

Langeled - Intervention Work Optimisation

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ABSTRACT

The design of the 42-in Langeled Pipeline North (LPN) – running from Nyhamna (Norway) to the Sleipner Platform in the North Sea – included the crossing of a very uneven seabed area along the Eastern Slope of the Norwegian Trench.

Gravel supports were designed to mitigate static and fatigue stress at free-spans. Because of the low soil strength, the application of standard design solutions would result in very large gravel volumes which in some cases could not be feasible.

This paper shows how the standard solutions were reviewed in order to develop solutions that minimize investments and operating costs while fulfilling project safety standards.

The optimisation process involved the schedule for execution of the gravel dumping, the interaction between pipeline and support vs. the applied load condition, the review of the applicable design criteria by means of a risk-based approach, and the use of ad-hoc 3D models to define the shape and to check the stability of the support.

As a result of this optimisation, each support was designed for specific purposes taking account of a safety level which referred to the applicable load conditions and to the consequences of failure.

The overall approach which was applied to the Langeled project resulted in a safe and reliable structural configuration of the free-spanning pipeline together with a reduction of gravel volumes whilst also demonstrating the feasibility of the support at the most critical locations.

KEY-WORDS: pipeline, on-bottom roughness, free-span, stability, intervention works.

INTRODUCTION

As part of the development of the Ormen-Lange gas field located 120 km off the west coast of mid Norway, a large-diameter export pipeline called Langeled has been laid from Norway to the UK. The Langeled development project has been managed by Statoil on behalf of Hydro.

Langeled is tied into the Sleipner field about mid-way to the UK. The 42-in diameter 250/215 bar northern leg (LPN) runs from Nyhamna to Sleipner, while the 44-in diameter 157 bar southern leg (LPS) runs from Sleipner to Easington (UK).

A feature of some of the areas crossed by the LPN is a very uneven seabed. Free-spans and bending required mitigation measures at several locations. Free-span height and number, site depth, and pipe diameter and weight, ruled out solutions like trenching or ploughing, which were found not convenient or even not feasible. Then the selected solution was to introduce artificial supports by means of gravel dumping.

The low bearing capacity of the foundation soil, which mainly consists of very soft to soft clay, and the high loads caused by the support height and the pipeline loads, was a major challenge during the design of the intervention works. In a typical design approach, this would result in large stabilisation counterfills, and large gravel volumes.

In addition to the use of the state-of-the-art analysis methods for routeing and on-bottom analysis, a substantial optimisation in the design of the supports was achieved by implementing a design methodology focused on the following points:

- Minimization of pipeline stress levels vs. timing for execution and configuration of the gravel support;
- Verification of geotechnical stability by means of purposely calibrated partial safety factors (risk-based approach) and ad-hoc 3D models (clay only);
- Accuracy in soil description and 3D modelling of seabed.

The selection of the route was based upon general principles aimed at minimising risks as well as the overall cost of the pipeline. To this purpose, in the most uneven areas the routeing was in the main focused on minimizing those free-spans whose configuration (number, length, and height) affected directly amount and feasibility of the intervention works.

The optimisation of the route was performed in parallel with the on-bottom roughness analyses and the design of the relevant intervention works. In order to either avoid or minimize the need of intervention works, the pipeline was locally rerouted where the results of these analyses identified a critical location.