SEPTEMBER 13, 2017

5:00 to 6:30 P.M. (1.0 PDH)

TECHNICAL PROGRAM

ASR and DEF Cracking - "It's Not As Bad As It Seems"

Speaker: Alfredo E. (Al) Bustamante, P.E. Walker Restoration Consultants, Tel: 281-280-0068

Mr. Alfredo E. (Al) Bustamante is a Principal and the Director of Restoration of Walker's Mid-South region. He is a registered Professional Engineer in Texas and Louisiana. He received his Bachelor of Science in Civil Engineering from Old Dominion University in Norfolk, VA and Master of Science in engineering with structural engineering emphasis from University of Illinois at Urbana-Champaign, Illinois. Mr. Bustamante has over sixteen years of experience as a project manager for a variety of projects related to structural, architectural, and material distress. His experience includes the evaluation, design, and construction phase services of many precast concrete parking garage structures.

Mr. Bustamante is a licensed professional engineer in Texas, past President of the Houston/Gulf Coast Chapter of SEAoT, past Chair of the FPA SC-02-0 subcommittee - Test Methods For Evaluating Existing Foundations (2007-2010), a member of the International Concrete Repair Institute (ICRI), the American Concrete Institute (ACI), the American Society of Civil Engineers (ASCE), The National Society of Professional Engineers (NSPE), National Academy of Forensic Engineers (NAFE), the American Institute of Steel Construction (AISC).

PRESENTATION SUMMARY

To an audience of about 60 at the HESS Club, Mr. Bustamante gave a slide presentation titled, "ASR and DEF Cracking - It Is Not As Bad As It Seems."

Concrete columns that are part of any structure exposed to moisture (e.g., bridge and parking structure perimeter columns) present a seemingly ugly picture when subjected to apparently severe cracking due to internal expansive forces from **Alkali-Silica Reaction (ASR)** and **Delayed Ettringite Formation (DEF)**. Based on the presenter's experience, and supplemented by several independent research studies, the apparently severe cracking in concrete elements subject to expansion forces from either ASR or DEF, or both, is often not as detrimental to the structural integrity of the column elements as it seems. The distress caused by internal expansion forces resulting from ASR and DEF primarily affects the concrete cover, but the core of the concrete columns confined by mild steel reinforcement is generally not significantly compromised.

Mr. Bustamante discussed the cracking mechanism in concrete columns caused by ASR/DEF, introducing a comprehensive approach to investigating this type of cracking, and describing a proven repair and monitoring program. The comprehensive approach to evaluate the significance of the cracking on existing precast concrete columns consists of up-close field observations, non-destructive testing, material sampling, inspection openings, petrographic studies, structural analysis, and reporting.

Some points made by Mr. Bustamante included:

- ASR/DEF issues can occur any time after curing require excess moisture to occur
- The only way to stop the initial occurrence of ASR/DEF cracking is to have the right chemistry in the concrete before it is placed.
- When ASR/DEF occurs in concrete columns exposed to the elements, if the concrete reinforcing steel is sufficient to properly restrain the column inside the cover concrete, the cracked cover concrete can be treated to mitigate the high relative humidity in the concrete provided the reinforcing steel has not begun corroding.
- Once corrosion of the reinforcing steel occurs, the expansion forces generated by the steel delamination process may require and entire replacement.
- The four main ingredients necessary to cause ASR cracking in concrete are reactive silica, sufficient moisture, high pH and calcium hydroxide.
- The calcium hydroxide causes the silica in the concrete to dissolve, causing it to start to gel. The addition of moisture causes the gel to expand which causes the ASR cracking.
- It takes a relative humidity of about 75% to start ASR cracking.
- Concrete with limestone aggregate is more prone to ASR cracking.
- ASTM C1260 – 14 is the standard test method to detect alkali reactivity of aggregates.
- DEF is a case of chemical sulfate attack when the source of sulfate ions happens to be internal (within the concrete) rather than external.
- DEF occurs when either a gypsum-contaminated aggregate or a cement containing unusually high sulfate content has been used in the concrete,
- DEF cases have been reported in cases where precast concrete plants use steam to speed the curing of the concrete. This is because ettringite is not a stable phase above 150°F. It decomposes to form monosulfate hydrate at temperatures higher than 150°F.
- The sulfate ions released by the decomposition of ettringite are adsorbed by calcium-silicate. Later, in service, when sulfate ions are desorbed, the re-formation of ettringite causes expansion and cracking.

Mr. Bustamante presented a case history of a Houston area 12-story precast concrete parking garage built in 1983 using non-prestressed reinforcing steel. The exterior load bearing columns experienced ASR/DEF cracking while the adjacent architectural precast columns did not. The column cracks were unsightly and mostly vertical (see attached photo), and were limited to the thickness of the concrete cover, i.e., the concrete outside the column reinforcing steel. Cracks were mapped, cores were taken, and nondestructive testing was done in accordance with ICRI's Guideline No. 2010.4-2009, "Guide for Nondestructive Evaluation Methods for Condition Assessment, Repair and Performance Monitoring of Concrete Structures" to determine the cause of the cracking.
Mr. Bustamante attributed causation as follows:

- DEF was the primary cause of the cracks and ASR was a secondary cause.
- The cracks did not have a structural significance.
- The cracks occurred in the structural columns and not the adjacent architectural columns because the plant making the structural columns used steam to speed the curing of the concrete (thereby triggering the DEF cracking), while the architectural plant slow-cured.

Mr. Bustamante's repair plan allowed the columns to be saved and cost $250,000 to implement, while column replacement would have cost 24 times that amount. The repair steps were to blast clean the cracked surfaces, apply Silane with 100% solids (as a water repellant), seal the cracks and joints with a flexible sealant, coat the columns with an elastomeric coating, and implement an annual monitoring program.

To download Mr. Bustamante's slide presentation, click here.

To read a summary of a previous FPA presentation by Mr. Bustamante, please click:
August 2010 - Test Methods for Evaluating Existing Foundations