KAUFMAN

PRODUCT INFORMATION

KAUFMAN PRODUCTS INC. 3811 CURTIS AVENUE BALTIMORE, MARYLAND 21226-1131 410-354-8600 800-637-6372 www.kaufmanproducts.net

Susceptibility of Kaufman Products to Alkali – Silica Reaction (ASR) Overview

ASR is a potentially destructive force in mature concrete caused by internal expansion that results in cracking. The chemistry is complicated with the presence of numerous mineral structures. There can be many co-existing crystalline species present in various concentrations that can influence the extent that ASR can occur. Essentially, it is caused by hydroxyl ions (OH^-) made available within the pore structure under high alkali conditions, chemically combining with reactive silica based aggregates in the presence of water to form an expansive ASR gel. *All three species must be present for ASR to occur.*

The available alkali source may be Portland cement, slag, fly ash, silica fume and / or other admixtures present. Reactive silica based aggregates are defined as those which can be broken down in highly alkaline conditions. There are four types if siliceous minerals that are known to contribute to ASR under certain conditions. They are Cristobalite (from Arenite), microcrystalline quartz opal (from Argillite), strained quartz tridymite (from Arkose), and volcanic glass (from Chert).

Non-reactive siliceous minerals include Flint, Gneiss, Granite, Greywacke, Hornfels, Quartz-Arenite, Quartzite, Sandstone, Shale, Silicified Carbonate, and Siltstone.

Kaufman Products sources our silica sands from quarries that do not contain potentially detrimental amounts of reactive silica.

A report from the Federal Highway Administration provides an excellent discussion of ASR:

http://www.fhwa.dot.gov/publications/research/infrastructure/pavements/pccp/06073/chapt2.cfm

Relevant excerpts from the report are below. Of particular interest is ASTM C1293, which is used to determine whether a particular aggregate is capable of contributing to the creation of an ASR gel and is a preferred test method over ASTM C227 as stated in Table 2:

Test Method	Comments
ASTM C 227: Standard Test Method for Potential Alkali Reactivity of Cement-	• Mortar bar test (aggregate/cement = 2.25), intended to study cement-aggregate combinations.

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Test Method	Comments
Aggregate Combinations (Mortar Bar Method)	• Specimens stored in high-humidity containers at 38 °C. • **Several reported problems with test, including excessive leaching of alkalis from specimens and its unreliable correlation to field performance.**

A year-long testing period per ASTM C1293 is generally considered the definitive result, as opposed to the shorter term screening test method, ASTM C1260. To quote the FHWA report, Section 2.3:

"ASTM C 1293, commonly referred to as the concrete prism test (CPT), is generally considered the most accurate and effective test in predicting the field performance of aggregates. In this test, concrete is cast with a cement content of 420 kg/m^3. The cement is required to have an equivalent alkali content between 0.8 percent and 1.0 percent, and additional alkalis (NaOH) are then added to the mixing water to obtain a total alkali content of 1.25 percent (by mass of cement), which equates to a total alkali content in the concrete mixture of 5.25 kg/m^3. Concrete prisms are cast, cured for 24 hours at 23 °C, and then stored enclosed over water at 38 °C. Expansion measurements are taken at regular intervals, and when testing plain concrete (without SCMs or chemical admixtures), the test typically is run for 1 year. When testing SCMs or lithium compounds, the test typically is carried out for 2 years. This relatively long period for conducting ASTM C 1293, either 1 or 2 years, has been the major drawback for the test and has somewhat limited its use."

"In recent years, more countries and agencies have adopted the CPT as a standard method. An expansion limit of 0.04 percent (at the end of the 1- or 2-year test) is typically specified because this value has been reported to correlate well with the cracking of test prisms. This expansion limit (0.04 percent) is referenced in the appendix to ASTM C 1293. In a few rare cases, ASR has been evident as cracks, extruding gel, and spalls (or popouts) in test prisms that have expansions greater than 0.04 percent (Whiting 1999). Noting the appearance of the test prism is part of the test procedure recommended by ASTM C 1293. As part of the most recent guidance provided by CSA (2000a), the expansion limits for the CPT (CSA A23.2-14A) were delineated further to assess aggregate reactivity as follows:

CSA A23.2-14A expansion criteria:

- *< 0.04 percent is considered nonreactive.*
- *0.04 percent to 0.12 percent is considered moderately reactive.*
- *0.12 percent is considered highly reactive."*

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The sand grade used by Kaufman Products, which is on the PENN-DOT Bulletin 14 approved materials list, has an expansion of 0.021% per ASTM C1293. This is half the expansion considered to be at the threshold of being a mildly reactive aggregate.

