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PROPERTIES OF NANOSTRUCTURED BINDING ELEMENTS DEPENDING ON APPLIED RESOURCE TYPE

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Abstract.

A nanostructured binder (NB) can be applied as an alternative type of mineral cementless binding systems the raw material components of which is a wide range of siliceous and aluminosilicate rocks of natural and technogenic origin. The promising areas of NB application are the building materials of various applications. A resource base was studied previously. This base was represented by quartz sand and perlite. In order to expand it the possibility of granite use as the main raw material component is regarded during NB preparation. The comparative analysis of NB dispersion and NB physical and mechanical characteristics was performed, depending on applied raw materials.

Keywords: aluminosilicate raw materials, silicate raw materials, nanostructured binder.

Introduction. Nowadays the construction industry is at the stage of dynamic growth. The production of a wide range of building materials depend on the characteristics of applied mineral binders. Cement and its varieties are among the most common and popular representatives of this class of substances. But due to its high consumption the situation appears when production does not provide demand sometimes in the industrialized areas. There is the deficit of cement products. The same can be said about remote and underdeveloped regions where industry is absent. An increased transportation period from the moment of cement production to its consumption makes the most adverse effect on its quality. The global trends of energy price increase make its impact.

Besides, cement industry is characterized by high power consumption and a negative impact on the environment. All these factors develop the need for new types of binders.

The Belgorod State Technological University named after V.G. Shukhov developed a nanostructured binder (NB) as an alternative type of binders, the main raw component of which is the wide range of siliceous and aluminosilicate rocks of natural and technogenic origin. A binder obtaining technology is represented by stepwise grinding of raw materials using wet process, followed by some modification [1-3].

Main part. NB special feature is a non-hydration curing type, the presence of a nanoscale component and certain rheological dependences expressed in the thixotropic nature of a flow transferred into a Newton one [4, 5].

The specified specificity of a nanostructured binder allows to recommend it for the building materials of various functional focus, in particular, cellular concretes, silicate materials and composite binders [6-10]. NB may be used as a main binding component and as a modifying additive (Fig. 1).

