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The behavior of biogenic silica-rich rocks and volcanic tuffs as pozzolanic additives in cement

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Cements currently produced, include a variety of pozzolanic materials, aiming for lower clinker addition and utilization of vast deposits of certain raw materials and/or mining wastes and byproducts. The major naturally occurring pozzolanic materials include glassy tuffs, zeolitic tuffs, diatomites and volcanic lavas rich in glassy phase, such as perlites. Therefore, based on the available raw materials in different locations, the cement composition might vary according to the accessibility of efficient pozzolanic materials.

In the present investigation, the behavior of pozzolanic cements produced with representative samples of the aforementioned materials was studied, following the characterization of the implemented pozzolanas with respect to their chemical and mineralogical characteristics.

Laboratory cements were produced by co-grinding 75% clinker, 5% gypsum and 20% pozzolana, for the same period of time (45 min). Regarding pozzolanic materials, four different types of pozzolanas were utilized namely, diatomite, perlite, zeolite tuff and glassy tuff. More specifically, two diatomite samples originated from Australia and Greece, with high and low reactive silica content respectively, two perlite samples originated from Turkey and from Milos Island, Greece, with different reactive silica contents, a zeolite tuff sample originated from Turkey and a glassy tuff sample originated from Milos Island, Greece.

The above pozzolana samples, which were ground in the laboratory ball mill for cement production performed differently during grinding and that was reflected upon the specific surface area (cm^2/gr) values. The perlites and the glassy tuff were the hardest to grind, whereas, the zeolite tuff and the Australian diatomite were the easiest ones. However, the exceedingly high specific surface area of the Australian diatomite renders cement difficult to transport and tricky to use for concrete manufacturing, due to the high water demand of the cement mixture.

Regarding late compressive strength, the worst performing cement was the one with the lowest reactive silica content with biogenic opal-A as the only reactive pozzolana constituent. Cements produced with perlites, raw materials consisting mainly of a glassy phase, were characterized by higher strength and a rather ordinary specific surface area. Cements produced with Turkish zeolite tuff and Milos glassy tuff exhibited higher late compressive strength than those mentioned above. The highest strength was achieved by the implementation of Australian diatomite for cement production. Its 28 day strength exceeded that of the control mixture consisting of 95% clinker and 5% gypsum. That could be attributed to both, high specific surface of cement and reactive SiO_2 of diatomite.

Therefore, a preliminary assessment regarding late strength of pozzolanic cements could be obtained by the consideration of two main parameters, namely: specific surface area of cement and reactive silica content of pozzolana.