Reactive Solutions

An FHWA Technical Update on Alkali-Silica Reactivity

Spring 2013

Welcome to the final edition of *Reactive Solutions*, a Technical Update on Alkali-Silica Reactivity (ASR) issues. This periodical served as a communication tool for the Federal Highway Administration's ASR Program, which facilitated the deployment of methods that State highway agencies can use to prevent and mitigate ASR. This has been achieved through technology transfer, including real-world field trials, demonstration projects, and tools for practitioners to address ASR in their State.

Features:

Also in This Issue:

Editor's Note

Welcome to the final edition of *Reactive Solutions.* We hope that this publication has kept you up to date on alkali-silica reactivity (ASR) related news and provided you with the tools and information necessary to address this complex concrete distress problem. This issue highlights work done under the Federal Highway Administration (FHWA) ASR Development and Deployment (D&D) Program. This program was created as a result of The Safe Accountable Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), which provided significant funding to focus on refining and deploying proven technologies and methods to address ASR.

Shortly after SAFETEA-LU was passed in 2006, the FHWA held an ASR Benchmarking Workshop in order to identify stakeholder needs, determine gaps in knowledge, and guide the direction of a new ASR program. After receiving valuable input, the FHWA established the ASR Development and Deployment (D&D) Program. The intent of this program is to increase concrete durability and performance, and reduce life cycle costs through prevention and mitigation of ASR in concrete pavements, bridges, and other highway structures. In addition, the FHWA worked to more effectively deploy current technologies to prevent and mitigate ASR in the field. In order to meet these program objectives, the following four task areas were identified by the FHWA and are discussed in detail in subsequent sections.

- Development of Testing and Evaluation Protocols
- Deployment and Technology Transfer
- Field Application Projects for the Prevention and Mitigation of ASR
- Assist States in Inventorying Existing Structures for ASR

A technical working group (TWG) was also organized to assist FHWA by serving as technical experts and volunteering to review reports, publications, and other deliverables. Biannual meetings were conducted across the country beginning in 2007, and during these meetings, the TWG proved to be crucial in helping assess and meet pertinent project goals. The FHWA would like to express their sincere gratitude towards the ASR TWG, whose members are listed below.

Gina Ahlstrom FHWA	**Emmanual Attiogbe** BASF	**Fatih Bektas** CP Tech Center	**Lizanne Davis** FMC Corporation
Doug Dirks Illinois DOT	**Peter Emmons** STRUCTURAL	**Fred Faridizar** FHWA	**Mark Felag** Rhode Island DOT
Thomas Fox Headwaters Resources	**Robin Graves** Vulcan Materials	**David Gress** University of NH	**Jim Grove** FHWA Contractor
Clint Hoops Idaho DOT	**Al Innis** Holcim (US) Inc.	**Moe Jamshidi** Co-Chair NE Dept. of Roads	**Rodney Joel** FAA
Steve Kosmatka PCA	**Kimberley Kurtis** Georgia Tech Univ.	**Brian Merrill** Texas DOT	**Mohammed Nabulsi** Massachusetts DOT
Claudia Ostertag UC-Berkeley	**Jim Pappas** Chair Delaware DOT	**Mike Praul** FHWA	**Tom Pyle** Caltrans
Prasad Rangaraju Clemson Univ.	**Terry Sherman** USACE	**Bryce Simons** New Mexico DOT	**David Stokes** FMC Corporation
Roger Surdahl FHWA	**Suneel Vanikar** FHWA	**Paul Virmani** FHWA	**Leif Wathne** ACPA
Ron Youngman ACPA (CO/WY Chapter)			

ASR Testing and Evaluation Protocols

During the 2006 Alkali-Silica Reactivity (ASR) Benchmarking Workshop, the FHWA learned that practitioners lacked clear information and guidance on the prevention of ASR in new concrete structures, as well as the mitigation of ASR in existing structures. To address these shortcomings, the FHWA developed guide documents based on existing information, specifications, and protocols.

The first document, titled "Report on Determining the Reactivity of Concrete Aggregates and Selecting Appropriate Measures for Preventing Deleterious Expansion in New Concrete Construction," was developed to improve the decision-making process associated with preventing ASR in new concrete. A framework is provided for practitioners to use when attempting to determine the level of aggregate reactivity and select preventive measures to minimize the risk of damage in new concrete structures. The methodology outlined in this report is comprehensive but very straightforward, taking into account field performance and various laboratory test methods in order to appropriately screen aggregates for ASR potential. Figure 1 illustrates the general sequence of testing and decisions to be made when evaluating a particular aggregate source. Suggested guidelines when carrying out ASTM International test methods for ASR are also provided.

