SHELL/NAM Monotowers F13-FI-1

LICengineering has an extensive track record for providing engineering services within offshore Oil & Gas monotowers. Nine substructures of the monotower type have been designed by LICengineering. Lately we completed design and analysis on the substructure for the L-13-FI-1 platform designed as the latest step-out on the NAM operated field L13. The substructure consists of a monopile and a monotower. The platform's topsides is placed on the substructure and the three parts are connected with two grouted connections. The L-13-FI-1 platform was installed in the Dutch sector of the Southern North Sea during May 2017.

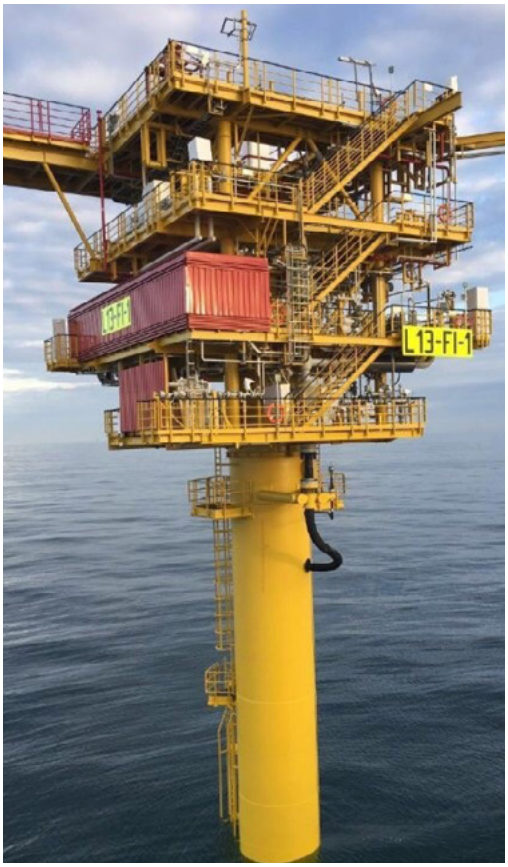
The L-13-FI-1 platform is operated by SHELL/NAM and is located in the Dutch sector of the North Sea. The unmanned facility has the main features:

1. Capacity of hosting 6 off 26" conductors for gas.

2. Power supply by the wind, solar, battery package on upper deck.

3. Stand-alone with Line-of-sight communication (LOS) to manned asset.

LICengineering performed detailed design and analysis for the pile and tower fully certified by Lloyd Register. LICengineering also provided engineering support throughout the project including installation analysis of pile and tower.

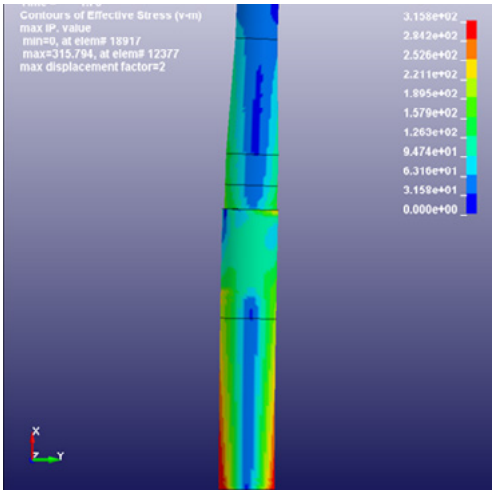


The platform was installed during 2017

Design Analysis

LICengineering has broad experience in developing minimum facility structures with cutting edge solutions ensuring an optimised design that suits a low yield or brown-field production platform. For this project, especially the design analyses, were focused to determine the required minimum wall thickness and penetration depth for the substructure. Dynamic analyses, including the vibrational behavior of the pile and tower, subjected to combined wave and wind loads were carried out. The substructure was designed to resist ultimate storm- and fatigue loads in minimum 20-years operational lifetime.

The substructure was analyzed for accidental and operational ship impact. The grouted connections were analyzed considering allowed pile tilt. Transport and lifting scenarios of the pile and tower were also analyzed. The dry topsides weight is 335 ton, the tower is 320 ton (excluding risers and ancillaries) and the pile is 355 ton.



Stress test using LS-DYNA

Foundation Layout

The substructure consists of a monopile with an outer diameter of 4.7 m and a monotower positioned inside the monopile top section and connected by a grout connection. The monotower has the following appurtenances: access platform, intermediate platform, ladders up to the topside and conduits entry/exit holes.

Design is according to EN/ISO 19902 and Shell internal standards including additions from DNVGL recommendations. Design and analysis is fully certified by third party Lloyds Register.

Installation Aspects

The LIC scope included lifting studies of the tower and weather window analysis during grout curing for the assembled structure.

