Pile Soil Analysis (PISA) Project
Joint-industry project: Improved design methods for laterally loaded piles

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Presentation by
PISA Academic Work Group (AWG)

Pile Soil Analysis (PISA) Project
~£3.5m JIP to improve monopile design for offshore wind

\[ p(y) = \begin{cases} 
  p_u \left( \frac{y}{y_c} \right)^{1/3} & \text{for } y \leq 8y_c \\
  \frac{p_u}{2} \left( \frac{y}{y_c} \right) & \text{for } y > 8y_c 
\end{cases} \]
Shortcoming of Existing Design Methods

Offshore Wind  Oil and Gas Design  Design Problems?

Nacelle  Tower  Transition piece  Monopile

Underestimation of measured frequency

(Kallehave et al., 2012)
### High Level Overview

1. Clearly define problems and identify constraints to the solution.
2. Identify possible design methodology.
3. Derive large scale test regime to prove proposed methodology.
4. Undertake large scale testing.
5. Analyse and compile results and report.

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**Academic Work Group**

- Principal Investigator: Professor Byron Byrne
- Professor Guy Houlsby, Dr Harvey Burt, Dr Chris Martin, Dr Ross McAleer
- Professor Lidija Zdravkovic, Dr David Taborda, Professor David Potts, Dr Richard Jardine
- Dr. Ken Gavin, Dr. Paul Doherty, Dr. David Igoe

**Lead Partner**

**DONG Energy**

- Project Manager: Jaeger Steen-Germand
- Technical Manager: Miguel Pacheco Andrade

**Assisting Consultants**

- UUK Consultant
- Testing Assistance
- Management
- Structural Designer and Site Supervision

**Testing Contractors**

- ESG
- Principal Testing Contractor
- Steel Supplier: Sangevin
- Pile Fabricator: GITA
- Fibre Optic Supplier: In Situ Concept
- Pile Installation: de Waal Consultants
- CPT Investigation: DAC
- Site Investigation

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**Independent Technical Review Panel**

- Chairman: Professor Gudmund Eiksund
- Liv Hamre
- Dr. Fabian Kirsch
- Tim Cemp
- Professor Werner Bucker

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**Discretionary Project Steering Committee**

**Non OWA Partners**

- University of Oxford
- Imperial College London
- UCD
- DONG Energy
- Carbon Trust
- PISA
Method Development

- High quality FE modelling
- Robust extraction of data from FE work
- Comparison of extracted data to current design methodologies
- Identification of improvements to current methods and additional components of model
- Comparison of new approach to FE simulations and current design methods
- Development and execution of field testing program to provide benchmark data at a range of pile sizes

High Level Overview

3D FE

Field testing

Design

Validate

Develop

Simplified 1D model

Apply

Accurate response prediction
Current Method

New Method

Short Pile – Clay (L = 20 m, D = 10 m)
Site Selection

- Cowden - stiff, over-consolidated clay site

- Dunkirk – Dense sand site

- Existing characterisation used as a basis for FE modelling

- Additional characterisation completed

Field Test Program - Layout

2 Sites – 28 pile tests – monotonic and cyclic
Monotonic Test Result

![Graph showing Horizontal Load vs. Ground Displacement with curves for FE and API/DNV]
Concluding Remarks

- Next generation monopile foundations will be large
  - Deeper water
  - Larger turbines

- New design methods needed for optimisation
  - Developed from numerical analysis
  - Benchmarked against field testing
  - Monotonic and cyclic loading
  - Results here suggest reduction of steel by 30% compared with the API / DNV method leading to significant savings in installation costs
  - Final report to be submitted in April 2016

- PISA – A great example of industry and academia working together to solve important technical challenges

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PISA Academic Work Group (AWG)