Geotechnics for Offshore Wind

Setting the scene – Phil Watson

A developer's perspective of geotechnics for offshore wind – Elisabeth Palix

An overview of 'new' challenges facing offshore wind – Zack Westgate

Geotechnical research to support offshore wind – Christelle Abadie

Close – Phil Watson

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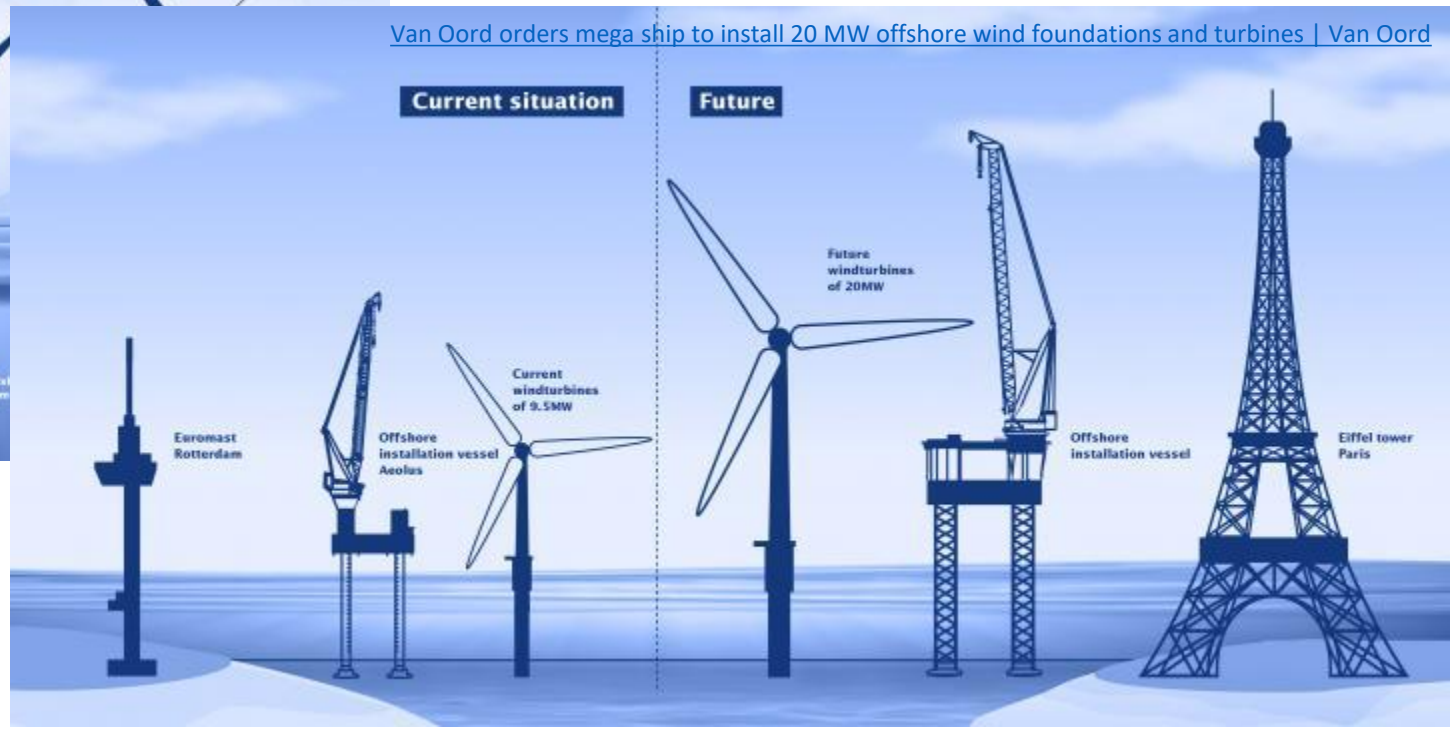
Offshore wind size – increasing wind turbine size



Van Oord orders mega ship to install 20 MW offshore wind foundations and turbines | Van Oord

Arcadis Ost 1's monopiles:

