Study on Waterproof and Air Permeability of Inorganic Insulated Decorative Panel

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Abstract. According to the climatic characteristics, the paper investigates relation between waterproof and air permeability of inorganic insulated decorative panel. The paper believes there are two main problems in the waterproof of inorganic insulated decorative panel, one is the gap is a weak link for waterproof as some weather proofing silicone sealants have poor elastic modulus, the other is the failure of construction details causes partial waterproofing failure. The composite panel system is best supplied in a complete set by the system supplier, which is a main comprehensive solution to the waterproofing problem of the composite panel. Through analyzing software simulation and experimental construction, the paper puts forward suggestion that hot summer and cold winter areas should take practical technical measures, including the use of the protective layer with high water vapor flux density or the installation of exhaust plugs in the outer wall base, or setting water vapor escaping channel such as PVC exhaust plug in the glue seam, in the actual project.

1 Introduction

Prefabricated in the factory, inorganic insulated decorative panels are composite plate products made of insulation materials, decorative panels, adhesives and connectors with excellent fireproof performance. At present, rock wool board and expanded perlite board are the main thermal insulation materials of the above composite panels. The Yangtze River Delta Area is hot and rainy, and has rain and heat over the same period. Waterproof and air permeability has a greater impact on the function of the composite panel and are closely related to energy efficiency, durability and feeling of comfort. Water resistance requires that composite panel materials can resist the intrusion of external liquid water; air permeability requires that indoor and outdoor water vapor migration should go normally.

2 Waterproofing problem

Inorganic insulated decorative panels avoid or reduce the liquid water from entering the inner system to achieve the purpose of waterproofing of materials by improving the own water-repellent properties of materials. At present, fiber rock wool board and inorganic mortar of the insulation materials of the inorganic composite panel are mixed with hydrophobic agent, and with the hydrophobic ratio controlled in a reasonable range it has enough cohesive force to ensure system security [1]. In addition, the decorative layer, such as fluorocarbon coating, real stone paint and elastic coating, has a waterproof function; completely foamed polyurethane caulking material forms a dense waterproof layer; the weather proofing silicone sealant also features sealing and waterproofing performance. There are two main problems in the waterproof of inorganic insulated decorative panel: 1) The gap is a weak link for waterproof as some weather proofing silicone sealants have poor elastic modulus, and the flexibility fails to meet the deformation of composite panel, causing cracking in case of large temperature difference between day and night, and large thermal expansion and cold contraction at the gap. 2) The failure of construction details causes partial waterproofing failure. For example, the horizontal thermal insulation decorative panel of cantilever should be paid attention to the lapping part to prevent water penetration into the insulation system; the insulation decorative panel at the outside windowsill should have a drip construction at a certain slope. Figure 1 shows the optimization of the waterproof construction of the node in the atlas of inorganic insulated decorative panels.

Inorganic insulated decorative panels are made of different building materials whose performance is not the same. The composite panel system is best supplied in a complete set by the system supplier to ensure compatibility and matching of materials, which is a main comprehensive solution to the waterproofing problem of the composite panel. In mature markets such as Europe, external thermal insulation systems being supplied by suppliers in complete set has become the norm.

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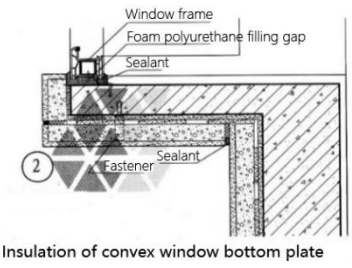
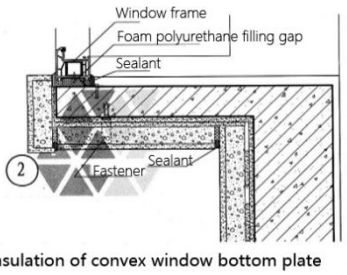
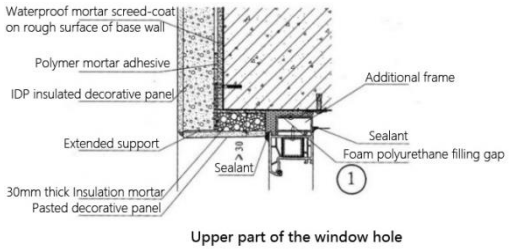


