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Discussion

A discussion of the paper “Role of delayed release of sulphates from clinker in DEF” by Weislaw Kurdowski[☆]

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In his paper, Prof. Kurdowski concludes that:

- Anhydrite, when present in clinker, can be the source of DEF expansion after heat treatment of the mortar at 90 °C; and that
- DEF caused by anhydrite can occur in cements poor in alkalis.

We feel that such conclusions are not supported by the experimental evidence reported and are incoherent with other experimental results in the literature.

Prof. Kurdowski has determined the expansion of EN 196 mortar prisms, prepared from five cements containing different amounts of SO_3 and alkalis, after curing at 90 °C. The cements were prepared in the laboratory from sulfate-rich clinkers produced in a laboratory furnace. The three cements with the highest SO_3 and alkali contents (i.e., $> 3.6\%$ SO_3 and $>1.1\%$ Na_2O eq.) all expanded by more than 5 mm/m after 200–300 days. The cement with the lowest SO_3 and alkali contents (i.e., 2.48% SO_3 and 0.3% Na_2O eq.) did not expand, whilst the cement with a high sulfate content and low alkali content (i.e., 3.62% SO_3 and 0.31% Na_2O) expanded slowly. These results are consistent with the literature where there is broad agreement that high sulfate and alkali contents increase the risk of delayed ettringite expansion. The fact that the high sulfate contents in this particular study occur in the clinker is not proof that their location or phase composition is in any way responsible for the observed expansion at 90 °C (as Prof. Kurdowski seems to be claiming, particularly for anhydrite) since this expansion is also predicted for conventional cements with the same contents of sulfates (from interground gypsum) and alkalis [1].

No experimental evidence from either X-ray diffraction or SEM is presented to support the claim that anhydrite in the clinker is directly responsible for the expansion observed.

For Prof. Kurdowski to prove that the clinker sulfates or anhydrites have specifically contributed to the observed expansion, he would need to test two cements identical in surface area and overall chemical composition including the SO_3 content, with the only difference being the distribution of sulfates. One cement would need to contain sulfate-rich clinker with anhydrite and Ca-langbeinite, and the control cement would need to contain normal clinker with interground gypsum. The tests would need to show that:

1. The anhydrite persists for weeks or months whilst the gypsum in the control cement is rapidly consumed by reaction with the C_3A, and possibly some C_4AF. (If both cements are oversulfated, both the anhydrite and gypsum will persist indefinitely as stable phases, not because they are reacting slowly, but because they are both stable phases in the final assemblage.)
2. The cement containing anhydrite results in significantly greater expansion at 90 °C (or any other temperature since the late reaction of anhydrite should also occur in the absence of heat treatment) than the cement interground with gypsum or natural anhydrite.

Attention is drawn to tests that have been performed in this way, i.e., by testing the hypothesis that clinker sulfates and anhydrite can result in late expansion without heat curing [2–4]. No significant expansion was observed in any of these studies regardless of the content and distribution of sulfate in the clinker. Furthermore, clinker anhydrite in those cements where it was present had completely reacted after a few hours of hydration [2]. In fact, nearly all the sulfate in the clinker had reacted within the first 28 days of hydration. Where some

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SO_3 did remain at 28 days in unreacted belite, it only amounted to approximately 0.2% by weight of the clinker and, furthermore, was stoichiometrically balanced by Al_2O_3, ruling out any likelihood of formation of ettringite.

References

[1] S. Kelham, Effects of cement composition and hydration temperature on volume stability of mortar, Proc. 10th Int. Congr. Chem. Cem. 4 (iv060) (1997).

[2] D. Herfort, S. Rasmussen, E. Jons, B. Osbaeck, Mineralogy and performance of cement based on high sulfate clinker, Cem., Concr. Aggreg. (CCAGDP) 21 (1) (1999) 64–72.

[3] V. Michaud, R. Suderman, Anhydrite in high SO_3/alkali clinkers: dissolution kinetics and influence on concrete durability, Presented at the ASTM Symposium on Internal Sulfate Attack on Cementitious Systems: Implications for Standards Development, San Diego, December 1997.

[4] P. Tennis, S. Bhattacharja, W.A. Klemm, F.M. Miller, Ambient temperature delayed ettringite: a reappraisal, Presented at the ASTM Symposium on Internal Sulfate Attack on Cementitious Systems: Implications for Standards Development, San Diego, December 1997.