Technical Bulletin

Inhibiting ASR with Lithium Admixtures

Synopsis

MasterLife® ASR 30 lithium nitrate-based liquid admixture is formulated for use in concrete containing reactive aggregates to inhibit and control Alkali-Silica Reaction (ASR).

ASR Background

ASR is a general term that describes the two-step reaction between alkalis (sodium and potassium) in concrete and aggregates containing reactive silica. The first step is the chemical reaction between the reactive silica in the aggregate with the alkali present in concrete to produce an alkali-silica gel.

Reactive Silica in Aggregate $[xSiO_2]$	+	Alkali in Concrete $[yNa(K)OH]$	→	Alkali-Silica Gel $[Na(K)_ySi_xO_z.aq]$

The second step is the expansion of the alkali-silica gel when it comes in contact with moisture.

Alkali-Silica Gel $[Na(K)_ySi_xO_z.aq]$	+	Moisture $[H_20]$	→	Expanded Alkali-Silica Gel $[Na(K)_ySi_xO_z.wH_20]$

The expansion and swelling of the gel creates internal pressures within the concrete. Visible symptoms of ASR include expansion-induced map cracking. Due to restraining conditions, longitudinal cracking can occur on bridge columns, beams and highway pavements. ASR may also cause localized pop-outs and extrusions of the gel product on the surface of the concrete.

The ASR-induced cracking results in a decrease in strength and an increase in permeability that increases the susceptibility of the concrete structure to subsequent damage from processes such as freezing and thawing, corrosion of the reinforcing steel, and sulfate attack. The overall effect is reduced structural integrity and shortened service life.

The consequences of ASR often take years to become visible. However, in some cases, the initial appearance of cracking can be observed only weeks after construction.

Figure 1. ASR-Induced Map Cracking in Pavement

Reactive Aggregates

Many different types of aggregates have been involved with ASR. All of these contain silicon dioxide (SiO_2). Rapidly reactive aggregates are rocks containing glass, finely crystalline quartz (chalcedony and chert), and opal. More slowly reactive aggregates are metamorphic rocks containing strained and microcracked quartz, including some graywackes, quartzites, and phyllites.

ASTM C 1778 Standard Guide for Reducing the Risk of Deleterious Alkali Silica Reactivity in Concrete provides guidance on how to address the potential for deleterious alkali silica reaction in concrete construction. Common tests to evaluate whether aggregates or cement/aggregate combinations are potentially reactive are petrographic examination as described in ASTM C 295, the mortar-bar expansion test described in ASTM C 227, the accelerated mortar-bar expansion test as described in ASTM C 1260, the quick chemical method as described in ASTM C 289, and the concrete prism test as described in ASTM C 1293.

However, ASTM C 1260 and ASTM C 1293 are the only two test methods recommended as suitable laboratory procedures for assessing ASR in FHWA-RD-03-047, "Guidelines for the Use of Lithium to Mitigate ASR." A modification of ASTM C 1260 is required when lithium admixtures are evaluated to prevent excessive leaching of lithium from the mortar bars into the soak solution. The modification consists of the addition of lithium to the 1 N NaOH soak solution to achieve the same lithium-alkali ratio as that used in the mortar admixture. The procedure for evaluating the efficacy of lithium admixtures is provided in the Corps of Engineers test method CRD C 662 "Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials, Lithium Nitrate Admixture and Aggregate (Accelerated Mortar-Bar Method)."

Alternative ASR Mitigation and Control

Traditional methods of mitigating ASR in concrete include the use of low alkali cement and non-reactive aggregates and can be a burden on the concrete producer. Both are becoming more difficult to find and/or manufacture, and may result in additional transportation costs. Alternatively, supplementary cementitious materials such as Class F fly ash, silica fume, metakaolin or slag cement have been added to concrete to combat ASR with varying degrees of success.

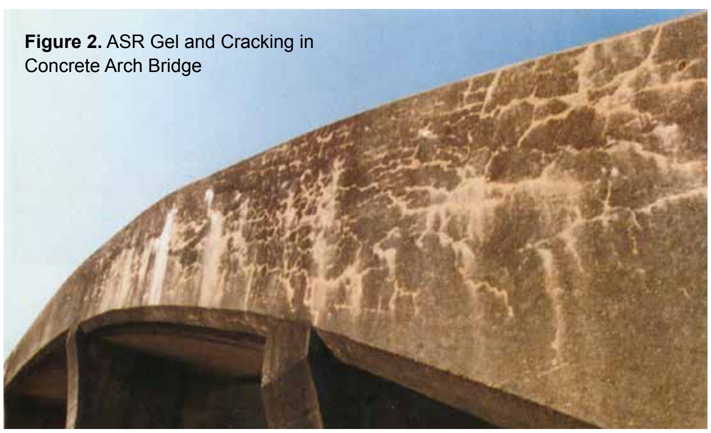

Figure 2. ASR Gel and Cracking in Concrete Arch Bridge

The MasterLife ASR 30 Prescription: The Ounce of Prevention for Concrete ASR

Since the early 1950s, lithium compounds have been shown to be effective in mitigating ASR in concrete, and in 1993, SHRP report C-343 depicted "extremely favorable" results. MasterLife ASR 30 admixture is based on this long term and extensively tested use of lithium as the preferred method for ASR control in concrete.

MasterLife ASR 30 Mechanism

The lithium ion in MasterLife ASR 30 admixture interferes with the expansive mechanism of the alkali-silica gel mentioned earlier by changing the reaction product. MasterLife ASR 30 admixture combines with reactive silica to form a lithium-silica gel that does not absorb water and, therefore, does not expand.

Reactive Silica Gel + in Aggregate $[xSiO_2]$	**Lithium in MasterLife ASR 30 $[yLi^+]$**	⟶	**Lithium-Silica Gel $[Li_ySi_xO_z]$**

Hence, MasterLife ASR 30 admixture converts reactive silica in the aggregate into a non-expansive, nondestructive material.

Reference

1. Stark D., Handbook for Indentification of Alkali-Silica Reactivity in Highway Structures, Strategic Highway Research Program, National Research Council; Washington, D.C. 1991

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