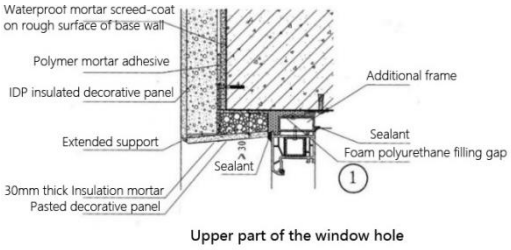
(a) Gap faced the water before modification.



(b) It is suggested that the gap should be located in the bottom of the shelter, with width of composite panel not more than 600mm, and be fully adhered to the convex window bottom plate.



(c) There was no setting for water dripping in the upper part of the window hole before modification.



(d)It is suggested that the upper part of the window hole should be tilted by 3%.

Figure 1. Waterproof construction improvement.

3 Air permeability problem

The external factors affecting the wall condensation include indoor and outdoor temperature and humidity; the internal factors include wall permeability and thermal conductivity. The temperature and humidity of the air in the wall are calculated according to the temperature, humidity, permeability and thermal conductivity of material[2]. In hot summer and cold winter area, the temperature is high in summer: the average temperature of hottest month is 25 ~ 30 ℃, the highest temperature is above 40 ℃, and the air relative humidity is between 70% ~ 80% or even higher; while the outdoor temperature is low in winter and the average daily temperature of the coldest month is 0 ~ 10 ℃. When the outdoor temperature is low and the relative humidity is high during winter heating, and in the intermittent period after the cold storage of the long-term operation of air conditioning in the summer, the water vapor in the wall will migrate and condensate in the wall under the comprehensive action of the indoor and outdoor conditions, causing condensation and mildew. Because the simulation of the wet environment is more difficult than that of the thermal environment, some simulation software avoids the problem of the wet characteristics of the envelope structure, so the study on water vapor condensation in the wall is less plentiful. The existence of condensation of the inorganic insulated decorative panel is studied as below using the software of PKPM Ver1.3, Ptemp1.0 and BEED.

3.1 Calculation using PKPM software Version 1.3

The condensation of the envelope structure of the heating building is calculated by the software in accordance with Shanghai construction specification of *Design Standard for the Energy Efficiency of Residential Building(DGJ08-205-2011)*. The software is designed to only check reinforced concrete walls. Indoor temperature calculated t_i is 18℃, outdoor temperature t_e calculated in winter: -2℃, indoor relative humidity in winter: 60.00%, dew point temperature T: 10.15℃. The parameters of the material are shown in Table 1.

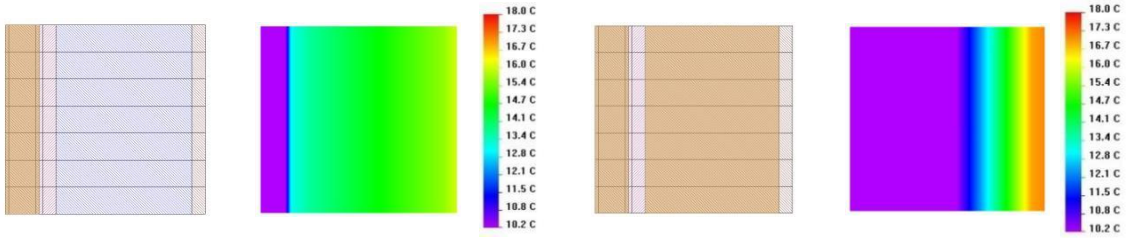
Table 1. Condensation Checking Calculation.

