Research Problem Statement

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I. TITLE

17-053 Evaluation of Potential Alkali-Silica Reactivity of Oregon Aggregates for use in Concrete Construction

II. PROBLEM

Alkali-silica reaction (ASR) is a leading cause of premature concrete deterioration in the world, widely viewed as second only to corrosion of reinforcing steel. This deleterious reaction is a result of alkali hydroxides in internal pore solution reacting with reactive silica in certain aggregates. Alkalis are typically supplied by the portland cement, but can also come from outside agents such as deicing chemicals or alkali-bearing minerals in certain aggregates. Once the silica is liberated from the aggregate an alkali-silica rich gel forms. This gel has a high affinity to absorb water and swell. If the swelling pressure of the gel exceeds the tensile capacity of the concrete, cracking may occur. While not all concrete is susceptible to this type of reaction, concrete suffering from such distress is more susceptible to further attack – corrosion, freeze-thaw, and/or sulfate attack. Concrete in transportation structures (namely pavements, bridge decks, and bridge elements) is more susceptible to ASR than concrete protected from exposure to moisture and/or temperature variations (e.g., interior concrete in buildings and industrial floor slabs).

Until the late 1990s the state of Texas thought their structures were immune to ASR. When 59 of 160 precast bridge girders showed extensive cracking during a 6 month waiting period prior to placement in a newly constructed bridge structure, the state began an extensive and expensive (~$1 million) research project to characterize this distress (TxDOT Project 0-4085). Since this study over $3 million in research money has been spent in the state of Texas alone. Today the state of Texas has a plethora of structures suffering from deleterious ASR and significant research is underway to quantify and mitigate the effects of ASR.

While the state of Oregon claims to not have an ASR problem it is known that aggregates in the Pacific Northwest (see report by Fred Shrimer, Senior Geoscientist at Golder Associates) are susceptible to this type of reaction under laboratory conditions. Laboratory testing at Oregon State University has identified potentially reactive aggregates in the Willamette Valley area. Extensive and costly repairs have been made to a bridge structure in Eastern Oregon as a result of deleterious ASR. The high costs associated with structures exhibiting ASR damage should justify preliminary research to determine the potential issues associated with ASR in Oregon. The Manette Bridge crossing the Puget Sound in Washington is currently being replaced due to extensive damage in the supporting concrete columns due to ASR at an estimated cost of $65 million dollars.

The goals of this research project are to a) identify potentially alkali-silica reactive aggregates in the State of Oregon b) determine the potential for alkali-silica reaction in existing structures c) develop a *proactive* approach to ASR detection and mitigation to minimize or prevent future ASR-related distress in transportation structures in Oregon.

III. PROPOSED RESEARCH, DEVELOPMENT, OR TECHNICAL TRANSFER ACTIVITY

Laboratory Testing - In the laboratory testing, a wide range of aggregates will be obtained from throughout the state (at least 15 different aggregate sources), representing fine and coarse aggregates.
These aggregates will be tested under four regimes:

- ASTM C 295 – Petrographic Analysis to Detect Potentially Reactive Minerals (~2 week/aggregate)
- ASTM C 1260 – Accelerated Mortar Bar Test to Detect ASR Related Expansion (16 day test/aggregate)
- ASTM C 1293 – Concrete Prism Test – Most Reliable Test Method (1 year for aggregate reactivity)
- Exposure site testing – large-scale concrete blocks (~2ft x 2ft x 3ft) will be exposed to outdoor ambient temperature cycles to bench-mark accelerated laboratory testing

Field Assessment – Field assessment will consist of condition surveys (according to FHWA Diagnosis Article) of approximately 10-15 field structures, namely bridge decks, columns, cross-over barriers and to a lesser extent pavement sections. Concrete samples will be obtained from the field structures for petrographic/microscopic evaluation, Los Alamos staining and residual expansion testing.

IV. POTENTIAL BENEFITS

The benefits to the Oregon Department of Transportation, and in fact the taxpayers of Oregon, are tremendous due to a proactive approach to ensuring the durability, service-life, and economic benefits of early detection of potential ASR issues and from implementing strategies that are simple and cost effective (e.g., replacement of portland cement by supplementary cementing materials at determined dosages to prevent ASR). In fact, the mitigation options to control ASR represent not only an environmental benefit (reducing the CO_2 footprint of concrete by reducing cement contents), but they also reduce permeability of concrete, increase strength (allowing lower cement contents as well), increase durability and service life and in many cases improve fresh concrete properties. The FHWA advocates that this type of approach be taken to assess the potential for ASR, and so should the State of Oregon.

V. IMPLEMENTATION

This is a holistic approach to evaluation and prevention of potential deleterious alkali-silica reaction in the state of Oregon and through continued partnership with ODOT the results of this research program will directly feed into their decision making process for materials qualification. If the potential for deleterious ASR does not exist this will provide sound benchmarking data that the state can use for future ASR-related concerns (e.g., if cement sources/manufacturers change, aggregate sources change in geology/mineralogy, or certain supplementary cementitious materials are no longer available). Should the potential for deleterious ASR and/or confirmation of ASR in field concrete is determined the research team will work with ODOT to develop prescriptive and performance based specifications to prevent ASR in new concrete. This will largely be adapted from the approaches outlined in ASTM C1778, AASHTO PP-65-11 and FHWA-HRT-04-113.

VI. LIST OF REFERENCES *(optional)*

Fournier, B., Bérubé M.A., Folliard, K.J., and Thomas, M.D.A., "Report on the Diagnosis, Prognosis, and Mitigation of Alkali- Silica Reaction(ASR) in Transportation Structures-Final Report," FHWA-HIF-09-004, Jan. 2010, 147 pp.

Shrimer, F.H., "Progress in the Evaluation of Alkali-Aggregate Reaction in Concrete Construction in the Pacific Northwest, United States and Canada," Bulletin 2209-K, United States Geological Survey, 2005, 11 pp.

Standard Practice for Determining the Reactivity of Concrete Aggregates and Selecting Appropriate Measures for Preventing Deleterious Expansion in New Concrete Construction, American Association of State Highway and Transportation Officials, AASHTO PP 65-11, 24 pp.

VII. CONTACT INFORMATION

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