PROJECT SUMMARY

Texas Department of Transportation

0-6656: ASR Testing: A New Approach to Aggregate Classification and Mix Design Verification

Background

In the past 5.5 years, the Texas Department of Transportation (TxDOT) spent approximately $2 million for recasting precast concrete products that had alkali-silica reaction (ASR). Aggregates belonging to false positive and negative categories based on the current test methods are gradually growing. Therefore, the demand for a rapid and reliable test, which can assess aggregate ASR potential at various alkali loadings, is high. This study developed a fast, reliable test method to determine aggregate alkali-silica reactivity based on the time-dependent nature of the onset and speed of reaction.

What the Researchers Did

Researchers used a volumetric change measuring device (VCMD) to simulate the aggregate-pore solution reaction that exist in concrete and to measure free solution volume change due to ASR (i.e., solution volume contraction) over time. Nearly 17 aggregates (both coarse and fine) were tested using the VCMD method at different temperatures and solution alkalinities. Researchers also used the VCMD to test pure phase material (i.e., borosilicate glass balls) as a proof of concept.

The measured solution volume change over time at multiple temperatures was modeled to determine activation energy (E_a) based on the rate theory. Activation energy is a measure of aggregate alkali silica reactivity. The lower the E_a the higher the reactivity is. An E_a-based aggregate classification system was developed subsequently. An apparent relationship between E_a and alkalinity was modeled to determine threshold alkalinity (THA) for each tested aggregate. An effective way of tailoring mix design depending on the level of protection needed was developed based on:

- Determination of E_a and THA from aggregate-solution test – in general, the higher the reactivity (i.e., the lower the E_a) the lower the THA is.
- Development of a concrete mix depending on E_a, THA, and some consideration on the severity of ambient conditions.
- Mix design adjustment/verification based on THA-pore solution alkalinity (PSA) relationship – PSA needs to be below THA in order to prevent/minimize ASR.
- Mix design validation using the accelerated concrete cylinder test (ACCT) – A new ACCT using the same VCMD with modified setup was developed to test concrete mixes in a short period of time.

Research Performed by:
Texas A&M Transportation Institute

Research Supervisor:
Anal K. Mukhopadhyay, TTI

Researchers:
Kai-Wei Liu, TTI

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What They Found

The VCMD-based test can reliably predict aggregate alkali silica reactivity in a short period of time (five days) by measuring activation energy of as-received aggregates. The E_a-based method has consistently identified the aggregates that belong to false positive and negative categories in a short period of time. This is the main benefit of the VCMD-based test method. A good correlation between E_a-based aggregate reactivity and ASTM C 1260 (14 days mortar bar expansion)/C 1293 (1-year concrete prism expansion) indicated that the proposed method has:

- The merit to be considered as a rapid and reliable ASR test method on one hand.
- The potential to be considered as an alternative method to the current accelerated mortar bar method (i.e., ASTM C 1260) on the other hand.

This step-by-step approach of developing ASR-resistant mix based on E_a, THA, PSA and ACCT is very effective. The ACCT method operates at 60°C and leach-proof conditions and measures expansion of concrete cylinder due to ASR. Because the data collection in the ACCT is automatic (no human error) under constant temperature (no error due to temperature difference) and leach-proof conditions, the reliability of the ACCT method is high. Although the testing period is not yet fully established, the ACCT method takes around 20–28 days to test a reactive aggregate and around 40–50 days to test a slowly reactive aggregate using a high concrete alkali loading similar to the current concrete prism test. The researchers also found that this method can effectively be used to pass/fail an aggregate at relatively low alkali loadings (straight cement mix without alkali boosting) in a short period of time.

What This Means

ASR E_a can serve as a single chemical material parameter to represent alkali-silica reactivity of aggregates with high reliability. The E_a-based aggregate classification can serve as a potential screening parameter in an aggregate quality control program.

The proposed step-by-step mix design approach will be effective in formulating ASR-resistant mixes with high reliability, which will save repair costs and increase concrete service life in the long run. The ACCT method has the potential to test a job mix in the laboratory and effectively formulate an ASR-resistant field mix with high reliability.

For More Information

Project Manager:
Andy Naranjo, TxDOT, (512) 506-5858

Research Supervisor:
Anal K. Mukhopadhyay, TTI, (979) 458-4618

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Research and Technology Implementation Office
Texas Department of Transportation
125 E. 11th Street
Austin, TX 78701-2483

www.txdot.gov
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