PROJECT SUMMARY

Texas Department of Transportation

0-6491: Non-destructive Evaluation of In-Service Concrete Structures Affected by Alkali-Silica Reaction (ASR) or Delayed Ettringite Formation (DEF)

Background

Alkali-silica reaction (ASR) and delayed ettringite formation (DEF) are expansive reactions that can lead to the premature deterioration of concrete structures. Both have been implicated in the deterioration of numerous structures around the world, including many transportation structures in Texas. The Texas Department of Transportation (TxDOT) has aggressively addressed these durability problems through specifications, test methods, and research (both within TxDOT and through universities).

Through these efforts and particularly through specifications, the occurrences of ASR and/or DEF in newly constructed concrete structures have become rare. However, there are many structures that were built prior to the discovery of ASR and DEF in Texas, and some built since then that are suffering from these durability problems. This project focused on the application of non-destructive test (NDT) methods to evaluate concrete elements, ranging from laboratory size to full scale, affected by ASR and/or DEF. The project was performed as a joint research project, uniting researchers from the University of Texas at Austin (UT) and Texas A&M University.

What the Researchers Did

Researchers at UT conducted a wide range of tests on plain and reinforced concrete at multiple scales. This included small cylinders and prisms, larger plain and reinforced concrete specimens in outdoor exposure, full-scale reinforced concrete beams, and core samples from the outdoor exposure specimens and full-scale reinforced concrete beams. Many laboratory tests currently recommended by the Federal Highway Administration (FHWA) and TxDOT guidance documents were conducted on the core samples, including mechanical tests, petrographic examination, chemical analyses, and residual expansion tests. Non-destructive test methods were applied at all scales, and the full-scale beams were also tested in four-point flexure to determine the effects of ASR and DEF on flexural strength and serviceability.

This comprehensive test program allowed not only for an assessment of the ability of NDT methods to characterize concrete deterioration and correlate to structural performance, but also to compare their effectiveness to that of tests currently recommended in the FHWA and TxDOT guidance documents. The work at Texas A&M utilized specimens designed to test the effects of ASR and DEF on D-regions and the development length of lap splices. Impact-echo was also investigated as a potential tool for detecting debonding of reinforcement in affected structures.

Research Performed by:
Center for Transportation Research

Research Supervisor:
Kevin Folliard, CTR

Researchers:
Eric R. Giannini, CTR
J. Zhu, CTR
O. Bayrak, CTR
K. Kreitman, CTR
Z. Webb, CTR
B. Hansen, CTR

Project Completed:
8-31-2012

What They Found

The following represent the most significant conclusions from this research:

- Full-scale beams cast at UT that suffered from significant ASR- and/or DEF-related expansion and deterioration showed little or no reduction in their flexural moment capacities, mainly due to the self-post-tensioning effect triggered by these expansive reactions.
- A full-scale dynamic test was the only NDT method that showed any correlation to structural behavior in the four-point flexure testing of the full-scale beams. Results from this test indicated that the stiffness of the reactive specimens in the longitudinal mode was the same or higher than that of the nonreactive specimen. This is most significant in that this test did not indicate a loss of performance in the reactive specimens.
- In-situ UPV and impact-echo tests and laboratory resonant frequency testing of cores were good indicators of low levels of expansion from ASR and DEF. For expansions above this level, the effectiveness of these NDT methods is greatly reduced.
- NDT methods cannot diagnose ASR or DEF as a cause of distress. They can be used to help assess the extent of distress, but a firm diagnosis requires petrographic examination of cores. Additionally, diagnosis of DEF is improved when coupled with a curing temperature history of the concrete and information regarding the cement chemistry.
- Chemical testing and residual expansion testing are useful tools for the prognosis of future expansion. Both water-soluble alkali and pore solution analysis can be coupled with residual expansion testing of cores to determine whether future expansion is likely. When DEF is suspected, a set of three different residual expansion tests can be used to separately assess the risk (although not necessarily the absolute magnitude) of future expansion from ASR and DEF.
- Impact-echo showed promise as a potential tool for detecting debonding of reinforcement in reinforced elements suffering from ASR and/or DEF.

What This Means

The research performed under this project was perhaps the most comprehensive body of work to date focusing on the application of NDT to structures affected by ASR and/or DEF. It is expected that the results of this study will serve as useful tools to practitioners and researchers when evaluating transportation structures affected by these two deterioration mechanisms.

For More Information

Project Manager:
Waded Odell, TxDOT, (512) 416-4737

Research Supervisor:
Kevin Folliard, CTR, (512) 232-3591

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

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

www.txdot.gov
Keyword: Research