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Study on the Flexibility of Self-insulation Wall with Energy-saving Sintered Bricks

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Abstract. This paper analyses the advantages of spreading self-insulation wall, which uses the energy-saving fired hollow bricks as the major structure, in cold region rich in natural resources of loess. Through calculating the thermal parameters, concluding that this kind of wall can meet the national requirement of saving-energy by 50%, even can meet the national requirement of saving-energy by 65% to limit the shape coefficient of building in some region.

Introduction

It is rich of loess resources in cold region in china, which most multistoried buildings are taken use of KP1 perforate bricks as main load-bearing material of walls, even in rural areas make use of clay bricks. Along with the protection of loess resources serious, it is forbidden to use clay bricks in some cities since 2000, named as "ban solid", for the purpose to reduce the damage of farmland and protect the environment. Because of small mass, high density and large consumptions in firing process of clay bricks, also the poor insulation, it is can not meet the requirement of energy-saving with single wall material. That's the reason for most buildings in rural areas having a poor thermal environment indoor. Ban solid complexes the current situation of China and the requirements of energy-saving, however, it should be separated treatment based on the resources in different regions.

According to incomplete statistics, sintered products accounts for more than 80% in whole wall materials all of country, which is due to the good durability, no distortion, better overall performance and lower prices, also because of no-replaced products in market. A survey 'it can do not destroy Tin to burned sintered bricks' taken by Baoji city of Shaanxi province is in the known that *the loess plateau of loess deposits available to national firing brick for more than ten thousand years, the loess resources of Shannxi can provide for whole province above thousands of years*, compares with the 30 years which main raw material of cement production limestone resources for exploitation, the loess resources is richer more[1].It contains more loess resources in cold region such as Gansu, shaanxi, shanxi province, and it takes advantages of developing self-insulation wall with energy-saving sintered hollow bricks for multistoried buildings in these areas.

Energy-saving sintered bricks structure characteristics

Through research investigation, knowing that most multistoried buildings of Shaanxi, Shanxi are maked use of KP1 perforated bricks as load-bearing wall materials, which void ratio for 26.4%, thermal conductivity for λ=0.52W/(m·K), thermal resistance for R=0.462(m^2·K)/W, coefficient of heat transfer for K=1.528 W/(m^2·K) when using for single material wall. Take Shaanxi province for instance, bases on "Design standard for energy-efficient civil building" and "Detailed rules and regulations of implementation in Shaanxi region", the limitvalue of coefficient of heat transfer for heating building wall in Shaanxi region shown in Table 1.

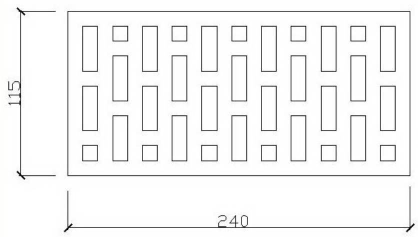
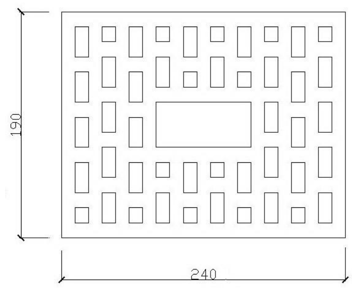
From Table 1, it is not satisfied the energy-saving requires using single wall material with KP1 Bricks, and have to adopt thermal insulation measurements to content the limitvalue of coefficient of heat transfer.

Table 1. The Limitvalue of Coefficient of Heat Transfer in Shaanxi region

Building subarea / shape coefficient	First subarea (Yulin)	Second subarea (Xi'an)	Third subarea (Baoji)
shape coefficient≤0.30	0.75	$\frac{0.85}{1.10}$	$\frac{1.00}{1.28}$
shape coefficient＞0.30	0.60	$\frac{0.62}{0.78}$	$\frac{0.70}{1.00}$

For the aim to spread 30% energy saving in Xi'an region and realize 50% energy saving, under the leadership of related departments from China country and ShaanXi province, Xi'an construction official has organized a group consisted of design company, science commission and universities to research *'Spreading hollow bricks building-- applied technology researching and experimental unit of hollow brick'* .Over many years researching and summing up thermal characters of traditional hollow bricks, the research group developed two types of hollow bricks named DS1 bricks and DS2 bricks with thermal conductivity for λ=0.41W/(m·K). Based on the two types of DS bricks, it is created more interior room space when 370 thickness walls being taken the place of 315 thickness walls. At present, along with the land for urban construction lack gradually, it has more significance to use 315 thickness walls. The geometrical parameters of DS bricks are shown in Table 2.

Table 2. The geometrical parameters of DS bricks

DS1 Brick	DS2 Brick
 Overall Dimension: 240*115*90[mm] Void ratio: 33% Holes: 33 square holes and rectangular holes	 Overall Dimension: 240*190*90[mm] Void ratio: 36% Holes: 46 square holes and rectangular holes, 1 scratchcore

Thermal characteristics of Self-insulation Walls with Energy-saving sintered bricks

Knowing from experiences, the lowest average thermal conductivity for 0.207W/(m·K) belongs to rectangular hole among four types of holes, including rectangular hole, rhombic hole, square hole and circular hole, the highest average thermal conductivity for 0.425W/(m·K) belongs to circular hole, 0.360W/(m·K) for rhombic hole and 0.404W/(m·K) for square hole[2]. Theoretically, the thermal insulation property of DS bricks wall is better than the thermal insulation property of KP1 bricks wall, because of the rectangular holes for DS bricks and circular holes for KP1 bricks.

