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Thermal Insulation Of The Foundation Walls Of Buildings And Calculation Of Its Thickness

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ABSTRACT

If the surface temperature of any building material drops sharply without changing the humidity and the surface temperature is lower than the dew point temperature, dew-like water droplets are formed on the surface of this material. This condition is called condensing humidity condition. Condensation moisture formed on the surfaces of building materials and external barriers is slowly absorbed into the body of building materials over time, increasing the relative humidity of this structure. Condensation moisture can be observed when the temperature of the surfaces of external barrier structures drops sharply. This condition can be observed everywhere where the basement is connected to the outer walls of the basement. The article deals with the issue of thermal insulation and calculation of basement walls of modern energy-efficient buildings, which are widely used in the country and abroad.

KEYWORDS

Air humidity, building material surface temperature, dew point, condensation humidity, relative humidity.

INTRODUCTION

With the constant increase in land prices, the problem of expanding the useful area of a residential building can be successfully solved by thermal insulation of the foundation of the building. This allows for more rational use of the underground parts of residential buildings. The basement or basement of a low-rise residential building allows you to place a garage, gym or sauna, in a multi-storey residential building - a parking lot, warehouse or other ancillary rooms.

To create a cosy microclimate in the basement or basement floor room, its external barrier structures must have sufficient thermal insulation. The foundation is the main structure of any building. Therefore, it must maintain its properties and performance for many years, be reliable and durable. Due to the cold climate and the presence of groundwater, freezing of soils leads to its swelling (increase in the volume of frozen soil within the freezing depth, uneven effect on the foundation of the building), which can lead to deformation of building structures and consequent destruction of the building.

By freezing the soil from the cold, the negative effects of its swelling can be eliminated in several ways. For example, placing the lower level of the foundations below the freezing depth or bringing the frozen soil to the freezing depth and replacing it with non-freezing soil [1]. However, these methods lead to a large amount of excavation and as a result, a lot of labour is required and the cost of the building increases. An effective method is to insulate the foundation. This significantly reduces or completely eliminates the effect of the forces generated by the freezing of the soil on the foundation. At the same time, it protects the foundation of the building and barrier structures from dangerous deformation. To completely eliminate the forces created by the freezing of the soil from the cold the foundation around the entire perimeter of the building should be thermally insulated.

The ingress of moisture into the body of the foundation structure not only contributes to its premature failure but also to the deterioration of the thermal protection properties of the foundation structure. If the basement walls are not insulated from the effects of moisture and low temperatures, up to 20% of all heat loss in the building falls on the basement or basement floor zones [2-5].

MATERIALS AND METHODS

High-quality thermal insulation of basement walls allows turning the underground structure into a heat accumulator, which provides a constant comfortable temperature in winter and summer. Thermal insulation of the foundation helps to significantly reduce heat loss through it. Protects walls from condensation, mould and fungus. Thermal insulation of the external barrier structures of the basement floor room allows maintaining a room temperature of 5-10 oC without additional heating. Currently, thermal insulation of basement walls is carried out using more expanded polystyrene-based materials and less - fibrous materials. These materials provide adequate thermal insulation. But their use has several drawbacks in itself - it is labour-intensive and not efficient enough [6]. In particular, these materials, which have a very high degree of absorption of water into their body, should be protected from the effects of soil moisture with a reinforced waterproofing layer. However, in such constructions, the waterproofing layer itself is required to be protected from the external mechanical effects of the soil. For example, to protect the waterproofing layer of the basement walls, an additional half-brick protective wall is built from the bottom of the basement exterior walls at its entire height, resulting in more complex construction and costly building [7].

If the thermal insulation of the basement walls of the building solves several problems at once, such a solution is a more effective solution:

- Provides thermal insulation of the basement or basement directly;
- Also, the basement or basement protects the outer walls of the floor from moisture;
- Protects waterproofing from mechanical damage. As a result, the main requirements for thermal insulation materials used for thermal insulation of the basement or attic floor of a building remain such parameters as compressive strength and moisture resistance.