the most unfavorable heat bridge type material of each layer	thickness (mm)	thermal conductivity W/(m·K)	heat storage coefficient W/(㎡·K)	thermal resistance value (㎡·K)/W	thermal inertia index D=R.S	correction factor α
inorganic insulated decorative panel	40.0	0.040	0.51	0.63	0.38	1.20
reinforced concrete	200.0	1.740	17.20	0.11	1.98	1.00
gypsum plaster mortar	20.0	0.760	9.44	0.03	0.25	1.00
sum of the layers	250.0			0.77	2.61	
normal resistance Ro=Ri+∑R+Re=0.92(㎡·K/W)			Ri= 0.110(㎡·K/W);Re=0.040(㎡·K/W)			
heat transfer coefficient K =1/Ro=1.09						

Condensation calculation formula:, wherein t_i is the winter indoor designed temperature calculated; internal surface temperature; the heat transfer resistance (㎡·K/W) in heat bridge part; t_e is the winter outdoor temperature calculated; *Ri* is the internal surface heat transfer resistance (㎡·K/W); it is calculated that θ_i =15.60 ℃, so $\theta_i \geqslant$ T dew point. According to Section 4.0.18 in *Design Standard for Energy Efficiency of Residential Building (DGJ08-205-2011)*, condensation will not occur on the inner surface of the wall of the inorganic insulated decorative panel [3].

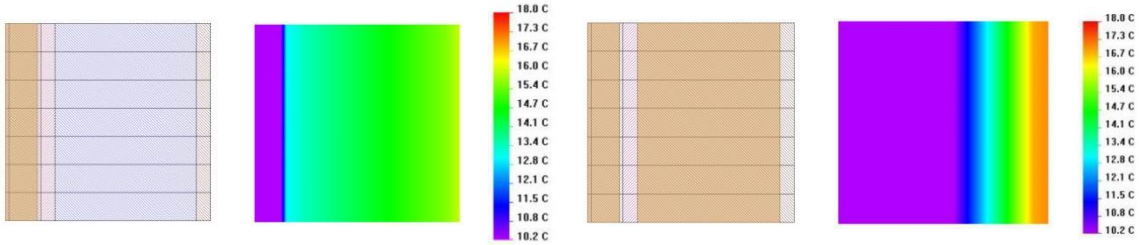
3.2 Calculation using Ptemp1.0 software

Ptemp1.0 software is prepared by the Research Institute of Building Physics, China Academy of Building Research. The two-dimensional temperature field calculation software it developed can be used as a thermal bridge calculation analysis tool. The minimum temperature of the inner surface of the wall in winter is calculated respectively with the aerated concrete block wall and the concrete wall with the same parameters and boundary conditions as the PKPM software Version 1.3. The results are shown in Figure 2 and Figure 3. The calculation shows that the temperature of the inner surface of the wall of inorganic insulated decorative panels in winter is close to the indoor temperature, and the water vapor in the aerated concrete block wall and the concrete wall is not likely to produce condensation when moving from indoor to outdoor.



(a) Calculation and results of concrete walls (b) Calculation and results of aerated concrete block wall

Figure 2. Rock wool composite panel (40mm).



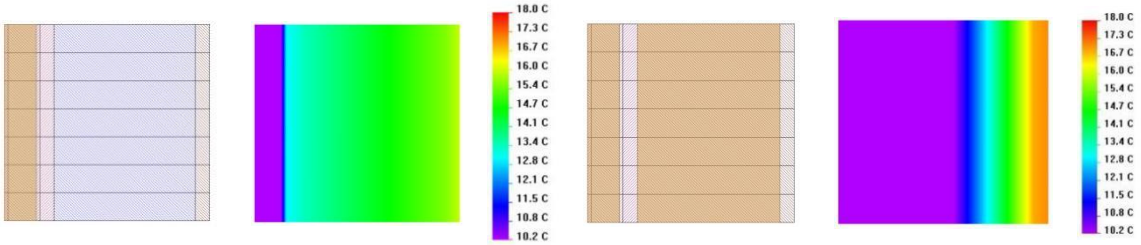
(a) Calculation and results of concrete walls (b) Calculation and results of aerated concrete block wall

Figure 3. Inorganic mortar rock wool composite panel (40mm).

