Texas A&M Transportation Institute

PROJECT SUMMARY

Texas Department of Transportation

0-6656-01: Further Validation of Alkali-Silica Reaction (ASR) Testing and Approach for Formulating ASR Resistant Mix

Background

Alkali-silica reaction (ASR) is recognized as a major concern for the Texas Department of Transportation (TxDOT). In the previous project 0-6656, a volumetric change measuring device (VCMD)–based aggregate chemical method was validated as a rapid (within 5 days) and reliable method to determine aggregate reactivity in terms of measuring composite activation parameter (CAP) and measure aggregate threshold alkalinity (THA). A new accelerated concrete cylinder testing (ACCT) was developed in that project as a potential concrete ASR test.

A combined innovative approach using both VCMD and ACCT methods with four recommended steps to formulate an ASR-resistant concrete mix was also proposed in the previous project:

1. Determination of CAP and THA by the VCMD method is performed in Step 1.
2. Performance-based mix design formulation is part of Step 2. Researchers developed guidelines on selecting suitable mix design controls depending on the CAP-based reactivity, THA, and some consideration on the severity of exposure conditions.
3. In Step 3, mix design adjustment/verification based on the THA-pore solution alkalinity (PSA) relationship (e.g., PSA needs to be below THA to prevent/minimize ASR) is recommended to perform as an optional control.
4. Mix design validation by using the ACCT method is a part of Step 4.

Researchers conducted extensive further work to validate the ACCT as a rapid and reliable concrete ASR testing method, and validated the combined proposed performance-based approach to formulate ASR-resistant concrete mixes.

What the Researchers Did

Researchers further validated the VCMD method by testing several challenging aggregates and measuring CAP and THA. Researchers determined threshold alkali loading (TAL) from the measured THA for all tested aggregates. ACCT was validated as a rapid and reliable ASR testing method through extensive concrete testing and parameter optimization. The effectiveness of the combined approach to formulate an ASR-resistant concrete mix was also validated. Researchers developed guidelines of different options covering combinations of the four steps to formulate ASR-resistant mixes with different levels of rapidity and reliability. Researchers proposed effective implementation recommendations.

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What They Found

Researchers further validated the ASR testing and approach for formulating ASR-resistant concrete mix and came up with the following main findings:

- For the aggregates belonging to false positive and false negative categories, CAP-based aggregate reactivity prediction by the VCMD method matches well with the ASTM C 1293–based prediction but not with the ASTM C 1260–based prediction. The VCMD method can be used as an alternative to ASTM C1260.
- The VCMD method can effectively determine aggregate TAL, which is a function of aggregate reactivity. The higher the reactivity, the lower the TAL. TAL for some highly reactive aggregates was found to be ≤ 3.00 lb/cy. Therefore, the current practice of assigning 3.5 lb/cy for all concrete mixes irrespective of aggregate reactivity and type of applications may not provide adequate protection.
- ACCT with relatively low alkali levels (4.5 lb/cy) as opposed to high alkali levels (8.9 lb/cy) in the current ASTM C1293 test can effectively be used to determine aggregate reactivity in a relatively short time (i.e., 28–45 days). The ACCT method was also found to be effective to determine optimum fly ash content to prevent ASR and can test the ASR potential of job concrete mixes within 75 days.
- All four mix design steps are recommended to develop ASR-resistant case specific mixes (performance based) with high reliability. If a strong agreement between mixes developed through Steps 1–3 and validation testing in Step 4 is observed, then requirement of concrete validation testing (Step 4) can be considered as optional.
- Determination of TAL along with reliable aggregate reactivity prediction promotes effective selection of TxDOT's current mix design options (Options 1–6) depending on TAL, aggregate reactivity, type of applications, and exposure conditions.

Researchers provided directions on using the developed approach in the current ASR prevention practices based on AASHTO R80-17/ASTM C1778. The VCMD and ACCT methods can be used wherever AASHTO R80-17 (ASTM C1778) recommends using ASTM C 1260 and ASTM C 1293 test methods to determine aggregate reactivity, respectively. The guidelines on mix design formulation based on CAP and TAL in Step 2 will facilitate effective selection of preventive measures matching with the level of ASR risk and level of prevention determined by AASHTO R80-17 (ASTM C1778).

What This Means

The combined approach with four steps will facilitate:

- Formulating case-specific ASR-resistant mixes (tailoring mix design depending on the level of protection needed) using locally available materials that ensure long-lasting durable concrete and saving repair costs.
- An effective and safe way to use locally available fly ashes that meet the future changes when class F fly ashes will no longer be available.

For More Information

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