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Discussion

A discussion of the paper "Redefining cement characteristics of sulfate-resistant Portland cement" by Paul J. Tikalsky, Della Roy, Barry Scheetz and Tara Krize☆

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Although the paper by Tikalsky et al. presents considerable information, it also further confuses the literature regarding sulfate attack. If a purpose was to determine the relationship between "sulfate attack" and C_3A content, the authors should have used calcium sulfate instead of sodium sulfate. As they state, sodium sulfate complicates any analysis by also causing calcium sulfate production that may (or may not, depending on your choice of previous researchers) also cause expansion.

Unfortunately, although they state that Portland cement hydration produces monosulfate, they fail to include that reaction in their equations, and like virtually all previous investigators, ignored the fact that during normal hydration, some or all of the sulfate of the cement causes a degree of innocuous "sulfate attack" (that is, monosulfate and ettringite production). Indeed, in the 21st century, it is time to realize that classical sulfate attack—that which produces ettringite—is not related to total C_3A content but to C_3A that has not already formed ettringite.

In the 1800s and for much of the 1900s, the molar ratio of SO_3 to C_3A was often considerably less than 1, ensuring plenty of potential for future ettringite formation due to sulfate attack. Now, most Portland cements have ratios more than 1, meaning that some ettringite is already present. Indeed, many have a ratio of about 3, suggesting absolutely no potential for sulfate attack that produces ettringite.

If one assumes that the SO_3/C_3A ratio for Portland cement is at least 1, then sulfate attack, perhaps as measured by expansion, is proportional to the amount of monosulfate present. This may be given by an equation we propose: $E = k(1.5C_3A - 1.695SO_3)$, where E is expansion, k is a proportionality factor, and C_3A and SO_3 are percentages in the Portland cement. Using the Tikalsky et al. data as an example, compare Cements 11 and 16. They both have C_3A contents of 9.5% but very different SO_3 contents. According to our equation, expansions for Cements 11 and 16 should be more related to their E values of 7.07 and 9.13, agreeing more with the expansion data. Such a relationship is not exact, as Tikalsky notes, because C_4AF contents are different and differences in their gypsum formation potentials probably exist.

An equation considering "available C_3A," C_4AF, and perhaps potential $Ca(OH)_2$ might be best, and we urge the authors to search for one.

ACI, ASTM, and all involved investigators should recognize that "modern" cements have at least twice the SO_3 contents of cements used for the sulfate attack experiments of the classical literature on which nearly everyone erroneously bases their work.

Finally, we note that Tikalsky et al. presented data only up to 6 months, when most of the samples are expanding rapidly. Although they state that later data are not presented because some of the samples broke, that data may have relevance and we would like to see it.

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