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Discussions

A discussion of the paper "Influence of superplasticizer, plasticizer and silica fume on the drying shrinkage of high-strength concrete subjected to hot-dry field conditions" by S.H. Alsayed☆

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Professor Alsayed deserves to be congratulated for his excellent paper on the long-term drying shrinkage (DS) of high strength concrete (HSC) with and without silica fume (SF) and with and without a superplasticizer [1]. To further enhance the technical value of this paper to the readership of the *Cement and Concrete Research*, I want to contribute the following:

First, although in this research an endeavor had been made to keep cement, sand, coarse aggregate, and water contents constant in the three concretes investigated, mix proportions per m^3 of concrete tend to change the moment one adds an extra ingredient without other adjustments. That is exactly what has occurred if one compares proportions of Mixes 1, 2, and 3 in Table 1 of the paper. By simple addition of 54 kg of SF in Mix 1 to make Mix 2, the yield of the Mix 2 becomes 1.026 m^3 (assuming particle density of SF $= 2,100 kg/m^3$ and an entrained air of about 2% both in Mixes 1 and 2). Accordingly, the quantities required to produce 1 m^3 of Mix 2 are (in kg): cement = 527; sand = 659; coarse aggregate = 1028; SF = 54; and water = 158, respectively, and not those shown in Table 1 of the paper. Further, the total paste contents of Mixes 1 and 2 are 0.37 and 0.39 m^3/m^3 of concrete, which are very similar. The water content of the Mix 2 is 158 instead of 162, as in Mix 1. More important, because of the very effective pozzolanic nature of SF, it is really the water cementitious material ratio of 0.27 of Mix 2 that matters and not the water/cement ratio of 0.3. (In reality, it is only proper to employ fluid/cementitious material ratio rather than water/cement ratio where SF, plasticizers, and superplasticizers are used, which is the case in most HSCs.) Now if one looks at the DS response of Mixes 1 and 2, the results are equally easy to explain. Lower water/cementitious material ratio, lower total water content, and somewhat similar total paste contents of Mix 2 should make it shrink less. In addition, pore porosity of the Mix 2 is lower to which the author has rightly alluded. As a consequence of all the above, the strength of Mix 2 of 74 MPa is substantially higher than that of 56 MPa, and as referred to in the paper, higher strength concretes are reported to shrink less than those of the lower strength. So, in summary, it is not only the effect of silica fume, per say, as shown in Figs. 1 and 2; rather, it is a complex combination of other concomitant effects that have caused the reduction in the DS of Mix 2 containing an additional 54 kg of SF without any adjustments of fine contents to maintain the yield.

Second, in the same vein, the increase in the DS of concretes with a plasticizer compared to that with a superplasticizer is not the simple effect of replacing the latter with the former, as shown in Figs. 3 and 4. Without going into the detailed analysis of the yield of Mix 3, using dosage of plasticizer of 30 mL instead of 20 mL/kg of cement, the effective water content of the Mix 3 is about 5.4 kg more and as a result the paste content of the Mix 3 is also higher than that of the Mix 2. In brief, again, it is not the effect of plasticizer, per say, as suggested in Figs. 3 and 4, which has increased the shrinkage of Mix 3 in comparison with Mix 2. There are, of course, other changes both in paste and water contents.

Third, it is now well established that the conversion of cube strength to cylinder strength cannot be affected by a simple factor of 0.8 for differing strength grades of concrete. As the strength level changes so does the factor [2].

Fourth, the drying shrinkage-induced stresses (if the concrete were to be restrained) calculated make no real sense, specially when the E values were "calculated" rather than experimentally determined. The calculated values are known to be within an accuracy of ±20% [3].

☆ Cem Concr Res 28 (1998) 1405–1415.

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[2] A.M. Neville, Properties of Concrete, 4th Ed., Longman, London, 1995.

[3] Standards Australia, Concrete Structures, AS 3600, Standards Australia, Sydney, 1994, p. 158.