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Thermal conductivity of lightweight concrete depending on the moisture content of the material

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ABSTRACT--*This article presents the results of theoretical and laboratory field thermophysical studies and defines the thermal conductivity coefficients of lightweight concrete. Using the "FEITRON" device, we studied the dependence of the thermal conductivity coefficient of expanded clay concrete on moisture according to the method based on the stationary thermal regime developed at the Moscow Scientific Research Institute of Building Physics on plate samples measuring 25x25x5 cm. At the same time, five degrees of moisture were selected for the concrete in the humidity range from absolutely dry to 2, 5, 10, and 15% humidity in the range of expanded clay concrete densities from 700 to 1300 kg/m^3. In addition, with the help of the "ИТС-1" device, a thermal conductivity meter, studies were conducted to determine the dependence of the coefficient of thermal conductivity of foam concrete on the moisture content of the material. The "ИТС-1" device is designed to measure the thermal conductivity and thermal resistance of building and heat-insulating materials using the stationary heat flux method in accordance with GOST 7976-99. The studies were conducted according to the method developed by representatives in Moscow (НИИЖБ) and St. Petersburg. The principle of operation of the device is based on the creation of a stationary heat flux passing through the studied flat sample. Expanded clay samples with a density of 700 to 1300 kg / m3 and foam concrete blocks with a density of 600 - 700 kg / m^3 from local raw materials were made to determine the heat transfer coefficient depending on the moisture content of the material. As a result of the research, empirical formulas were proposed for determining the thermal conductivity of expanded clay concrete with a density of 700, 740, 900, 1050 and 1300 kg / m^3 and foam concrete blocks with a density of 600–700 kg / m^3 depending on the moisture content of the material.*

Keywords-- *Thermal conductivity of lightweight concrete depending on the moisture content of the material*

I. INTRODUCTION

It is known that the main thermophysical properties of building materials and structures is the coefficient of thermal conductivity. Under operating conditions, all building materials and structures are in some wet condition. With increasing humidity of the material, its thermal conductivity increases. The calculated thermal conductivity coefficients of building materials and structures are given SNiP (ҚМҚ) 2.01.04-97 * [8]. These values are used

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in theoretical studies of the thermophysical qualities of external building envelopes. Currently, Uzbekistan has become widely used as external walls of residential and public buildings lightweight concrete from expanded clay concrete, foam concrete and aerated concrete from local materials. But until now, the thermal conductivity coefficient of expanded clay expanded concrete and aerated concrete, depending on humidity, has not been systematically determined. As a result of determining the thermal conductivity of such blocks in full-scale laboratory conditions, it is possible to propose an energy-efficient thickness of the outer walls. In addition, according to SNiP (ҚМҚ) 2.01.04-97 *, the level of thermal protection of the external walls of such buildings is required to hang [8]. Since the reduced resistance to heat transfer of building envelopes must beat at least a value determined on the basis of sanitary and hygienic conditions and the exclusion of condensation, corresponding to the first level of thermal protection. During the construction, reconstruction and overhaul of residential buildings, medical institutions, children's institutions, schools, lyceums, colleges, boarding schools, carried out at the expense of state capital investments or local budgets, the second level of thermal protection should be adopted [8]. Therefore, the determination of the coefficient of thermal conductivity of expanded clay and foam concrete depending on the moisture content of the material is an unimportant task and is of practical importance in the construction of energy-efficient residential and public buildings. In this regard, a group of young scientists and undergraduates from the Department of “Buildings and Structures” of the Samarkand State Architecture and Construction Institute are conducting a study of the thermophysical characteristics of foam and aerated concrete blocks from local materials. Using the “FEITRON” device, we studied the dependence of the thermal conductivity coefficient of expanded clay concrete on moisture according to the method based on the stationary thermal regime developed at the Moscow Scientific Research Institute of Building Physics on plate samples measuring 25x25x5 cm. [1,2]. At the same time, five degrees of wetting of the concrete were selected in the humidity range from an absolutely dry state to a moisture content of 2, 5, 10 and 15% in the range of expanded clay concrete densities from 700 to 1300 kg / m3. For uniform distribution of moisture over the cross section, the samples were kept in plastic bags for 2-4 months. The humidity level of 5 and 10% corresponds to the calculated humidity of expanded clay concrete for the operation of fences according to the regimes in accordance with SNiP (ҚМҚ) 2.01.04-97 *. Construction heating equipment. [8]. Table 1 shows the results of changes in the coefficient of thermal conductivity of expanded clay concrete, depending on its humidity.

II. RESULTS

The coefficient of thermal conductivity of expanded clay concrete on perlite and expanded clay sands at various values of humidity by weight.

