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Assessment of Free Spanning Pipelines Frequency and Vortex Induced Stress Ranges

[Seyedeh Sara . Salehyar]
[Mohammad Reza . Bahaari]

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Introduction

Offshore pipelines in their route pass through uneven sea beds. Free spans may be caused by seabed unevenness and changes of seabed topology such as scouring or sand waves. If dynamic forces be exerted on free spanning pipelines with frequency in the range of the free spanning pipe line frequency, free span will vibrate, and time varying stresses may cause fatigue. The main source of dynamic stresses for subsea pipelines is the vibrations caused by vortex shedding. Inherently these vortices are shed periodically, therefore, the forces exerted by them on free spanning pipelines are cyclic, which can cause fatigue damage. In recent years, many studies have been done on free spanning pipelines (eg, [1], [2], [3], [4], [5]& [6]).

In this paper, pipeline free spanning and its interaction with surrounding soil and fluid have been modeled in ABAQUS; the main difficulty in the modeling process is the interaction of the free span with sea water flow. This interaction has been modeled by a distributed, harmonic, amplitude dependent load, and the influence of different parameters including soil stiffness, hydrotest and operation conditions on the free spanning pipeline frequency and stress ranges in cross-flow direction have been assessed.

Model and analysis procedure

In this paper, three stages have been considered for analysis:

- *Static analysis, in order to obtain the correct configuration of the free span*
- *Eigen value analysis based on the static configuration to identify natural frequencies*
- *Dynamic analysis in order to obtain vortex induced stress ranges*

Static analysis

In the static analysis, PIPE31 elements have been used for three dimensional modeling of the free spanning pipeline. The elements' length has been considered equal to the pipe outer diameter [6]. PIPE 31 elements are two nodes, three dimensional elements with 12 degrees of freedom. As the internal pressure can be excreted on these thin walled elements, they are very suitable for the modeling of free spanning pipeline.

In the free spanning analysis, structural damping ratio is considered as to be 0.005 [6]. Analysis starts with a horizontal free spanning pipeline; its ends are restrained in all degrees of freedom. At both ends, in the lengths recommended in [7] nonlinear vertical, horizontal and axial springs have been considered to model the seabed soil. Springs stiffness has been assigned according to DNV-RP-F105 recommendation [6].