Research on Self-thermal Insulation Wall Construction Technology of Autoclaved Aerated Concrete Block

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Abstract: To promote the application of autoclaved aerated concrete(AAC) block self-thermal insulation system in severe cold and cold zones, this paper proposes the construction of self-thermal insulation wall, shear wall insulation treatment measures and the detail construction of beam column thermal bridge. According to design standard for energy efficiency of residential building, this paper analyzes the thermal performance of self-thermal insulation wall of AAC block, and focuses on the inner surface condensation trouble by illustrating the example of 200mm-thick reinforce concrete shear wall in Jinan region. The research results show that, AAC block of different levels with different thickness can meet the requirements of residential building energy conservation design standard in the cold and severe cold zones. The construction treatment of pasting heat-thermal plates outside concrete shear wall and smearing thermal-insulating mortar can avoid the inner surface condensation trouble of AAC block self-thermal insulation system wall.

Introduction

In the practice of building external wall insulation, the application of exterior wall external insulation is the most widely practice. With the popularization of engineering application, the exterior wall external insulation is troubled with the issues of poor durability, non-synchronous feature in service life of buildings, difficulty in maintenance, apt to cracking on finish coat and poor fireproofing nature[1]. Self-thermal insulation wall of AAC block integrates the functions of load bearing and thermal insulation, which realizes the same life of thermal insulation and building structure. It fundamentally solves the maintenance of exterior wall external insulation and secondary change. The AAC block is made of inorganic materials, undoubtedly with its fireproofing performance. Thus, in recent years, self-thermal insulation system of AAC block has been the focus of industrial research and has been applied in the engineering practice of summer-hot and winter-cold areas in the south. However, the northern cold areas propose high thermal performance requirements on walls. AAC block is usually used as the interior walls or the exterior walls neglecting the thermal-insulation effect. To promote the application of AAC block of self-insulating system in the severe cold areas, this paper proposes the construction of self-thermal insulation wall of AAC block, shear wall and thermal-bridge thermal-insulation processing measures. Meanwhile, combined with the design standard for energy efficiency of residential building in severe cold and cold zones, it makes thermo technical analysis on self-thermal insulation wall, shear wall and thermal-processing measures of beam column hot bridge.

Structural design of self-thermal insulation wall of AAC block

Self-thermal insulation system of AAC block is the self-thermal insulation wall of AAC block, which composes of reasonable matched shear wall thermal-insulating processing measures and thermal bridge insulating construction. The exterior-decorated surface of self-thermal insulation wall can be made by two ways, coating or facing bricks. Fig.1 is the structural diagram of of self-thermal insulation wall of AAC block pasting facing bricks, including those aspects from inside to outside as follows, internally-decorated surface, batch-embedding processing layer, AAC block wall, waterproof interface layer, crack-resisting protecting layer, external-decorated surface layer[2]. This wall effectively lowers the heat losses of self-thermal insulation wall on the parts of concrete beam, pillar, and shear walls, solves the condensation trouble of exterior wall heat-bridge parts, and improves the anti-permeability and the construction of exterior-finish coating of AAC block. It is applicable to the thermal insulating construction of building exterior walls.

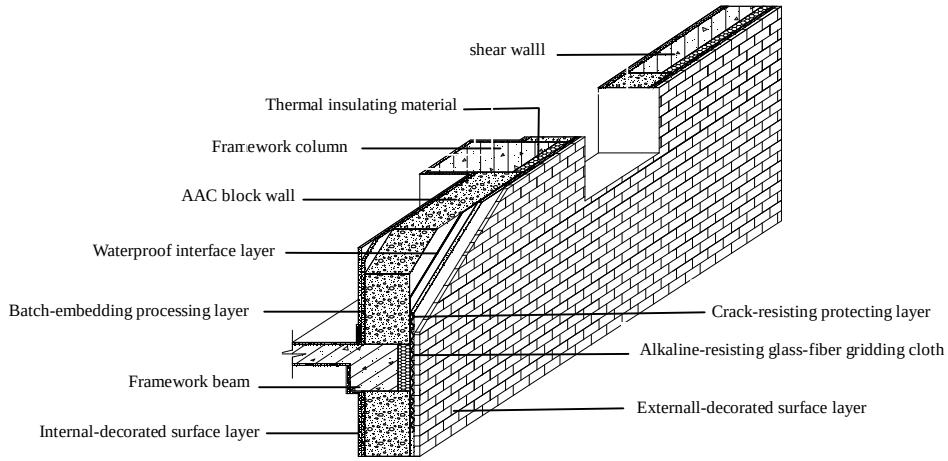


Fig. 1 Structural diagram of self-thermal insulating wall of AAC block

Construction of self-thermal insulation wall of AAC block. GB11968-2006, *Autoclaved Aerated Concrete Block* has proposed requirements on the intensity level and thermal conducting coefficient of AAC block (Table 1). Due to the lower B03 masonry block strength and the large thermal-conducting coefficient of B07 and B08 blocks, thus it is not appropriate to be taken as the building block materials of self-thermal insulation wall. Self-thermal insulation wall of AAC block may be built from AAC block of B04, B05 and B06 level. The thickness of wall shall be determined according to the requirement of energy-saving design.

