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Liquefaction assessment based on combined use of CPT and shear wave velocity measurements

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Soil liquefaction is one of the most devastating secondary effects of earthquakes and can cause significant damage in built infrastructure. For this reason liquefaction hazard shall be considered in all regions where moderate-to-high seismic activity encounters with saturated, loose, granular soil deposits. Several approaches exist to take into account this hazard, from which the in-situ test based empirical methods are the most commonly used in practice.

These methods are generally based on the results of CPT, SPT or shear wave velocity measurements. In more complex or high risk projects CPT and V_S measurement are often performed at the same location commonly in the form of seismic CPT. Furthermore, V_S profile determined by surface wave methods can also supplement the standard CPT measurement. However, combined use of both in-situ indices in one single empirical method is limited.

For this reason, the goal of this research was to develop such an empirical method within the framework of simplified empirical procedures where the results of CPT and V_S measurements are used in parallel and can supplement each other. The combination of two in-situ indices, a small strain property measurement with a large strain measurement, can reduce uncertainty of empirical methods.

In the first step by careful reviewing of the already existing liquefaction case history databases, sites were selected where the records of both CPT and V_S measurement are available. After implementing the necessary corrections on the gathered 98 case histories with respect to fines content, overburden pressure and magnitude, a logistic regression was performed to obtain the probability contours of liquefaction occurrence. Logistic regression is often used to explore the relationship between a binary response and a set of explanatory variables. The occurrence or absence of liquefaction can be considered as binary outcome and the equivalent clean sand value of normalized overburden corrected cone tip resistance (q_{c1Ncs}), the overburden corrected shear wave velocity (V_{S1}), and the magnitude and effective stress corrected cyclic stress ratio ($CSR_{M=7.5,\sigma'_v=1atm}$) were considered as input variables.

In this case the graphical representation of the cyclic resistance ratio curve for a given probability has been replaced by a surface that separates the liquefaction and non-liquefaction cases.