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U.S. Department of Transportation
Federal Highway Administration

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Reactive Solutions

An FHWA Alkali-Silica Reactivity News Publication

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Texas DOT Specifications to Prevent Alkali-Silica Reactivity

Brian D. Merrill, P.E.
Texas State Bridge Construction Engineer
Texas Department of Transportation

In 1993, TxDOT declined an FHWA invitation to sponsor an ASR Showcase. We knew we had some isolated ASR cases involving a few known reactive aggregate sources but didn't feel that we had a big enough problem to warrant a showcase. A few years later we were in the middle of an ASR "explosion" with cases popping up in new and somewhat unusual locations: bridges. Almost all ASR cases in Texas have been in bridge structures rather than concrete pavements.

Once we determined that the distress in our structures was in fact due to ASR we had three fundamental questions:

1. Has structural capacity been affected?
2. Can we keep it from getting worse?
3. How do we prevent it in new concrete?

TxDOT launched a massive research campaign to address all three questions. Project 0-4085, "Preventing Premature Concrete Deterioration Due to ASR/DEF in New Concrete" conducted at the University of Texas' Center for Transportation Research by Dr. Kevin Folliard addressed the third question. This project used extensive laboratory testing along with a large exposure site (the first of its kind in the United States) to evaluate the effectiveness of various ASR mitigation methods. TxDOT used the results to confirm and expand our 1999 specifications to prevent ASR.

TxDOT's ASR specifications are largely prescriptive due to the high volume of concrete usage (> 60M cy of concrete in 2006) and the time it takes to run tests on more than 150 commonly used aggregate sources. All aggregates are treated as if they are potentially reactive unless we have test data confirming otherwise. The following eight mix design options were developed with industry input to provide maximum flexibility:

Option 1. Replace 20% to 35% of the cement with Class F fly ash.

Option 2. Replace 35% to 50% of the cement with GGBFS or modified F fly ash (MFFA).

Option 3. Replace 35% to 50% of the cement with a combination of Class F fly ash (35% max), GGBFS, MFFA, ultra-fine F fly ash (UFFA), metakaolin, or silica fume (10% max).

Option 4. Use Type IP or Type IS cement. (Up to 10% of a Type IP or IS cement may be replaced with Class F fly ash, GGBFS, or silica fume.)

Option 5. Replace 35% to 50% of the cement with a combination of Class C fly ash (35% max) and at least 6% of silica fume (10% max), UFFA, or metakaolin.

Option 6. Use a lithium nitrate admixture at a minimum dosage of 0.55 gal. (30% solution) per pound of alkalis present in the hydraulic cement.

Option 7. Use straight cement if the total alkali contribution from the cement in the concrete does not exceed 4.00 lb. per cy of concrete when calculated as follows:

$$\text{lb. alkali/cy.} = (\text{lb. cement/cy.}) \times \frac{(\text{max \% Na2O eq. in cement mill cert})}{100}$$

Option 8. For custom mitigations methods that don't comply with Options 1-5, test both coarse and fine aggregates separately in accordance with ASTM C 1567 and certify that expansion for each aggregate does not exceed 0.10%.

Options 7 and 8 are not allowed with certain known highly reactive aggregates.

TxDOT continues to study new ASR mitigation methods for new concrete mixes and existing facilities affected by ASR. For more information, please contact: Brian D. Merrill, P.E., at bmerrill@dot.state.tx.us , (512)-416-2232 or Lisa Lukefahr, P.E., at elukefah@dot.state.tx.us, (512) 506-5858.

Outdoor exposure site at the University of Texas

Editor's Corner

Dear Readers,

Our first issue of Reactive Solutions was released this past February, and we would like to take this opportunity to thank the editorial committee and the readers for making the first issue a success. We were very excited to receive ideas and content from our readers, as well as several requests from many folks asking to receive future newsletters. As the distribution of Reactive Solutions grows, we would like to keep encouraging our readers to take advantage of this publication to voice your ASR problems and to interact with other engineers in your shoes.

Thank you, and we hope you enjoy this Spring Issue.

Sincerely,

Mike Thomas

Dr. Michael Thomas, University of New Brunswick

"Findings from laboratory investigations have shown that the modern deicers are capable of inducing deleterious reactions in concrete containing alkali-silica reactive aggregates."

