Summary of Final Report, BC354-13
August 2004

INSITU ROCK MODULUS APPARATUS

PROBLEM STATEMENT

Drilled shaft foundations socketed into limestone support many Florida structures and bridges through weaker overburden soils, providing capacity through a combination of side shear and end bearing. The current design method used to calculate the side shear capacity in the highly variable Florida limestone relies on the compressive and tensile strength tests of rock cores. However, these tests represent only the recovered, intact portion of the rock core, not the rock mass which may contain weathered zones, soil inclusions, unconsolidated carbonates, and voids. Many designers conservatively assign zero strength to the softer material lost during the coring process. Research could improve drilled shaft design procedures for Florida limestone through the use of insitu testing, i.e. obtaining design parameters directly from rock mass, rather than from core tests. Testing all of the rock, both weak and strong, should provide for safe shaft design while also improving design efficiency and reducing construction costs.

Different types of insitu tests may be used to characterize a rock mass. Geophysical methods provide information from which to identify stratigraphic changes and to infer changes in density and stiffness, but they do not directly measure the engineering properties required for drilled shaft design. Florida limestone is generally much stronger than soil, which makes most penetration tests impractical. Although the Florida Department of Transportation (FDOT) often reports Standard Penetration Test (SPT) results in limestone, this dynamic test provides a better model for the behavior of driven piles than for drilled shafts, and it has substantial inherent variability as well. Therefore, on a practical basis, only insitu tests performed from within a borehole can provide the rock properties desired. Among several possible borehole tests, the pressuremeter test (PMT) seems to provide the strongest theoretical and practical direct measurement of rock stiffness for use with a strength-stiffness correlation. By using a high-pressure probe, the PMT also can measure the strength of the rock directly.

OBJECTIVES

The goal of this study is to explore the use of pressuremeter test results in designing drilled shafts. The pressuremeter measures rock strength insitu and should accurately reflect the properties of the rock mass, and thus reduce the lab testing effort. This research includes pressuremeter tests in both laboratory and field tests to estimate the strength and stiffness of Florida limestone. It also includes the measurement of the modulus and strength of rock core samples by both FDOT and the University of Florida (UF). Specific objectives of this project included the following:

- Literature Search and Survey
- Laboratory Tests of Florida Limestone
- Pressuremeter Design
- Laboratory and Field Pressuremeter Trials
- Correlation of Florida Limestone Properties
- Drilled Shaft Side Shear from SR20 PMT

FINDINGS AND CONCLUSIONS

UF performed both Probex-1 and Texam pressuremeter tests, eight tests in the lab in "Gatorock," a synthetic limestone developed for this research, and 31 tests in the field at the SR20 Blountstown Bridge adjacent to two test shafts. The high-pressure Probex-1 is well designed and has the capacity necessary for testing most Florida limestone. However, field problems controlling the size of the corehole in weaker limestone will be difficult to remedy. This report compares the pressuremeter modulus, yield pressure, and limit pressure to similar core test results. It presents a database of 419 comparisons of q_u vs. q_t and 173 comparisons of q_u vs. E_i based on limestone core tests from six bridge sites. Pressuremeter tests in the lab proved successful, but tests using the Probex-1 in the field compared poorly with core tests and with the capacity of the adjacent test shafts. Site variability and weak rock significantly affected these comparisons. The pressuremeter test applies a unique stress field to the material tested, combining axisymmetric and plane strain conditions. However, its results may prove amenable to inverse finite element modeling that was not within the scope of this research. Additional field work or lab work with the Probex-1 can confirm (or deny) the viability of this test for drilled shaft design. An empirical design method, published by Laboratoire des Ponts et Chaussees (LPC), provided the best estimate of the drilled shaft unit side shear, but it requires further calibration before design use in Florida.

BENEFITS

The results of this project confirm a relationship, at least on a site-specific basis, between modulus and unconfined compressive strength that may prove useful for drilled shaft foundation design. The LPC design method appears to provide a viable alternative to the current design method. This research also indicates a need for the development of an insitu test capable of measuring the rock's shear strength more directly. Previous attempts include pullout tests of cast-in-place concrete plugs and the Iowa Borehole Shear Test (IBST), both used successfully on FDOT bridge projects in the past. A shear device similar to the IBST with a flexible membrane, such as used for the pressuremeter, should conform better to the irregular and variable corehole dimensions often encountered in Florida Limestone. The results of this study are being further explored in FDOT research project, *Insitu Rock Shear Apparatus* (BD545-01).

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