Alkali-Silica Reactivity in the State of Montana

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https://www.mdt.mt.gov/research/projects/mat/alkali_silica.aspx

MONTANA MDT DEPARTMENT OF TRANSPORTATION | MONTANA CONTRACTORS ASSOC. THE CONSTRUCTION ASSOCIATION | MONTANA STATE UNIVERSITY Western Transportation Institute

Background

- Alkali-Silica Reactivity (ASR) is a deleterious reaction that takes place in concrete between alkalis present in the binder and reactive forms of silica in the aggregates.
- ASR can cause significant damage leading to reduced life span, costly repairs, and/or replacement of the concrete.
- While ASR has been documented as an issue in many states, little work has been conducted to determine the potential/presence of ASR in Montana.


Typical ASR Crack Patterns

Research Objective and Scope

Objective

- The primary objectives of this research were to evaluate the potential for deleterious ASR in the state of Montana, to evaluate current and newly developed aggregate testing methodologies, to identify existing cases of ASR damage in the state, and to test the reactivity of several aggregate sources using the methodologies evaluated in this research.

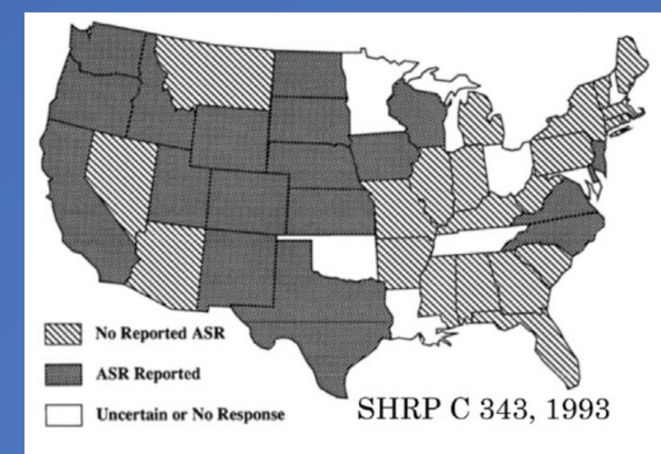
Scope

- An extensive literature review was conducted to determine ongoing regional and federal ASR practices (Chapter 2). Current and newly developed aggregate testing methods, as well as techniques for identifying ASR in existing structures were investigated and summarized.
- Research was conducted on several existing concrete structures exhibiting ASR-related distress. Several concrete cores were obtained from the sites and further examined in a laboratory setting to determine if ASR was the cause of deterioration and assess the extent of damage. Several of the cores were tested using the Los Alamos Staining Method, and all were evaluated with petrographic analysis. The results of these tests are discussed in detail in Chapter 4 of this document.
- Aggregates from various locations around the state were evaluated in accordance with ASTM C1260 and AASHTO T380. The results of these tests are discussed in detail in Chapter 5 of this document.

Literature Review

Summary of Practices from Regional States and Neighboring Canadian Provinces

- States investigated
  - Colorado
  - Idaho
  - Iowa
  - Minnesota
  - Nebraska
  - Nevada
  - North Dakota
  - Oregon
  - South Dakota
  - Utah
  - Washington
  - Wyoming



Documented Occurrences of ASR

- Canadian Provinces
  - British Columbia
  - Alberta
- Federal Agencies
  - Federal Aviation Administration
  - Federal Highway Administration
- Summary of Findings
  - The neighboring Canadian provinces, and all investigated states (sans North Dakota), directly address ASR in their material specifications, to varying degrees
  - FHWA leaves it to the individual states to determine ASR practices
  - FAA was found to have fairly stringent specifications

Summary of Testing Methods

- Aggregate Testing Methods
  - ASTM C1260
  - ASTM C1293
  - AASHTO T380
- Methods for Identifying and Quantifying ASR Damage in Existing Concrete
  - Los Alamos Staining Method
  - Petrographic Analysis
  - Non-Destructive Methods for Determining Damage Caused by ASR in Concrete

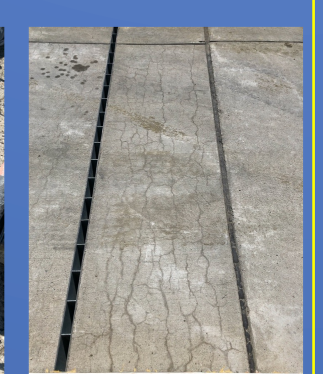
Cases of ASR Damage in Montana

Billings Logan International Airport

- Two Aprons showing signs of distress
- Cores evaluated via Los Alamos Staining Method and Petrographic Analysis
- Both cores determined to have significant damage associated with ASR

