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Implementing AASHTO TP 110 for Alkali-Silica Reaction Potential Evaluation of Idaho Aggregates

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Abstract

The reaction between the active silica constituents of aggregates and alkalis in cement in the presence of moisture is called Alkali-Silica Reaction (ASR). ASR forms a swelling gel which can expand and cause internal stresses in cementitious materials leading to cracking, loss of strength, and eventually failure. The primary objective of this research study is to evaluate the advantages associated with implementing the new test method AASHTO TP-110 to better characterize the ASR potential of Idaho aggregates. Total of 8 identified aggregate types will be tested. The sources of those aggregate types are across Idaho with different degrees of ASR potential.

Implementing AASHTO TP 110 for Alkali-Silica Reaction Potential Evaluation of Idaho Aggregates

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1. INTRODUCTION

- **The Alkali-Silica reaction (ASR)** is a destructive chemical reaction that occurs between the active silica SiO_2 constituents (reactive minerals) of aggregate and alkalis (Sodium-Na and Potassium-K) in the cement and other pozzolanic materials causing a definite expansion in the presence of moisture or a pore solution of concrete.
- ASR forms a swelling gel, which can expand and cause internal stresses in cementitious materials leading to cracking, loss of strength, and eventually failure of concrete or concrete structures.
- Three essential conditions are necessary to create ASR-induced damage in concrete structures:
  - Presence of reactive siliceous components in aggregates
  - Sufficient availability of OH^- ions and alkalis (Na^+ and/or K^+)
  - Sufficient moisture (above 75% RH).

2. OBJECTIVE

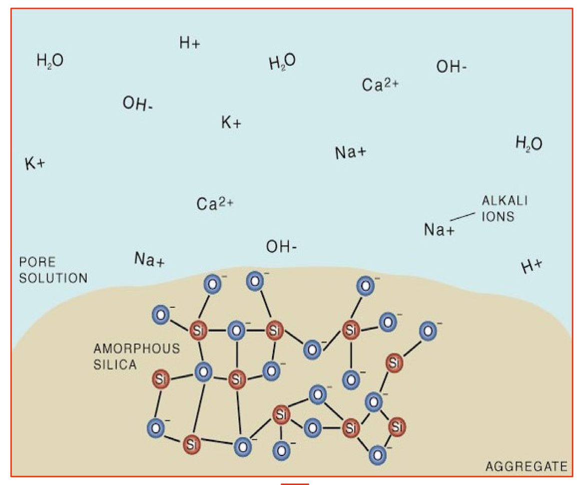
- Evaluate advantages (as compared to other test methods) associated with implementing AASHTO TP-110, a new test method to evaluate aggregate susceptibility to ASR within ITD specifications to better characterize the ASR potential of Idaho aggregates.
- The baseline ASR susceptibility for Idaho aggregates will be established. ASR potentials quantified through the **AASHTO TP-110 procedure (MCPT)** will be evaluated in light of ASTM C1293 and ASTM C 1260 (AASHTO T 303) test results.

3. ASR IN IDAHO AGGREGATES

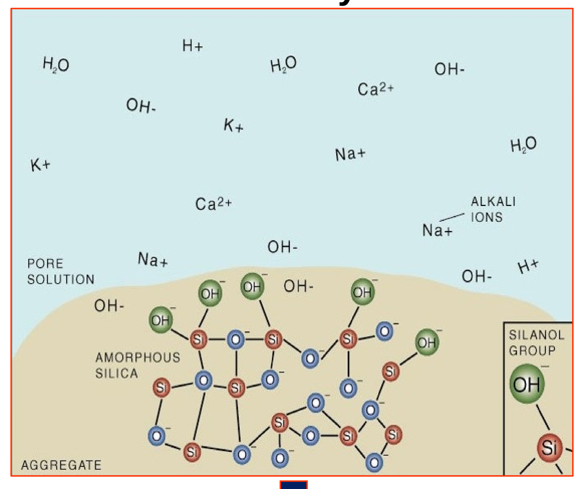
- Results from Idaho Transportation Department (ITD) research project RP 212 confirmed 80% of the aggregates used in Idaho are reactive, or highly reactive.
- The primary bases for determining the reactivity of Idaho aggregate are still ASSHTO T 303 or ASTM C 1260 and ASTM C 1293.
- According to RP 212, a very limited number of Idaho aggregate sources passed the ASTM C1260 test. Meanwhile, several aggregates that failed in ASTM C1260 passed the one-year ASTM C1293 test (Gillerman and Weppner, 2014).
- **ASTM C 1260 gives false negative and false positive results** for different aggregate samples of Idaho.

