Project Summary

Texas Department of Transportation

0-5550: Guidelines for the Use of Fly Ash and Ground Granulated Blast Furnace Slag Blends in Concrete Pavement

Background

The substitution of a portion of cement in concrete with supplementary cementing materials (SCMs) frequently results in delayed setting and low early strength. When SCM-containing concrete is placed during cold weather and/or contains certain chemical admixtures, these problems can intensify and can seriously impact the performance of a pavement.

This study evaluated the setting time, early strength gain, maturity, bleeding, and plastic shrinkage cracking of several concrete pavement mixtures containing SCM under different temperature conditions (mimicking summer, spring, and winter weather). The data was used to develop guidelines for identifying potentially problematic, slow-setting mixtures and preventing their use in pavements.

What the Researchers Did

Ten concrete mixtures were selected for testing using typical materials and proportions for pavements in El Paso. Three SCMs were used, including two types of fly ash and one ground granulated blast furnace slag. Mixtures used varying proportions of SCM, and included a ternary blend (fly ash and slag) and a mixture with optimized aggregate gradation. Additionally, a mixture that had shown problems in the field was extensively examined with varying water-to-cementitious materials ratios (w/cm) and chemical admixture amounts.

Mixtures were cured in the laboratory under temperature conditions simulating actual field pavement temperatures in El Paso in summer, spring, and winter. The temperatures were modeled using PavePro (software developed through project 0-1700) and used to program circulating water-baths containing the concrete specimens. Mixtures cured under these conditions were tested for setting time and early strength gain (12 hours – 7 days). Additional specimens were tested for maturity, semi-adiabatic temperature rise, bleeding, and plastic shrinkage cracking. All of these properties have implications for pavement cracking and durability.

What They Found

Several mixes cured at winter temperatures exhibited significant delays in setting and early strength gain. The mixture known to have had problems in the field also experienced very slow setting in the laboratory at all w/cm tested.

One of the best ways to identify potential setting problems in the field is to test for setting time in the laboratory under realistic field temperatures, as was done in this study. However, this test method is extremely tedious and time-consuming. A simpler test is needed. Researchers observed that all mixtures with extended setting times (final set > 10 hours) had 24-hour compressive strengths less than 500 psi.

Research Performed by:

Center for Transportation Research (CTR), The University of Texas at Austin

Research Supervisor:
Maria Juenger, CTR

Researchers:
Andre Edson, CTR
David Fowler, CTR
Chul Suh, CTR
Moon Won, CTR

Project Completed:
11-30-06

This observation was used to develop the guidelines that follow. It should be noted that the sample must be cured under similar temperature conditions to the field; otherwise this 24-hour strength cut-off is inappropriate. When curing under realistic temperatures is not feasible, curing at the minimum expected temperature is acceptable for this testing.

What This Means

Based on the results from this project as well as a review of the literature, recommendations can be divided into two categories: prevention of delayed setting and early identification of potential problems related to delayed setting.

Prevention of delayed setting

Ideally, concrete mixtures that will experience delayed setting should be identified prior to placement in the field. This demands that all concrete mixtures to be used in the field first be evaluated for set times and early strength at the temperatures expected during paving on the project. At this point, the most accurate technologies available for detecting the potential for delayed setting of concrete mixtures are not simple enough for use in the field. However, in most cases, delayed setting can be prevented by following the recommendations below:

- Setting time problems should be identified before field placements through testing of the trial batches. Testing the 24-hour compressive strength of a mix cured *under similar temperature conditions to the field* gives an indication of setting time. The results of this project show that 24-hour strength greater than 500 psi indicates that the mix set in a reasonable window of time (final set < 10 hours).
- Actual delivered mixture proportions in field concrete should be monitored to ensure that they do not deviate from the approved mix designs. If the source of fly ash, cement, or chemical admixtures changes, the mixture must be re-evaluated and appropriate adjustments made.
- *The manufacturer's recommended dosage of chemical admixtures should not be exceeded*. The dosage should be calculated using the manufacturer's guidelines, particularly with regard to dosing based on the amount of cementitious material (cement + SCM) or based on the amount of cement. Dosing based on cementitious material may result in the addition of too much admixture, causing delayed setting, especially during cold weather. The intended admixture dosage and SCM proportions should be discussed with the manufacturer's representative to identify any unforeseen problems with cold weather concreting.
- Admixture *dosage in the field* must be monitored closely and recorded accurately on the batch ticket.

Early identification of problems related to setting

If the above procedures are not followed, it is possible that some concrete mixtures will experience delayed setting. Early identification of potentially problematic mixtures is possible, before performance problems set in. Compressive testing of field cylinders (stored outdoors) at 24-hours will help identify problems. Twenty-four-hour compressive strengths less than 500 psi indicate that the concrete might have potential problems due to delayed setting. The mixture designs must then be evaluated to identify the cause of the delayed setting and appropriate adjustments made.

For More Information:
Research Engineer - German Claros, TxDOT, 512-465-7403
Project Director - Tomas Saenz, TxDOT, 915-790-4350
Research Supervisor - Maria Juenger, CTR, 512-471-7751

Technical reports when published are available at:
http://library.ctr.utexas.edu/index.htm

www.txdot.gov
keyword: research

Texas Department of Transportation
Research and Technology Implementation Office
P.O. Box 5080
Austin, Texas 78763-5080
512-465-7403