Concrete Deterioration by Alkali-Silica Reaction (ASR)

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Alkali-silica reaction (ASR) is a common form of alkali-aggregate reaction that naturally occurs in concrete. The potential for ASR exists throughout North America because aggregates containing reactive silica are prevalent and often used in concrete mixes. Under conditions of high alkali content cement, reactive aggregates, and water presence, ASR can cause expansion and cracking within concrete. If left unmitigated, ASR can cause serious deterioration and damage to concrete structures over time.

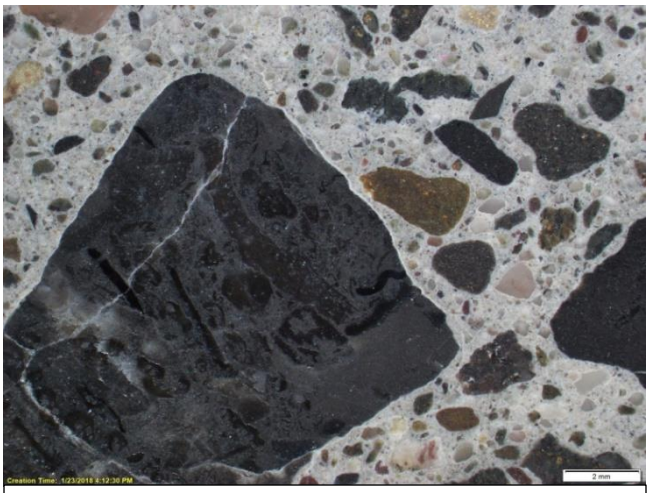
If water is present, ASR gradually occurs when alkalis in cement paste and silica in certain aggregate rock types react to produce a gel:

$2(K,Na)(OH)$	+	$2H_2O$	+	SiO_2	→	$(K,Na)_2H_2SiO_4 \cdot 2H_2O$
alkalis in the paste		water		silica in the aggregates		gel

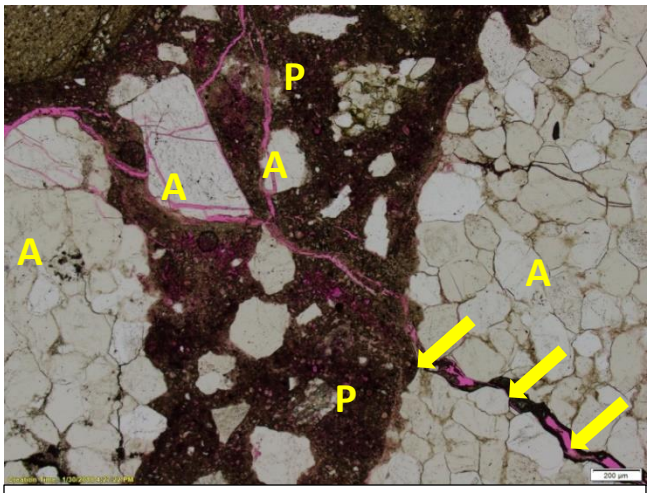
The ASR gel expands as it hydrates, causing the surrounding concrete to also expand and eventually crack due to the build-up of internal tensile stress. Over time, the gel may emanate from the cracks as a type of efflorescence and form thin coatings or thick, localized accumulations (including stalactites) on the exterior surfaces of the concrete.

A microscopic examination of the concrete (as outlined in ASTM C856, *Standard Practice for Petrographic Examination of Hardened Concrete*) can confirm the presence of ASR, since cracking and efflorescence may result from several different physical and physiochemical causes. The microscopic examination can also identify ASR within the concrete even before the concrete begins to crack.

A common way to avoid the potential for ASR is to use non-reactive aggregates in your concrete mixture. ASTM C1260, *Standard Test Method for Potential Alkali Reactivity of Aggregate,* is one of the fastest and most economical ways to screen aggregates for potential reactivity. In this method, a concrete sample is cast using the coarse or fine aggregates to be evaluated and soaked in an alkali-rich solution (sodium hydroxide). The length of the sample is measured over time; expansion indicates aggregate reactivity and the potential for ASR damage in concrete using those aggregates.



Cut and polished concrete showing white ASR gel filling a crack in a coarse aggregate particle; magnification x8.



Microscopic view of cracks within aggregates (A) and adjacent paste (P) partially-filled with ASR gel (arrows); magnification x40.

Readily available aggregate sources, dictated by local geology, may restrict aggregate choices and an alternate concrete mix using supplemental cementitious materials may be the only option for ASR mitigation. ASTM C1567, *Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate,* can be used to evaluate the effectiveness of fly ash or slag to mitigate ASR alkali-silica reactivity.

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