CASE STUDY: VEHICLE LOADING (HOLLOW CYLINDER APPARATUS)

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The laboratory of engineering and technology for soft soil foundation and tideland reclamation of Zhejiang province, was founded in 2006. The laboratory main focus is on four key areas, high-speed traffic, levees and underground engineering construction all on thick soft ground, land reclamation development and construction along the coastal industrial belt.

The laboratory has more than 2,000 square meters of space for research purposes, with the research equipment totalling a cost of more than 30 million yuan. The results produced have been applied to the construction of Wenzhou Yiongqiang runways, Wenzhou City Highway and projects on the development of underground space in the coastal industrial belt of Wenzhou.

Website Link:
http://cic.wzu.edu.cn/

THE PROBLEM

Marine soft clay with weak engineering properties, is widely distributed in Southeast China. As the most developed area in China, Zhejiang has a vast transportation infrastructure including highways, roads, railways and airport runways which have been constructed on the marine clay. With long-term vehicle loading, excess settlement tends to occur on the existing infrastructure. In order to reveal these effects on the marine clay caused by vehicle loading, and to predict future settlement, research was undertaken.

Vehicle loading is not only a long-term cyclic loading, it is unique in the shape of stress path's during each cycle. Along with the wheels, approaching and then leaving, the stress components of the soil change in both magnitude and direction (see Fig 1.1). Moreover, the angle of major principal stress σ rotates during each cycle. When plotted together in the $2\tau_{z\theta}$ (σ_z - σ_θ) space, the stress paths form the shape seen in Fig 1.4.

According to the finite element analyses by previous researchers, the ratio of shear stress to axial stress decreases as the depth increases, instead of remaining constant, leading to the change in shape of stress paths.

To simulate the stress path of a vehicle loading, accurate control of each stress component is required (as shown in Fig 1.2). It further necessitates the redefined waveforms according to the shape of loading.

THE SOLUTION

A Dynamic Hollow Cylinder Apparatus (HCA) was the system of choice for the research project. An HCA is able to independently apply axial force, torque, inner and outer pressures throughout the test. It is therefore, widely used to research the deformation behaviour of soil with cyclic rotation of principal stress axes.

GDS Instruments supplied a customised HCA to Wenzhou University, to meet their required specification. It is able to independently apply axial force W, torque MT, inner cell pressure pi

Fig 1.1

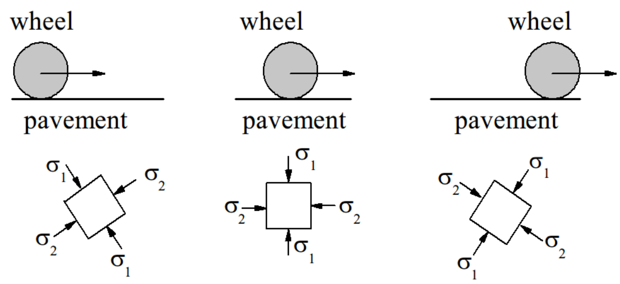
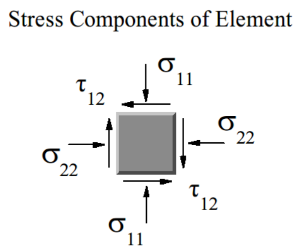


Fig 1.2



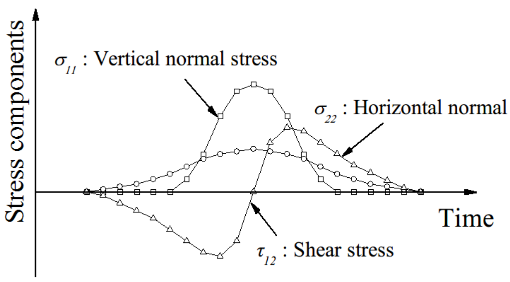


Fig 1.3

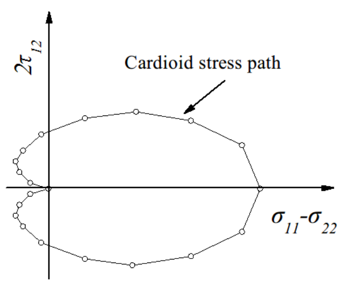


Fig 1.4

Fig 1. Stress components of the soil element in soft subsoil induced by vehicle loading

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and outer cell pressure p_o and thereby control the stress state of the soil (axial stress σz, radial stress σr, tangential σθ, shear stress τzθ). Since the magnitudes of three principal stresses, and the angle of major principal stress axis α can be controlled, the tests with rotation of principal stress axes can be performed.

Taking two test results as an example, Fig 2 demonstrates the comparison of the actual and desired stress paths correlation during the test. This confirms the GDS Hollow Cylinder Apparatus (HCA) can accurately simulate the vehicle loading stress path required to perform the research.

Fig 2.

