HIGHLIGHTER

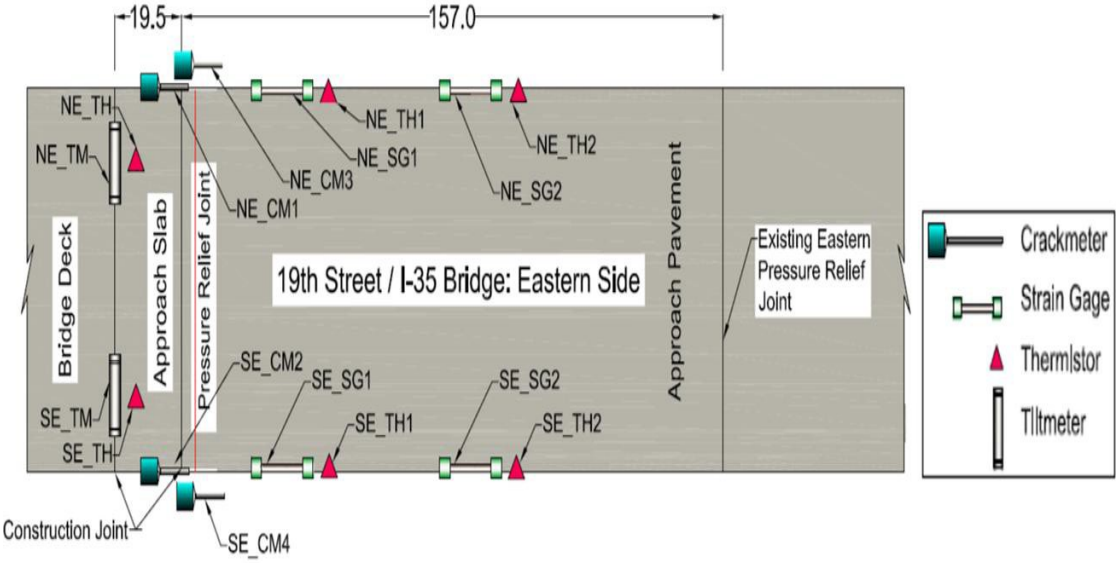
OVERTURNING FORCES AT BRIDGE ABUTMENTS AND THE INTERACTION OF HORIZONTAL FORCES FROM ADJACENT ROADWAYS

June 2018

OVERVIEW The Oklahoma Department of Transportation (ODOT) is experiencing a number of problems related to the interactions between bridge abutments (non-integral), bridge decks and adjacent roadways, including expansion joints closing, roller support bearings tilting, and beams pushing against abutment backwalls. Guidance for design, construction, repair, and maintenance of these elements will facilitate ODOT in alleviating the adverse effects and preserve the infrastructure.

RESULTS Guidance has been developed based on field observations, instrumentation of selected bridges, and computer simulations. Three bridges were selected for detailed instrumentation (typical instrumentation is illustrated in the figure) to obtain:

- measurements of strains at various locations of approach slabs, approach pavements, and bridge decks,
- relative displacements between approach slabs and approach pavements,
- relative tilt of the abutment backwalls and pier caps, and
- temperatures at various locations over a period of seven years.



At two of these bridges (19th Street Bridge over I-35 in Moore and SH-3 North Bridge over BNSF Railroad in Ada), measurements were also made before and after repairs. In addition, strains near newly-installed expansion joints on five other bridges were monitored. The observed distresses were classified into two main categories. One related to rigid approach pavements exerting pressures on the bridges and the other related to lateral displacements from tall approach embankments early in the life of the bridges.

PROJECT TITLE
OVERTURNING FORCES AT BRIDGE ABUTMENTS AND THE INTERACTION OF HORIZONTAL FORCES FROM ADJACENT ROADWAYS

FINAL REPORT ~
FHWA-OK-17-03
ODOT SP&R 2228

REQUEST THE FINAL REPORT:
odot-library@ou.edu
http://www.ou.edu/oktl

INVESTIGATORS
K.K. Muraleetharan, Ph.D., P.E.
Gerald Miller, Ph.D., P.E.
Royce Floyd, Ph.D., P.E.
Bo Zhang, Ph.D.
Amirata Taghavi, Ph.D.
Tommy Bounds, M.S., P.E.
Zachary Bright, M.S., P.E.,
The University of Oklahoma

