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A Discussion of the Paper "THE INFLUENCE OF POZZOLANIC MATERIALS ON THE MECHANICAL STABILITY OF ALUMINOUS CEMENT"

by M. Collepardi, S. Morosi and P. Piccioli*

John Bensted
Department of Crystallography
Birkbeck College, University of London
Malet Street, London WC1E 7HX, U.K.

The experiments undertaken by Professor Collepardi and his colleagues[1] have demonstrated that calcium aluminate (high alumina) cement containing condensed silica fume (csf) shows an increasing compressive strength trend at 20°C and 40°C for water/solids ratio 0.4, unlike the situation where pulverised fly ash (pfa) is present. This beneficial effect, particularly at 15% csf addition, is due to the high silica csf favouring the formation of gehlenite hydrate (strätlingite) C_2ASH_8 which appears to hinder transformation of the hexagonal calcium aluminate hydrates CAH_{10} and C_2AH_8 from converting to the denser cubic hydrate C_3AH_6. The transformation is accompanied by increased porosity and compressive strength loss[2,3]. For calcium aluminate cement with 15% replacement by csf, the strength decrease at 20°C and 40°C is almost completely reduced.

The aforementioned work has demonstrated the benefits to be gained in hydrating calcium aluminate cement systems when the silicate hydration is optimised. Indeed, the whole area of silicate hydration in calcium aluminate cements is one in which more information is required on long term strength and the consequent durability in particular since it appears to be beneficial overall. The hydration of larnite β-C_2S to C-S-H appears to convert to gehlenite hydrate in the aluminous medium with time, but this does not yet appear to have been quantified. Some silicate is also contained in the poorly hydraulic pleochroite glassy phase. The effects of the observed intergrowths between pleochroite and gehlenite hydrate as well as other observed intergrowths of silicate with C_3AH_6 that arise upon longer term hydration need to be further explored, so as to quantify their influences upon compressive strength and durability.

Some data I have obtained for a dark grey calcium aluminate cement (Ciment Fondu) hydrated for 91 days neat and with 10% csf is given in Table 1.

Qualitatively there was more C-S-H with csf present (about 4% larnite β-C_2S was contained in the calcium aluminate cement employed in this investigation). Also, much more gehlenite hydrate C_2ASH_8 was being formed with csf present in the hydrating cement. Less conversion of

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Table 1: Compressive Strength Data for Ciment Fondu with 0 and 10% wt CSF Replacement at Water/Solid Ratio 0.40

CSF wt%	Compressive Strength (N/mm^2), days					
	1	3	7	28	56	91
0	52.9	58.0	66.9	75.1	71.2	65.8
10	45.1	52.5	60.4	69.5	68.1	67.3

the hexagonal calcium aluminates to the cubic C_3AH_6 up to the end of the 91 day period investigated was found with csf present. This could be attributed to less CAH_{10} being produced as well as to gehlenite hydrate being formed which uses up more aluminate from the hydrating system. There is effectively less available lime for participating in conversion because of the competing presence of csf. It is not clear whether more calcium silicate hydrate C-S-H is actually formed in the hydrating calcium aluminate cement in the presence of the reactive silica from csf by some reaction with the lime-containing calcium aluminate hydrates, or whether because of the main influence of csf being to form C_2ASH_8, there is less Al_2O_3/SiO_2 in the cement paste to encourage at least some further change of C-S-H into C_2ASH_8.

The immediate impact of csf upon calcium aluminate cement hydration is much less dramatic than upon Portland cement hydration owing to the effective absence of calcium hydroxide (CH) and much lower alkali content in the former cement. This means that the active pozzolan effect of csf observed with Portland cement is not effectively available with calcium aluminate cement. Notwithstanding the pronounced lack of significant pozzolanicity as normally understood by this term, csf does certainly influence the hydration reactions of calcium aluminate cements.

The studies by Professor Collepardi and his colleagues[1] have successfully shed more light on the influence of pozzolanic materials upon the mechanical stability of calcium aluminate cement in their very interesting studies with csf and pfa.

References

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