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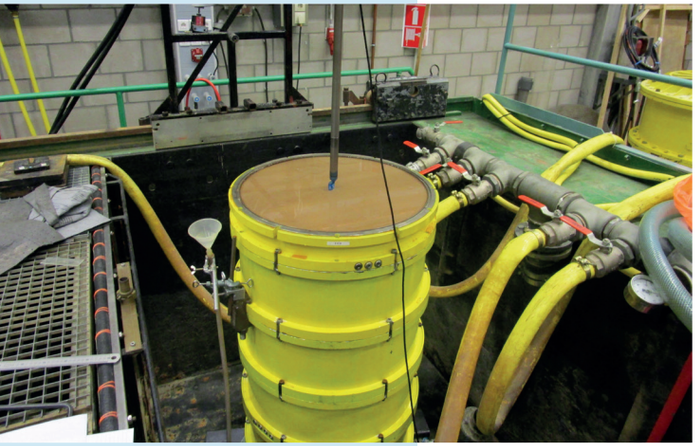
Cone penetration tests in layered soils

Cone penetration testing (CPT) is used widely to determine the geotechnical engineering properties of soils and to analyse the stratigraphy. However, it is hard to estimate a representative value for cone resistance when thin layers of sand and clay or peat alternate because the surrounding layers affect the measured cone resistance and result in an average value. The effect of multiple thin alternating layers is being studied in the laboratory in Delft.

The soil deposits of interest are "flaser beds": a sedimentary bedding pattern created in an environment with intermittent flows that result in alternating sand and clay layers. This type of bedding is mainly found in marine environments. The thicknesses of the sand layers are typically between 5 millimetres and several centimetres. The aim of this study is to determine the correction factor needed for individual layers to obtain representative values from the measured ones.

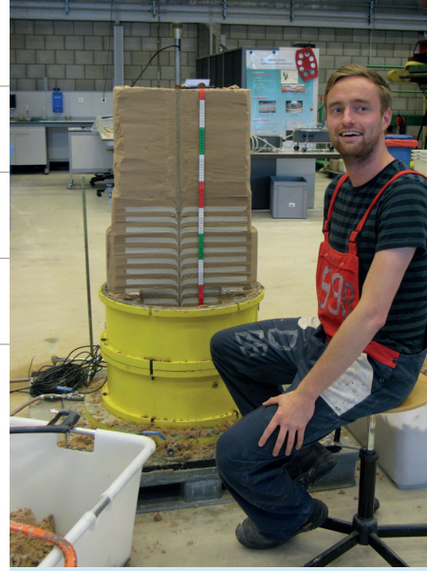


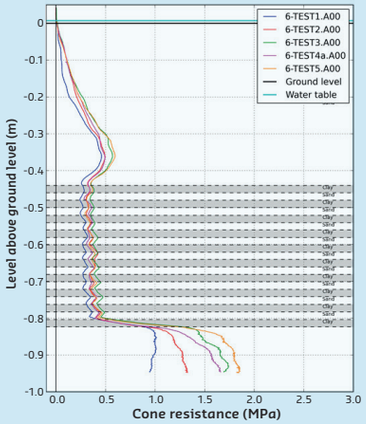
Unique laboratory tests were conducted to determine cone resistance in layered deposits. Two CPTs were performed in artificially formed sequences of sand and clay layers. The thickness of the layer was 20 mm in the first test and 80 mm in the second. The thin sand layers and clay layers always had the same thickness in this experiment. In addition, separate reference tests were performed on sand only and on clay only. The preparation of these soil set-ups in a cylindrical steel tank in the laboratory was a tedious and meticulous job. The cylindrical steel tank was approximately 0.6 m in diameter and the diameter of the measured cone was 25 mm. A cross-section of the soil body was inspected visually after the completion of CPT.

The experiments showed that tests on artificial, thin-layered deposits produce reliable results. The results of the tests were used to validate a range of correction factors for cone resistance based on analytical models. The correction factors mainly depend on the ratio of the characteristic resistances of the individual sand and clay layers, as well as the ratio of layer thickness to cone diameter.

Representative cone resistance values are essential for liquefaction potential studies, which are conducted to assess the liquefaction potential of sands in response to earthquakes. This is important knowledge in many places in the world. As a first step in the analysis, CPT soundings were converted to liquefaction potential on the basis of measured values. In practice, the liquefaction potential of multi-layered soils is often overestimated because of the low values of measured cone resistances. The new correction factors help to determine liquefaction potential reliably for multi-layered soils during an earthquake.

The research was performed in collaboration with Fugro and Delft University of Technology. Additional laboratory tests and research are planned for 2017 to extend the work to higher stress levels corresponding to deeper soil layers.





Further reading:
van der Linden, (2016) Influence of multiple thin soft layers on the cone resistance in intermediate soils. MSc thesis TUDelft. Available at: http://repository.tudelft.nl/islandora/object/uuid:756ae85e-c1a2-4d3e-b070-5f237d521699