4. CHEMICAL REACTIONS INVOLVED IN ASR

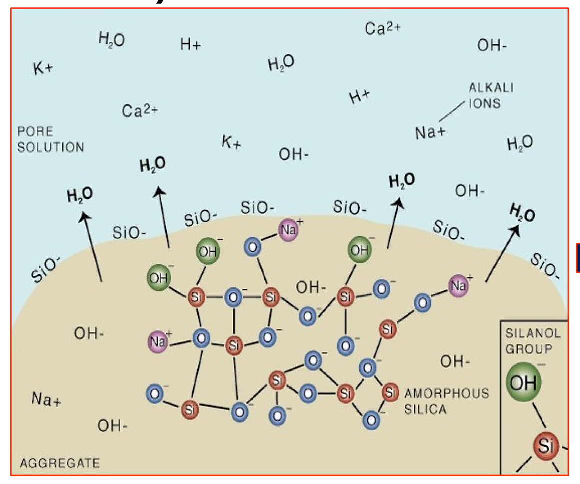
Siliceous aggregates get in contact with the solution



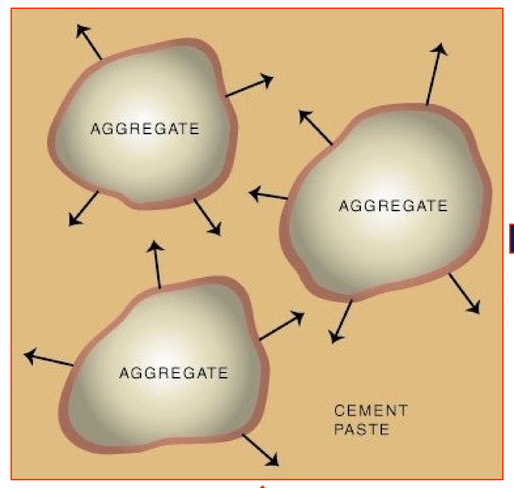
Surface of Aggregate Attacked by OH^-



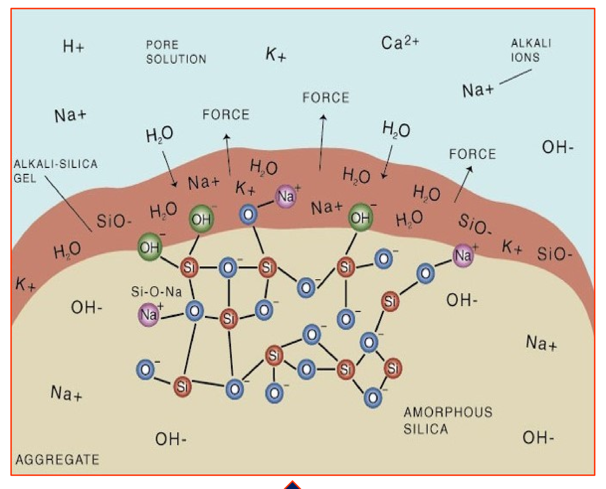
OH^- breakdown Silanol Groups (Si-OH) into SiO^- Molecules



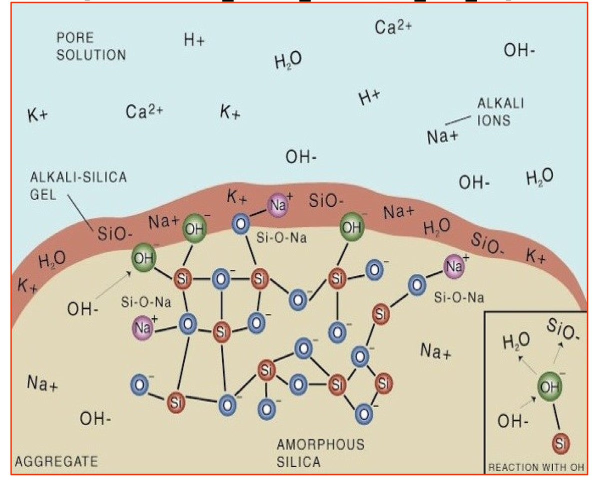
Expansion Pressure Exceeds the Tensile Strength of the Concrete



