

DEDICATION

TO THE SOUL OF MY PARENTS

MY LIFE COMPANION MY WIFE

MY DEAR SONS

MY SISTERS, BROTHERS AND FRIENDS

ACKNOWLEDGEMENTS

Praise be to Allah, and peace be upon his messengers.

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to achieve this work.

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Mukdad M. Al-Amery / 2005

ABSTRACT

In this study 24 sites in Khartoum City were analyzed using ADINA program to find the ultimate vertical capacity for the piles with different lengths and diameters. The analysis process depended on information derived from previous soil investigations for the sites considered in the thesis. In each site the average value for each soil parameter was estimated from all boreholes in that site. Also the average thickness of each soil layer had been calculated. In this study the piles and soil were modeled by solid 2-dimensional rectangular isoparametric 8 or 9-node elements. The elements of the pile were assumed to remain elastic at all times, and the soil was idealized as either a linear elastic material or a Mohr-Coulomb elastoplastic material.

The analysis process started with applying loads to piles incrementally until a failure was encountered. The analysis results coupled with the coordinates of the sites, were loaded into a 3D Field Pro Beta v0.76 program for mapping contour lines for them. From these contour maps it had been found that pile load capacities in the north-western region of Central Khartoum are larger than those in the south-eastern region. Also pile load capacity for Khartoum Airport site and the surrounding area was small at all depths, this indicated generally the low strength of the soil in this area.

From analysis results it had been found that pile axial capacity increased with the increase in the pile diameter and length. But the settlement of pile decreased with the increase of pile length and diameter. Besides that pile load capacity and pile settlement are affected by soil type around it.

Also it had been found that the shear stress on the pile surface and in the soil near it are affected by pile load value, pile diameter and soil type around it, and the effect of soil plasticity on the axial response of a single pile is significant at high loads.

When the pile is loaded, the distribution of vertical stress along pile decreases with the increase in pile diameter. The highest vertical stress is on the top of the pile and decreases gradually towards its bottom. But the stresses on the soil are low (compared to the pile) and they decrease gradually towards the top of the pile and away from it. The highest strain is in the soil surrounding the bottom of the pile, and it decreases gradually also towards the top and away from pile. But the strain in the pile is small. The highest vertical displacement is in the vicinity of the pile. The settlement

of the soil around the pile will be less according to its distance away from it. The horizontal strain is tension at the bottom of the pile and compression at the top of the pile.

الخلاصة

في هذه الدراسة تم تحليل 24 موقع في مدينة الخرطوم باستعمال برنامج (ADINA) لإيجاد التحمل العمودي الأقصى لركائز مختلفة بالطول و القطر. عملية التحليل تعتمد على معرفة مستمدة من استطلاعات تربيه سابقة للمواقع المدروسة في هذه الأطروحة. في كل موقع تم حساب المعدل لكل خاصية للتربة من كل حفر الاستطلاع في ذلك الموقع. كذلك تم حساب معدل السمك لكل طبقة تربة.

في هذه الدراسة مثلت الركائز و التربة بواسطة عناصر محددة مستطيلة ثنائية البعد صلبة موحدة الخواص ذات 8 أو 9 عقد. العنصر المحدد في الركيزة فرض بقاءه مرن في كل الأوقات، والعنصر المحدد في التربة مثل كمادة مرنة خطية أو مادة مرنة- لدنه مستوفية لنظرة مور - كولمب (Mohr-Coulomb elastoplastic).

عملية التحليل تبدأ بتسليط الأحمال على الركائز تدريجيا حتى يحدث الفشل. هذه النتائج تربط مع إحداثيات المواقع وتحمل على برنامج (3D Field Pro Beta v0.76) لرسم الخطوط الكنتورية لها. من خلال هذه المخططات الكنتورية وجد أن سعة تحمل الركائز في منطقة الشمال الغربي لمركز الخرطوم أكبر من منطقة الجنوب الشرقي كذلك وجد أن سعة تحمل الركائز لموقع مطار الخرطوم و المساحة التي حوله صغيرة في كل الأعماق و هذا مؤشر عام لانخفاض قوة التربة في هذه المساحة.

