Key Engineering Materials
ISSN: 1662-9795, Vol. 761, pp 189-192
doi:10.4028/www.scientific.net/KEM.761.189

Submitted: 2017-04-27
Revised: 2017-08-02
Accepted: 2017-08-09
Online: 2018-01-22

Phytotoxicity Analysis of Different Compositions of Nanostructured Binder

STROKOVA Valeria[1,a], NELUBOVA Victoria[2,b], SIVALNEVA Mariana[3,c] and KOBZEV Vadim[4,d]

[1,2,3,4]Belgorod State Technological University named after V.G. Shoukhov, Russian Federation, Belgorod, Kostyukov St., 46

[a]vvstrokova@gmail.com, [b]nelubova@list.ru, [c]549041@mail.ru, [d]9087815876@mail.ru

Keywords: nanostructured binder, toxicity, phytoanalysis

Abstract. Nanostructured binder (NB) based on silicate and alumosilicate raw materials is prospective type of binders that can be applied for production of construction composites with different purpose. Production technology of nanostructured binder is characterized by using of natural raw materials only (independently of its genesis) as well as zero of chemically aggressive additives, that indicates on environmental friendliness and health safety of NB. Indicator of ecological safety of NB can be toxic effect on life activity of crop plants (phyto-effect) determined with phytoanalysis. In this paper it is determined NB to be characterized by low toxicity, so we can say about its environmental friendliness and health safety.

Introduction

Last time stronger interest in construction industry is focused on new materials those are competitive to ordinary construction materials. NB is able to replace (partially or fully) Portland cement in wide range of construction composites. The name of this type of material is associated with their belonging to the classical definition of the term "nanostructured", i.e. having a structure containing boundary elements, one or more dimensions of which are in the nanometer range, excluding any primary atomic or molecular structures. It should be noted that NB is determined not only by the presence of elements of the nanoscale level, which are formed as a result of production in an amount up to 15%, but also by their influence on the formation of special characteristics of composites. Potential raw materials for NB can be silicate and aluminosilicate rocks. At present time scientist from Belgorod State Technological University named after V.G. Shoukhov developed a production technologies of NB based on quartz sand, perlite, granite as well as formulations of based construction composites [1–4].

NB can be applied as main binder and as an active modifying additive in the production of autoclave hardening materials, composite binders based on cement, composite gypsum binders, non-autoclaved cellular materials. Production technology for NB consists of wet grinding process with mono- or poly- stage loading depending on genetic features (origin) and initial natural parameters of applied raw material. Final stage of mechanoactivation is, generally, modification of binding system by additive complex which is similarly determined by the type of applied raw materials.

As analogous production process is cement production. Cement is hydraulic binder. Cement production is characterized by high energy consumption and labor intensity of technological process including extraction of raw materials, grinding, burning and homogenization. In total, it negatively effects on ecology anв human health due to a lot of CO_x, N_x, SO_x emissions as well as hazardous organic components into atmosphere.

At the same time NB production technology is characterized by using of natural raw materials only (independently of its genesis) as well as zero of chemically aggressive additives, that indicates on environmental friendliness and health safety of NB.

Nowadays at the production and operation of building materials, much attention is paid to their impact on the environment in general, and in particular to factors that support the normal functioning of people. Indicator of ecological safety of NB can be toxic effect on life activity of crop plants (phyto-effect) determined with phytoanalysis.

Materials and Methods

Studied materials are samples of NB, obtained on the base of quartz sand and granite. Also, Portland cement CEM 42.5N (ZAO «Belgorodsky cement», Belgorod, Russia) as reference component is used.

Toxicological analysis of the experimental binders is realized with phytoanalysis by determination of class of hazard [5]. This method is consists of measurement of germination intensity of testing culture (grain crop), placed in medium of water extract from experimental binders. Oats grains are used as testing culture due to its stability and reproducibility of experimental data vs. others analogues (germinating ability should be 95 %, at least).

According to method [5–7] hardened samples are grinded up to powder state. After that 10 g of each powdered sample is placed in calibrated flasks with distilled water with following stirring and curing at ambient conditions for a day.Before the extract preparing using filtration method the experimental suspensions are stirred for 2 hourswith shaker LAB-PY-02. After filtration the following solutions «extracts – water» are prepared: 1/10, 1/100, 1/1000 and 100 %.

Reference medium is distilled water with pH = 6.1–6.3. The experiment is following: filter paper is placed on bottom of Petrie dish with following wetting with experimental extracts (5ml) and deposition of testing culture (25 oats grains). The prepared samples is placed in for thermostat 7 days.

After 7 days of testing period the measurement of length of oats grains roots. The longest root of the grain is fixed (calculated method). But calculated method is not unbiased estimation method of phytotoxicity. So, visual analysis also is applied.

