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Long Term Characteristics Of Nigerian Deltaic Sand

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***Abstract*—Global energy demand is on the increase yearly. Understanding the behaviour of offshore wind load on turbines will help in building stable foundations for it. Results of cyclic shear test in direct simple shear machine is presented for the explanation of the effective stress cyclic behaviour of the Nigerian deltaic silty sand. Relative density used in the work are 65% and 70% and behaviour of the tested soil is with regard to cyclic shear strain amplitude, relative density, cyclic stress ratio and number of loading cycles.**

Keywords—Cyclic stress ratio, cyclic loading, relative density, cyclic shear strain, wind turbine.

Introduction:

Offshore geotechnical problems could be largely solved if the if the marine silty sand behaviour could be understood. Dynamic behaviour of sand and clay have been studied by many workers (Vucetic et al 1988, Wijewickreme et al 2005, Anderson 2009, Soren et al, 2012) against which the present work is compared.

Simple shear test

This method is very reliable for measurement of undrained shear strength, in the same way as in carrying out the consolidated undrained triaxial test. Simple shear test simply measures shear stress and vertical stress acting on a sample predetermined surface, while constraining all other displacements. The bottom boundary of sample is theoretically fixed with zero radial strain.

The sample was tested in accordance with ASTM D6528-07; in which the sample is consolidated with the vertical load and sheared horizontally on completion of consolidation, in order to keep the volume constant. The sample height is also maintained continuously throughout the shear. The sample is not completely saturated, therefore, the generated pore pressure is inferred from the vertical stress change, which is constantly monitored (Baxter et al, 2010). In so doing, it is assumed that the changes in the applied normal stress ($\Delta\sigma_v$) is equal to the generated excess pore water pressure (Δu) if it were undrained test with measurement of pore pressure (Finn, 1985, Dyvik et al 1987).

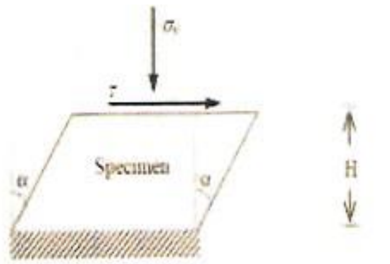

Figure 1: Simple shear Condition (Dyvik et al., 1987)

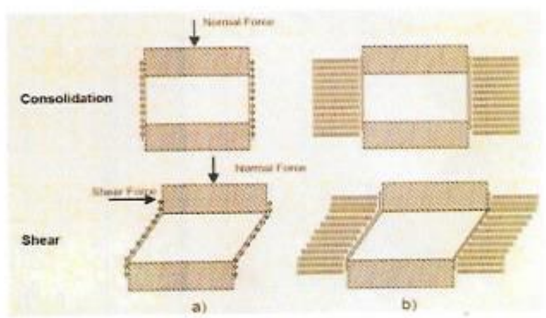

Figure 2: Wire Reinforced Membrane and Stacked Rings (Baxter et al., 2010

The stress condition applied could be cyclic or static stress or a combination of both. Wijewickreme (2010) studied cyclic shear response of river silt using constant – volume direct shear apparatus; while Anderson (2009) studied clays in cyclic triaxial and simple shear conditions. The presentation in this paper shows result obtained from cyclic simple shear tests with zero statics or mean shear stress.

Preparation of test sample

The sample height and diameter were carefully chosen in other to achieve height to diameter ratio of less than 0.4 in accordance with ASTM D6528-07.

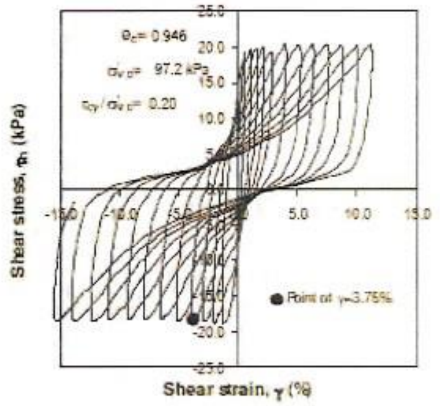

Figure 3: Stress-stress responses of NC Fraser River silt under constant volume cyclic DSS loading (σ'_V = 97 kPa; CSR = 0.20; α = 0; OCR = 1.0) Wijewickreme (2010).

Experimental program

The behaviour of deltaic silty sand were analysed with regards to relative density, number of loading cycles and cyclic stress ratio.

Relative density effect of 65% and 70% were studied for the various parameters. In order to simulate insitu (ko) stress conditions prior to shearing, a normal consolidation stress of 100kPa was applied in all the samples tested.