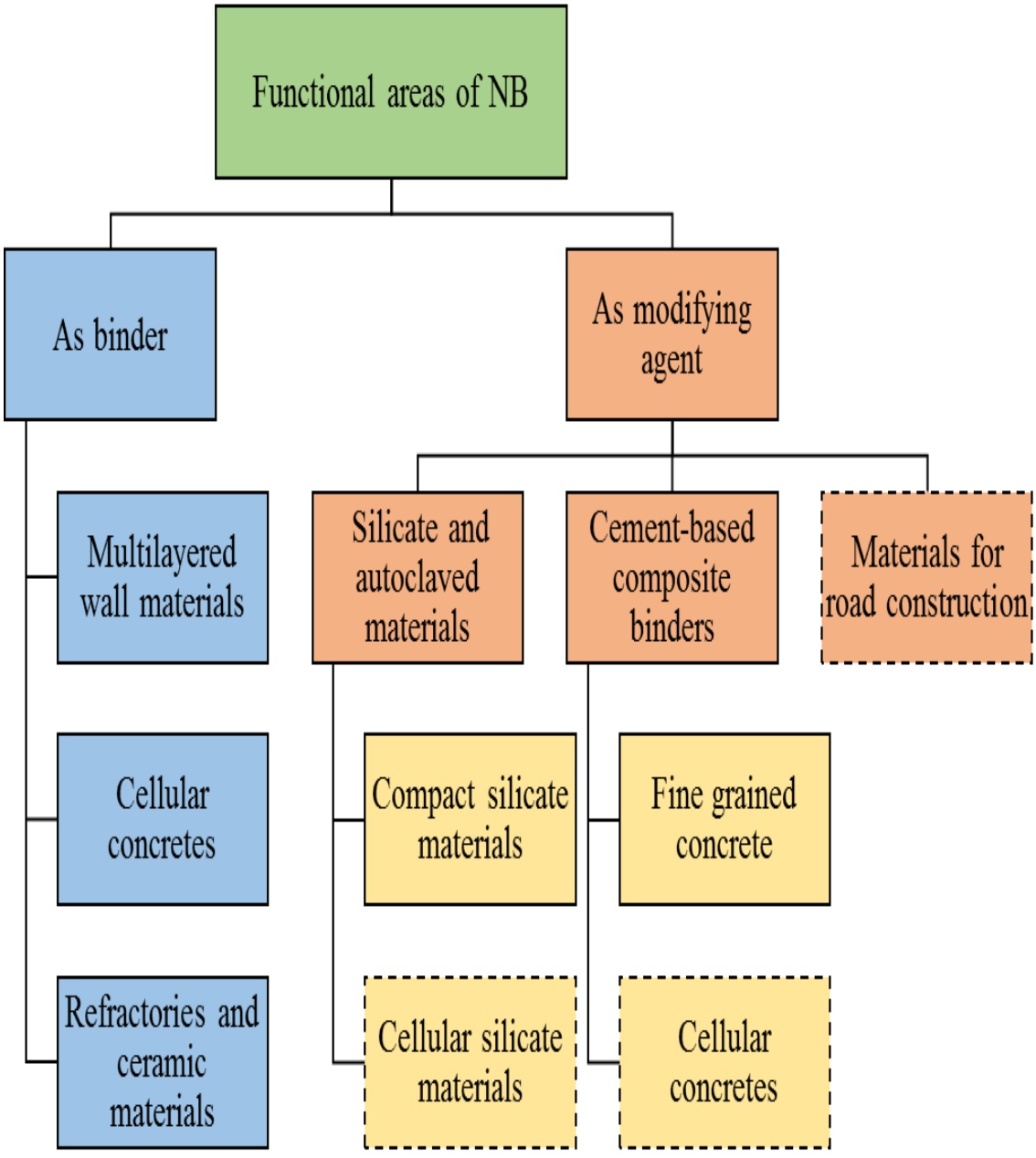


Figure 1. – Perspective areas of nanostructured binder application

The most traditional mineral raw material for a nanostructured binder production is silica sand - the product of acid magmatogene-intrusive rock weathering. Among aluminosilicate rocks, the quartz content of which makes no less than 40%, natural materials of complete crystalline structure - granite and cryptocrystalline - perlite are of interest [11]. They developed and studied NB based on quartz sand and perlite in the works carried out previously. The possibility of their use in the production of building materials was confirmed experimentally [7, 8]. In order to expand the resource base of NB one should consider the possibility of granite rocks use, represented by crushing rubble screening. In this regard to perform the comparative analysis of the basic NB characteristics the following raw materials were examined depending on raw material type: quartz sand of Korochansky deposit (Russia, Belgorod Region), perlite from Mukhor-Talin deposit (Russia, Republic of Buryatia) and the granite from Pavlovsk deposit (Russia, Voronezh), the chemical composition of which is presented in tables 1-3.

Table 1: The chemical composition of quartz sand at Korochansky deposit

Oxides	**SiO_2**	**Al_2O_3**	**Fe_2O_3**	**CaO**	**MgO**	**SO_3**	**п.п.п.**
Amount, %	92,65	4,18	0,6	1,69	0,69	0,19	1,23

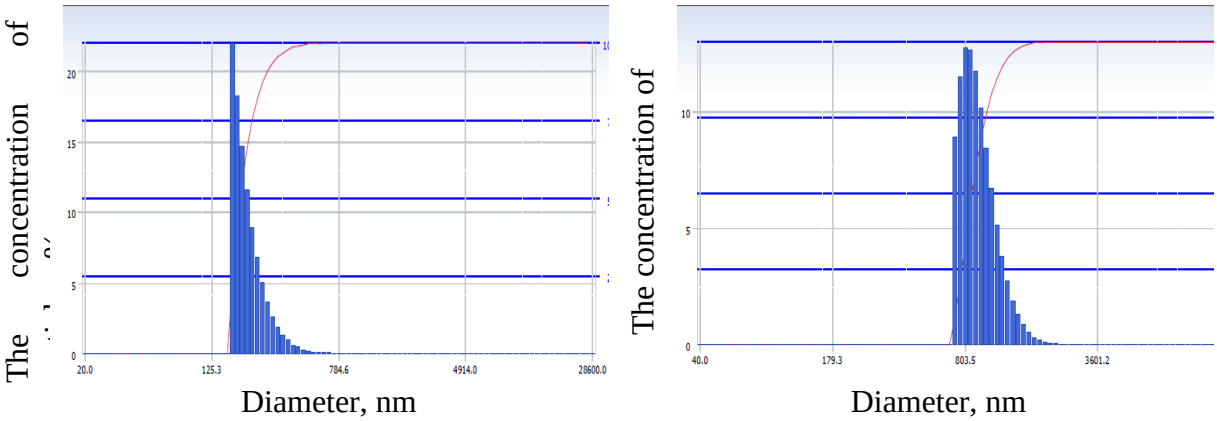
Table 2: The chemical composition of perlite at Mukhor-Tala deposit.

