Reactive Solutions

An FHWA Technical Update on Alkali-Silica Reactivity

Summer 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 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:

Editor's Note

This edition of Reactive Solutions highlights research presented at the 14th International Conference on Alkali-Aggregate Reaction (ICAAR), held in Austin, TX in May. Since its inception in 1974, this symposium has grown tremendously, evolving into a quadrennial conference that hosts attendees from all over the world. During the 14th ICAAR, more than 140 papers were presented over five days of technical sessions, with topics ranging from the diagnosis of AAR to testing and petrography. Conference registrants were also offered a tour of the University of Texas at Austin Concrete Durability Center, which includes one of the largest outdoor exposure sites dedicated to the study of ASR in the world. Congratulations are offered to the following conference award recipients:

- **Gunnar Idorn Award for Lifetime Achievement -** Dr. Phillip Nixon
- **Best Paper** - "Structural Behavior of Plain and Reinforced Concrete Beams Affected by Combined AAR and DEF," Theodore Chappex & Dr. Karen Scrivener
- **Best Student Paper** - "Controlling Alkali-Silica Reaction by Understanding the Contribution of Aluminum Provided by Supplementary Cementing Materials," Renaud-Pierre Martin, Jean-C Renaud, Stephane Multon, & Francois Toutlemonde

Update on FHWA ASR Development and Deployment Program Presented at ICAAR

During the 14th International Conference on Alkali-Aggregate Reaction (ICAAR), a special session was held which focused on work being performed under the FHWA Alkali-Silica Reactivity (ASR) Development and Deployment Program. This program strives to effectively deploy current technologies in order to prevent and mitigate ASR in the field, and ultimately reduce life cycle costs and increase the durability and performance of concrete pavements, bridges, and other highway structures.

During the session, an overview of the ASR Development and Deployment Program's four main task areas were presented. The Program Areas are the development of testing and evaluation protocols, field application projects for the prevention and mitigation of ASR, support of States in inventorying existing structures for ASR, and deployment and technology transfer.

The recently published American Association of State Highway and Transportation Officials (AASHTO) provisional practice, "Standard Practice for Determining the Reactivity of Concrete Aggregates and Selecting Appropriate Measures for Preventing Deleterious Expansion in New Concrete Construction" (PP65-11), was presented to attendees. In addition to a performance-based approach, this practice outlines a prescriptive approach to preventing ASR by determining the required level of prevention and appropriate preventive measures based on various factors, including aggregate reactivity and structure type.

An update on current field demonstration projects, which are implementing a variety of techniques for mitigating the deleterious effects of ASR, was also presented. The efficacy of topical treatments applied to highway structures in Maine, Vermont, Massachusetts, and Texas was discussed in detail. Ongoing performance monitoring at these sites has demonstrated that silane treatments have been beneficial in reducing expansion rates, while the use of lithium as a post-treatment for ASR has shown limited efficacy at hindering the progress of expansion in ASR-affected elements.

For more information about the FHWA ASR Development and Deployment Program, please visit http://www.fhwa.dot.gov/pavement/concrete/asr.cfm or contact Gina Ahlstrom at Gina.Ahlstrom@dot.gov.

FHWA Alkali-Aggregate Reactivity Workshops for State DOTs Announced

In order to effectively transfer the deliverables developed under the FHWA Alkali-Silica Reactivity (ASR) Development and Deployment Program, a total of six one-day alkali-aggregate reactivity (AAR) workshops will be offered to State Department of Transportation (DOT) pavement engineers, materials engineers, and practitioners. A limited number of webinars will also be available. Material to be covered is listed in Table 1 and attendees will receive a Workshop Reference Guide, Participant's Manual, and other reference materials, including an ASR Facts Book and the AASHTO provisional ASR specification. It is anticipated that workshops will be available beginning in Fall 2012 and webinars will follow in 2013.

Table 1. FHWA AAR Workshop Agenda.

