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Features of quality control of free of cement binder of non-hydration type

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Abstract Analysis of methods of quality control, applied for binding systems and based materials was curried out. Also the classification of quality control methods for nanostructured binder (NB) in the light of its adaptability to this binder and composites on its basis is developed.
The scheme of quality parameter control for NB and based materials in the framework of technological process "raw→binder→final composite" is developed. The basic characteristics of NB on the basis of quartz sands of different deposits are studied as well as the norms and requirements to controlled parameters when production process, allowing supplying quality of final product are determined.

Introduction

Update stage of development of production of construction materials, and applied technologies of new generation provides for using new approaches including nanotechnology for synthesis of construction materials. It is due to the research methods for traditional materials are not fully meet requirements applicable to designing of updated construction materials where the using of nanotechnology when their production is necessary. Especially among these ones are low-cement and non-cement binding systems well as nonhydration composites [1, 2].

In connection with it the necessity to extend the research procedures range as well as development of monitoring system when designing of new technology and improvement of current ones with application of nanomaterials. That allows development of updates competitive, high-ecological and energy effective construction materials.

Now, taking into account the growing trend of increasing in production volume with using of new types of high-performance products the requirement in acceptance of some reference documents, standards, regulations and manuals about healthy using of nanomaterials at international and national level is takes place. So, in the framework of the Federal Target Program "Development of infrastructure of nanoindustry in Russian Federation for 2008–2011" to establish the integrated, scientifically based method of to recognize and quantitative determination the most significant types of nanomaterials in natural biological and abiological objects the methodological recommendations "1.2 Hygiene, toxicology, sanitary. Determination of prefered types of nanomaterials in natural environments, nutrition products and living organisms MP 1.2.2641–10" were accepted [3].

According to this document reference samples of nanomaterials are classified subject to their chemical composition. As basic was used the classification, accepted in international register of nanoparticles and nanomaterials:

1. metal nanoparticles (Au, Ag, Pt, Pd, Ru, Ni, Cu etc.);
2. nanoparticles of metal and non-metal oxides (SiO_2, Al_2O_3, TiO_2, SnO_2, ZnO, MoO_3, V_2O_5, PbO, Fe_2O_3, NiO etc.);
3. semiconductive nanoparticles (CdS, CdSe, PbS, PbTe, GaN, GaAs, InN etc.);
4. carbon nanoparticles (fullerens C_{60}, carbon nanotubes etc.);
5. nanoparticles of organically modified layered silicates and aluminosilicates (nanoclays of different composition);
6. nanoparticles based on organic branched polymer (dendrimer of different composition).

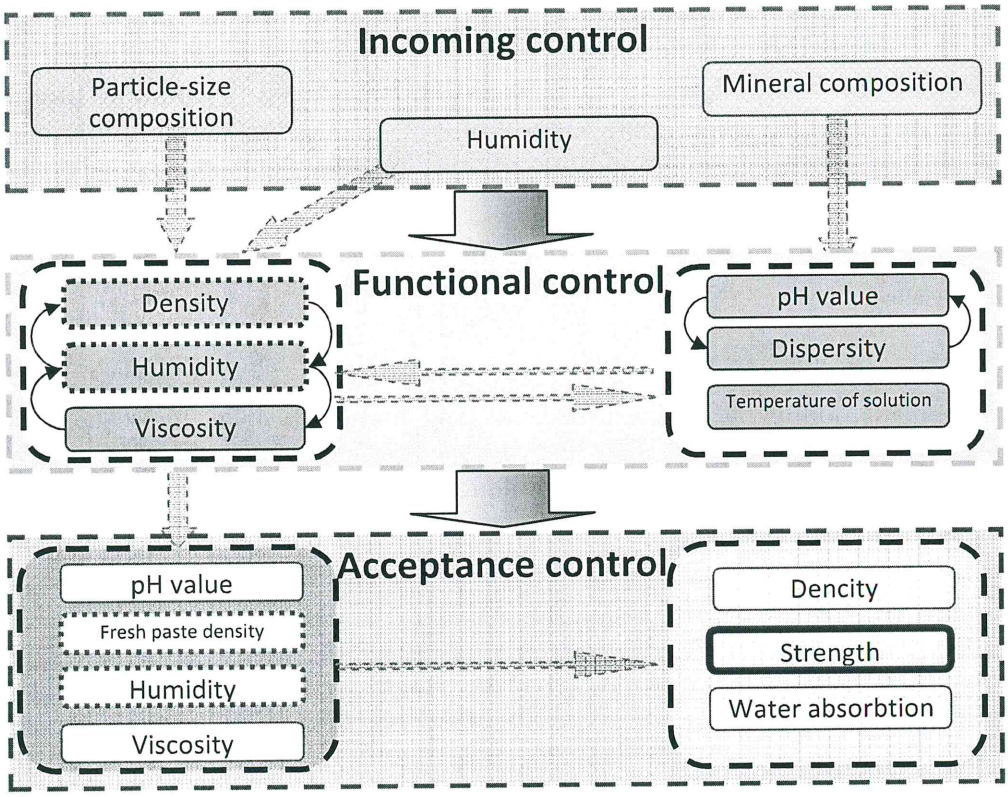
On the basic of this classification the earlier developed nanostructured binder [135] can be referred to non-metal oxides of SiO_2. Nanostructured binder (NB) in non-organic polydispersed mineral system mainly of silicate/aluminosilicate composition with high concentration of reactive solid phase containing nanodispersed component [4].

