RECLAMATION

Managing Water in the West

Scoping Study on Leaching Lithium

Science & Technology Program

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prepared by
Bret Robertson, M.S., E.I.T.

Peer review by
Janet White, P.E.

U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
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Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

BUREAU OF RECLAMATION
Science &Technology Program
Materials Engineering and Research Laboratory, 86-68180

Scoping Study on Leaching Lithium

Prepared: Bret Robertson, M.S., E.I.T.
Civil Engineer, Materials Engineering and Research Laboratory Group, 86-68180

Peer Review: Janet White, P.E. 9/27/2012 Date
Civil Engineer, Materials Engineering and Research Laboratory, Group 86-68180

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Date	Description	Prepared	Checked	Technical Approval	Peer Review

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Abstract

The primary objective of this scoping study was to develop a laboratory research plan utilizing lithium as a mitigation method for alkali silica reaction (ASR). The report also has findings from a literature review, developing a partnership, and researching concrete durability models.

Introduction

Concrete is one of the most widely used construction materials in the world. However, an important issue with concrete is ASR. ASR is a form of concrete deterioration caused by a reaction between alkalies in the cement used in concrete and certain types of aggregates. The reaction was discovered in the 1930s, and methods were developed to prevent the reaction from damaging concrete structures. Those methods were principally to limit the amount of alakalies in the cement used in the concrete and to use non-reactive aggregates. However, these methods are no longer as effective as they were once considered. This is due to a couple of factors: the lack of economically available high quality aggregate sources and the increase in alkali content in cement due to energy use issues. It seems ASR will always be around some areas of the country, and will likely start to be more of a problem in the foreseeable future. Fortunately, a solution has been found that has the potential to reduce or eliminate ASR in new concrete structures.

Lithium is that solution. When added to concrete lithium chemically mitigates the formation of ASR, thus maintaining durability and increasing service life. One concern with using lithium to mitigate ASR is leaching of the lithium by water out of the concrete. If the lithium were to leach out of the concrete, over time the concrete would be at risk of suffering from ASR, then expanding and developing cracks. Knowing the long term leaching characteristics would help us determine if lithium is a viable solution for ASR mitigation for concrete exposed to water.

Conclusions

This scoping study has identified a laboratory research plan which includes a short and long term evaluation of leaching lithium in concrete. Multiple methods will be analyzed to better understand the potential outcome for Reclamation. Some of the methods will focus on lithium being added to hardened concrete while others will focus on freshly made concrete. This could be key to protecting Reclamation's existing and future structures from potential ASR.

Discussion

Literature Review

Lithium compounds have been known to reduce expansion caused by ASR, for over 50 years[1]. Although researches may not agree on the mechanisms involved, there is a general agreement that the ASR product formed with lithium is present is non-expansive and thus not deleterious. A standard lithium-to-alkali ratio of 0.74 has been used as an accepted lithium nitrate dosage, effective in suppressing expansion in laboratory specimens[2]. Lithium nitrate was found to be the most common active component in commercially available, lithium-containing liquid chemical admixtures for control of expansion associated with ASR[3].

Research Partnership

A few partnerships have been developed for this study. Mr. Miles Dee has offered to supply lightweight aggregate for making concrete samples. Mr. David Stokes has availability to many admixtures. His advice and recommended admixtures will be used the duration of the project.

Research Concrete Durability Models

A program called STADIUM was created in 1999. It uses time-step finite element analysis to simulate the progress of harmful ions including chloride, sulfate, and hydroxide through concrete, by considering the chemical and physical properties of the concrete being analyzed. Recently added modules to the model including: time dependent variation of exposure, moisture content tools, and temperature; cracked and un-cracked condition tools; life-cycle cost analysis tools; and tools to suggest guidance on repair techniques that takes into account existing deterioration mechanisms. Plans to include lithium migration have been discussed with current staff for STADIUM. Reclamation has access to its own server provided by STADIUM.

Laboratory Research Plan

Long Term Testing

Samples will be made using two techniques of adding lithium before or during mixing. One involving chemical admixtures and the other involving lithium presoaked lightweight aggregate. Lightweight aggregate is porous and is known to supply late stage hydration by supplying water internally after concrete has hardened. This internal curing with lightweight aggregate could aid sustainability in structures. Presoaking lightweight aggregates with lithium could eliminate potential ASR in structures. Samples will also be made and cured before adding lithium to simulate already existing structures.

Some of these samples will then be placed in an outdoor location with continuous running water. The rest of the samples will be kept at the lab in a water bath with periodically changed water. At multiple ages these samples will be tested for the amount of lithium in the concrete. Over time samples will be monitored to see if leaching occurs and at what rate, if possible. Samples will be made with known reactive aggregate and known nonreactive aggregate. This coupled with an exposure sight will offer a practical long term scenario while maintaining a baseline of data with in-lab testing. This will also offer data for long term mitigation of ASR when lithium is used with a known reactive source.

Short Term Testing

ASR testing according to ASTM C1260 and C1567 will be conducted. Since both methods are 16 day tests MERL would like to see positive results of lithium presoaked lightweight aggregate with reactive aggregate and known test failures. This is a chemically harsh test method for ASR testing and will be only be used confirm the applicability of lithium presoaked lightweight aggregates. Other recent studies on changing pore solution utilizing presoaked lightweight aggregates have shown great promise with increasing concrete durability, particularly for freeze/thaw damage.

References

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[3] Millard, Marcus, "Effects of Lithium Nitrate Admixture on Early Age Concrete Behavior," Georgia Institute of Technology, August 2006.