Introduction

Nearly two-thirds of new highway bridges in the United States are constructed using precast, prestressed concrete. In Oklahoma, about 90% of new bridges are constructed with PC Beams supported cast-in-place deck slabs.

The research focuses on performing a low-cost structural monitoring of prestressed girders. Also, this research focuses on investigating the effects of changes in the camber and the placement of reinforcement details. Strand patterns, rebar, cables and concrete are factors that can change during the construction process.

Objectives:

1. Design, Build and Demonstrate the Instrumentation and Data Acquisition Systems that can achieve Structural Monitoring of Bridges Continuously 24h/7/365.
2. Evaluate Variations in Reinforcement Details in End Regions and at Midspan to Limit Camber, Camber Variation, and End Regions and at Midspan to Limit Camber.
3. Measure Concrete Strains in End Regions and at Midspans from the time of PC Beam Fabrication, including casting and de-tensioning, and reducing Prestress Losses.
4. Measure Concrete Temperatures Continuously for the purpose of improving means and methods during PC Beam fabrication and their effect on temperature effects through life In-Service. Assess the Effects of Temperature on Short-and Long-Term Performance.
5. Provide Recommendations for Design Improvements.

Background

From literature we know that camber can be controlled by the inclusion of mild steel in the bottom flange. A good control of camber in prestressed girder bridges:

- Eases construction.
- Reduces the variation of camber between adjacent PC girders.
- Eases formwork placement.
- Eases elevation control.

SH 4 Bridge Location and Description

The SH 4 Bridge over the N. Canadian R., Canadian, OK. The bridge features fifteen (15) 100 ft. spans. Each span is supported by four (4) AASHTO Type IV PC Girders. Girders are simply supported on neoprene bearing pads with “poor-boy continuous” deck slabs over the joints.

Girder Design Variables

Four different reinforcement layouts were used in the PC Beam fabrication. Each span utilized one of the four reinforcement details. Case A consists of a traditional strand pattern with no mild reinforcement in the bottom flange. Case B adds mild reinforcement (4-#7’s) into the bottom flange in order to control creep. Cases C and D utilize a “distributed prestressing strand pattern.” Case D matches Case C except mild reinforcement is added to the bottom flange.

Instrumentation & Data Acquisition System

Two PC Bridge Beams were instrumented with vibrating wire strain gages (VWSGs) at the end regions and at midspan. Thermocouples were used to measure concrete and ambient temperatures. Data was collected through multiplexers that allow large numbers of data channels to be stored by a data logger. The Data Acquisition (DAQ) system was built and remained “onboard” each beam. The data is transmitted continuously via cell phone technology, and available for examination, analysis and review 24h/7/365.

Photographs of Instrumentation

Instruments were installed in four (4) different locations:

- @ 4.0 in. from the end region.
- @ 16.0 in. from the end region.
- @ 32.0 in. from the end region.
- @ midspan of the girder.

Instrumentation was installed 24h before girder cast, and has remained in-place and functioning from April 2020 through present day.

Results and Discussion

The system has been collecting data continuously 24h/7/365. Concrete strain has been monitored. The figure below displays the measured concrete strain for Girder Mark 42 located in Span 14. Strain data can be used directly to assess prestress losses and girders can.

Note that Camber data that was computed using concrete strain at midspan correlates with the physically measured camber using traditional surveying equipment.

Conclusion:

- The instrumentation and DAQ systems can be used to monitor strains, stresses, cambers, and temperatures through the life of the bridge beam.
- The strain and temperature data are acquired continuously and in real-time. These data are useful for analysis of overall bridge girder behavior and overall bridge performance.
- The instrumentation and data acquisition systems enable the direct measurement of prestress losses.
- The systems enable the direct computation of PC Bridge Beam cambers.
- The Structural Monitoring (SM) systems can be employed as part of a broad effort for asset management and evaluation for performance maintenance and possible replacement over time.