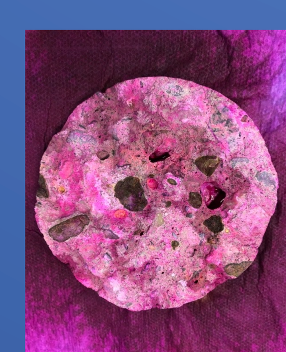
Site Locations at Airport

Site 1

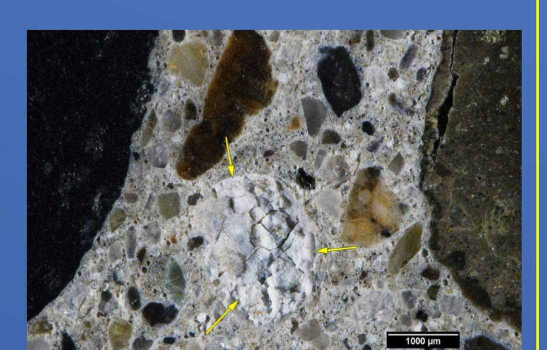


Site 2

Coring of Site 1



Core after Los Alamos Staining Method

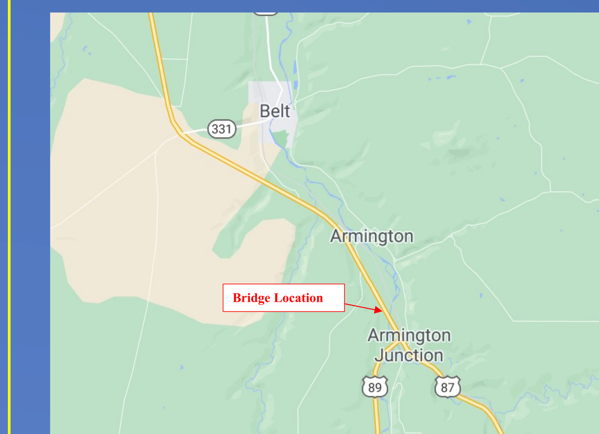


Magnified View of Core from Petrographic Analysis Showing ASR Gel

Cases of ASR Damage in Montana

US-87/US-89/MT 200 Bridge over Belt Creek

- Bridge Backwall and Beam Showing Signs of Distress
- Cores evaluated via Petrographic Analysis
- Core determined to have significant damage associated with ASR



Bridge Location

Backwall Location on Bridge

Backwall and Beam Showing Signs of Distress

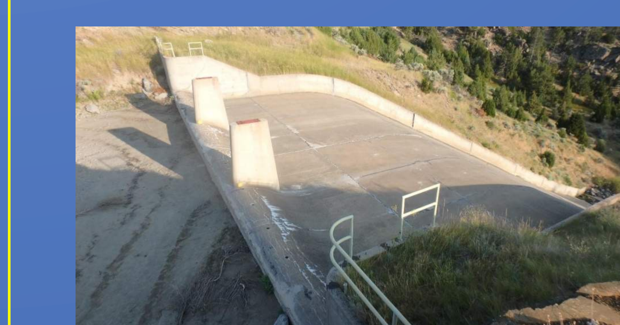
Backwall Being Cored

Extracted Core

Magnification of Core from Petrographic Examination Showing ASR Gel

Willow Creek Dam Spillway

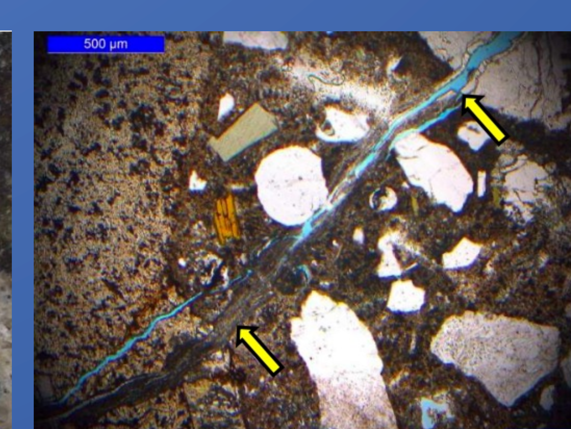
- Spillway showed signs of distress
- Cores evaluated via Petrographic Analysis
- Cores determined to have varying degrees of damage associated with ASR



