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STEAM CURING CHARACTERISTICS OF CELLULAR CONCRETE ON THE BASE OF NANOSTRUCTURED BINDER

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ABSTRACT

In this paper the results of study of steam curing characteristics of cellular concrete on the base of non-cement nanostructured binder vs. the closest analogues are demonstrated. The influence of applied micro-reinforced component (fibre) with different composition on properties of cellular composites is studied.

Keywords: cellular concretes, fibre, nanostructured binder, non-cement binder, steam curing characteristics, vapour permeability, sorption humidity, capillary suction

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1. INTRODUCTION

Due to acceptance of enhanced requirements to thermal protection system of buildings the study of steam curing characteristics of construction materials becomes more relevant. At the same time a special attention is focused on new types of nanostructuring composites and technologies of its production. Particularly, in this work the fibre-bearing foam concrete products on the base of non-cement nanostructured binder (NB) are studied. Generally, humidification degree of construction materials in buildings takes place depending on followings parameters: vapour permeability, vapour sorption, capillary suction.

Humidity of building envelopes is varied depending on structure and properties of material, indoor microclimate as well as climate features of construction zone that influenced on thermo-technical characteristics of building envelopes.

Subject of this study is fibre-bearing foam concrete on the base of silicate NB.

NB is non-hydration binder, produced with environmentally friendly technology [1–4].

Vapor permeability test is carried out on prisms with 20 mm of thickness. Vapour sorption values is determined according to standard method under relative air humidity of 75–97 % with samples of arbitrary geometry prepared from central part of a massive. Capillary suction method is based on the generalized low of capillary suction:

$$M = Kz^{n}, \qquad (1)$$

Where M is water content absorbed by 1 m^2 of a sample surface during required time period, g/m^2; K is capillary suction coefficient, $g/(m^2 \cdot h^n)$; z is time period from start of experiment to planned weighingprocedure, h.

Comparison of the generalized low with the «squire root of time» low allows more accurate description of water capillary suction process in construction materials. Experimental samples are three prism of 50×50×140 mm.

To determine K and n parameters the logarithm of eq. (1) should be taken:

$$\ln M = \ln K + n \ln z. \qquad (2)$$

After that we can draw a plot on logarithm coordinates «ln*M* – ln*z*». Capillary suction coefficient K is determined from eq.:

$$\ln M = \ln K \quad \text{at } z=1$$

To determine the index n in eq. (1) the data point of the plot on logarithm coordinates are approximated by straight-line segment. The slope obtained is an index n.

The capillary suction low realizing in the studied material is described by eq. (3) and applied in calculation of humidity conditions of buildings envelopes.

$$M = 3z^{0,12}. \qquad (3)$$

2. RESULTS AND DISCUSSION

Study of steam curing characteristics as well as influence of different types of fibre on properties of foam concrete products is carried out by determination of the followings parameters: vapour permeability, sorption humidity, capillary suction

Vapour permeability test. Vapour permeability is capacity of material to conduct or hold vapour due to gradient of partial vapour pressure from both sides of material under ambient pressure. Vapor permeability coefficient is characterized by resistance to vapour penetration. For comparison an average values of this parameter for following materials with density grade D500 are shown in Table 1: NB based fibre-bearing foam concrete (NB concrete), fibre-bearing foam concrete with NB and basalt fibre (NB+BF), fibre-bearing foam concrete with NB and micro-fibre (NB+MF), cement based foam concrete (Foam concrete) and autoclave gas concrete (Gas concrete).

Table 1. Vapour permeability parameters for different types of cellular concrete

Type of cellular concrete	Water vapour permeability resistance, R_p, $m^2 \cdot h \cdot Pa/mg$	Vapour permeability, μ, mg/(m·h·Pa)
NB concrete	0,110	0,180
HB+BF	0,076	0,245
NB+MF	0,074	0,234
Foam concrete	0,100	0,200
Gas concrete	0,240	0,105

Analyzing the data in Table 1 it should be conclude the NB concrete can be applied in building envelopes as heat-insulating and structural material. The presented vapour permeability values promise good vapor conductivity to outside and holding of construction moisture in structural layer. They allow formation a quasi-stationary moisture conditions enhancing the heat-insulation and durability of structure. The data obtained demonstrate increasing of vapour permeability when introduction of fibre component due to formation of extra channels to conduct water and vapor. But influence of type of fibre on vapour permeability value is not significant.

Vapour sorption humidity test. Sorption humidity parameter of construction materials is used when study of humidity conditions of materials in structures. Sorption humidity is determined as ratio water content (by wt. %), absorbed from air to mass of dry material (by wt. %).

