Deep influence of passive low energy consumption multi-storey residential building in cold region

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Abstract. The example of passive architecture demonstration building in Jilin Province, China, based on the practical experience of this project, the control index of passive and low energy consumption residential buildings in cold and passive buildings is referenced by reference to the German construction standard and the Chinese residence construction document, "passive ultra-low energy consumption green Building Technology Guide (Trial)". The requirement of passive low energy residential buildings on the ground heat transfer coefficient limits is determined, and the performance requirements of passive residential buildings are discussed. This paper analyzes the requirement of the passive low energy residential building on the ground heat transfer coefficient limit, and probes into the influence factors of the ground thermal insulation of the passive low energy consumption residential building. The construction method of passive low energy consumption residential building is proposed.

1. Introduction
China's building energy-saving work started later, but developed rapidly. At present, some Chinese provinces and cities have already implemented energy-saving standards of residential building energy saving 75%. Although after nearly 30 years of development, the level of building energy efficiency in China still lags behind that of developed countries in Europe and the United States. Passive building energy-saving technology due to its advanced concepts, superb technology, excellent energy saving effect more and more attention. The research on passive and low energy residential buildings in China often ignores the important role of energy-saving of building foundation in passive energy-saving technology. Based on the above reasons, with the implementation of the new passive model building in Jilin Province, the author has studied the energy-saving design of the passive low energy residential building in the cold area under the positive and negative 0 elevation.

2. Performance requirements of passive low energy residential buildings
The control index of passive and low-energy residential buildings is very strict, in the implementation of the new passive model building in Jilin Province, reference to the passive construction standards of Germany and the China residential building document "passive ultra-low energy consumption green Building Technology Guide (Trial)" of passive low energy consumption residential building control
indicators, Combined with the climatic characteristics of the cold region in north China, the requirements of the passive and low energy residential buildings are determined.

2.1. Heat transfer coefficient limit value
Passive and low-energy residential buildings have strict requirements on the enclosure structure and the overall air tightness of the house, and the heat transfer coefficient of opaque enclosure structure is controlled in 0.15 W/(m²·K), the maximum heat transfer coefficient of the whole window and door is controlled by 0.80 W/(m²·K), the surface heat transfer coefficient is controlled in 0.15 W/(m²·K).

2.2. Air tightness requirements
The air tightness limit of passive low energy consumption residential building is n50 ≤ 0.6h, and good gas tightness is an important condition to guarantee its energy-saving effect, and the gas-dense layer of passive and low energy-consumption residential building should be continuously uninterrupted in the construction section. It is also proved that the exterior retaining structure of passive low energy residential buildings which have been carefully designed and constructed can maintain good air tightness for a long time.

2.3. Ventilation requirements
To meet the requirements of gas tightness, in order to maintain the fresh and healthy indoor air, passive and low-power residential buildings should be equipped with a full heat exchange of fresh air system, the heat exchange rate should be controlled at more than 75%, in order to achieve passive low-power residential buildings energy-saving and comfortable requirements.

2.4. Durability requirements
The insulating layer of the passive low energy residential building needs not only enough heat transfer coefficient to meet the thermal resistance requirement of the periphery retaining structure, but also has a considerable durability to meet the requirement of the service life. For the external wall insulation materials also need to have a certain strength to cope with external influence, direct contact with the soil insulation materials need to have a wet performance, the roof insulation layer need to have a certain waterproof ability.

2.5. Construction requirements
The insulating layer of the ground and the insulating layer of the outer wall shall be connected as a whole, in order to eliminate the heat bridge caused by the insulation layer disconnection. For the positive and negative 0 elevation of the following part of the thermal performance does not make the request, after the research found that the penetration of the ground into the interior of the basic pillars and other components, if not to do thermal insulation treatment, the indoor heat will be passed from the column to the outside, so in order to achieve better energy For this penetration of the surface insulation layer of the positive and negative 0 elevation of the following parts also need to do insulation treatment. The building Foundation and the wall, the ground link position according to the different structure form will appear the different tectonic form, these constructs the node often is the weak link, therefore needs to attach specialized separate steam layer to meet these connection nodes, satisfies the gas tightness request.