Ogee of Dam

Sidewall

Core from Chute Showing ASR Gel Deposits

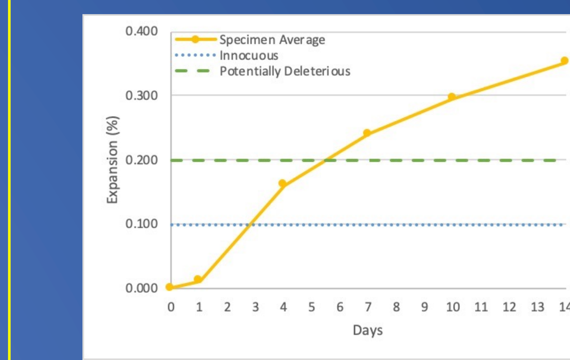


Core from Ogee Showing ASR Gel Deposits

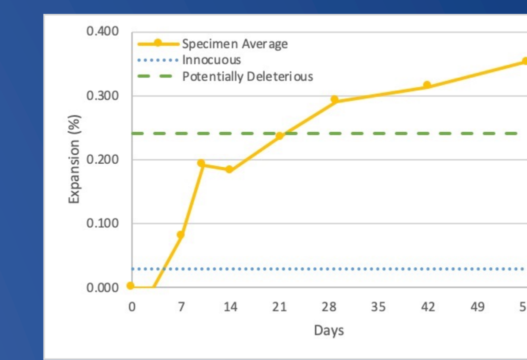
Aggregate Testing

Experimental Design

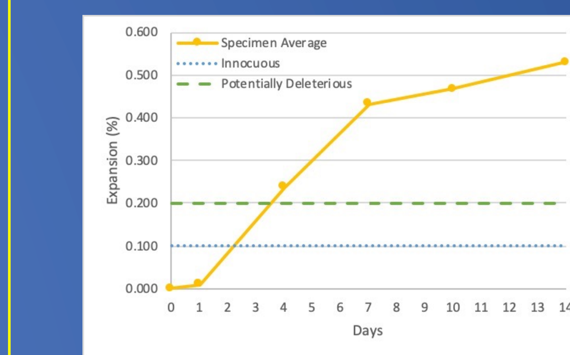
- Tested Aggregates using ASTM C1260 and AASHTO T380
- 4 Fine and 4 Coarse Aggregate Sources in MT
- All Reactive to Various Degrees



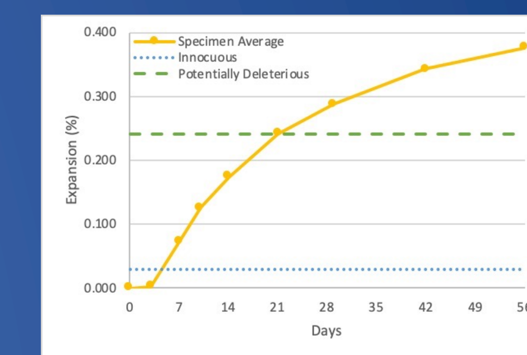
Mix F-1: ASTM C1260 Average



Mix F-1: AASHTO T380 Average



Mix F-2: ASTM C1260 Average



Mix F-2: AASHTO T380 Average

Mix ID	Location	ASTM C1260, 14 Days		AASHTO T380, 56 Days	
		Expansion (%)	Degree of Reactivity	Expansion (%)	Degree of Reactivity
F-1	Helena Sand & Gravel - Lake Helena Drive Pit	0.351	Reactive	0.352	Very Highly Reactive
F-2	Knife River Billings - Sindelar Pit	0.529	Reactive	0.376	Very Highly Reactive
F-3	Knife River Billings - Sindelar Pit	0.568	Reactive	0.419	Very Highly Reactive
F-4	Knife River Missoula - Allen Pit	0.347	Reactive	0.364	Very Highly Reactive
C-1	Helena Sand & Gravel - Lake Helena Drive Pit	0.036	Innocuous	0.056	Moderate Reactive
C-2	Knife River Billings - Sindelar Pit	0.333	Reactive	0.143	Highly Reactive
C-3	Knife River Billings - Sindelar Pit	0.324	Reactive	0.147	Highly Reactive
C-4	Knife River Missoula - Allen Pit	0.076	Innocuous	0.157	Highly Reactive

Overall Conclusions

- All of the states and provinces investigated in this research (sans North Dakota) directly address ASR in their material specifications, to varying degrees. The FHWA defers to individual states to determine ASR practices, while the FAA has fairly stringent specifications.
- ASR Damage was found in the 3 sites investigated in this research.
- All of the tested aggregates showed some reactivity (either with ASTMC 1260 or AASHTO T380).
- Overall, while there is not an overwhelming amount of evidence of ASR being a major problem in Montana, this research clearly demonstrated the potential for deleterious ASR in the state.

Recommendations

- MDT should not use the Los Alamos Staining method for determining the presence/severity of ASR in existing concrete. This methodology was found to be highly subjective, with inconclusive results.
- MDT should consider adopting the AASHTO T380 - miniature concrete prism test for aggregate testing when applicable. Previous research has clearly demonstrated the added benefits of this methodology; it provides more accurate, less conservative results than the ASTM C1260 methodology, in significantly less time than the ASTM C1293 methodology. Further, the miniature concrete prism test can be conducted with the same equipment used for the C1260 (less the forms), requiring a small upfront commitment to make the change.
- The current practice in Montana (limiting the alkalis in cement) seems appropriate/effective for mitigating ASR in Montana and should be continued. It should be noted that the current cement alkali loading limits prescribed by MDT are similar to the limits prescribed for Prevention Level X by AASHTO R80 (Standard Practice for Determining the Reactivity of Concrete Aggregates and Selecting Appropriate Measures for Preventing Deleterious Expansion in New Concrete Construction). However, if the availability of low alkali cements becomes problematic MDT should revisit this approach and consider adopting the methodology prescribed by AASHTO R80 or at least some aspects of this methodology (e.g., prescriptive total alkali loading limits).