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Abstract

Wind turbine foundations are components which have seen increased levels of innovation in recent years, be it through new technologies for existing techniques, such as XL Monopiles, or various types of floating turbine design.

The FSFound project relates to a third innovative design route – that of Self-Installing Gravity-Base Foundations, or “Float/Submerge Gravity-Base Foundations” – FS GBFs. As with all novel concepts, proving the concept at full scale requires a large amount of numerical modelling, as well as instrumentation to measure the “real-world” loadings. Instrumentation to investigate corrosion related properties is also deployed. Data is linked to turbine and meteorological conditions to allow for categorisation and analysis of data. Ultimately, data from the project will be used to investigate key indicators for prognostic monitoring systems for foundations of this type.

Project Objectives

The wider FSFound project has the following global objectives:

- To move the FS GBF solution from TRL 6 to TRL 7, thereby verifying the research and disruptive innovation initiative;
- To verify the manufacturing and installation methodology and benefit from the lessons learnt in order to optimise plans for the future transnational exploitation of GBFs;
- To minimise potential delays and cost overruns through the development of multiple installation scenarios against a meteorological model;
- To compare the actual costs and performance with the cost-benefit analysis performed;
- To design and install a condition monitoring system on two GBFs to monitor their behaviour;
- To assess the structural response to extreme and fatigue loads on the GBF and compare theoretical loads with real ones.

These last points involved the design, manufacture and installation of a bespoke measurement system to monitor in-service loads and conditions on the foundation.

Methods

Of the five FS GBFs deployed as part of the Blyth Offshore Demonstration Project Array 2 construction, two GBFs have been fitted with extensive instrumentation systems. These include Inclinometers, Strain Gauges, Pressure Sensors, and Dissolved Oxygen sensors.

This data is linked to turbine operational parameters via: a direct connection to the turbine control system (e.g. rotor load, rotational speed, power generation, etc.); wind data from a hub height met mast on the site; and a wave buoy located in the wind farm. This additional data will enhance the ‘meta-searchability’ of the load dataset.

IP-based data collection, logging and data transmission systems allow connection to shore, where main data collection and processing can take place.

All measurement systems were installed during the onshore construction of the FS GBFs in the summer of 2017.

Results

The foundations were floated out of the Tyne during the Summer of 2017, with turbine installation following directly afterwards. With 66kV inter-array cables connected and turbine datalinks commissioned, the project team will be able to download data from the monitoring systems for analysis.

Lessons learned during installation have already been fed back to understand how installation of bespoke measurement systems can be further integrated into the construction of novel foundation structures.

Conclusions

Inclusion of research measurement systems on a time-constrained commercial project is not a simple or low risk undertaking. Equally, for the research community, it is unthinkable that a novel system could be deployed without measurement systems which could, at the very least, serve to validate design models. The lessons learned from this project provide important pointers for the deployment of research systems into commercial project timelines for future undertakings.

With this in mind, key learning from this project includes the demonstration of how good research outcomes can be derived, despite strong commercial programme requirements; there is a win-win scenario.

Additionally, commercial ‘Off-The-Shelf’ components, not originally intended for subsea use, but providing “best-in-class” measurement performance, can be successfully integrated into offshore wind foundation measurement systems.