For thermal insulation of underground parts of buildings, taking into account the difficult working conditions resulting from the constant interaction of the basement or the outer walls of the basement with groundwater and groundwater, as well as mechanical loads caused by freezing of the ground from cold and. It is difficult to find an analogue of the ground pressure extruded URSA XPS EPS plates. The material has low thermal conductivity and water absorption coefficient, high strength properties. The thermal conductivity of URSA XPS does not decrease even when operating in a humid environment. Because a very small amount of water is absorbed into his body. This ensures a comfortable temperature and humidity regime inside the heat-insulated basement or basement floor room. The closed porous structure of extruded polystyrene URSA XPS and the surface properties of the material prevents capillary moisture permeability and ensure minimal moisture absorption even under hydrostatic pressure conditions. Extruded polystyrene URSA XPS can be used in direct contact with ground and groundwater [8]. URSA XPS plates have high resistance to cyclic temperature changes, providing frost resistance up to 500 cycles. Such a material, which retains its mechanical and thermal insulation properties, allows its use in the construction of basement or basement floor external walls, which are affected by frequent changes in temperature regimes. Despite the organic nature of the raw material, URSA XPS materials are absolutely resistant to the effects of organic acids released by microorganisms. Therefore, this material can be used in structures in direct contact with soil and vegetation [9].

The high deformation-strength properties of plates made of extruded polystyrene foam allow accepting short-term distributed load up to 50 t m2. The materials retain their stable physical and mechanical properties, shape and size for at least 50 years. The combination of physical and mechanical properties of URSA XPS slabs prevents freezing of the foundation body and the base soil.

When underground structures are protected with extruded polystyrene foam boards, it significantly increases the long-term durability of the waterproofing membrane, which protects the structures from the ingress of groundwater and moisture. Extruded polystyrene foam boards mounted on the waterproofing layer protect the waterproofing layer from premature failure, temperature changes and mechanical damage during ground movement. Thus, thermal insulation of the foundation not only helps to make efficient

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use of the space of the underground rooms but also prolongs the life of the whole building. The level of thermal protection of buildings is determined by the project assignment. When designing the level of thermal protection of a building above the first level, it is allowed to take the value of the first level for some enclosing structures. However, it is necessary to increase the thermal resistance of another structure or several barrier structures. In addition, the total amount of heat lost through all external barrier structures must not exceed the amount calculated for the accepted thermal protection level.

The degree-day value of the heating season D_d for the construction site is determined by the following formula:

$$D_d = (t_B - t_{om.nep.}) \cdot Z_{om.nep.} \quad (1)$$

Here t_B - estimated room temperature in the room, °C. Parameter of the microclimate in the room;

$t_{om.nep.}$, $Z_{om.nep.}$ - the average temperature during the period when the outside air temperature is $\leq$ 10 °C, respectively, and its duration in days.

The required value of the resistance to heat transfer is determined from table R_0^{TP} 2b [2] based on the values of the degree-day D_d index of the heating season according to the "Second level of thermal protection".

$$R_0^{TP} = a \cdot D_d + b \qquad (2)$$

The total resistance R_0 to the heat transfer of the external barrier structure shall not be less than the required value of the heat transfer resistance R_0^{TP} .

The total resistance of the external barrier structure to heat transfer is determined by the following formula:

$$R_0 = \frac{1}{\alpha_B} + R_K + \frac{1}{\alpha_H} \quad (3)$$

where α_B -is the heat transfer coefficient of the inner surface of the outer barrier structure, determined according to table 5 *

α_H - is the heat transfer coefficient of the outer surface of the external barrier structure, determined according to Table 6 [2].

R_K - is the thermal resistance of the external barrier structure, the sum of the heat transfer resistances of its constituent layers, determined by the following formula:

$$R_K = \frac{\delta_1}{\lambda_1} + \frac{\delta_2}{\lambda_2} + \frac{\delta_3}{\lambda_3} + \frac{\delta_4}{\lambda_4} \quad (4)$$

where δ -is the layer thickness according to the project;

λ -layer material thermal conductivity (material characteristic).

Calculation of thermal insulation thickness

Calculation of the thickness of the thermal insulation layer of extruded polystyrene URSA XPS for thermal insulation of warm basement walls of a residential building built in Taylak district of Samarkand region. The basement walls are a monolithic reinforced concrete foundation with a thickness of 400 mm (Fig. 1).

