EVALUATION OF THE STIFFNESS AND STRENGTH PARAMETERS OF HARDENING SOIL MODEL FOR THE SIMULATION OF THE TWIN TUNNELS INTERACTION IN KENNY HILL FORMATION RESIDUAL SOIL

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by

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LIST OF ABBREVIATIONS

ANN	Artificial Neural Network
C/D	Cover to Tunnel Diameter Ratio
CIU test	Consolidated Isotropic Undrained triaxial test
CPT	Cone Penetration Test
DEM	Discrete Element Method
FE	Finite Element
FEM	Finite Element Method
HS	Hardening Soil
IDW	Inverse Distance Weighting
OK	Ordinary Kriging
KVMRT	Klang Valley Mass Rapid Transit
MC	Mohr Coulomb
MZ	Morphological Zone
NB	North Bound tunnel
PMT	Pressuremeter Test
SB	South Bound tunnel
SBK	Sungai Buloh Kajang
SPT	Standard Penetration Test
SPT-N	Standard Penetration Test Blow Count Value
TBM	Tunnel Boring Machines
Z4h	Region in Zone 4 with twin tunnels in horizontal alignment
Z4i	Region in Zone 4 with twin tunnels in inclined alignment
Z4v	Region in Zone 4 with twin tunnels in vertical alignment

LIST OF SYMBOLS

$Z(X_o)$	Interpolation value of Inverse Distance Weighting (IDW) function
$Z(X_i)$	Value at measured data points
n	Number of data points (borehole)
W_i	Weighted value assigned to data point
h_i	Distance between data points
μ	Stationary mean
λ_i	Kriging weight
$\mu(x_o)$	Mean of sample within search boundary
γ	Semivarience of true value Z
S(x)	Surface settlement at point x
S_{max}	Maximum point of tunnelling induced surface settlement trough
i	Horizontal distance between tunnel centreline and point of inflection
V_s	Volume of settlement trough
z_o	Tunnel overburden
R	Tunnel radius
V_L	Volume loss
V_t	Over excavation volume
β	Stress release factor
P_o	Original soil pressure at tunnel boundary
P_β	Soil pressure at tunnel boundary
τ’	Effective stress shear strength
c’	Effective stress cohesion
σ’	Effective overburden pressure

ϕ'	Effective stress friction angle
E_i	Initial stiffness modulus
R_f	Failure ratio
q_f	Ultimate deviatoric stress
E_{50}	Secant stiffness in standard drained triaxial test
E_{oed}	One-dimensional compression stiffness
E_{ur}	Unload-reloading stiffness
σ_h'	In-situ horizontal pressure
σ_v'	In-situ vertical pressure
P_l	Limit pressure of soil
G	Shear modulus of soil
E_m	Elastic modulus of soil
S_u	Undrained shear strength
ψ	Dilation angle
ϕ_{peak}	Peak angle of friction
Lu	Lugeon value
K	Coefficient of permeability
e	Void ratio
P_c	Pre-compression pressure
C_c	Compression index
V_{ur}	Poisson's ratio for unload-reloading

PENILAIAN PARAMETER KEKAKUAN DAN KEKUATAN DALAM MODEL PENGERASAN TANAH UNTUK SIMULASI INTERAKSI ANTARA TEROWONG BERKEMBAR DI DALAM TANAH SISA FORMASI GEOLOGI KENNY HILL

