

Alkali Activated Cements Versus Geopolymers



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Opinion

Nowadays the scientific community of “cement people” is involved into discussions: are the alkali activated cements and geopolymers the same or not? In these discussions the scientists apply different approaches based on chemistry of the processes that take place, final phase composition of the resulted cement stone that is formed, or types of raw materials that are used as cement components. In order to put more light on the “very hot” topic of the above discussions, I would like to start from the very beginning. The idea taken as a basis for creation of a new class of cements (alkali-activated cements) can be described as the following. The cement and chemist specialists know that the processes of revealing hydraulic activity by traditional aluminosilicate-based cements are attributed to a possibility to transform and to fix aluminium-silicon-oxygen tetrahedrons in a discrete state, at which their hydrates (sols) are capable to polycondensation with the formation of gels-colloid solutions and, finally, crystalline formations. In case of Portland cement this process takes place due to blocking a discrete state of $[\text{SiO}_4]^{4-}$ by Ca^{2+} -ion (for example, C_3S , C_2S).

In this state, an autocatalytic destruction of the above minerals when they are mixed with water with following polycondensation of monomeric structures into layered CSH-structures due to protonization of the Ca-O bond takes place. When the CS-mineral is mixed with water, the ionic force of water is not enough, because the covalent phases are prevailing, and in order to break them high temperatures or other activators that are capable to break the covalent bonds of the silicon-oxygen framework of the structure with the largest discreteness of $[\text{SiO}_4]^{4-}$ are required. Just this idea was put forward in 1957 by the Ukrainian (USSR) scientist Viktor Glukhovskiy (those times PhD, his DSc (Eng) degree and corresponding title of professor were earned in 1966). He proposed to use compounds of the elements of group 1 of the periodic table, which are known to create in aqueous medium an alkaline reaction, these are, for example: $\text{Na}(\text{K})_2\text{O}$, CO_3 , $\text{Na}(\text{K})\text{OH}$, $\text{N}(\text{K})_2\text{O} \cdot n\text{SiO}_2 \cdot m\text{H}_2\text{O}$. This idea was supported by deep analysis of the processes of rock-mineral formation taking place in nature and a role played by

alkali metal compounds in these processes Palomo et al. [1], As a result of these processes the alkaline or mixed alkaline-alkali earth aluminosilicate hydrates-analogues of natural zeolites (for example, $\text{Al}_2\text{O}_3\text{-SiO}_2\text{+NaOH+H}_2\text{O} \rightarrow \text{Na}_2\text{O-Al}_2\text{O}_3\text{-SiO}_2\text{-H}_2\text{O} \rightarrow \text{CaO-Na}_2\text{O-Al}_2\text{O}_3\text{-SiO}_2\text{-H}_2\text{O}$) are formed.

Taking into account that in normal conditions these processes of synthesis flow very slowly and require rather high temperatures Barrer RM [2], in analogy to predominant processes taking place in nature of the mixed type zeolite (Na-Ca) formation, Viktor Glukhovskiy showed that elements of group 2 of the periodic table could accelerate these processes (for example, Ca^{2+}). Viktor Glukhovskiy proposed TWO new cement types: alkaline and alkaline-alkali earth aluminosilicate hydrate cements. Volyanskyy et al. [3] With account of similarity of two processes: Glukhovskiy [4] proposed to call these cements “soil silicates” or “soil cements” (“gruntotsementy” or “gruntosilikaty” in Russian) in attempt to reflect this similarity to natural minerals formations. Glukhovskiy [5] later, depending upon raw materials used as cement components and composition of the resulted hydration products these cements were called as listed below:

- a. Geopolymers (Davidovich-1973)
- b. Alkali-activated cements (Narang, Chopra-1983)
- c. F-cement (Forss-1983)
- d. Gypsum-free portland cement (Odler, Skalny, Brunauer-1983)
- e. SKJ-binder (Channgo-1991)
- f. Geocement (Krivenko-1991)
- g. Alkaline cements (Krivenko-1994)

However, in mechanism of hardening and hydration products their essence remains the same-to break an aluminium-silicon-oxygen framework by alkaline activators with the formation of alkaline ($\text{Na}(\text{K})_2\text{O-Al}_2\text{O}_3\text{-SiO}_2\text{-H}_2\text{O}$) or mixed alkaline-alkali

earth hydration products ($\text{Na(K)}_2\text{O-CaO-Al}_2\text{O}_3\text{-SiO}_2\text{-H}_2\text{O}$) due to the processes of polycondensation (polymerization reaction). A conclusion can be made that in their basic feature (chemical processes of hydration and hardening) geopolymers are alkali activated materials. Nowadays, with account of variety of raw materials (cement components) which could be activated, the above mentioned phases can be formed in parallel with the CSH-phases (so-called "hybrid cements"), thus giving a possibility to use a variety of available raw materials to provide the required properties (Shi C, Jiménez & Palomo [6] and Fernández-Jiménez et al. [7] The first RILEM Technical Committee 224-AAM [8] has proposed, with consideration of the above arguments, to call these cementitious systems and materials based on them "the alkali activated materials". Currently, the second RILEM Technical Committee 247- DTA "Durability Testing of Alkali-Activated Materials" is dealing with durability aspects of these materials.

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