THE UNITED STATES FEDERAL HIGHWAY ADMINISTRATION'S ALKALI-SILIA REACTIVITY DEVELOPMENT AND DEPLOYMENT PROGRAM

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Abstract

In 2006 The United States transportation legislation, The Safe Accountable Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) provided the Federal Highway Administration (FHWA) with nearly $10 million to continue efforts to address alkali-silica reactivity (ASR) as a major durability issue. The ASR Development and Deployment Program was established in 2006 to provide technical assistance to States and practitioners to address ASR issues. This paper will briefly discuss previous national ASR programs, discuss the scope of the ASR Development and Deployment Program, and the successes achieved to date through the Program.

Keywords: United States Federal Highway Administration, Alkali-Silica Reactivity, national program, highway structures, pavements

1 INTRODUCTION

A coordinated effort to address ASR was initiated in the 1980's through the Strategic Highway Research Program (SHRP) [1]. Additional funding dedicated to address ASR was made available under TEA-21, which authorized the Federal surface transportation programs from 1998-2003. The funding provided under TEA-21 was focused on the use of lithium based technologies to address ASR prevention and mitigation. Documents [2, 3] were produced to aid practitioners in the use of lithium based technologies for the prevention and mitigation of ASR. The largest dedicated funding for ASR however, was provided through SAFETEA-LU in 2006. The SAFETEA-LU legislation was much broader and focused on refining and deploying proven technologies and methods to address ASR. In preparation for the FHWA to develop a new ASR program a benchmarking workshop was held in 2006 to identify stakeholder needs, gaps in knowledge, and input on the direction of the new ASR program. More information on previous ASR funding and the ASR benchmarking workshop can be found in the ASR Benchmarking Workshop Final Report [4]. After receiving input from the workshop participants the FHWA outlined the ASR Development and Deployment Program, which strives to:

- Increase durability and performance, and reduce life cycle costs through prevention and mitigation of ASR in concrete pavements, bridges, and other highway structures (structures).
- More effectively deploy current technologies to prevent and mitigate ASR in the field.

The ASR Development and Deployment Program was created in 2006 and will end in 2013.

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2 SCOPE OF FHWA'S ASR DEVELOPMENT AND DEPLOYMENT PROGRAM

Two primary objectives for the ASR Development and Deployment Program were established. The first goal is to increase durability and performance, and reduce life cycle costs through prevention and mitigation of ASR in concrete pavements, bridges, and other highway structures (structures). The second goal is to more effectively deploy current technologies to mitigate ASR in existing concrete pavements, bridges, and other highway structures.

In order to meet the program, objectives task areas were identified by FHWA. The ASR Development and Deployment Program consists of the following four tasks, which will be discussed in more detail in subsequent sections:

1. Development of Testing and Evaluation Protocols
2. Field Application Projects for the Prevention and Mitigation of ASR
3. Assist States in Inventorying Existing Structures for ASR
4. Deployment and Technology Transfer

2.1 Development of Testing and Evaluation Protocols

From the ASR Benchmarking Workshop [4], FHWA learned that practitioners lacked clear information and guidance on the prevention of ASR in new concrete structures and the mitigation of the deleterious effects of ASR in existing concrete structures. As a result, two documents were developed. The first document was developed to assist practitioners in designing new concrete structures that minimize the risk of ASR potential. The second document was developed to provide information on surveying and monitoring existing structures with ASR. The primary audience for both documents are State Departments of Transportation (DOT) and consulting engineers and practitioners.

2.1.1 Guidance on Prevention ASR in New Concrete Structures

"The Report on Determining the Reactivity of Concrete Aggregates and Selecting Appropriate Measures for Preventing Deleterious Expansion in New Concrete Structures" [5] was written to outline a process for designing concrete mixtures that minimize the risk for ASR potential. The report discusses how to use field performance, petrographic assessments, and test methods to appropriately screen aggregates for ASR potential. In general, it is recognized that ASTM C 1293 (the Concrete Prism Test) [6] is the most accurate test for evaluating aggregate reactivity and ASTM C 1260 (the Accelerated Mortar Bar Test) [7] is a very severe test [5]. The report discusses that the Concrete Prism Test is the recommended test method for screening aggregates for ASR potential. However, it is recognized that the concrete prism test duration of one year is lengthy and may not be practical for project level testing. As a result, guidance is provided on the use of the Accelerated Mortar Bar Test and correlating those test values to the Concrete Prism Test.

The report outlines a performance approach and a prescriptive approach to select preventative measures for ASR. When using the performance approach, the preventative measure is tested in combination with reactive aggregates in order to evaluate its performance using the modified version of the ASTM C 1293 and ASTM C 1567 [6, 8]. The prescriptive based approach considers the class of structure, size of structure, degree of aggregate reactivity, and the level of alkalis in the portland cement alone to determine the appropriate preventative measure.