3. Influence of ground thermal insulation of passive low energy consumption residential building on foundation burial depth

3.1. Burial depth of common building foundation in cold area
There are many factors that affect the depth of the foundation, such as the water level of the groundwater, the load of the building itself, and so on, but the two main factors that affect the
foundation of the multi-storey residential building in the cold area of the north are the influence of the deep of the bearing layer and the permafrost layer.

3.1.1. The influence of the holding force layer. The load of the building itself requires different bearing capacity of the bearing layer to carry the foundation, so that the depth of the holding layer determines the depth of the building foundation buried deep. However, in the geological exploration of general civil buildings, the soil bearing capacity is determined only for the soil below the permafrost layer.

3.1.2. The influence of permafrost layer. In the northern Cold area, the foundation depth of the building is accustomed to the local frozen soil layer, this is to avoid the house tilt, cracks and other problems, because of uneven frost along the surrounding house and seasonal freeze-thaw cycle of deformation caused by. In time is a single layer of residential, the underlying depth often need to be under the local permafrost layer. For example, the frozen soil depth of Changchun is 1.76 meters, and the depth of permafrost in Heilongjiang Province can be up to 2.98 meters. So in the northern cold region, even if the depth of hundreds of mm deep buried can meet the structural requirements of the housing, but still need to bury deeper than permafrost depths, to ensure the safety and requirements of the House. For single or multi-storey residential buildings, even if the building is not high, the load is not large, but also need to bury the foundation under the frozen layer, at least 2 meters deep, this is undoubtedly a huge economic expenditure.

3.2. Factors influencing the buried depth of residential buildings with passive and low energy consumption

3.2.1. Load of the building itself. Compared with the ordinary multi-storey residential buildings, the passive and low energy consumption multi-storey residential buildings although in the enclosure structure of the treatment, structural approach is different, increasing the thickness of a lot of insulation, but because the thermal insulation material light heat transfer coefficient of small characteristics, the increase in load is not small, and ordinary multi-storey residential buildings, compared with no increase in a large load, basically can be ignored.

3.2.2. The influence of permafrost layer. In the cold regions of northern China, the permafrost is caused by the low air temperature in winter, low-temperature air will gradually take the heat away from the soil, as the temperature decreases and the accumulation of time, the formation of the frozen layer, although the sun will pass to the soil part of the heat, but can not keep the soil in winter low temperature not passively frozen. But the soil below the ground below the passive low-energy residential building is another.

In order to ensure the energy saving effect, the ground needs 0.15 W/(m²·K) in the passive and low energy residential buildings within the heat transfer coefficient, so that indoor heat will not be mass transfer out of the ground. Therefore, in order to make the ground to achieve such performance, often need to lay the appropriate thickness of the ground insulation layer. This layer of insulation can not only prevent the indoor heat transfer to the ground below the soil, but also prevent the winter outdoor cold air to take the soil heat away. Because of the protection of a layer of insulating layer, the soil in winter and cold outdoor air isolation, and although the ground insulation layer is very thick, with very low heat transfer coefficient, but not completely adiabatic, there is always a small amount of heat from the ground to the soil. Therefore, the passive low energy consumption of residential buildings below the ground soil becomes frozen.

3.2.3. The foundation of passive and low-energy residential buildings. Under the ideal condition of the soil holding layer, because of the influence of the ground thermal insulation method of the passive and low-energy residential building, the soil bearing the foundation of the building has become the
permafrost, so the effect of the permafrost layer is not existed when considering the depth of the building. Under the condition that the soil bearing capacity is allowable and conforming to the structural Foundation design, the passive and low energy residential building can meet the requirement of the foundation stability and deformation under the precondition that the depth of deep burial may only be greater than the 500 mm depth required by the design Code of Building Foundation.

