Better Cement. **Better Concrete**

Technical Report

V.04-13

CERATECH™ Cement Concrete Demonstrates Inherent Resistance to ASR

Applies to ekkomaxx™, KEMROK™ & FIREROK™

Background

Alkali Silica Reaction (ASR) is found in concrete manufactured with portland cements. There are three conditions required for ASR to occur:

- Sufficiently high alkali content of the cement (or alkali from other sources.)
- Reactive aggregate, such as chert or a highly siliceous aggregate.
- The presence of water or high levels of moisture.

In conventional concrete, the use of pozzolan as a partial cement replacement can reduce the likelihood of ASR occurring as the pozzolan reduces the alkalinity of the pore fluid.

CERATECH™ cements are 95% fly ash and offer inherent barriers, chemically and structurally. Deleterious ASR can not occur as the reaction products are harmlessly distributed, the gels that form do not swell and the CERATECH™ cements have an inherently low water to cement ratio that limits the matrix permeability (which consequently limits the availability of internal moisture).

Test program

The University of Texas, Concrete Durability Center conducted tests on CERATECH™ cement with a coarse aggregate (low to non-reactive) from Martin Marietta Materials, and three fine aggregates (low to highly reactive). The fine aggregates used in this evaluation are identified as:

1. A low reactive aggregate; source - Fordyce
2. A moderately reactive aggregate; source - Wright
3. A highly reactive aggregate; source - Jobe

In addition to the three fine aggregates, the main fly ash source of the cement was varied. This was done to determine if the levels of alkali available from the CERATECH™ cement were influential. With these two fly ash sources, different levels of retarder were needed due to the reactivity of each. In all, six (6) test configurations were conducted.

Testing was conducted in accordance with ASTM C1293, “Standard Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction” with modifications. This test method covers the determination of the susceptibility of an aggregate, or combination of an aggregate, with fly ash or slag with cement for participation in expansive alkali-silica reaction by measurement of length change of concrete prisms. In these tests, the cement used was CERATECH™ cement.

The two (2) modifications to this test method were 1) the extension of time before the start of the exposure of the concrete and 2) the W/C ratio was adjusted to meet the requirements of the cement.

The samples were aged seven (7) days prior to start of exposure. This was done to allow the concrete time to mature and consume the alkali that is normally available in CERATECH™ cement at early ages. CERATECH™ cements have higher levels of alkali available initially, a by product of their activation/hydration system. These alkalis are quickly consumed in chemical reaction and are not available for later reaction with the aggregates.

Water requirements of CERATECH™ cement concrete are drastically lower than the requirement for portland cement concrete. The W/C ratios are shown on page 2 in *Table 1*.

Test results

Concretes were batched as indicated in *Table 1* below. Specimens were cast for compressive strength determinations at one (1), seven (7) and twenty-eight (28) days of age for each mixture. Additionally, enough prisms were cast for exposure at both 100ºF / 38ºC, and 140ºF / 60 ºC. A summary of strength development is found in *Table 1*.

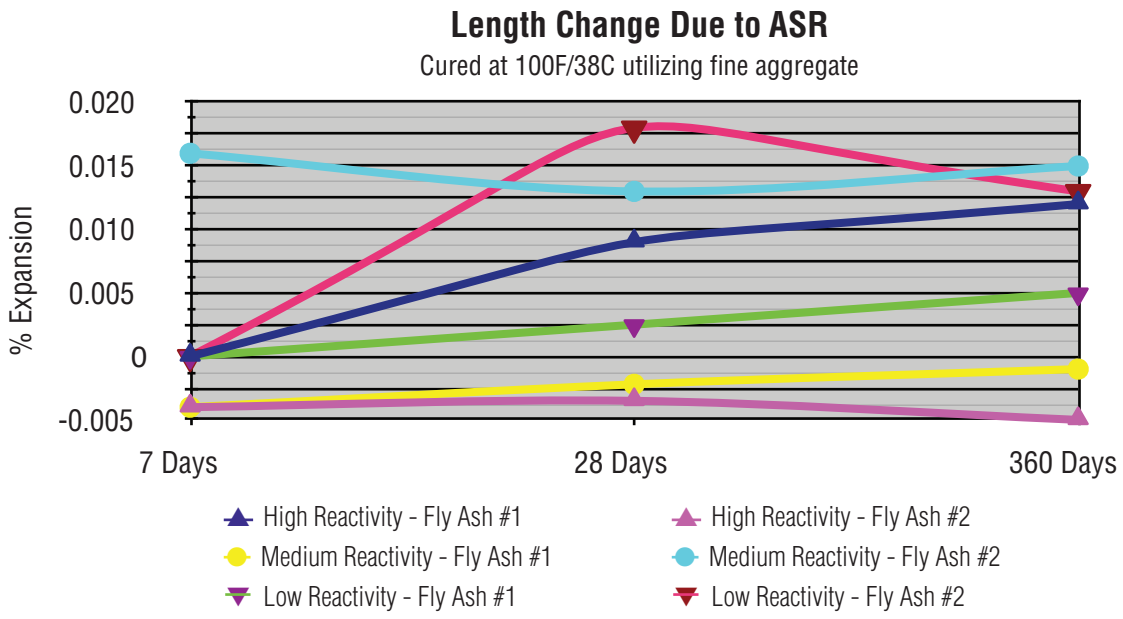
The length change over time, for up to one year, are found in graphs 1 and 2 for the two curing temperatures.