Table 1 Physical property of AAC block

Level of dry density		B03	B04	B05	B06	B07	B08
Level intensity	Superior product (A)	A1.0	A2.0	A3.5	A5.0	A7.5	A10.0
	Qualified product (B)			A2.5	A3.5	A5.0	A7.5
Heat conductivity coefficient (dry status) /($W \cdot m^{-1} \cdot K^{-1}$) ≤		0.10	0.12	0.14	0.16	0.18	0.20

AAC block used for self-thermal insulation wall requires special mortar, with the mortar thickness of 3-5mm.The national industrial standard, *Masonry Mortar and Plastering Mortar for Autoclaved Aerated Concrete Block* JC890-2001, was issued in 2002. The performance indicators of special building mortar of AAC Block regulated in the standard refers to Table 2. The special masonry mortar has small thermal conducting coefficient. The AAC block built with special mortar is characterized by good thermal performance and balanced heat transfer, which can efficiently avoid wall cracking[3].

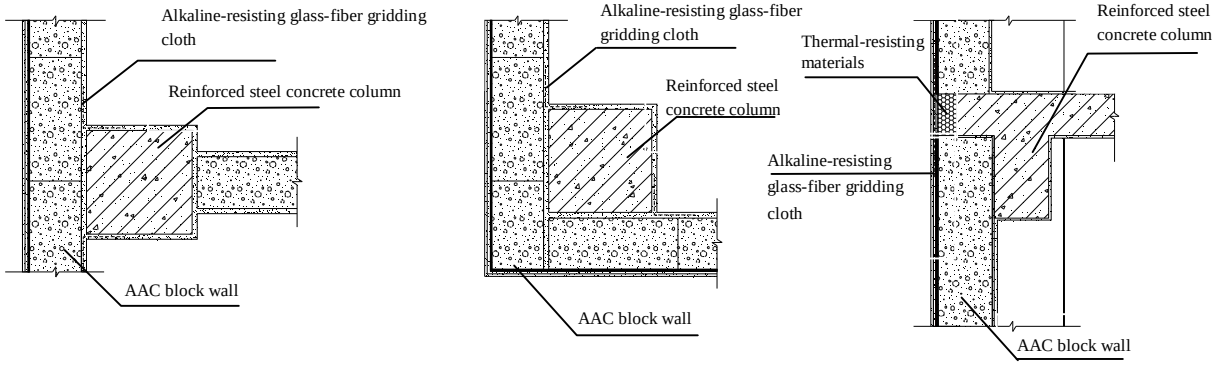
Table 2 Performance indicator of special masonry building mortar of AAC block

Item	Dry density /(kg·m^{-3})	Thermal conducting coefficient /(W·m^{-1}·K^{-1})	Compressive strength /MPa	Bonding strength /MPa	Frost-resistance 25 times/%	Hierarchy/ mm
Building mortar	≤1800	≤1.1	2.5、5.0	≥0.20	Quality losses ≤20 Strength losses≤5	≤20

Shear wall thermal-insulating processing measures. The selected materials of shear wall thermal-insulating construction processing may be adopted from (1) thermal-insulating mortar, like glass bead, adhesive polystyrene granule, (2) thermal-insulating materials, like EPS panels, XPS panels, and AAC block batten. When adopting thermal-insulation materials for shear wall thermal-insulating process, glass bead and adhesive polystyrene granule may be plastered at the outside of reinforced concrete shear wall. Implement mortar for coating or anti-crack mortar on the surface (adding reinforcement glass fibre); then conduct the internal and external decorated surface processing (coating decorated surface or surfacing brick decorated surface) [4]. When adopting thermal-insulating plates for shear wall insulating processing, it is required using special pasting mortar EPS plates, AAC block battens. When necessary, special anchored parts and L-shape special hanging parts may be used to fix thermal-insulating panels on the outside of shear wall.

