Florida Department of Transportation
Summary of Final Report, BC-374
May 2000

INITIAL DEVELOPMENT OF METHODS FOR ASSESSING CONDITION OF POST-TENSIONED TENDONS OF SEGMENTAL BRIDGES

PROBLEM STATEMENT

Examination of post-tensioned tendons of the Niles Channel Bridge during Spring 1999 indicated severe corrosion damage and strand separation near the anchorage points on two tendons.

OBJECTIVES

Initial examination of the Niles Channel Bridge led to further investigation. This research project was part of a subsequent, extended study, and this document reports primarily upon the second of two phases of examination. The goals of the extended study included the following:

1. Develop techniques for measuring tension from dynamic response to excitation of the tendons and conduct these measurements.
2. Develop methods for analysis of experimental measurements and apply these methods to the data obtained.
3. Provide a baseline for all tendons so that comparative measurements may be conducted over the remaining service life of the bridge.
4. Describe the tension of the tendons with respect to location in the bridge.
5. Identify a candidate list of tendons exhibiting anomalous response that may indicate failed strands.
6. Develop and implement an electrical resistance technique for further examining tendons from the candidate list for possible failed strands.

FINDINGS AND CONCLUSIONS

The second phase of the extended examination took place during October 1999, during which time the follow was accomplished:

- A series of electrical resistance tests were conducted on a set of tendons identified as suspect as a result of the first survey.
- A small number of tendons, for which uncertain data resulted during the first survey, were retested.
- An experiment was conducted to assess the possibility of making static deflection measurements. One tendon was deflected using a jack and lever arrangement, placed at the center. Deflection was measured by a dial gauge. An estimate of tension was made using elementary string formulas. The resulting tension value was (+21.8kN/strand) greater than

previously estimated. No attempt to incorporate stiffness or boundary conditions into the measurement was made. Although the results were comparable to those of vibrational testing, the actual measurement procedure was quite difficult and would require considerable effort to adapt to some of the other tendons due to physical constraints. This method does not appear promising and is not recommended for future development

- Reproducibility and sensitivity checks were conducted for several tendons by placing the accelerometer in the usual position but by striking in different fashions, then moving the accelerometer to alternate positions and repeating.

The following were among the conclusions drawn:

- A database of tendon tension was developed, which through comparisons with future vibrational testing results will prove useful for detecting tendon deterioration.
- A method used to recover tendon tension from the frequency response of the tendon was developed and improved: several filters and checking steps were added to remove unreliable frequency information prior to analysis. The most reasonable assumption for the tendon ends was the clamped condition. Numerical analysis techniques were derived to permit recovery of apparent stiffness, in addition to tension.
- Tension and stiffness characteristics possibly indicative of mechanical distress were considered, including low tension, low stiffness, and unusual tension disparity between both ends of a tendon. Tension disparity was extreme for 09AM, the one tendon known to have failed strands in the bridge. Tension was lowest by far for 19AM, a tendon that did not show unusual behavior upon electrical testing. A list of tendons exhibiting exceptional tension/stiffness conditions has been formulated based on these possible indicators. However, it must be emphasized that these conditions could result either from strand breakage or structural loading.
- A small group of tendons have been subjected to electrical testing, based on the results of preliminary vibrational testing. At present, it is reasonable to conclude that with one exception, these tendons are simply detensioned and do not show evidence of actual strand breakage. The results of the electrical tests are not yet conclusive, but the method appears to be promising.
- Due to substantial evidence and previous history, it is recommended that all tendon segments adjacent to open expansion joints be subjected to more intense scrutiny. Such effort might include more frequent vibrational and electrical testing as well as studies of corrosion susceptibility (including pourback removal for visual inspection and chloride analysis).
- Conditions leading to strand corrosion in the Niles Channel bridge need to be assessed, with special attention to the source and accumulation mechanisms of chloride ions, and to the factors that may affect corrosion performance after any remedial action is taken.
- The vibrational method shows promise as a structural assessment tool. The tests revealed global tension patterns along and across the bridge. In particular, a trend of generally lower tensions on the Atlantic side of the bridge observed in preliminary work was confirmed. Further development and improved calibration of the vibrational tension estimation method are recommended.

This research project was conducted by Alberto Sagues, Ph.D, P.E., at the University of South Florida. For more information on the project, contact Rod Powers, Project Manager, at (352) 337-3134 or on the web at rodney.powers@dot.state.fl.us