من نتائج التحليل وجد أن التحمل الرأسي للركيزة يزداد بزيادة قطر وطول الركيزة. لكن هبوط الركيزة يقل مع زيادة طول وقطر الركيزة وبجانب ذلك فأن سعة تحمل الركيزة و هبوط الركيزة يتأثران بنوع التربة التي حولها. كذلك وجد أن إجهاد القص على سطح الركيزة وفي التربة القريبة منها يتأثر بمقدار حمل الركيزة وقطر الركيزة ونوع التربة التي حولها. تأثير لدونة التربة على الاستجابة الرأسية لركيزة مفردة يبرز في التحميل العالي. عند تحميل الركيزة يقل توزيع الإجهاد العمودي على طول الركيزة مع زيادة قطر الركيزة. أعلى إجهاد عمودي يكون على أعلى الركيزة ويقل تدريجيا باتجاه الأسفل ولكن هناك إجهادات قليلة على التربة (مقارنة مع الركيزة) تقل تدريجيا باتجاه أعلى الركيزة و بعيدا عنها. أعلى انفعال يكون في التربة حول أسفل الركيزة ويقل تدريجيا كذلك باتجاه الأعلى وبعيدا عنها ولكن الانفعال في الركيزة يكون صغيرا.

أعلى إزاحة عمودية للركيزة تكون في جوار الركيزة بينما الهبوط للتربة التي حولها يقل تدريجيا استنادا إلى بعدها عن الركيزة والانفعال الجانبي يكون شدا في التربة التي حول أسفل الركيزة وضغطا في التربة التي حول أعلى الركيزة.

Table of Contents

	<u>Page</u>
<i>Dedication</i>	<i>i</i>
<i>Acknowledgement</i>	<i>ii</i>
<i>Abstract</i>	<i>iii</i>
<i>Abstract in Arabic</i>	<i>v</i>
<i>Table of Contents</i>	<i>vi</i>
<i>List of Figures</i>	<i>ix</i>
<i>List of Tables</i>	<i>xiv</i>
<i>List of Symbols</i>	<i>xv</i>

Chapter One : INTRODUCTION

1.1 Introduction.....	1
1.2 Objectives.....	1
1.3 Methodology.....	1
1.4 Thesis organization.....	2

Chapter two : LITERATURE REVIEW

2.1 Introduction.....	3
2.2 Types Of Piles In Terms Of Material.....	4
2.2.1 Steel Piles.....	4
2.2.2 Concrete Piles.....	5
2.2.3 Timber Piles.....	5
2.2.4 Composite Piles.....	5
2.3 Types Of Piles In Terms Of Load Transfer Mechanism.....	5
2.4 Load Transfer Mechanism.....	6
2.5 Classical Method For Calculation Of Bearing Capacity.....	9
2.6 Finite Element Analysis of Piles.....	17

Chapter Three : FINITE ELEMENT METHOD

3.1 Introduction.....	34
3.2 Description Of The Method.....	36
3.3 General Finite Element Formulation.....	36
3.3.1 Finite Element Formulation of 8-node Quadrilateral Element.....	39
3.3.2 For plane strain element.....	41
3.3.3 Stress-strain relation.....	43
3.3.4 For axisymmetric element.....	43
3.4 Constitutive Models For Soils And Pile.....	45
3.5 Solution Scheme in ADINA(Newton-Raphson Iteration Algorithm).....	49

Chapter Four : ANALYSIS PROCEDURE

4.1 Introduction.....	52
4.2 ADINA Program.....	53

Chapter Five : SOIL CONDITIONS IN CENTRAL KHARTOUM

5.1 Site location.....	65
5.2 Study Area.....	66
5.2.1 Basement Complex.....	66
5.2.2 Omdurman Formation.....	68
5.2.3 Tertiary Basalts.....	69
5.2.4 Gezira Formation.....	69
5.2.5 Groundwater in Khartoum Area.....	70
5.3 Description of Soil Profile of the Sites.....	72

Chapter Six : RESULTS AND DISCUSSION

6.1 Introduction.....	76
6.2 Soil Parameters.....	76
6.3 Typical Results.....	77
6.4 Contouring of Ultimate Pile Capacity.....	83
6.5 Insight into The Behavior of Piles	97
6.5.1 Distribution of Vertical Normal Stress & Shear Stress with Depth on Pile.....	101
6.5.2 Location of Yielded Elements in The Piles.....	104

6.5.3	Effect of Soil Yield.....	104
6.5.4	Effect of Pile Diameter.....	105
6.5.5	Effect of Pile Length.....	105

Chapter Seven : SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

7.1	Summary.....	111
7.2	Conclusions.....	111
7.3	Recommendations.....	113

<u>REFERENCES</u>		114
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APPENDAX

