NEVADA DEPARTMENT OF TRANSPORTATION

FFY 2014 RESEARCH PROBLEM STATEMENTS

I. PROBLEM TITLE:

Calibration of Resistance Factors for LRFD Design of Axially Loaded Drilled Shafts in Las Vegas Valley

II. PROBLEM DESCRIPTION:

Load and Resistance Factor Design (LRFD) has been used increasingly and has become mandatory for all bridge projects funded by the Federal Highway Administration (FHWA). Compared with the allowable-stress design (ASD) method, LRFD can achieve a compatible reliability between the superstructure and substructure. The uncertainty of load and resistance are quantified separately and are reasonably incorporated into the design process. Therefore, this reliability-based design approach will generally produce a more efficient and consistent design than the traditional factor of safety approach.

Currently, AASHTO specifications (AASHTO 2012) recommend using resistance factors for single drilled shafts in an axial compression range from 0.40 to 0.60 at a reliability index of 3.0, depending on different soil conditions. The recommended resistance factors, however, were calibrated on the basis of a drilled-shaft database that was collected from a limited number of sites and do not necessarily reflect the local soil condition or local design practice. As a result, resistance factors recommended by the existing AASHTO LRFD manual should be verified and recalibrated to account for local soil conditions and design practice.

Research has been performed in an effort to calibrate resistance factors for drilled shafts from case histories both nationally and locally, and the results have indicated the benefits of calibrating the resistance factors based on local soil conditions. For example, a recent study by Mackiewicz and Lehman-Svoboda (2012) demonstrated that side resistances predicted by the FHWA method significantly underestimate the capacities in heterogeneous soil conditions typical of the Central Las Vegas Valley. According to the paper, refining the shaft resistance estimated based on the full-scale load tests resulted in remarkable foundation construction net savings (~$5M) for a large development project in Las Vegas. The study highlights the importance of calibrating LRFD resistance factors for predicting drilled shaft side resistance for soil conditions in Las Vegas where the soil profile often consists of hard and soft clay with interlayered sand and cemented soils (caliche).

Calibration of LRFD resistance factors for the Las Vegas region, where drilled shafts are commonly used as the foundation system for elevated highways and bridges as well as high-rise commercial and residential buildings, will result in significant savings in the foundation construction of projects including NDOT projects. Therefore, the application of properly refined resistance parameters can

provide designers better information that can be used to refine shaft resistance estimates and, in turn, reduce project costs.

The proposed research study addresses three critical research clusters from the NDOT 2014 Research Critical Areas including: (1) Infrastructure and Materials, (2) Data-Driven Decision Making, and (3) Economics.

III. OBJECTIVE:

The main objective of this study is to calibrate the resistance factors for LRFD design of axially loaded drilled shafts for the soil conditions in the Las Vegas region. Other secondary objectives include a database of the load tests conducted on drilled shafts in Las Vegas valley or in similar soil conditions. This database should be compatible with NDOT computer systems while maintaining the flexibility of including future tests.

IV. CURRENT PRACTICE and RELATED RESEARCH:

Several other state DOTs have initiated and completed calibrating LRFD resistance factors for drilled shafts based on their local soil conditions as per suggestion by the AASHTO LRFD specifications. Example projects include: Yu et al. (2012) for Louisiana; Yang et al. (2008) for Kansas, Colorado, and Missouri; McVay et al. (2000) for Florida; and Allen (2005) for Washington.

V. RESEARCH METHODOLOGY:

The objectives of this research can be achieved through four stages. Stage one consists of collecting and compiling available data of full-scale load tests on drilled shafts in the Las Vegas Valley. Data from neighboring states with similar soil conditions such as Arizona, New Mexico, and Southern California will also be considered if needed. Stage two consists of evaluating the data and checking its compliance with the FHWA criteria. Stage three focuses on designing drilled shafts based on current practice and implementing a database that can be easily queried. Stage four aims at using the compiled data to calibrate the LRFD resistance factors.

VI. IMPLEMENTATION POTENTIAL:

Using the referenced NDOT's Five Stages of Research Deployment, the nature of the proposed research falls under Stage 1, Concept Stage, because the calibration of resistance factors will be based on the collected field data in Las Vegas and analysis.

The main deliverables of this research are: 1) database of axially load tests conducted on drilled shafts in Las Vegas (or in similar soil); and 2) new resistance factors for design of axially loaded shafts in Las Vegas region. These deliverables should be fully implementable by the end of the project.

VII. URGENCY AND PAYOFF POTENTIAL:

NDOT's current practice is to use the AASHTO recommended resistance factors for LRFD design of drilled shafts and this approach is believed to be too conservative for soil conditions in the Las Vegas Valley. It is crucial to

develop more realistic and less conservative design approaches to be used by NDOT and other designers for projects involving drilled shafts in the Las Vegas Valley.

The prime payoff potential of this research is the savings expected in foundation costs due to more tuned resistance factors. The secondary payoff is the production of a compiled dataset of load test data.

VIII. ESTIMATED BUDGET:

Approximately $197,000 for two years (2013-2015)

IX. DATE AND SUBMITTED BY:

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X. NDOT CHAMPION, COORDINATION AND INVOLVEMENT:

This proposal addresses primarily the geotechnical division of NDOT, although it also directly impacts structural and bridge engineering. The PI has had meetings with the geotechnical division of NDOT (Mr. Mike Griswold, Mr. Abbas Bafghi, and Mr. Ron Siegel) to discuss this research. Furthermore, the PI has discussed the technical aspects with Mr. Abbas Bafghi in detail. The PI believes Mr. Bafghi to be in earnest support of the project. The PI anticipates that all input from NDOT required to complete the proposed body of work would be under the review of the geotechnical and bridge divisions through regular meetings.