- 9,5m diameter
- 2000 tones
- 110m long

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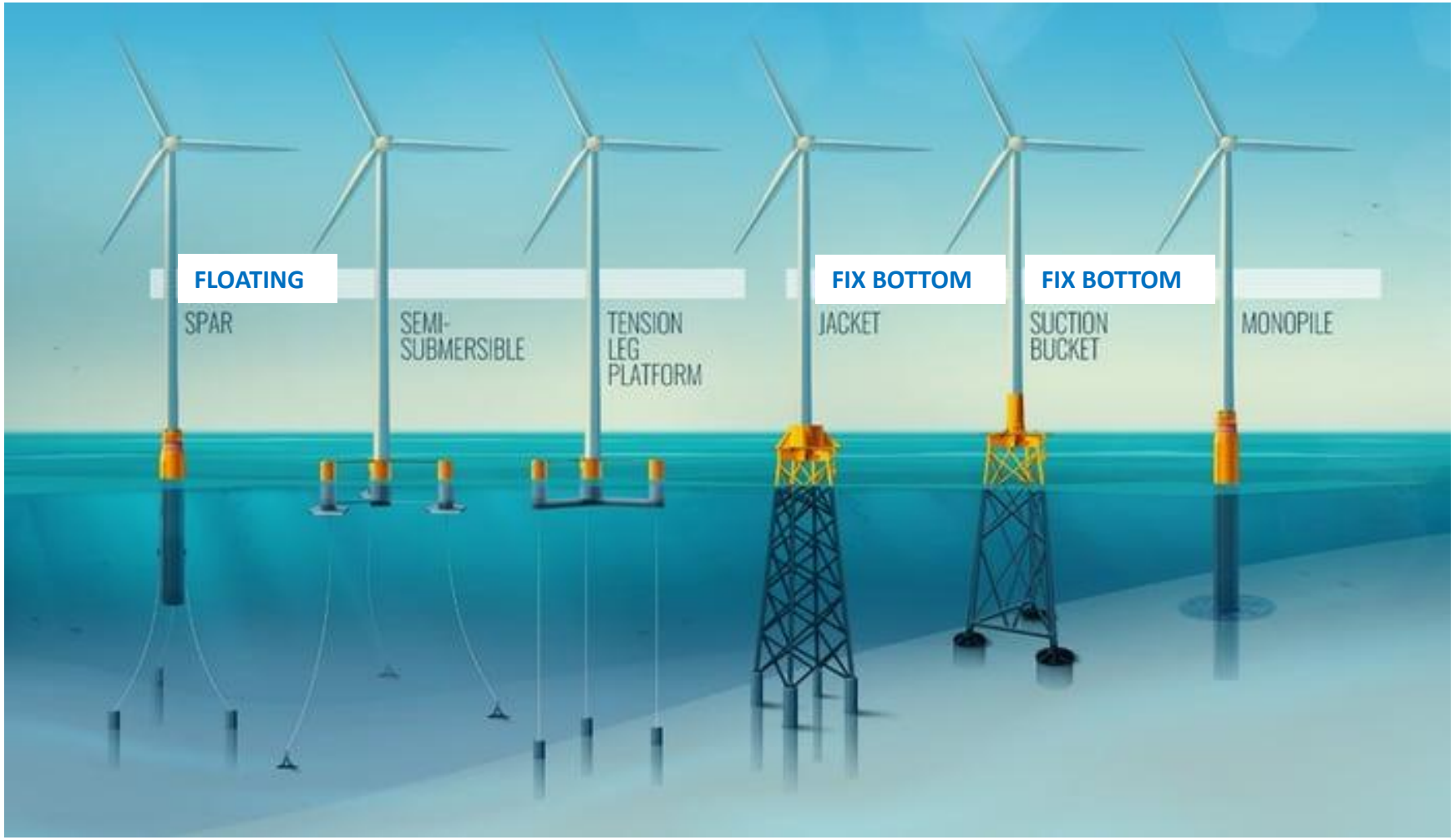
Offshore wind size – increasing water depth



