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What is ASR - Alkali-Silica Reactivity?

Deterioration of concrete in building materials is costly to mitigate and leads to reduced service life of a structure. Here is what you need to know.

BRIEF
CASE STUDIES

01
parking garage

SKA was called to consult on a concrete materials issue shortly after a parking garage was constructed. SKA discovered as part of the review process that known reactive aggregates were used in the concrete without use of pozzolans or other additives to mitigate the effects of ASR. SKA provided guidance to evaluate the likelihood for distress for the particular situation and worked with the team to develop a testing protocol to confirm reactivity and appropriate corrective action in the interest of arriving at an equitable solution.

02
pre-school

SKA assessed a pre-school constructed in the late 1950's that included concrete columns. As part of the assessment, extensive distress (including surface map cracking and subsurface cracking) was confirmed to be a result of ASR through petrographic evaluation. SKA conducted non-destructive stress-wave testing on columns to determine the extent of the deterioration. Although repair and service-life options were offered, the Owner decided to decommission the structure.

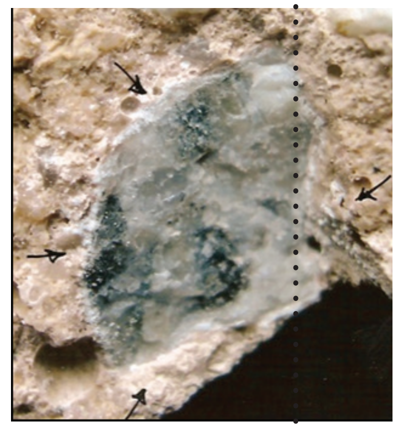
03
water treatment plant

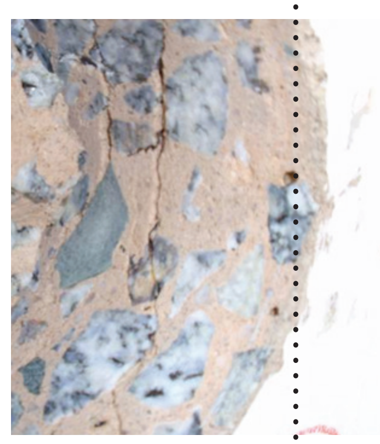
SKA was the designer of record for a new clarifier to be installed as part of a water-treatment facility. The continuous submersion makes these components particularly vulnerable to ASR if the mixture is conducive to promoting distress. Aggregates proposed for use as part of the mixture were found during the submittal stage to be potentially very highly reactive. Because there were components of the water treatment facility that were up to 7 feet thick, temperature rise from heat of cement hydration was also a concern, as it relates to possible thermal cracking and delayed ettringite formation (DEF). SKA worked with the ready-mix producer and contractor to provide options for addressing. Although aggregate could have been used with more extensive mitigation, the end result was use of a less reactive aggregate, lower overall cementitious materials content, class F fly ash and a lower alkali cement. In addition to significantly reducing the likelihood of ASR becoming a problem within the useful life of the structure, the mixture modifications significantly reduced the heat generation of the concrete and made thermal effects easier to address during construction.

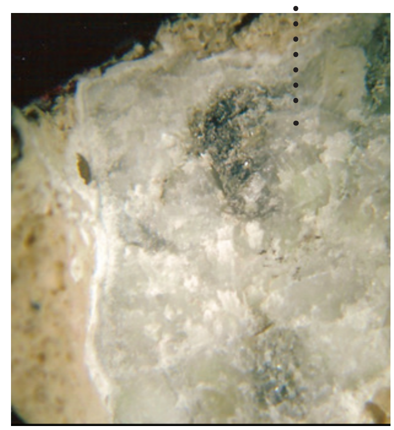
04
dam structure

A previous investigation identified that reactive aggregates has caused extensive cracking within the dam structural components and the extensive cracking had been capped with epoxy caps in an effort to slow down the distress mechanism. SKA was commissioned to determine the safety of the dam structure and the amount of service life remaining. SKA conducted extensive evaluations and testing of the concrete and assisted in providing existing concrete strength properties to another consultant which evaluated the safety of the dam. SKA then evaluated the expected "safe" existing service life of the structural components of the dam which included additional chemical treatments to the ASR conditions to extend the "safe" existing service life of the distressed dam structure.

What is ASR?







Concrete is a very durable building material when properly designed, proportioned and constructed. Unfortunately, deterioration can occur if attention is not paid to detail in the design construction phases of a project. One such situation is that associated with Alkali-Silica Reaction (ASR). ASR is an expansive process in concrete between alkali hydroxides in portland cement and certain forms of siliceous aggregates (or their components) in the presence of moisture. It can lead to significant cracking, structural depreciation and ultimately reduced service-life of a structure. Coarse aggregate (stone), fine aggregate (sand), or both in a particular mixture may be susceptible. Significant risk factors for development of ASR in concrete structures include 1) reactivity of aggregate sources, 2) amount of alkalis in cement or other concrete making materials, as well as exposure to alkalis in service (such as from some types of deicing salts and other sources), and 3) amount of available moisture.

Concrete exposed to continuous or frequent wetting, such as that used in water treatment facilities, dams, marine structures, exterior slabs (parking and transportation structures, etc.), or others (submerged, partially submerged, buried, frequently wet or in humid areas) can be particularly susceptible. However, because the reaction only requires about 80% internal relative humidity (RH) to occur detrimentally, even exterior vertical concrete components and covered slabs on ground can be susceptible within the expected service life. Even some interior concrete components, such as those in manufacturing and processing facilities (textiles, plating, athletic, food processing, boiler rooms, etc) can be highly susceptible due to moisture exposure. Risk of ASR development should be evaluated on a case by case basis.

Method of Mitigation

Because ASR-affected structures can be difficult (or sometimes economically infeasible) to repair once the structure has been built, it is important to take appropriate steps when specifying and proportioning concrete to avoid costly mistakes. Preservation once a structure is already in place can require extensive repair, post-tensioning, surface treatments or other methods to attempt to retard the effects. These options are sometimes only partially effective or provide modest service-life extension. Indeed, the remedy for addressing significant ASR distress often includes partial or full replacement of the affected structure. Fortunately, there are test methods to evaluate aggregate sources, ways to mitigate ASR in the design and proportioning phase, and ways to test and confirm mitigation is appropriate, but not excessive.

A number of test methods and industry guides have been developed to assess the potential for aggregate reactivity. Two of the more common test methods used by engineers and specifying agencies are the concrete prism test (ASTM C1293) and the accelerated mortar bar test (ASTM C 1260). Each has advantages and disadvantages with important points of interpretation that should be carefully calculated by a knowledgable professional. Industry standards and best practices continue to evolve.

Although an approach for addressing reactive aggregates is to use alternate sources , this is often unnecessary and can add significant cost to a project. More cost-effective methods can include limiting the alkali content in concrete, use of supplemental cementitious materials such as fly ash, slag and/or silica fume, and/or use of specialty admixtures. Tests, such as the accelerated mortar bar test with different percentages of supplementary cementitious materials (ASTM C1567) or others can be used for evaluating mitigation for concrete with reactive aggregate. ASTM C1778, *Standard Guide for Reducing the Risk of Deleterious Alkali-Aggregate Reaction in Concrete*, provides guidelines for reducing risk associated with ASR and *ACI 301 Specifications for Structural Concrete* provides specification language.

How can we help?

SKA can help in preparation of specifications, interpretation of specifications, development of mitigation measures, providing expert consultation services, and evaluation/repair of existing structures to address alkali-silica reactivity.