Excerpting from the FWHA report again, an effective means to prevent ASR is to use a non-reactive aggregate:

"*2.4 METHODS OF MITIGATING ASR*

This section briefly describes common methods of mitigating or preventing ASR in new and existing concrete structures. The main focus is on minimizing ASR expansion in new concrete, with less emphasis on methods of extending the service life of structures already affected by ASR.

2.4.1 Minimizing or Preventing ASR in New Concrete

The most common methods of minimizing the risk of expansion resulting from ASR are discussed next, including:

- *Using nonreactive aggregates.*
- *Limiting the alkali content of concrete.*
- *Using supplementary cementing materials.*
- *Using lithium compounds.*

Using Nonreactive Aggregates

Using nonreactive aggregates is certainly a viable method of preventing ASR-induced damage. However, to use this approach, one must have a very high level of confidence that the subject aggregates to be used are, in fact, nonreactive. To confirm nonreactivity, the aggregates must be tested strictly (e.g., using ASTM C 1260 and ASTM C 1293), good quality control ensured, and, preferably, field performance well-documented. ***If the above conditions are met, such aggregates may be used without special precautions.*** *However, given that these conditions often are not met, and given that some aggregates that were believed to be nonreactive (based on testing methodologies available at the time of construction) have caused damaging ASR expansion in field structures, further precautions should be taken in some situations. Instances that warrant such extra caution, even when using aggregates believed to be nonreactive, include the design of critical structures (e.g., prestigious structures or those with an extended design life) and the construction of structural elements exposed to a very aggressive environment (e.g., structures exposed to seawater or deicing salts, which may provide an external source of alkalis). The use of a suitable SCM is an example of taking special precautions with aggregates presumed to be nonreactive."*

Conclusions:

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- **Kaufman Products does not use any admixtures which will increase the alkalinity of the pore structure, nor use any reactive aggregates, thus mitigating any potential for future ASR problems.**
- **All sand and cement Kaufman Products exceed the requirements for Alkali-Silica Reactivity based on the most reliable and recommended test method for ASR as determined by the U.S. Federal Highway Administration, specifically ASTM C1293.**
- **All sand and cement Kaufman Products, having exceeded the requirements in the year-long test, ASTM C1293, will also meet or exceed the ASR requirements in ASTM C227 and ASTM C1260, which are short-term accelerated screening tests for ASR.**

Appendix A: Comparison of test methods used for evaluating Alkali-Silica Reactivity (from FWHA report):

Table 2. Available Standard Tests for Assessing Alkali-Silica Reactivity.

Test Method	Comments
ASTM C 227: Standard Test Method for Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar Bar Method)	• Mortar bar test (aggregate/cement = 2.25), intended to study cement-aggregate combinations. • Specimens stored in high-humidity containers at 38 ℃. • Several reported problems with test, including excessive leaching of alkalis from specimens and its unreliable correlation to field performance.
ASTM C 289: Standard Test Method for Potential Alkali-Silica Reactivity of Aggregates (Chemical Method)	• Aggregate test in which crushed aggregate is immersed in 1M NaOH solution for 24 hours-solution is then analyzed for amount of dissolved silica and alkalinity. • Poor reliability. • Problems with test include: ○ Other phases present in aggregate may affect dissolution of silica (Bérubé and Fournier, 1992). ○ Test is overly severe, leading aggregates with good field performance to fail the test. ○ Some reactive phases may be lost during

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Table 2. Available Standard Tests for Assessing Alkali-Silica Reactivity.

