Company profile

Sustainable EPC and Marine Contractors

- Leading international contractor
- Specialising in:
  - Dredging and marine engineering
  - Offshore oil & gas
  - Offshore wind
- Innovative partner for clients
- Dutch-based, independent family business
- Large state-of-the-art-fleet
## Company profile

### Activities

**Dredging & reclamation**
- Ports and waterways
- Land reclamation
- Artificial islands
- Environmental dredging
- Coastal defences, dike and revetments, breakwaters
- Vertical drainage
- Underwater drilling and blasting

**Offshore Oil & Gas**
- Subsea Rock Installation
- Dredging and backfilling
- Laying oil and gas pipelines in shallow water
- Single Point Moorings
- Gravity Based Structures

**Offshore Wind Projects**
- Construction entire offshore wind farms as an EPC (Engineering, Procurement and Construction) contractor
- Supplying services to offshore wind farm industry

### Sustainable EPC and Marine Contractors

**Van Oord Offshore Wind Projects**
- Building the entire Balance of Plant of offshore wind farms under EPC contract (with responsibility for design, engineering, procurement and construction)
- Supplying services to offshore wind farm contractors
Offshore Wind Projects

- OWP office is situated in Gorinchem
- OWP has recently taken over the offshore division from Ballast Nedam including the HLV Svanen to strengthen its position in the offshore wind sector.

General

Equipment

- Trailing suction hopper dredger
- Cutter suction dredger
- Flexible pipeline vessel
- Barge
- Water injection drill
- Split hopper barge
- Mopper barge and pushbaster
- Land-based equipment
- Other equipment
- Shallow-water pipe lay barge

Aeolus

Nexus

Jan Steen

HAM 601&602
Wind turbines

WTG: Wind Turbine Generator

One of the largest rotating structures in the world placed in a harsh dynamic environment of waves and wind.

Rotor diameter: up to ~170 [m]
Pile toe to blade tip: up to ~270 [m]

Type of foundations

- Monopile
- Tripod
- Jacket
- Gravity Based
- Floating
This presentation focuses on the Monopile foundation:

**Pro**
- Most cost efficient (simple steel no complex joints)
- Relative easy, and therefore rapid, installation process
- Requires the least storage size on-shore
- Relatively simple transportation.

**Con**
- Complex dynamic behaviour due to its flexibility
- Maximum water depth up to ~40 [m]
- Structure-soil interaction beyond current knowledge
- Large diameter piles (\(\varnothing7-8\) [m]) can only be manufactured at few fabrication sites.
Offshore
- CPT for every WTG location
- Boreholes for representative locations

Onshore Laboratory investigations
- Classification of the soil
- Density
- Relative density
- Tri-axial tests: static & dynamic
- Soil gradation

Cyclic Tri-axial tests
- Cyclic pore pressure accumulation
- Cyclic accumulation deformations
- Cyclic stiffness degradation
- Post cyclic undrained shear strength

Cyclic load tests are performed with loads that are expected from the foundation design cycles for the SLS are 10000 and the ULS 100

Resulting is a possible reduction for the used PY curves
Soil interpretation

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Soil interpretation

Standort WEA-Nr. 21 (CPT 21, BH 21, BH 21A)