ABSTRAK

Simulasi berangka untuk masalah geoteknikal sering melibatkan proses pemudahan dan andaian kerana ia merupakan tugasan hampir mustahil untuk mensimulasikan semua ciri-ciri yang terlibat dalam persekitaran tanah. Untuk pembinaan berskala besar, terutamanya seperti pembinaan terowong berkembar Klang Valley Mass Rapit Transit (KVMRT) dibawah persekitaran bandar, simulasi geoteknik yang realistik adalah penting kerana pembinaan terowong akan mempengaruhi kestabilan struktur-struktur di atas permukaan dan bawah tanah. Dalam kajian ini pendekatan parameter penentuan dicadangkan untuk menentukan kekerasan dan kekuatan parameter untuk model Pengerasan Tanah (HS) berdasarkan tafsiran ujian tanah in-situ dan makmal. Penyiasatan ciri-ciri subpermukaan tanah dilakukan dengan membentuk model tanah, model terowong tiga dimensi dan keratan rentas subpermukaan tanah untuk empat zon yang dibahagikan daripada kawasan kajian berdasarkan keserupaan dari segi litologi dan taburan nilai SPT-N. Tiga keratan rentas tanah yang kritikal telah dikenalpastikan berdasarkan input daripada model terowong, keratan rentas tanah, konfigurasi terowong berkembar yang terlibat dan data pergerakan tanah yang disebabkan oleh pembinaan terowong yang sedia ada. Profil dan parameter lapisan tanah dalam keratan rentas subpermukaan tanah telah dikenalpastikan untuk membangunkan model konseptual bagi simulasi pergerakan tanah teraruh daripada pengorekan terowong secara unsur tidak terhingga (FEM).

Parameter untuk sisa tanah geologi formasi Kenny Hill telah dinilaikan dengan membandingkan lengkungan tegasan-terikan yang dipantau daripada simlasi berangka dan ujian in-situ pressuremeter (PMT). Model HS diselaraskan dengan meoptimumkan parameter kekakuan dan kekuatan untuk memadankan lengkukan tegasan-terikan yang dipantau dalam ujian PMT. Analisis kepekaan parameter HS terhadap reaksi tanah menunjukkan bahawa parameter kekakuan oedometer lebih berkesan dalam mengawal canggan plastik manakala parameter kekakuan unload-reload menunjukkan kesan yang ketara dalam canggan anjal reaksi tanah. Keberkesanan penyelarasan model tanah ditentukan daripada pengesahan analisis pengorekan terowong berkembar. Analisis terowong dengan parameter yang diselaraskan meramalkan keputusan yang selari dengan pergerakan tanah yang dipantau dari pembinaan terowong berkembar dengan penjajaran mendatar, condong dan menegak. Walau bagaimanapun, simulasi dengan model Mohr Coulomb (MC) menramalkan pergerakan tanah yang bercanggar dengan arah pergerakan tanah yang dipantau. Analisis parametrik dijalankan untuk menentukan pengaruh konfigurasi terowong dan turutan pembinaan terowong berkembar terhadap interaksi terowong berkembar dalam formasi Kenny Hill. Kajian ini menunjukkan pendekatan bersepadu untuk penentuan parameter model juzuk dengan pengabungan pemodelan subpermukaan dan penyelarasan model juzuk bersama penentusahan. Parameter HS sisa tanah formasi Kenny Hill yang diselaraskan menyumbangkan untuk projek pembinaan masa depan yang mempunyai ciri-ciri geologi yang sama sebagi rujukan. Pendekatan penentuan parameter dengan penyelarasan model juzuk membantu jurutera dan penyelidik dalam pendekatan alternatif untuk penentuan parameter selain daripada data empirikal atau persamaan korelasi.

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ABSTRACT

Numerical simulation for geotechnical problem often involved simplifications and assumptions as it is nearly impossible to simulate all features involved in the ground environment. For large scale construction like Klang Valley Mass Rapid Transit (KVMRT) twin tunnels construction under urban environment, realistic geotechnical simulation is essential. In this study, a parameters determination approach is developed to determine stiffness and strength parameters for Hardening Soil (HS) models based on evaluation of in-situ and laboratory soil testing data for the simulation of twin tunnels interaction in Kenny Hill Formation residual soil. Subsurface characterization conducted to develop three-dimensional (3D) ground models, tunnel filtered models and ground sections for four zones divided from study area based on similarity in lithology and Standard Penentration Test Blow Count (SPT-N) Value distribution. Three critical ground sections were selected based on input of tunnel filtered models and ground sections, twin tunnels configuration associated in respective sections and availability of tunnelling induced ground movement data. The soil profiles and corresponding soil parameters were determined for selected ground sections to develop conceptual model for finite element method (FEM) simulation of tunnelling induced deformation. The soil parameters for Kenny Hill residual soil were evaluated by comparing numerical simulated and in-situ monitored Pressuremeter test (PMT) stress strain curves. The HS model is calibrated by optimization of stiffness