Appendix A		117
Appendix B		123
Appendix C		147
Appendix D		167

List of Figures

<u>Figure #</u>	<u>Title</u>	<u>Page</u>
2.1	Conditions for Use of Pile Foundations. (Source : Dass, 1999).....	4
2.2	Load Transfer Mechanism For Pile. (Source : Dass, 1999).....	8
2.3	Ultimate Load-Carrying Capacity of Pile. (Source : Dass, 1999).....	9
2.4	Nature of Variation of Unit Point Resistance in A Homogeneous..... Sand. (Source : Dass, 1999).	10
2.5	Variation of $(L_b/D)_{cr}$ with Soil Friction Angle. (Source : Dass, 1999).....	10
2.6	Variation of The Maximum Values of N_c^* and N_q^* with Soil Friction Angle ϕ . (Source : Dass, 1999).	11
2.7	Compaction of Sand near Driven Piles. (Source : Dass, 1999).....	12
2.8	Unit Frictional Resistance for Piles in Sand. (Source : Dass, 1999).....	12
2.9	Variation Of λ with Pile Embedment Length. (Source : Dass, 1999).....	15
2.10	Variation Of α with Undrained Cohesion of Clay..... (Source : Dass, 1999).	15
2.11	(A)Schematic Diagram of Pile Load Test Arrangement;..... (B)Plot of Load Against Total Settlement; (C)Plot of Load Against Net Settlement (Source : Dass, 1999).	17
2.12	Typical Finite Element Mesh Used by Mohamedzein et al. (1999).....	20
2.13	Comparison of Vertical Movement Of Pile Between F.E. and Field..... Experiment (After Mohamedzein et al. 1999).	21
2.14	Typical Finite Element Meshes: A)Single Pile Mesh ;..... B)Two-Pile Mesh (Source: Trochanis et al. 1991).	23
2.15	Comparison of Soil Surface Displacements away from Pile as Predicted..24 by Three-Dimensional Model and by Elastic Theory (a)vertical displacements;(b) horizontal displacements(Source : Trochanis et al. 1991).	24
2.16	Comparison Of Three-Dimensional Model With File Test In Mexico..... City, Head Load –Settlement Curves. (Source : Trochanis et al. 1991).	24

2.17	Effects of Pile-Soil Slippage and Soil Plasticity on Axial Pile Response...26 a)Load-Settlement Curves ; b)Shear Friction Distribution with Depth (Source : Trochanis et al. 1991).	
2.18	Effects of Pile-Soil Slippage and Soil Plasticity on Vertical Soil.....26 Surface Displacements Away From Pile Loaded Axially: (a)Detail Of Deformed Pile-Soil System Around Pile Tip ; (b)Normalized Vertical Soil Surface Displacements (Source : Trochanis et al 1991).	
2.19	One-Dimensional Beam-Column Elements : a) Discretization ; 27 b)Beam-Column Element. (Source : Armaleh and Desai 1987).	
2.20	Comparison between Finite Element Predictions and Observations,... 28 Pile2 a) Load-Displacement Curves; b) Gross Load Versus Tip and Wall Loads; c) Distribution of Load in Pile (Source : Armaleh and Desai 1987).	
2.21	Load Displacement Curve for Comparison with O'Neil's(1982b) Test....30 (Source : Kucukarslan and Banerjee 2004).	
2.22	Load Displacement Curve for Comparison with31 Berezantzev et al.'s (1961) test (Source : Kucukarslan and Banerjee 2004).	
2.23	Load Displacement Curve for Comparison with31 Berezantzev et al.'s (1961) test (Source : Kucukarslan and Banerjee 2004)	
2.24	Finite Element Mesh (Source : Madabhushi and Haigh 2004).....32	
2.25	a)True boundary conditions b)Modeled boundary conditions.33 (Source : Madabhushi and Haigh 2004).	
3.1	The Process Of Finite Element Analysis (Bathe 1996).....34	
3.2	8-node Isoparametric Quadrilateral Element.....38	
3.3	The Yield Surfaces Of The Mohr-Coulomb Model And.....45 The Drucker-Prager Model.	
3.4	The Mohr-Coulomb Model In $I_1, \nu s, \sqrt{J_2}$ Space.....45	
3.5	Shapes of The Mohr-Coulomb and The Drucker-Prager Yield46 Criteria on The Plane.	
3.6	Corner Treatment Of The Mohr-Coulomb Model.....46	
4.1	Typical Finite Element Mash Used in This Study.....53	
4.2	Simple Schematic for ADINA Program.....54	
4.3	Degree of Freedom Selection Interface Menu in ADINA.....55	