Thermal bridge parts construction of beam column. In the system of self-thermal insulation wall, beam column mainly refers to the reinforced steel concrete beam and pillar parts in the exterior wall. Compared with thermal-insulating wall, these parts are characterized by thermal resistance, strong heat-transfer capability and strong heat flux, easily causing large building heat loss. If heat bridge of beam pillar is not processed appropriately, the temperature of internal surface is lower than the indoor dew point temperature, causing indoor condensation. The heat bridge parts construction of beam pillar includes the following two parts.

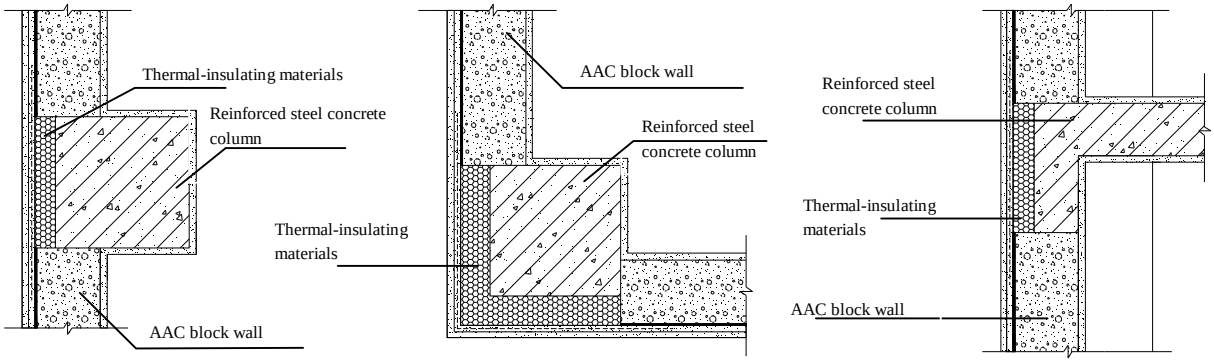
(1) Construction of externally-packed pillar thermal bridge: While adopting building scheme design, under the conditions of meeting structure requirements, arrange the floor slab out of column 200-250mm as designed and make masonry wall is built out of framework column. That is, AAC block will enclose the column totally (Fig.2), reinforced concrete beam, pillar-treatment heat bridge will disappeared totally. The bridging piece is processed by the packaging of insulating materials, which reduces the influence of thermal bridge effectively.



a)Side pillar insulating detail b)Collar pillar insulating detail c) Beam insulating detail

Fig. 2 Thermal bridge construction of total packing pillar

(2) Construction of exposed pillar thermal bridge: the exterior wall of AAC block is picked out some distance away from floor slabs. Then thermal-insulation materials with some thickness shall be pasted on the pillar thermal bridge parts, so as to make the surface level with the exterior wall (Fig.3). Exterior-picked size shall be determined by specific design. If the picking size is excessive, the load-bearing performance of brickwork may be affected and cause wall fails to meet the requirement of bearing capacity. The excessive small value can't meet the requirement of thermal performance of thermal bridge, generally as 40mm-80mm.



a) Side pillar insulating detail b) Collar pillar insulating detail c) Beam insulating detail

Fig. 3 Thermal bridge construction of exposed pillar

Thermotechnical analysis on self-thermal insulating system of AAC block

thermotechnical analysis on AAC blockwork. Calculate the heat transfer coefficient of AAC block with different thicknesses in different types so as to judge whether it can meet the requirements of exterior wall heat-transfer coefficient limiting value in cold areas of *Energy-Saving Design Standards of Living Buildings in Cold and Sever Cold Regions* (JGJ26-2010). The internally-decorated surface of self-thermal insulation wall is cement mortar (20mm); the externally-decorated construction is made of special adhesion agent (2mm), anti-crack mortar with fiberglass mesh (5mm) and exclusively-decorated mortar and coating (5mm). The wall surface shall be built with thermal-insulating mortar and the mortar joint thickness shall be controlled within 3-5mm. The thermal performance of self-thermal insulation wall of AAC block refers to Table 3.

