Demand from the wind energy market inspires new GDS shear testing equipment and a inclinometer for monopile driving from Fugro

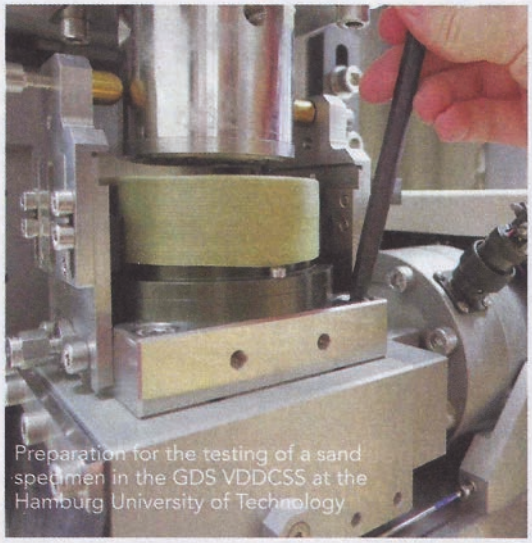
Advanced testing equipment

GDS Instruments has released a new advanced soil testing system that was initially developed to better understand the dynamic response of infrastructure in a growing sector of the wind energy market but which the company believes will have wider benefits.

The Variable Direction Dynamic Cyclic Simple Shear (VDDCSS) is designed to deform soil elements statically and dynamically under bi-directional simple shear loadings, enabling soils to be sheared in any horizontal direction.

According to GDS, this development offers expanded test functionality compared with other commercially available direct simple shear devices, which typically allow the soil to be deformed along a single fixed horizontal axis. The company says given the extensive use of direct simple shear testing to characterise soil behaviour in practice and during research studies, the VDDCSS offers an exciting prospect for element testing.

To create the VDDCSS, GDS based the hardware design on its EMDCSS, a uni-directional simple shear system – but the main modification is a secondary shear axis located on top of the primary shear actuator, which applies deformation in a direction perpendicular to the primary axis (ie at 90°). The system can operate each horizontal actuator independently or together in tandem, allowing almost any loading pattern in the horizontal plane to be applied.



Preparation for the testing of a sand specimen in the GDS VDDCSS at the Hamburg University of Technology

The driving force behind development of the VDDCSS was a request from the Hamburg University of Technology in Germany.

Academics at the university wanted to intensify research into soil behaviour under varying shear directions.

Hamburg University researcher Christina Rudolph says: "The early test results indicate that a pile-soil system possesses a memory of its loading history, including the loading directions. However, it is still unclear how that memory works in detail."

By using the VDDCSS, Rudolph and her colleagues are able to directly apply cyclic strain or stress paths to a soil specimen with varying direction, while the resultant stresses or strains can be analysed to gain more insight into the nature of soil memory.

"By applying shear forces to a small soil specimen in the VDDCSS, rather than to a laterally-loaded pile, we are able to isolate the soil behaviour from the pile-soil system behaviour," concludes Rudolph.

Offshore piles on the straight and narrow

Demand for pile driving accuracy on the latest offshore wind developments has led Fugro to develop a system, called the Inclino Cam, designed to safely check the verticality of piles during installation.

"The need to measure verticality of wind turbines starts with the foundation," explains Fugro Survey positioning and remote services manager Dieuwertje Smallenburg. "Most offshore wind turbines are founded on monopiles that typically measure 70m in length with a diameter of 6.5m and weigh in at around 850t. These monopiles are driven into the sea floor using a hydraulic hammer – a process which can take several hours – so verticality is a key requirement but difficult to achieve or measure.

"Previously inclinations of 1° were tolerated, but with the increasing size and developing technology 0.25° is now generally used as maximum tolerated inclination."

According to Smallenburg, the conventional way to check the verticality is with a hand-held inclinometer, but the irregularity of the outer pile surface may affect the accuracy of the results, so multiple measurements are needed to ensure the reading is accurate.

"This causes delays in the piling operations as the hammering has to stop for the measurement and processing of the information for the crane and hammer operators," he says. "There are also health and safety issues associated with the manual measurement."

Fugro's Inclino Cam system is based on intelligent visual object recognition combined with vessel motion compensation.

Two high-resolution cameras are placed at an angle pointing towards the monopile to measure the inclination in two directions and to compensate for vessel movement the cameras are connected to inertial motion units (IMU). The camera images and IMU data are synchronised using Fugro's Star Port technology and processed by its Starfix.NG navigation software to give a visual display of the verticality during the driving process.