| Tiefe unter | Lagerungsdicke | Konsistenz | Wichte | Schonungszahl | Scherparameter für die Berechnung nach DIN 18125-1 & 2 | Min. Nen. | Gehalt | Gehalt | Gehalt |
| Meterboden | [m] | [m] | [g/cm³] | | AF (Ausschlag) | | | | |
| Druck | | | | | | | | |
| 0.7 | 3.1 | Sand | mächtig | 16/11 | 18.0 | 0.0 | 37.0 | 0.0 | - | 10 | 30 | 90 |
| 2.1 | 3.8 | Sand | mächtig | 18/5 | 17.0 | 0.0 | 36.0 | 0.0 | - | 0 | 30 | 20 |
| 2.4 | 3.8 | Sand | mächtig | 18/5/10/5 | 32.0 | 0.0 | 38.0 | 0.0 | - | 0 | 30 | 20 |
| 3.1 | 3.9 | Sand | dicht | 16/11 | 37.5 | 0.0 | 40.0 | 0.0 | - | 10 | 40 | 60 |
| 3.2 | 3.2 | Sand | sehr dicht | 16/11 | 37.5 | 0.0 | 40.0 | 0.0 | - | 10 | 40 | 60 |
| 3.8 | 3.2 | Sand | sehr dicht | 16/11 | 37.5 | 0.0 | 40.0 | 0.0 | - | 10 | 40 | 60 |
| 4.0 | 3.9 | Sand | sehr dicht | 16/11 | 37.5 | 0.0 | 40.0 | 0.0 | - | 10 | 40 | 60 |
| 5.0 | 2.2 | Sand | sehr dicht | 16/11 | 40.0 | 0.0 | 42.0 | 0.0 | - | 10 | 40 | 60 |
| 6.0 | 3.9 | Sand | sehr dicht | 16/11 | 40.0 | 0.0 | 42.0 | 0.0 | - | 10 | 40 | 60 |
| 7.0 | 2.2 | Sand, sandige Eins. | sehr dicht | 16/11 | 40.0 | 0.0 | 42.0 | 0.0 | - | 10 | 40 | 60 |
| 7.7 | 2.6 | Sand, sandige Eins. | sehr dicht | 16/11 | 38.0 | 0.0 | 35.0 | 0.0 | - | 30 | 60 | 90 |
| 8.0 | 3.0 | Sand, sandige Eins. | sehr dicht | 16/11 | 35.0 | 0.0 | 35.0 | 0.0 | - | 30 | 60 | 90 |
| 9.0 | 4.0 | Sand, sandige Eins. | sehr dicht | 16/11 | 40.0 | 0.0 | 42.0 | 0.0 | - | 30 | 60 | 90 |
| 10.0 | 4.3 | Sand, sandige Eins. | sehr dicht | 16/11 | 40.0 | 0.0 | 42.0 | 0.0 | - | 30 | 60 | 90 |

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Soil & Foundation schematisation

Schematisation foundation

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The following loads act on the WTG structure:
- Self Weight + variable loading i.e. on platforms
- Wind loads (mostly <50 [m/s])
- Wave (mostly < 20 [m] height) and current loads
- In case of ice invested area’s: ice loads (thickness mostly < 1 [m]).

All loads are dynamic loads and do interact with the response frequencies of the WTG structure.

To avoid resonance the Eigen frequencies of the WTG structure must be tuned into a narrow band.

Load calculation is an integrated iterative process between the foundation and turbine designer:

Loads are dependent on the design (frequency interaction)
Resulting from the load analysis a stochastic time domain signal is retrieved at each lever over the height of the foundation.

This signal can then be simplified (depending on type of calculation):
- Full time series
- Binned values (Markov Matrix)
- Equivalent value (Rain Flow Count)

Special load cases
- Breaking waves (dependent on water depth)
- Freak waves
- Earth quakes
- Tornado
- Impact ice bergs
- Impact unauthorized vessels or authorizes vessels with too high velocity
- Other unforeseen
Breaking waves

Ship impact

Unforeseen
**Soil schematisation horizontally**

- **P(force) – Y (displacement) springs**
  - Non linear horizontal springs
  - Uncoupled / non associative
  - Developed by API for piles up to Ø0.6-1.2 [m]

Now used >Ø6 [m] with corrections

**PY-Sand**

**PY-clay**

**Soil schematisation horizontally**

**PY-status over depth**
Soil schematisation horizontally

1D pile-soil interaction          3D pile-soil interaction

Soil schematisation vertically

Vertical load capacity
- Usually calculated as unplugged foundation due to the large diameter, so only skin friction & toe resistance
- Seldom governing for WTG but may be governing for substation (OSS)

WTG          OSS
Questions?