Session	Topic
1	Introduction and Workshop Objectives
2	Fundamentals of AAR
3	Symptoms of AAR
4	AAR Test Methods
5	Prevention of ASR
6	AAR Specifications
7	Diagnosis and Prognosis of AAR
8	Repair Methods

The instructors for this series of workshops, Drs. Michael Thomas, Kevin Folliard, and Benoit Fournier, have worked extensively over the past 20 years with provincial (Canada), state, and federal agencies to assist in managing AAR-affected structures. Recently, the team has also developed firsthand knowledge of local and regional AAR training needs through a leadership role in the FHWA ASR Technical Working Group, and through conducting field trials and demonstration projects under the ASR Development and Deployment Program.

Workshop locations are still being finalized, but if you would like more information, please contact your local FHWA Division Office or Gina Ahlstrom at Gina.Ahlstrom@dot.gov.

European Field Sites Monitored to Assess Reliability of Various Test Methods

For the past eight years, concrete specimens located at outdoor exposure sites across Europe (see Figure 1) have been continuously monitored to evaluate the suitability of various test methods designed to assess alkali-aggregate reactivity. This research, which was recently presented at the 14th International Conference on Alkali-Aggregate Reaction (ICAAR), is being conducted by the central organization of the German cement industry (Verein Deutscher Zementwerke) in cooperation with other European research institutes. This project builds upon the EU PARTNER Project (2002-2006), which had the overall objective of establishing a unified test procedure for evaluating the reactivity of aggregates across the different economic and geologic regions of Europe. In this new study, the potential reactivity of different European aggregate combinations was evaluated using regional tests and select RILEM test methods, including AAR-1 (petrographic method), AAR-2 (accelerated mortar bar method), AAR-3 (concrete prism method), and AAR-4 (accelerated concrete prism method).

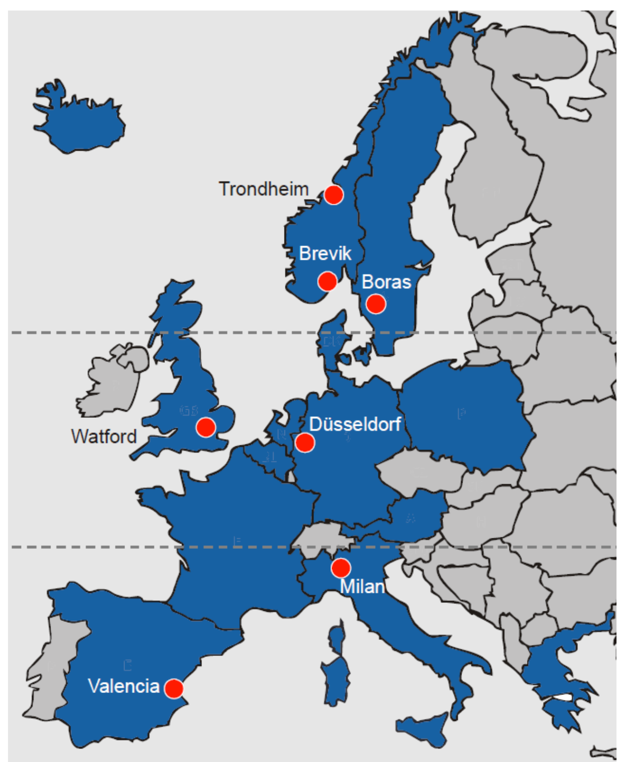

Figure 1. Locations of European field sites.

Thirteen aggregate combinations were selected, encompassing most types of reactive aggregates throughout Europe with respect to mineralogical properties and alkali-reactivity. Based on field experience, the aggregates were grouped into three categories: "normally" reactive aggregates that begin to react in roughly 5 years, "slowly" reactive aggregates (15-20 years), and non-reactive aggregates. Table 2 provides a summary of each aggregate combination.

Table 2. Aggregate combinations used in this study.

