Texas A&M Transportation Institute

PROJECT SUMMARY

Texas Department of Transportation

5-6656-01: Verification of ASR Resistance Property of the Selected Concrete Mix Designs by the Precast Industries in Texas

Background

The Texas Department of Transportation (TxDOT) has dedicated considerable resources to expanding the use of precast concrete in Texas bridges for decades. The use of precast panels eliminates the majority of formwork for concrete bridges, decreases construction time, and reduces construction costs. However, alkali-silica reaction (ASR) has been identified in precast bridge structures (e.g., moderate cracking in precast girders) and is widespread throughout North America.

The Texas A&M Transportation Institute conducted the development and validation of ASR testing and an approach for formulating ASR-resistant concrete mixtures during TxDOT Projects 0-6656 (ASR Testing: A New Approach to Aggregate Classification and Mix Design Verification) and 0-6656-01 (Further Validation of ASR Testing and Approach for Formulating ASR Resistant Mix). Development and validation of the two innovative ASR test methods (i.e., volumetric change measuring device [VCMD] and accelerated concrete cylinder testing [ACCT]) and a combined performance-based approach with four recommended steps were performed in these two previous projects.

What the Researchers Did

Researchers verified the ASR resistance property of the selected concrete mix designs of bridge girders by the precast producers (PCPs) in Texas by applying the developed combined performance-based approach. The specific objectives were:

- Use the VCMD method to measure the ASR reactivity of the studied aggregates in terms of measuring compound activation parameters using AASHTO T364-17 and threshold alkalinity (THA).
- Determine alkali loading by converting the aggregate THA using the calibration curve developed in Research Project 0-6656-01.
- Determine the reactivity of the studied aggregates by the ACCT method and by comparing reactivity predictions by the three methods (i.e., VCMD method, ACCT method, and ASTM C1260–based reactivity data obtained from TxDOT) to ensure reactivity prediction with greater reliability.
- Establish an easy procedure to determine pore solution alkalinity (PSA) for each mix from the selected precast producers.
- Identify and quantify alkali-contributing crystalline phases in cements and fly ashes by the quantitative x-ray powder diffraction (QXRD) method.

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- Reproduce the selected precast mixes in the laboratory and test by the ACCT method to determine if the mixes are adequate to prevent ASR.
- Propose additional implementation recommendations.

What They Found

Researchers verified the ASR resistance property of the selected concrete mix designs of bridge girders by the precast industries in Texas and found:

- All the fly ashes used by the selected PCPs were determined to be good-quality Class F ashes. The relatively lower abundance of alkali sulfate phases determined by the QXRD method and lower available alkali measurement by ASTM C311 are the characteristics of these ashes, which are favorable factors in designing ASR-resistant mixes with relatively lower levels of replacement.
- Based on the earlier ACCT criteria (expansion limit of 0.04 percent at 75 days), the selected PCP mix design with 20 percent fly ash replacement seems to produce safe mixes. However, the denser microstructure of the precast mixes in the ACCT testing can minimize ASR expansion (especially at the early ages) compared to the ACCT testing using standard mixes. The relatively higher PSA in some precast mixes because of a low water-to-cement ratio may enhance ASR depending on the THA of the tested aggregate. In this situation, there is a possibility some precast concrete may show relatively lower expansion than the standard mixes at the early ages (same age) and with the same alkali loading.
- A combined use of QXRD, particle size distribution, and pore solution alkalinity data along with the conventional ASTM C618 data can help predict fly ash performances and make recommendations on fly ash selection along with the approximate level of replacement (lower or higher range at the best) to prevent ASR in Portland cement concrete.
- The developed options allow TxDOT to successfully implement this approach for validation of PCPs' concrete mix design to prevent ASR. The approach can also enable producers and owners to formulate ASR-resistant mixtures using locally available aggregates, even in the event of shortages of Class F ash.

In order to validate ASR-resistant concrete mix designs for different applications (e.g., cast-in-place bridge deck concrete and other substructure and superstructure concrete), researchers recommend additional implementation using the developed and validated combined approach to test different job concrete mixes containing different types of supplementary cementitious materials (SCMs) (e.g., Class C fly ashes, blended ashes, and slag).

What This Means

The combined approach with four steps facilitates:

- Verification and validation of ASR-resistant concrete mix designs for different applications using locally available materials that ensure long-lasting, durable concrete and save on repair costs.
- An effective and safe way to use locally available SCMs that meet the future changes when Class F fly ashes will no longer be available.

For More Information

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