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STUDY OF CARRYING CAPACITY BY THE ROCK SOCKETED REGION OF BORED CAST IN-SITU PILES

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(09/8818)

Degree of Master of Engineering in Foundation Engineering and Earth Retaining System

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The Dissertation was submitted to the Department of Civil Engineering of the University of Moratuwa in partial fulfillment of the requirements for the Degree of Master of Engineering

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Declaration

I hereby declare that the research dissertation entitled "Study of Carrying Capacity by Rock Socketed Region of Bored Cast In Situ Piles" submitted by me in partial fulfillment of the requirements for MEng, is my original work and that it has not previously formed on the basis of any other academic qualification at any institution.

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The above candidate has carried out research for the Masters dissertation under my supervision.

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Abstract

Bored cast in-situ pile socketed in to hard rock is the widely used method to transfer the heavy super structure loads to the rock through soft over burden soil. Finding carrying capacity of the socketed region is the most significant part in the design of in situ piles. There are many empirical formulae and factors shall be used to find the ultimate loads. Finite element analysis offers an excellent opportunity to study pile-soil interaction, pile response and soil movement under vertical loading in different sub surfaces. The common geotechnical software *PLAXIS* 2D which is capable for analyses different subsurface and bed rock with different loading conditions used for the research studies.

This research was attempted to find out the vertical carrying capacity with settlement of the bored cast in-situ piles socketed into bed rock and embedded through weathered rocks.

The *PLAXIS* 2D software was examined for its validation to use for the research studies. The Mohr-Coulomb model, axi-symmetric problem is simulated for single pile. The applied load is simulated as uniform pressure at the top. The following publications were examined and has been confirmed its validation; such as "Numerical simulation of vertical loaded piles" (Proceedings of Indian Geotechnical Conference December 15-17, 2011, Kochi (Paper No. N-118)), "Load distribution curves in Rock Socketed Piles", (Based on Kulhawy& Goodman, 1987) and "Distribution of side wall shear stress curve in relation to socket length and modulus ratio" (after Osterberg and Gill).

For these research studies bed rock parameters were extracted from the table 3.5: Rock Mass Rating System (After Bieniawski, 1989) for RMR; 20, 40, 60 and 81 rocks. The parameters are given in Table 3.6 to Table 3.9. Weathered rock, completely weathered rock and soft soil parameters are assumed based on Tomlinson and given in Table; 3.13.

Axi-symmetry finite element models are developed with the use of *PLAXIS 2D* software. The FEM models are developed and run for all type of rocks considered for

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this studies with varying embedded lengths. The ultimate carrying capacities and the settlement of the pile top are found.

The theoretical end bearing capacities are estimated for the bored piles socketed into bed rock using the method proposed in BS 8004.The equation proposed by William et al.(1981) (after Tomlinson, 1995) $F= \alpha\beta q_{uc}$ and chart proposed by William et al.(1981) and Rosenberg & Journeaux (1976) are used to estimate the ultimate shaft resistance for the same. The theoretical settlement was estimated for bed rocks and weathered rocks using equation proposed by Poulos and Davis (1996) and the pile head settlement proposed by Tomlinson.

Results from the FEM analysis and the values determined from the empirical formulae were compared. From these studies very reasonable agreements were found for carrying capacities and the settlements for both bed rock and weathered rocks. The vertical carrying capacity of the pile embedded in to completely weathered rock is significant value.

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Key words: Bored Cast in-situ piles, Vertical Carrying capacity, Ultimate Shaft Resistance, End bearing capacity, FEM Model, *PLAXIS 2D*

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Delegation

I delegate this thesis to my beloved family members who are the pillars of my strength and existence.

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Appendix A - Model Studies

Appendix B - Historical Studies

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List of symbols & Abbreviations

A_p Cross-sectional area of pile

C Cohesion

CNL Constant normal load

CNS Constant normal stiffness

C_p Pile perimeter

D Pile diameter

E_m Rock mass modulus

E_p Pile elastic modulus

E_s Soil elastic modulus

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E_{SB} Initial tangent modulus

f_s Unit shaft resistance

Fs Ultimate shear resistance

f'_c 28-day compressive cylinder strength of the concrete

f_{max} Ultimate unit shaft resistance

FOS Factor of safety

G_s Soil shear modulus at small strain

GSI Geological strength index

I Settlement influence factor

J	Mass factor
JCS	Joint wall compressive strength
JRC	Joint roughness coefficient
L	Socketed length
LRP	Laser roughness profiler
m_b	Material constant for rock mass
m_i	Material constant for intact rock
q_{max}	Unit ultimate toe resistance
F_S	Total shaft resistance on Rock
R_{inter}	Strength Reduction factor
q_{uc}	Unconfined compressive strength
Q_u	Ultimate end bearing
q_{all}	Allowable end bearing pressure
Q_{TU}	Ultimate total carrying capacity
RMR	Rock mass rating
RQD	Rock quality designation
u	Horizontal displacement
UCS	Unconfined compressive strength
v	Vertical displacement

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α	Adhesion empirical factor
β	Shaft resistance empirical factor
γ	unit weight.
δ_{inter}	Real Interface Thickness
σ_c	Unconfined compressive strength
σ_{ci}	Unconfined compressive strength of intact rock
σ_{cm}	Unconfined compressive strength of rock mass
σ_n	Normal stress
τ	Shear stress
v_p	Poisson's ratio of pile concrete
v_m	Poisson's ratio of rock mass
v_s	Poisson's ratio of soil
$\emptyset_b$	Basic friction angle
$\emptyset_r$	Residual friction angle
ψ	Dilatation angle

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