4.4	Define Time Function Interface Menu in ADINA.....	55
4.5	Defining Time Steps Interface Menu in ADINA.....	56
4.6	Point Coordinate Table Interface Menu in ADINA.....	57
4.7	Define Surface of The Model Interface Menu in ADINA.....	58
4.8	Define Pile and Soil Layer Material Interface Menu in ADINA.....	58
4.9	Define Element Group Interface Menu in ADINA.....	50
4.10	Apply fixity Interface Menu in ADINA.....	61
4.11	Subdivision of a Model Interface Menu in ADINA.....	61
4.12	Mesh Surface Interface Menu in ADINA.....	63
4.13	Apply Load Interface Menu in ADINA.....	63
4.14	ADINA Solution Interface Menu in ADINA.....	64
5.1	Location Map Showing The Investigated Boreholes Stations in The Study Area-Khartoum (Source : Mohamed 2001).	65
5.2	General geological map of Khartoum area..... (Based on Sudan geological map 1981) (Source : Mohamed 2001).	67
5.3	Sketch block diagram of the northern part of Khartoum basin. (Source : Mohamed 2001).	71
6.1	Location Map Showing The Investigated Boreholes Stations in Central Khartoum.	80
6.2	Settlement-Load Relationship for Sudanese Company Site..... Piles Lengths 6,8,10,12 and 15m.	81
6.3	Settlement-Load Relationship for N.E.C. Head Quarters Site..... Piles Lengths 6,8,10,12 and 15m.	82
6.4	Contour Lines for the Ultimate Pile Capacity for Piles of Length of 6m and Diameter of 0.5m in Central Khartoum.	86
6.5	Contour Lines for the Ultimate Pile Capacity for Piles of Length of 8m and Diameter of 0.5m in Central Khartoum.	87
6.6	Contour Lines for the Ultimate Pile Capacity for Piles of Length of 10m and Diameter of 0.5m in Central Khartoum.	88

6.7	Contour Lines for the Ultimate Pile Capacity for Piles of Length of 12m and Diameter of 0.5m in Central Khartoum.	89
6.8	Contour Lines for the Ultimate Pile Capacity for Piles of Length of 15m and Diameter of 0.5m in Central Khartoum.	90
6.9	Location Map Showing The Two Different Regions. in Central Khartoum.	91
6.10	Contour Lines for the Ultimate Pile Capacity for Piles of Length of 8m and Diameter of 0.5m in Central Khartoum / Region 1	93
6.11	Contour Lines for the Ultimate Pile Capacity for Piles of Length of 12m and Diameter of 0.5m in Central Khartoum / Region 1	94
6.12	Contour Lines for the Ultimate Pile Capacity for Piles of Length of 8m and Diameter of 0.5m in Central Khartoum / Region 2	95
6.13	Contour Lines for the Ultimate Pile Capacity for Piles of Length of 12m and Diameter of 0.5m in Central Khartoum / Region 2	96
6.14	Horizontal and Vertical Displacements for Pile of Length 10m and Diameter of 1.0m in Burri Power Station Site.	98
6.15	Stress Vector Plot for Pile of Length 6m and Diameter of 0.5m (N.E.C. Burri Power Station Site).	99
6.16	Strain Vector Plot for Pile of Length 10m and Diameter of 1.0m (N.E.C. Burri Power Station Site).	100
6.17	Distribution of Vertical Stress with Depth for Pile of Length 10m in N.E.C. Head Quarter Site.	102
6.18	Distribution of Shear Stress with Depth for Soil and Pile of Length 10m and Diameter of 0.3m in N.E.C. Head Quarter Site.	102
6.19	Distribution of Shear Stress with Depth for Soil and Pile of Length 10m and Diameter of 0.5m in N.E.C. Head Quarter Site.	103
6.20	Distribution of Shear Stress with Depth for Soil and Pile of Length 10m and Diameter of 0.76m in N.E.C. Head Quarter Site.	103
6.21	Distribution of Shear Stress with Depth for Soil and Pile of Length 10m and Diameter of 1.0m in N.E.C. Head Quarter Site.	104
6.22	Location of Yielded Elements for Pile of Length 10m and Diameter of 0.76m in N.E.C. Head Quarters Site.	106
6.23	Location of Yielded Elements for Pile of Length 10m and Diameter of 0.3m in N.E.C. Head Quarters Site.	107

6.24	Load-Settlement Curves for N.E.C. Head Quarter	108
	(Pile Length 8m and Pile Diameter 0.3m).	
6.25	Load-Settlement Curves for Sudanese Company for Insurance 108	
	and Reinsurance Site (Pile Length 8m and Pile Diameter 0.3m).	
6.26	Effect of Pile Diameter on Maximum Load 109	
	for Sudanese Company for Insurance and Reinsurance Site.	
6.27	Effect of Pile Diameter on Maximum Load 109	
	for Hotel and Commercial Development Site.	
6.28	Effect of Pile Length on Maximum Load 110	
	for Sudanese Company for Insurance and Reinsurance Site.	
6.29	Effect of Pile Length on Maximum Load 110	
	for Hotel and Commercial Development Site.	