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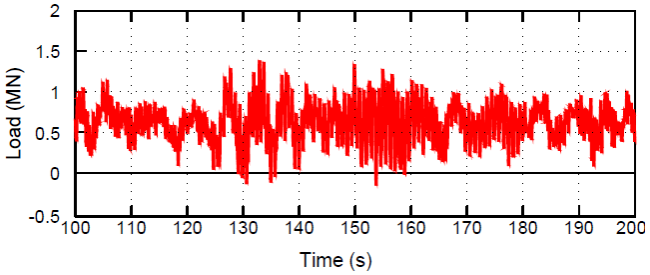
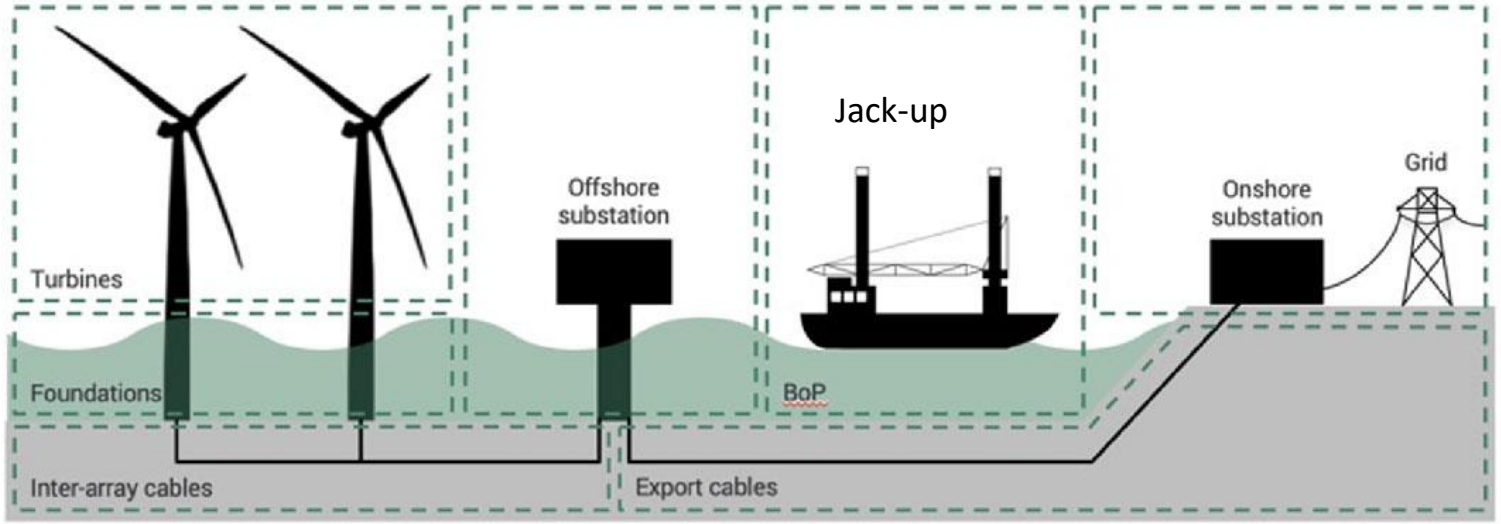
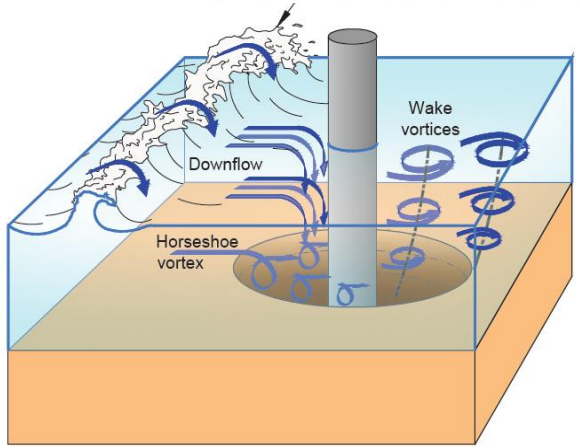
Examples of typical offshore topics to be analysed



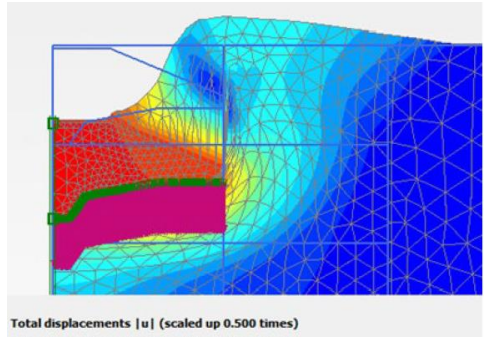
Effect of cyclic loading on soil structure interaction





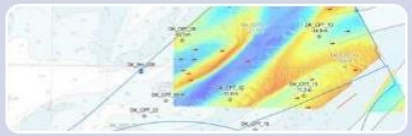
Global and local scour

Cable burial assessment



Spudcan penetration assessment

Offshore Geotechnical engineer duty





Prospectif	Developpement	Contractualisation	Construction	O&M
Selecting best site	Align technical solutions with project constrains	Secure technical choice	Master technical project risks	Ensure asset performance
• Major geohazards • Difficult ground conditions for installation • …	• Definition of geo conditions • Layout optimisation • Foundation design and optimisation • certification • Installation analyses (e.g. pile driving spudcan penetration…) • Risk assessment	• Challenge contractor's solutions • Participate to contractual negociation (e.g. definition of rely upon data)	• Follow installation operations (e.g. drilling rate, suction caisson installation…)	• Bathymetric surveys (follow potential scour deevlopment) • Follow monitored foundation to ensure proper performance (natural frequency, settlements…)

