I. RESEARCH PROJECT TITLE

Finite Element Analysis of Concrete Approach Slab on Soil Embankment

II. RESEARCH PROBLEM STATEMENT

Current AASHTO specifications for structural design of bridge approach slabs do not take into account the interaction of slabs with the underlying soil. Consequently, the slabs experience a distress primarily in the form of cracking, also known as "the bump at the end of the bridge" because they are not designed to sustain the effects of differential settlements. Passing of large heavy vehicles over distressed slabs generates impact loads that cause further damages to bridges and pavements and may become a safety concern. In addition, the accumulation of settlement over time necessitates frequent maintenance, thus increasing the whole life cycle costs of bridges and incurring additional costs due to the associated traffic disruptions. While several different suggestions have been proposed for the alleviation of this problem (Stark et. al., 1995; Monley and Wu, 1993; Helwany et al., 2003) none of them have been widely accepted or implemented.

It is because of a sheer number of bridges, including 25,620 in Kansas alone, and 590,111 in the U.S. that the current design approach negatively affects the resilience, durability, safety and economy of transportation infrastructure. Kansas has the fourth largest number of bridges, following Texas, Ohio and Illinois. In addition, according to Bakeer et al. (2005) Kansas was also the second state to build the integral bridge in 1935. Today Kansas has about 1,000 integral bridges. This type of a bridge is more sustainable choice than its non-integral counterpart because it boasts multiple advantages. However, the bridge approach settlement in integral bridges is even more significant due to a complex soil-structure interaction. Significant differential settlements occur below the approach slab because integral bridges accommodate thermal expansions and contractions of the deck through the cyclic deformation in the adjacent soil.

Devising a design that will enable the approach slabs to sustain larger differential settlements will directly contribute to the increased resilience, longevity, safety and economy of transportation lifelines, thus increasing their overall sustainability rating.

III. RESEARCH PROPOSED

The main objective of the research proposed herein is to assess internal forces in approach slabs by means of a 3D finite element analyses. To this end, the state-of-the-art software ABAQUS, with 3D graphical animation capabilities will be used. The objective will be accomplished through the following tasks:

Task 1: Numerical simulation. The response of a typical approach slab used for Kansas bridges will be modeled. The slab will be subjected to the worst loading scenario comprising a combination of dead and live loads. In addition, two extreme cases of differential settlements will be considered ranging from an initial full contact with the soil to the contact at the end of the slab only.

Task 2: Parametric study. The effects of a differential settlement magnitude as well as of the slab dimensions on the induced internal forces will be evaluated. In addition, the recommended amount of steel reinforcements will be determined for different amounts of differential settlements. They will be subsequently checked against the current design guidelines used by Kansas Department of Transportation.

Task 3: Design tools. To help practicing engineers a graphical design tool that relates maximum bending moments, deflections and rotations in the slab on grade and simply supported slab will be developed.

Task 4: Final report. The results of the study will be summarized in the final report.

IV. ESTIMATE OF FUNDING AND RESEARCH PERIOD:

Project duration: June 1 2009- May 31, 2011
Budget: $30,000

V. URGENCY AND PAY- OFF POTENTIAL:

Distress of bridge approach slabs, which occurs mainly due to not accounting for the soil structure interaction in design guidelines, is costly in terms of time and money and it is also a safety concern. A timely solution will bring multiple benefits including: 1) alleviated distress of bridge approach slabs, 2) decreased impact loads on the bridges, thus preventing further damages, 3) decreased maintenance costs, 4) improved rideability and safety of the traffic, and 5) decreased traffic disruptions due to maintenance. Due to a sheer number of bridges in Kansas and in the nation this project has a high pay off potential.

VI. IMPLEMENTATION STRATEGY:

Computational modeling, which accounts for the embankment settlement, will provide the essential information for the structural design of approach slabs. Upon the completion of the parametric study, the current design will be checked against different amounts of differential settlements. Furthermore, a design tool that will facilitate the computation of internal forces in the slabs subjected to differential settlements will be developed. Ultimately, with this design tool practicing engineers can design approach slabs to have enough capacity to sustain the fill settlements without a significant distress.

VII. PROJECT PERSONNEL:

The Principal Investigator for this research will be Dr. Dunja Peric. She has many years of experience in numerical, analytical and experimental areas of geotechnical engineering. She has supervised three M.S. students (including the current one) who successfully worked with ABAQUS. Dunja holds Dipl. Ing. Degree in Civil/Structural Engineering from University of Zagreb, and M.S. and Ph.D. degrees in Civil/Geotechnical Engineering from University of Colorado at Boulder.

The co-PI will be Dr. Asad Esmaeily. He has more than 13 years of experience in the experimental and analytical studies on reinforced concrete structures, including experimental and analytical work on bridges in general and bridge piers in particular. He is a Professional Engineer (State of California) and holds a Ph.D. in Civil/ Structural Engineering and two M.S.'s in Earthquake and Electrical Engineering from University of Southern California, Los Angeles, and an M.Sc. in Civil Engineering from Tehran University, Tehran.

In addition, this research program will be conducted by a qualified graduate student at Kansas State University.

VIII. SUBMISSION INFORMATION:

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