

# GEO

## Geotechnical and Geophysical Surveys >

Offshore Wind Farms

GEO has supplied specialized geotechnical services for over 30 offshore wind farms – since the world's first project in 1991





Front page picture: Copyright © Vestas Wind Systems A/S - Horn's Reef I

## » GEO's experience

In 1991 GEO carried out the site investigations for the world's first offshore wind farm in Vindeby, Denmark. Since then, we have completed more than 30 offshore wind farm projects across Northern Europe. This makes GEO one of the most experienced suppliers of geotechnical and geophysical surveys to the offshore wind energy industry.



## » GEO's commitment

In GEO more than 200 competent and dedicated employees offer state-of-the-art geotechnical and geophysical services.

We are aware of how large projects call for integrated solutions. This is why GEO offers a complete package to our clients - from the initial and detailed site investigations, the related laboratory work and foundation design and construction phase services - to the final reports. GEO also supplies the services separately if required by the client.

## » Geophysical survey

The initial geophysical survey is performed to map the seabed and sub-bottom configuration.

The survey is based on several geophysical methods. These include multibeam echo sounder for accurate bathymetry, side-scan sonar and magnetometer for seabed geology and identification of obstructions that may impede installations of cables and turbine foundations.

For the sub seabed soil configuration, sub-bottom profilers such as pinger, boomer and sparker are deployed.

The geophysical data are processed and interpreted to produce a geological model of the surveyed area.

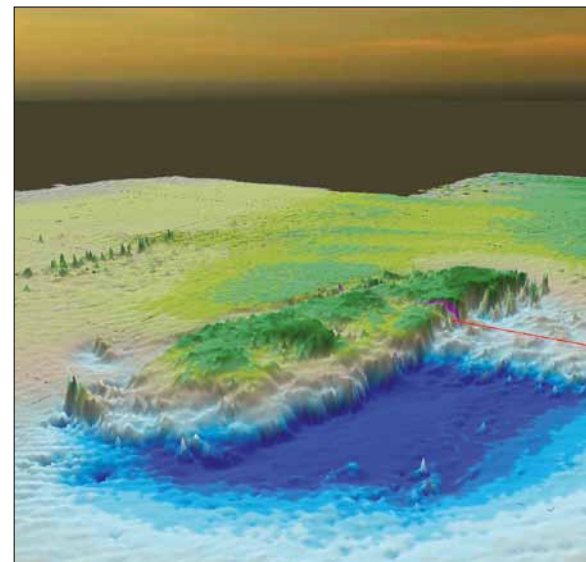


Chart showing ship wreck on the seabed

## ➤ Geotechnical investigation

To obtain further geological and geotechnical data, various geotechnical methods are put into operation. These include CPT and vibrocore samples conducted from GEO's in-house developed seabed rigs, as well as borings from offshore platforms using drilling techniques optimized for the regional soil/rock formations. The methods used are fast and flexible, ensuring a cost-effective campaign.

The geotechnical investigation provides data for the assessment of turbine locations and the structural design of the turbine foundations, the transformer platforms and the cable laying.



## ➤ Working offshore

GEO has a long tradition of deploying field teams for short and extended offshore assignments. Our teams work 24 hours a day, 7 days a week and represent our biggest asset and the foundation of the quality we deliver. They are acknowledged for their skills for improvising workable solutions to unexpected challenges during a campaign.



Ensuring a good working relationship with our client representative is a priority of ours. A productive dialogue and sparring with the client representative benefits the site investigation as well as the whole project.

## » GEO's HSE

Safety is our main priority along with the protection of the environment. GEO has implemented a safety management system covering Method Statements and corresponding Risk Assessments for all man/machine interface work process and other mobilization and demobilization situations. Toll Box Talks is an integrated

part of start-up activities and when unplanned situations occur. Even though GEO's activities have a negligible impact on the environment, environmental management is an integrated part of all activities. GEO is working on implementing a certified management system to comply with ISO 9001, ISO 14001 and OHSAS 18001.

## » Offshore & onshore geotechnical lab

The sampled cores are logged in GEO's on-board geotechnical laboratory staffed by geologists 24 hours a day, 7 days a week. All data are recorded systematically and instantaneously made available to our client, enabling the client to make adjustments to the ongoing campaign.

Further laboratory tests are conducted at our state-of-the-art geotechnical laboratories in Copenhagen and Aarhus.

Our laboratories carry out all tests, ranging from simple classification to advanced testing designed in close dialogue with the client.