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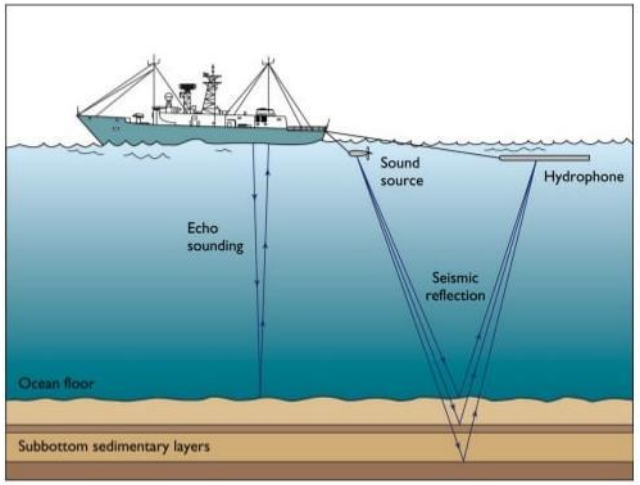
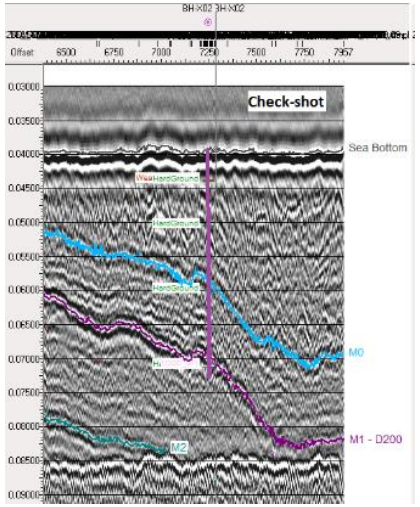
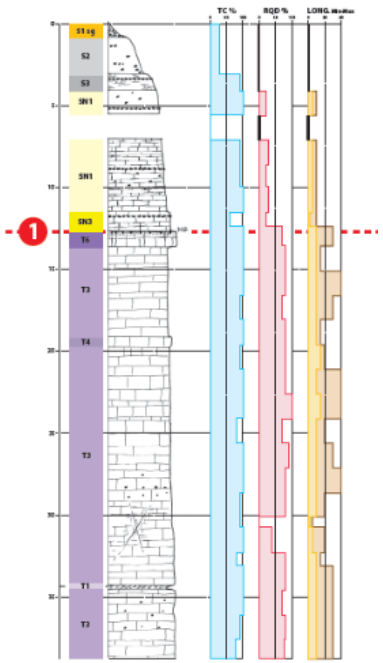
A developer's perspective of geotechnics for offshore wind

Geomodel



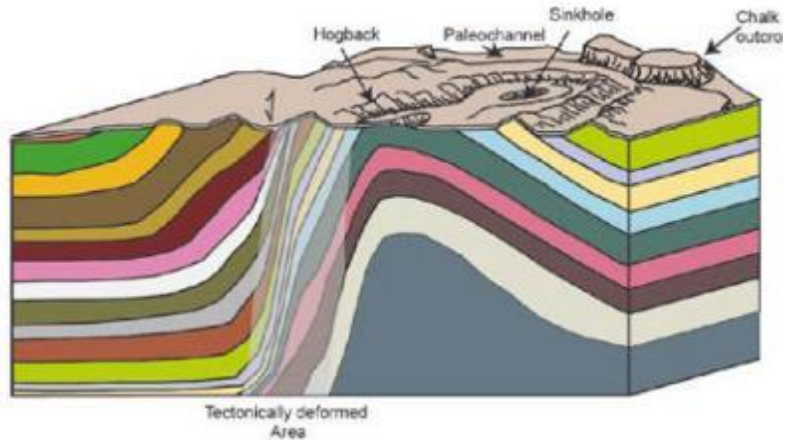




Do we need to make one borehole per WTG? Or even per pile?

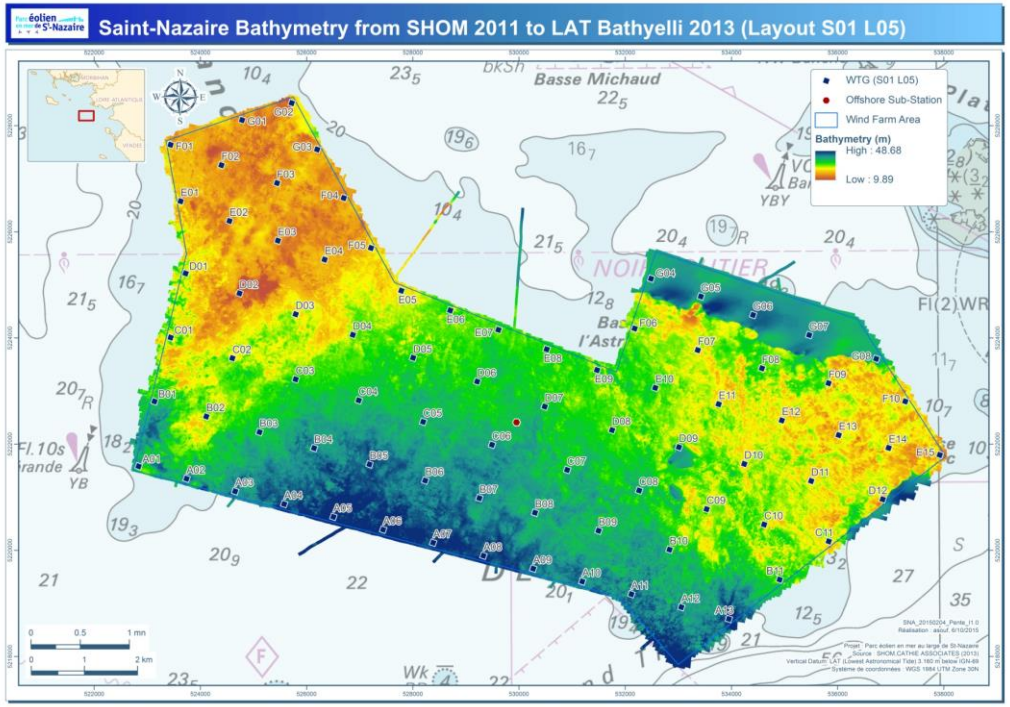
Ground complexity
Design optimisation
Risk mitigation

