Pergamon

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Discussion

Reply to the discussion of the paper "Sulfate attack," or is it?☆

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One of us (Mather) replied to a copy of the discussion he received from Dr. Skalny, as follows:

> I am glad you and your codiscussers are taking an interest in Hime and Mather in *Cement and Concrete Research* (29) 789–791, as indicated by your fax of 17 August.
>
> DePuy (your reference [5]) does, in fact, talk about the mechanism of ASTM C 88 under the heading "sulfate attack" and recognizes it as "a purely physical form of sulfate attack [which] is sometimes included under the general category of sulfate attack," for which he references Tom Reading in 1982 in ACI SP-77. However, he is completely wrong, in my opinion, when he says the C 88 mechanism is "crystallization pressures," when it is actually rehydration volume increase; and he makes it clear that it is only "sometimes" included in sulfate attack. In any event, it is not a mechanism the effects of which can be mitigated by limiting the Bogue calculated C_3A in the cement, which is the kind of sulfate attack that most of the treatments of the subject (e.g., 201-2R) are trying to address.
>
> I never realized before that Verbeck's and my papers in the Thorvaldson symposium had identical titles misquoted by you; it is "sulphate," not "sulfate" in both.
>
> Your reference [15] to Hansen says it is in reference [5]—it isn't, it is in reference [7]. I have just reviewed reference [5], and I did not locate any passage in which he says, as I can understand it, that he (Hansen) questioned the topochemical, in situ, solid-state formation of ettringite as an expansive mechanism in sulfate attack. He does, of course, review and summarize the work and speculations of others who do question this.
>
> You say to try to draw a distinction between "chemical" and "physical" processes does not serve a useful purpose. I do not agree if, as I believe is likely, the sort of thing involved in C 88 is not related to the reaction of sulfate ion with anything, but instead merely is related to the change in volume of anhydrous sodium sulfate and hydrated sodium sulfate, and cannot be mitigated by the extra cost of obtaining sulfate-resisting cement.

The other of us (Hime) replies as follows:

> Drs. Skalny, Odler, and Young have stated the antithesis to our comments. They say that "to draw a distinction between 'physical' and 'chemical' process does not serve a useful purpose and will only confuse engineers." We not only disagree but also believe they have demeaned engineers.
>
> That "sulfate attack" refers to the deleterious reaction of sulfate with cement paste to produce ettringite is demonstrated by a host of books and articles. Indeed, Types II and V cements were developed solely to prevent this reaction from causing damage to concrete in service.
>
> Somewhat later, it was found that sulfates entering concrete as, for example, sodium sulfate could produce gypsum, which might cause deleterious expansions. Other scientists reported that the development of gypsum did not cause distress.
>
> The discussers also note that magnesium sulfate causes decalcification. So does magnesium chloride, magnesium nitrate, etc. To lump the effects of magnesium ion or hydrogen ion (sulfuric acid) with sulfate attack surely will confuse not only engineers but also chemists.
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> To say that the conversion of thenardite to mirabilite is a "chemical change" presents truth in a misleading

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manner. The conversion causes some aggregates to disintegrate in the ASTM C 88 test, a process in which the sulfate ion plays no role. Many nonsulfate salts that have different hydration states can cause the same distress, for example MgO and $Mg(OH)_2$. To use the term "sulfate attack" for such a process gives sulfate attack a bad name. To use Type V cement to prevent damage from hydration/rehydration is not only technically wrong but also foolhardy.

We repeat: research should concentrate on determining what the reaction is—acid attack, magnesium attack, sulfate attack, hydration/oxidation, corrosion, etc.—and how to prevent or stop it.