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UTC Spotlight

University Transportation Centers Program

This month: Mid-Atlantic Universities Transportation Center at Penn State's Larson Institute

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This monthly report from the University Transportation Centers Program highlights some of the recent accomplishments and products from one of the University Transportation Centers (UTCs). The UTC Program is administered by the U.S. Department of Transportation's Research and Innovative Technology Administration.

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New Highway Spurs Advanced Bridge Construction Technologies

Pennsylvania roadway bridges are not just designed to bear traffic, they must handle the extreme temperature fluctuations of the winter and summer cycles. Recent construction of Interstate 99, in central Pennsylvania, has provided an ideal arena for examining two popular bridge types that are the subject of separate studies by Pennsylvania State University.

Field Monitoring of Integral Abutment Bridges

As the success of integral abutment bridges (IABs) has led to increasingly longer spans, uncertainties in predicting the long- and short-term performance of these bridges and related design principles has warranted real-world validation. The Pennsylvania Department of Transportation (PennDOT) engaged researchers at Penn State's Thomas D. Larson Pennsylvania Transportation Institute to conduct a field monitoring program to determine the actual response of this bridge type to thermal loads.

IABs are cheaper to build and maintain than conventional jointed bridges. With no metal expansion joint to install or repair, the deck is watertight, preventing deicing chemicals from damaging critical bearings.

Kongsak Pugasap

Dr. Woo Seok Kim, formerly the graduate research assistant on the PennDOT integral abutment monitoring project, pauses while installing instrumentation during bridge construction.

Current IAB design software does not provide displacement data. Penn State's monitoring program, however, allowed the development of analysis methods that directly predict the bridge's behavior. The 7-year monitoring program resulted in the development of models that predict thermal load behavior up to a 75-year design life. In addition, direct student involvement reaped valuable educational dividends.

Four bridges in the I-99 corridor were instrumented extensively—including piles, backwall, girders and slab—using over 5 miles of cable and 240 instruments. Documented structure behaviors were compared to Penn State numerical models and to PennDOT design methodology specifications. According to the project's principal investigator, "In general the observed behaviors follow the Penn State numerical models fairly well...and the original design models/assumptions do not match observed behavior."

The study drew several important conclusions that should prove useful to future IAB analysis and design. Among these, it was observed that bridge concrete girder stresses due to thermal load are significant and should be considered in the design. Also, IAB movements and stresses are significantly influenced by time-dependent effects and long-term behavior

The numerical modeling methods developed as a result of this study, considering soil-pile interaction, backfill-abutment interaction and construction joint behavior under thermal loading, temperature gradient, time-dependent effects and backfill pressure, accurately predict actual IAB measures.

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Superstructure of Bridge #207, carrying State Route 322 over Interstate 99 in Centre County, PA, showing shoring (yellow) used to stabilize horizontally curved steel girders during construction. Researchers from Penn State's Larson Institute are developing better approaches for designing and analyzing curved and skewed structures during construction to ensure that costly and hazardous fabrication mistakes are a thing of the past.

Prediction of Movement and Stresses in Curved and Skewed Bridges

Across the nation, horizontally curved and skewed bridges are becoming increasingly popular as state DOTs find it is more economical to fit the bridge to the roadway than fit the roadway to the bridge.

Because certain aspects of the behavior of these structures during construction and while in service still are not well understood, PennDOT authorized a study examining the effects of design, fabrication, and construction on the geometry and load distribution in a curved or skewed bridge system. The construction of both curved and skewed bridges in the I-99 Advanced Technology Test Bed provided a unique opportunity to investigate curved and skewed structures not only during their construction, but also while in service. In this case, construction data collected will be used to assess the accuracy of three different numerical models.

Engineering students were heavily involved in establishing the system for remote data acquisition on two such bridges in the I-99 corridor. Students prepared and placed instrumentation and data-acquisition systems, collected and reduced data, and prepared and ran computer models. From their work, information on how to design and construct these structures safely and more efficiently is being obtained.

According to the study's principal investigator, how well the numerical models predict bridge behavior depends on the complexity of the models. "Some do quite well – within 10 percent or less for some parameters, others not as well – within 30 percent for some parameters. Work has shown the sensitivity of modeling decisions on accuracy." The goal of the study "is to develop a 'design-for-construction' manual for PennDOT that will provide quantitative information for both bridge engineers and builders that will guide the construction process, prevent delays and accidents and provide finished bridges that behave as anticipated."

About This Project

Dr. Martin Pietrucha (mtp5@psu.edu) is the director of the Mid-Atlantic Universities Transportation Center and director of the Larson Institute, located at Penn State. "Field Monitoring of Integral Abutment Bridges" was conducted at Penn State under the direction of principal investigator Dr. Jeffrey Laman (jlaman@engr.psu.edu). "Prediction of Movement and Stresses in Curved and Skewed Bridges" is being conducted at Penn State under the direction of principal investigator Dr. Daniel Linzell (dlinzell@engr.psu.edu).