List of Tables

<u>Table #</u>	<u>Title</u>	<u>Page</u>
2.1	Average Values of Effective Lateral Earth Pressure Coefficient, K , (Source : Das, 1999).	14
2.2	Categories of analysis /design procedures (Source :Poulos,1995)	19
3.1	Interpolation Function For Four to Eight Nodes For Two Dimensional Isoperimetric Element. (Source :Mohamedzein, 1989).	40
6.1	Typical Values of Poisson's Ratio, ν , and Modulus of Elasticity, E , (Source : Das, 1999).	77
6.2	Summary of Ultimate Pile Load Capacity for All Sites.	84

List of Symbols

Q_1	The side friction developed along the shaft of pile.
Q_2	The soil resisting below the tip of the pile.
$Q(z)$	The load carried by the pile shaft.
$f(z)$	The frictional resistance per unit area at any depth (z).
p	Perimeter of the pile cross section.
Q_p	The maximum point resistance of pile (The point bearing of piles).
Q_s	The unit skin friction f along the pile shaft.
f	Unit friction resistance at any depth z .
z	The depth of pile.
Q_u	Ultimate pile capacity.
A_p	Area of pile tip.
c	Cohesion of the soil supporting the pile tip.
q_p	Unit point resistance of pile tip.
q'	Effective vertical stress at the level of the pile tip.
N_c^*, N_q^*	The bearing capacity factors.
ΔL	Incremental pile length over which p and f are taken constant.
L	Length of the pile embedment in soil.
L_b	Length of the pile embedment in bearing stratum.
D	Diameter of the pile.
ϕ	The soil friction angle.
q_l	The limiting point resistance of pile.
c_u	Undrained cohesion of the soil.
L'	the critical depth of pile when the unit skin friction remains constant.
K	Effective lateral earth pressure coefficient.
σ'_v	Effective vertical stress at the depth under consideration.
δ	Soil-pile friction angle.
$\overline{\sigma'_v}$	Average effective overburden pressure. (Mean effective vertical stress for the entire embedment length)
$\overline{N}_{COR}$	Average corrected value of standard penetration resistance.

λ	Factor changes with the depth of pile penetration.
α	Empirical adhesion factor.
Q_{all}	Allowable load-carrying capacity for each pile.
FS	Factor of safety.
S_{net}	Net settlement of the pile.
s_e	Elastic settlement of the pile itself.
S_t	Total settlement of the pile.
f_i^s	Applied surface reaction on surface s.
f_i^h	Applied body forces on volume v.
du_i	Displacement incremental vector.
σ_{ij}	Stress tensor.
$d\varepsilon_{ij}$	Strain incremental tensor.
$\underline{du}$	Displacement field within a finite element.
$\underline{N}$	Interpolation polynomials.
$d\underline{U}$	Nodal displacement.
$\underline{B}$	The strain –displacement transformation matrix.
$\underline{C}$	Material constitutive matrix (stress-strain matrix).
$\underline{\sigma}$	Stress matrix.
$\underline{\varepsilon}$	Strain matrix.
$\underline{R}$	Nodal force.
$\underline{K}$	Structure stiffness matrix.
$\underline{U}$	Nodal displacement.
h_k	The interpolation function.

$\underline{J}$	The Jacobian matrix.
$\underline{J}^{-1}$	The inverse of the Jacobian.
$(\underline{J}^{-1})^T$	The transpose of the inverse of the Jacobian.
${}^t_0 \sigma$	Engineering stresses.
${}^t_0 \varepsilon$	Engineering strains.
ψ	The dilatation angle (a material constant).
tI_1	The first stress invariant at time t .
tJ_2	The second deviatoric stress invariant at time t .
tJ_3	The third deviatoric stress invariant at time t .
$\underline{dP}$	System of applied forces.
$\underline{dF}$	Nodal forces equivalent to element stresses.
E_s	The modulus of elasticity of soil.
ν	Poisson's ratio.
N_F	Field standard penetration number.
N_{cor}	The corrected standard penetration number.