Alkali–silica reaction in volcanic rocks: a worldwide comparative approach

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Extended Abstract

The potential alkali–silica reactivity (ASR) of some volcanic rocks, especially basalts, remains poorly understood within the scientific community that studies this thematic.

In the literature of the subject, it is known that the reactivity of basaltic rocks is usually associated with the presence of volcanic glass, devitrified volcanic glass, different types of reactive silica (e.g., chalcedony, opal, and microcrystalline and cryptocrystalline silica), and swelling clay minerals.

There are not many countries where field concrete structures are affected by ASR due to the use of basalts. Argentina and Iceland are among the countries where basalts were used as concrete aggregates in structures with ASR problems. Moreover, a number of reports and articles refer the potential reactivity of basalts tested by different test methods. However, some of the different laboratory testing methods that are used to evaluate the potential character of these rocks have produced a number of contradictory data, especially in the case of the accelerated mortar bar test (AMBT). On the other hand, the concrete prism test (CPT) is considered a more reliable test. In order to better understand the behaviour of basalts in concrete and some of the inconsistencies within the methods, the present study applied several methods for characterizing potential aggregate alkali reactivity: (1) petrographic characterization, (2) accelerated mortar bar test (AMBT), and (3) the concrete prism test (CPT). The present study was carried out on different volcanic aggregate samples from several places around the world, namely Azores (Portugal), Brazil, Canada, the Canary (Spain) and Hawaiian Islands (USA), Iceland, Japan, Mozambique, New Zealand, Norway, and Turkey. Besides basalts, two andesites and a rhyolite were included in the study for comparative purposes. Also, coarse and fine sand of variable composition from Iceland and one sample from Hawaiian Archipelago were included in this study.

In the petrographic studies an Olympus CX31 polarizing microscope was used mainly to identify the potentially reactive forms of silica present in the aggregates. For a more detailed study, two other methods were used: (a) scanning-electron microscopy with an energy dispersive X-ray spectrometer (SEM/EDS) and (b) electron probe microanalysis (EPMA).

Different mixtures were prepared for the AMBT and CPT. Most of the mortar and CPT mixtures were prepared at Université Laval and followed the CSA A23.2-25A and CSA A23.2-14A standards, respectively. The mixtures incorporated a general use (GU) Portland cement with an alkali content of 0.94% Na_2O_{equiv}. The other tests were performed at LNEC with mixtures in accordance with the ASTM 1260 standard and RILEM AAR-3 recommendation. The cement used included a cement type CEM I 42.5 R with 0.86% Na_2O_{equiv}. and a water/cement (w/c) ratio of 0.47.

In terms of results, the petrographic characterization of the volcanic aggregates showed that volcanic glass is present in nearly half of the samples, although in very low content in some of them. The EPMA showed high SiO_2 content in the volcanic glass of some of the basaltic aggregates from Iceland and the Hawaiian Islands, with an average of 73% SiO2.

AMBT and CPT results showed that most samples were classified as non-reactive by both methods. However, some of the samples that were classified in the AMBT as potentially reactive were classified as not-reactive in the CPT, especially in the case of sand fractions. In fact, only some basaltic samples were considered reactive in all the methods. This included a coarse and fine sand, with a mixture of crushed aggregate and sand fraction, both from Iceland, and a sand from the Hawaiian Islands. The andesites included in this study were classified as reactive according to all methods, as expected, due to its known reactivity in the literature.

According to the results attained, it was concluded that most of the tested sands are responsible for the reactivity observed and that the AMBT method overestimated the reactivity of many of the basaltic samples. Also, volcanic glass was identified as the main potentially alkali-silica reactive component in practically half of the samples.

The results obtained from this work will contribute to assess more accurately the potential alkali reactivity of volcanic aggregates, particularly basalts, and will improve the understanding of their different behaviours.

Keywords: *alkali–silica reaction, petrography, accelerated expansion tests, volcanic aggregates*

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