

## **DEDICATION**

**To my family.....**

## **ACKNOWLEDGEMENTS**

Praise be to Allah, and peace be upon his messengers

First I acknowledge profusely and all the thanks are due to my god who enabled me to achieve this work.

Then I acknowledge with profound gratitude and sincerity the supervision and guidance I received from my supervisor Dr.Omer E. M.FADOL, for his interest, advice, help, constructive criticism and encouragement throughout the preparation of this research.

I would like to thank my parents and my family for their encouragement throughout my study. The completion of my study would not have been possible without the supporting and understanding from my family.

## **Abstract**

The behavior of pile-cap in expansive soils layers under axial loading was investigated using axi-symmetric state , finite element model, these consists of soil continuum elements, with material non-linearities for the soil, and the pile-cap is simulated as linear elastic material. The simulation of soil swelling is based on the softening model to determine swelling potential and hence upheaval deformation in pile-cap-soil system.

The literature review was undertaken in order to provide a framework of available information regarding expansive soils and pile foundation on them.

The behavior of pile-cap has been studied extensively using different load, pile diameter, cap diameter and thickness of cap. It is found out from the results of simulation analysis that the addition of a cap to a pile and taking advantage of the axial load resistance of pile cap have been found to increase the axial load carrying capacity of pile-cap system.

The increase in size of pile cap has been found to increase the axial load carrying capacity of pile significantly.

Axial behavior of a pile-cap system is directly related to the axial capacity of the piles. Also, the results obtained using the softening model confirm the fact that the cap on expansive soils increases upheaval deformations in Pile-Cap-Expansive soils systems and induces high tensile stresses in piles.

**Key words:** expansive soil, swelling potential, softening model, upheaval deformation, pile-cap through expansive soil.

## الخلاصة

في هذه الدراسة تم التعرف علي سلوك نظام الخازوق -الوسادة في التربة المنتفخة تحت تأثير الحمل المحوري وذلك باستخدام نموذج محوري متماثل بطريقة العنصر المحدد. تم تمثيل عناصر التربة بعناصر مرنة لا خطي وعناصر الخازوق - الوسادة مُثلت بعناصر مرنة خطي. لإيجاد جهد الانتفاخ وتشوهات الانتفاخية في الخازوق والكاب تم ذلك بطريقة أنموذج الليونة الميكانيكي لحساب تشوهات التربة الطينية الانتفاخية. تم استعراض المعلومات المتوفرة بخصوص التربة المنتفخة وتأسيس الخوازيق في هذا النوع من التربة.

تمت دراسة سلوك الخازوق- الوسادة ذلك بتغير الأحمال وأقطار خوازيق والوسادة وسمك الوسادة .

من النتائج التي تم التحصل عليها من هذه المحاكاة وجد انه من محاسن إضافة الوسادة للخازوق إن الوسادة تعمل علي زيادة المقاومة التحميلية وبالتالي زيادة الحمل المحوري لنظام كذلك الزيادة في حجم الوسادة تنتج عنها زيادة في الحمل المحوري المحمول بواسطة النظام.أيضا وجد أن السلوك المحوري للنظام مرتبط بالزيادة اوالنقصان في قيمة الحمل.

وأیضا وجد في هذه الدراسة المبينة علي أنموذج الليونة و التي تؤكد علي حقيقة أن نظام الخازوق-الوسادة في التربة المنتفخة يعمل علي تفاقم مشكلة التشوهات الناتجة من الانتفاخ وزيادة الاجهادات المحورية في الخازوق وذلك إذا كان الكاب يستند علي سطح التربة مباشرة.

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### List of Symbols

<u>Symbols</u>	<u>Definition</u>
LL	Liquid limit
PI	Plasticity index
SL	Shrinkage limit
Ac	Activity of soil
C	Colloids (or clay) content
$\Delta V$	Change in initial volume of the specimen
V	Initial volume of the specimen
V <sub>s</sub>	Final volume of the specimen
$COLE_{ws}$	Coefficient of linear extensibility on a whole-soil
$\gamma_{d\ 33<2mm}$	Dry density at 33 kPa water retention on a <2 mm
$\gamma_{d\ <2mm}$	Dry density, oven-dry or air-dry, on a <2 mm
$C_m$	Coarse fragment (moist) conversion factor
$e_0$	Voids ratio
$e_f$	Final voids ratio
$\Delta e$	Change in voids ratio during heave
$\rho$	Total heave
N	Number of layers
$z_i$	Initial thickness of layer $i$
$C_{mi}$	Matric suction index for layer $i$
$C_{ti}$	Effective stress index for layer $i$
$\sigma$	Total stress
$u_a$	pore air pressure
$u_w$	pore water pressure

$\alpha$	Compressibility factor (slope of specific volume versus water content curve)
$B$	slope of suction versus water content curve
$G_s$	Specific gravity of solids
$F_i$	a reduction factor for layer $i$
$PE_i$	potential expansiveness for layer $i$
$\varepsilon_{ve}$	Swelling strain
$\sigma_{v0}$	Vertical stress
$\varepsilon_{ve0}$	Swelling strains under free load
$\varepsilon_{ve}$	Swelling strains under load
$\Delta\varepsilon_{vc}$	additional compression strain induced by softening
$P_{ev}$	Swelling pressure
$\bar{E}_c$	additional compression modulus
$\bar{E}_{cp}$	additional compression modulus according to swelling pressure
$\bar{E}_{ci}$	additional compression modulus of layer $i$ derived from the softening model.
$\bar{E}_{cp}$	additional compression modulus according to the swelling pressure
$Su$	upheaval deformations on ground of site with expansive soil layers
$\sigma_{z0i}$	Vertical stress of central point of soil layer $i$
$D$	diameter of the pile
$K$	ratio between the horizontal and vertical pressure
$Z$	depth of the active zone
$C$	cohesion of the soil

$\phi$	angle of internal friction
$\gamma$	total unit weight of the soil
$\phi_{ps}$	Effective angle of shaft-soil friction
$\alpha_1$	coefficient of uplift between the pile and the soil
$\bar{\sigma}_s$	Swelling pressure in terms of effective stresses
$W$	withholding forces
$q_{dl}$	unit dead load pressure
$f_s$	skin friction below active zone.
$L$	length of the pile
$R$	radial body forces
$Z$	Vertical body forces
$M$	Poisson's ratio
$G$	Tangent shear modulus
$\theta$	Rotational angle
$u$	Radial displacements
$w$	Vertical displacements
$P_{ev}$	Swelling pressure
$\sigma_{vo}$	Initial stresses
$\bar{E}_c$	Additional compression modulus induced by softening
$\bar{E}_{cp}$	Additional compression modulus according to swelling pressure,
$\varepsilon_{ve0}$	Swell strain under free load and
$\tau_{rzp}$	Shear stress induced by swelling
$A$	Area of element
$\sigma_1$	Major principal stresses
$\sigma_3$	Minor principal stresses



$\sigma_z$	Vertical stress
$\sigma_r$	Lateral stress
$R_f$	failure ratio
$P_a$	Atmospheric pressure
$K_{\max}$	Shear stiffness coefficient
$D_r$	Reference shear displacement