The report by Thomas, et al. [5] was used as a basis for the AASHTO provisional Standard Practice for "Determining the Reactivity of Concrete Aggregates and Selecting Appropriate Measures for Preventing Deleterious Expansion in New Concrete Construction" [9]. Prior to the provisional standard a practice for determining aggregate reactivity and determining preventative measures for ASR was not standardized. The provisional practice was published in 2011 with a commentary section that includes additional clarification on the content in the practice and also provides worked examples for determining preventative measures.

2.1.2 Guidance on Mitigation of ASR in Existing Concrete Structures

"The Report on the Diagnosis, Prognosis, and Mitigation of Alkali-Silica Reaction (ASR) in Transportation Structures" [10] was developed to discuss a process that may be used to investigate structures with ASR. The report provides information on how to confirm the presence of ASR, estimate the expansion to-date of a structure, and estimate the future expansion of a structure. Information is also provided on measures to mitigate the effects of expansion due to ASR. The process outlines three investigation levels to determine the presence and severity of ASR in a field structure. The level 1 process consists of a performing a condition survey of the structure. The level 2 process consists of determination of a cracking index, obtaining samples from the structure, and conducting a petrographic analysis. The level 3 process includes conducting an in-situ and a laboratory investigation and is much more detailed and labor intensive than the level 1 or 2 investigations. The in-situ investigation consists of conducting expansion, stress, temperature, and non-destructive testing and a conducting a structural evaluation. The laboratory testing includes a detailed petrographic analysis of samples, mechanical testing, expansion testing, and determination of the water soluble alkali content of the concrete. The appendices of the document include detailed instructions on performing the tests outlined in the report. Information is also provided on mitigation measures for existing structures affected with ASR.

2.2 Field Application Projects for the Prevention and Mitigation of ASR

Stakeholders at the ASR benchmarking workshop indicated that more information and performance data was needed for techniques used for the prevention and mitigation of ASR. As a result a portion of the ASR Development and Deployment Project was dedicated to field trials. The purpose of field trials is to gain additional information on methods, techniques, and materials to mitigate the deleterious effects of ASR expansion. Information such as application details (application rates, dosage, materials requirements, etc.), timing the application of mitigation measure, and expected life cycle of mitigation measure will be compiled. Currently, nine field trials in seven States have been conducted and will be monitored until 2013 [Figure 1].

2.2.1 Mitigation of ASR

Most of the field trials conducted were selected to evaluate methods to suppress or mitigate the effects of deleterious ASR in existing structures. As shown in Table 1 various mitigation methods have been explored under the ASR Development and Deployment Program. Many of the field trials have use silane sealers, which have been shown to reduce the internal humidity of the structure while preventing the ingress of additional moisture [10].

Field trials are being monitored twice a year for each project for the remainder of the ASR Development and Deployment Program. A report documenting each field trial and recommendations for future mitigation options for concrete structures will be completed in 2013.

2.2.2 Prevention of ASR

In addition to exploring and refining mitigation measures for structures afflicted with ASR, validation of the guidelines for determining aggregate reactivity [5] and the AASHTO provision specification [9] are being done under the ASR Development and Deployment Program for the State of Hawaii. Aggregates and mixture designs being used by the Hawaii DOT are being tested using ASTM C 1293 and ASTM C 1260 [9, 10]. The Hawaii DOT requested that an additional investigation be conducted to evaluate their specific aggregates in combination with their environmental conditions. To accommodate the request and to enhance the field trials being conducted through the ASR Development and Deployment Program an outdoor exposure site was created.

A more detailed investigation of a local quarry was also conducted in Hawaii. The outdoor exposure site was constructed in June 2011. Thirty exposure blocks were cast with locally available aggregates, fly ash, and lithium nitrate. The blocks will be used to gather real-world data and be used to compare to other exposure block sites at the University of Texas at Austin [11] and at CANMET in Ottawa [12, 13].

2.3 Assisting States in Inventorying Existing Structures for ASR

The Congress Report that accompanied the SAFETEA-LU legislation specified that ASR projects and programs should "…assist states in inventorying existing structures for ASR." As a result, several documents are currently under development to meet these requirements.

The first document is an alkali-silica reactivity field identification handbook. Stakeholder feedback obtained during the ASR benchmarking workshop indicated that practitioners found the "Handbook for the Identification of Alkali-Silica Reactivity in Highway Structures" developed under the SHRP program very useful [4, 14]. However, the document is out of date and hard copies of the document are not readily available. To address stakeholder needs an updated version is being developed for publication under the ASR Development and Deployment Program. The updated version of the handbook briefly discusses the basics of the ASR mechanism. Detailed pictures showing varying degrees of ASR in field structures is presented in an easy to use format for practitioners. Currently, the updated handbook is under final review by FHWA and publication in 2012 is anticipated.