Table 1: it is seen that with increasing humidity of the material, the coefficient of thermal conductivity increases.

№	Name of materials	Indicators: λ / W, $\frac{Вт}{м\ ^{o}C}$ /%.			
1	**2**	**3**	**4**	**5**	**6**

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1	Expanded clay 0,17/0 0,20/3,08 0,25/10,05 0,32/15,0 perlite sand with a density of 710 kg/m^3	0,17/0	0,20/3,08	0,25/10,05	0,32/15,0
2	Expanded clay on expanded clay sand with a density of 740kg/m^3	0,20/0	0,22/4,8	0,29/10,0	-
3	Expanded clay on perlite sand with a density of 900 kg/m^3	0,22/0	0,24/2,4	0,31/9,4	0,36/13,6
4	Expanded clay on perlite sand, density 1059 kg/m^3	0,29/0	0,30/2,44	0,32/4,86	0,40/11,61
5	Expanded clay on expanded clay sand with a density of 1300 kg/m^3	0,40/0	0,51/5,0	0,58/9,6	-

From table 1 it is seen that with increasing humidity of the material, the coefficient of thermal conductivity increases.

As a result of theoretical and laboratory field thermophysical studies, an empirical formula was proposed below for determining the coefficient of thermal conductivity of expanded clay concrete, depending on their humidity:

1. For expanded clay concrete on perlite sand with a density of 710 kg/m^3

$$\lambda_w = \lambda_0 + 0.01 x W ;$$

2. For expanded clay concrete on expanded clay sand with a density of 740 kg/m^3

$$\lambda_w = \lambda_0 + 0.09 x W$$

3.For expanded clay concrete on pearlite sand with a density of 900 kg/m^3

$$\lambda_w = \lambda_0 + 0.01 x W ;$$

4. For expanded clay concrete on perlite sand with a density of 1050 kg/m^3

$$\lambda_w = \lambda_0 + 0.009 x W ;$$

5. For expanded clay concrete on expanded clay sand with a density of 1300 kg/m^3

$$\lambda_w = \lambda_0 + 0.012 x W ;$$

The corresponding graphical dependencies are shown in Figure 1.

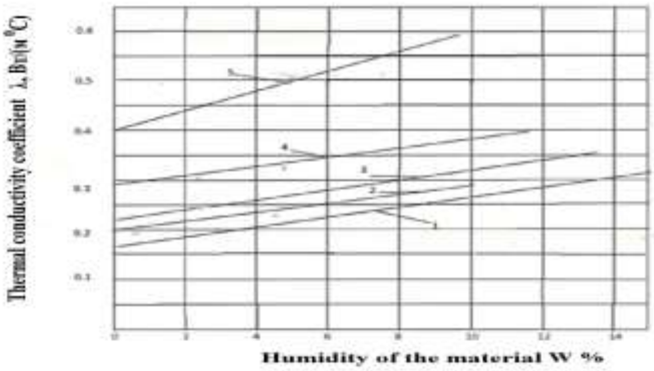

Figure 1: Dependence of the coefficient of thermal conductivity of expanded clay concrete on the moisture content of the material.

In order to determine the thermal conductivity coefficient of foam blocks, ALINA Invest jointly produced foam concrete samples with sizes of 60x30x10, 60x30x15 and 15x15x3 cm. The average density of foam concrete samples is 600-700 kg/m^3. We used the "ITS-1" device to conduct a heat conductivity meter to determine the dependence of the coefficient of thermal conductivity of foam concrete on material moisture. The ITS-1 device is designed to measure the thermal conductivity and thermal resistance of building and heat-insulating materials using the stationary heat flux method in accordance with GOST 7976-99 [10-12]. The studies were carried out according to the method developed by representatives in Moscow (NIIIZhB) and in St. Petersburg. The principle of the device is based on the creation of a stationary heat flow passing through the studied flat sample.

By the magnitude of this heat flux, the temperature of the opposite faces of the sample and its thickness, the thermal conductivity of the sample is calculated by the formula.

$$\lambda = \frac{d * q}{\Delta T}$$

Where is the d-thickness of the sample;

q- is the heat flux density;

Δ T – is the temperature difference between opposite faces of the sample.

The thermal resistance of the sample is calculated by the formula:

$$R = \frac{\Delta T}{q}$$

The test sample should be in the shape of a rectangular parallelepiped, the front faces of which are square with dimensions 150x150 mm. The thickness of the sample should be within 5 ... 35mm.

To determine the coefficient of thermal conductivity, depending on the moisture content of the material, we chose 5 degrees of moisture in the foam concrete in the humidity range from an absolutely dry state (w = 0%) to a moisture content of 4, 8.2, 11.7, 20.1%.

