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Discussion

Reply to the discussion of the paper "Durability of the hydrated limestone-silica fume Portland cement mortars under sulphate attack"☆

J. Zelić[a,*], R. Krstulović[a], E. Tkalčec[b], P. Krolo[a]

[a]*Faculty of Chemical Technology, University of Split, Teslina 10/V, HR-21000 Split, Croatia*
[b]*Institut für Neue Materialien, Universitat des Sarlands, Gebaüde 43, D-66123 Saarbrücken, Germany*

The authors thank Dr. B. Mather for his interest in our paper and for his comments, which we find most helpful. We feel that we should try to clarify some things.

Our experiments were performed with industrial, blended Portland cement produced in the Croatian Cement Works, with 30% mass blast furnace slag and the 28-day strength class of 45 MPa, marked PC30z45s according to the Croatian standard HRN.B.C1.011—conforming to the European cement standard EN 197.1:cement type: CE II-S, strength class 42,5. Table 2 lists the potential mineralogical composition (the Bogue calculation) of cements used. In addition to this, the C_3A content of the cement clinker is 10.5% mass, according to Bogue.

Many studies have dealt with the ettringite formation mechanism and the damage mechanism associated with ettringite formation in hardened mortar/concrete. We agree with the statement in Dr. Mather's discussion that the mechanism of the ettringite formation is the result of complex, long-term processes, in which the cement composition, the concentration conditions and pH values in the pore solution, and ambient effects play important roles. Various study results show that the ettringite formed at high pH values is probably microcrystalline (Type II according to Mehta) and less stable, and can therefore gradually dissolve in the pore liquid of a moist concrete and recrystallize in the voids, cracks, or contact zones. As a rule, the occurrence of ettringite crystals in concrete cracks is only a consequence, and seldom the cause, of the cracks [1].

Fig. 6 shows that after the 120-day immersion in Na_2SO_4 solution, the scanning electron microscopy (SEM) of mortar containing 8% mass of silica fume detected large, long-needle ettringite crystals (Type I as defined by Mehta) in pores. Based on the experimental results, given in our paper, we have concluded that this type of ettringite crystal, formed under conditions of low calcium hydroxide concentration, resulting from silica fume addition to the cement mixture, is not expansive.

The same photomicrograph also shows a couple of cracks transecting the void, as Dr. Mather points out.

In our opinion, however, microcracks observed in Fig. 6 have only resulted from the effect of the high vacuum in the specimen chamber of the SEM.

Artefacts (specimen changes, cracks) caused by the method preparation and the effects of high vacuum in the sample chamber are typical and only occur in a conventional high vacuum scanning electron microscope (conventional SEM), as have been reported by Möser and Stark [2]. The investigations also confirm that any information associated with contraction of the hardened cement paste observed with conventional SEM is to be regarded with caution.

The sulphate performance was examined using the ASTM C 452-68 mortar bar expansion test. In conformance to this standard, we did not incorporate additional gypsum into the mortar mix and the expansion difference was measured after 28 days of water storage and thereafter every 30 days within a 6-month period of sulphate immersion. The initial length measurements of mortar were carried out by means the length comparator after the 28-day water storage. We agree with Dr. Mather that the ASTM C 425-68 method applies only to Portland cement. It is for this reason that we have used only a part of this test, as described, but not emphasized in section 1.2. (Test methods) of our paper, and have adjusted it for testing the sulphate resistance of blended cement (i.e., the Portland cement–silica fume–limestone systems). The experimental procedure used corresponds to the ASTM C1012-84, for both plain Portland cements and blended cements or composite cements [3], as Dr. Mather has suggested.

References

[1] J. Stark, K. Bollmann, K. Seyfarth, Ettringite—cause of damage, damage intensifier or uninvolved third party? ZKG International 5 (1998) 280–291.

[2] B. Möser, J. Stark, ESEM-FEG: A new scanning electron microscope for building materials research, ZKG International 4 (1999) 212–221.

[3] C.D. Lawrence, Sulphate attack on concrete, Mag Concr Res 42 (1990) 249–264.

☆Cem Concr Res 29 (1999) 819–826.

* Corresponding author. Tel.: +385-21-385-633; Fax: +385-21-384-964.
E-mail address: jelica.zelic@ktf-split.hr (J. Zelić)

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