

**FINITE ELEMENT MODELLING OF DEFORMATION  
CHARACTERISTICS OF SOFT SOILS IN COLOMBO OCH  
PROJECT**

**DEGREE OF MASTER OF ENGINEERING  
FOUNDATION ENGINEERING AND EARTH RETAINING SYSTEMS**



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CHARACTERISTICS OF SOFT SOILS IN COLOMBO  
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This Thesis was submitted to the Department of Civil Engineering of the University  
of Moratuwa in partial fulfillment of the requirements for the

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Foundation Engineering and Earth Retaining Systems



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December 2012

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## DEDICATION

Dedicated to  
My beloved Parents and My Husband Prasanna



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## ABSTRACT

In Sri Lanka, currently many development projects such as major highways are being constructed over soft soil deposits of low bearing capacity and excessive settlement characteristics, mainly due to unavailability of good land and high cost involved in land acquisition. The Colombo Outer Circular Highway (OCH) is one such infrastructure development project, being constructed with the objectives of encouraging the development of current or future growth centers connected by radial routes, and diverting through traffic from the center of the city.

Deformations, stability and time required for consolidation are major considerations in the design and construction of embankments over soft sub-soils. The sub-soil of OCH Southern section consists of peat, organic and inorganic-clay and loose sand. Therefore countermeasures are required to control the settlement of underlying deep and extensive layers of soft soil. One method adopted is to install pre-fabricated vertical drains (PVD) into the underlying soft soils and place earth embankments on top, partly as necessary substructure of the highway, and partly as preload to accelerate the settlement of soft soils beneath.

This work presents a numerical simulation of the deformation of the earth embankments and soft soil underlying the Colombo Outer Circular Highway. Finite Element analysis software Plaxis 8.2(2002) is used to model the long-term creep deformation behavior of soft soil loaded by embankments, with pre-fabricated vertical drains installed in the soft soil strata. Two constitute models are used for the analysis; Mohr-Coulomb Model to represent the earth embankment and Soft Soil Creep model to simulate the soft sub soils.

A major effort was needed to determine appropriate material parameters for input to the selected constitutive models, and the final selection was made based on empirical considerations. The actual three-dimensional problem domain is converted to equivalent two-dimensional plane-strain domain. The equivalence between the plane-strain and axi-symmetric analyses were established by a permeability matching

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procedure. All field conditions including the load incrementing sequences are simulated, and coupled consolidation/creep analysis is performed to predict the settlement behavior. Numerical predictions are compared with observed field settlement records, and agreement is seen between the predicted results and the observed field measurements, indicating the feasibility of using the numerical model for predicting purposes, and the empirical method need to determine the applicable material parameters for the selected constitutive models.



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Weerawarna Nilaweera Ran Patabandighe Nadeeka Nilminie

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## List of Symbols

B - Half width of plane strain cell

$b_s$  - Half width of the smear zone

$b_w$  - Half width of the drain

C - Cohesion

$C_c$  - Compression Index

$C_r$  - Recompression index

$C_\alpha$  - Coefficient of Secondary Compression

D - Influence zone

$d_w$  - Equivalent diameter of band drain

E - Young's modulus

$E_s$  - Static deformation modulus

$e_{int}$  - Initial voids ratio

$k_{hp}$  - Plane Strain horizontal permeability

$k'_{hp}$  - Smear zone horizontal permeability

$k_h$  - Vertical permeability

$k_s$  - Smear zone permeability

$k_v$  - Horizontal permeability

$k_x$  - Plane strain Horizontal permeability

$k_y$  - Plane strain Vertical Permeability



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n- Spacing ratio

$q_z$  -Equivalent plane strain discharge capacity

R- Radius of axisymmetric unit cell

$r_s$  - axisymmetric radii of smear zone

$r_w$  - axisymmetric radii of drain

s- Drain spacing

$\bar{s}^2$  - Mean square distance of flow net

T- Ultimate Tensile Strength

$T_{hp}$  - Time factor in Plane strain

$U$  -Overall degree of consolidation

$U_r$  - Average degree of consolidation due to radial drainage

$U_v$  - Average degree of consolidation due to vertical drainage

$\bar{U}_h$  - Average degree of consolidation for axisymmetric

$\bar{U}_{hp}$  - Average degree of consolidation for equivalent plane strain condition

$\bar{u}$  - Pore pressure at time t

$\bar{u}_0$  - Initial excess pore pressure

$\phi$  - Internal friction Angle

$\Psi$  -Dilatancy Angle

v- Poisson's ratio

$\gamma_{sat}$  - Saturated Unit weight

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$\gamma_{unsat}$  Bulk Unit weigh



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