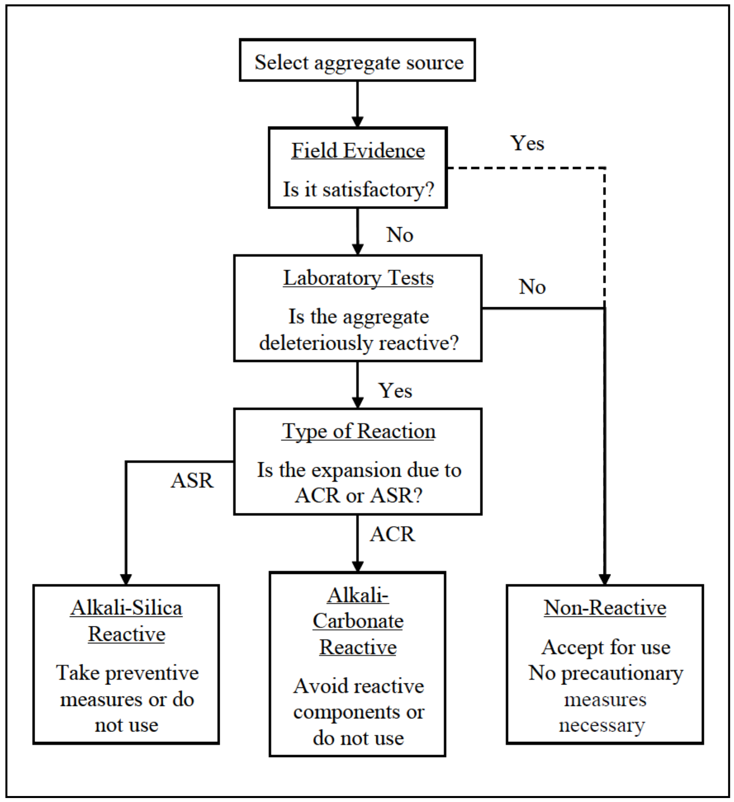

Figure 1. Summary of stages in the process of evaluation.

Two distinct approaches for selecting preventive measures against ASR are outlined in this report. The first approach is performance-based and centers upon laboratory testing, while the second approach is prescriptive-based and considers a combination of factors including aggregate reactivity, type and size of the structure, exposure conditions, and the composition of cementitious materials being used. These approaches served as the basis for the AASHTO PP 65-11 "Standard Practice for Determining the Reactivity of Concrete Aggregates and Selecting Appropriate Measures for Preventing Deleterious Expansion in New Concrete Construction." The FHWA recently published a report, "Selecting Measures to Prevent Deleterious Alkali-Silica Reaction in Concrete - Rationale for the AASHTO PP65 Prescriptive Approach," to provide additional clarification on the rationale of standard practice. A software program to accompany the AASHTO Standard Practice is currently in development.

In order to assist practitioners in the diagnosis and prognosis of alkali-aggregate reactivity (AAR) in existing transportation structures, the FHWA also published "Report on the Diagnosis, Prognosis, and Mitigation of Alkali-Silica Reaction (ASR) in Transportation Structures." This report provides guidance on confirming the presence of ASR through visual surveys, in-situ investigations, and if necessary, extensive laboratory testing. An overview of mitigation measures for ASR-affected structures is provided, as well as decision factors to consider prior to their implementation. In addition, the appendices of this report contain a significant amount of information to aid practitioners including techniques used in the diagnosis of ASR, visual signs of ASR, and test procedures for evaluating current and future expansion.

Technology Transfer and Deployment

The FHWA quickly learned that it is vital to deploy technologies and provide practitioners with information on alkali-silica reactivity (ASR) in a timely manner. As a result, the first effort initiated under the ASR Development and Deployment (D&D) Program was *Reactive Solutions*, a technical update newsletter on ASR. Distributed quarterly since 2008, *Reactive Solutions* featured articles by State Department of Transportation (DOT) personnel, leading researchers, and the private sector. Each issue spanned a wide variety of topics including ASR-related specifications, developments within the international community, and updates on current ASR field trials. *Reactive Solutions* is distributed electronically via email, and all issues are available on the FHWA ASR website (see page 8).

An ASR Reference Center was developed to provide State engineers and practitioners with readily accessible information on ASR. As the first resource of its kind, the Reference Center contains a vast library of ASR case studies, guidance documents, and laboratory research documentation. A significant number of State DOT, international, and national agency specifications are also provided on the site. The Reference Center is accessible through the FHWA ASR website and is frequently updated to ensure the most recent and relevant information is available.