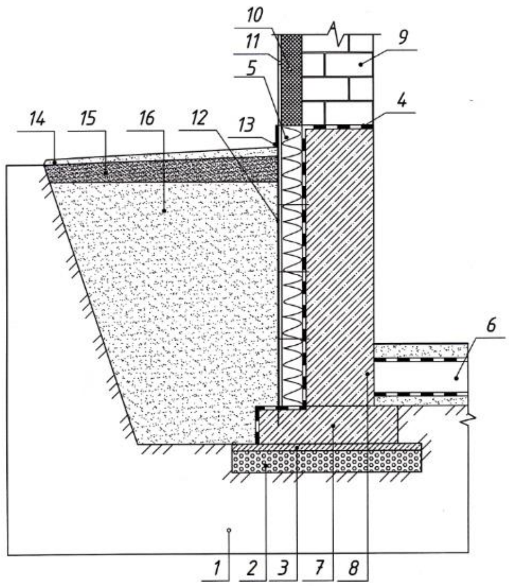

Figure 1. Thermal insulation of heated basement walls: 1-basis ground; 2 rubble pavement; 3 concrete pavement; 4 waterproofing; 5-extruded polystyrene foam; 6-basement floor; 7 foundation base; 8 foundations; 9 walls; 10- wall thermal insulation layer; 11 wall plaster; 12 flat asbestos cement sheet barrier; 13- pallet; 14- blind area; 15 sandy bedding; 16 refilled.

We determine the degree-day value of the heating season for a construction site using the following formula:

$$D_d = (t_B - t_{om.nep.}) \cdot Z_{om.nep.}$$

By default:

- Construction site - Samarkand region, Taylak district;
- The purpose of the building - residential and public building;
- Calculated air temperature in the room according to table 1 in [2],
  $t_B = 20^o C;$
- Relative humidity of indoor air according to Table 1 in [2], 55%;
- In Table 4 in [1] we record the data on the value of the average temperature $t_{om.nep.}$ and the duration of these periods (per day) $Z_{om.nep.}$, respectively, for periods when the outside air temperature $t \leq 8^o C$

  and $t \leq 12^o C$ in Samarkand region, Taylak district:
- For periods with $t \leq 8^o C$, the average temperature $t_{om.nep.} = +3{,}1^o C$, duration is 172 days;
- The average duration of temperature $t_{om.nep.} = +4{,}8^o C$, for periods with $t \leq 12^o C$ is 133 days.

- On the basis of these values we determine the value of the average temperature $t_{om.nep.}$ for periods with $t \leq 10^o C$ and the duration of these periods (per day) $Z_{om.nep.}$:

  $t_{om.nep.} = \frac{3,1+4,8}{2} = 3,95^o C$ and $Z_{om.nep.} = \frac{133+172}{2} = 152,5 \approx 153$ in a day

- Humidity regime of the room - moderate.

  Using formula 1, we determine the value of the degree-daily indicator D_d of the heating season for the Samarkand region, Taylak district:

$$D_d = (t_{\text{B}} - t_{om.nep.}) \cdot Z_{om.nep.} = (20 - 3.95) \cdot 153 = 2455$$

degrees per day.

We determine the required value of resistance to heat transfer R_0^{TP} using the following formula

$$R_0^{\text{TP}} = a \cdot D_d + b$$

For housing, health and children's facilities, schools, boarding schools, hotels and dormitories, a = 0.00035 and b = 1.4 are assumed to be equal.

$$R_0^{\text{TP}} = a * D_d + b = 0,00035 * 2455 + 1,4 = 0,86 + 1,4 = 2,26 \ \text{м}^2 \cdot {}^o C / \text{BT}.$$

The total resistance of the external barrier structure to heat transfer is determined by the following formula:

$$R_0 = \frac{1}{\alpha_{\text{B}}} + R_{\text{K}} + \frac{1}{\alpha_{\text{H}}} \quad (3)$$

Where we determine the heat transfer coefficient of the inner surface of the α_{B}-outer barrier structure according to table 5 $\alpha_{\text{B}} = 8,7 \ \text{BT}/(\text{м} \cdot {}^o C)$ [2].

α_{H} is the heat transfer coefficient of the outer surface of the outer barrier structure according to table 6, $\alpha_{\text{H}} = 23 \ \text{BT}/(\text{м} \cdot {}^o C)$ [2].

URSA XPS extruded polystyrene board used to cover a basement or basement floor may be wet. There are 2 ways to measure wet conductivity.

