

## APPENDIX A NOMENCLATURE

<u>Symbol</u>	<u>Definition</u>
$A$	cross-sectional area
$A_0$	original cross-sectional area
$A_{corr}$	corrected cross-sectional area
$A_m$	cross-sectional area of membrane
$A_{mo}$	original cross-sectional area of membrane
$A_s$	cross-sectional area of specimen
$A_{so}$	original cross-sectional area of specimen
$A_{surf}$	area of perimetric surface of specimen
$a$	ratio of total specimen height to deforming height
$a$	radius of internal surface of membrane
$B$	pore pressure coefficient
$B$	radius of external surface of membrane
$C_c$	coefficient of curvature
$C_u$	coefficient of uniformity
$c$	cohesion intercept
$c$	ratio of deforming height to total specimen height
$D$	cylinder diameter
$D_i$	displacement vector
$d$	specimen diameter
$d_r$	relative density
$E$	elastic modulus
$E_m$	elastic modulus of membrane
$E_s$	elastic modulus of specimen
$e$	void ratio
$e_{max}$	maximum void ratio
$e_{min}$	minimum void ratio
$\Delta e$	change in void ratio
$F$	force
$F_{cell}$	force on membrane due to cell pressure
$F_{\theta m}$	lateral force in membrane
$F_{\theta s}$	lateral force in specimen
$FS$	factor of safety
$FS_{liq}$	factor of safety against liquefaction
$G$	shear modulus

<b>Symbol</b>	<b>Definition</b>
$G_s$	specific gravity of solids
$g$	acceleration due to gravity
$H$	cylinder half-height
$h$	specimen height
$h_0$	original specimen height
$J$	Jacobian matrix
$J_1$	first principal stress invariant
$J'_1$	first effective principal stress invariant
$J_{2D}$	second deviatorical stress invariant
$K$	stiffness matrix
$K$	constant for Drucker-Prager yield criterion
$k_j$	power curve coefficient for interface stiffness relationship
$k_n$	normal stiffness of the interface
$k_{nc}$	compressive normal stiffness of the interface
$k_{nt}$	tensile normal stiffness of the interface
$k_s$	shear stiffness of the interface
$k_{si}$	initial shear stiffness of the interface
$k_{sf}$	failure shear stiffness of the interface
$L$	cylinder length
$N_i$	Lagrangian interpolation functions
$n$	power curve exponent for interface stiffness relationship
$p$	pressure
$p'$	mean effective normal stress in two dimensions
$q$	shear stress on plane oriented at 45 degrees
$r$	radial coordinate in cylindrical coordinate system
$r_0$	initial radius
$N$	Lagrangian interpolation functions
$P$	pressure
$P_a$	axial pressure
$P_i$	internal pressure
$P_o$	external pressure
$R$	nodal load vector
$R$	cylinder radius
$R_f$	reduction factor
$r_c$	corrected radius
$r_s$	radius of soil specimen
$r_{so}$	initial radius of soil specimen
$S$	shear strength
$S_u$	undrained shear strength
$S_{us}$	steady state undrained shear strength

<b>Symbol</b>	<b>Definition</b>
$s$	slope
$T$	transformation matrix
$t$	time
$t_0$	initial time
$t_m$	membrane thickness
$t_{m0}$	initial membrane thickness
$U$	strain energy
$u$	pore pressure
$u$	displacement
$u_r$	radial displacement
$u_{rm}$	radial displacement in membrane
$u_{rs}$	radial displacement in specimen
$u_z$	axial displacement
$u_\theta$	circumferential displacement
$V$	volume
$V_o$	initial volume
$\Delta V$	volume change
$\Delta V_{mp}$	volume change due to membrane penetration
$v$	displacement in second coordinate direction
$W$	specimen weight
$w$	relative displacement
$w_n$	relative normal displacement
$w_s$	relative shear displacement
$x$	first coordinate direction in cartesian coordinate system
$y$	second coordinate direction in cartesian coordinate system
$z$	third coordinate direction in cartesian coordinate system
$z$	axial coordinate in cylindrical coordinate system
$\alpha$	angle of inclination of shear plane
$\alpha$	constant for Drucker-Prager yield criterion
$\gamma$	shear strain
$\gamma$	unit weight
$\gamma_w$	unit weight of water
$\gamma_d$	dry unit weight
$\gamma_{d \min}$	minimum dry unit weight
$\gamma_{d \max}$	maximum dry unit weight
$\gamma_m$	moist unit weight
$\gamma_{sat}$	saturated unit weight
$\gamma'$	buoyant unit weight
$\varepsilon$	normal strain