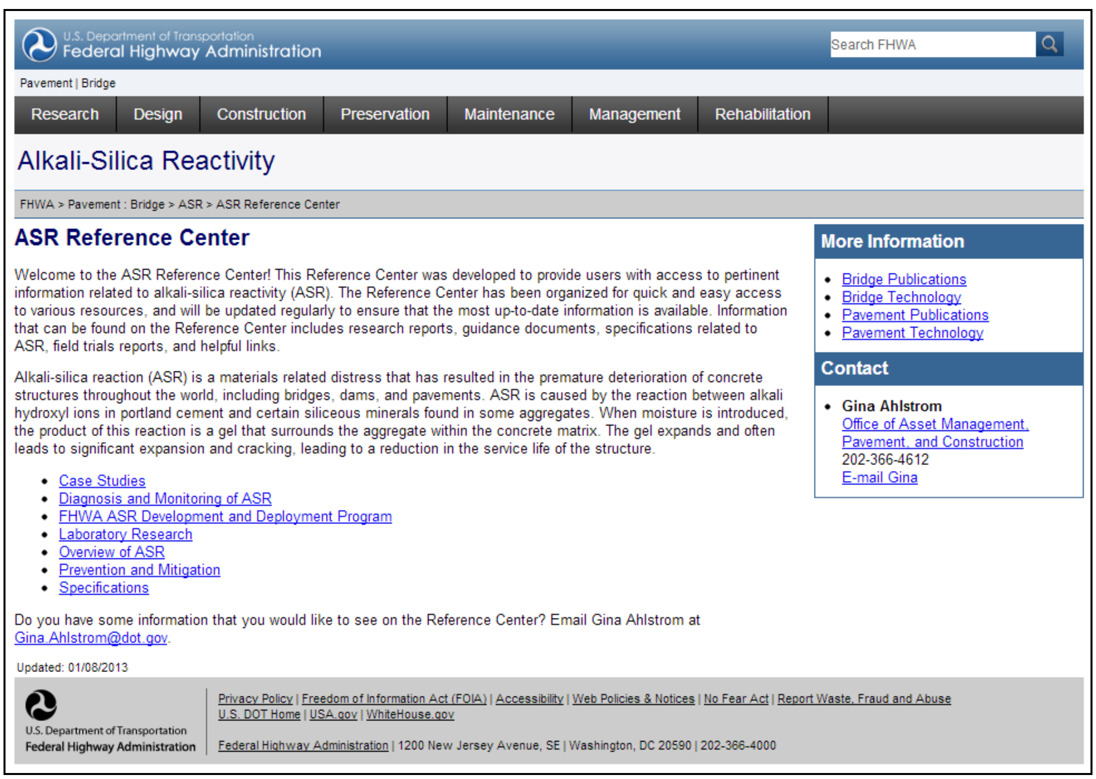

Figure 2. Screenshot of the FHWA ASR Reference Center.

In order to effectively transfer the deliverables developed under the ASR D&D Program, a series of one-day alkali-aggregate reactivity (AAR) workshops were recently offered to State DOT pavement engineers, materials engineers, and practitioners. These workshops covered a wide variety of topics related to AAR, including:

- Fundamentals and Symptoms of AAR
- Diagnosis, Prognosis, and Prevention of AAR
- AAR Test Methods and Specifications
- Repair Methods

Figure 3. FHWA AAR Workshop.

The material covered during the workshops was also presented over the course of a very popular webinar series in February 2013. Recordings of the webinars will soon be available through the FHWA ASR website, in addition to an ASR Facts Book and other reference materials that were provided to attendees.

ASR Field Application and Demonstration Projects

During the Alkali-Silica Reactivity (ASR) Benchmarking Workshop, State Department of Transportation (DOT) personnel and practitioners indicated that more information and performance data is necessary to assess techniques used to prevent and mitigate alkali-silica reactivity (ASR). Although many different technologies had been experimented with in the past, including lithium nitrate, supplementary cementitious materials, silanes and other sealing materials/products, more work was needed to determine which methods are actually successful in eliminating or mitigating ASR. As a result, a large portion of the ASR D&D Program was dedicated to putting these technologies into practice through field applications and demonstration projects.

