PROJECT DESCRIPTION FOR PROPOSED POOLED FUND STUDY

Research Project Title: Development of p-y Criteria for Drilled Shafts in Loess

Research Problem Statement:

Highway bridge foundations are designed for lateral loads resulting from wind, traffic, earth pressures, and occasionally extreme event loadings (at waterways or in seismic areas). In many cases the lateral loading controls the diameter and reinforcing required for a drilled shaft foundation. The most common method in use today utilizes the p-y approach in which the soil resistance is modeled as a series of nonlinear elastic springs acting against a pile or drilled shaft foundation. This approach has a long history of use for foundation design and is implemented effectively via computer codes such as LPILE and FLPIER.

The key feature of this approach is the development of nonlinear p-y curves (p= soil resistance, y = displacement) for modeling the soil behavior. Empirical correlations of p-y response to soil strength and stiffness parameters have been developed for a variety of soil types from observation of the results of instrumented field load tests. The use of empirical correlation with field tests is both a blessing and a curse: a blessing because the results are very reliable for those soils for which correlations have been developed thanks to the basis in full scale field tests; a curse because there exists great uncertainty when dealing with soil or rock formations in which there are no correlation full scale instrumented field tests.

Loess is a type of soil for which there has not been a thorough and systematic development of a p-y criterion for design of laterally loaded deep foundations. Loess is an aeolian (wind-blown) deposit of predominantly silt sized particles and is often cemented to various degrees. This soil is widespread across the Midwest, especially Kansas, Nebraska, Missouri, Iowa, and in many areas of the lower Mississippi River valley (Mississippi). There is a need for research to develop rational p-y correlations for loess soil so that highway bridge foundations can be designed with reliability and cost effectiveness in these soils.

Research Objectives:

The purpose of the proposed research is to develop a rational and reliable criterion for p-y curves in loess soil for use in design of drilled shaft foundations for highway bridges. Consistent with the p-y approach for design, this criterion should be based upon carefully conducted full scale field loading tests, and correlated with conventional laboratory and/or in-situ tests which are widely available and commonly conducted as part of a bridge foundation investigation. The following tasks are proposed to accomplish this objective:

1. Review available research information regarding the behavior of loess for laterally loaded deep foundations, the availability and effectiveness of various in-situ and

laboratory strength tests for characterizing loess, and the applicability of this information to the problem of laterally loaded drilled shaft foundations in loess.

2. Develop plans for field lateral loading tests of drilled shafts at four locations, including site selection, site characterization (borings and tests), and development of specific plans for load testing at each site. Tentative plans are as follows:

3. A site in the Kansas City area will serve as the focus for a major testing program including a range of variables such as cyclic loading, rapid loading, and diameters of three and four feet.

4. Three additional sites will be selected to provide simple static lateral load tests for a range of differing soil conditions in the general geologic setting characterized as loess. It is expected that one site in northern Kansas would be utilized, one site in western Kansas, and one site yet to be determined. The fourth site is intended to represent loess in a differing environment from the other three sites, such as in Missouri, Nebraska, or Mississippi (and depending upon project participants and funding levels.)

5. Conduct the field testing program at each of the test sites. Tests are expected to consist of static lateral loading tests at each site, tentatively planned for a pair of 3-foot diameter by 25-foot deep shafts. These would be heavily reinforced and instrumented to provide information on the subsurface response of the test shaft and soil resistance. At the Kansas City site additional tests are planned for larger (4-foot) diameter shafts, for shafts subjected to repetitive cyclic loading, and for shafts subjected to rapid lateral loading using the Statnamic device. All of the test sites will include soil borings with lab classification and triaxial strength tests and in-situ tests such as pressuremeter and borehole shear. Other in-situ tests which may be promising in developing reliable correlations with p-y curves will be evaluated and considered for inclusion in the study.

6. Analyze the field load test to develop a criterion for p-y curves which can reliably correlate the observed soil resistance with the site characterization across the range of conditions encountered in the four sites used for this research. The p-y criterion developed as part of this research will be implemented into a new release of LPILE as an available subroutine for computation of p-y curves in loess. This development is an important feature of the research and will allow immediate implementation of the results of the research into practice.

7. Produce a final report documenting all of the research including the testing and results, along with a detailed presentation of the p-y criterion produced as a result of the research. The report will provide documentation so that the research can be readily implemented by other researchers and in other software packages which may be used for design. It is also anticipated that a final presentation will be made to project sponsors.

Benefits:

As a result of the proposed research, highway bridge designers will be able to design foundations in loess soils using existing methodology and computer software, but with a user-selectable criterion for generating p-y curves which has been derived specifically for this unusual type of soil. These more representative p-y curves should yield foundation designs that are more cost effective than current designs and have a similar or increased reliability.

Budget and Schedule:

The estimated budget for the pooled fund is $450,000 that includes travel costs for state representatives. . Financial commitments from industry to support this project in the amount of $115,000 have also been received due to significant industry interest making the overall total estimated budget $565,000

The industry support includes Hayes Drilling of Kansas City, MO which has offered to provide equipment and labor to construct the shafts at sites in the Kansas City area. Other ADSC members are expected to provide similar construction services at the other sites. The estimated value of these donated services is $80,000.

Ensoft, Inc. of Austin, Texas has offered to co-sponsor and participate in the research by providing engineers to develop modified versions of LPILE (the commercial version of COM624) to implement the research and to assist in planning the testing program in whatever way may be helpful. Ensoft's contribution has an estimated value of $20,000 and will provide a route for transferring the information to the public in a timely manner.

Statnamic has agreed to provide its testing services at a reduced rate.

The University of Kansas Department of Civil, Environmental, and Architectural Engineering has agreed to provide reinforcing steel with a value of $15,000.

If staffing and workload allow at the time the project agreement is signed, the Kansas Department of Transportation has agreed to provide site characterization services, and construction support to reduce the cost of the project. The services will include soil profiling, undisturbed sampling, and in-situ testing that will include the pressuremeter and borehole shear and the required laboratory testing. Expected savings to the pooled fund will be $70,000 to $100,000 if this option is exercised. If realized, these savings will be returned to the participating states on a pro rata basis.

The estimated time schedule is 2 years with a start as early as January 2003.

Project Personnel:

Project co-principal investigators will be Dr. Robert L. Parsons, Assistant Professor at the University of Kansas; and Dr. Dan A. Brown, Gottlieb Associate Professor at Auburn University. Dr. Parsons has significant experience with research in site investigations. Dr. Brown has a long history of research on design, construction, and testing of drilled shafts for lateral loads and has been active in this area for over 20 years.

State Contributions:

The minimum recommended state financial contribution is $90,000 and is based on 5 states participating. Travel costs for all state representatives to attend panel meeting are included.

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