4. Construction practice of the following parts of the passive low-energy residential building plus zero elevation

4.1. Selection of insulating layer materials

Thermal insulation material is the most important factor to determine the thermal performance of the passive and low energy consumption multi-layer residential building. At the same time, external insulation materials also need to have a certain strength and the corresponding waterproof. Therefore, in the material selection, we must choose a low heat transfer coefficient, with a certain strength of impervious insulation material. It should also take into account that the external construction practices are more complex, in the premise of quality assurance to facilitate the construction of paste. Building plus or minus 0 elevation the following parts of the contact between the air and the sun, affecting its durability and thermal insulation performance of the main factors are the soil extrusion and precipitation infiltration, so B1 grade fire insulation material can meet the requirements. At present, the main thermal insulation material in domestic market is divided into two kinds: organic material and inorganic material. Organic type has EPS (polystyrene board), XPS (extruded PS foam board), PU (Polyurethane), PF (phenolic resin foaming materials) and other materials, their low thermal conductivity, is a good insulation material, Polyurethane is an excellent insulation material, now the construction site foaming polyurethane foam with low heat transfer coefficient, construction convenience, good strength and good waterproof and moistureproof performance; inorganic materials including foam glass, foam concrete, rock wool, such as materials, such as the insulation performance of organic materials. In organic materials, EPS board is the lowest cost material, is currently the most widely used insulation materials in China, but the intensity density is poor, waterproof moistureproof performance is not good; XPS Board is improved by EPS board, which has the advantages of high strength and more resistance to combustion than EPS board, but the XPS Board and EPS board raw materials are the same, The performance of waterproof moisture is poor; EPS module is a new type of materials developed independently in China, and the expandable polystyrene beads are heated by foaming and then processed with special equipment. This new type of insulation material has the advantages of low heat transfer coefficient, good mechanical properties and so on, after calculating EPS module board only need EPS board 65% to 75% thickness can achieve the same insulation effect, fire grade can reach B1 level, and has a better waterproof and moistureproof performance. Conforms to the standard request, is the foundation insulation material better choice. See table 1 for specific parameters.

Table 1. Comparison of heat transfer performance and fireproof performance of insulating materials. 

| Insulation material | Organic materials | Inorganic materials |
|---------------------|-------------------|--------------------|
| Material name       | EPS               | EPS model          | XPS | PU | PF | Rock wool | Foam Glass | Vacuum Insulation Board |
| Coefficient of heat transfer | 0.038 | 0.019 | 0.028 | 0.017 | 0.02 | 0.041 | <0.058 |
| Fire Protection Grade | B2 | B2(B1) | B2(B1) | B2(B1) | B1(A) | B1(A) | A | A |

*a"Brackets" in the fire retardant or modified can be achieved after the grade.

4.2. Construction procedure

4.2.1. Plate Foundation. For the passive low energy residential buildings of the plate Foundation, the structure of the following part of the positive and negative 0 elevation is relatively simple, just need to
change the position of the ground insulation layer to the plate Foundation can meet the requirements. Here are two points to note: 1, because the insulation layer directly contact the soil, so the basis of the insulation layer should have a certain strength and can be moisture-proof water. 2, the insulation layer under the foundation should be connected with the wall insulation layer into a continuous whole, in order to ensure the overall thermal performance and tightness of the housing requirements.

4.2.2. Bar Foundation. If the basic form of passive and low-energy residential buildings is a relatively complex bar foundation, the construction practice will be different. Under each weighing wall there will be a strip of base weighing, if in the basic production process is not in the wall and the foundation between the similar high-strength, low heat transfer coefficient of material, such as bubble concrete to do the disconnection, then it is necessary to put the wall insulation layer down the foundation, for penetrating the ground insulation layer Foundation. The ground insulation layer should also be extended down the base, the length of the extension should be determined according to the calculation, the purpose of this practice is to increase the heat transfer path of the wall, can not make the indoor heat mass along the wall transmission to the basis and then passed to the outside.

4.2.3. Independent basis. Independent basis is the most complex form of the foundation, if the form of the building is independent foundation, then there will be a foundation on the extension of the column, as well as the beam, which is undoubtedly the passive low energy residential buildings with the positive and negative 0 elevation of the following parts of the construction procedure to increase the difficulty. But through good design and construction, it can meet the requirement of passive and low energy residential building.