Currently, there are 12 field trials being conducted in nine different States, as shown in Figure 4. At each site, the FHWA worked with State DOTs to provide technical guidance, instrument field structures, implement monitoring programs, and analyze collected data to determine the efficacy of various technologies. All activities were performed in full collaboration with State DOT personnel to ensure full technology transfer. In addition, individual project reports were prepared for each implementation or demonstration in order to document the lessons learned and aid in future field trials.

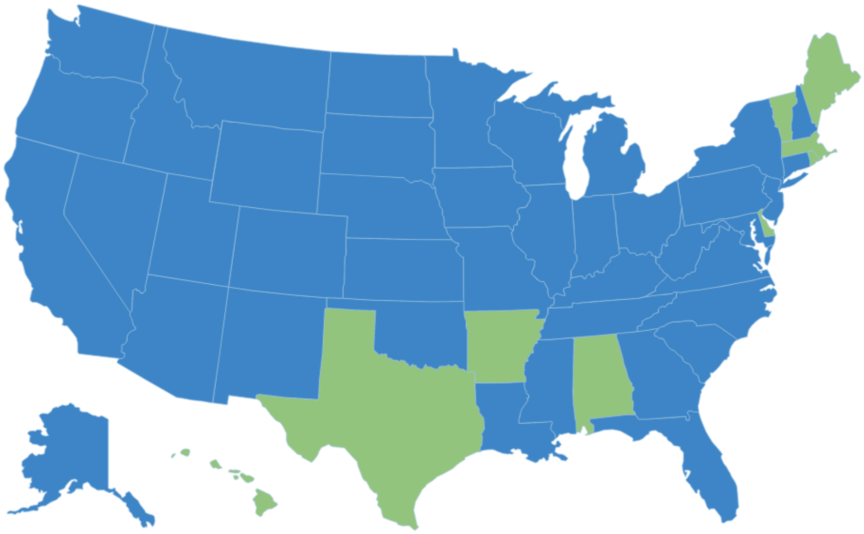

Figure 4. Locations of field trial application projects.

A summary of the field trial locations, structures, and techniques used to mitigate or prevent ASR is provided in Table 1. Most of the field trials were selected in order to evaluate methods designed to mitigate the effects of ASR in existing structures, with silane sealers being the most common. At each site, the testing program sought to advance the state of the art by generating key data including application details, timing, and the expected life cycle of each mitigation measure. In addition, monitoring efforts were performed twice a year in collaboration with State DOTs.

Table 1. Summary of field application and demonstration projects.

State	Structure	Mitigation/Prevention Technique
Alabama	Historic bridge arch	Topical application of silane
Arkansas	Pavement	Topical application of silane
Delaware	Pavement	Topical application of lithium nitrate
	Pavement	Monitoring an asphalt overlay of pavement with lithium nitrate
Hawaii	Aggregates	Testing aggregates and development of field exposure site
Massachusetts	Median barrier	Silane sealers; topical application of lithium nitrate
	Aggregates	Testing aggregates and development of field exposure site
Maine	Bridge abutments and piers	FRP wrap; silane sealer; electrochemical application of lithium nitrate
Rhode Island	Bridge abutments and barrier walls	Topical silane and elastomeric treatments
Texas	Bridge columns	Electrochemical application of lithium nitrate; vacuum impregnation of lithium; silane sealers
	Precast bridge girders	Aggregate testing and investigation of specific mixture designs
Vermont	Bridge barrier walls	Silane sealers

In addition to evaluating and refining mitigation measures for structures already suffering from ASR, there was an effort to validate guidelines used to determine aggregate reactivity and select appropriate preventive measures. Most recently, the FHWA worked with the Massachusetts DOT and Hawaii DOT to determine the reactivity of several of their commonly used aggregates in accordance with the published document, "Report on Determining the Reactivity of Concrete Aggregates and Selecting Appropriate Measures for Preventing Deleterious Expansion in New Concrete Construction." Outdoor exposure sites were also constructed that consist of exposure blocks cast with local aggregates, lithium nitrate, and supplementary cementitious materials. The exposure sites, which are shown in Figure 5, are monitored to begin determining the susceptibility of certain aggregates and/or mix designs to ASR.

Figure 5. Hawaii DOT and Massachusetts DOT outdoor exposure sites.

Through the field trials and demonstration projects, the FHWA and State DOTs have gained valuable insight on methods, techniques, and materials to mitigate the deleterious effects of ASR expansion. Individual project reports are posted on the FHWA ASR Reference Center (see page 8) and a final report will be developed at the end of 2013. The final report will provide an analysis of all field projects and attempt to provide conclusions about the efficacy of the treatments and technologies implemented.

