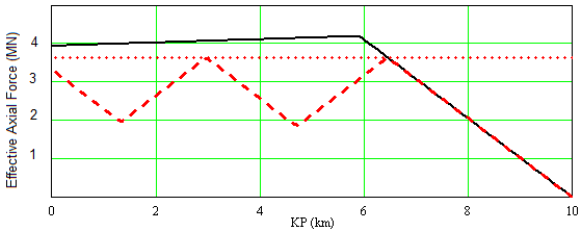
Global Buckling Analysis and Design of HPHT Pipelines

FE Modeling of Subsea Pipelines Global Buckling

Another aspect of advanced analysis and design capability at Z-Subsea is Lateral and Upheaval Buckling of subsea pipelines.

For HPHT systems in deep waters, lateral buckling is a major design concern. The traditional approaches such as trenching/ backfilling cannot be utilized to prevent pipeline global buckle and therefore controlled lateral buckle is necessary to release the axial force while preventing excessive bending in the pipeline.

For initial assessment of lateral buckle formation, calculations sheets are used. This will provide an estimate to effective axial force and distance between buckles based on pipeline properties, pressure & temperature profiles and soil properties.

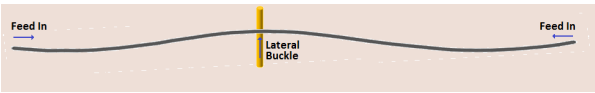


Pipeline Lateral Buckle Assessment

Nonlinear Finite Element models are developed to assess and design pipelines for engineered lateral buckles more efficiently. As there are inherent uncertainties in design parameters, traditional deterministic approaches cannot be utilized to ensure a certain reliability level in the design.

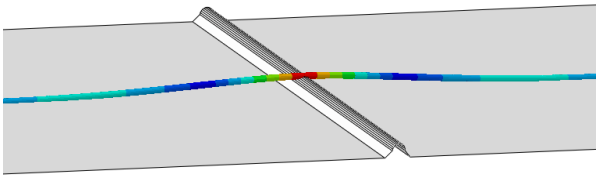
The main design parameters for such FE-based analyses are:

- Pipeline cross sectional dimensions.
- Pipeline configuration and seabed features
- Pipe-soil monotonic and cyclic interaction
- Cyclic start-up/shut-down
- Pressure/temperature transient profiles
- Material and geometric nonlinearities
- Pipeline sleepers or buoyancy modules



Plan View of Subsea Pipeline FE Lateral Buckling Analysis

The sensitivity of target design or failure (local buckling, stress/strain level, low cycle fatigue, etc.) with respect to the above parameters will be established through running numbers of FE sensitivity cases.



FE Lateral Buckling Parametric Model of Pipeline on Sleeper

The results of these parametric analyses will be used for Structural Reliability Analysis (**SRA**) and Monte Carlo simulation to ensure acceptability of design and reliability of initiation of engineered lateral buckles at deliberate locations and with certain intervals to fulfill a specific limit of reliability in line with pipeline safety class.

In this type of analysis, one of the main targets is to reduce number of required FE analyses used for the SRA without losing the accuracy on calculation of reliability.

Z-subsea ensures the best lateral buckling initiation strategy i.e. snake-lay, sleepers, dual sleepers or buoyancy modules based on specific field features and architecture are selected.

Engineered Lateral Buckle in a Subsea Pipeline

For Upheaval Buckling (UHB) and Out-Of-Straightness (OOS) design, similar design variables are looked into and used in the FEA and structural reliability analysis. The backfill interaction behavior with buried pipe will then become an important parameter for FEA and reliability analysis.

The target of UHB design will be optimizing the required backfill and rockdump, while maintaining the required safety factor against upheaval buckle and having acceptable level of stress/strain and fatigue life.

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