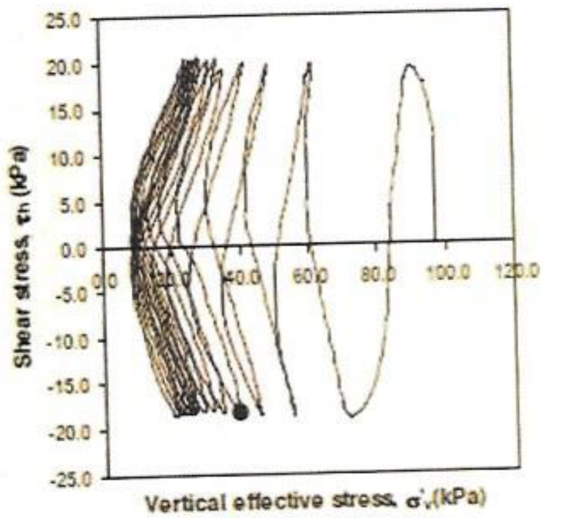

Figure 4: Stress-path responses of NC Fraser River silt under constant volume cyclic DSS loading (σ'_V = kPa; CSR = 0.20; α = 0; OCR = 1.0) (Wijewickreme, 2010).

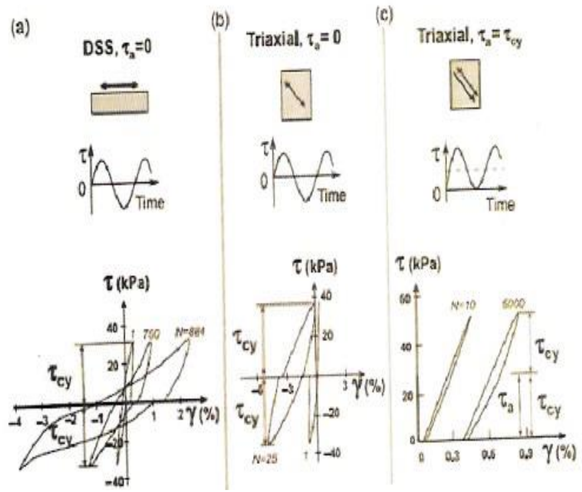

Figure 5: Stress-strain behaviour under various loading conditions (Andersen, 2009)

Test Results

Fig 6, shows that the shear strain reaches the failure criterion of 4% double amplitude shear strain at nearly 290 cycles; while Fig. 7 and 8 show stress paths for 0.1 and 0.2 critical stress ratio respectively and shows that the effective stress is inversely proportional to the cyclic stress ratio; and Fig. 9 and 10 show stress strain responses for cyclic stress ratio of 0.12.

Fig 11 shows results from four test (void ratio of 0.896, Relative density 65%) and another four tests (void ratio 0.845, relative density 70%) and in both group of tests, cyclic stress ratio of 0.10, 0.12, 0.14, 0.16 and 0.20. Results show that samples reach large shear strain faster at high cyclic stress ratio; and that the higher the relative densities of samples the higher the number of loading cycles required to reach the failure criterion. Also, the number of loading cycles to reach 4% double amplitude shear strain is reduced by increasing the cyclic stress ratio. Increasing loading cycles degrade the silty sand which is a useful design information.

Priorities for further research includes obtaining more detailed dynamic properties of the Nigerian deltaic silty sand by extensive laboratory testing.

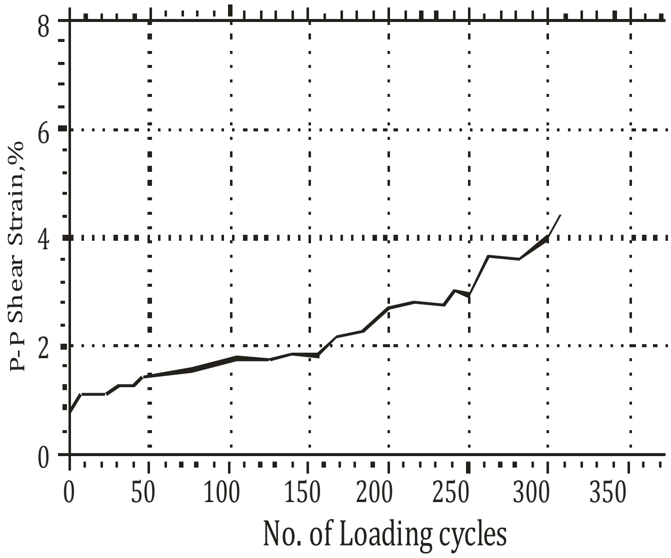

Figure 6: Peak-Peak Shear Strain versus No. of loading cycles for CSR = 0.10 and e_c = 0.896

Conclusion

Results obtained from this study show that samples reach large shear strain faster at high cyclic stress ratio; and that the higher the relative densities of samples the higher the number of loading cycles required to reach the failure criterion. Also, the number of loading cycles to reach 4% double amplitude shear strain is reduced by increasing the cyclic stress ratio. Increasing loading cycles degrade the silty sand, which is a useful design information. Priorities for further research includes obtaining more detailed dynamic properties of the Nigerian deltaic silty sand by extensive laboratory testing.

