4th Quarter 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

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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 was originally scheduled to be completed on December 19, 2009. A no-cost extension to the project has been granted by PennDOT and the new scheduled completion date is June 1, 2010. This report covers the time period from the September through December 2009.

Organizational Structure

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 through to project completion.

Project Tasks

In the past months work has progressed in four areas. First, the destructive evaluation has been fully completed; the last phase of which involved the exposure of the second layer of strands at selected locations with the goal of evaluating whether correlation exists between the state of corrosion at the bottom and second strand layers. Second, all NDE vendor reports have been received and evaluated. Third, draft reports have been submitted to PennDOT for approval and comments. Fourth, a project extension was granted in-which three NDT technologies will be inspected more closely. A concrete test-slab will be designed and created and the two magnetic NDT technologies will be used to attempt to detect various reinforcement damage. 3D Laser Scanning methods will be analyzed for feasibility and practicality of field use. Additionally, a new bridge rating method has been recommended for use; refer to the Forensic Evaluation Report submitted to PennDOT in December of 2009.

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 Chicago
2. Remnant Magnetization Method – Vector Corrosion Technologies Ltd.
3. Electromagnetic Corrosion Detection and Galvanostatic Pulse Corrosion Rate – Gress and Associates with LIMCMT Inc.
4. Line Scanning Thermography – Physical Acoustics Corporation
5. Ground Penetrating Radar – Infrasense Radar Inc.

6. Ultrasonic Inspection Methods – The Dynasty Group

Reports have been submitted by all of the NDE inspection groups listed above. The final reports will be included in their entirety as appendices in an NDE project report. The results of the inspections were synthesized and compared to the results of the destructive evaluation to identify correlations between the NDE inspections and the actual conditions of the strands. Additionally, data on costs and feasibility of these methods was gathered through an NDT Questionnaire sent out to all involved inspection groups. The draft version of the NDT Report was submitted to PennDOT in early December of 2009 and is under review. The report reference is listed below.. Lehigh University is in the process of having three NDT inspection teams return for additional testing.

- Jones, L., Pessiki, S., Naito, C., Hodgson, I., "Inspection Methods & Techniques to Determine Non Visible Corrosion of Prestressing Strands in Concrete Bridge Components - Task 2.2 Assessment of Candidate NDT Methods Used to Identify Corrosion of Prestressing Strands in Concrete Bridge Components," ATLSS Report No. 09-09, November 2009, 70 pages.

Destructive Evaluation of Beams
The destructive evaluation of the beams has been completed.

Forensic Evaluation of Concrete Cores

Erlin and associates has returned their full report. All data has been analyzed and included in the draft Forensic Report issued to PennDOT in December of 2009.

Forensic Results
The following final forensic report has been submitted to PennDOT for review.

- Naito, C., Jones, L., Hodgson, I., "Inspection Methods & Techniques to Determine Non Visible Corrosion of Prestressing Strands in Concrete Bridge Components - Task 2 – Forensic Evaluation," ATLSS Report No. 09-10, December 2009, 117 pages.

The key findings of the report are reproduced below.

- The forensic evaluation revealed that large tolerances should be expected in 1950-1960 era prestressed box beams construction.
- Significant corrosion damage was observed on the bottom layer of strands in the beams. Clear cover of the strands was measured at each cut section. The clear cover was less than the prevailing AASHTO requirement of 1.5 in. in 92% of the cases inspected.
- The average chloride percent by mass of concrete for strands with corrosion damage was 0.0183; this exceeds the ACI chloride threshold of 0.013. The average chloride percent by mass of concrete for strands with no corrosion damage was 0.0704; this is under the ACI threshold.
- Based on the results of the study, Half Cell Potential methods are not a viable means of detecting corrosion of prestressing strands in box beams.
- A comparison of surface acid soluble chloride measurements and half cell potential readings indicate that a poor correlation exists.

    - An examination of the relationship between longitudinal cracking and corrosion was conducted. 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 a longitudinal crack is present on the bottom beam surface, an adjacent strand has a 30.5% probability of having corrosion
- A revised rating recommendation for prestressed concrete box beams with deterioration was developed based on the forensic evaluation conducted. The proposed recommended practice is as follows:
    - Visually observed strands - Deduct 100% of all exposed strands from capacity calculations.
    - Strands adjacent to, above or intersecting a longitudinal crack shall be reduced to 77.4% of their original cross-sectional area.
    - For beams with longitudinal cracking or spalling all strands shall be reduced to 97% of their original cross-sectional area.

Upcoming Schedule

In the next six months the following tasks will be completed:

1. Conduct a secondary evaluation of magnetic inspection methods. Determine accuracy and provide a comprehensive assessment of the viability of the methods.
2. Evaluate the cost, accuracy, and practicality of utilizing laser scanning techniques for inspection of corrosion damage of adjacent prestressed concrete box beam bridges.
3. Apply the updated inspection guidelines to a non-composite adjacent prestressed concrete bridge and evaluate the changes in the load rating of the structure (Specialty Engineering, Inc.).
4. Summarize the findings of tasks 1 through 3 in a report and PowerPoint presentation.