Executive Summary and Implementation

Performance Evaluation of Inverted Tee (IT) Bridge System

Research Objectives

The primary objective was to conduct an assessment of the structural performance and durability of the IT girder system, as well as to evaluate its constructability and economy relative to other systems. These other systems included slab and NU-girder bridges at the lower and upper-bound span lengths (approximately 30 and 80 feet), respectively.

Research Benefits

Recommendations made were to enhance this existing bridge system, if warranted. These modifications resulted in modified girder designs with a shallower and more economical superstructure for both new construction and replacement projects, as well as prioritized maintenance strategies.

Principal Investigators

Richard Wood (P.I.) and George Morcous (Co P.I.)
University of Nebraska

Lead TAC Member

Fouad Jaber, PE, Assistant State Bridge Engineer

Background

The Inverted Tee (IT) girder bridge system was originally developed in 1996 by the University of Nebraska – Lincoln (UNL) researchers and Nebraska Department of Transportation (NDOT) engineers. This bridge system currently accounts for over 110 bridges in Nebraska used for both state highways and local county roads. Extensive longitudinal and transverse deck cracking have been observed and noted in numerous bridge inspection reports. Since the IT girder bridge system is relatively new, limited data and knowledge exist on its structural performance and behavior. This study evaluated the IT girder bridge system by conducting twenty field observations as well as recording accelerometer, strain gauge, and LVDT time histories and lidar scans for a selected subset of these bridges and then a three-dimensional finite element analysis (FEA) was conducted. The field observations included visual inspection for damage and developing deck crack maps to identify a trend for the damage. System identification of the bridge deck and girders helped investigate the global and local structural responses, respectively. Operational modal analysis quantified the natural frequencies, damping ratios, and operational deflected shapes for the instrumented IT girder bridges. These results helped diagnose the reason for the longitudinal deck cracking. The IT girders responded nonuniformly for the first operational deflected shape and independently for higher modes. Two comparable bridges, namely one slab and one NU girder bridge, were instrumented to verify and demonstrate that the IT girder behavior is unique.

Conclusion

An advanced geospatial analysis was conducted for the IT girder bridges to develop lidar depth maps of the deck and girders elevations. These depth maps helped identify locations of potential water/chloride penetration and girders set at various elevations and/or where the deck thickness is non-uniform. Live load tests helped quantify the transverse dynamic behavior of the bridge girders. Quantifying the transverse dynamic behavior helped validate the source of longitudinal deck cracking in IT girder bridges, which was determined to be the differential deflection between adjacent IT girders. The FEA analysis was conducted to evaluate the live load moment and shear distribution factors and compare that to the predicted values calculated from the AASHTO Standard and LRFD bridge design specifications. The comparison indicated that the predicted distribution factors were conservative. Also, interviews with IT bridge producers and contractors were conducted to determine production and construction advantages and challenges of this bridge system.

Executive Summary and Implementation

Interested in finding out more?

Final report is available at:
NDOT Research Website

Recommendations for Implementation

The IT system details will be revised according to the research recommendations.

Bridge Division will add additional stiffening to the IT system in order to eliminate the observed bridge deck longitudinal cracks.

The District will assist by visually monitoring, periodically, the performance of additional stiffened provided.

This brief summarizes Project SPR-P1 (17) M062
"Performance Evaluation of Inverted Tee (IT) Bridge System"
Nebraska Department of Transportation Research Program