Origin	Sample	Reactivity	Aggregate Details
Belgium	B1	Normal	Silicified limestone
Denmark	D2	Normal	Sea-dredged sand with semi-dense flint
France	F1	Slow	Gravel with flint
	F2	Non-reactive	Non-reactive limestone
Germany	G1	Normal	Crushed gravel with siliceous limestone and chert
Italy	It2	Slow	Gravel with quartzite and gneiss
Norway	N1	Normal	Cataclasite
	N2	Slow	Sandstone
	N3	Non-reactive	Granitic sand
	N4	Slow	Gravel with sandstone and cataclasite rocks
Sweden	S1	Slow	Gravel with porphyritic rhyolite
United Kingdom	UK1	Normal	Greywacke
Portugal	P1	Slow	Silicified limestone

Concrete cubes measuring 300 mm (11.81 in) on each side were cast with 440 kg/m^3 (742 lb/yd^3) of the RILEM standard cement (CEM I 42.5R), with a water to cement ratio of 0.50 and an air content of 2% by volume. Reference studs were fixed to each specimen in order to obtain field expansion measurements. Select specimens at each site were exposed to ambient conditions, while others were partially submerged in water, as shown in Figure 2, to determine if deterioration would be accelerated. In addition, deicing salts were applied to one set of specimens by storing the cubes beside a highway in Sweden in order to evaluate the influence of external alkalis.

Figure 2. Concrete specimen storage conditions.

After eight years, all specimens containing normally reactive aggregate combinations have exhibited significant deterioration, while five of the six slowly reactive aggregate combinations have began to expand slightly. The specimens constructed with non-reactive aggregate have shown no signs of deterioration. It was also observed that for some aggregates the degree of deterioration was noticeably worse for specimens located in warmer climates. In addition, no significant differences in deterioration were seen between specimens submerged in water and those exposed to ambient conditions, nor did the influence of external alkalis have a noticeable impact.

The field performance observed to date has demonstrated that all laboratory test methods under evaluation have been successful in identifying "normally" reactive aggregate combinations. It has also been shown that RILEM test methods AAR-2 and AAR-4 have proven to be most reliable in identifying "slowly" reactive aggregate combinations, although ongoing measurements will continue to reveal emerging trends. For more information about this research, please contact Dr. Ingmar Borchers at Ingmar.Borchers@vdz-online.de.

Multi-laboratory Study Conducted to Evaluate Aggregate Used for ASR Research

A recent study conducted by the Ontario Ministry of Transportation (MTO) in order to qualify a new stockpile of coarse aggregate used for the calibration of alkali-silica reaction (ASR) test methods was presented at the 14th International Conference on Alkali-Aggregate Reaction (ICAAR). The Spratt aggregate is a siliceous limestone that originates from a quarry near Ottawa and has been available free of charge from the MTO for research purposes since 1986. After the original stockpile was exhausted in 1991, a new one (Spratt 2) was established but nearly depleted by 2006, thus necessitating the need for a third stockpile (Spratt 3). In order to determine the ability of this new aggregate supply to serve as a control material for ASR studies, a multi-laboratory study was carried out to compare the newest stockpile to previous ones.

A total of 57 laboratories volunteered to participate in this study, which was divided into three parts as summarized in Table 3. Part I of the test program consisted of performing comparative accelerated mortar bar testing (AMBT) of the provided Spratt 2 and Spratt 3 aggregate in accordance with either of the test methods listed in Table 3. In Part II, laboratories cast two separate concrete mixtures incorporating the Spratt 3 aggregate, in addition to control and local non-reactive sands, and carried out the concrete prism test (CPT) at 38°C. Laboratories that chose to participate in Part III cast three additional prisms and ran the accelerated CPT at 60°C.

Table 3. Test program for multi-laboratory study.