Materials and methods

As initial raw materials for NB production quartz sands of Ziborovka, Korocha and Razumnoe deposits were used.
The binder obtaining was accomplished in laboratory ball mill with volume of 200 liters in optimal range of pH values 7–8. When the binder sampling the residual at sieve№ 0063 should be 1 %, no more.

Results and discussions

NB is produced by mechanic synthesis, consisting of mechanoactivation of natural and industrial raw materials in wet medium at high concentration of solid phase and raised temperature [4]. Process of NB production is controlled by sampling and analysis of the data obtained during milling process. (Fig. 1, *Functional control*).



– Control methods allowing making parameter control without any modification in testing procedure.
–Control methods, required the insignificant corrections including specific requirements, applicable to NB
– Control methods, required the designing of new ways of measurement of controlled parameters for NB

Fig. 1. The scheme of functional control of NB

Necessity of formation of individual control system for this binder system is connected with features of structuring mechanism and production technology of binder of non-hydration hardening type that is different from traditional binding systems.

Structuring mechanism of silica based component NB is following:
First stage – dissolution of silicate raw component with subsequent formation of aluminate ions and orthosilicic acid ions in high-basic medium. Second stage – formed complexes of $Si(OH)_4$ work as monomers, which in further copolymerization in different proportions form aluminosilicate gel and third stage – final polymer structure by condensation of $Si(OH)_4$ groups with formation of Si-O-Si bonds [4].
In comparison with traditional hydraulic binders like Portland cement, gypsum etc. when NB production water acts as dispersive medium for alkaline activation of silicate anions and doesn't participate in structure formation process. Therefore, extra water in the binding system is not desirable due to reducing of pH value of reactive medium and pretending the structure formation process.
Taking into account the features of NB production, the suitability of arrangement of continuous technological process "raw→binder→final composite" It is distinctive characteristic of construction products based on NB in comparison with traditional binding analogues (for example, cement, gypsum, where material production involves the application of ready binder as raw component). In this case, quality control parameters for final construction product are monitored at different enterprises independently. It is possible due to availability of standard control methods for classical binders. At the same time, when production of material based on NB, quality of products needs to control as from raw components (Fig. 1, *Incoming control*) and binder production B To Functional control to production of final products (Fig., *Acceptance control*) in the framework of one technological process.
When production of experimental samples of the binder the analysis of basic controlled parameters is curried out that allows determination the most suitable control methods for NB system.
The scheme of functional control of NB (Fig. 1) represents character of interaction of controlled parameters when production of the studied binding system. Also the sequence of monitoring of basic parameters, influenced on quality of final binding product is determined. Including the features of structure formation and production of NB the curried out analysis allows determination optimal control methods as well as suitability of its application when quality estimation of the studied binder.
In this work the following classification of chosen control methods according to degree of its suitability to NB and based materials is proposed:
1. Control methods allowing making parameter control without any modification in testing procedure. They consider application of standard control methods or procedures to obtain the adequate results. It can be following procedures: chemical analysis, measurement of temperature, pH value, paste viscosity, water requirement, freeze-thaw resistance, specific effective activity of natural radionuclides.
2. Control methods, required the insignificant corrections including specific requirements, applicable to raw components, as well as features of the studied binders production. Editing feature of this group of methods consists in insignificant deviations from standard methods when preparation and measurement of required parameters of studied materials. It can be following procedures: measurement of dispersity, density and humidity of binding system.
3. Control methods, required the designing of new ways of measurement of controlled parameters for studied binders. It can be following procedures: compressive strength testing. For NB the highest analogous to control strength properties is standard for Gypsum binder (ASTM C472-99, Russian standard 23789-79). Basing on this method, test beams set at ambient conditions (25±2 °C) for 2 hours. Taking into account structuring mechanism of NB, should be noted followings:
– hardening and strength kinetics of the composite is accomplished proportionally to water removing. Therefore maximal strength values are achieved under drying process – at 3^d days under ambient conditions – at 28 days. So determination of strength characteristics of NB should be realized including the above features of this binder.

At present time, application of NB is limited due to absence of required normative documents and insufficient information about norms and requirement to quality parameters for the binder and based materials.

In this work the basic production features of the studied binders were analyzed as well as rules and regulations to controlled parameters, allowing supplying quality of final product with using of NB on the basis of quartz sands of Ziborovka, Korocha and Razumnoe deposits (Table 1).

Table 1

Rules and regulations applicable to NB

№ p/p	Parameter	Unit	Norm	1*	2*	3*
1	Yield compressive strength	MPa	3 at least	4,0	4,5	4,3
2	Yield tensile strength	MPa	1,5 at least	2,1	2,5	2,4
3	Dencity	kg/m^3	2000–2250	2138	2140	2140
4	Dispersity	%	1at most	0,78	0,89	0,69
5	Viscosity	Pa·s	25 at most	17,4	16,3	16,0
6	pH value of reaction medium	pH	7–10	8,3	8	7,9
7	Humidity	%	14–20	14,7	14,5	14,5
8	specific effective activity of natural radionuclides	Bq/kg	370 at most	200	210	205

*1 – Ziborovka depozit; 2 – Korocha depozite; 3 – Razumnoe deposit

It needs to note the list of controlled parameters for NB based on three types of quartz sands has not meaningful differences.

Conclusion

The scheme of functional control of NB properties, allowing realization the monitoring of NB production is proposed.

Classification of basic quality methods which subsequently can be used as prototype when designing of normative documentation for this type of binders is proposed.

The basic properties of NB based on quartz sands of different deposits are studied, as well as the rules and regulations of controlled production parameters allowing supplying quality of final product are determined. It is identified the properties of the studied binder based on different types of quartz sands are similar at common parameter of its production.

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