Reactive Solutions

An FHWA Technical Update on Alkali-Silica Reactivity

Fall 2012

Welcome to the newest edition of *Reactive Solutions*, a Technical Update on Alkali-Silica Reactivity (ASR) issues. This periodical is a communication tool for the Federal Highway Administration's ASR Program. The program's goal is to deploy methods that state highway agencies can use to prevent and mitigate ASR. This goal is being achieved through technology transfer, including real-world field trials, demonstration projects, and tools for practitioners to address ASR in their state. This periodical helps achieve the program's goal by providing readers with the tools and information needed to address this complex concrete distress problem.

Features:

Also in This Issue:

FHWA Publishes Surveying and Tracking Guidelines for ASR

The Federal Highway Administration (FHWA) recently published "Alkali-Silica Reactivity Surveying and Tracking Guidelines (FHWA Publication FHWA-HIF-12-046)," a comprehensive document that provides guidelines for State Highway Agencies (SHA) to follow when managing transportation infrastructure affected by alkali-silica reaction (ASR). The guidelines are collectively referred to as STAR (**S**urveying and **T**racking of **A**lkali-Aggregate **R**eaction) and primarily focus on bridges, pavements, and tunnels, although similar approaches can be followed for other transportation assets. Given that routine inspections are not detailed enough to capture many signs of ASR, the guidelines attempt to bridge the gap between existing infrastructure management systems and tools specific to the diagnosis of ASR. They have been written with SHA engineers, inspectors, and consultants in mind, enabling these individuals to collect, quantify, and rank typical signs of ASR in a simple, efficient manner.

As part of their bridge management system, most SHAs currently use a software product called AASHTOWare Bridge Management to collect inspection data in accordance with the "American Association of State Highway and Transportation Officials (AASHTO) Guide Manual for Bridge Element Inspection." This manual facilitates bridge inspection on an elemental level with regards to identification, quantification, and evaluation of various defects. For each bridge element, the presence and extent of defects are recorded in a standardized fashion. Some defects inherent to ASR, such as spalling, are already included in the AASHTO manual and integrated into Pontis. However, there are additional defects whose identification is necessary in order to provide a more accurate and specific tracking index of ASR-induced distress, and these are not included in Pontis, AASHTO, or other types of infrastructure management systems.

Fortunately, the STAR guidelines identify specific defects unique enough to suggest that the distress type may be attributed to ASR, including map cracking, gel exudation, and relative dislocation/misalignment. For each defect, a condition state is assigned based on its presence and severity as it relates to the element type. Condition states one, two, and three refer to a structure in good, fair, or poor condition, respectively, while condition state four is typically reserved for conditions that warrant safety concerns. These condition states are summarized in Table 1 as they relate to defects observed in structures potentially suffering from ASR.

Table 1. Recommended Distress and Condition States for Bridges Potentially Affected by ASR.

Defect	Condition State 1	Condition State 2	Condition State 3	Condition State 4
Map Cracking	None to hairline	Narrow size or density, or both	Medium size or density, or both	The condition is beyond the limit of Condition State 3, warranting a structural review to determine the strength or serviceability of the element, bridge, or both.
Aligned Cracking	None to hairline	Narrow size or density, or both	Medium size or density, or both	
Gel Exudation	None	Moderate	Severe (with gel staining)	
Relative Dislocation/ Misalignment	None	Tolerable	Approaching or exceeding limits (including causing local crushing)	

While there is a general trend towards using AASHTOWare Bridge Management, no single product has emerged to help SHAs manage their pavement inventories. Pavement management systems (PMS) vary widely among states and there is no standardized manual or approach for pavement inspection. As a result, the STAR guidelines for pavements follow a similar approach as bridges, with jointed concrete pavements (JCP) and continuously reinforced concrete pavements (CRCP) serving as the element types to be tracked in an infrastructure management system. Detailed information regarding distress mechanisms most commonly associated with ASR in pavements (e.g., popouts, joint sealant failure, and map cracking) are gathered in addition to other performance attributes typically tracked using most PMS.

A similar set of guidelines was also developed for tunnels. Tunnel management systems are still in the early stages of development, but increasing concerns over tunnel safety has accelerated the development of a comprehensive inspection and management system. The STAR guidelines define a set of tunnel elements susceptible to ASR, present a detailed description of defects, and assign condition states based on the overall extent of the defects.

In addition to the "Alkali-Silica Reactivity Surveying and Tracking Guidelines," it is strongly recommended that the "Alkali-Silica Reactivity Field Identification Handbook (FHWA Publication FHWA-HIF-12-022)" is available to inspectors. This handbook provides guidance in identifying ASR in the field, serving as an illustrated guide (see Figure 1) and also provides fundamental information about ASR. It is important to note, however, that visual inspection alone is not sufficient in identifying ASR and a more detailed evaluation is required to confirm its presence.