Determination of phytotoxic effect is realized by comparison of experimental data including for reference sample. Quantitative indicator of phytotoxic effect is E_{inh} value (inhibitor effect) calculated with eq. (1):

$$Einh = \frac{Lref - Lexp}{Lref} \cdot 100\ \%, \qquad (1)$$

where L_{ref} – average length of testing culture roots in for reference sample (mm),

L_{exp} – average length of testing culture roots in for experimental sample (mm).

Limited E_{inh} value of for plants is 20 % at least; for animals E_{inh} value is 50 % at least.

Results and Discussions

After 7 days of testing period all samples have sprouting (Fig. 1). Difference in root length as well as oats grains purity is observed. The most pure samples (i.e. without visible defects) are ones containing quartz sand based NB extract. Granite and Portland cement based analogues as well as reference sample contain some spoiled grains (dark grains). Non- sprouted grains also take place.

Figure 1 – Sprouting intensity of testing culture in:
a – distilled water, b – Portland cement extract, c – quartz sand based NB extract,
d – granite based NB extract

Calculated data of phytoeffect depending of binder type and extract concentration are shown in Table 1.

Table 1 – Effect of binder type and extract concentration on E_{inh} value

Concentration	1:10	1:100	1:1000
E_{inh} for quartz sand based NB, %	20.43	23.23	25.79
E_{inh} for granite based NB, %	–3.96	22.57	23.69
E_{inh} for Portland cement, %	7.69	12.45	17.82

Results of experimental data for different type of binder represent its toxicity degree and bio-friendness. For all experimental samples a similar character of phytoeffect is observed: increasing of diluting ratio (from 1:10 to 1:1000) leads to increasing of inhibitory effect of the grains sprouting. It can be associated with presence of micro- and macroelements, solts and others impurities in experimental extracts providing favorable growing medium vs. reference sample (distilled water). So, dilution of experimental extracts with distilled water leads to reducing of required elements concentration in growing medium and increasing of E_{inh} value.

For granite based NB extract (1:10) E_{inh} has a negative value (Table 1). It means the inhibitory effect absents: sprouting process is better vs. reference sample. Further dilution E_{inh} transforms from «–» to «+» and increases up to 23.69 %.

Note, inhibitory effect for all experimental samples is acceptable (higher then 20 %). So, NB and Portland cement is bio friendly for activity of plants and for a human.

Summary

Thus, nanostructured binders obtained on the basis of quartz sand and granite are characterized by a low toxicity level. In this regard, it is necessary to consider these binders and materials on their basis, regardless of the type of raw materials used, biopositive and ecologically safe in relation to the environment of human activity. Providing favorable and comfortable conditions for the production and application of these binders in the system "Person - Material - Habitat" justify their prospects in the design of building composites for various functional purposes.

Acknowledgements

This work is financially supported by the Russian Federation Ministry of Education and Science in the framework of the state task. Project 7.872.2017/PCh.

References

[1] M.N. Kapusta,V.A. Kobzev, V.V. Nelubova, Kinetics of mechanical activation during the manufacturing process of nanostructured binders, Applied Mechanics and Materials. 670 (2014) 412–416.

[2] N.V. Pavlenko, V.V. Strokova, M.N. Kapusta, D.D. Netsvet, About application prospectivity of rocks with different geological and morphological features as basic raw component for free-cement binder production, Applied Mechanics and Materials. 670 (2014) 462–465.

[3] N.V. Pavlenko, V.V. Strokova, A.V. Cherevatova, D.D. Netsvet, E.V. Miroshnikov, Cellular concretes based on nanostructured perlite binder, Applied Mechanics and Materials. 496–500 (2014) 2383–2386.

[4] V.V. Strokova, A.V. Cherevatova, N.V. Pavlenko, V.V. Nelubova, Prospects of application of zero-cement binders of a nonhydration hardening type, World Applied Sciences Journal. 25 (1) (2013) 119–123.

[5] V.V. Strokova, V.V. Nelubova, M.N. Sivalneva, V.A. Kobzev, A.M. Ayzenshtadt, Properties of nanostructured binding elements depending on applied resource type, International Journal of Pharmacy & Technology. 8 (4) (2016) 22743–22748.

[6] N.I. Kozhukhova, M.S. Lebedev, M.I. Vasilenko, E.N. Goncharova, Ecology-toxicology study of low-calcium solid wastes from power plants, International Journal of Pharmacy & Technology. 8 (3) (2016) 15349–15360.

[7] N.I. Kozhukhova, I.V. Zhernovsky, V.V. Strokova, Evaluation of geopolymer binders biopositivity based on low-calcium fly ash, International Journal of Applied Engineering Research. 10 (15) (2015) 35527–35529.