TECHSUMMARY October 2014

SIO No. 30000546 / LTRC Project No. 12-1ST

Data Collection and Evaluation of Continuity Detail for John James Audubon Bridge #61390613004O1

INTRODUCTION

This project allowed the continuation of collecting monitoring data from Bridge #61390613004O1 in the John James Audubon Project for an additional two-year period. Bridge #61390613004O1 was instrumented as part of an earlier project (LTRC Project No. 08-1ST), whose findings raised questions about its performance under thermal gradients, which warranted resuming data collection to monitor the performance of Bridge #61390613004O1 over a longer period of time. The focus of the monitoring effort for both projects is on the employed continuity detail, which transfers forces between adjacent girders via positive moment reinforcement based on the recommendation of the National Cooperative Highway Research Program (NCHRP) Project 12-53. Continuity details are typically used to eliminate the need for high-maintenance joints that often lead to the acceleration of element deterioration in the vicinity of the joints.

Data collected from both projects (12-1ST and 08-1ST) were analyzed and interpreted. Furthermore, four field visits were conducted to document the condition of the girder ends in the monitored segment. Finally, the modified RESTRAINT program (mRESTRAINT) was further improved to add a thermal gradient analysis feature to allow engineers to estimate restraint moments using one tool that can handle all long-term effects.

OBJECTIVE

The main objective of this project was to continue data collection for the purpose of further investigating the performance of the NCHRP continuity diaphragm detail, which is different than the standard continuity detail used in Louisiana. More precisely, the research effort goals were to: (1) collect, analyze, and interpret field monitoring data to further understand the behavior of Bridge #2 under long-term and complement findings from the original project; (2) conduct periodic site visits to perform visual inspections of monitored segment with special emphasis on monitoring girder crack development; and (3) provide DOTD with recommendations to assist in the development of the new Bridge Design and Evaluation Manual and planning of future inspection routines for Bridge #2.

SCOPE

The study focused on one skewed bridge segment that was instrumented as part of LTRC Project 08-1ST. The instrumentation plan was designed to provide information about the performance of the positive moment continuity detail in the monitored bridge segment that covers Spans 23, 24, and 25, and is part of Bridge #2 of the John James Audubon Project. Therefore, the scope of the project was limited by the monitored segment as well as the installed monitoring system characteristics. The effects of live loads on the detail were not investigated for this project as they were in Project 08-1ST, because it was determined in the previous effort that live load effects are not the controlling factor for positive moment continuity details.

LTRC Report 526

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METHODOLOGY

The performance of the new positive moment continuity detail was evaluated for long-term effects via Structural Health Monitoring (SHM) of a bridge in service that employs the new detail. The SHM system was comprised of embedded and surface mounted sensors that measured strains, temperatures, rotations, and gap widths. Data from an additional 24-month monitoring period was collected and appended to the original monitoring data collected as part of LTRC Project 08-1ST, as well as visual inspections and implementation of an analytical model for the analysis of thermally induced stresses.

CONCLUSIONS

The conclusions from this study can be summarized in the following:

1. Positive restraint moment can cause cracking in the diaphragm and/or girder ends. In addition to the old crack that was documented in LTRC Report 477, new cracks were observed during visual inspections in bottom flanges at girder ends as a result of local stress concentrations around hairpin bars. Cracking can affect the performance of the continuity detail and the bridge. More importantly, girder cracking may have adverse effects on the durability and on the shear capacity of the girders. Therefore, special care should be given to the level of positive restraint moment during design.
2. Seasonal and daily temperature variations, especially temperature gradients, can cause large restraint moments in the bridge. The level of restraint moment due to the combined seasonal and daily temperature is probably the most important factor in the design of this detail, since the designer has no influence on the temperatures at the bridge site. The other positive-moment causing factor, i.e., girder creep caused by prestressing forces, can be greatly reduced by not introducing continuity until a large portion of the creep takes place prior to pouring the diaphragm.
3. The first repair attempt of the crack in Girder G3 used an epoxy-like sealant, which was not successful in sustaining one hot summer seasonal cycle due to its brittleness. The second repair attempt for all girder ends, which relied on an elastomeric crack-bridging coating with ultra-high stretching capabilities, seems to be working. After two hot summer months (July and August), no surface cracks were observed.
4. Five years after casting the prestressed girders, sensor readings indicate that most of the long-term effects, such as creep, have already taken place.
5. The monitoring system is now over five years old. At this age, some maintenance work may be needed to troubleshoot some of the sensors that are exhibiting erratic behavior, such as shifting or large fluctuations.

RECOMMENDATIONS

Based on the findings of this project, which confirm earlier findings in the final report of Project 08-1ST, it is recommended that a simpler detail that eliminates the expansion joint without developing a large continuity moment over the supports be adopted for Louisiana bridges. This can be achieved by pouring continuous decks over simply supported girders to develop what is normally referred to as partial integration. Large thermal gradients in Louisiana during summer months are typical and can cause large restraint moments if full integration details are employed.

If employment of the NCHRP 519 positive moment continuity is inevitable (e.g., design-build projects), a thorough investigation of its benefits, both structural and economical, on a per project basis should be conducted. The investigation should consider all factors that contribute to the development of the positive moments acting on the continuity detail including creep due to prestressing forces, differential shrinkage, and seasonal as well as daily thermal variations. Special consideration shall be given to the effects of temperature gradient in the design of this detail.

Temperature gradient effects, which is one of the most important causes of positive restraint moment, must be considered in the design of bridges employing the new detail. mRESTRAINT in its latest version is capable of conducting primary and secondary thermal analysis of continuous girder bridges. It is therefore recommended that thermal effects be studied using mRESTRAINT or any other structural analysis tools with thermal analysis capabilities.

Regular inspection routines (every two years) of the monitored segment are recommended since it appears that most of the creep effects have already taken place and the likelihood of major changes in short-time intervals is low.