INTRODUCTION

The purpose of this study was to evaluate several computer programs for analysis of deep foundations, with specific interest in the program features that relate to user friendliness and efficiency. The project focused on axial and lateral loading of single piles, drilled shafts, and pile groups. A number of example problems were used to compare the programs. A single drilled shaft and a single driven H-Pile in sand and clay soil sites were analyzed for axial and lateral loading. The lateral load analyses were conducted for fixed head and free head conditions. In addition, analyses of groups of six piles were conducted for both example sites.

This report, through the evaluation of twelve deep foundation computer programs, is intended to provide an overview of the software available for analysis of deep foundations. It provides a guide to the features and capabilities of each program, as well as the user interface provided. Contact information and cost are also included. The programs evaluated were selected through an informal survey of engineers in practice.

A NOTE ABOUT ACCURACY

The computer programs reviewed here do not all provide the same results for the same set of conditions. For example, the computed values of lateral deflection differ by a factor of two or more. There is no clear way to determine which of the computed results is more accurate, and we believe that the range of answers is indicative of the level of uncertainty involved in the evaluation of deep foundation performance using conventional computational methods.

The most accurate means of assessing the behavior of a deep foundation is through field load tests, and each of the computer programs evaluated here is based initially on modeling field load test results. Our review of the computer programs compares the programs with each other, but no attempt was made to compare with field load test results. Such a comparison would introduce a new set of uncertainties regarding soil properties and interpretation of load test results that are beyond the scope of this study.

COMPUTER PROGRAMS FOR LATERAL LOAD ANALYSIS

Five computer programs for lateral load analysis of single piles or drilled shafts were evaluated -- CLM, COM624P, Lpile Plus 3.0©, LTBASE, and SWM©.

CLM

CLM is an Excel spreadsheet program written by T. Brettmann at Fugro-McClelland (Brettmann and Duncan, 1996). It is available at no cost. The spreadsheet uses empirical equations developed by Duncan et. al. (1994) and Ooi and Duncan (1994) to approximate the results of nonlinear p-y analyses. The program provides only ground line deflections and maximum moments. There is essentially no learning curve associated with this program. Once the spreadsheet is copied onto a computer and opened in Excel, it displays an example problem (the last problem saved), as shown in Figure 1. The boundary conditions at the top of the pile can be a free or fixed head condition. The soil profile must be simplified to one layer of either sand or clay. The program provides reasonable answers for single piles very quickly. CLM can be used to analyze groups as well as single piles, but it overestimates deflections of pile groups by a wide margin. The only graphical result is the spreadsheet, which can be printed for use in a report. CLM is a fast, easy-to-learn, easy-to-use program that provides relatively reasonable results for single laterally loaded piles, but overestimates deflections of pile groups.

COM624P

COM624P was developed under the sponsorship of the U.S. Department of Transportation Federal Highway Association. It is available at no cost. This program has an MS DOS-based user interface. It uses the p-y curve method in an iterative process to model the nonlinear response of soils. COM624P can be used to determine the deflection, rotation, bending moment, and shearing forces along the entire length of a single pile or drilled shaft.

Because the program operates in MS DOS mode, it has a slightly longer learning curve than a Windows-based program. However, once the user becomes accustomed to the program, it is easily navigated through use of pull- down menus which open data input screens, as shown in Figure 2.

COM624P is capable of performing many types of analyses. The boundary conditions at the top of the pile can be (1) specified shear and moment, (2) specified shear and rotation (rotation = 0 for “fixed head” condition), (3) specified shear and rotational restraint (rotational restraint = M_t/θ_t = moment/ rotation), or (4) specified moment and deflection. The pile can be subjected to cyclic, static, or distributed lateral loads. The soil profile can be divided into multiple sub-layers. Each sub-layer is represented by a user-specified p-y curve or a default p-y curve supplied by the program. COM624P allows drilled shafts or reinforced concrete piles to be represented by their concrete strength and reinforcing bar layout. The program can calculate the flexural stiffness of such foundations as it varies with