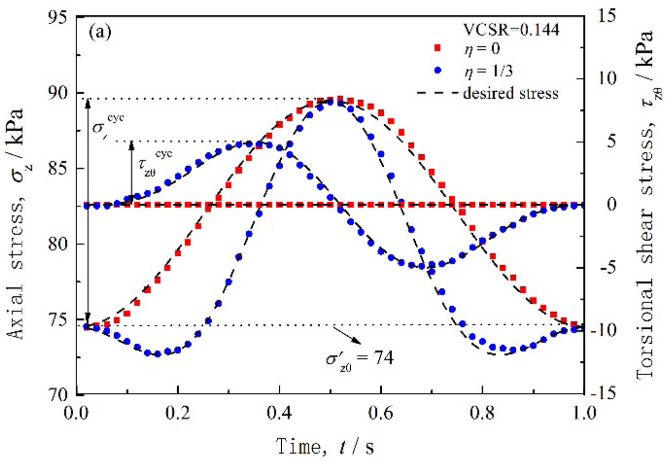
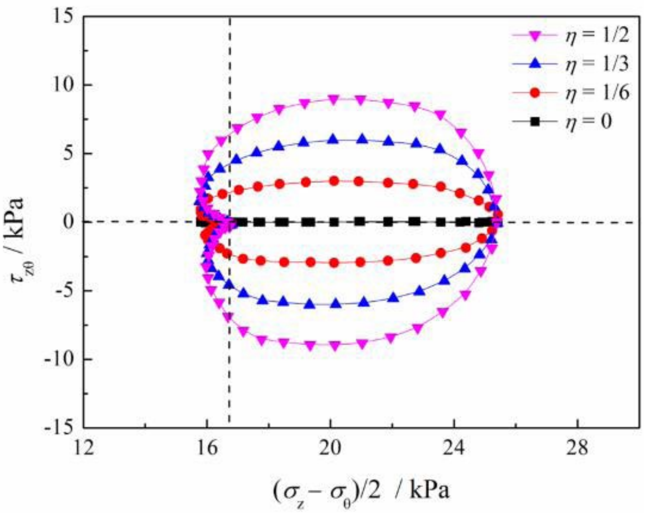


Fig 3 shows different shapes of stress paths for each test. The different shapes of stress paths indicate the different ratios of torsional shear stress & vertical cyclic stress.

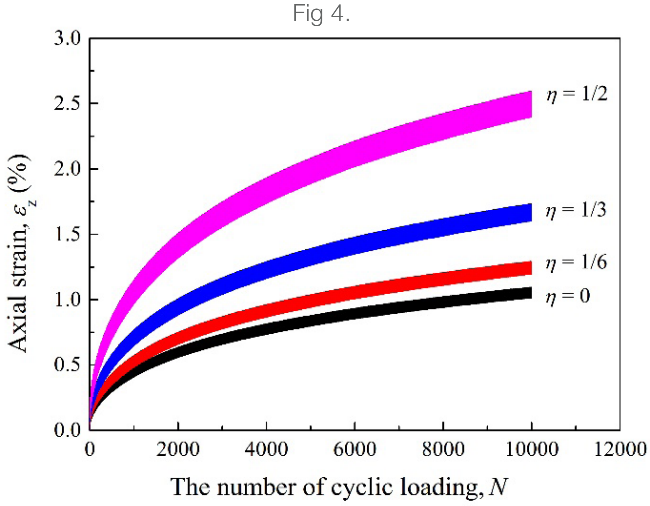
Fig 3.



THE RESULTS

The test results shows the influence of torsional shear stress on the strain development of the soft clay samples. As shown in Fig 4, all the test results show a similar progression of axial strain development. But the η value affects the level of axial strain development. The higher the η value the larger the permanent strain the specimen has.

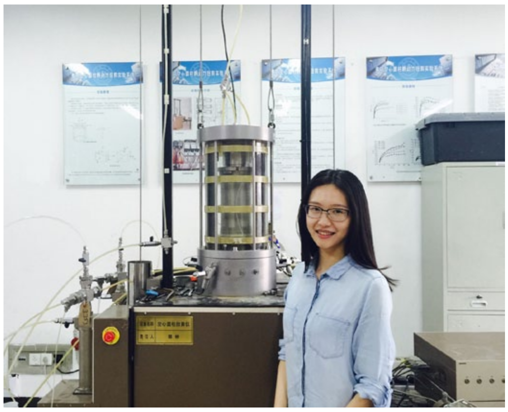
Fig 4.



CONCLUSION & TESTIMONIAL

According to this series of cyclic HCA tests, the shear stress level has significant effect on the development of strain and pore pressure, therefore accelerating the failure of marine clay. The specifications at present, however, consider the axial stress only, therefore overestimating the subsoil. Further research is required to perfect current theories and prediction models.

During the whole process, experts from GDS Instruments provided a lot of help & support. We look forward to working with them on future projects.



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REFERENCES

GUO Lin, CAI Yuan-qiang, WANG Jun, GU Chuan. Long-term cyclic strain behaviour of Wenzhou structural soft clay[J]. Chinese Journal of Geotechnical Engineering, 2012, 34(12): 2249-2254.

Guo L, Wang J, Cai Y, et al. Undrained deformation behaviour of saturated soft clay under long-term cyclic loading[J]. Soil Dynamics & Earthquake Engineering, 2013, 50(7):28–37.