Modification of a Critical-state Constitutive Model for the Prediction of Inherent Anisotropy in Sands

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ABSTRACT

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A critical state constitutive model for sands was previously developed with emphasis on capturing the main aspects of the behavior of loose liquefiable sands. The model, which was presented in detail in previous publications, was formulated and verified for various drained and undrained loadings of sands under monotonic conditions. However, in order to enable the model to predict the behavior of in-situ soils, which often exhibit strong inherent anisotropy, it was found important to extend the model formulation such that it will also be able to predict the behavior of sands with strong anisotropy.

In this paper, it is shown that by adding a new anisotropy parameter to the model, it is possible to simulate the behavior of strongly anisotropic sands. The anisotropy parameter depends on sand fabric and loading condition. Ability of the modified model to account for soil inherent anisotropy is verified by comparing observed and predicted responses of inherently anisotropic sand subjected to various loadings.

KEYWORDS

Constitutive modeling, Anisotropy, Numerical analysis, Sand behavior



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$$G .$$

$$(p_{\rm f} - p_{\rm c}) \qquad (p_{\rm f} - p_{\rm c})_{\rm ini}$$

$$d = \frac{d\varepsilon_p^{p}}{d\varepsilon_q^{p}} = A (M_{cs} - \eta)$$

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$$G = G_{r} \frac{(2.973 - e)}{1 + e} (p/p_{a})^{1/2}$$
$$K = K_{r} \frac{(2.973 - e)^{2}}{1 + e} (p/p_{a})^{1/2}$$

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K_r G_r

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$$\begin{split} A_c &= 9/(9 - 2M_{PT,c}\eta + 3M_{PT,c}) \\ A_e &= 9/(9 - 2M_{PT,e}\eta - 3M_{PT,e}) \end{split}$$

M_{PT,e} M_{PT,c}

Α

 $\sin \varphi_{PT,c} = \sin \varphi_{cs} + k_{PT} \psi$

 $\sin \phi_{PT,e} = \sin \phi cs + a_{PT} + k_{PT} \psi$

$$\frac{\partial \mathbf{p}_{e}}{\partial \varepsilon_{q}^{p}} = \frac{\mathbf{h}G}{(\mathbf{p}_{f} - \mathbf{p}_{e})_{ini}} (\mathbf{p}_{f} - \mathbf{p}_{e})$$

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Transversely isotropic trace vector magnitude Lode Angle state parameter flow rule