How to assure CPT quality at ever increasing water depths?

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Cone Penetration Testing (CPT) is by origin a Dutch soil investigation method (Begemann 1965) to predict the bearing capacity of the soil and determine its stratification (presence of clay, peat or sand). The test method consists of pushing a cone into the soil while recording different parameters (real-time) including the cone tip resistance, sleeve friction, pore water pressure and inclination. The data is used by geotechnical engineers to calculate the required foundation for structural designs.

For almost 50 years A.P. van den Berg designs and supplies advanced equipment for this method. The company in Heerenveen, the Netherlands, provides a complete package, including the CPT pushing equipment, measuring tools and instrumentation, that is available for onshore, near-shore and offshore in situ soil investigation.

Offshore soil investigation extends to ever increasing depths, where the conditions place great demands on the technology to be used. Seabed soil investigation is for example performed preceding construction works for marine infrastructure, for installations on behalf of the oil and gas industry and for wind farms.

A.P. van den Berg is generally focused on offering its customers innovative, easy to handle and above all high quality CPT technology, where for its offshore technology it is preferred to use concepts that have already been proven, e.g. in other applications or environments. Examples are:

- Digital data transmission – although the offshore industry is synonymous with more challenging environments the move to smart digital communication in the Icone technology ensures accuracy and offers the capability to measure additional parameters with click-on modules.
- Pressure compensated cones – standard Icones are filled with oil as a simple and reliable measure to eliminate inaccuracy due to high water pressure effects.
- Continuous penetration – uninterrupted pushing avoids static friction on the CPT string and reduces the risk of breaking this string. As a result, deeper CPTs can be achieved.
- Automation – a fully automated CPT cycle reduces the safety risks during handling of the equipment and reduces downtime which can occur during (dis)assembly on board of a vessel.

Above topics will be included in the presentation, and the latest innovation, the (un)folding CPT string applied offshore (ROSON-ST), will cover most part of it. The ROSON-ST (Single Twist) builds on the unrivalled track record of the existing ROSON seabed system and digital cone technologies. The fully digital Icone is around for some 15 years now and the ROSON technology has proven itself for robustness, reliability and CPT quality over the last 35 years. The remaining challenge has been to eliminate the need to support the CPT string, particularly with ever increasing CPT penetration depths. This external string support makes a ROSON system sensitive to sea currents, more difficult to handle and time consuming to set up. Compact solutions available in the market today, however, introduce shortcomings of their own, concerning achievable penetration depth, data reliability, cone sizes to choose from and increased wear and tear.

With A.P. van den Berg's ROSON-ST the answer to all of these issues is provided. By incorporating the patented folding ST-Rods in the ROSON seabed system, a compact and easy to handle ROSON-ST is created. It is suitable for 50 m penetration of standard CPT rods, works with all Icone sizes and click-on modules and does not require any exterior CPT string support, assuring fast deployment and high productivity. The use of standard CPT rods with a sturdy threaded coupling ensures the straight push that customers may expect from a CPT system.

The main goal while creating the ROSON-ST, was keeping it simple. Reducing the active movements for fulfilling the required functions as much as possible, contributes to the reliability. The existing ROSON is a perfect match, as the system consists of:

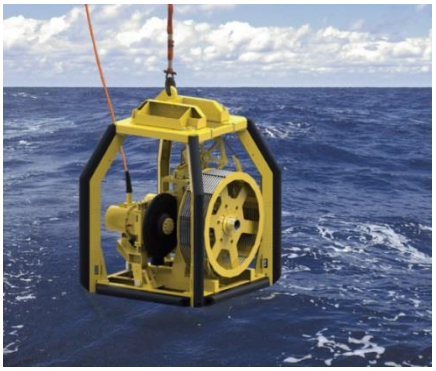
- just two drive wheels to drive the rod into the soil, actuated by two 3-phase electrical motors submerged in hydraulic oil for pressure compensation.
- just two rotary seals, with a minor pressure difference, ensuring a solid barrier between the sea water and electrical motors.
- a single hydraulic cylinder to clamp the wheels against the rod to create the required friction and generate the pushing and pulling force.

For the ROSON-ST just two drive motors and a twisting clamp had to be added for locking and unlocking the CPT rods. The key to create a self (un)folding string is the use of a thread joint. A thread joint normally requires multiple rotations and vertical movement to follow the pitch. The new ST-technology reduced this to a single twist without the vertical movement. The mechanical shape of this bayonet type of thread only requires a roughly vertical orientation and some pushing force to line up both bayonet thread columns. When both rods are mated, a single twist of 60 degrees is sufficient to generate a solid joint. When retracting the CPT string a single twist anti-clockwise and a pulling force is sufficient to unlock the joint.

The combination of this single twist technology and the advantage of a standard thread is unique. A thread connection ensures a preload that creates a stiff and secured joint. Friction between the bearing and thread surfaces however can affect the joint quality. By measuring both the torque and angle displacement the friction uncertainty is significantly reduced. The bayonet shape, torque and rotation angle can also determine whether a connection is in the locked position, or in the open position.

To keep all the rods together when it is in the unlocked state, a ball joint is applied. This ball joint enables the string to be folded onto a reel, the only requirement is to keep a constant tension on the string. To feed and position the rods from the reel to the ROSON and vice-versa, a simple Sprocket is used. The CPT string now acts as a kind of timing belt. This belt drastically reduces the complexity of the control software and required sensors, commonly found in traditional robot “pick and place” solutions.

This timing belt in combination with an absolute encoder on the sprocket provides all required information about the state of the system. It allows the system to easily change between a pushing state (downwards movement of the CPT string) and pulling state (upwards movement).



Most of the brain storming and design effort has gone into the core question that had to be answered to make this ROSON-ST a reality: how to create a 50 m string that is both segmented and whole, both flexible and rigid and can be transformed from one state to the other, without much additional hard- or software, during the natural flow of a CPT push and pull operation? With the mainly mechanical solutions outlined above, the ROSON-ST is able to meet the quality and safety standards set by the industry and provides a compact, versatile and reliable tool, appreciated by offshore CPT operators around the world.

References:

- Begemann, H. K. S, 1965, "The Friction Jacket Cone as an Aid in Determining the Soil Profile"; Proceedings, 6th ICSMFE, Montreal, Quebec, Canada, Vol I, pp.17-20.