Expansion of Alkali-Silica Gel



Formation of Alkali-Silica Gel (CaO-Na_2O/K_2O-SiO_2-H_2O)



Map Cracking in Concrete

Once ASR damage has begun, expansion continues which leads to further cracking

Increased cracking leads to increased permeability of the concrete

Ingress of water into the concrete increases the alkali content, and therefore the ASR

5. MINIATURE CONCRETE PRISM TEST (MCPT)

- The new test method **Miniature Concrete Prism Test (MCPT)** was developed at Clemson University in 2013. It was developed **as an alternative** to the existing standard test methods such as ASTM C1260 and ASTM C1293 to evaluate aggregate **ASR** reactivity.

MCPT

Test duration: 8 weeks (56 days) or 12 weeks(84 days) for slow reactive aggregates	Test Temperature 60.0 ± 1.7°C (140 ± 3°F)
Maximum coarse aggregate size 12.5 mm (½ in.). Volume fraction coarse aggregate in concrete: 65%	Non-Reactive: If expansion <0.030% at 56 days. Reactive : If expansion > 0.040% at 56 days.

6. CORRELATION OF MCPT WITH AMBT AND CPT

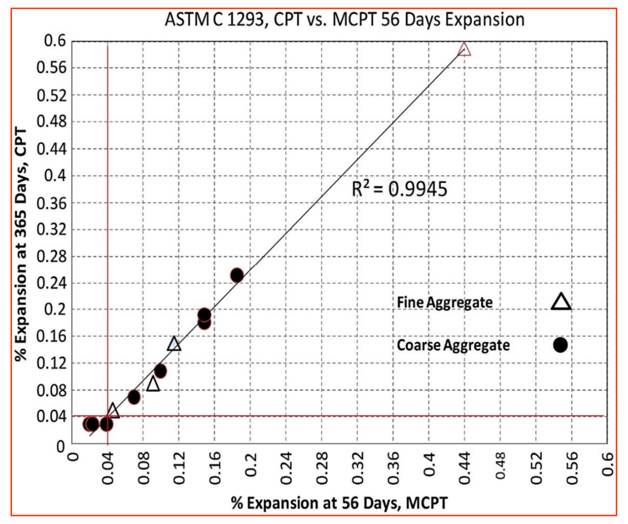
- During the development of MCPT, a total 33 aggregates sample were tested (19 coarse aggregate and 14 fine aggregates).
- Correlation of MCPT with AMBT and CPT are developed based on the results found for the selected aggregates.

