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Structural Monitoring of the Rigolets Pass Bridge

Introduction

The Louisiana Department of Transportation and Development (LADOTD) has been gradually introducing high performance concrete (HPC) into their bridge construction programs. The Rigolets Pass Bridge is a 62-span bridge with a total length of 5,489 ft. (1,673 m). HPC was used in two of the 62 bridge spans. These spans each utilized four 131.2-ft. (40-m) long BT-78 girders at 12-ft. 7-in. (3.83-m) spacing. In conjunction with the Rigolets Pass Bridge Project, the state initiated a research program with the objective of monitoring the structural behavior of one of the two HPC bridge spans. The research program was jointly performed by the Tulane University Department of Civil and Environmental Engineering, CTLGroup, and Henry G. Russell, Inc. under the sponsorship of the Louisiana Transportation Research Center (LTRC) in cooperation with LADOTD.

Objective

The overall objective of this research project was to evaluate the structural behavior of prestressed HPC long-span bulb-tee girders utilized in Louisiana bridge construction. Other more specific objectives included (1) obtaining and measuring strain and deflection data from one instrumented span of the Rigolets Pass Bridge, (2) obtaining material property data for the prestressing strand and concrete used in the superstructure of the instrumented span, and (3) evaluating the measured data based on recognized analytical or design methodologies.

Methodology

One span of the Rigolets Pass Bridge was instrumented and monitored to obtain measured strain and deflection data for a period of one year after completion of construction. Four 131-ft. (40-m) long BT-78 girders fabricated using HPC were instrumented to measure concrete strains and deflections at midspan. During the fabrication of the four instrumented girders, representative samples of the prestressing strand and HPC were obtained and used for material property studies. After fabrication, the four instrumented girders were used to construct Span 43 of the Rigolets Pass Bridge. After erecting the instrumented girders at the bridge site, an HPC deck slab was added. During the deck slab construction, instrumentation was added to measure concrete strains at midspan. Samples of the deck slab concrete were also obtained and used for material property studies.

Throughout the bridge construction process, instrumentation readings were taken and recorded at selected time- or event-based intervals. Following completion of the Rigolets Pass Bridge construction, the strain gauge instrumentation installed in the HPC girders and deck slab of Span 43 were connected to an automated on-site data acquisition system with remote access capabilities. The system was used to record concrete temperature and strain data at selected time increments for a period of one year after the completion of construction. Manual measurements of midspan deflections were taken for Span 43 at the beginning, middle, and end of the one-year bridge monitoring period.

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Results from both instrumentation monitoring and material property studies performed for Span 43 were compiled in a research report. The results obtained from this research provide detailed information related to the long-term behavior of a long-span structure fabricated using HPC. Measured results were compared with corresponding design values based on American Association of State Highway and Transportation Officials (AASHTO) specifications and results from other previous HPC research sponsored by LTRC.

Conclusions

Design and construction of the Rigolets Pass Bridge has demonstrated yet again that a bridge using HPC can be successfully constructed in Louisiana using locally available materials. The measured concrete compressive strengths for the four instrumented girders and deck slab exceeded specified strength requirements. Findings from the HPC material property studies indicated that existing AASHTO equations for both concrete modulus of elasticity and modulus of rupture provide a conservative prediction of actual measured properties. Measured chloride permeability of the girder concrete was considerably less than the 2,000-coulomb limit stipulated in the project specifications. Based on results from this research and other LTRC-sponsored HPC research, it is concluded that silica fume provides a much greater benefit relative to reducing overall permeability than class C fly ash.

Total prestress losses measured in the four instrumented girders were considerably less (approximately 50 percent) than corresponding calculated values determined using provisions of the AASHTO standard specifications. Total prestress loss calculated using the AASHTO *LRFD Bridge Design Specifications* (using the approximate estimate of time-dependent loss approach) provided a better correlation with the measured loss but still tended to overestimate by as much as 35 percent when design values are used in the calculations. The relatively low measured prestress losses exhibited by the four instrumented girders were consistent with results obtained from creep and shrinkage tests performed on representative cylindrical specimens during material property studies.

Girder deflections at various stages of construction were calculated using a traditional moment-area approach considering both design (as-designed) and measured (as-constructed) properties. The as-designed calculated deflection values generally provided a better correlation with corresponding measured values than the as-constructed calculated deflection values. However, it should be noted that neither of the calculated deflection scenarios accounted for the effects of prestress loss or shrinkage of the deck slab concrete. It is also significant to note that the girder deflection measurements were taken under different temperatures and cloud cover conditions and, therefore, could have been influenced by subtle concrete temperature gradients within the bridge superstructure.

Based on trends and fluctuations of the measured concrete temperatures and strains documented during the bridge monitoring period, it is apparent that changing weather conditions at the bridge site will have an effect on in-service stress levels in both the girders and deck slab. However, quantifying these weather-induced changes in stress levels is a very complex problem requiring consideration of several parameters including non-linear temperature gradients, material properties, longitudinal continuity of the bridge span, and sources of restraint.

Recommendations

Based on the results from this research program, it is recommended that LADOTD should continue implementing HPC with specified compressive strengths up to 10,000 psi on all bridges where its use is beneficial and economical. In addition, LADOTD should continue the implementation of research programs similar to this program on projects where HPC is specified in order to continue expansion of the existing material and performance database.