Part	Test Methods		Coarse Aggregate	Sand	Cement	Expansion Monitoring
I	Accelerated Mortar Bar Test	(CSA A23.3-25A, ASTM C 1260, or RILEM AAR-02)	Spratt 2	--	Local (general use)	Up to 28 days
			Spratt 3	--		
II	Concrete Prism Test (38°C)	(CSA A23.2-14A, ASTM C 1293 or RILEM AAR-03)	Spratt 3	Control (provided)	Local (general use)	Up to 1 year
			Spratt 3	Local		
III	Accelerated Concrete Prism Test (60°C)	RILEM AAR-04	Spratt 3	Control (provided)	Local (general use)	Up to 6 months
			Spratt 3	Local		

Results of the AMBT in accordance with the Canadian Standards Association (CSA) A23.3-25A and ASTM C 1260 procedures are shown in Figure 3. These two procedures differ only by the use of slightly different water to cement ratios as well as a specified cement alkali content in the CSA method. Despite these variations, very similar expansions were measured at both 14 days and 28 days for the Spratt 2 and Spratt 3 aggregates. In addition, expansions measured with the CPT (38°C) and accelerated CPT (60°C) for the Spratt 3 aggregate correlated very well with results obtained for the Spratt 2 aggregate during a previous study.

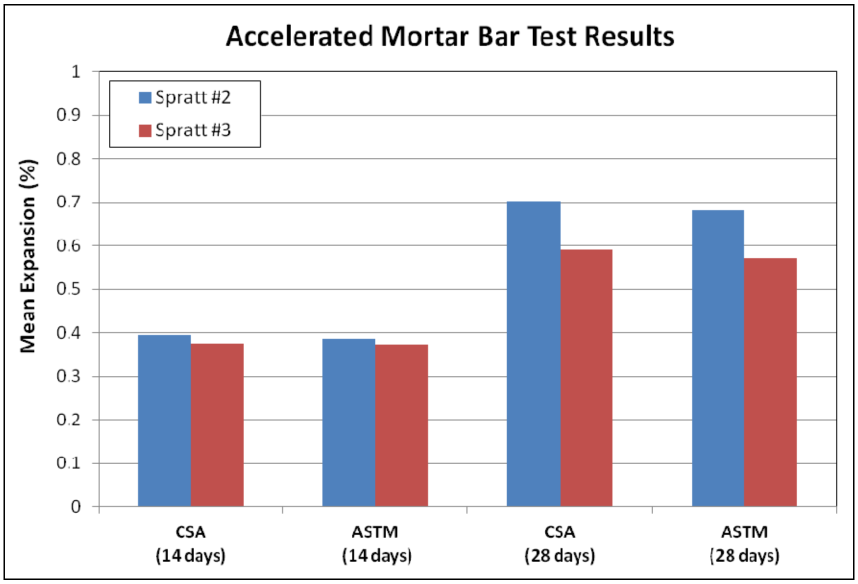

Figure 3. Summary of accelerated mortar bar test results.

Overall, this study has provided confidence that the new stockpile of Spratt aggregate has similar levels of reactivity as earlier supplies, thus providing a consistent and reliable aggregate for research purposes and use as a laboratory reference standard. For more information about this research, please contact Dr. Benoit Fournier at Benoit.Fournier@ggl.ulaval.ca. If you would like to obtain a supply of Spratt aggregate, please e-mail Carole Anne MacDonald (MTO) at Caroleanne.Macdonald@ontario.ca.

Schedule of Events

August
5-10
AASHTO Subcommittee on Materials
Biloxi, Mississippi

12-17
AASHTO Subcommittee on Construction
San Francisco, California

27-31
National Pavement Preservation Conference
Nashville, Tennessee

September
17-20
Summer Winter Integrated Field Technologies (SWIFT) Conference
Banff, Alberta, Canada

18
Technology Transfer Concrete Consortium (TTCC) and National Concrete Consortium (NCC)
Seattle, Washington

18-21
International Conference on Long-Life Concrete Pavements
Seattle, Washington

October
18-22
2nd International Conference on Sustainable Construction Materials: Design, Performance, and Application
Wuhan, China

21-25
American Concrete Institute (ACI) Fall 2012 Convention
Toronto, Ontario

To view this technical update on the web, please go to
http://www.fhwa.dot.gov/pavement/concrete/reactive/v05issue03.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.