TABLE 1

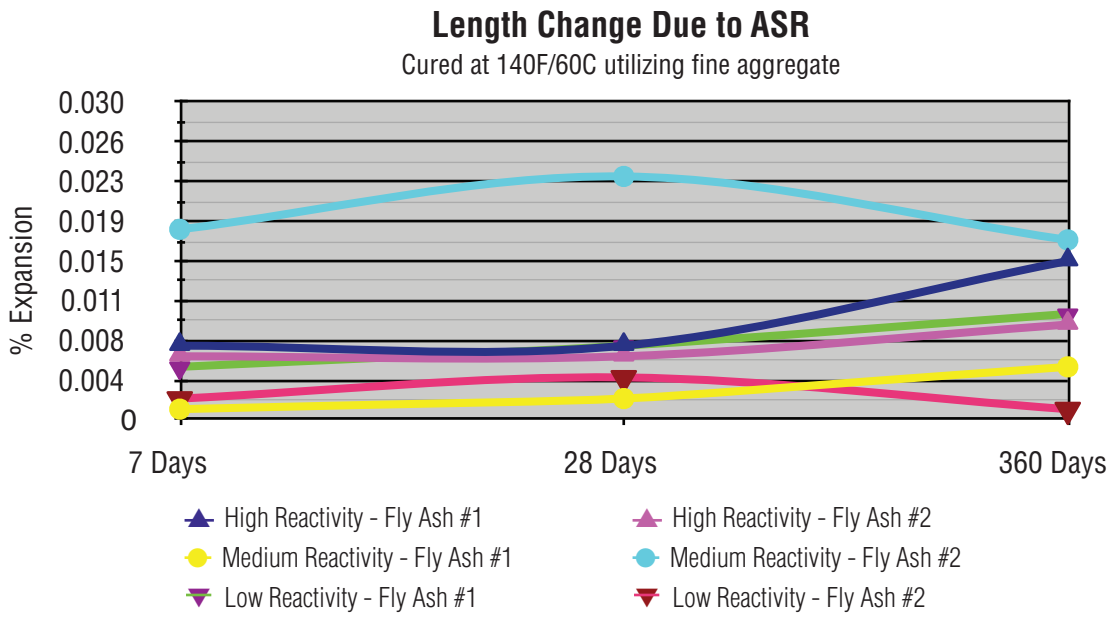
Fly Ash Source 1	Sand Type / Reactivity	Stone Type / Reactivity	Actual W/C Ratio	Compressive strength (psi)		
				1 Day	7 Days	28 Days
Mix ID 3	Jobe / High	Martin Marietta / No	0.19	3230	5230	6560
Mix ID 6	Wright / Mid	Martin Marietta / No	0.16	2430	4020	4610
Mix ID 9	Fordyce/ Low	Martin Marietta / No	0.18	3020	4740	5540

Fly Ash Source 2	Sand Type / Reactivity	Stone Type / Reactivity	Actual W/C Ratio	Compressive strength (psi)		
				1 Day	7 Days	28 Days
Mix ID 12	Jobe / High	Martin Marietta / No	0.19	2330	3870	4650
Mix ID 15	Wright / Mid	Martin Marietta / No	0.16	3100	4710	5700
Mix ID 18	Fordyce/ Low	Martin Marietta / No	0.19	2700	4310	4540

GRAPH 1



GRAPH 2



Conclusions

Despite what appears to be a minor outlier (data point) the data is very consistent and indicates stability of the concrete over the course of a year. Any expansion of samples with highly reactive sands, was generally within the same range as the low reactive sand / aggregate mixtures. With no additional additives or treatments, CERATECH™ cement effectively mitigates expansive Alkali-Silica reactions. When tested at 100ºF (38ºC) expansion is constrained to well below 0.02%. Even at 140ºF (60º C), the expansion can be controlled to 0.02% or below in most cases.

The data conclusively shows that the alkali present (from the activator) within CERATECH™ cements are consumed and prevented from reaction with the aggregates through both a chemical reaction and the very low to low permeability of the matrix.