Figure 1. Illustrations provided in the ASR Field Identification Handbook.

The "Alkali-Silica Reactivity Surveying and Tracking Guidelines" and "Alkali-Silica Reactivity Field Identification Handbook" are now available for download from the FHWA website: http://www.fhwa.dot.gov/pavement/concrete/asr.cfm. For more information, please contact Gina Ahlstrom at Gina.Ahlstrom@dot.gov.

Study Warns of Dangers of Using ASTM C1260 as a Job Mix Test

ASTM C1260, or the accelerated mortar bar test (AMBT), is one of the most common test methods for determining the potential for aggregate reactivity due to alkali-silica reaction (ASR). In this test method, coarse and fine aggregates are tested separately to determine their reactivity. The AMBT is also widely favored due to the duration of the test method as results are produced only 16 days after casting. While the AMBT was created to determine the reactivity of a single aggregate, many agencies in North America have recently encouraged the evaluation of "job" or actual concrete mixture designs within the test method.

In order to evaluate the effects of carrying out a non-standard version of the AMBT, a study was conducted at the University of Texas on 15 aggregate sources (9 coarse and 6 fine aggregates) from across North America. These aggregates represented a wide range of reactivity based on prior testing in accordance with the AMBT and ASTM C1293, or the Concrete Prism Test (CPT), and were selected in order to provide a broad range of results. A typical ASTM C150 Type I high-alkali cement was chosen for all testing. To determine the reactivity of mixtures resembling actual concrete mixture designs, combinations of the aggregates at various ratios were tested, with the majority of testing involving the replacement of 30 and 40% of coarse aggregate (CA) with a non-reactive fine aggregate (NFA).

In most cases, the mixture tended to decrease in expansion as the proportion of NFA was increased, even though not all combinations fell below the AMBT 0.10% expansion limit or passed the CPT. Conversely, some mixtures in this study exhibited a pessimum effect such that a higher expansion was observed as the percentage of NFA increased. Figure 2 illustrates this trend; it can be seen that a mixture containing 40% NFA met the AMBT expansion limit while a mixture containing 75% NFA exhibited nearly three times greater expansion.

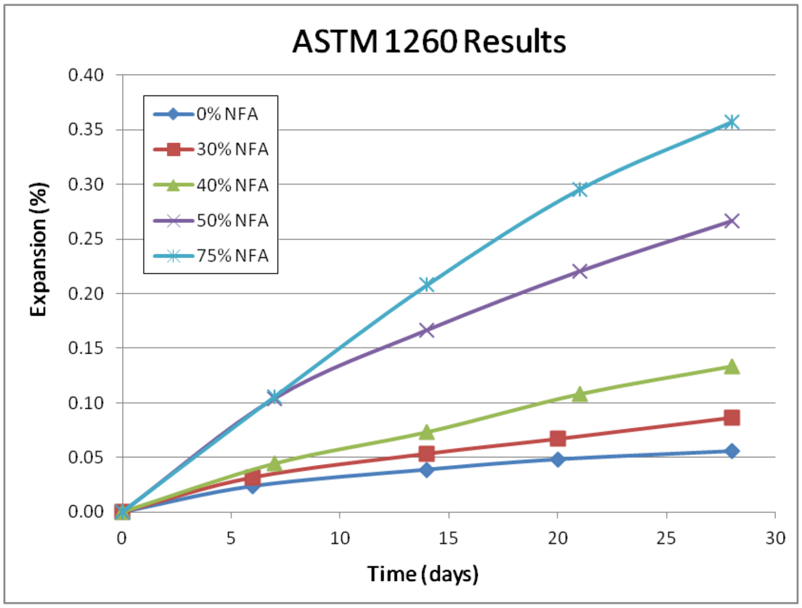

Figure 2. Example of pessimum effect.

This study demonstrates that carrying out a non-standard version of the AMBT is a dangerous approach to follow without proper benchmarking to actual concrete tests, outdoor exposure blocks, and long-term field experience. The AMBT was developed to test a single aggregate and testing a combination of aggregates further complicates interpretation of the test results. Furthermore, depending on the nature of the reactive material/aggregate, dilution with a non-reactive aggregate can result in pessimum effects with maximum expansion being observed at specific replacement levels. Future work in this area will involve the comparison of test results to exposure blocks in order to determine how these AMBT mixtures compare to actual concrete mixtures in outdoor environments. For more information, please contact Thanos Drimalas with the University of Texas at Austin at Thano.Drimalas@utexas.edu.