Table 3 Thermal performance of self-thermal insulation wall of AAC block

Blockwork level	Thermal conducting coefficient /($W \cdot m^{-1} \cdot K^{-1}$)	wall thickness/ mm	Thermal transmitting coefficient /($W \cdot m^{-2} \cdot K^{-1}$)	Floor ≤3, Regulated limit value 1/ ($W \cdot m^{-2} \cdot K^{-1}$)	3 < Floor < 9 Regulated limit value 2 /($W \cdot m^{-2} \cdot K^{-1}$)	Floor ≥9, Regulated limit value 3 /($W \cdot m^{-2} \cdot K^{-1}$)
B04	0.12	200	0.60	Not Satisfied	Satisfied	Satisfied
		250	0.49	Not Satisfied	Satisfied	Satisfied
		300	0.42	Satisfied	Satisfied	Satisfied
B05	0.14	200	0.68	Not Satisfied	Not Satisfied	Satisfied
		250	0.56	Not Satisfied	Satisfied	Satisfied
		300	0.48	Not Satisfied	Satisfied	Satisfied
B06	0.16	200	0.76	Not Satisfied	Not Satisfied	Not Satisfied
		250	0.63	Not Satisfied	Not Satisfied	Satisfied
		300	0.54	Not Satisfied	Satisfied	Satisfied

By analyzing thermo technical analysis of AAC blockwork, it can be known that AAC block with different levels, with the selected suitable thickness, can meet the requirements of specification. Self-thermal insulation wall of AAC block has good thermal performance and has wide applicable prospect in cold areas.

Condensation checking calculation of shear wall internal surface. Shear wall, beam and pillar thermal bridge parts are the weak parts of self-thermal insulating system thermal performance of AAC block. When the internal surface temperature is lower than the indoor air dew point temperature, moisture condensation would cause. The dew condensation is directly related to the thermal resistance and indoor temperature with enclosing construction. Usually, shear wall thickness is smaller than the thickness of beam and pillar thermal bridge part. The thermal resisting value is small relatively. Under the circumstance of taking the same insulation measures, condensation trouble mainly appears on shear wall construction.

Taking Jinan district as the example, to calculate 200mm-thick reinforced steel concrete shear force, adopt different internal surface temperature under different temperature-keeping construction, so as to judge whether dew condensation appears. The externally-decorated surface of wall shall adopt 20mm-thick polymer cement anti-crack mortar. The internally-decorated surface shall be 5mm-thick painted coating. The surface temperature of shear wall of thermal bridge part shall be calculated in accordance with Article 4.3.3 of GB50176-93, *Thermal Design code for Civil Buildings*[5].

The outdoor calculating temperature in winter in Jinan district is taken as -7℃. The internal calculation temperature shall be taken as 18℃[6]. When the relative humidity of indoor air is 60%, the indoor dew-point temperature shall be 10.1℃. The dew condensation of 200m-thick reinforced steel concrete shear wall under different temperature-keeping construction refers to Table 4.

Table 4 Checking calculation of shear wall dew condensation of 200m-thick reinforced concrete

Types of thermal insulation materials		Thickness of thermal insulation materials/mm	Wall thermal resistance /(m^2·K·W^{-1})	Wall internal surface temperature /℃
Thermal-insulating plate	B04 AAC block	40	0.63	13.61
		20	0.46	12.02
	B03 AAC block	40	0.69	14.03
		20	0.49	12.42
	EPS plate	40	1.25	15.79
		20	0.77	14.42
Thermal-insulating mortar materials	termal-insulating mortar mixed with expanded and vitrified beads	40	0.79	14.53
		20	0.54	12.94
	Insulating plaster of Mineral binder and expanded polystyrene	40	0.96	15.13
		20	0.63	13.61

When the internal wall surface temperature is lower than indoor dew condensation temperature, the indoor air would get dew formation at the part. The above-mentioned dew formation checking

calculation can obtain that, 200mm reinforced steel concrete shear wall shall take the construction measures of pasting thermal insulation plate materials. As for plates of AAC block B03 and B04 level, EPS plate thickness of 20mm, and the internal surface temperature within wall higher than indoor dew condensation temperature, they shall not produce surface dew condensation phenomenon on wall surface. Adopt the construction measures of smearing thermal-insulating mortar materials. Build the thickness of termal-insulating mortar mixed with expanded and vitrified beads and Insulating plaster of Mineral binder and expanded polystyrene as 20mm. Then the internal surface dew condensation will not occur on wall surface.

Conclusion

1) This paper proposes the self-thermal insulation wall construction of AAC block, shear wall processing measures, detailed parts construction of beam and pillar bridge.
2) By calculating the thermal transmitting coefficient of AAC block wall of different types under different thickness, it is known that the B04, B05 and B06 AAC block with suitable thickness can meet the requirements of residential building energy conservation design standard in the cold zones. The self-thermal insulating system of AAC block witnesses extensive prospect in cold areas.
3) The reinforced concrete shear wall in self-thermal insulating system of AAC block can avoid the internal surface dew condensation on walls by pasting thermal-insulating places and plastering thermal-insulating mortar materials.

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