

Recovered Cement Fines as Supplementary Cementitious Materials

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Abstract - Supplementary Cementitious Materials (SCM's) are added to the cement or to the concrete mixtures for various reasons: improving durability, decreasing permeability, aiding in pumpability and finish ability, mitigating alkali reactivity and improving the overall hardened properties of concrete and cement through hydraulic or pozzolanic activity or both. SCM's sometimes are added to concrete in addition to, or as a partial replacement of Portland cement or blended cements. Fly Ash, Ground Granulated Blast Furnace Slag, Silica Fume, Calcium Carbonate, Natural Pozzolans - such as calcined clays, shale, and metakaolin. These are the most common SCMs that are used in the concrete and cement industries. A new approach for additional SCM is concrete waste.

Concrete waste consists mainly of unbound particles of stone (natural aggregate), particles of natural aggregate fully or partially surrounded by old cement paste/mortar, and lumps of old cement paste/mortar. The portion of the old cement paste is only partially hydrated and, therefore, is a source of unhydrated cement with great potential for recovery. All types of concrete contain residual unhydrated cement. For example, unhydrated cement is found in high-strength concrete due to low water/cement ratios, as well as in old concrete due to coarser cement particle size, and in fresh concrete waste due to the lack of curing. These residues of unhydrated cement are a waste of resources with recovery potential. An efficient activation is required to liberate the unhydrated cement core surrounded by hydrates.

The content of the residual cement and the degree of hydration of various cement pastes were quantified by different methods, including X-ray diffraction, thermogravimetric analysis, computer simulations, and analytical calculations, to explore their recovery potential. The efficiency of different grinding parameters and techniques was investigated, and the activation effect was assessed using isothermal calorimetry. The recovery efficiency was calculated based on the content of residual unhydrated cement, and the correlation between specific surface area and recovery efficiency was established. The effect of recovered cement fines as supplementary cementitious material (SCM) in new mortar was evaluated and compared to inert fillers. A k-factor for the recovered cement fines was calculated based on late compressive strength.

Recent research included cement pastes with water/cement ratios of 0.2-0.6, and residual unhydrated cement was found to be in the range of 6-36 %, indicating great recovery potential. Grinding beyond a certain specific surface area did not contribute to hydraulic properties. Recovery of up to 86 % was achieved. The most efficient method for liberating the active cement core and activating the residual cementing properties was grinding in a planetary mill with a low concentration of grinding aids.

Recovered cement fines reached higher compressive strength values than inert fillers and equivalent values to cement at later ages. The increment in compressive strength after 28 days indicated late hydraulic activity due to the high content of belite in the residual cement. A k-factor of 0.9 was achieved.