July 2009 – Sept. 2009 Project Update

PennDOT Project #070202

Project Title: Inspection Methods & Techniques to Determine Non Visible Corrosion of Prestressing Strands in Concrete Bridge Components (LU ID 541671)

Contract #: 355I01

Lehigh University / ATLSS Research Center

Clay Naito, Stephen Pessiki, Richard Sause, and Ian Hodgson

Overview

This interim report provides an update on the progress of PennDOT Project: Inspection Methods & Techniques to Determine Non Visible Corrosion of Pre Stressing Strands in Concrete Bridge Components. The project initiated in December 20, 2007 and is scheduled to be completed on December 19, 2009. This report covers the time period from the July 1, 2009 to September 30, 2009.

Organizational Modifications

The project has continued to operate with the original upper level staff. The project is being conducted by Clay Naito (PI), Stephen Pessiki (co-PI), Richard Sause (co-PI), and Ian Hodgson (co-PI). Larry Jones is working as the primary graduate researcher on the project and will continue with the project until the end date of the task.

Project Tasks

In the past months work has progressed in three areas. First, the destructive evaluation has been completed. The destructive evaluation consisted of three phases: i) Concrete coring, ii) Exposure and examination of the first level of strands, iii) select exposure and inspection of secondary level of strands.

Second, NDE vendor reports were received and have been evaluated. Detailed comparisons were made to the damage index survey from the destructive evaluation task. The report from one NDE vendor has yet to be received. The results of this report will be incorporated when it is received.

Finally, the report from The Erlin Company (TEC) on the concrete cores was received and interpreted. Statistical methods were used to evaluate the correlation between chloride content, observed damage index and half-cell potential at each core location.

NDE Inspections

In total six NDE vendors visited Lehigh to inspect the box beams. The companies are listed below:

1. Magnetic Flux Leakage – Professor Al Ghorbanpoor, University of Wisconsin-Milwaukee
2. Remnant Magnetization Method – Vector Corrosion Technologies Ltd.
3. Electromagnetic Corrosion Detection and Galvanostatic Pulse Corrosion Rate – Gress and Associates and LIMCMT Inc.
4. Line Scanning Thermography – Physical Acoustics Corporation
5. Ultrasonic Shear-Wave Test, Ultrasonic Impact Echo Test, 3D Laser Scanning, and Ground Penetrating Radar – The Dynasty Group
6. Ground Penetrating Radar – Infrasense, Inc.

Reports have been submitted by all NDE inspection groups listed above except for contractor #6. The final reports will be included in their entirety as appendices in an NDE project report. The results of the inspections will be synthesized and compared to the results of the destructive evaluation to identify correlations between the NDE inspections and the actual conditions of the strands.

Destructive Evaluation of Beams

The destructive evaluation of the beams has been completed. A summary of what occurred during each phase is listed below:

i.) Cores with nominal diameters of 1 in., 2 in., and 4 in. were taken from the bottom flange of each beam; these cores would be sent for laboratory analysis to The Erlin Company (TEC) as well as have steel strands extracted and assessed for corrosion damage. The 2 in. nominal diameter cores were assessed for concrete compressive strength as per ASTM C39.

ii.) A concrete saw and a pneumatic air-gun were used in combination to fully expose each prestressed seven wire strand along its length. Each strand was assessed for corrosion damage; identifying the type and location of damage. Each beam was done one at a time; approximately one per week. After each beam was skinned, a damage profile was developed; encompassing each beam with every case of detected corrosion damage for all strands.

iii.) The second layer of strands was inspected at select locations; a pneumatic air-gun was used. After the exposed strands were inspected for damage, a comparison was drawn to the 1st level of strands.

Forensic Evaluation of Concrete Cores

Forensic evaluation of the concrete cores was completed. Data concerning core petrography, air void analysis, chloride analysis, carbonation depth, water to cement ratio, and degree of corrosion in the steel strands were generated.

Brief Overview of Findings

A brief overview of the findings of the forensic evaluation are presented below:

- The required concrete compressive strength was achieved in all but three beams.
- The concrete air quality did not meet the industry requirements needed to protect critically saturated concrete from damage by cyclic freezing and deicing chemicals.
- Carbonation was not present in six of the beams studied. Main Street Beam 2 was found to have carbonation present up to 1.25 in. below the soffit surface.
- The clear cover was less than the prevailing AASHTO requirement of 1.5 in. in 92% of the cases inspected. The clear cover varied from a maximum of 1.75 in. to a minimum of 0.69 in.
- Chloride content was found to be highest at the lower surface (soffit) of the beam, decreasing towards the top of the bottom flange.
- The average half cell potential reading tends to increase with the severity of damage
- It was found that if a longitudinal crack is present, there is a 70.4% probability of having corrosion underneath.
- When there are no surface indicators of corrosion (no crack) there is a 10.3% probability of finding corrosion on the prestressing strands underneath.
- When corrosion damage was found at the 1st level of strands, damage was present on the 2nd level of strands 45.1% of the time.
- Where corrosion damage was present for both levels of steel, it is shown that the damage index is larger on the 1st level of strands 87% of the time.
- When a longitudinal crack is present on the bottom beam surface, an adjacent strand has a 35.4% probability of having corrosion.

Upcoming Schedule

- Two reports will be completed in the next quarter.
- The first report consists of the details of the Forensic Evaluation of the Bridge Beams.
- The second report compares the NDE results with the in-situ conditions of the strands.