3.3 Calculation using BEED software

The simulation software of BEED follows the building thermal calculation method in *Thermal Design Code for Civil Building(GB50176-93)*, and the building energy consumption simulation part is mainly based on the building load calculation method in *Code for Design of Heating Ventilation and Air Conditioning(GB50019-2003)* and *the HVAC Design Manual* prepared by Lu Yaoqing. The software is installed with the databases of saturated vapor pressure, building materials

classification, building materials thermo physical properties parameters and solar radiation absorption coefficient. The Yangtze River Delta Area is hot-summer and cold-winter zone. The climatic conditions are similar there. The meteorological parameters of Hangzhou in the Yangtze River Delta Area are calculated and the condensation is reviewed by BEED. The results show that there is possibility of internal condensation near the outer surface of aerated concrete block wall (Figure 4).



(a) Calculation and results of concrete walls (b) Calculation and results of aerated concrete block wall

Figure 4. Wall condensation checking calculation.

Different software has different design concepts, and the results are deviated. In the earlier product experiment of the inorganic mortar composite panel, the filler wall on the northern side had local condensation &bubbling problem, matching the BEED calculated results. The water absorption capacity and water vapor flux density of the composite wall
should be satisfied at the same time, reaching a comprehensive balance. As the experimental building is not equipped with exhaust pipe structure, there is a problem of poor coating ventilation. In the latter period, the composite panel adopts the coating with larger vapor flux density, and the bubble disappears in the same absence of exhaust pipe. In order to make less water enter the wall, *External Thermal Insulation Composite Systems Based on Expanded Polystyrene(JG/T149-2003)* provides that the external insulation system's 5mm thick protective layer should have a water absorption of less than 500g/m^2. The water vapor penetration amount of the protective layer should be greater than that of the insulation layer and the water vapor flux density of the protective layer should be greater than 0.85g/(m^2·h) [4]. The provision also has a reference value for the inorganic insulated decorative panel. If the water vapor flux density of the coating is slightly lower, the surface color distortion is likely to happen, and if it is severely lower, mold and thermal performance deterioration are likely, or even thermal performance damage is likely.

4 Conclusion

When the water resistance and air permeability meet the suitable ratios, the composite panel will provide good protection [5]. At present, the composite panel waterproof technology is mature. For example, the actual project is supplied by the system supplier in complete sets; the responsibility subject is clear; the construction follows the provisions of *Technical Specification for Waterproofing of Exterior Wall of Building (JGJ/T235-2011)*; waterproof quality problems can be avoided. Air permeability is the focus of attention for composite panel. Air permeability requires that the material should not have water vapor diffusion resistance, and should gradually increase from the inside to the outside. The national standard which is based on the fact that the actual situations of all kinds of thermal insulation decorative composite panels are complicated, has canceled the requirement on water vapor transmission performance. *The Materials of External Thermal Insulation Systems Based on Insulated Decorative Panel(JG/T287-2013)* provides that the water vapor transmission performance will not be checked if inorganic insulated materials are adopted or the system has a breathable construction. However, according to the above simulation calculation and practical experience, hot summer and cold winter areas should take practical technical measures, including the use of the protective layer with high water vapor flux density or the installation of exhaust plugs in the outer wall base, or setting water vapor escaping channel such as PVC exhaust plug in the glue seam, in the actual project. Only in this way can the composite panel be resistant to the intrusion of liquid water from outside and allow the normal migration of internal water vapor.

Acknowledgements

This paper is supported by the Foundation of Green Building and Construction Industrialization (Grant No. 2017YFC0702402).

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