-Investigation of Deicer-Induced Pavement Distress in Airfield Concrete Pavements (pg. 3)

9th International Conference on Concrete Pavements

The International Society of Concrete Pavements 9th Conference will be held in San Francisco from August 17 to August 21. The conference will kick off with a 4-hour Alkali Silica Reactivity Workshop Sunday afternoon. You are invited to hear cutting edge presentations on:

- Protocols for the Prevention and Mitigations of ASR (FHWA)
- New minimum fly ash requirements for ASR Prevention in DOD Airfield concrete pavements (NAVFESC)

- Evaluation of basic ASR chemistry and potential of aggregate and concrete using the dilatometer method (TTI)
- Practical issues concerning ASR testing (Industry)
- Comparisons of the ASTM C-1260/1567 mortar bar test versus the ASTM C-1293 concrete prism test
- Other timely discussions on ASR issues

Moderated by Randall Stewart - RMS Consulting. Register for the ISCP Conference and ASR Workshop at: www.concretepavements.org

FHWA Petrographic Manual Update

D. Stephen Lane
Virginia Transportation Research Council

Petrography is a branch of the geological sciences that focuses on the description and classification of rocks and minerals. Over many years it has proven to be very useful in the evaluation and assessment of concrete quality and condition as well as its constituent materials and is an essential tool in establishing the cause(s) of concrete deterioration.

Petrographic Methods of Examining Hardened Concrete: A Petrographic Manual (FHWA HRT-04-150) details equipment and procedures used to conduct petrographic examinations of concrete, describes features and constituent materials commonly encountered with explanations of their meaning and relevance. It describes both alkali-silica and alkali-carbonate (a distinct mechanism) reactions provides features key for their identification as a cause of concrete distress. The manual includes a chapter on the use of scanning electron microscopes (SEM) and an appendix on rock and mineral identification.

The manual was originally published in 1992 by the Virginia Transportation Research Council. This version of the document was revised and published in 2007.

The document is accessible in HTML or PDF formats at: http://www.fhwa.dot.gov/pavement/pub_details.cfm?id=477

Ask The Experts

According to ASTM C1293 a wicking material is to be used inside the bucket around the outer edge. Note 1 suggests polypropylene geotextile fabric or blotting paper. For those of you that have been testing by this method, which do you prefer and what advantages do you see?

How are you suspending the material from the top?

Submitted by Scott Grossenbacher, Nebraska Department of Roads

Several wicking materials have been used for this test, such as polypropylene type geotextile fabrics and terry cloth towels.

Polypropylene type geotextile fabrics, with thicknesses around 3 to 4 mm have been used, placing the material around the side of the bucket without any glue to hold it in place; the material showed better absorbent capacity and durability. A study was conducted that demonstrated that as long as the wicking material was placed on the sides, any additional material would not change the results.

Terry cloth towels have also been used, and have been shown to perform for a few years as long as the heaviest type was used. Hot glue was used to affix the material to the side of the wall. Absorbing fabric, which has the same thickness as plotting paper, has also been used and has shown to last about 2 years in most case, with the material being held in place using duct tape. In addition, large sheets of chemical paper (500 by 500 mm) have also been used; no tape is needed as the material clings to the side when wet.

However, canvas is not recommended for use in this test.

Investigation of Deicer-Induced Pavement Distress in Airfield Concrete Pavements

Prasad Rangaraju, Ph.D., P.E.
Associate Professor
Clemson University

In recent years, a significant number of concrete pavements in commercial airfields across the United States have exhibited premature deterioration and reduced service lives when exposed to pavement deicing chemicals. Investigations of these pavements have suggested that mechanisms similar to those of alkali-silica reaction (ASR) distress and freeze/thaw damage in concrete are responsible for the observed deterioration.

The Federal Aviation Administration (FAA) through the Innovative Pavement Research Foundation (IPRF) has undertaken a major research initiative to investigate the underlying causes. In addition the FAA is working to develop appropriate mitigation strategies to minimize/eliminate pavement distress and prolong service life. The IPRF research has been focused on studying the impact of new generation anti-icing and deicing chemicals (i.e. alkali-acetate and alkali-formate salts) that have been introduced for use on airfield pavements during the past 16 years.

