# A Laboratory Investigation into the Behaviour of Sand at Low Confining Stresses

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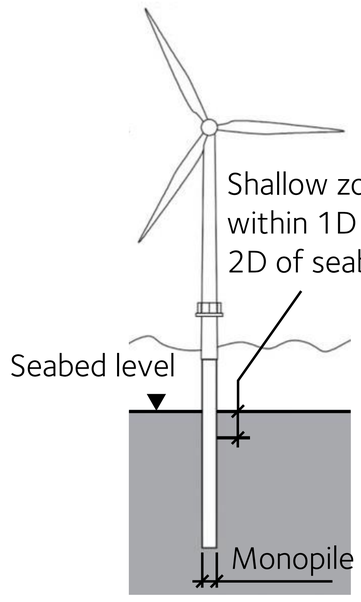
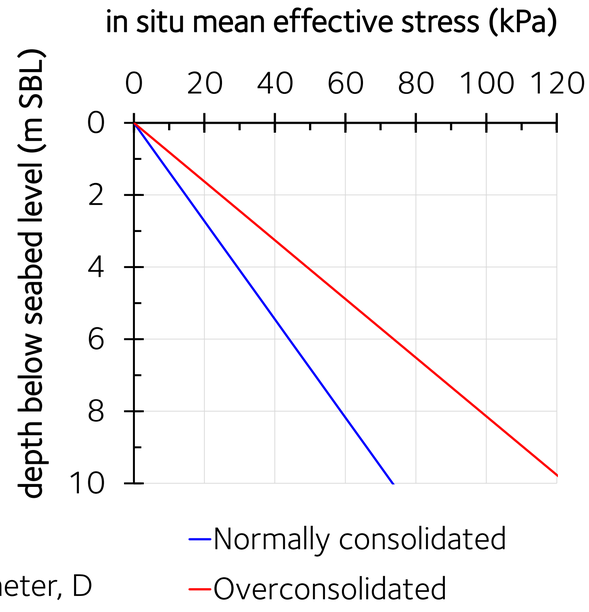
## 1. Introduction

- There are several situations in the design of offshore wind farms where the strength and deformation properties of the near-surface are important, e.g. design of wind turbine foundations, cabling and pipelines
- For a typical North Sea site, in situ confining stresses at shallow depths (0 to 10m below sea bed) are relatively low (0 to 120kPa)
- Current design methods use constitutive models that require calibration against laboratory tests, undertaken at confining stresses appropriate to the design situation
- Published, high-quality experimental tests undertaken on sands at low stresses are currently very limited and have yielded inconsistent results



