Tuesday 3/14/2017

9:45–11:15 a.m.

Laboratory Testing of Offshore Sediments

Chairs: Antonio Carraro, Imperial College London; Rune Dyvik, Norwegian Geotechnical Institute

Effects of Salinity on Compression and Shear Behavior of Offshore Gulf of Mexico Sediments
Brendan Casey, Exponent; John Germaine, Tufts University; Brian Fahy, Ward & Burke Construction
One-dimensional compression tests and triaxial shear were performed on two high plasticity resedimented clays from the offshore Gulf of Mexico: Ursa clay (liquid limit, wL= 52 %) and Eugene Island Clay (wL= 79 %). The resedimentation technique was used to prepare fully saturated samples of identical composition for laboratory testing at effective stresses ranging from 0.1 MPa to 85 MPa. For a given stress level, increasing pore fluid salinity causes a reduction in void ratio, compressibility and coefficient of lateral earth pressure at rest (K0) but an increase in permeability. Increasing salinity has no discernible effect on the friction angle measured at critical state, but increases undrained strength at low effective stresses. These variations in properties are correlated to clay plasticity and mineralogy. Tests performed on specimens in which the natural salts had first been leached out and NaCl subsequently reintroduced showed little difference in measured properties.

Linking Carbonate Sand Fabric and Mechanical Anisotropy from Hollow Cylinder Tests: Motivation and Application
Ming Fook Lim, J. Antonio H. Carraro, and Susan Gourvenec, University of Western Australia
In addition to density and stress, fabric is also a key state variable strongly affecting soil behavior. While fabric influence on mechanical behavior of soils has been investigated experimentally, the available database is limited in terms of boundary conditions and soil types tested. Offshore carbonate sediments are of special interest for offshore geotechnical analyses due to their prevalence in tropical waters and unique mechanical behavior that stems from their mostly biogenic origin. A key gap in the availability of experimental data on soil fabric relates to the anisotropy of offshore carbonate sediments. In practice, anisotropy studies (whether rigorously correlated to fabric or not) are typically carried out experimentally for simple boundary conditions such as idealized plane strain and axisymmetric states. In real geotechnical applications, stress paths subjected to soil elements in the field are far more complex, often involving the combined variations of both the orientation and magnitude of all three principal stresses. This paper presents a new multi-scale approach to assess soil fabric at the micro-scale level and relate it to the macro-mechanical response observed for generalized loading conditions. A new sampling method is illustrated that enables preservation and evaluation of the fabric of offshore sediments specimens following generalized stress disturbances imparted by a hollow cylinder apparatus. The link between fabric evolution and the observed stress-strain behavior of sand is discussed along with preliminary results. The approach is part of a broad framework that will be used to systematically study the evolution of soil fabric and anisotropy and their relationship to multi-directional loading scenarios.

Challenges in Assessing the Shear Strength of Offshore Sediments using Simple Shear Tests
Shambhu Sharma, Nick Ramsey, Francis Lee, and Binaya Bhattarai, Fugro AG Pty. Ltd., Perth, Australia
This paper investigates the monotonic and cyclic response of offshore carbonate sediment and silica sand using two different types of simple shear apparatus (referred to as 'rigid' boundary and 'flexible'

boundary simple shear apparatus in this paper). In the 'rigid' boundary apparatus a series of concentric rings were used around the specimen to transfer the shear strain from the bottom to the top of the specimen, whilst in the 'flexible' boundary apparatus an unreinforced membrane was used to confine the specimen. All the tests were carried out on reconstituted specimens with similar initial conditions. The effects of these different boundary conditions on the monotonic and cyclic shearing response are presented in this paper. Comparisons between inferred and directly measured pore-water pressures and shear strain responses are also presented in this paper. This paper demonstrates that there are significant differences in the results obtained using the two types of simple shear apparatus. The difference is more pronounced for silica sand compared to the fine grained carbonate sediment used in this study.

In-Situ and Laboratory Measured Dynamic Properties of a Marine Clay

Albert Kottke and Michael R. Lewis, Bechtel Corp.; Andrew K. Keene, Yaning Wang, Boonam Shin, and Kenneth H. Stokoe, University of Texas at Austin

Combined resonant-column/torsional-shear tests were performed on four specimens of marine clay collected at varying depths over a range of confining pressures commensurate with the specimen depths. Using the small-strain measurements from these tests, the influences of stress state and void ratio on the small-strain shear stiffness, shear-wave velocity, and material damping ratio were studied. As the confining pressure increases and the specimen consolidates, both the shear stiffness and velocity increase. The rate of this increase follows typical trends of consolidation curves: less sensitive during recompression and unloading, and more sensitive during virgin compression. The laboratory-measured Vs showed good agreement with the field values with little evidence of sample disturbance. The influence of stress on Gmax and Vs was also found to be in good agreement with the laboratory. The relationship between the stress state, void ratio, and material damping is more complicated and does not show as consistent a behavior.

Comparisons of Two Reconstitution Methods for Clay Specimens

Yusuke Suzuki and Rune Dyvik, Norwegian Geotechnical Institute

This paper compares laboratory element test results on kaolin clay reconstituted by two different methods. One method was to consolidate a slurry in a large consolidation box producing a block sample that could be cut into triaxial-sized specimens. This produced consistent specimens near the liquid limit. The other method was to use a pug mill, a device used to mix, de-air and extrude clay that can be used for pottery. Consistent specimens with a water content below the liquid limit could be prepared in this way. The testing program presented herein included one-dimensional incremental loading oedometer and undrained triaxial compression loading tests on the two reconstituted specimen types. The results show that the two reconstitution methods significantly influence the test results because of kaolin particle arrangement. The slurry-based specimens show more compressibility and contractive shearing behavior while the pug mill specimens show less compressibility and somewhat dilatant shearing behavior.

Interface Friction Angle Soil-on-Steel from Ring Shear Tests on Offshore North Sea Sands

Vicente S. Quinteros and Rune Dyvik, Norwegian Geotechnical Institute; Niels Mortensen, nmGeo

The Bishop Ring Shear (RS) apparatus is typically used to obtain interface residual friction angles (δ_{res}) of marine sands for design of either axial pile capacity after the ICP-method or pipeline design at shallow

depths. Past research studies have proposed either a fixed value of $\delta_{res} = 29^\circ$ for pile design, or correlations between δ_{res} and the mean particle size (D_{50}). In current design practice δ_{res} is mostly assumed to be equal to 29° and RS tests are only performed to clarify whether δ_{res} can be increased or not. This paper presents a database of RS-tests on offshore North Sea sands that suggest that δ_{res} could be stress dependent when the vertical effective stresses are less than 50 kPa, while the fines content are of secondary importance. Moreover, δ_{res} is affected by the roughness of the chosen steel interface and D_{50}, but the effective stresses effects can also be predominant. The aim of this paper is to assist practitioners with the evaluation of a realistic value of δ_{res} for the design of offshore infrastructure in North Sea type of sands.