Generally, thermal resistance R and coefficient of heat transfer K are used to describe the insulation property of wall, and thermal inertia index D is used to describe the heat-shielding performance of wall. Taking 240 thickness walls for instance, comparing the thermal insulation properties between DS bricks wall and KP1 bricks wall. DS bricks wall uses inorganic insulation mortar to replace cement sand rendering with thermal conductivity for λ=0.1W/(m·K). The structures of DS bricks wall and KP1 bricks wall are shown in Table 3.

Table 3. Structures of DS bricks wall and KP1 bricks wall

Wall type	Structures
DS bricks wall	①Paint layer: λ=0.93[W/(m·K)], d=2[mm],S=11.37[W/(m^2·K)];
	② Inorganic insulation mortar: λ=0.1 [W/(m·K)], d=20[mm],S=3.5 [W/(m^2·K)];
	③DS brisk: λ=0.41[W/(m·K)], d=240[mm],S=5.525[W/(m^2·K)];
	④ Inorganic insulation mortar: λ=0.1[W/(m·K)], d=30[mm], S=3.5 [W/(m^2·K)];
	⑤Paint layer: λ=0.93[W/(m·K)], d=2[mm], S=11.37[W/(m^2·K)];
KP1 bricks wall	① Cement sand rendering: λ=0.93 [W/(m·K)], d=20[mm],S=11.37 [W/(m^2·K)];
	②KP1 brick: λ=0.52[W/(m·K)], d=240[mm], S=6.88[W/(m^2·K)];
	③ Cement sand rendering: λ=0.93[W/(m·K)], d=20[mm], S=11.37 [W/(m^2·K)];
	④Polymer mortar: λ=0.93[W/(m·K)], d=3[mm], S=11.37[W/(m^2·K)];
	⑤XPS board: λ=0.028[W/(m·K)], d=30[mm],S=0.7[W/(m^2·K)];
	⑥Polymer mortar: λ=0.93[W/(m·K)], d=3[mm], S=11.37[W/(m^2·K)]
	① Cement sand rendering: λ=0.93[W/(m·K)], d=20[mm], S=11.37 [W/(m^2·K)];
	②KP1 brick: λ=0.52[W/(m·K)], d=240[mm], S=6.880[W/(m^2·K)];
	③ZL rubber powder mortar: λ=0.059[W/(m·K)], d=30[mm], S=1..077 [W/(m^2·K)];
	④Anti-crack mortar: λ=0.93[W/(m·K)], d=4[mm], S=11.37[W/(m^2·K)];

Insulation properties Comparison. Based on parameters from Table 3, thermal resistance equation and coefficient of heat transfer equation numbered (1)-(2), calculating the R for three wall types and the results listed on Table 4.

$$R_0=R_i+\sum d/\lambda+R_e \tag{1}$$

$$K=1/R_0 \tag{2}$$

Table 4. Results of R, K,D

Wall type	R_0/[(m^2·K)/W]	K/[W/(m^2·K)]	D
DS bricks wall with inorganic mortar	1.240	0.807	4.903
KP1 bricks wall with XPS insulation	1.635	0.612	4.487
KP1 bricks wall with ZL rubber powder mortar	1.100	0.909	4.212

From the results shown in Table 4, it is known that the insulation property of DS bricks wall is lower than KP1 bricks wall with XPS insulation, but is upper than KP1 bricks wall with ZL rubber powder mortar. Although the insulation property of DS bricks wall is not the best type to choose, using inorganic mortar to replace cement sand rendering without any other insulation material can reduce the investment of building compared with the wall which using KP1 bricks wall with XPS insulation.

Heat-shielding performance Comparison. Based on parameters from Table 3 and the thermal inertia index equation numbered (3), calculating the D for three wall types and the results listed on Table 4.

$$D=\sum R_i\cdot S_i \tag{3}$$

Comparison the thermal inertia index of three wall types, it is known that DS bricks wall has the highest D among three walls, means DS bricks wall has the best thermal stability.

Advantages of Self-insulation Wall with Energy-saving sintered bricks

From the calculation of R, K and D between DS bricks wall and KP1 bricks wall which using different insulation material, it shows that DS bricks wall with inorganic mortar can satisfy the require of 50% energy-saving. Comparing with external thermal insulation system, the self-insulation wall system has its own advantages to extend:

(1) Durability. The materials of external thermal insulation system can be used only 15-30 years, but the main structures of building can be used at least 50years, so it causes that the insulation player and main structures having an inconsistent service life. When the building making uses of self-insulation walls, it solves the problem of inconsistent service life between insulation materials and main structures, improves the durability of whole building.

(2) Fire Safety. The materials of external thermal insulation system belong to organic materials which are flammability. When using self-insulation walls, it is nonentity with the problems and insures the fire safety of external walls.

(3) Mechanical shock. The materials of external thermal insulation system use to be fixed on the surface of wall by anchor bolts or poured with main structure as a lining of exterior sheathing. Whatever method used, the insulation material won't be a unity with main structure if building, its mechanical shock is worse than self-insulation wall.

Conclusions

Energy-saving as a policy should be carried through whole the country, it is better to develop self-insulation wall with energy-saving sintered bricks such as DS bricks in the regions which is rich of loess resources in China, combining the research of matched mortars. Thus, developing of self-insulation wall with DS bricks can be called 'tailor measures to suit local conditions' in the areas rich of loess resources in cold region in China and it solves problems produced by external thermal insulation system during use.

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