Expansion Data for Selected Aggregates Determined using Different Test Methods

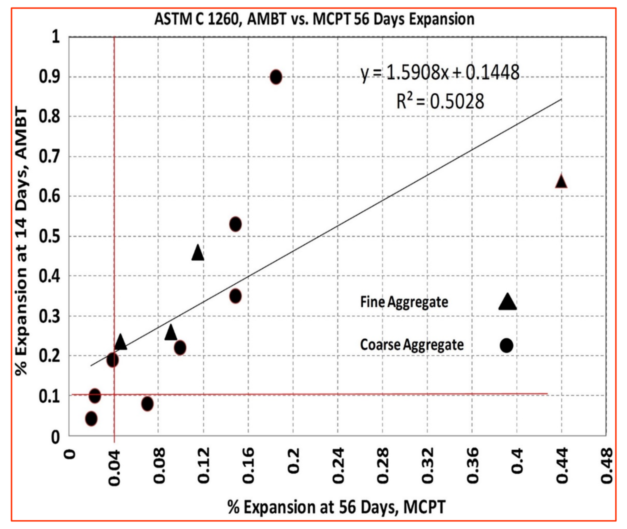
Aggregate Identity	%Expansion			Average % rate of expansion (8 to 12 weeks)	Field Experience
	MCPT 56 days (CV %)	ASTM C1293 (ASTM 2007a) 365 days	ASTM C 1260 (ASTM 2007b) 14 days		
SP	0.149 (4.08)	0.181	0.350	0.0152	Reactive
SD	0.099 (4.97)	0.109	0.220	0.0043	Reactive
NM	0.185 (3.43)	0.251	0.900	0.0231	Reactive
NC	0.149 (1.16)	0.192	0.530	0.0092	Reactive
BB	0.017 (8.81)	0.032	0.042	0.0047	Innocuous
GLN	0.046 (4.34)	0.050	0.235	0.0122	Reactive
QP	0.070 (3.01)	0.070	0.080	0.0193	Reactive
SLC	0.039 (8.31)	0.030	0.190	0.0102	Low
MSP	0.023 (2.47)	0.030	0.100	0.0070	Innocuous
TX	0.440 (4.21)	0.590	0.640	0.0250	Reactive
GI	0.091 (9.93)	0.090	0.260	0.0288	Reactive
SB	0.115 (9.83)	0.150	0.460	0.0320	Reactive

Proposed Criteria for Characterizing the Aggregate Reactivity in the MCPT Protocol

Degree of Reactivity	Expansion at 56 Days, % (8 Weeks)	Average 2-Week Rate of Expansion from 8 to 12 Weeks
Non-reactive	< 0.030	N/A
Non-reactive	0.031-0.040	<0.010% per 2 weeks
Low/Slow reactive	0.031-0.040	>0.010% per 2 weeks
Moderately reactive	0.041-0.120	N/A
Highly reactive	0.121-0.240	N/A
Very highly reactive	>0.240	N/A



Correlation between the 56-Day MCPT Data and the 365-Day CPT Data



Correlation between 56-Day MCPT Data and the 14-Day AMBT Data

7. IDENTIFIED AGGREGATE MATERIALS

- A total of 8 aggregate materials have been identified. Both coarse and fine parts will be tested for each aggregate type. Currently, twelve test set-ups are operating in our lab to expedite the total testing time required. The expected test completion date of our first aggregate is July 1st , 2019.
- Several AMBT (AASHTO T-303) tests were run on different aggregates to identify the non reactive reference aggregate types

AASHTO T-303 Test Results of Reference Aggregates

Name	Expansion at 16 Days, (%)	Reactivity (max expansion allowed 0.10%)
Wn 56	0.616	Reactive
Dolomite	0.187	Reactive
Quartz	0.198	Reactive
Lemhi	0.381	Reactive
Granite L1	0.075	Non-reactive
Granite L2	0.009	Non-reactive

AASHTO T-303 Test Results of Identified Aggregates Sample

Name	Expansion at 16 Days, (%)	Reactivity (max expansion allowed 0.10%)
EL 116c	0.50-0.59	Reactive
ORE 8c	0.50-0.59	Reactive
MD 45c	0.50-0.59	Reactive
BG 111c	0.10-0.19	Reactive
BN 155c	0.30-0.39	Reactive
Ma 22c	>0.70	Reactive
LN 80c	0.40-0.49	Reactive
WN 56c	0.61	Reactive

8. SUMMARY

- Implementing the MCPT test method into Idaho practice and mitigation of ASR reactivity will help increase the longevity of concrete structures.

References:
1. AASHTO, TP 110-14. 2014. "Standard Method of Test for Potential Alkali Reactivity of Aggregates and Effectiveness of ASR Mitigation Measures (Miniature Concrete Prism Test, MCPT)". American Association of State Highway and Transportation Officials (AASHTO), Washington, DC, USA. https://www.transportation.org/
2. Gillerman V. S., and Weppner K. N. (2014), Lithologic Characterization of Active ITD Aggregate Sources and Implications for Aggregate, Idaho Geological Survey, University of Idaho, Moscow, Idaho
3. Latifee, E. R., & Rangaraju, P. R. (2014). Miniature concrete prism test: rapid test method for evaluating alkali-silica reactivity of aggregates. Journal of Materials in Civil Engineering, 27(7), 04014215.