EVALUATION OF UNSATURATED SOIL RESPONSE UNDER SEISMIC LOADING

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Influence of matric suction as a stress state variable on shear modulus and also nonlinearity of soil has been recognized in several researches. So it is clear that presentation of seismic response of unsaturated soil profile with consideration of the suction effect provides a more realistic response of the soil profile.

Wong et al. (2014) extracted model parameter values of Biglari et al. (2011) model for three different low plasticity fine grained soils, namely Zenoz Kaolin, Completely Decomposed Tuff (CDT) and Po silt reported by Biglari et al. (2011), Ng and Yung (2008) and Vassallo et al. (2007) respectively, and predicted shear modulus at very small strain in variable matric suctions and mean net stresses.

Furthermore, recent investigation on the measurements of shear modulus of an unsaturated soil at wider shear strain range by suction-controlled cyclic triaxial apparatus showed that G-γ and D-γ curves are influenced by the suction levels too (Biglari et al., 2011). On the basis of this experimental evidence, Biglari and Ashayeri (2012) modified the empirical equation proposed by Ishibashi and Zhang (1993) for G/G_0-γ and D-γ to take into account the influence of the suction level as well as stress state and index properties for unsaturated soils. In order to produce G/G_0-γ and D-γ curves, the empirical equations presented by Biglari and Ashayeri (2012) were used. Equations (1) to (7) represent the empirical equations for G/G_0-γ and D-γ:

$$G/G_0 = A(\gamma,\xi,PI)\left(\frac{P''}{P_{atm}}\right)^{(n(\gamma,PI)-n_0)} \tag{1}$$

$$A(\gamma,\xi,PI)=0.5[1+\tanh\{\ln(\frac{0.00005+0.0167\xi^{12.16}+f(PI)}{\gamma})^{(0.26+3.61\xi^{11.6})}\}] \tag{2}$$

$$f(PI)=\begin{cases} 0 & \text{for}\ PI=0 \quad \text{(sandy soils)} \\ 3.37\times10^{-6}PI^{1.404} & \text{for}\ 0<PI\leq15 \quad \text{(low plastic soil)} \\ 7.0\times10^{-7}PI^{1.976} & \text{for}\ 15<PI\leq70 \quad \text{(medium plastic soils)} \\ 2.7\times10^{-5}PI^{1.115} & \text{for}\ 70<PI \quad \text{(high plastic soils)} \end{cases} \tag{3}$$

$$n(\gamma,PI)-n_0 = 0.272[1-\tanh\left\{\ln(\frac{0.000556}{\gamma})^{0.4}\right\}]e^{(-0.0145PI^{1.3})} \tag{4}$$

$$p'' = (p - u_a) + s_r (u_a - u_w) \tag{5}$$

$$\hat{\imath} = f(s).(1 - s_r) \tag{6}$$

$$D = f\left(\frac{G}{G_0}\right) A(PI) = \left[0.358\left\{-0.11\left(\frac{G}{G_0}\right)^2 - 0.587\left(\frac{G}{G_0}\right) + 1\right\}\right]\left[\frac{1 + e^{-0.0145 PI^{1.3}}}{2}\right] \tag{7}$$

Where A(γ,ξ,PI) is stiffness index ratio defined as Eq .(2), p_{atm} is the atmospheric pressure, p"is the average skeleton stress as Eq. (5), n(γ,PI) as defined in Eq .(4), is the stiffness coefficient accounts for the effect ofp" on stiffness, n_0 is the stiffness coefficient accounts for the effect of p" on stiffness in small strain range, p is average total stress s_r is degree of saturation, u_a is air pressure, u_w is water pressure, s is matric suction equal to (u_a-u_w), ξ is the bonding variable defined as Eq.(6) where f(s) is a function that depends on the size of the particles and the value of the water surface tension. The value of f(s) was considered equal to 1 for the range of suctions in this study.

In this study, this three different soil specimens that earlier have been studied on unsaturated dynamic models is used to produce various profiles with a variety of suction for analysis of their seismic response in both frequency domain (linear and equivalent linear) and time domain (nonlinear) analyses. DEEPSOIL.V5 software isused based on the latest achievements and various techniques in both solution domains.The results are discussed in terms of amplification ratio, maximum acceleration and acceleration-displacement response spectra of the transferred ground motion by changing the amount of suction.

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