The topsides, tower and pile was transported to site on one barge. The CAPE VLT vibrohammer tool was used to lift, upend and vibrated into the soil. Pile position and verticality is provided without any use of subsea templates or vessel outriggers. The target depth was obtained by using an impact hammer for the last meters. The monotower is then place inside the monopile and structurally supported by a landing ring designed for all installation and in-place loads. Finally the topsides is place on the monotower. Both pile/tower and tower/topsides are grout-type connections that are grouted simultaneously. All appurtenances, risers and secondary steel are pre-installed before ship-out and very little commissioning of sub-structure is required.

Finally up to six wells can be drilled through the 26” conductors inside the sub-structure.The vibro-driving will reduce installation fatigue and eventually allow life-extension of the facility but is also much less noisy than impact driving. Also it allowed a much reduced procedure for positioning and levelling of the pile.

Geotechnical Conditions

The geotechnical conditions of a CPT and a borehole sample on the location has been evaluated to show fine sand at the upper lay of the seabed and very dense sand all the way down to the pile tip.

LIC have made the soil interpretation, soil springs and pile installation analysis works. Soil springs are benchmarked against PLAXIS and the latest developments from the offshore wind energy industry with soil initial stiffness increase provided by Kallehave et al. (2012).

The pile installation analysis is done using GRLWEAP 2010 for both impact and vibro installation scenarios. This includes a backlog calculation to reassess soil parameters and fatigue.

Transport of tower and monopile prior to installation

A closer look at both tower and monopile

Installation

Scour Design

The upper lay of the seabed comprises fine sand which will move due to current and waves, and create scour hole around the monopile. The scour protection of the substructure will be rock dump designed for the local conditions at L13-FI-1 and applied 3 weeks after installation of the substructure.

Hydrographics

The platform is placed in the Dutch sector of the southern North Sea. The water depth is 26.5 m with the maximum tide ranging to 2.4 m.

Project Facts for L13-FI-1 Platform

- Type of Structure: Oil & Gas monotower (unmanned)
- Operation: Unmanned with sea access only. Line of sight (LOS) communications Fully equipped with metering, HPPPS and injection. Powered with solar, wind and battery package on top deck
- Location: Dutch sector of the Southern North Sea
- Water Depth: 26,5 meter
- Pile Diameter at Seabed: 4,7 meter
- Soil Condition: Very dense sand
- Installed: May 2017
- Installation Method: Driving with vibro hammer to 25 meters depth and completed with impact hammer to a target depth 31.5 m
- Sub-Structure: Pile 355 ton / Tower 325 ton
- Connections: Grouted connections with weld beads and landing ring. Grout operation finalized simultaneous for both connections after complete stacking of pile, tower and topsides.
- Topsides Structure: 335 ton in dry condition
- Conductors: 6 off 26” casing conductors (gas)
- Scour Protection: Rock dump 3 weeks after installation

Installation

Installation during night

Project References for SHELL Oil & Gas Monotowers

- 2012/2018: L13-FI-1 Monotower Design - Design Package for the monotower substructure. package based on previously installed L09-FA platform. Water depth is approximately 27 m.
- 2011: Trident Monotower Wellhead 6 Riser Platform FEED - Project and Design package for a monopile and monotower for combined wellhead and riser platform. Based on earlier design (L-09-FA & L-09-FB). Water depth approximately 26 m. Remains a FEED study
- 2010: Sweep Project FEED - Monotower step-out production platform with a suction bucket foundation design- Determination of minimum penetration of Riser Access Tower. Water depth approximately 27 m.
- 2008: Carrack West Monopile & Monotower - Project Design and Design Package for monopile and monotower based on previous designs. Water depth approximately 28 m. Remains a FEED study
- 2006: Shamrock Monotower - Monotower Design. Water depth approximately 30 m.
- 2006: L09-FB Monotower - Monotower Design. Water depth is approximately 24 m.
- 2006: L09-FA Monotower - Monotower Design. Water depth approximately 22 m.
- 2005: K5F Feasibility Study - Determine if driven monopile foundation is feasible for the platform. Water depth approximately 38 m. Remains a FEED study
- 2005: Caravel Monopile Development - Concept Investigation. Investigate consequences for Trident monotower if the stem is increased from OD 2.5 m to OD 3.7 m both with respect to pile penetration and with respect to mass. Water depth approximately 30 m.
- 2004: K17 Monotower Development - Development & Detailed Design. Water depth approximately 38 m
- 2004: Cutter Field - Conceptual Design & Monopile Design. Water depth approximately 30 m.

L-09.FB Monotower

Shamrock Monotower

Caravel Monotower

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