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BEARING CAPACITY PREDICTION BY WAVE EQUATION ANALYSIS—STATE OF THE ART

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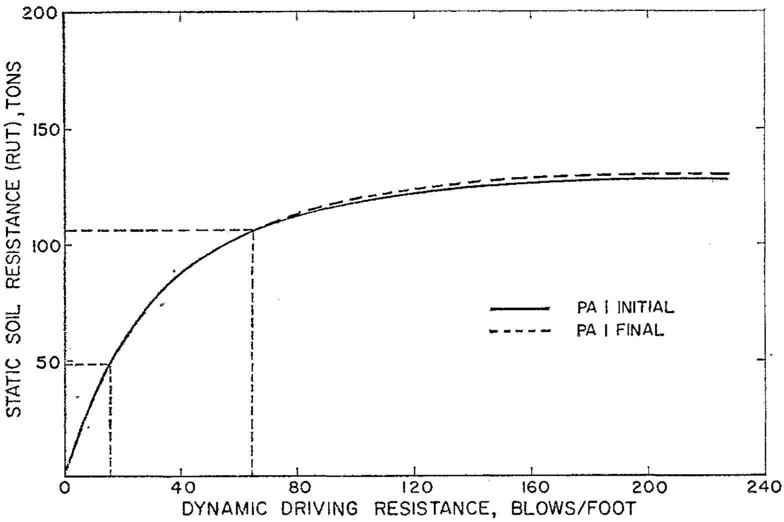

Bearing Graph for Port Arthur Test Pile No. 1

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Bearing Capacity Prediction by Wave Equation Analysis—State of the Art

by

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This investigation was conducted under Research Study 2-5-67-125 entitled "Bearing Capacity for Axially Loaded Piles" which is a cooperative research endeavor sponsored jointly by the Texas Highway Department and the U. S. Department of Transportation, Federal Highway Administration. The broad objective of this study is to develop a procedure whereby the bearing capacity of an axially loaded pile can be determined for any combination of soil and driving conditions.

A brief historical outline of the developments leading to the use of the wave equation method for pile driving analysis is presented. For purposes of analysis, the total pile driving system is considered as being composed of two distinct entities, the hammer-pile system and the pile-soil system. The technique by which each system is mathematically simulated within a digital computer program is described, and required program input parameters are explained.

Two steel pipe piles in clay and three prestressed concrete piles in sand and clay are instrumented with strain gages at the head and tip to determine static load distribution between friction and end bearing. Intermediate gages are installed at various points to determine load transfer versus pile movement. The piles are driven and load tested statically within one to two hours. After a period of eight to eleven days the piles are again load tested and then redriven an additional two to three feet. A complete soil profile, driving record, and static load test data tabulation is given for each pile test.

The test data are used to determine several soil parameters which are associated with the pile-soil system simulation in the wave equation computer program. Normalized load transfer and tip-load versus pile movement curves are plotted for sand and clay, from which the soil loading quake (idealized maximum elastic deformation) values are determined. Unloading quake values are determined from observed pile rebound upon removal of static test load and the elastic constants of the pile.

Dynamic force versus time data at the top of each test pile were recorded for the last two to three feet of initial driving and the first two to three feet of redriving. These data are used to determine the friction damping parameters J′ and the point damping J for sand and clay. These parameters are associated with the method for simulating the dynamic load versus deformation characteristics of the soil. Damping parameters are chosen on the basis of matching computed pile stresses and blow counts with the corresponding values measured during field testing.

The soil quake and damping parameters determined from static load test and force-time data are used to predict pile stresses and blow counts using a method which simulates the action of the pile driving hammer to compute the force applied at the head of a pile during driving. Hammer input data are also used to compute a bearing capacity versus blow count curve for each test pile for prediction of bearing capacity from the field driving records. When diesel hammer simulation data are used it is found that the computed stiffness value at the head of the pile must be reduced to obtain acceptable agreement between computed and measured pile stresses. Better results are obtained with measured force versus time input.

Applications of wave equation analysis to several types of pile driving problems are discussed. Field control of driving stresses, development of bearing capacity versus depth curves from driving records, and comparison of pile driving hammers are discussed.

The following salient conclusions are made:

1. Force versus time input data yield the most accurate prediction of pile stress and blow count. Sufficiently accurate results for use in practice are achieved with adjusted AE/L values in connection with hammer input data.

2. Computer input parameters for the pile-soil system are:

a. $Q_{side} = Q_{point} = 0.1$ (loading and unloading), $J_{side} = 0.2$, $J_{point} = 0.01$ for piles in clay.

b. $Q_{side} = 0.2$, $Q_{point} = 0.4$ (loading), $Q_{side} = Q_{point} = 0.1$ (unloading), $J_{side} = 0.5$, $J_{point} = 0.15$ for piles in saturated sand.

The following recommendations are offered:

1. A simple device for recording the peak dynamic force at the head of a pile should be developed and field tested.

2. Instrumented piles should be driven and tested in silts and unsaturated sands, and differing soil profiles, to validate the findings of this study for other field conditions.

3. At least one instrumented prestressed concrete pile should be driven and tested at 25%, 50%, and 75% total penetration to investigate tensile stresses.

4. A standard procedure should be developed for field determination of blow count.

5. The present method of static analysis should be refined so that an accurate determination of pile load distribution can be made when instrumented pile data are not available.

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