Worldwide Petrographic Atlas in Development to Help Identify Alkali-Reactive Aggregates

Since its original identification by Thomas Stanton in 1940, alkali-silica reaction (ASR) has been recognized on all continents. Virtually all rock types have been identified as potentially alkali-reactive in one location, whereas the same rock types classify as innocuous elsewhere. The deficient knowledge of aggregates is responsible in large part to the significant amount of money spent every year rehabilitating structures damaged by ASR. Although a number of standards for assessment of concrete aggregate by petrography are available, the distinction of potentially deleterious rock types is still problematic, and strongly relies on the personal experience of the petrographer. In addition, it has been verified by field performance of aggregates that the application of geological nomenclature alone is not sufficient, as the geological history and development of a given rock type as well as a particular mineralogical or textural/microstructural aspect may strongly influence its performance in concrete.

Fortunately, RILEM (International Union of Laboratories and Experts in Construction Materials, Systems and Structures) Technical Committee 219–ACS (Alkali Aggregate Reaction in Concrete Structures) and the revised RILEM Test Method AAR-1 (Petrographic Method) have contributed to the development of a worldwide petrographic atlas that aims at improving petrographic characterization of aggregates. This atlas uses standard criteria for the classification and nomenclature of rock types, and presents typical characteristics of selected rock types from concrete aggregate with particular emphasis on features affecting the reactivity potential. Characteristic features of alkali-reactive rock types are presented in detail, with special emphasis given to the nature of the silica present. In addition, micrographs showing selected areas provide greater detail on specific features with the aid of scanning-electron microscopy (SEM) and other techniques. To date, sample materials have been contributed by specialists all over the world including Argentina, Australia, Brazil, Canada, China, Finland, France, Germany, Japan, Netherlands, New Zealand, Norway, South Africa, Spain, Sweden, Switzerland, United Kingdom, and the United States, comprising the aggregate types listed in Table 2. A preliminary version of the petrographic atlas will be released in 2013. For additional information about this work in progress, please contact Professor Isabel Fernandes with the University of Porto (Portugal) at ifernand@fc.up.pt.

Table 2. Aggregate types included in the atlas.

Igneous	Sedimentary	Metamorphic
basalt	flint/chert	phyllite
volcanic glass	quartz sandstone	schists
andesite	greywacke	cataclasite
rhyolite	siliceous limestone	mylonite
granodiorite	siltstones and argillites	gneiss
granite	unconsolidated (and/or polymict) sediments	meta-arenite
trachyte		pseudotachylite
microdiorite		

FHWA Alkali-Aggregate Reactivity (AAR) Webinars Announced

A webinar series is being conducted through the Federal Highway Administration (FHWA) Alkali-Silica Reactivity (ASR) Development and Deployment Program in order to provide information on ASR prevention and mitigation techniques to engineers and practitioners. The webinars will consist of three separate training sessions and cover the following:

- Part I (February 6) - Fundamentals of AAR, Symptoms of AAR, AAR Test Methods
- Part II (February 13) - Prevention of ASR, AAR Specifications
- Part III (February 20) - Diagnosis and Prognosis of AAR, Repair Methods

The presenters for these webinars are Drs. Michael Thomas (University of New Brunswick in Fredericton), Kevin Folliard (University of Texas at Austin), and Benoit Fournier (Laval University in Quebec City). This team has worked extensively over the past 20 years with provincial (Canada), state, and federal agencies to assist in managing AAR-affected structures.

The webinars will be free of charge and downloadable reference materials will be made available to registered attendees. More details will be available soon on the FHWA ASR website: http://www.fhwa.dot.gov/pavement/concrete/asr.cfm. For additional information, please contact Gary Crawford at Gary.Crawford@dot.gov.

Schedule of Events

December
2-5
ASTM International Committee C09, Concrete and Concrete Aggregates
Atlanta, Georgia

4-6
Standing Committee on Public Transportation and Multi-State Technical Assistance Program
San Diego, California

January
13-17
Transportation Research Board (TRB) 92nd Annual Meeting
Washington, D.C.

17
TRB Workshop 835: Advances in Preventing and Mitigating Alkali–Aggregate Reactivity
Washington, D.C.

February
5-7
Mid-Atlantic Quality Assurance Workshop (QAW)
Williamsburg,VA

5-8
World of Concrete
Las Vegas, Nevada

6, 13, 20
FHWA Alkali-Aggregate Reactivity (AAR) Webinar: Parts I, II, III

13-14
Wisconsin Concrete Pavement Association (WCPA) 2013 Annual Concrete Pavement Workshop
Appleton, Wisconsin

To view this technical update on the web, please go to
http://www.fhwa.dot.gov/pavement/concrete/reactive/v05issue04.cfm

This material is based upon work supported by the Federal Highway Administration Alkali-Silica Reactivity (ASR) Development and Deployment Program to share information related to ASR.

If you would like to subscribe to future issues, receive more information on the ASR Program, or receive further details on any of the articles in this issue, email us at asrnewsletter@transtec.us.