

Effect of detonation nanodiamond dopant on phase composition and strength of Portland cement materials

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Anhydrous Portland cement is essentially made of a synthetic rock, referred to as “clinker”, which contains at least four major phases. Alite and belite are two calcium silicates, Ca_3SiO_5 (C_3S) and Ca_2SiO_4 (C_2S), respectively, with a few percent of impurities. Two calcium aluminate phases are also observed: $\text{Ca}_3\text{Al}_2\text{O}_6$ (C_3A) and $\text{Ca}_4(\text{Al,Fe})_4\text{O}_{10}$ (C_4AF).

In the paper, the results of researching synthesized Portland cement materials based on the clinker from Suhologsky work doped detonation nanodiamond (DND) are presented.

As is known, there are a large number of active functional groups on the surface of DND, which additives are suggested to affect significantly on the features of cement materials properties. Also there was shown the addition of the DND in an amount of 0.1 wt.% increases the strength of cement materials [2].

There were two series of syntheses new materials doped DND (0; 0.1; 0.2; 0.5; 1 – 9 wt. %), distinguished by the absence (1st series) or presence (2nd series) gypsum $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ addition in the amount of 5 wt. %. Phase composition was determined by X-Ray method (STOE STADI P powder diffractometer, transmission geometry, $\text{CuK}_{\alpha 1} = 1.54056$, $2\theta = 5-55^\circ$, $\Delta 2\theta = 0.02^\circ$, exposition 100 sec.) Besides, to identify features of DND particles distribution in hydrated samples light and scanning electron microscopy (Leica Microsystem CMS CmBh and Quanta 200 3D, respectively) were used. SEM research was carried out in reflected electrons (high vacuum, $U = 15-20\text{kV}$, analyst S.J. Yanson).

Maximum strength of researching samples in 1st series of experiments is achieved at 0.1-0.5 and 4-5 wt.% DNA content with a large concentrations of calcium carbonates and portlandite $\text{Ca}(\text{OH})_2$, which is a measure of hydration degree [2]. At higher contents of DND material becomes brittle and disintegrates. Gypsum addition alters the rate of hydration: there are a gradual increase of portlandite and calcium carbonates. Maximum strength in 2nd series is observed at 0.1 wt.% DND. The destruction of the material in investigative range isn't observed.

In general, the results had shown the addition of DND significantly affected on the phase composition and strength characteristics of Portland cement materials that is explained by the features of their hydration.

[1] Boikova A.I. et al, Alitinform: Cement. Concrete. Dry mixtures **8**(1) 37 (2009).

[2] Reichel W., Canrad D. Beton: in 2 B. B. 1. Eigenschaften Projektierung Prüfung. VEB Verlag für Bauwesen, Berlin, 1976.