A CONSTITUTIVE MODEL FOR SILTY SANDS

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Liquefaction is usually attributed to a group of incidents in which a remarkable loss of shear strength together with the excessive increase in pore water pressure as well as large irreversible deformations take place in granular soil masses. Recent findings have revealed that sands containing non-plastic silt are quite prone to liquefaction and numerous case histories of earthquake-induced liquefaction phenomena have been reported in silty sand alluvia. In silty sands, fine grains fill the voids between coarser grains; however, they do not participate actively in load carrying structure of soil. As a consequence, adding non-plastic fines to a coarser granular structure leads to a decrease in soil overall void ratio without a tangible improvement of load bearing structure. To get rid of the false reduction of the global void ratio with adding of fines without the increase in soil strength, the concept of intergranular void ratio defined in terms of the total space between active particles in load carrying structure has been introduced (Thevanayagam & Martin, 2002; Thevanayagam et al., 2002) for binary mixtures of granular soils, intergranular void ratio, e*, is defined by:

$$e^* = \frac{e + (1-b)FC}{1-(1-b)FC} \tag{1}$$

where b varies within the range [0,1] and indicates the participation of fines in load bearing structure. For b=0, fines grains acts as filler without any participation in load bearing. For b=1, fines and coarse phases have identical participations.

The so-called state of the art sand constitutive models for simulation of the mechanical behaviour of granular soils are usually formulated based on state parameters in which density of granular soil is expressed in terms of the global void ratio. However, when silty sands are considered, these state parameters are failed to consider the partial participation of the fine phase in load carrying structure and hence, they usually over-predict the shear strength of silty sands. A remedy for this drawback is put forwarded here by considering intergranular void ratio (i.e., Eq. 1) instead of the global void ratio in definition of state parameters. It is worth noting that a unique critical state line in e*-p plane (p=mean principal effective stress) is obtained when intergranular void ratio is used in lieu of global void ratio (*see* Figure 1). This observation eliminates the number of experiments required for the model calibration. In this paper, the state-dependent constitutive model of Golchin and Lashkari (2014) for clean granular soils is re-formulated in such a way that the global void ratio is replaced by the intergranular void ratio. To this aim, elastic moduli, state parameter, location of critical state line, plastic hardening modulus, and dilation are explicitly linked to the intergranular void ratio. The modified model predictions are directly compared to the experimental data of undrained tests on different sands. It is shown that the modified constitutive model based on the intergranular void ratio can capture the essential elements of the mechanical behaviour of clean and silty sands using a unique set of parameters. Besides, it is shown that the modified model can simulate the flow liquefaction and instable behaviour of silty sands, realistically.

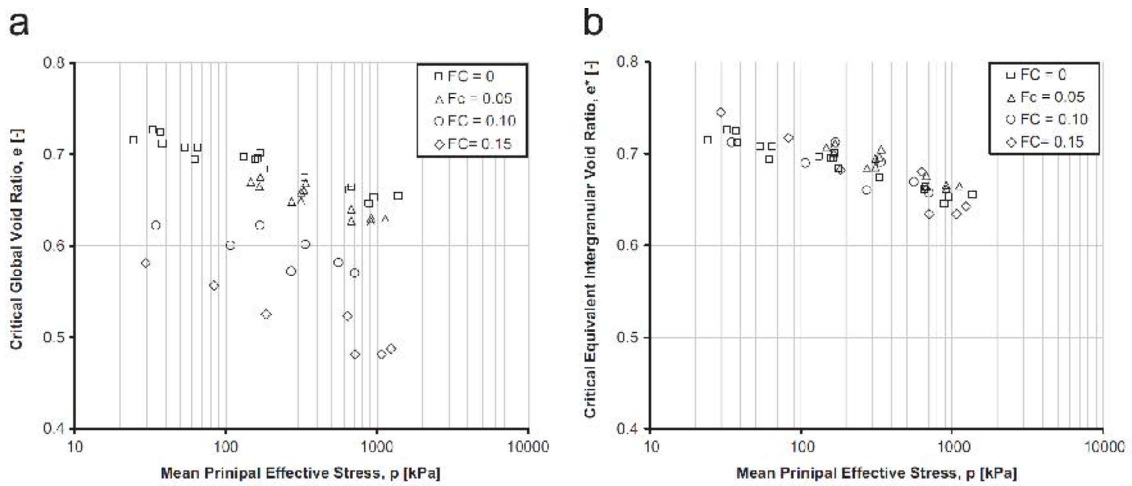

Figure 1. Critical state of Ottawa sand-SilCoSil 106 mixtures for various fines contents in terms of: (a) global void ratio, and (b) intergranular void ratio

REFERENCES

Golchin A and Lashkari A (2014) A critical state sand model with elastic-plastic coupling, *International Journal of Solids and Structures*, 51: 2807-2825

Thevanayagam S and Martin GR (2002) Liquefaction in silty soils- screening and remediation issues, *Soil Dynamics and Earthquake Engineering*, 22: 1035-1042

Thevanayagam S, Shenthan T, Mohan S and Liang J (2002) Undrained fragility of clean sands, silty sands, and sandy silts, *ASCE Journal of Geotechnical and Geoenvironmental Engineering*, 128(10): 849-859