KANSAS DEPARTMENT OF TRANSPORTATION

TECHNICAL SUMMARY

DEVELOPMENT OF RECOMMENDED RESISTANCE FACTORS FOR DRILLED SHAFTS IN WEAK ROCKS BASED ON O-CELL TESTS

Report Number: K-TRAN: KU-07-4

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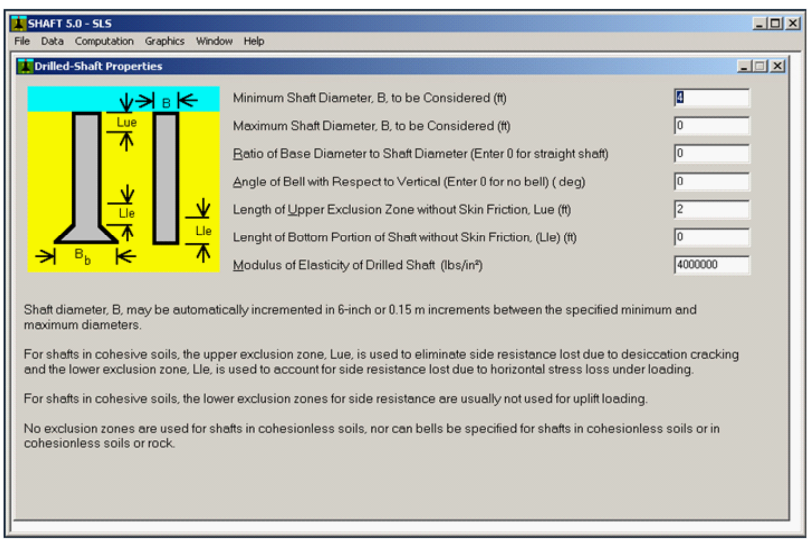
Publication Date: March 2010

Introduction

Since October 1st 2007, federal-funded projects including new bridges have been mandated to be designed to meet American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD) Bridge Design Specifications. The transition from Allowable Stress Design (ASD) to Load and Resistance Factor Design (LRFD) has caused a challenge to geotechnical designers. KDOT engineers have indicated that the design of drilled shafts in weak rocks following the AASHTO LRFD specifications sometimes results in a considerably different design from that according to the original ASD. Designers also have had problems in applying load and resistance factors into their computer programs that are based on ASD.



Weak rock is widely distributed in the state of Kansas. Drilled shafts are the most commonly used foundation type for bridges in such rock formations. In most projects, KDOT has used a serviceability criterion of 0.25 inch settlement to design drilled shafts. To verify the reasonableness of design, Osterberg Cell (O-Cell) load tests have been performed in several projects in Kansas. The test results indicated that measured shaft capacities are often several times higher than those predicted by the Federal Highway Administration (FHWA) design method (O'Neill and Reese, 1999). The AASHTO LRFD Bridge Design Specifications (AASHTO, 2006) do include recommended resistance factors for drilled shafts in weak rock (the terminology "intermediate geomaterial" used in the AASHTO specifications). However, these resistance factors were converted from typical factors of safety or nationwide load test database, which may not accurately reflect the local conditions and practice in Kansas. Therefore, a research project was funded by KDOT through the K-TRAN research program to evaluate and recalibrate the LRFD resistance factors for drilled shafts based on the properties of the weak rock formations in Kansas and other nearby states using O-Cell test data.

Project Objective

The objectives of this study were threefold:

1. Collect O-Cell test data on drilled shafts in weak rocks from Kansas and other nearby states
2. Analyze the data and calibrate the side and base resistance factors based on the FHWA design method; and,
3. Develop a design procedure and example to illustrate the application of LRFD resistance factors with the software currently used by KDOT.

Project Description

Twenty-six O-Cell test data were collected from the states of Kansas, Colorado, Missouri, Ohio, and Illinois for drilled shafts in rocks. Seven methods available in the literature were selected to estimate the load capacities of 25 out of 26 drilled shafts. Calculated load capacities from five methods (FHWA 0.05D, Davisson's, Brinch-Hansen's 80%, Butler and Hoy's, and Fuller and Hoy's methods) were used for statistical analyses.

Resistance factors calibrated in previous parts of the study were used to calibrate slide resistance factors from two different sources of measured resistance: total side resistance and layered unit side resistance. Two examples were presented to illustrate load and resistance factor design of drilled shafts in weak rock based on the Strength Limit State design and the Service Limit State design. Design procedures using Shaft V5.0 were provided for the Strength Limit State design.

Project Results

The comparison of the seven methods studied showed that Butler and Hoy's method is most reliable but the interpreted capacity by this method is to some extent overestimated. The "FHWA 0.05D" method was found to yield the closest and conservative predictions of the ultimate resistances to the representative values. Therefore, the resistance corresponding to a displacement of 5% shaft diameter is recommended as the ultimate resistance of drilled shafts. This method was adopted in this study when the resistance factors were calibrated for the Strength Limit State design.

Report Information

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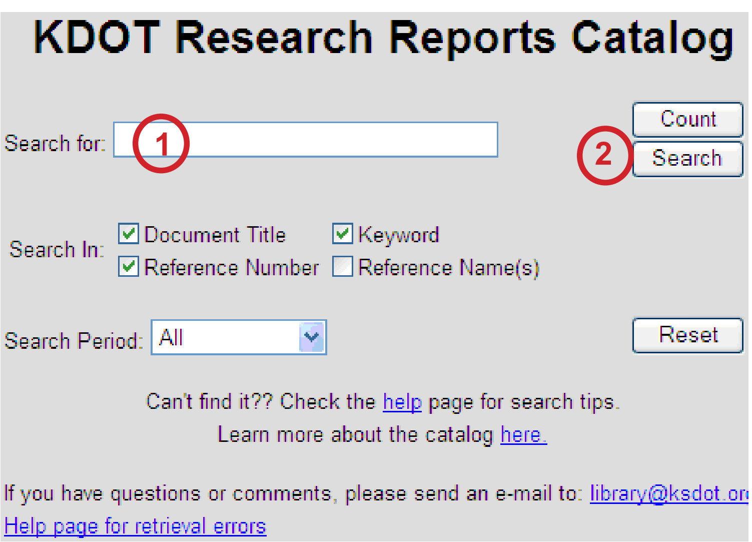

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