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PHASE COMPOSITION, STRUCTURE AND PROPERTIES OF CEMENT STONE AFTER MODIFYING FULLERENES[1]

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Carbon nanomaterials are perspective additives for modifying cement composites. In this work the influence of carbon nano-modifier (CNM) formed in plasma chemical reactor on phase composition, structure and properties of cement stone was investigated. Method of dispersion of nanoparticles has been used, which consists in sonication mixing water with carbon nano-modifier and super plasticizers (SP).

Change in phase composition, structure and properties of modifying cement stone were investigated. The effects of the CNM on the early hydration process of cement were studied using X-ray diffraction analysis and scanning electron microscopy analysis. The CNM were found to accelerate the hydration reaction of the C_3S in the cement. In particular, the CNM appeared to act as nucleating sites for the hydration products, with the CNM becoming rapidly coated with C-S-H. With the introduction of CNM is reduced porosity of cement stone, which leads to high strength characteristics of modified cement.

Experience of application CNM in technology of cement composites and concrete shows that the effect of their influence on cement system varies depending on a kind used nanomaterials. It is connected by that at various ways and conditions of reception carbon nano particle their form and the sizes, the maintenance in the received mix of fullerenes and carbon nanotubes change. Considering, that introduction CNM leads to considerable effect of improvement of the basic properties of cement and concrete, carbon nanomaterials, received plasma-chemical method, research of possibility of use is of interest for updating of a cement stone.

Synthesis of initial carbon nano-modifier carried out on a plasma chemical reactor or Arc discharge apparatus. The basis of the system is based on the erosion of graphite electrodes in the arc discharge plasma. The discharge is initiated at a pressure of 10^5 Pa, by passing through the electrodes and current frequency 44 or 66 kHz. Erosion of rods occurs in close sealed volume filled with helium.

Carbon condensate containing fullerenes of 10-12%, the benzene was allocated fullerenes. CNM contains parts by weight: 0.8 - C_{60}; 0.15 - C_{70}; the rest - higher fullerenes and oxides $C_{60}O$ and $C_{70}O$.

Changing the properties with the introduction of CNM associated with changes in the phase composition and structure of modified cement stone.

According to X-ray diffraction analysis, the original Portland cement includes traditional phase characteristic of OPC: calcium silicates and Ca_3SiO_5 Ca_2SiO_4, calcium aluminates $Ca_2Ca_2(FeAl_{0,9}Mg_{0,1})O_5$ and $Ca_3Al_2O_6$ and calcium sulfate $CaSO_42H_2O$. In hydrated cement decreased intensity of peaks attributable to the original cement phases, appear peaks attributable to $Ca(OH)_2$ and hydrated calcium sulfoaluminate in low-sulfate form $Ca_3Al_2O_6(SO_4)14H_2O$ (d=0,4729 nm) with expressive intensity of peak. Introduction of CNM into the cement causes a change of distance from d=0.4682 nm to d=0.4833 nm.

Contents of aluminates $Ca_2(FeAl_{0,9}Mg_{0,1})O_5$ and $Ca_3Al_2O_6$ in hardened specimens is reduced, which is testified to intensive hydration of these phases, especially in the presence of CNM. For example, for phase $Ca_3Al_2O_6$ (PDF 00-006-0495 ICCD) a decrease in intensity of the reflection is d_{100}= 0.2700 nm. Furthermore, the introduction of CNM into hydrated cement leads to change in samples of distance from d=0.2561 nm to d=0.2604 nm for this plane. This variation can be explained in terms of the degree of crystalline of hydrated cement samples. So in the control sample cement content of the amorphous phase reaches 46%, and the addition of fullerenes leads to an increase in crystalline up to 63%, which indicates an increase the degree of hydration of PCs in the initial period of hardening.

Introduction of CNM changes not only phase composition of hydrated cement but also the microstructure of cement stone. Introduction of CNM reduces porosity of cement stone due to formation of gelatinous hydration products filling interporous space. It should be noted that an increase in hardening time from 3 to 7 days leads to a substantial reduction in porosity of the hydrated stone and reducing crystallite size. All of this favorable effect on the changes in physical and mechanical properties of modified cement stone.

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IMPROVING THE QUALITY OF ASPHALT COATING WITH FULLERENES[1]

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This work deals with the possibility of modifying the binder by adding carbon nanomodifier (CNM) to bitumen to improve the quality of asphalt. Synthesis of initial carbon nano-modifier carried out on a plasma chemical reactor or Arc discharge apparatus. The basis of the system is based on the erosion of graphite electrodes in the arc discharge plasma. The discharge is initiated at a pressure of 10^5 Pa, by passing through the electrodes and current frequency 44 or 66 kHz. Erosion of rods occurs in close sealed volume filled with helium.

Carbon condensate containing fullerenes of 10-12%, the benzene was allocated fullerenes. CNM contains parts by weight: 0.8 - C_{60}; 0.15 - C_{70}; the rest - higher fullerenes and oxides $C_{60}O$ and $C_{70}O$.

Addition of 0.05% - 0.5% of nanomodifier significantly changes the properties of bitumen. Asphalt with this astringent has increased strength, heat resistance and shear resistance.

For managing the process of bitumen structure formation with specific parameters (distribution of different fractions of bitumen according to thickness of its adsorption layer) a variety of modifiers is being used, both organic and mineral compounds. These compounds are working in different ways: first, formation of the polymer “grid”, which is responsible for increasing the interval of flexibility, or second, enlargement of quantity of active centers on mineral part surface, which can take part in chemical reacting with bitumen (chemisorptions). The first method is provided by adding different organic compounds, such as rubber, polymeric additives, their combinations, etc. The second technique is implemented by other agents, such as phosphoric acid or hydrochloric acid. Different nano additives like nanotubes, fullerenes, astralenes and nanodiamonds compose a separate group of agents which performance is poorly investigated

Table 1. Properties of the original bitumen and the bitumen modified by CNM

Name index bitumen	Initial bitumen BND 90/130	Bitumen + 0.05 % mas CNM	Bitumen +0.1 % mas CNM	Bitumen +0.25 % mas CNM	Bitumen+0.5 % mas CNM
Penetrationat 25°C, 0.1mm	95	90	81	78	62
Temperature of softening, °C	46	45	43	42	40

Table 2. Physical and mechanical parameters of organic compounds on the basis of bitumen, modified with CNM, identified by the StSt 12801-98 methods.

Sample	Average density, g/cm^3	Breaking point at compressing specimens, MPa			Water resistance index	Water saturation in volume, %
		$R_{50°C}$	$R_{20°C}$	$R_{0°C}$		
-	2.37	0.91	2.53	4.31	0.94	3.22
Mechanical mixing by 140°C, 0.05% CNM	2.38	1.05	2.5	4.13	0.95	2.98
Mechanical mixing by 140°C, 0.1% CNM	2.39	1.53	2.75	4.37	0.98	2.31
Spreading CNM in toluene, 0.1% CNM	2.37	1.21	2.53	4.55	0.97	2.29
Requirements of the StSt 9128-97		Least 0.9 MPa	Least 2.2MPa	Not more 10MPa	Least 0.9	1.5%-4.0%

[1] This work was supported by the RAS Presidium program "Arctic", project № 84.