We will extend the insulation layer of the outer wall to the bottom of the parcel beam and the ground insulation layer to connect, so that the ground beam into the insulation layer under the cover. For the penetration of the foundation of the beam, the ground short column, there are two solutions: first, all the basic short columns are the corresponding thickness of the insulation layer, the insulation layer should be wrapped in the entire foundation and the basic short column, and the ground, the wall insulation layer interconnected into a whole. The benefits of this approach is that the energy-saving effect is good, if the passive low energy consumption of residential building indicators is difficult to control, this method is the energy-saving effect of the obvious scheme, but due to the complex shape of the foundation, insulation layer of sticky paste needs a lot of time and money. The second is to build a weight-bearing lightweight wall that surrounds and connects the foundation to the outer wall. When laying the insulation layer can directly along the light wall wall insulation layer directly connected to a whole. An enclosure consisting of an insulating layer that encloses the ground and the underground part of the building as a whole. The advantage of this approach is the overall performance of the insulation layer better, reduce the corner, joints and other parts of the quality of the insulation layer of risk, but also reduce the foundation and wall, the ground connection may leak the risk, improve the passive housing overall air tightness.
4.2.4. The level extension of the basic insulating layer. In order to further reduce the possibility of frozen ground bearing soil, a horizontal insulating layer extension zone should be arranged below the ground (figure 1). The setting of the insulation band plays a role in blocking heat transfer, the effect of cold air on the soil in winter can be reduced, so that the decaying path of the basal part of the soil loses heat longer, and the soil can be better ensured that the ground bearing soils do not pass the heat to the outdoor cold atmosphere in winter, which reduces the risk of soil freezing. This extends the length of the insulation layer, the foundation part of the soil loses heat transmission path longer, the greater the heat attenuation, after the practice proved that in northern China, the cold zone, the length of the insulation belt should be around 1 meters more appropriate.

The basic form of the pilot project is an independent foundation, so it adopts the practice of laying the insulating layer separately, and also sets up the horizontal thermal insulation extension zone, and the overall heat transfer coefficient of the ground structure is checked as 0.148 W/(m²·K) to meet the requirement of the passive residential building to maintain the heat transfer coefficient limit of the structure.

5. Conclusions
The pilot project is located in Changchun, Jilin Province, China, the geographical location belongs to the cold region of China, the pilot project has also completely adopted a basic shallow burial method, the energy saving rate after the completion of the project construction drawings, the results are 82.8%. Building energy efficiency benchmark is based on the the 1980s reform and opening up of residential buildings as a basic building comparison, because there is no standard at that time, the current simulation of the reference building according to Jilin Province, "residential building energy-saving design standards (Energy saving 65%)" db22/t450-2007 in the relevant requirements to establish, The calculated 82.8% energy saving rate is equivalent to energy saving 65% of the basis and energy saving 82.8%, converted down, based on the 80’s residential building energy-saving rate of 94%, to achieve the building energy efficiency 92% target. The pilot project is now fully completed and has been tested for the first heating period.

Based on the above reasons, through these positive and negative 0 elevation of the construction procedure can ensure that the passive low energy consumption of residential buildings in northern China cold areas of the foundation bearing soil is not frozen, so in the geological conditions to meet the requirements of building load, passive low energy consumption of residential buildings can be shallow buried foundation. The significance of passive low energy consumption residential building foundation lies not only in improving the speed of construction, but also in reducing the overall cost of passive building, which plays an active role in the popularization of passive building. The construction
method of the following part of the passive and low energy residential building's 0 elevation is also a reference for the research on energy-saving technology of passive and low-energy building in China. Through the research on the influence of the ground thermal insulation of the passive low energy consumption residential building on the foundation burial depth, the energy-saving technology of the passive and low-energy residential buildings is perfected, more systematic and more comprehensive. The significance lies in complying with the tendency of countries to vigorously promote the technology progress of building energy conservation, providing new concepts for the development of building energy-saving technology and making more people see the great significance of building energy saving.

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