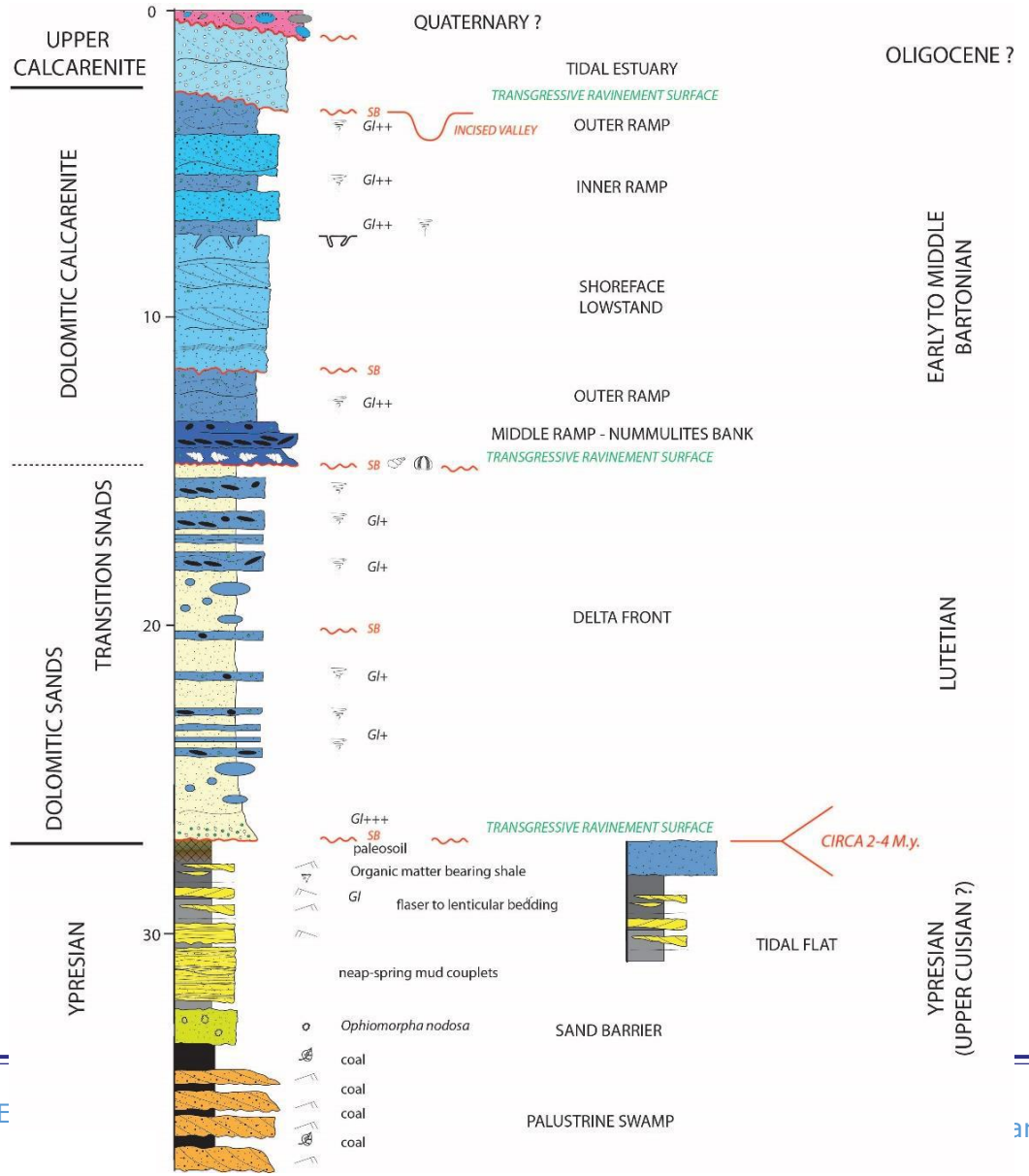
Cost planning



A developer's perspective of geotechnics for offshore wind

Example of Saint Nazaire





- ✓ Calcarenite bank on the majority of the site
- ✓ Thickness of the calcarenite bank varying from 0 to more than 30m
- ✓ Very variable rock state (fracturation, resistance)

