of the FCB composite panel, the heat transfer performance rule of FCB composite panel is finally obtained.

#### 3.2 The choice of finite element model.

Steel keel choose DS4 thermal shell element, cement fiber board and rock wool selecting thermal DC3D8 entity unit. According to the thermal design code for civil building "GB50176-93": the winter outdoor temperature of Shenyang area is  $-19^{\circ}\text{C}$ , the average winter indoor heating temperature is  $18^{\circ}\text{C}$ .The exterior surface coefficient of heat transfer is  $23 \text{ W}/(\text{m}^2 \cdot \text{K})$ ; The inner surface heat transfer coefficient is  $8.7 \text{ W}/(\text{m}^2 \cdot \text{K})$  [1]. Material parameters of the FCB composite panel are shown in Table 2.

Table 2 The material parameter table of FCB composite panel

Material	Coefficient of thermal conductivity $\text{W}/(\text{m}^2 \cdot \text{K})$	Density $\text{Kg}/\text{m}^3$	Specific heat capacity $\text{KJ}/(\text{Kg} \cdot \text{K})$
Steel keel	58.2	7850	0.48
Cement fiber board	0.34	1000	2.51
Rock wool	0.054	200	1.22

#### 3.3 The basic assumptions.

On the premise of meet the accuracy, using the three hypotheses to simplify the calculation.Assuming one: Indoor and outdoor temperature is constant. Simplified to steady heat transfer problem[2].Assuming two: Don't consider the contact thermal resistance and radiation heat transfer[3]. Assuming three: Assume that each part material for binding contact, the connection between the keel without considering the influence of welding.

### 3.4 Boundary conditions.

In this paper, according to the winter indoor and outdoor air calculation parameters of Shenyang area for calculating basis. Given the third kind boundary condition, according to the steady state heat transfer analysis. Calculation of winter indoor heating temperature of  $18^{\circ}\text{C}$ , the outdoor calculated temperature of  $-19^{\circ}\text{C}$ , Indoor and outdoor convective heat transfer coefficient of  $8.7 \text{ W}/(\text{m}^2 \cdot \text{K})$  and  $23 \text{ W}/(\text{m}^2 \cdot \text{K})$  respectively. Undefined touching part considered insulation parts.

### 3.5 Determination of heat transfer coefficient.

With convective heat transfer calculation formula for heat flux, heat transfer coefficient and the relationship between the temperature, Finite element analysis on panel heat transfer coefficient is equal to the interior and exterior panel heat flux density of average divide the internal and external surface temperature of the average temperature difference [4].

### 3.6 The finite element results.

Three types of panel heat transfer coefficients are shown in table 3.

Table 3 The heat transfer coefficients of three types of FCB composite panel

The type of panel	The external surface heat flow density $\text{W}/\text{m}^2$	The Internal surface heat flow density $\text{W}/\text{m}^2$	The average heat flux density $\text{W}/\text{m}^2$	The temperature difference $^{\circ}\text{C}$	Heat transfer coefficient
FCB-600	14.98	12.96	13.97	37	0.378
FCB-800	15.01	14.95	14.83	37	0.401
FCB-hole	20.70	17.36	19.03	37	0.514

From the analysis of heat transfer coefficient FCB composite panel: The heat preservation performance of the above three kinds of FCB composite panel are meet the residential building energy efficiency design standards of Liaoning province for the cold (C) envelope thermal performance parameters of the limit (Heat transfer coefficient  $K \leq 0.6 \text{ W}/(\text{m}^2 \cdot \text{K})$ ) [5]. Also found that the heat preservation performance of FCB-600 is the best, the second is the FCB-800, the last is the FCB-hole. Figure 3 shows the three kinds of the surface heat flow density distribution of FCB composite panel and keel internal temperature distribution in the cloud.

