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Discussion

A discussion of the paper "Laboratory assessment of alkali contribution by aggregates to concrete and application to concrete structures affected by alkali–silica reactivity" by M. -A. Berube, J. Duchesen, J. F. Dorion and M. Rivest[☆]

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The determination of available alkalis from aggregates is very important for design of durable concrete. In the paper, the authors used 0.7 M NaOH or KOH solution to extract K or Na in a variety of aggregates at a solution-to-aggregate ratio of 1, and found that the alkalis released by the aggregates in these alkali solutions can be up to 12.7 kg/m^3 Na_2O_e depending on the nature of the aggregate. However, the alkali solution extraction procedure presented in the paper is an ion-exchange test in nature and seems incorrect to be used to evaluate the available alkalis from aggregate for alkali–aggregate reaction in concrete.

The charge balance state of the aggregates should not change under the testing condition as compared to their original state. This means that the moles of Na or K going into the solution from the aggregate will be the same as those of K or Na going into aggregate from the solution. Thus, the total alkali concentration in the solution remains the same. Of course, the nature of the aggregate determines its ion exchange capacity.

The other critical issue is the solution to aggregate ratio. Let us assume that a concrete has a weight of 2400 kg and contains 1850 kg of aggregate per cubic meter, as suggested in the paper. Then the cement and water contents will be 367 kg and 183 kg per cubic meter of concrete when a water-to-cement ratio of 0.5 is used. Thus, the maximum water-to-aggregate ratio in the concrete is less than 0.1 before the cement starts to hydrate. If it is assumed that (1) pore solution of hardened cement paste has an alkali concentration of 0.7 M and (2) the ion-exchange reactions at a solution-to-aggregate ratio of 0.1 happen in the same way as those at a solution-to-aggregate ratio of 1, then the maximum exchanged alkalis are only one tenth of 12.7 or 1.27 kg/m^3. In hardened concrete, aggregates are partially coated with cement paste, which will also affect the alkali-exchange capacity of the aggregate.

As discussed above, the total available alkalis in the pore solution should remain the same if only K–Na or Na–K ion exchange is considered. Of course, other cations such as Ca^{2+} and Mg^{2+} will also exchange the alkalis in the aggregate, which result in the increase of alkalis in pore solution.

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