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RILEM TC 258-AAA Round Robin Test: Alkali release from aggregates. Critical review of the test method AAR-8

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Extended Abstract

The investigation concerning the potential contribution of certain aggregates to the content of alkalis in the concrete solution in structures started in the 1970´s. Different approaches have been applied in the research since then and some methods suggested, although with variable advantages and limitations.

In the scope of RILEM TC 219-ACS, AAR-8 “Determination of alkalis releasable by aggregates in concrete” was prepared. It is a testing method intended to be used to assess the potential amount of alkalis released by aggregates in concrete. The determination of the potential amounts of sodium and potassium ions discharged by aggregates is measured by immersion of aggregates particles, whose size has been reduced, in (KOH, NaOH) solutions, with excess of calcium hydroxide. It is intended to evaluate the amount of alkalis releasable by aggregates in the long term in concrete by measuring the amounts of alkalis released in NaOH (K release) and KOH (Na release) solutions at elevated temperature. The solutions should be in contact with excess (solid) calcium hydroxide as this is the situation in concrete in practice and potentially can increase the alkali leaching through ion exchange with Ca^{2+}.

This method is based on a literature survey on the subject, on methods previously developed at LCPC (now Université Gustave Eiffel, (prev. IFSSTAR), France), Laval Univ. (Quebec City, Canada), Institute Eduardo Torroja IETcc-CSIC (Spain) and LNEC (Portugal).

A Round Robin Test was carried out at five laboratories which tested five aggregates with different composition, namely phonolite, cataclasite, granodiorite, granite and dredged sea basaltic sand. Specimen of 500 g were sieved to obtain the grain size distribution defined in the method, then were immersed in specific volumes of NaOH or KOH solutions with excess calcium hydroxide maintained at 38 °C and 60 ºC. Twice a week, the test containers were agitated for about 10 seconds. At 2, 6, 13, 26 and 52 weeks of age the samples are removed from the oven where they were stored in contact with the extraction solution and the samples were left in idle position at environment temperature during 24 h. Subsequently, 10 mL of solution is extracted, filtered and the alkalis are determined by analytical methods:(Atomic Absorption Spectroscopy, Atomic Emission Spectroscopy or Inductively Coupled Plasma): potassium (NaOH test solution) or sodium (KOH test solution). The amount of alkalis released were expressed in milligrams of Na_2O, K_2O, and Na_2O_e per kilogram of aggregates and in %.

In addition, the bulk-rock chemical composition, the petrographic characterization, the bulk density and the porosity of each sample were carried out to define the possible influence of these parameters on the alkalis release results.

The values of porosity reveal that the sea dredged sand and the phonolite are the more porous. The bulk chemical composition of the samples shows that these are alkali-bearing aggregates. The content in Na_2O_e of the phonolite is much higher than in the other lithologies, corresponding to the double of the content in the granodiorite, which exhibits the second highest content.

The obtained results for the AAR-8 test show that most of the aggregates tested release higher quantity of alkalis at 60 ºC than at 38 °C, except for cataclasite and granodiorite which present similar results at

both temperatures. The results also show that the rates of alkali release always tend to decrease with time but the alkali release at 52 weeks is still progressing for all aggregates tested at both 38 and 60ºC. On average, there is a higher release of Na^+ than of K^+ except for granodiorite and granite. The phonolite and the sea dredged basalts are the two aggregates that release the highest amounts of alkalis. The granodiorite and the granite are the ones with the lowest release. Finally, the cataclasite releases slightly more alkalis than the last two, but values remain relatively low.

In terms of alkalis release, the order of the aggregates tested is the following: phonolite > sea dredged > basalt > cataclasite > granodiorite > granite.

The obtained results show, however, a high dispersion between laboratories and therefore several changes to the test method are proposed. The main subject of discussion is to avoid the agglomeration of fine aggregate particles and the alkali precipitation by reaction especially with fine aggregates, but also to promote the stabilization of the solution, to reduce the errors related to the method and mainly, to reduce the test time to 26 weeks instead of to 52 and the recommendation that the test temperature is set at 38 °C.

The following amendments are proposed:

- The containers must be resistant to high temperatures in contact with alkaline solutions; and will be of a single use to avoid breakages;
- The coarse fractions of the aggregates should be washed to remove the fine particles, and later dried at 105ºC before being tested;
- To avoid aggregate agglomeration and alkali precipitation, the quantity of aggregate sample should be reduced to 100 g, the liquid:solid ratio is maintained at 4:1 and the container will be shaken twice a week during 30 seconds and rolled 20 times in a longitude of 80 cm;
- The extraction solutions should be added 2 g/L $Ca(OH)_2$ to obtain a saturated calcium hydroxide solution with excess solid $Ca(OH)_2$; and to avoid interference there will be no replenishing of the withdrawn solution.
- The stabilization of the solution should be done using 5 drops of HNO_3 concentrate, for each 10 ml of alkaline solution.
- For the filtration process of the solution containing the extracted alkalis, the vacuum pump is replaced by a micropore 0.2 µm filter aiming to reduce the errors related to the method;
- The sampling time is fixed at 0, 2, 6, 13 and 26 weeks, instead of 52 weeks;
- Finally, to validate the analytical results, standards mimicking the matrices is introduced through the samples.
- The results obtained with the RRT1 indicate that there is no need to test aggregates at 60 °C. because temperature increase did not exacerbate the alkali release as much as expected, except for granite, which might be related to the texture of the rock. In consequence, it is proposed that the test is performed just at 38 ºC.

***Keywords**: alkali release, aggregates, alkali-aggregate reaction, prediction of alkali-release, test method*

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