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Discussion

# Discussion of the paper “Durability of the hydrated limestone-silica fume Portland cement mortars under sulphate attack” by J. Zelić, R. Krstulović, E. Tkalčec, and P. Krolo☆

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This interesting paper contains a photomicrograph (Fig. 6), “SEM of the fractured surface of the P-8 sample showing the long-needle ettringite crystals produced by sulphate attack during 120 days of immersion in the N solution.” The crystals are in what appears to be a relatively spherical air void in the P-8 mortar which had 8% by mass of silica fume and a w/c between 0.50 and 0.67, depending on the water requirement for a given flow; the cement was a Portland blast-furnace slag cement with 45% slag. The $C_3A$ content of the clinker was not reported. The cement had 5% gypsum. The photomicrograph shows a couple of cracks transecting the void. The specimens were moist cured 24 h, stored in water until an age of 28 days, then stored in 0.26 mole/L sodium sulfate solution for 120 days. It may well be that the specimen suffered sulfate attack, but it is, in this discusser’s opinion, unlikely that the presence of these attractive crystals in this air void indicates anything about sulfate attack. It is my view that the scenario that caused these crystals to be where they are is as follows. The mortar mixture was made; since it contained Portland-cement clinker and gypsum, ettringite formed by reaction of the sulfate ion in solution with the $C_3A$ of the clinker. Some time later, microcracking took place. As a result of microcracking, pore fluid from the mortar entered the void. The pore fluid contained dissolved ettringite. Some time later, the concentration of the pore fluid increased and the ettringite crystals shown in the micrograph grew. This could all have taken place without the specimen ever having been stored in sulfate solution. The fact that it was so stored, however, makes it possible for the sulfate that entered the specimen after the post 28-day water storage began to have reacted with either previously unreacted $C_3A$ or previously unsulfated $C_3A$ hydrate, but such reaction need not be postulated to account for the presence of the ettringite in the void. All that is necessary is that the normal ettringite formed as cement hydrates be present, that there be water available thereafter, and that some mechanism caused cracking that allowed the pore fluid with dissolved ettringite to enter the compromised void, some water to be lost by evaporation or used in hydration, and voilà—ettringite crystals in a broken-into void.

A second comment: I think the authors misspoke when they wrote (p. 820): “The cement stone potential sulphate resistance was determined according to ASTM C 452-58.” I think what they meant was that they made mortars of the compositions reported and stored them in water, as are the specimens made following C 452. However, there is no indication that the specimens tested by the authors all had their $SO_3$ content adjusted to 7.0% by mass and that the C 452 test was regarded as complete after 14 days in water since no such results are in the paper. In any case, C 452 is not an appropriate test for sulfate resistance of blends of the sorts tested by the authors. This is explained in Section 3.1 of ASTM C 1012, a procedure similar to that used by the authors.

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