ODOT SPONSORS
Walt Peters,
Assistant Bridge Division Engineer

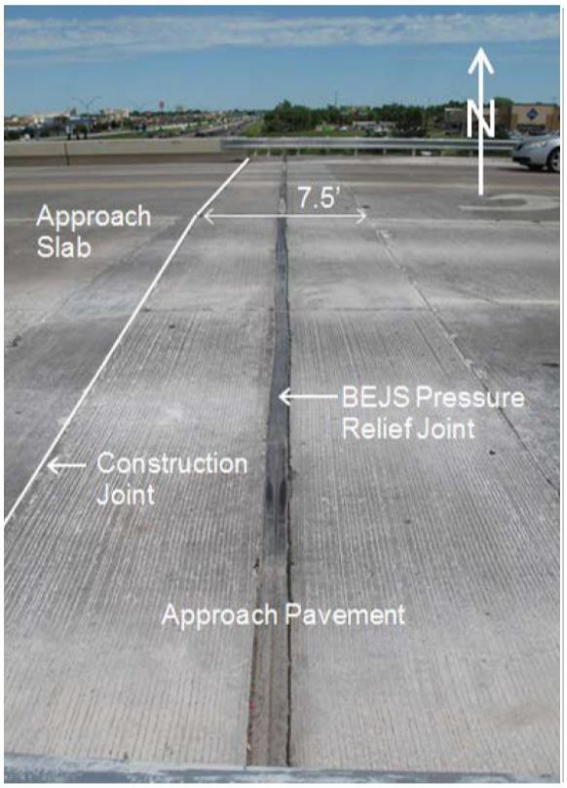
Office of Research & Implementation

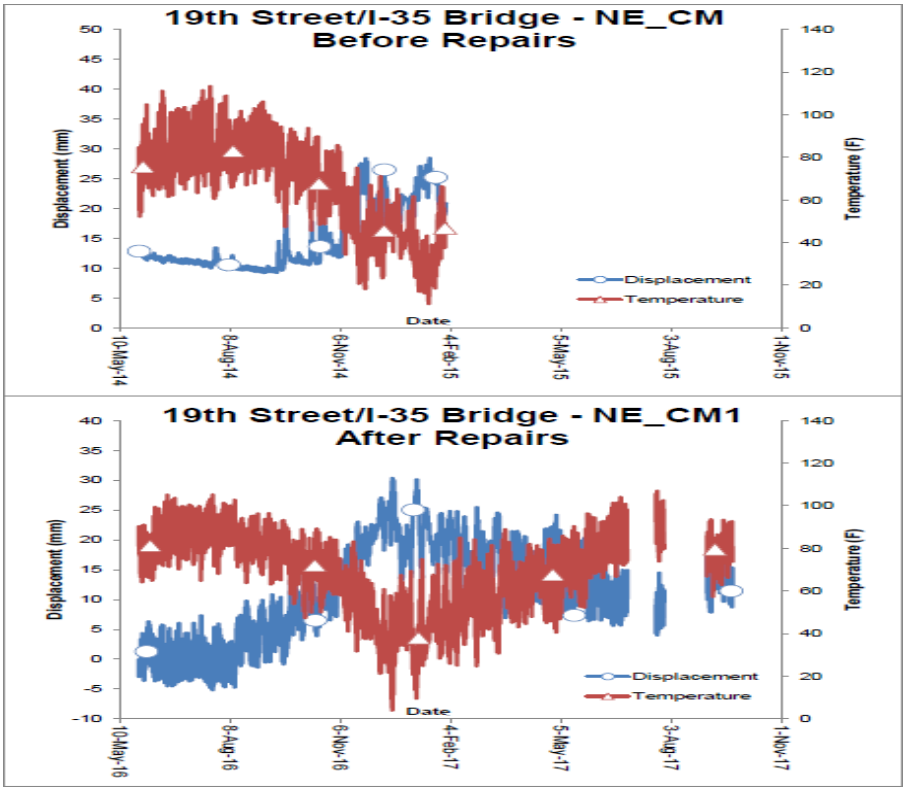
Oklahoma Department of Transportation
200 NE 21st Street,
Oklahoma City, OK
73105-3204

Implementation of Research for Transportation Excellence

MORE INFORMATION
odot-spr@odot.org

A 4-inch pressure relief joint installed on east approach pavement of the 19th Street Bridge (photo, shown left) was found to relieve bridge stresses caused by the rigid approach pavement (as data indicate in the graphs, shown right).





Saturated and unsaturated finite element analyses were performed for the east embankment of SH-3 North Bridge. These analyses were conducted to present lateral deformation of the approach embankments as a mechanism of initiating stress buildup in bridges. Reasonable results were obtained for the horizontal deformation of the embankment to support the hypothesis that the lateral deformation of the embankments is the cause of the movement at the SH 3 bridges. It is believed that the lateral deformation of the embankments was responsible for closing all four of the expansion joints on the bridge. Once the expansion joints locked up, it is likely that thermal expansion of the pavement induced additional stress on the bridge causing the damage that was observed. Repairs to SH-3 North Bridge included elimination of two of the expansion joints and the installation two new expansion joints. Measurements after the repairs indicate that the new expansion joints are performing as expected on this bridge.

Some of the recommendations made to prevent or remediate the observed distresses include:

- providing expansion joints on rigid approach pavements at regular intervals,
- installing pressure relief joints closer to the bridge relief distress due to pavement pressure,
- maintaining expansion and pressure relief joints on bridges and pavements, and
- conducting geotechnical analyses to calculate lateral displacements from tall approach embankments during the design phase.

POTENTIAL BENEFITS This project provides recommendations for design, construction, repair, and maintenance to assist ODOT in alleviating the adverse effects of interactions between bridge abutments (non-integral), bridge decks, and adjacent roadways. Results can be used to facilitate preserving infrastructure throughout the state.