

CAPWAP CORRELATION STUDIES

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Abstract

The correlation results of CAPWAP and static load test are presented. The original, automatic, best match, and radiation damping CAPWAP results are compared with the static load test. The importance of using CAPWAP restrike result when comparing capacities is discussed. The guidelines for selecting shaft radiation damping parameters used in this correlation studies are also presented.

Introduction

Dynamic pile testing with a Pile Driving Analyzer is routinely required on many piling projects worldwide. The testing procedure is documented by many standard agencies such as the American Society for Testing and Materials (ASTM D 4945). The Case Pile Wave Analysis Program, or "CAPWAP", is a rigorous signal matching computer program which uses dynamic pile testing data to compute pile static bearing capacity and its distribution along the shaft and at the toe, soil damping and stiffness, and a simulated pile static load-set graph.

CAPWAP combines a wave equation type soil model and a continuous pile model with the field recorded dynamic pile testing data, and iteratively determines the unknown soil parameters by signal matching. While wave equation analysis (WEAP) models the hammer and must assume its level of performance, CAPWAP replaces the hammer model with the measurements as a boundary condition. Furthermore, while wave equation

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analysis requires assumptions regarding soil parameters, CAPWAP computes these parameters in the signal matching process. Further description of the CAPWAP method is presented in the program manual (GRL 1995).

The objectives of the CAPWAP correlation study presented here include: first, to investigate the statistical reliability of CAPWAP capacity predictions; second, to critically re-evaluate CAPWAP procedures and results for future improvement; third, to study CAPWAP's soil radiation damping model and to provide guidelines for its proper use, and fourth, to investigate relationships between the dynamic parameters (damping and quake) with respect to soil types. A total of 82 piles selected from the GRL database were used in the correlation studies.

Description of Database

GRL maintains a database which currently contains more than 200 cases or static load test piles with dynamic tests also performed on the same pile. This database is regularly updated with new cases submitted from all over the world which must meet the following basic requirements:

- Static load test was carried to "failure" as defined by the Davisson's failure criterion. An exception is granted if failure was not reached but could be extrapolated within at most 110% of the maximum applied load. Pile description and length, tip elevation, date and time of test, and pile top load-set curve are the minimum required static load test data.
- A dynamic restrike test was performed after a meaningful waiting time following pile installation (a comparable time to static load test time). The force and velocity records from the beginning of restrike (BOR) are available, and preferably also for end of driving (EOD). For a meaningful comparison with static load test, CAPWAP results of the dynamic restrike test were used in the correlation studies. Using dynamic restrike test data for pile capacity evaluation is a standard procedure; due to a disturbed soil, pile capacity at the end of driving often does not reflect the soil condition encountered during a static load test.
- Soil information is available including soil description, soil strength information such as SPT, and other relevant information. Soil boring should be in the vicinity of the load test pile and extend below the pile toe.
- Pile driving record (or at least the blow counts from EOD and BOR) must be available and include pile length, pile tip elevation at EOD and BOR, hammer and driving system information.

Correlation Considerations

It was assumed the static load test had been accurately performed. It is recognized, however, that force or displacement measurements of any static load test may contain errors. The "*static load test capacity*", evaluated by Davisson's criterion which is among the more conservative criteria, allows more static tests to reach "failure" rather than criteria with more liberal deflection limits. Thus, it permits more data to qualify for admission into the database. Of course, other failure criteria would result in a range of failure loads for the same test.

In many soils, pile capacity continually changes with time due to setup or relaxation, and thus many specifications require a wait period after installation before the static load test is performed. Since static and dynamic testing usually occurs after different waiting periods, further differences in capacity should be expected, and differences increase as time between tests elapses. Potential measurement errors in both static and dynamic tests, alternative failure definitions in static test evaluation, and differences in time of testing after installation are the most important reasons why exact agreement between static and dynamic test results is virtually impossible.

Correlation Procedure

For all 82 cases investigated, several CAPWAP results are presented. The *original* CAPWAP results were performed by different engineers on a variety of computers over a period of many years as the data was acquired and thus came from different versions of CAPWAP. Later in this paper, a comparison between the original CAPWAP results and the reanalyzed CAPWAP results from the 1.993.1 version will be presented.

For consistency of comparison, dynamic data were also reanalyzed with CAPWAP, Version 1.993-1. This version of CAPWAP program has a built in automatic search routine based on over 25 years experience to provide a solution with no user interaction. The "*automatic*" results thus obtained were independent of any engineer's interaction or skills. A responsible engineer will always check and modify the CAPWAP results and almost always include additional analysis. The automatic result, however, is presented to show that the completely automated solution gives reasonable results.

After CAPWAP automatic matching was complete, the soil model was manually iteratively improved to obtain a "*best match*" (with lower error differences) with a standard soil model. This standard practice involves, as a minimum, the review of resistance distribution and other dynamic