Oxides	**SiO_2**	**Al_2O_3**	**SO_3**	**Fe_2O_3 + FeO**	**CaO**	**K_2O + Na_2O**	**п.п.п.**
Amount, %	65–74	13–14	–	0,8–2,6	0,8–2,6	8,6–10,2	5–8,0

Table 3: The chemical composition of granite at Pavlovsk deposit.

Oxides,	**SiO_2**	**Al_2O_3**	**Fe_2O_3**	**CaO**	**MgO**	**SO_3**	**K_2O**	**Na_2O**	**п.п.п.**
Amount, %	68,3	15,1	3,75	4,33	0,83	0,1	1,98	3,96	1,65

The determination of raw material size in the nanometer range was performed using the particle analyzer "DelsaNano C Zeta", the record area of which makes 0.6 nm - 7 micrometers. Figure 2 shows the measurements of particle percentage distribution according to a nanostructured binder size based on silica sand, perlite and granite.



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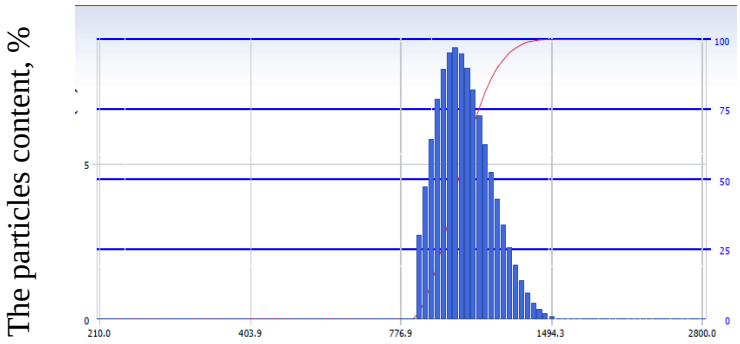

c

Figure 2. Raw material particle size: a – quartz sand, b – perlite, c – granite[1]

Presented raw material components have a polydispersed granulometric composition. The presence of a nanoscale component and a close presence of particles in a measuring scale may indicate the feasibility of these materials use as the raw material for NB production. The presented graphs show that the granulometric composition of granite is more homogeneous granite as compared with quartz sand and perlite, most of the particles (≈ 9%) makes 900-1100 nm. Granulometric sand and perlite compositions have noticeable peaks - 22% and 12% at a larger range of particle distribution. It can be assumed that the process of a binder grinding on the granite will have similar characteristics with perlite NB.

The main characteristics of NB are the average density, strength, porosity and a solid phase concentration (Table 4).

Table 4: Physical and mechanical properties of a nanostructured binder, depending on used raw materials

System type	**Raw material**	**Density, kg/m^3**	**Solid phase concentration**	**Porosity, %**	**Cast durability limit, MPa**
Silicate	Sand	2150	0,75	14–16	3,5–5
Aluminosilicate	Perlite	1880	0,68	16–18	3,5–4
	Granite	2080	0,79	13–15	5,5–7

As can be seen from the abovementioned data, all kinds of binders have similar properties. However, a granite based binder has a maximum strength, making it a promising one as the main binder component to get a wide spectrum of building materials of various structures.

Summary.

The comparative analysis of cementless binders was performed in the work using the examples of nanostructured binders made of silica and aluminosilicate. The main characteristics of raw materials and a final binder are

determined. In this regard the possibility of NB raw material base expansion is explained through the use of acid composition rock - granite.

Conclusions. Undoubtedly, a nanostructured binder showed its reasonability during the obtaining of various materials for construction purposes, allowing to expand certain technical and operational parameters, as well as to eliminate the disadvantages of those components instead of which or in addition to which it is applied. The selection of raw material base for NB production is carried out by the determination of rock deposit locality in the regions with the deficit of construction products.

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