For uniform distribution of moisture over the cross section of the sample for 2-3 months, kept in plastic bags. The moisture level of 8.2 and 11.7% is close to the calculated humidity of the foam and aerated concrete for the operating conditions of the fences in regimes A and B according to ҚМҚ 2.01.04-97 * Construction heat engineering.

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Below are the results of changes in the coefficient of thermal conductivity of foam concrete depending on its humidity:

1.With humidity W = 0%; coefficient of thermal conductivity λ_0 = 0,125 Вт/м.^{0}C.

2. With humidity W=4%; coefficient of thermal conductivity λ_w = 0,142 Вт/м.^{0}C.

3. With humidity W=8,2%; coefficient of thermal conductivity λ_w=0,155 Вт/м.^{0}C.4. With humidity W=11,7%; coefficient of thermal conductivity λ_w=0,17 Вт/м.^{0}C.

5. With humidity W=20,1%; coefficient of thermal conductivity λ_w=0,23 Вт/м.^{0}C.

From the above it is seen that with increasing humidity of the material, the thermal conductivity increases. As a result of theoretical and laboratory field thermophysical studies, an empirical formula was proposed for determining the coefficient of thermal conductivity of foam concrete with a density of 600 - 700 kg/m^3, depending on humidity.

$$\lambda_w=\lambda_0+0.004.W$$

Where λ w – is the coefficient of thermal conductivity of foam in a wet state;

λ_0 - coefficient of thermal conductivity of foam concrete in a dry state;

W - material moisture

The following figure 2 below shows a graph of the coefficient of thermal conductivity of foam concrete on the moisture content of the material.

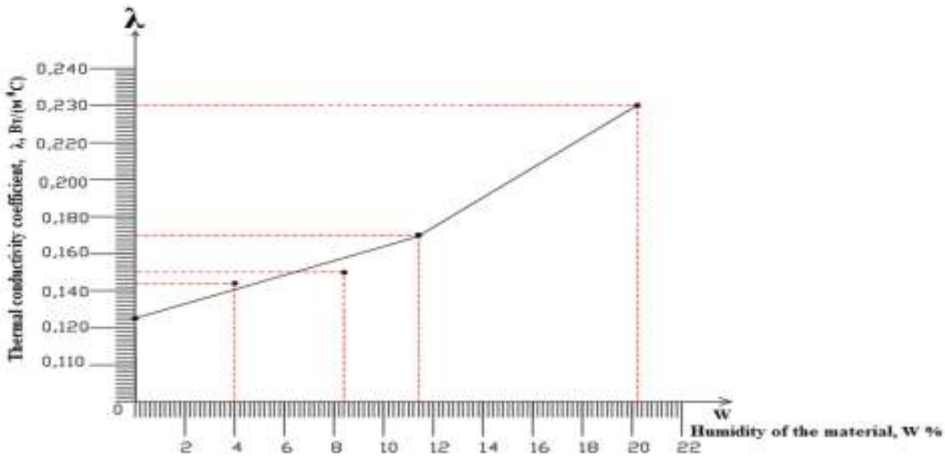

Figure 2: Thermal conductivity graph foam concrete from moisture content of the material.

III. CONCLUSION

As a result of research, the following conclusions can be drawn:

1. With increasing humidity of the material, the thermal conductivity increases;

2. As a result of theoretical and laboratory field thermophysical studies, an empirical formula was proposed for determining the thermal conductivity of expanded clay concrete with a density of 710, 740, 900, 1050 and 1300 kg/m^3 depending on their humidity;

3. The difference between the coefficient of thermal conductivity determined as a result of laboratory field thermophysical studies and the coefficient of thermal conductivity of certain theoretical studies does not exceed 10-15%.

4. The moisture level of 5 and 10% corresponds to the calculated humidity of expanded clay concrete for the operation of fences according to the regimes according to SNiP (ҚМҚ) 2.01.04-97 *. Construction heat engineering.

5. In addition, the moisture level of 8.2 and 11.7% is close to the calculated humidity of the foam concrete for the operating conditions of the fences according to regimes A and B according to SNiP (ҚМҚ) 2.01.04-97* Construction heat engineering;

6. The thermal conductivity coefficient offered by us is foam concrete stone 3-4 times less than the thermal conductivity coefficient of brick;

7. Thermal resistance to heat transfer of foam concrete 40cm thick. equal to 2.35 m^2. ^{0}C/W;

8. The given heat transfer resistance of foam concrete meets the requirements of the first and second levels of thermal protection of external walls, according to SNiP. 2.01.04-97 *.

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