Average experimental data of sorption humidity for different types of cellular concretes of density grade D500 under relative air humidity of 75 % and 97 % are shown in Table 2. They are used for thermotechnical calculations of buildings envelopes when building design according the SNiP 23-02-2003 providing with two types of service of buildings envelopes: A and B depending on internal humidity and climate zone [5].

Table 2. Sorption humidity parameters for different types of cellular concrete

Type of cellular concrete	Sorption humidity (by wt. %), at 20±2 ^{o}C and with relative air humidity, %	
	75	97
NB concrete	6	10
HB+BF	0,71	3,0
NB+MF	1,05	4,07
Foam concrete	8	12
Gas concrete	1,23	2,19

The data obtained in Table 2 demonstrate the sorption humidity under 75 % of relative air humidity of HB+BF NB concrete is 6 times lower vs. NB concrete and 1.5 time lower vs. Gas concrete. At 97 % of relative air humidity the sorption humidity of NB based foam concrete is increased significantly vs. Gas concrete but is within acceptable limits. So, when design of building envelopes based on HB+BF the reference data of humidity according to sorption humidity and calculated heat conductivity (heat conductivity values in A and B types service conditions) should be used. Slight water sorption at surface of pore space of fiber-bearing foam concrete allows forecasting the stability of heat-insulating characteristics of composite when its service.

Capillary suction test. Capillary suction of water is physical process of water absorption by material when their contacting leading to water diffusion in material under capillary forces. The results obtained allow determination the presence of long capillaries in structure of fiber-bearing cellular concretes influenced on drying time. The study of capillary suction of water in foam concrete with different types of fiber is carried out. Water content absorbed by surface unite of fibre-bearing foam concrete is the square root of time (Fig. 1). But due to absence of linear relationship on the experimental curves the application of general low of capillary suction followed by logarithmation is required (Fig. 2). In the experiment according to standard method three samples are used (Sample 1, Sample 2, Sample 3).

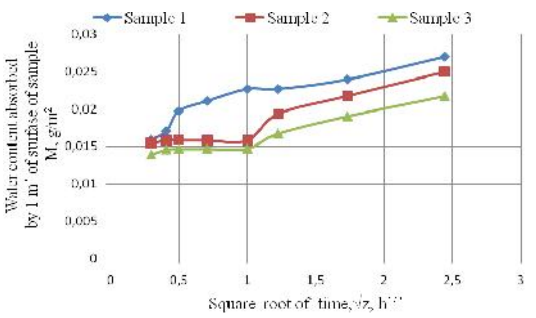

Fig.1. Capillary suction values of fiber-bearing foam concrete

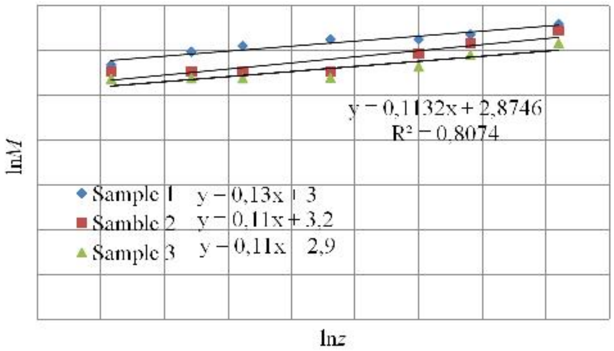

Fig.2. Capillary suction values of fiber-bearing foam concrete in logarithmical coordinates

To determine the index *n* in eq.(1) the data points on plot in logarithmical coordinates are approximated into straingt line. The slope is index *n*. The data of slopes obtained are presented in Table 3.

Table 3. Capillary suction parameters for different types of cellular concrete

Sample	Capillary suction coefficient *K*, $g/(m^2 \cdot h^n)$	Index *n* in eq. (3) of capillary suction
1	3,1	0,13
2	3,0	0,11
3	2,8	0,11
Average value	3,0	0,12

Analysis of data obtained allows concluding the HB+BF cellular concrete is characterized by optimal values of capillary suction according to parameters for cellular concrete with density grade D500. Lower values of capillary suction followed by impossibility of further reinforcing of material [1]. Higher values of capillary suction lead to structure destruction, extra content of long capillaries (capillary porosity) and degradation of heat-insulating characteristics.

3. CONCLUSION

Taking into account features of studied binder the steam curing characteristics of cellular concrete on cellular samples with density grade D500 as the most popular ones on construction market. It is determined the values of vapour permeability and sorption humidity of studied material is lower vs. analogous, that confirms their efficiency. Capillary suction values obtained is optimal for cellular concrete D500. Thus, the studied fibre-bearing foam concrete meets requirements of standards and is characterized by enhanced steam curing characteristics vs. analogous.

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