TECHSUMMARY June 2014

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Field Demonstration of New Bridge Approach Slab Designs and Performance

INTRODUCTION

The Louisiana Department of Transportation and Development (DOTD) has launched a major effort to solve the bridge bump problem by changing the design of approach slabs where differential settlement is expected. The objective is to find a feasible solution that makes the approach slabs strong enough to allow them to lose a portion or all of their contact supports without detrimental deflection. In this solution, the flexural rigidity (EI) of the approach slabs will be increased by increasing the slab thickness and reinforcement, and therefore some embankment settlement will be allowed without a decrease in ride quality. As a result, the slab and traffic loads will be carried by the two ends of the slab (simply supported) rather than being distributed over the length of the slab. Accordingly, a footing will be needed to support the concentrated load at the R/S joint. To increase the bearing capacity of embankment soil and to reduce the footing settlement due to concentration load, the soil underneath the footing needs to be reinforced with geosynthetic reinforcement, such as geogrids.

OBJECTIVE

The main objective of this proposed research project was to perform field tests on concrete approach slabs to validate the findings and design recommendations developed in the previous research projects and update the design and construction guidelines of DOTD for bridge approach slabs to mitigate the bridge end "bump" problem. The validity of the proposed piezocone penetration test- (PCPT-) based method for prediction of embankment settlement was also evaluated in this study.

SCOPE

The west approach slab of the Bayou Courtableau Bridge was designed using the proposed new method and the east approach slab was designed using the traditional method. Static load tests and IRI measurements were performed at different times to evaluate the performance of the two approach slabs. The field performance measurements, including deformation and internal stresses of the concrete slabs, contact stresses between slab and embankment, stress distributions within RSF, and strain distributions along the geogrids, were monitored. Horizontal inclinometers were also installed on both embankment sides of the bridge to monitor the embankments' settlements at specified time intervals during and after construction. Predicted settlements by both the laboratory and PCPT methods were compared with the field measurements.

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METHODOLOGY

A comprehensive field and laboratory testing program was conducted to investigate the soil properties of the Bayou Courtableau Bridge site, which included moisture content, density, Atterberg limits, particle size analysis, 1-D consolidation tests, UU tests, ko-CU tests, and piezocone penetration and dissipation tests. The east approach slab of the bridge was designed according to standard (traditional) DOTD's Bridge Design Specifications for comparison. The design of the west approach slab of the bridge was changed to follow the new proposed approach slab design system. The rigidity of the west approach slab was increased by increasing the thickness from standard 12 in. to 16 in. The bottom slab steel bars were increased from standard No. 6 to No. 10, while the other reinforcement configurations remained the same as the east approach slab. A 4-ft. wide strip footing was placed at the roadway pavement/approach slab joint to support the slab dead load and traffic loads. The soil underneath the footing was reinforced with six layers of BX1500 geogrid placed at a spacing of 12 in. To monitor the performance of the new approach slab system, an instrumentation plan, which included electrical resistance strain gages, pressure cells, and "sister bar" strain gages, was developed and deployed.

Two static load tests were conducted on both west and east approach slabs at Bayou Courtableau Bridge to evaluate their performance. The first one was conducted right before the bridge was opened to traffic (October, 2009). The second one was conducted one and half year later (March 2011). Dead loads were placed on the slab by positioning the 20-ton large cone truck at strategic locations. International Roughness Index (IRI) measurements were also performed on both the east and west approach slabs.

CONCLUSIONS

The west approach slab of Bayou Courtableau Bridge, with the new design method, retained its contacts and supports from the embankment soil during the first static load test (at the time when the bridge was ready for traffic). However, during the second static load test (after about a year and half), the west approach slab lost most of its supports from the embankment soil. The maximum measured contact pressure underneath the west approach slab decreased from 1.5 psi (during first static test) to 0.5 psi (during second static test), while at the same time the pressure increased underneath the footing mainly due to load transfer caused by increased slab rigidity. On the other hand, the east approach slab, with the standard design method, showed gradual loss of its contacts from the embankment soil starting from the bridge abutment side towards the pavement side. The maximum measured contact pressure underneath the east approach slab changed from 1.1 psi (during first static test) to 1.4 psi (during second static test).

The internal strain distribution within the west approach slab shows that the top of the slab is in compression, while the bottom of the slab is in tension. The maximum measured compression strain (after one and a half years) for the top steel reinforcement is about 0.004%, and the tension maximum measured strain for the bottom steel reinforcement is also about - 0.004%. No measurements from the east approach slab is available for comparison.

The maximum measured strains in the geogrid due to 20-ton truck loading were considerably lower than the 2% strain (max strain at 1 ft. below footing < 1 %), which is the typical normal value published by geosynthetic manufactures.

The roughness profiles show better performance of the new approach slab system (west approach slab) with much lower IRI values.

The superior performance of the new approach slab system (west approach slab) was visually observed in the Bayou Courtableau bridge demonstration project after a year and half.

The comparison between PCPT-based settlement prediction methods and field measurements clearly showed that the PCPT and dissipation data were able to reasonably estimate the magnitude and rate of consolidation settlement.

RECOMMENDATIONS

More demonstration projects are needed to further verify the proposed new approach slab design system, especially in cases where excessive embankment settlements are expected. It is recommended to continue monitoring the performance of new approach slab system by conducting continuous IRI measurements periodically.