The second document provides guidelines for agencies to survey and track structures with ASR. The document provides a framework for an owner or agency to use when inspecting bridges, pavements, and other assets. Guidance is provided on defects associated with ASR and suggested condition states for structure elements with ASR. The guidelines follow the AASHTO Guide Manual for Bridge Element Inspection [15]. Currently, the surveying and tracking guideline document is under final review by FHWA and publication in 2012 is anticipated.

2.4 Deployment and Technology Transfer

Providing information and deploying technologies in a timely manner is vital. As a result two efforts for providing ASR related information to practitioners was initiated early in the ASR Development and Deployment Program.

The first effort is the development and distribution of an ASR technical summary called "Reactive Solutions". "Reactive Solutions" started as a printed publication in 2008. The newsletter was distributed quarterly and contained information specific to ASR such as articles written by personnel from State DOT's and other public agencies on ASR activities in their organization, articles on activities underway through the ASR Development and Deployment Program, ASR research activities, and international developments related to ASR. In 2010 the newsletter evolved into a technical summary that is electronically distributed quarterly. Past and current issues of "Reactive Solutions" can be found on FHWA's website [16].

The second effort was the creation of an ASR Reference Center. The purpose of the Reference Center is to house information related to ASR so that practitioners can readily obtain information without searching multiple locations. Information such as documents describing the basic fundamentals of the ASR mechanism, research reports, guidance documents, case studies, and specifications from State Departments of Transportation, North America, and internationally are located in the ASR Reference Center. The Reference Center can also be found on FHWA's website [16].

3 CONCLUSION

The ASR Development and Deployment Program was created as a result of legislative funding designated to address ASR in the United States. The FHWA developed a program after obtaining input from stakeholder on the needs and gaps in information related to ASR. The program focuses on providing technical guidance to practitioners on the prevention and mitigation of ASR. A large part of the program has been on using field trials to gather additional information and provide technical guidance on methods and techniques to mitigate the affects of ASR in existing structures and prevent ASR in new structures. A large focus was placed on technology deployment and information sharing. The ultimate goal of the program is to put tools needed to address ASR in the hands of practitioners. Information on the ASR Development and Deployment Program and documents developed under the Program can be found on FHWA's website [16].

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6 FIGURE AND TABLE

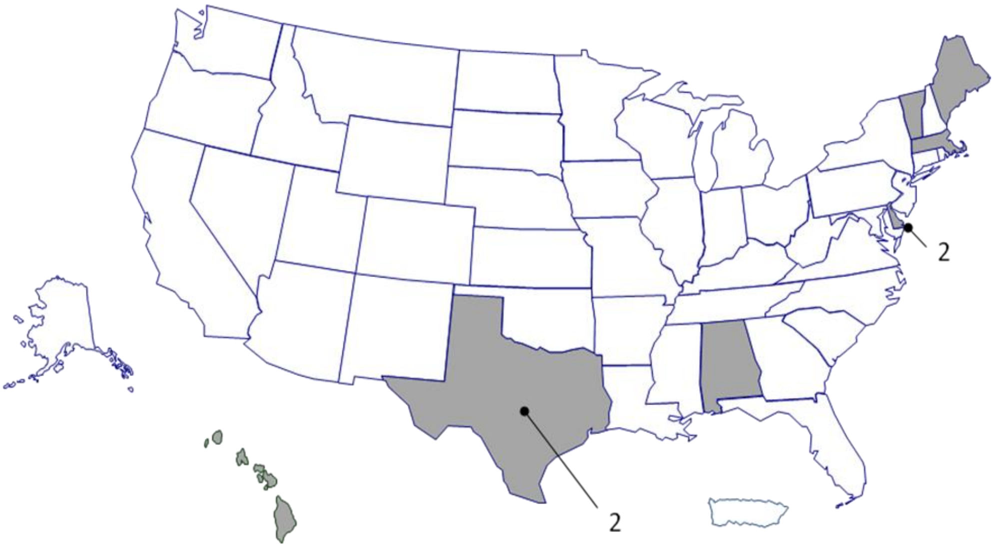

FIGURE 1: Location of field trials included in the FHWA ASR Development and Deployment Program.

TABLE 1: State, structure, and associated mitigation and prevention technique included in the FHWA ASR Development and Deployment Program.

State	Structure	Mitigation/Prevention Technique
Alabama	Historic bridge arch	Silane sealer
Delaware	Pavement	Topical application of lithium nitrate
Delaware	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
Maine	Bridge abutments and piers	FRP wrap; silane sealer; electrochemical application of lithium nitrate
Texas	Bridge Columns	Electrochemical application of lithium nitrate; vacuum impregnation of lithium; silane sealers
Texas	Precast Bridge Girders	Aggregate testing and investigation of specific mixture designs
Vermont	Bridge barrier walls	Silane sealers