CENTER FOR TRANSPORTATION RESEARCH

PROJECT SUMMARY

Texas Department of Transportation

0-6813: Evaluation of ASTM C 494 Procedures for Polycarboxylate Admixtures Used in Precast Concrete Elements

Background

Over the past few decades surface cracking has become more and more apparent on girders produced at precast plants all throughout Texas. The cracking became a cause for concern when TxDOT's quality control noticed that the map cracking would develop even prior to girder installation, occurring in the precast yard (Figure 1).

Figure 1: Micro-cracking focused on the top flange at a TxDOT producer precast plant

These micro-cracks represent a loss in resources (time, money, labor, materials) for the precast producers and TxDOT since the micro-cracks have resulted in the rejection of several girders. After alkali-silica reaction and delayed ettringite formation were eliminated as the cause of the microcracking, TxDOT was prompted to consider whether the high range water reducers (HRWRs), specifically the polycarboxylate admixtures, could be contributing to the cracking issue. This project examined the performance of actual precast plant mixtures as well as the effect of HRWR admixture dosage on volumetric changes. A key aspect of this project was to determine the suitability of ASTM C494, Standard Specification for Chemical Admixtures for Concrete, for use as a tool to screen mixtures containing HRWRs in order to determine a mixture's micro-cracking susceptibility.

What the Researchers Did

The project involved three primary modes of investigation:

- Information survey to gather information about the use polycarboxylate admixtures on micro-cracking
- Forensic evaluation of in-service precast elements, concrete blocks, and mini-scale girders
- Laboratory investigations on concrete and paste mixtures.

What They Found

Forensic Investigation Results

In-service bridge girders were evaluated at two sites (Dallas and Texarkana). A trend between higher crack rating results and relative humidity measurements conducted 2" from the depth of the girder surface was observed.

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Natural Exposure Results

- Surface exposure to the elements (rather than seasonal factors) exacerbates the surface micro-cracking observed.
- Specimens with measurable pin and demic locations at different depths showed that in cracked blocks expansion occurred at 2" depth from the top surface.
- Carbonation shrinkage is not a driving factor inducing the micro-cracks.
- Performance variability depends on how the mixes are processed
- The exposure specimens cast in the shape of girders exhibited cracking more quickly than the exposure specimens cast into the shape of blocks. This suggests that the volume:surface ratio had an impact on mechanism driving the micro-cracking.

Evaluation of ASTM C494 with HRWR

No test required under ASTM C494 Type F guidelines successfully screened out a bad performer, as the guidelines were interpreted in this project.

Effect of HRWR Dosage/Type

Autogenous shrinkage testing indicates a correlation between a reduction in autogenous shrinkage and an increase in HRWR dosage (this occurred in over 75% of cases). This tendency was also shown by drying shrinkage results.

Effect of HRWR Dosage on Bleeding

Cement paste analysis with respect to autogenous shrinkage showed that increasing the HRWR dosage retards the final set of the mixture. The delay in set time causes delayed reabsorption of bleed water. The swelling incurred by the paste during reabsorption decreases the ultimate autogenous shrinkage of the paste compared to a paste mixture with a lower HRWR dosage. Correlating this paste study back to field performance, the use of higher admixtures dosages used in the field may be a factor in delaying or minimizing micro-cracking associated with autogenous shrinkage.

Restrained Shrinkage Results

The restrained shrinkage testing results correlated poorly with a mixture's field performance. Almost all of the mixtures took a significant number of days to crack (>20 days) due to their high compressive strength, high tensile strength, and high elastic modulus. Based upon their performance in restrained shrinkage, compressive, tensile, and modulus testing, all the mixes would be classified as having a low cracking potential.

What This Means

Polycarboxylate HRWRs are unlikely to be the source of the cracking. More likely "culprits" include ambient humidity and the extremely low w/cm ratio. One recommendation is that precast plants lower their cementitious content, to the lowest extent possible without compromising strength. This could be accomplished by optimization of aggregate gradation since this enables a paste content reduction and thus mitigates volumetric changes in the concrete. Evaluating the impact of fly ash and other supplementary cementitious mixtures on micro-cracking behavior in low cementitious content precast concrete mixtures should be investigated. Also recommended is using the highest w/cm ratio that provides adequate durability and strength, as well as re-evaluating concreting procedures to mitigate surface self-desiccation (e.g., better curing) and shrinkage (e.g., chemical shrinkage).

For More Information

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