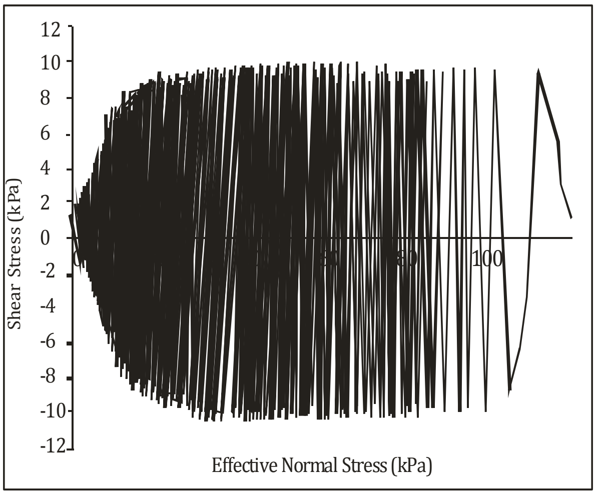

Figure 7: Stress Path during constant volume cyclic DSS loading of silty sand for CSR = 0.10 and e_c = 0.896

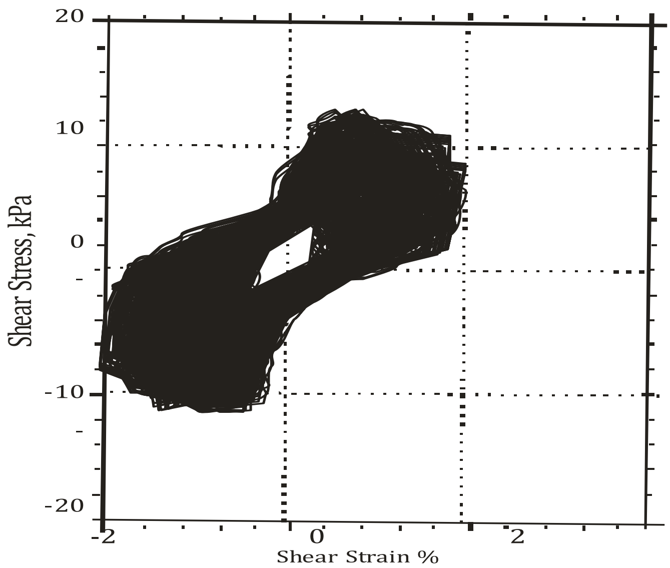

Figure 8: Stress- stress response of deltaic marine silty sand under constant volume cyclic DSS loading (σ'_v = 100 kPa; CSR = 0.12; e_c = 0.845 α = 0; OCR = 1.0

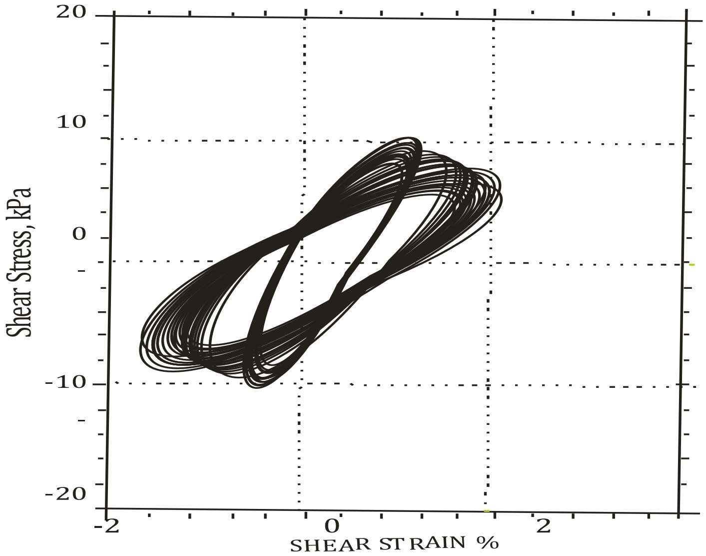

Figure 9: Stress- stress response of marine silty sand under constant volume cyclic DSS loading (σ'_v = 100 kPa; CSR = 0.12; e_c = 0.896 α = 0; OCR = 1.0)

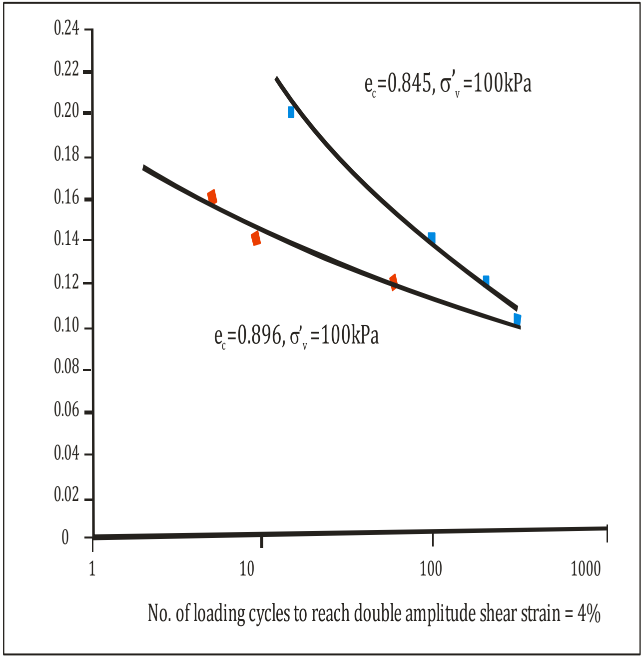

Figure 10: CSR versus No. of Loading cycles to reach 4% double amplitude shear strain

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