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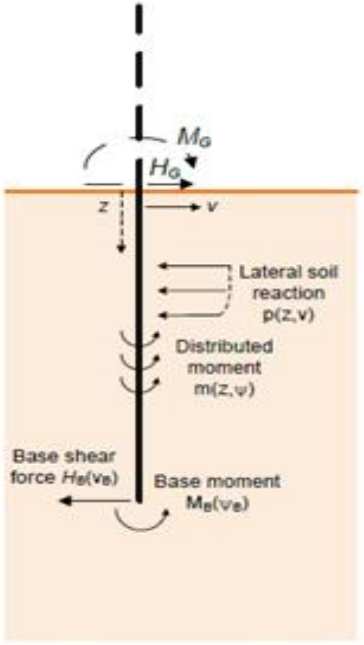
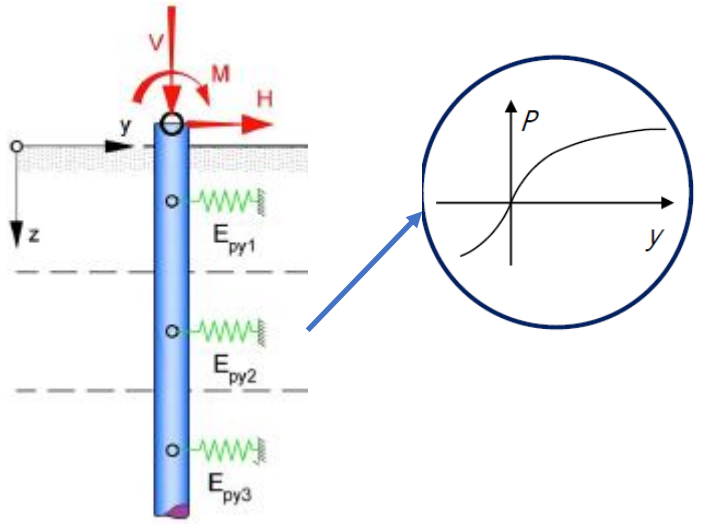
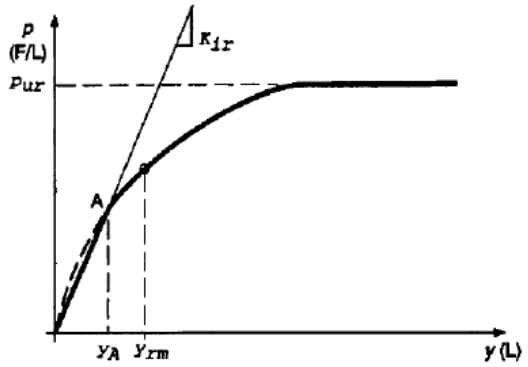
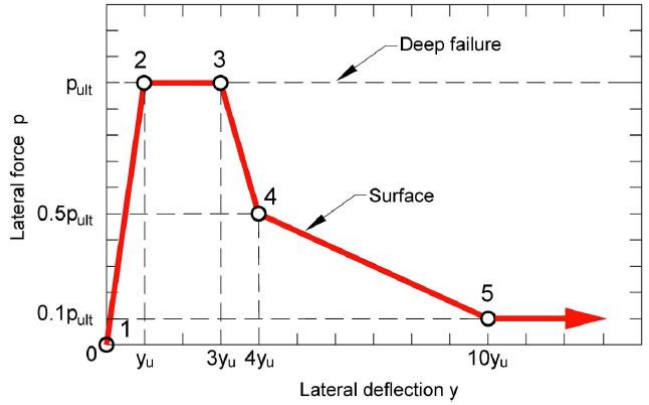
Soil structure interaction in weak rock

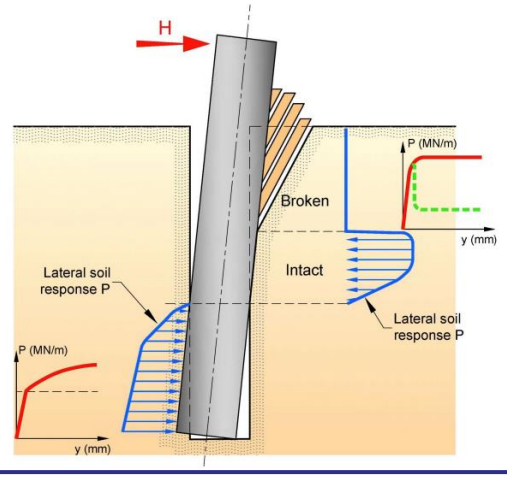


Simplification in rock?









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A developer's perspective of geotechnics for offshore wind

Onshore pile tests

- 11 piles of 0.76 and 1.2m diameter
- L/OD=2.6-4.0
- Different installation methods tested: driving only, drive/drilled/drive and drilled and grouted
- Lateral load applied at 5m above ground level

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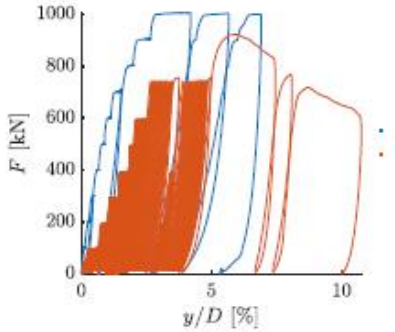
Implementation of observations and results in FEM