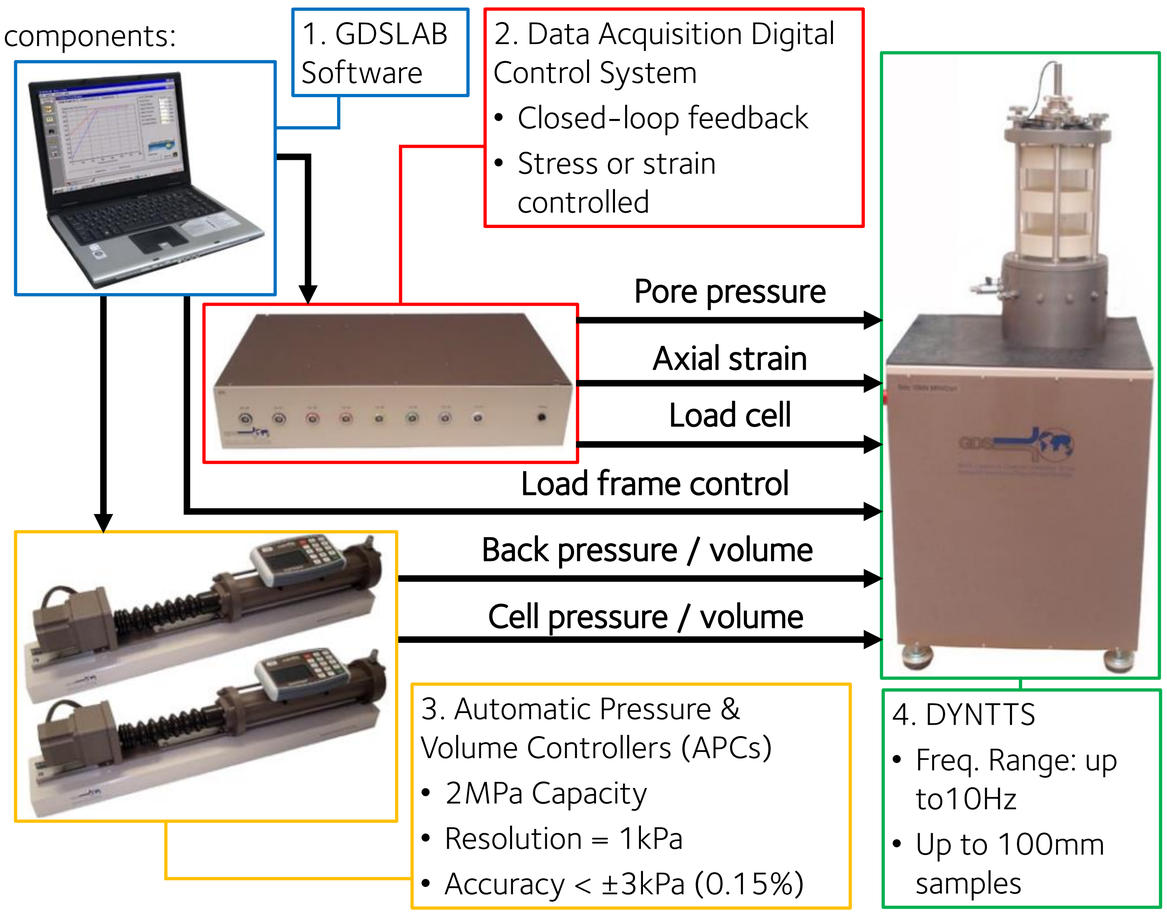




## 2. Research Objectives

- To develop our understanding of the constitutive behaviour of sands at very low stress levels and clarify the conflicting results seen in the literature
- To provide a database of advanced, high-quality, drained monotonic and cyclic triaxial stress path tests, utilising local strain measurement devices and vertical & horizontal pairs of bender elements
- To investigate the effect of the number of cycles, stress amplitude and cyclic stress path on the development of dynamic secant stiffness values
- To review and compare constitutive models used in commercially available Finite Element Analysis (FEA) software packages and assess their capability of modelling sands at low stress levels

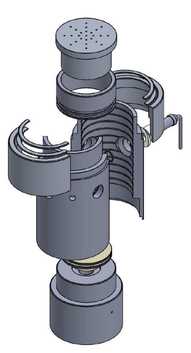
## 3. Laboratory Apparatus

Tests have been undertaken using an advanced dynamic triaxial testing system (DYNTTS) manufactured by GDS Instruments Ltd. The system comprises four principal components:




## 4. Sample Preparation

- 'Undisturbed' sand samples are expensive and difficult to obtain from the field
- Test specimens have been reconstituted using the wet pluviation technique to simulate natural marine depositional processes



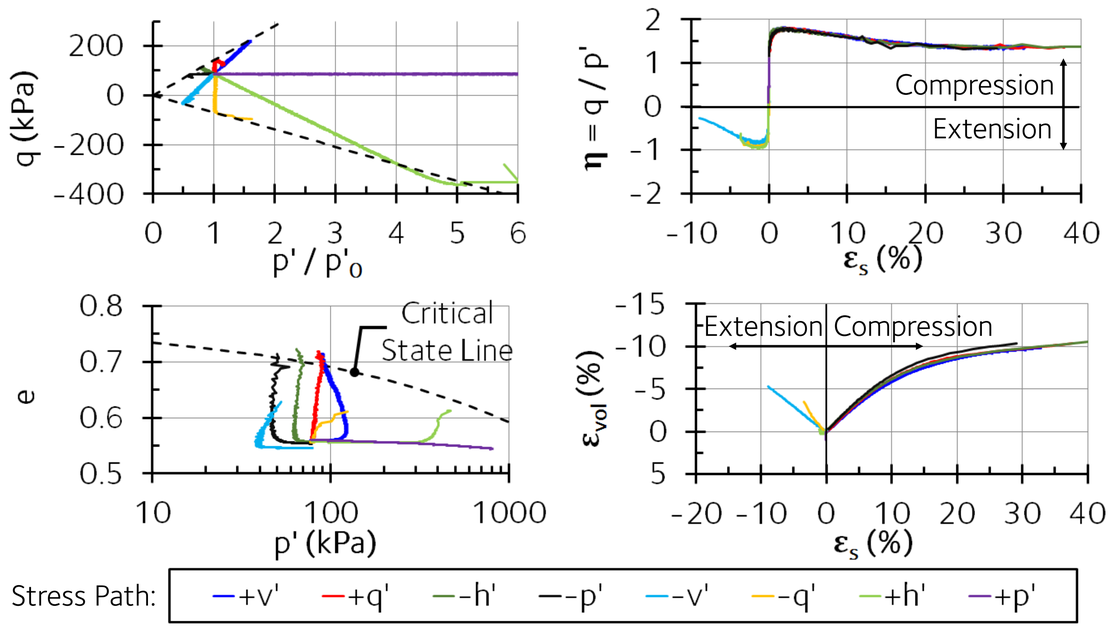
## 5. Preliminary Results

Test Material: Leighton Buzzard 14/25 sand (fraction B)

- Yellowish brown, sub-angular to rounded, uniformly graded SAND

Test variables:

- Confining stress, $\sigma'_c$ = 50kPa; Relative density, $D_r$ = 80%; OCR = 1.0; Stress path




- In triaxial compression: $\varphi'_{max(TXC)}$ = 44.1°; $\varphi'_{c(TXC)}$ = 33.6°
- In triaxial extension: $\varphi'_{max(TXE)}$ = 31.7°; $\varphi'_{c(TXE)}$ = ?? (unable to determine)
- Significant barrelling/necking observed in compression/extension tests, respectively

## 6. Summary and Conclusions

- Compression test results agree well with published and empirically determined values
- Extension test results unsatisfactory – method of enforcing uniform strains required
- Enlarged, lubricated end platens required to reduce end restraint and improve uniform stress & strain distribution
- Higher-accuracy components required for future tests at confining stresses < 50kPa

## Acknowledgements

The author would like to thank the staff at Fugro GeoConsutling (FGC) for providing training, and access to their facilities and soil-testing apparatus

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