HAHN READY MIX

Alkali-Aggregate Reactivity

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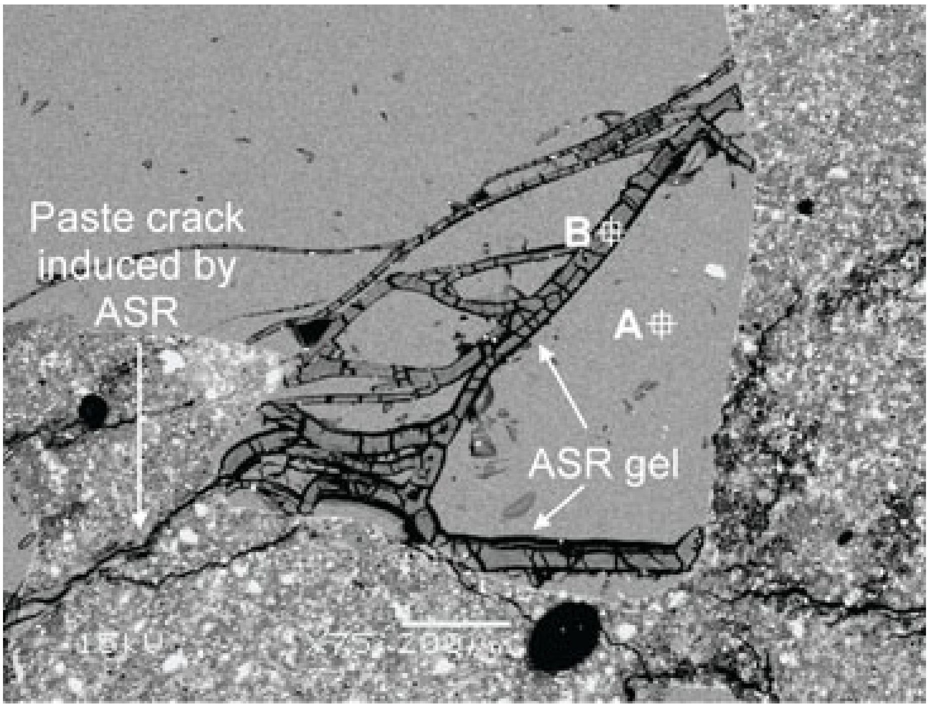
Alkali-Aggregate Reactions… What are they?

Alkali-Aggregate reactions are the late-age formation of an expansive gel in concrete that can build such pressures as to structurally destroy concrete from the inside out. This gel forms when alkalis (such as sodium and potassium, primarily from cement) react with silica in sand (ASR) or carbonate in rock (ACR).

Alkali-Silica Reactivity

Alkali-Silica Reactivity or ASR, is the most common form of alkali aggregate reactivity. Silica in the sand and alkalis from cement can form a gel that may absorb water and expand. Concrete, while strong in compression, is relatively weak in tension and susceptible to pulling pressures or pressures from within. The expansive gel can break the internal bonds of the concrete and cause it to structurally fall apart.



ASR can be difficult to predict, and the established methods to assess potential ASR reactivity all have their issues.

ASTM C1260 is a mortar bar test on a sand and cement to determine the potential reactivity between the two materials. The mortar bars are immersed in a sodium hydroxide solution, and the length of the bars are measured for change over a 14-day period. Expansion below .10% in 14 days is considered to be non-reactive. This method is flawed for various reasons: first, it is a mortar test and not a concrete test, and so it is not actually testing a proposed mix design. The presence of a coarse aggregate reduces the abundance of fine aggregate in the mix and therefore the potential for ASR. Additionally, it does not consider any other materials in the mix design that might mitigate ASR such as SCMs or admixtures. Various studies have also suggested that the sodium hydroxide solution is too aggressive and does not accurately represent the ASR potential in normal situations. Because of these factors, ASTM C1260 tests often show “false positives". This test should be used to determine the potential reactivity of an aggregate, NOT the potential reactivity of a mix design.

ASTM C1567 addresses the second of the above concerns to an extent, as this is a mortar bar test run the same way but with any SCM's that may be used at their intended proportion. It does not factor in coarse aggregates or admixtures. Again, the threshold for potential reactivity is .10% at 14 days. The purpose of this test is to determine the ASR mitigation effectiveness of an SCM, NOT to evaluate the potential reactivity of a mix design.

FAA P-501 modified C1567 is a variant of the C1567 test where coarse aggregates are included, allowing for a more realistic view of the reactivity of a proposed mix design. However, the debate about the sodium hydroxide solution still remains and this method is typically not approved for any non-FAA projects.

ASTM C1293 the “Concrete Prism Method” is an effective way to determine ASR potential. It can be done on just a sand and cement to determine material compatibility or on a specific mix design. However, this test takes a year to run. If at one year in a sodium hydroxide solution, the prism has expanded by .004% or less, the materials are considered to be non-reactive. This method, while seemingly accurate, is impractical for most construction projects as a year is far too long to wait on a test.

For an example of how these tests might differ in results, experience tells us that any of our sand and cement combinations will spectacularly fail the ASTM C1260. Depending on the SCMs used and how much of each, the C1567 test can be a bit of a challenge. We consistently pass the FAA C1567 test when we use slag. However, our materials easily pass the C1293 test even with just cement and sand when that test has been run. New ASR tests are in development that can hopefully bridge the gap between accuracy and timeliness.

Mitigating ASR

If there is concern about ASR potential on a project, a number of options are present to mitigate ASR. The first option an engineer will suggest is often to change sand or cement sources. Sometimes this is feasible and sometimes there are differences in reactivity between two nearby sand sources. Often times, however, these changes do not really move the needle unless you go far afield where the geology and makeup of the fine aggregates are significantly different. SCMs, on the other hand, are the most logical and easiest way to mitigate ASR. Class C fly ash is moderately effective at mitigating ASR. Class F fly ash and slag are both excellent at mitigating ASR. All of these SCMs work both by replacing some of the cement, diluting the alkalinity and reducing ion diffusion coefficient of mortars. One way of determining if SCM mitigation will be successful, is to calculate the total alkalis in your mix design using data form a cement mill test report. Limiting alkalis to 3-5lbs per cubic yard is an effective way to prevent ASR. A final, extreme step is the use of lithium nitrate admixture. This incredibly expensive admixture essentially controls the pH of the concrete and inhibits the growth of ASR. While effective, the cost of lithium makes this option cost-prohibitive in most situations. It is also critical to know that ASR only expands when it has access to moisture. A floor in a climate controlled building, for example, would likely not experience ASR issues.

Alkali-Carbonate Reactivity (ACR)

The other type of Alkali-Aggregate reactivity is Alkali-Carbonate reactivity. This rare phenomenon happens with certain carbonate rocks that expand when in contact with alkalis in cement. Since it is not a gel that forms but the entire aggregate piece that expands, it cannot be mitigated by SCMs or admixtures. The only choice is an aggregate source change. Luckily, the very specific geology necessary for this to occur is rare. Aggregate sources that have developed ACR are excluded for use in concrete.

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