1. Experimental. The method for determining the calculated values of thermal conductivity of building materials under operating conditions is given in Appendix E of SP 23-101-2004-Design of thermal protection of buildings [3].
2. Calculated. According to [4], the dependence of the thermal conductivity of the material on the volumetric moisture can be expressed by the empirical formula:

$$\lambda_{влаж} = \lambda_{сух} + \Delta\lambda \cdot \omega \quad (4)$$

Where $\lambda_{сух}$ is the coefficient of thermal conductivity of the material in the dry state;

Increase in the amount of $\Delta\lambda$ -thermal conductivity for each volume percentage of moisture;

ω is the volume of moisture, %.

The value $\Delta\lambda$ at the negative temperature of inorganic materials is assumed to be equal to $3{,}5 \cdot 10^{-3}$ ВТ$/(м \cdot {}^oC)$.

The moisture content of extruded polystyrene URSA XPS plate does not exceed 0.3% of its volume due to moisture on the surface of the particles.

Extruded polystyrene has a thermal conductivity of 0.031 ВТ$/(м \cdot {}^oC)$.

Thus, the thermal conductivity of the wetted thermal insulation layer is as follows:

$$\lambda_{влаж} = \lambda_{сух} + \Delta\lambda * \omega = 0{,}031 + 3{,}5 * 10^{-3} * 0{,}3 = 0{,}031 + 0{,}0035 * 0{,}3 = 0{,}0104 \text{ ВТ}/(м \cdot {}^oC).$$

Table 1. Layers in the proposed construction

№	The name of the material	Density kg / m3	Thermal conductivity ВТ$/(м \cdot {}^oC)$	Thickness, m
1	Monolithic reinforced concrete slab	2500	2,04	0,400
2	Waterproofing	-	-	-
3	Extruded poly-tyrol URSA XPS plate	35	0,035	X
3	Flat asbestos cement sheets	1800	1,79	0,02

The general equation for determining the total resistance of an external barrier structure to heat transfer is as follows:

$$R_0 = \frac{1}{\alpha_В} + \frac{\delta_1}{\lambda_1} + \frac{\delta_2}{\lambda_2} + \frac{\delta_3}{\lambda_3} + \ldots\ldots \frac{\delta_n}{\lambda_n} \ldots\ldots + \frac{1}{\alpha_Н}$$

And it must not be less than the required value of the resistance to heat transfer $R_0^{ТР}$

$$R_0 = \frac{1}{8,7} + \frac{0,400}{2,04} + \frac{X}{0,035} + \frac{0,02}{1,79} + \frac{1}{23} = 0,115 + 0,196 + 0,057 + 28,57X + 0,011 =$$
$$= 0,362 + 28,57X = 2,26$$

$$28,57 * X = 1,898$$

We determine from the equation X = 0.07 m = 7 cm = 70 mm

Thus, since the minimum thickness of the URSA XPS extruded polystyrene insulation in the proposed design is up to 30 mm, we assume that the thickness of the URSA XPS insulation layer is 70 mm.

Initially, a layer of waterproofing is laid along the levelled outer surface of the basement walls. This waterproofing layer can be rubbed or glued. URSA XPS plates are attached over the waterproofing layer.

Wall mounting of URSA XPS plates is as follows:

- Three or five points of the waterproofing layer are melted and the thermal insulation board is firmly pressed to it. If mastic is used to fasten the thermal insulation boards, mastic is applied to the surface of the thermal insulation board measuring 1250x600 mm, marking 8-10 points, and it is pressed firmly on the waterproofing layer. In the basement area of the building, the slabs are fastened using anchors. In this case, one plate is fastened by 4 anchors. The plates are placed in a checkerboard pattern. Each URSA XPS plate of the selected quarter shape is assembled by placing it close to the adjacent plates with the edge side. In this case, a special groove in the top plate should cover the groove in the bottom plate. This in turn ensures that there are no gaps (breaks) through the thermal insulation layer and reduces heat loss. Once the pit (pit) around the foundation is filled with soil, the URSA XPS slabs are pressed firmly against the basement walls due to the ground pressure.

CONCLUSION

This article discusses one of the priority issues today - the construction of underground structures of the building, their protection from freezing, waterproofing and insulation. Increasing the thermal protection of residential and public buildings in order to save fuel and energy resources and reduce operating costs for heating is an urgent problem of construction. The solution to this problem can be achieved primarily through the use of structures covered with a layer of thermal insulation with high resistance to heat transfer of walls, basement walls and loft coverings.

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