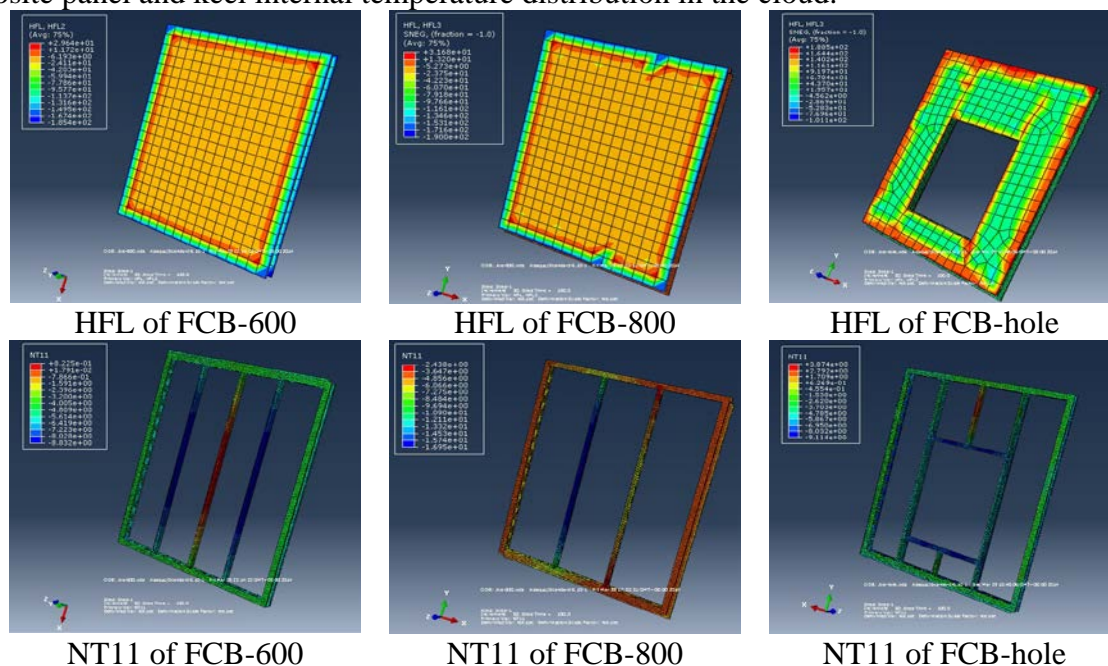


Fig.3 Heat flow density distribution and temperature distribution

Diagram shows that the existence of the internal keel make a certain impact of the wall surface heat flow density distribution, the change in temperature along the cross section of vertical keel is not obvious. Due to the vertical keel in the middle of the cross section height below the edge keel cross section height, and the vertical keel is staggered along the section height, Lead to vertical keel don't contact with the top panel and bottom surface panel at the same time. Combined with rock wool good

heat preservation performance, make the wall panel to reduce the cold bridge on the heat preservation in a certain extent. Along the direction of vertical section, due to the vertical keel side temperature influence, the end and the central vertical keel of the temperature difference is produced. Fig.4 shows the temperature of each point on the FCB-600 and FCB-800. In the same place, different keel spacing of wall temperature variation along the thickness direction is almost the same. The temperature of the rock wool received great influences on the surrounding keel. In comparison, 600 mm distance between vertical keel has less effect on the temperature changes of the upper rock wool, 800 mm distance between vertical keel greatly influenced by the temperature changes of the upper rock wool. Due to the vertical keel upper and lower flange for the concave section, the vertical keel and rock wool reduce the contact area. Under the effect of temperature difference, the keel on both sides of the rock wool double flange width area temperature field affected by the keel and a non-uniform variation phenomenon is not obvious, so there is no "keel affected zone", But on the edge keel exists the "keel affected zone", and the effect is more obvious.

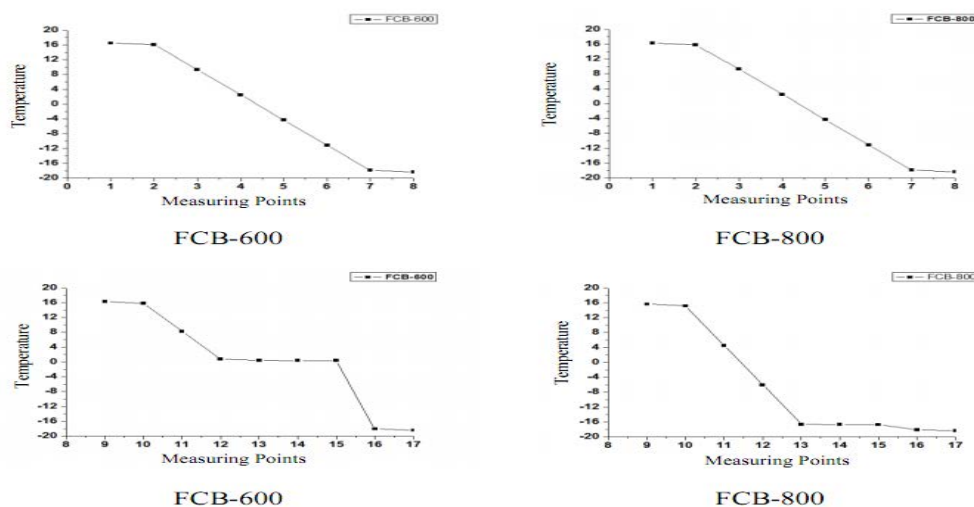


Fig.4 Measuring point temperature change curve

#### 4. Conclusion

Through the finite element software ABAQUS to simulate the heat transfer process of FCB composite panel, the heat transfer coefficient of three kinds of FCB composite wallboard are less than the cold (C) top outer wall heat transfer coefficient of the limit (K 0.6 or less), which is required in the residential building energy efficiency design standards of Liaoning province, and the heat preservation performance of FCB-600 is the best, the second is the FCB-800, the last is the FCB-hole.

By cutting section height of the keel, designing the keel of top flange and bottom flange design into a concave shape, as well as the methods of staggered keel, reduced "keel affected zone" within the influence of the temperature change of rock wool. Effectively reduces the heat bridge effect on the negative impact of the wall heat preservation performance.

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