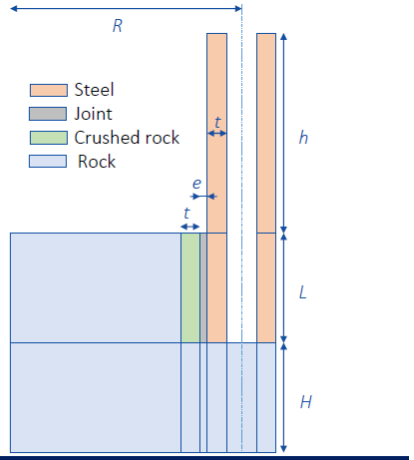
Gap behind the pile

Crushed rock around the pile

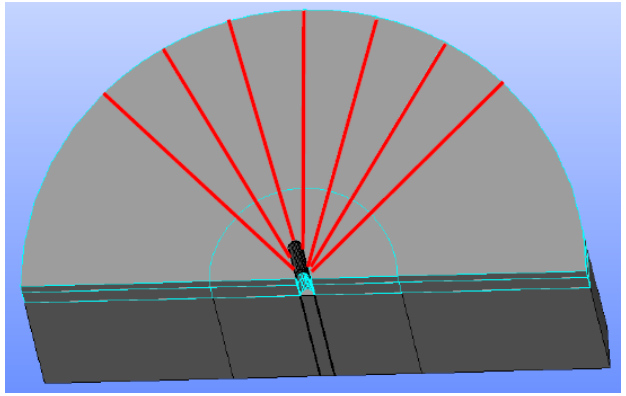
Cracks

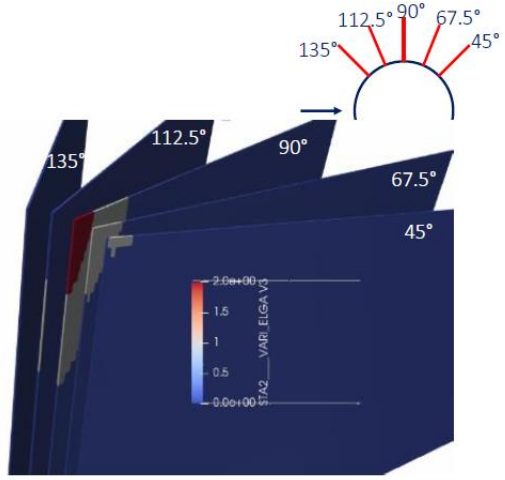


Cyclic accumulation & Creep



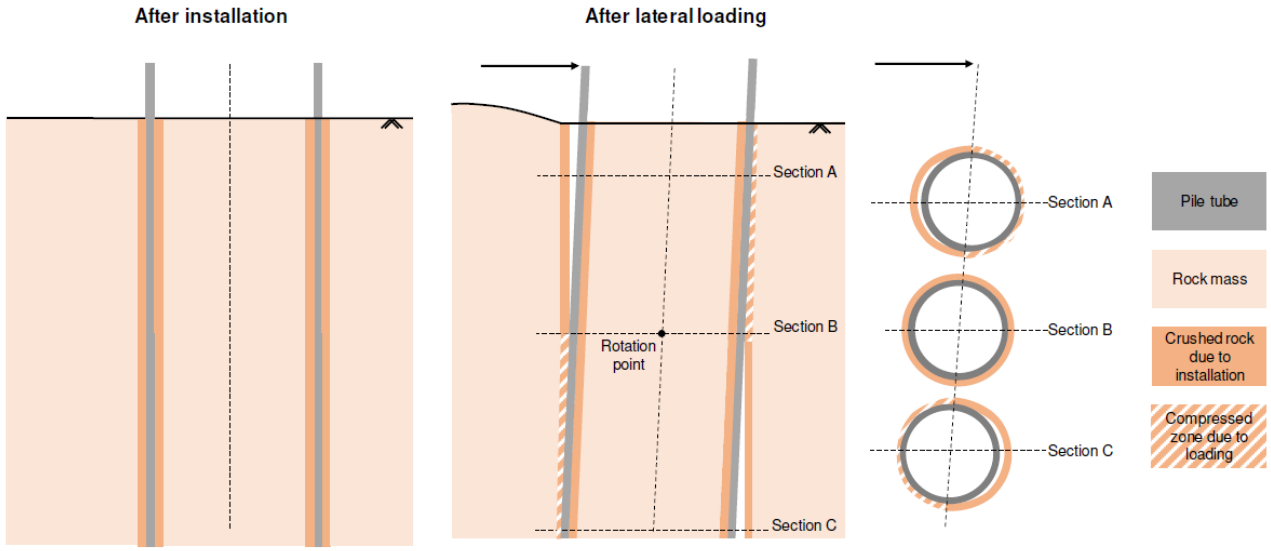
3D FEM

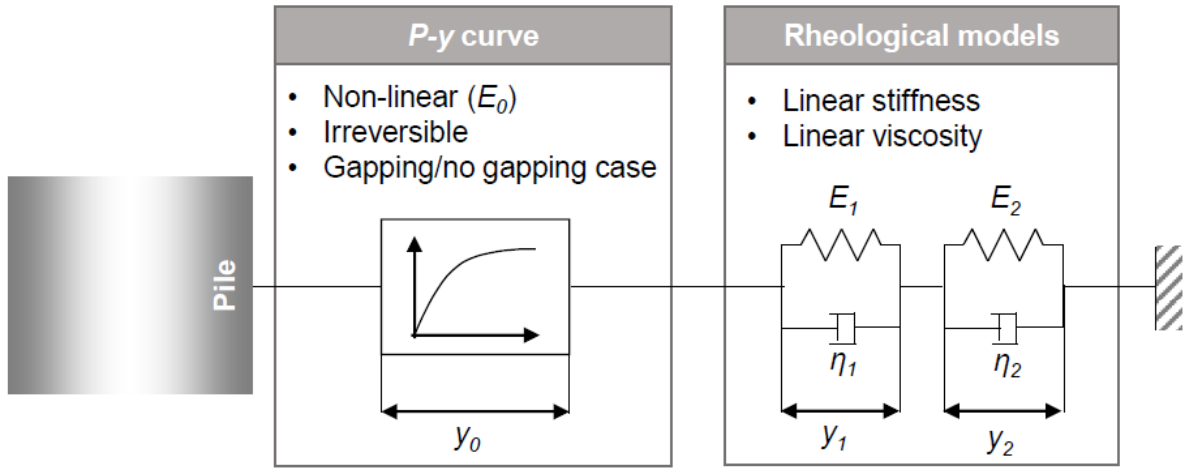




3D FEM

Observation to rheological model (Anaïs Lovera PHD thesis)





Lovera, A. (2019). Cyclic lateral design of offshore wind turbines monopiles in weak rocks. PhD Thesis, L'Université Paris-Est, Paris.

Palix, E. and Lovera, A., 2020. *Field testing for monopile to be installed in weak carbonated rock*. 4th International Symposium on Frontiers in Offshore Geotechnics.

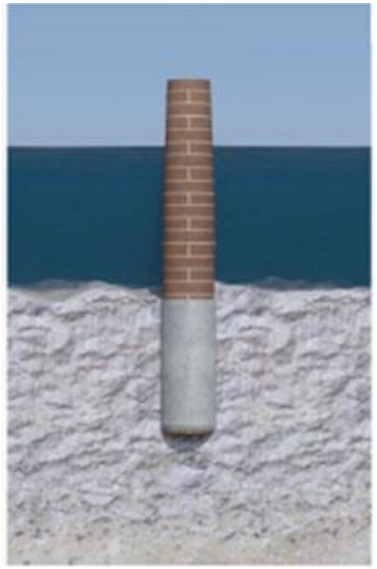
