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Shear deformations in fine-grained soils – effects of plasticity

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An experimental investigation has been undertaken to evaluate the cyclic response of fine-grained soils. Advanced testing methods and facilities are required to characterize dynamic response of soils as well as soil vulnerability to earthquake-induced failures.

The primary objective of this study was to investigate the liquefaction potential of non-plastic and low plasticity silt-clay blended mixtures by means of undrained cyclic, torque-controlled ring-shear tests. The cyclic and post-cyclic behavior of silt-clay soils assumed to be on a sliding surface were investigated to assess the resistance to liquefaction and cyclically-induced deformation in level and sloping ground. The effects of plasticity have been investigated to better characterize liquefaction susceptibility of silts and clays with varying levels of plasticity. Specimens were prepared by mixing of non-plastic silt with 0 to 100 % of commercially available clay gaining the plasticity in the range of PI (plasticity index) = 0 – 16%. Six different initial static shear stresses corresponding to slope angles from 0° to 25° were examined. These tests were conducted to simulate field conditions prior to earthquakes with initial static shear stresses corresponding to slopes and those with no initial static shear stresses corresponding to level ground.

The undrained response of the soil to cyclic loading with constant amplitude revealed the significant effects of the plasticity on the apparent friction coefficient at steady state (Figure 1). The presence of clay within silt-clay mixtures with PI>10 markedly increases the soil resistance against liquefaction. In soils with PI>10 the state of initial liquefaction (u_r=100%) never developed although the samples experienced approximately the same levels of deformation in terms of shear displacement as their liquefied partners (PI<10). Liquefaction resistance in slopes significantly decreases in soils with PI=2.3 – 7.5% at clay contents of 30 – 50% by weight. The lowest resistance to flow liquefaction was observed for soils with PI of 5.3% for all tests simulating sloping ground.

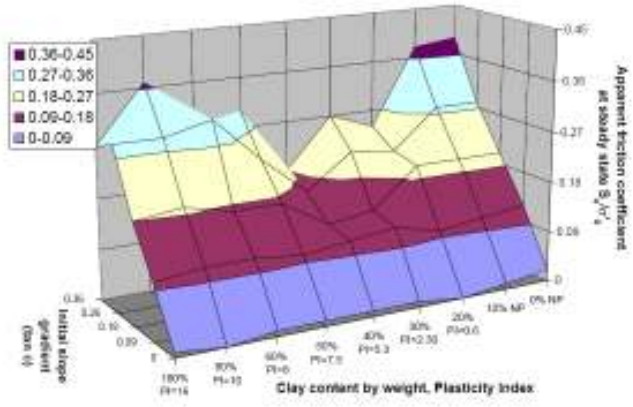

Figure 1 Undrained cyclic ring shear test results on silt – clay mixtures with PI of 0 – 16%, σ'_0 = 150kPa, CSR (= $\Delta\tau_d / \sigma'_0$) = 0.5, N=50 cycles, f=0.5Hz, NP = non plastic; graphical representation of relationship between apparent friction coefficient at steady state and both the clay content (plasticity) and the initial slope gradient