RELIABLE SEABED DATA FOR OFFSHORE WIND FACILITIES

Windmills on the Horizon

Scandinavia is bustling with the building of ocean windmills, and the potential for bigger and better offshore wind facilities seems endless. However, survey remains a challenge. The need for reliable data grows ever stronger for each oceanic project, as engineers and energy needs push at the boundaries of oceanic construction. Using heavy seabed rigs for deep-push Cone Penetration Test (CPT) may, however, produce reliable seabed soil data at depths of up to 200 metres, as described here. In recent years the distinctive profile of offshore windmill facilities has become a landmark for visitors to Scandinavia. As Bill Clinton remarked during a visit in 2005, “You are smart, and we are not”. He meant our approach in contrast with the historically strong US dependence on oil for energy. The windmills are all part of a huge effort to reduce dependence on oil and gas and to further explore the potential of renewable energy sources. This in turn requires new knowledge of oceanic construction, seabed conditions and feasible testing methods.

Tip of the Iceberg

The Scandinavian windmill sector has created a strong global position for itself. Whilst some companies specialise in ocean survey, contractors are turning years of experience in building bridges and offshore oilrigs to new uses, windmill manufacturers are turned overnight into global players, and energy companies are busy planning larger and yet larger new facilities, farther and farther offshore. The explanation for this somewhat puzzling ‘wirtschaftswunder’ is actually quite simple. Scandinavian consumer and government alike have since the beginning of the eighties been increasingly focused on a better environment. So much so, in fact, that practically every movement, citizen and political party has approached and accepted the need for environmental sustainability in our way of life. So seeing windmills in the horizon is in a sense just the tip of the iceberg. In Denmark the government recently proposed an increase in Danish offshore wind energy to 50% of total energy production.

Deep-push CPT

Prior to the development of oceanic survey as a business field, we at GEO had performed more than sixty thousand geotechnical and environmental surveys of soil conditions in Denmark and Northern Europe. But, ironically, it was the need for surveys in relation to the placement of offshore oilrigs in the North Sea that made us develop new equipment for this new field of knowledge on seabeds. Investigation and verification of subsoil conditions at a site can be validated in several ways. The traditional method is to perform one or more borings from a jack-up platform or vessel. This method normally provides good soil data for verification of soil conditions at the site. The method is, on the other hand, also relatively expensive. Another much used method for offshore investigation is the Cone Penetration Test, a method recognised as standard investigation method for providing in situ measurement of soil layers penetrated during the test. The CPT can be utilised as stand-alone seabed rig or in conjunction with a drilling. The main advantage of the seabed CPT is that the results provide a continual profile over the total investigation depth (no gaps in data coverage) and the test can be performed relatively fast, e.g. testing to 35-metre depth below seabed complete within approximately two hours.

Soil to Surface

CPTs are carried out using a very heavy, special seabed rig, operated from any suitable vessel or jack-up platform capable of having the launch-recovery system implemented onboard. To be able to obtain penetration depths up to 40 metres (or more) the CPT rig needs to be very heavy. So far we have made it possible to ballast our rig Scope up to 28 tonnes, which ensures 200kN effective push force on the seabed. So far there are but a handful of these rigs around the globe capable of conducting ‘deep push’ with so-called Cone Penetration Test (CPT) on depths of up to 200 metres and thus providing valuable information on the strength and composition of the seabed. The CPT system is remotely operated and controlled whilst the rig is placed on the seabed. During testing (penetration) the CPT-cone measures ‘the resistance’ from the soil while the cone penetrates at a constant speed of 2cm/s. Data from the cone is transmitted to the surface unit, where the measured data is digitally stored and displayed online during the test (see Figure 2). The cone data normally includes measurements from three sensors placed in the cone, tip resistance, sleeve friction, and pore-water pressure in the formation. Many years of international experience with CPT data has resulted in broad correlation between it and geotechnical engineering soil parameters; typical engineering parameters interpreted/deduced from the data include soil strength, deformation properties and soil type.

Tricky Conditions

Carrying out accurate testing under oceanic conditions is tricky at times, so shortening the time needed for testing is a great bonus for both engineers and data. Even the most hardened sea-dog finds it a special experience to be part of such a task, especially when you think about the importance of the data as a basis for the builders, who themselves are continually trying to set new standards from an at-sea construction point of view. On a typical wind-facility survey it is customary to perform one CPT for every mill foundation site. To enhance knowledge on seabed composition, traditional drilling is used. At a facility of one hundred mills one would thus perform a hundred CPT tests and some eight to nine drillings depending on the soil conditions.

Onsite Results

Can deep-push CPT information alone ensure the required soil data information at a given site? In short, it depends on the site. If it is a

question of verification of the actual soil condition, e.g. at location in an area with ‘known’ geology from previous investigations, deep-push CPT could very well be a cost-effective way of gaining the required data. However, in general the selection of investigation method drilling and/or CPT will be based on an engineering judgement during the planning phase to optimise the investigation. The main limitation of the seabed CPT is that it cannot ‘drill’ through obstructing objects in the seabed, such as large stones. If the obstruction is a single object the problem can be overcome relatively easily by moving the CPT rig a few metres and simply repeating the test.

How Low Can We Go?

GEO have over recent years successfully carried out a number of deep-push CPTs at different jack-up locations in the North Sea region and offshore windmill projects, e.g. at Greater Gabbard (UK) and Horns Rev 2 (DK). At these locations a penetration up to 35 metres below seabed was achieved. This year one of the larger projects involves site investigations with CPT and borings at the planned offshore windmill-park at Kriegers Flak in the Swedish part of the Baltic Sea. Windmill facilities are planned on the Swedish, Danish and German parts of Kriegers Flak.

Future Uses

The market for offshore wind is expected to grow over coming years, and the demand for optimal soil investigations will follow. In the UK, Germany, Sweden, Denmark and many other countries there are currently ongoing development plans for expansion of offshore wind energy. The combination of drilling capability and CPT will continue to play a major role. Since offshore wind projects still vary greatly both in size and requirements there is an obvious need for flexible solutions, with the combination of deep-push CPTs and borings continually proving an effective and reliable set-up. Developments are still ongoing to improve and even to optimise systems such as Scope, further to ensure state-of-the-art technology for future projects. So when next you see windmills rising up above a hundred metres over the sea-level horizon, just think how work began several hundred metres below.

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