Lovera, A., Ghabezloo S., Sulem, J., Randolph, M.F. and Palix, E. 2020. *Extension of the P-y curves framework for cyclic loading of offshore wind turbines monopiles*. 4th International Symposium on Frontiers in Offshore Geotechnics.

Installation methodology

Installation scenarios

Full height driven
No grout

Typical soil profile:
Sand over full length

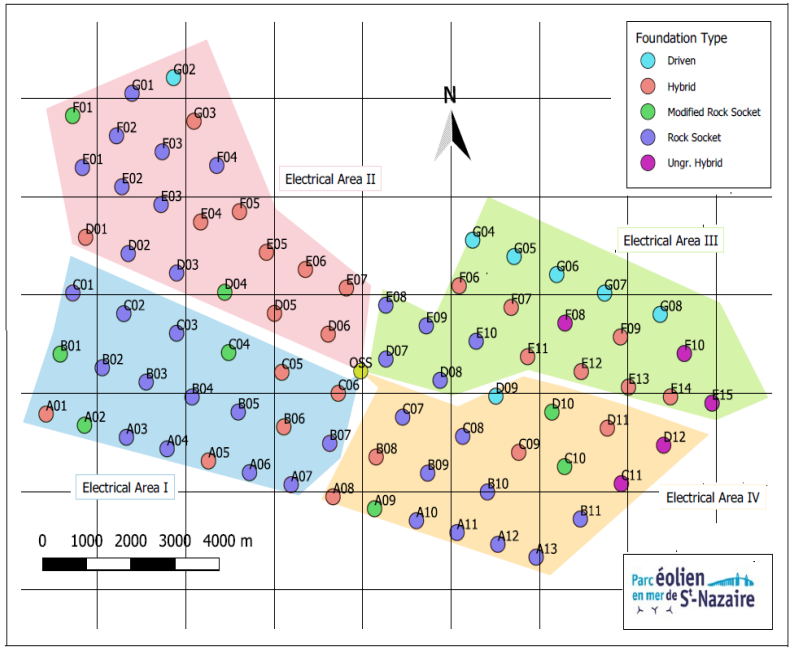


Full height drilling
Full height grouted

Typical soil profile:
Calcarenite over full length

X% drilled
Y% driven
Grout optional

Typical soil profile:
Calcerenite over sand



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Installation Operations

S-4000 Hammer (IHC)

Offshore Drilling machine (7,7m diameter) developped by Herrenknecht specifically for this project (first vertical boring machine of this kind used for offshore wind)