Lab tests on applicability of S-wave-based and CPT-based liquefaction evaluations

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In the present liquefaction evaluation using penetration resistance, the aging effect may not be properly evaluated because the penetration process is too destructive to discern delicate soil fabric developed during aging. In contrast, shear-wave velocity (V_s) is considered to be promising that may be able to differentiate subtle changes in soil fabric affecting *CRR* because of its non-destructive nature.

In this research, bender-element triaxial tests are carried out to investigate the CRR~V_s relationship for two kinds of reconstituted sands with variable relative densities D_r and fines contents F_c. Then, accelerated tests adding a small amount of cement to fines-containing sands are conducted to examine the cementation effect on the R_L~V_s relationship. Furthermore, intact samples recovered from in situ sand deposits at several places are also tested and compared with reconstituted sands from the same samples to examine the aging effect on the liquefaction resistance of in situ soils.

Major findings are as follows:

1) A R_L -V_s relationship of reconstituted sands may be approximated by a single unique curve despite the differences in D_r or F_c for the same sand.
2) However, the curve is different for different sands, indicating that the R_L -V_s relationship is sand-dependent and not applicable to sands in general.
3) In the R_L -V_s relationship of reconstituted sands, while R_L increases by 100% from 0.1 to 0.2 for instance, V_s increases only by 17~25%, indicating that V_s measurement has to be precise enough to be able to make reliable R_L-estimation in situ.
4) Specimens with artificial aging effect by adding small amount of cements tend to have higher R_L and V_s, making different R_L-V_s relationships reflecting the artificial cementation.
5) Intact specimens from in situ have higher R_L and V_s than those reconstituted from the same specimens, presumably reflecting the aging effect. The differences in R_L and V_s depend not only on geological ages but also strongly on fines content F_c and its plasticity.
6) R_L-V_s relationships of natural intact soils considering the aging effect seem to be quite different from site to site and also different from artificially cemented sands. It is also different from previously proposed curves by other researchers. However, a common trend can be observed that the increment in R_L for the same V_s-increment becomes larger with increasing F_c.
7) The same two kinds of sands are tested also in a mini-cone triaxial test apparatus (Kokusho et al. 2011) to investigate R_L -q_t relationship. Comparison of the two test results reveals that R_L -q_t relationship is almost uniquely applicable even to different sands, though it may not be able to detect subtle effect of soil fabrics.

Reference: Kokusho, T., Ito, F. and Nagao, Y. (2011): Aging effect on liquefaction strength and cone resistance of fines-containing sand investigated in triaxial apparatus, *Proc. 5th International Conference on Earthquake Geotechnical Engineering* (*Santiago*), ISSMGE, 509-516.