Inventorying Existing Structures for ASR

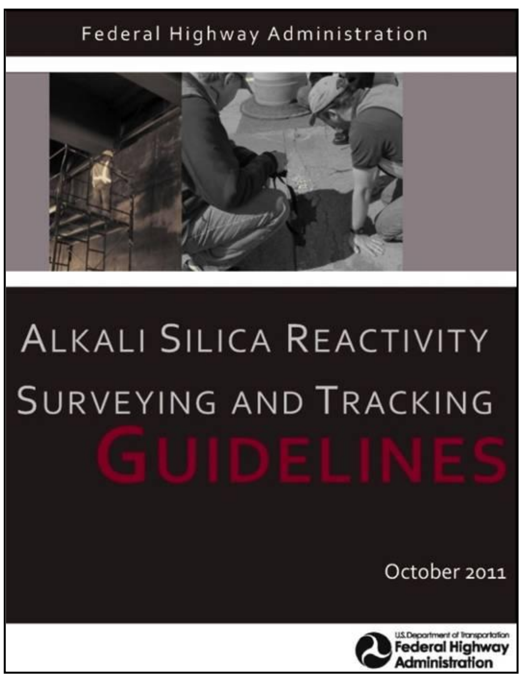

Figure 6. FHWA ASR Surveying and Tracking Guidelines.

The Congress report that accompanied the SAFETEA-LU legislation explicitly stated that an alkali-silica reactivity (ASR) program "shall assist states in inventorying existing structures for ASR." As a result, the FHWA acknowledged this request and developed strategies to enable State Highway Agencies (SHA) to collect, quantify, and rank typical signs of ASR in a simple, efficient manner. The most recent publication, "Alkali-Silica Reactivity Surveying and Tracking Guidelines," provides guidelines for engineers, inspectors, and consultants to follow when managing transportation infrastructure affected by ASR. Collectively referred to as STAR (**S**urveying and **T**racking of **A**lkali-Aggregate **R**eaction), the guidelines 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, this document attempts to bridge the gap between existing infrastructure management systems and tools specific to the diagnosis of ASR.

In conjunction with the surveying and tracking guidelines, the "Alkali-Silica Reactivity Field Identification Handbook" is also available for use by inspectors. This handbook serves as an updated version of a previous guidebook developed under the Strategic Highway Research Program (SHRP) that practitioners found very useful. The latest handbook provides detailed guidance in identifying ASR in the field, as well as fundamental information about ASR and tips on identifying ASR under several scenarios. Most importantly, a large number of detailed images are provided in a format that is easy to apply in the field. Figure 7 provides an example of the supplementary images that are included within the handbook.

Figure 7. Images provided in the FHWA ASR Field Identification Handbook.

For more information about the FHWA ASR Development and Deployment Program, please contact Gina Ahlstrom at Gina.Ahlstrom@dot.gov. A list of publications and helpful links associated with the program can be accessed below.

Publications

- Report on Determining the Reactivity of Concrete Aggregates and Selecting Appropriate Measures for Preventing Deleterious Expansion in New Concrete Construction
- Selecting Measures to Prevent Deleterious Alkali-Silica Reaction in Concrete - Rationale for the AASHTO PP65 Prescriptive Approach
- Report on the Diagnosis, Prognosis, and Mitigation of Alkali-Silica Reaction (ASR) in Transportation Structures
- Alkali-Silica Reactivity Surveying and Tracking Guidelines
- Alkali-Silica Reactivity Field Identification Handbook

Links

- FHWA ASR Website
- ASR Reference Center
- Reactive Solutions

Schedule of Events

April
2-4
Technology Transfer Concrete Consortium (TTCC) and National Concrete Consortium (NCC)
Philadelphia, Pennsylvania

May
6-8
2013 International Concrete Sustainability Conference
San Francisco, California

June
9-12
ASTM International Committee C09, Concrete and Concrete Aggregates
Indianapolis, Indiana

9-12
American Society of Civil Engineers (ASCE) 2013 Airfield and Highway Pavements Conference
Los Angeles, California

10-13
American Concrete Pavement Association (ACPA) Mid-Year Meeting
Itasca, Illinois

12-14
ASTM International Committee C01, Cement
Indianapolis, Indiana

July
16-19
Mid America Association of State Transportation Officials (MAASTO) Annual Meeting
Milwaukee, Wisconsin

To view this technical update on the web, please go to
http://www.fhwa.dot.gov/pavement/concrete/reactive/v06issue01.cfm