Findings from laboratory investigations have shown that the modern deicers are capable of inducing deleterious reactions in concrete containing alkali-silica reactive aggregates. Ongoing IPRF research is focused on conducting forensic investigations of deteriorated concrete pavements at several major U.S. airports to determine the role of deicing chemicals in causing the observed distress. Further effort is geared towards developing test methods to characterize the susceptibility of concrete to deleterious reactions in presence of deicing chemicals. The FAA is also coordinating with the concrete industry and other transportation agencies to expedite additional research in this area.

Based on the findings to date, *interim* guidelines have been issued by FAA through Engineering Brief No. 70 to evaluate aggregates and preventive measures in the presence of deicing chemicals. IPRF sponsored research has also focused on evaluating efficacy of lithium admixtures in minimizing/preventing ASR distress in new concrete airfield pavements. Alternate deicing chemicals have been developed by the industry and will be investigated and tested in the near future. Additional information on IPRF projects and final reports from past projects can be obtained at www.iprf.org.

A.sk
S.end
R.eceive

This Issue's Question

"If you have cracks in your concrete pavement or structure, how do you know it is ASR?"

Submit your answers to: asrnewsletter@transtec.us

An Update on Federal Highway's ASR Development and Deployment Program

The ASR Development and Deployment Program TWG (technical working group) met in Austin, Texas on March 25 and 26 to discuss the progress of the program.

Field Trials

It is anticipated that the initiation of field trials will be underway by late fall 2008. Field trials will be used to implement ASR prevention and mitigation techniques and to gain data on the life cycle to evaluate the effectiveness of the various solutions to ASR. FHWA will provide funding to States for projects exploring methods to prevent ASR in new construction and mitigate the deleterious effects of ASR in existing concrete structures. If you are interested in a field trial in your State please contact Gina Ahlstrom of FHWA at 202-366-4612 or gina.ahlstrom@dot.gov

For more information about the progress of this program, visit http://www.fhwa.dot.gov/pavement/concrete/asr.cfm
or contact Gina Ahlstrom at:
Gina.Ahlstrom@dot.gov

Protocols

The following guidance documents on the prevention and mitigation are under final review:

"Determining the Reactivity of Concrete Aggregates and Selecting Appropriate Measures for Preventing Deleterious Expansion in New Concrete Construction"

"Diagnosis and Prognosis of Alkali-Silica Reaction (ASR) in Transportation Structures"

FHWA anticipated receiving the final documents in May 2008. Stay tuned for information in a future issue of *Reactive Solutions* on how to obtain a copy of the published guide documents.

For more information on the ASR Development and Deployment Program visit:

http://www.fhwa.dot.gov/pavement/concrete/asr.cfm

Schedule of Events

May

4-7
2008 Concrete Bridge Conference, St. Louis

18-21
Symposium on Mechanics of Pavements and Paving Materials, Minneapolis

June

16-18
6th RILEM International Conference on Pavement Cracking, Chicago

16-19
13th International Conference on Alkali-Aggregate Reaction in Concrete (ICAAR) Trondheim, Norway

18-20
5th International ACI/ CANMET Conference on High Performance Concrete, Manaus, Brazil

19-21
2nd International Conference on "Advances in Concrete and Structures", Changsha, China

July

20-23
6th International conference on Road and Airfield Pavement Technology, Sapporo, Japan

This Issue's Photo

Have a picture you'd like to send us of an ASR-affected structure in your state? Send us what you like - a bridge, a core, a snapshot of your lab, etc. - our editorial committee will select one picture and post it here for all to see.

Email your pictures at asrnewsletter@transtec.us

Cracking due to ASR in a five-year-old bent cap with high cement factor and no preventive measures. Sent by: Brian Merrill, Texas DOT

Editor: *Dr. Michael Thomas (University of New Brunswick, mdat@unb.ca)*

Editorial Committee: *Gina Ahlstrom (Federal Highway Administration), Lizanne Davis (FMC Corporation), Steve Lane (Virginia DOT), Colin Lobo (National Ready Mix Concrete Association), Brian Merrill (TxDOT), Peter Taylor (CP Tech Center), Paul Tennis (Portland Cement Association), Leif Wathne (American Concrete Pavement Association)*

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