Ain Shams University
Faculty of Engineering
Department of Structural Engineering

Behavior of Piled Raft Foundation in Calcareous Cemented Sand

A Thesis
Submitted in Partial Fulfillment for the Requirements of the Degree of Doctor of Philosophy in Civil Engineering (Structural Engineering)

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STATEMENT

This dissertation is submitted to Ain Shams University for the degree of Doctor of Philosophy in Civil Engineering (Structural Eng.)

The work included in this thesis was carried out by the author in the Structural Engineering Department, Faculty of Engineering, Ain Shams University, Cairo, Egypt.

No part of this thesis has been submitted for a degree or qualification at any other university or institution.

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ABSTRACT

The calcareous cemented sand exists in many places around the world where in last two decades there was a huge development. During such huge development, the foundation design was a major challenge. This research aims to introduce the piled raft foundation as a competitor solution for this challenge.

To achieve this goal, a research plan consist of four stage was planned by the author. These stages are investigating the characteristic behavior of calcareous cemented sand, selecting a presentable constitutive law for the calcareous cemented sand, utilizing pile load test result to calibrate the constitutive law parameters, and analysis a case history dealing with conventional piled foundation using the piled raft concept respectively.

Investigating the characteristic behavior of calcareous cemented sand reveals a cohesion intercept because of existence of carbonates as bonding agent at points of contact between the particles and interlocking between the particles. Also, investigating the characteristic behavior of calcareous cemented sand shows increased stiffness with depth, small difference between the peak friction angle and residual friction angel, and unloading reloading stiffness is higher than the loading stiffness.

Based on this characteristic behavior of calcareous cemented sand, double hardening soil model has been utilized as a suitable constitutive law to represent the stress strain behavior of calcareous cemented sand. In light of available published triaxial tests on calcareous cemented sand, the parameters of double hardening soil model were estimated. Moreover, calibration of these parameters was conducted via back calculation of real pile load tests in calcareous cemented sand.

In the end of this research, a conventional case history dealing with pile foundation was redesigned applying the piled raft concept, where raft, pile, and soil mutual interactions were introduced using a 3D finite elements analysis. The soil was modeled by the double hardening model, the raft was utilized using plate element, and the piles were modeled using embedded pile model.

Keywords: Calcareous cemented sand, hardening soil model, single pile, piled raft.

GLOSSARY OF SYMBOLS

B	: Pore water pressure coefficient
c	: Cohesion
c_u	: Coefficient of Uniformity
C_N^*	: Correction Factor of Standard penetration Test
D_{10}	: size of 10 % passing in sieve analysis
D_r	: Relative Density
E	: Young's modulus
E_{50}	: Young's modulus at stress equal to 50% of ultimate stress
E_u	: Young's modulus for triaxial unloading condition
E_{oed}	: Young's modulus for oedometer
Eb	: Base Stiffness (modulus of soil below the base)
fb	: Ultimate Base Bearing
fs	: Ultimate Shaft Friction
G	: Shear modulus of the soil
K_0^{nc}	: The value of K_0 in primary one-dimensional compression
$K_{0(u)}$	: at rest earth pressure coefficient during initial unloading
L	: Length of the pile
LL	: Liquid Limit
Ms	: Shaft Flexibility factor
m	: The power of the stress-dependent stiffness formulation
PL	: Plastic Limit
P_{ref}	: Reference stress level
Q	: Applied load
R_f	: Failure ratio, which determines the strain level at failure
r_0	: Pile radius
r_m	: Influence radius at which shear stresses become negligible
u	: Pore water Pressure
$\Delta\phi_1$	: Correction for the particle shape

$\Delta\phi_2$: Correction for the particle size (effective size, D_{10})

$\Delta\phi_3$: Correction for gradation (uniformity coefficient, c_u)

$\Delta\phi_4$: Correction for relative density (D_r)

$\Delta\phi_5$: Correction for type of mineral

υ : Poisson’s ratio

υ_{ur} : Poisson's ratio for unloading and reloading

ϕ : Friction angle

ϕ_{max} : Peak friction angle

ϕ_{cv} : Critical state friction angle

ψ : Dilatancy angle

σ_3 : Confining Pressure of the Triaxial Cell

σ_n : Total Normal Stresses

σ'_n : Effective Normal Stresses

$\sigma'v$: Effective Overburden Stresses

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