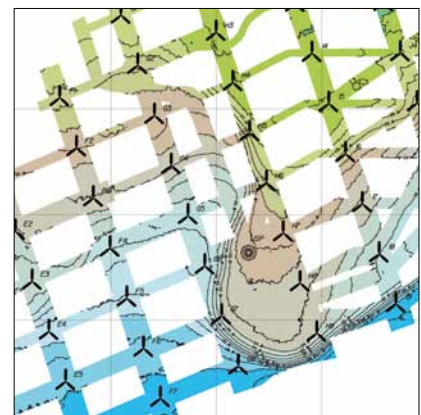
*Limestone core sample taken with Geobor S- system*

## » Reporting the facts

When data have been collected and processed, they are reported according to the client's requirements. This can include a unified bathymetric and geological model illustrated as charts and cross sections.

Comprehensive charts are produced, displaying on one sheet, the water depth, seabed features and sub-surface geology in the wind farm area.

When requested, detailed charts are produced of selected sub sections or of each turbine position.



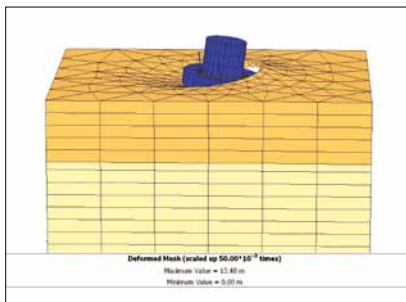
*Chart showing various seabed information and turbine positions*

## » Offshore foundation design

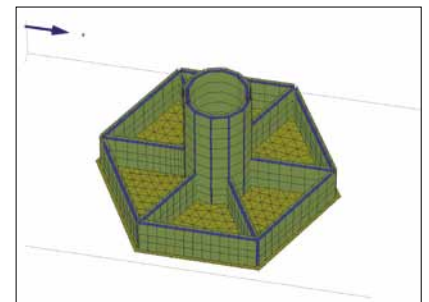
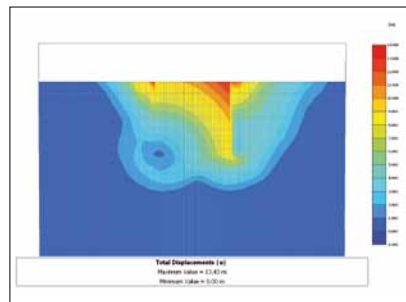
Over the past 25 years, GEO has established a unique expertise in geomechanical modelling and foundation design of offshore structures through our work for the oil- and gas industry. Today this expertise is vital to the fast expanding industry of offshore wind energy, which is facing similar challenges when designing the foundations for offshore wind turbines and transformer stations.

GEO's expert engineers use a number of methods and software packages in the process of modelling and evaluating the capacity and integrity of the offshore foundations. The methods include conventional analysis, our unique in-house developed programmes and a series of commercial tools, such as:

- » The Plaxis FE program series [2D, 3D (Foundation & Tunnel), Dynamic, Flow] applied to modelling of soil-structure interaction and foundation design.
- » Abaqus CAE/Standard/Explicit applied to foundation design and large deformation analyses.
- » Elfen Implicit / Explicit Analyses applied to large deformation analyses.
- » LPILE 6 applied to design of single driven piles under lateral loads.
- » APILE PLUS 5 applied to design of single driven piles under axial loading.
- » TZ PILE 2 applied to calculation of short term load-settlement curves for axially loaded piles.
- » GRWEAP 2005 applied to dynamic analysis of driven piles or pile drivability.



3D FE modelling of soil-foundation interaction for transformer platform



3D FE modelling of wind turbine gravity foundation

The soil data are provided by GEO's own field teams as well as by the clients. The soil parameters applicable to the foundation design are often interpreted in combination with back-analyses based on observations from similar installations. The results are delivered

following our client's requirements. GEO also often provides a second opinion or alternative design of the offshore foundations, which initially have been carried out by other consultants or our client's in-house engineers.



Map showing the offshore wind farms GEO has supplied with geotechnical services

## » Construction phase services

GEO provides services to the operator and the contractor. In and out survey, e.g. multi beam echo sounder providing detailed bathymetric mapping of each turbine location. The information is delivered on charts or as digital files to be uploaded directly to the vessel's navigation systems. GEO also carries out control investigations of the seabed prepared for gravity foundations.

*"The contractor can be qualified as an excellent and professional operating company. During the whole campaign the atmosphere on board was superb which contributed a lot to the high productivity and quality of the investigation."*

**Centrica's client representative,  
Lincs Offshore Wind Farm**



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## » GEO

GEO is a Danish engineering consultant and contractor. More than 200 employees offer Denmark's most comprehensive expertise concerning soil and water. The company's core competences are

within geotechnical site investigations, both onshore and offshore. GEO also specializes in geotechnical engineering and laboratory testing. GEO offers a wide range of services for offshore structure installations.

They include geophysical surveying and site investigations based on in-house developed equipment, the related laboratory work and consulting.

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