<b><u>Symbol</u></b>	<b><u>Definition</u></b>
$\epsilon_0$	initial strain
$\epsilon_a$	axial normal strain
$\epsilon_{at}$	total axial normal strain
$(\epsilon_a)_{avg}$	average axial strain
$\epsilon_l$	lateral normal strain
$\epsilon_v$	vertical normal strain
$\epsilon_h$	horizontal normal strain
$\epsilon_r$	radial normal strain
$\epsilon_{rm}$	radial normal strain in membrane
$\epsilon_{rs}$	radial normal strain in soil
$\epsilon_z$	axial normal strain
$\epsilon_{zm}$	axial normal strain in membrane
$\epsilon_{zs}$	axial normal strain in soil
$\epsilon_\theta$	circumferential normal strain
$\epsilon_{\theta m}$	circumferential normal strain in membrane
$\epsilon_{\theta s}$	circumferential normal strain in soil
$\epsilon_1$	normal strain in direction of major principal stress
$\epsilon_2$	normal strain in direction of intermediate principal stress
$\epsilon_3$	normal strain in direction of minor principal stress
$\epsilon_{mp}$	unit membrane penetration
$\epsilon_V$	volumetric strain
$(\epsilon_V)_{meas}$	measured volumetric strain
$(\epsilon_V)_{true}$	true volumetric strain
$(\epsilon_V)_{mp}$	volumetric strain due to membrane penetration
$\zeta$	third coordinate direction in natural coordinate system
$\eta$	second coordinate direction in natural coordinate system
$\theta$	circumferential coordinate in cylindrical coordinate system
$\lambda_{ss}$	slope of steady state line
$\mu$	coefficient of friction
$\nu$	Poisson's ratio
$\nu_m$	Poisson's ratio of membrane material
$\nu_s$	Poisson's ratio of specimen material
$\xi$	first coordinate direction in natural coordinate system
$\Pi_p$	potential energy
$\pi$	pi

<b>Symbol</b>	<b>Definition</b>
$\sigma$	normal total stress
$\sigma_0$	initial stress
$\sigma_1$	major principal total stress
$\sigma_2$	intermediate principal total stress
$\sigma_3$	minor principal total stress
$\sigma_a$	axial normal stress
$\sigma_{am}$	axial normal stress in membrane
$\sigma_{as}$	axial normal stress in soil
$\sigma_l$	lateral normal stress
$\sigma_{lm}$	lateral normal stress in membrane
$\sigma_{ls}$	lateral normal stress in soil
$\Delta\sigma_{am}$	correction to axial stress in soil due to membrane stresses
$\Delta\sigma_{lm}$	correction to lateral stress in soil due to membrane stresses
$\sigma_h$	horizontal normal stress
$\sigma_v$	vertical normal stress
$\sigma_r$	radial normal stress
$\sigma_{rm}$	radial normal stress in membrane
$\sigma_{rs}$	radial normal stress in soil
$\sigma_z$	axial normal stress
$\sigma_{zm}$	axial normal stress in membrane
$\sigma_{zs}$	axial normal stress in soil
$\sigma_\theta$	circumferential normal stress
$\sigma_{\theta s}$	circumferential normal stress in soil
$\sigma_{\theta m}$	circumferential normal stress in membrane
$(\sigma_{\theta m})_{avg}$	average circumferential normal stress across membrane thickness
$(\sigma_{\theta s})_{avg}$	average circumferential normal stress in soil
$\Delta\sigma_{zs}$	correction to axial deviator stress in soil due to membrane stresses
$\Delta\sigma_{rs}$	correction to lateral stress in soil due to membrane stresses
$\Delta\sigma_{\theta s}$	correction to lateral stress in soil due to membrane stresses
$\sigma_{atm}$	atmospheric pressure
$\sigma_{avg}$	average normal stress
$\sigma_{cell}$	cell pressure
$\sigma_n$	normal stress on the interface
$\sigma_t$	tensile strength of the interface

<b><u>Symbol</u></b>	<b><u>Definition</u></b>
$\sigma_y$	yield stress
$\sigma'$	normal effective stress
$\sigma'_{cons}$	effective consolidation pressure
$\sigma'_i$	initial effective stress
$\sigma'_f$	final effective stress
$\sigma'_1$	major principal effective stress
$\sigma'_2$	intermediate principal effective stress
$\sigma'_3$	minor principal effective stress
$\sigma'_m$	mean effective stress
$\sigma_1 - \sigma_3$	deviator stress
$(\sigma_1 - \sigma_3)_{ss}$	steady state deviator stress
$\tau$	shear stress
$\tau_d$	driving shear stress
$\tau_{rz}$	shear stress in the rz plane
$\tau_s$	shear stress on the interface
$\tau$	shear stress
$\Phi$	potential energy
$\Phi_i$	surface traction vector
$\phi$	friction angle
$\phi_{int}$	interface friction angle
$\phi'$	effective stress friction angle
$\phi'_{ss}$	steady state effective stress friction angle
$\Psi$	state parameter
$\Omega$	energy due to external work