Test Method	Comments
	pretest processing.
ASTM C 295: Standard Guide for Petrographic Examination of Aggregates for Concrete	• Useful evaluation to identify many (but not all) potentially reactive components in aggregates. • Reliability of examination depends on experience and skill of individual petrographer. • Results should not be used exclusively to accept or reject aggregate source-findings best used in conjunction with other laboratory tests (e.g., ASTM C 1260 and/or ASTM C 1293).
ASTM C 856: Practice for Petrographic Analysis of Hardened Concrete	• Useful for analyzing concrete (from laboratory or field) and for identifying presence of reactive aggregates or reaction products. • Reliability of examination depends on experience and skill of individual petrographer. • Essential for relating aggregate reactivity to field performance.

Table 2. Available Standard Tests for Assessing Alkali-Silica Reactivity (cont.).

Test Method	Comments
ASTM C441: Standard Test Method for Effectiveness of Mineral Admixtures or Ground Blast-Furnace Slag in Preventing Excessive Expansion of Concrete Due to the Alkali-Silica Reaction	• Mortar bar test, intended to assess effectiveness of SCMs in reducing ASR expansion. • Test uses high-alkali cement and Pyrex™ glass. • Test not very reliable because of the use of Pyrex glass, which is sensitive to test conditions and contains alkalis that may be released during the test. Test does not correlate well with data from concrete mixtures containing natural aggregates (Bérubé and Duchesne, 1992).

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Table 2. Available Standard Tests for Assessing Alkali-Silica Reactivity.	
Test Method	**Comments**
ASTM C 1260: Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method) • **Recommended Test**	• Mortar bar test, originally designed to assess aggregate reactivity. • Bars are soaked in 1N NaOH solution for 14 days. • Accelerated test suitable as screening test, but because of the severity of the test, it should not be used, by itself, to reject a given aggregate. If aggregate is tested using both ASTM C 1260 and ASTM C 1293, the results of ASTM C 1293 should govern. • Modified method (ASTM C 1567) has been used with success to evaluate effectiveness of SCMs to control ASR expansion (Thomas, et al., 2005). • Effectiveness of the method for testing lithium compounds has also been evaluated by adding lithium to the bar and/or soak solution; limited success to date (chapter 3).
ASTM C 1293: Standard Test Method for Concrete Aggregates by Determination of Length Change of Concrete Due to Alkali-Silica Reaction • **Recommended Test**	• Concrete prism test, generally regarded as best indicator of field performance, is conducted at high humidity (close to 100 percent) at 38 °C. • Uses high-alkali cement (raised to 1.25 percent Na_20_e), with a cement content of 420 kg/m^3. • Originally intended as aggregate test (using nonreactive fine aggregate to test reactivity of coarse aggregate, and vice-versa); test can also be used to evaluate potential alkali-reactivity of job combinations of fine and coarse aggregates. • Test requires 1 year for completion. • Also can be used to test effectiveness of SCMs and lithium compounds, but test is then typically run for 2 years. • Widely accepted test method; however, long duration of test is major drawback.

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Appendix B: PENN-DOT Bulletin 14 listing

PENN-DOT Bulletin 14 Whibco, Inc.

Attribute	Product 1	Product 2
Supplier Name	Whibco, Inc.	Whibco, Inc.
Supplier Code	WHINJA14	WHINJB14
Material Code	207	207
Material Class	A	A
Location	PORT ELIZABETH	PORT ELIZABETH #2
Status	Approved	Approved
Approval Date	3/27/2014	3/27/2014
Primary Address	Whibco, Inc. 87 East Commerce St. Bridgeton, NJ 08302	Whibco, Inc. 87 East Commerce St. Bridgeton, NJ 08302
Physical Address		
Phone Number	(609) 455-9200	(609) 455-9200
Fax Number		
Lab Number	L14036042	L14036043
Restrictions		
Specific Gravity	2.63	2.64
Bulk Specific Gravity	2.627	2.638
Absorption	0.28	0.2
Sodium Sulfate Soundness	2%	1%
Alkali-Silica Reactivity (ASR) AASHTO T303		0.07
Alkali-Silica Reactivity (ASR) ASTM C 1293	0.021	
Uncompacted Voids	40	40
Sand Equivalency		
Rock Compositions & Order Of Abundance	QS (Quartz Sand): 1	QS (Quartz Sand): 1
Skid Resistance Level Type		
Los Angeles Abrasion		
Micro-Deval Loss		
Crush Count % 1-Face		
Crush Count % 2-Face		
Thin & Elongated Pieces (5:1)		