

The Offshore Bucket

Trial Installation

X Universal Foundation

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Abstract

Universal Foundation has in cooperation with a group of Carbon Trust Partners and Aalborg University conducted an offshore campaign on Dogger Bank, Hornsea and Dudgeon to confirm the bucket concept installation process.

The UNIVERSAL FOUNDATION bucket is a novel foundation concept with potential for significant cost reduction in the water depth range of 15-55 m with large rotor wind turbines.

These benefits, include reductions in installation costs (no piling or seabed preparation, no hammer/vibrator noise, fast installation process) and fabrication costs (simple monopile design with no Transition Piece), and the ability to function on a wide range of soil conditions.

CARBON TRUST

> DONG energy

eon



Results

Route and Positions



Soil profile for the selected positions

Installation no.	Installation name	Profile description	Layering	Depth			
1		Very dense sandy profile	, ,	15m			
2		layered profile, medium sand upper layer then firm to stiff clay		1,9m 4,5m 15m			
3		pebbles and cobbles at seabed. layered profile , medium sand upper layer then stratified profile stiff clay and medium to dense sand		2m 2,2m 3m 3,5m 3,7m 4m 4,4m 5m 5,2m 7,5m 8,3m			
12		layered profile . Medium sand upper layer then firm becoming stiff clay. Finally very dense sand.		1,2m 4,5m 11,4m 19,4m			
14		sandy profile, loose to medium sand upper layer then medium dense to very dense sand. Finally stiff to very stiff clay		0,4m 10,9m 36.7m			
15		sandy profile with several interbedded clayey and silty layers		0,2m 3,0m 3,1m 4,1m 6,1m 12,3m			
4		Stiff to very stiff clayey profile .Medium sand upper layer then stiff to very stiff clay		0,65m 10,45m 11m			
5		layered profile. Medium sand upper layer then stiff clay then dense sand. Finally very stiff clay		0,8m 1,4m 2,1m 10m			
7		layered profile. Difficult layerering. Surface sand with clay and silt mixtures. Firm clay and embedded layers containing sand,silt and clay.		1m 1,3m 11,4m 4,2m 11m			
9		layered profile . Surface sand with clay and silt mixtures. Then a clayey layer and a sandy layer. Layered firm clay mixt with sand and silt mixtures. Finally stiff clay		0,6m 2,1m 3,1m 4,2m 19,4m			
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The Offshore trial Project History:

- Summer 2011 project initially proposed by Carbon Trust in OWA
- Summer 2012 interested partners EON, DONG, Statkraft, Statoil
- Statoil nominated as Lead Participant
- Scaled down 5MW design planned to be trialled
- 4 x test locations on Dogger Bank
- Cost indication: £4.5 project (£2.0m from OWA and £2.5m from UF and EUDP)

Objectives

The trial Installation activity was undertaken by the Carbon Trust Offshore Wind Accelerator to further de-risk the Universal Foundation bucket concept and move it towards full commercialization. A main issue is to calibrate the calculation factors for the penetration prediction used in DNV - Foundation 1992 - classification notes NO. 30-4 and the Aalborg University method.

It is generally considered complicated to install skirts/"buckets" in multi-layered soils including "impermeable" clayey layers and other profiles containing dense sandy soils. Furthermore, the verticality control for single compartment structures is not so well documented.

The main risks associated with the installation process have been identified as: • Installation of the bucket foundation in difficult soils (e.g. clay and layered soils)

- Achieving verticality during installation
- Robustness of the skirt during handling and installation

Full penetration was demonstrated by use of an internal soil levelling system which enable to remove the plug heave.

Roll: -3 Pitch:-55 Dpt: 28.0m	Hdn:119	Date: 140929 Clk:13:05:51	Roll: -6 Pitch:-25 Dpt: 32.3m	Hdn:152	Date: 1409 Cik:13:37:
DB_1038_U	030		DB_1038_U		

Examples of test results

The plots presented from left to right: Predicted maximum penetration calculated in accordance with the standards. Actual penetration. Inclination during installation.







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The trial bucket foundation was a scaled-down foundation design, 8 x 6 m (D x H), weighing approx. 60 tons. The multi-shell skirt design with clay chambers was used. For reference a cylindrical probe of 4 x 6 m was installed in parallel.

Project goal:

- Planning operations at Dudgeon, Hornsea and Dogger Bank wind farm zones
- Acquire as many tests as possible in a 28 day offshore period using the Fred. Olsen Windcarrier jack-up vessel Brave Tern.
- Site selection aim to test performance in challenging layered soils (clay over sand) and other conditions representative for UK Round 3 wind farm sites

The Trial Campaign

The trial bucket and the reference bucket were fitted with instrumentation at quay side in Frederikshavn, DK. The instrumentation for the different measurements complied of:

- > Accelerometers: Movements during splash-zone penetration
- > Inclinometers: Verticality during installation
- Pressure gauges: Driving force during installation and penetration depth
- Flow meters: Seepage and water injection
- Echo sounders: Penetration depth and plug heave

The trial bucket and the reference bucket were installed all in all 29 times during the 24 days of operation from first jack-up to last jack down. The achieved data for further data processing:.

Pressure, kP

✓ Data from the Click-on Pump Unit and the Structural Monitoring System

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ocation: DGN 025a U

- ✓ Data form the Reference Probe system
- ✓ Data from the Crane Log

> Strain gauges: Stress in skirt and lid structures.

The deck layout on the jack-up vessel Brave Tern. Right side: Reference bucket ready for deployment.

✓ Video from the ROV operation

= 8.00 m, L = 1.25 m

- ✓ Video from Slash zone penetration
- ✓ Daily Project progress reports

Conclusions

The Bucket trial Installation project has gathered a substantial amount of date in a unique soil database which enable update of the used standards for penetration prediction. This update will lead to less conservative design of bucket foundations and is vital for the aim of cost reduction in the offshore wind business. Furthermore serial offshore operation with the bucket concept was demonstrated, achieving full installation depth and inclination within given tolerance.

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