OTC 19438

Subsea Umbilical Stability Analysis

M.K. Hossain, K-M. Tjok, and A. Nobahar, Fugro GeoConsulting, Inc.

Abstract

Subsea umbilicals are widely used as an essential component in offshore oil and gas recovery and production facilities to transport chemicals, hydraulic fluids and electrical power and signals. The umbilical layout on the seafloor usually has a straight section near the riser touch-down-point (TDP) connected to a floating unit, followed by curved sections further beyond on the seabed. The heave motions of the floating unit at the sea surface due to environmental loading can induce cyclic tension loads on the umbilical at the seafloor and move the TDP location, resulting into axial, lateral and vertical motions along the umbilical. In addition to altering available umbilical embedded length this can also alter the field layout and may constitute violation of the design assumptions. This paper describes the results of a parametric analysis of an umbilical static stability with curved and straight sections, in a deepwater Gulf of Mexico seafloor environment, using finite element method (FEM). The finite element model of the umbilical and the surrounding soil was constructed using thin-walled, pipe elements and non-linear springs, respectively. Both, soil resistance to axial and to lateral motions along the umbilical were modeled. Degradation of soil shear strength due to cyclic loading was considered. Umbilical responses to increasing bottom tension loading at the TDP for a selected set of embedment, axial stiffness, radii and lengths of curved sections were examined and the axial and lateral displacements along the length of the umbilical are presented. Based on the results of the parametric analysis, a simple procedure for estimation of umbilical ultimate bottom tension load is presented.

Introduction

A parametric study on the stability of a subsea umbilical was performed and the response characteristics of the umbilical to increasing bottom tension loads were investigated. The effects of the following parameters were studied: umbilical layout and embedment, and umbilical axial stiffness. In this paper, the results of the parametric study and the procedures used in the analyses are presented.

A schematic illustration of a subsea umbilical layout and its embedment is presented in Figure 1. The primary umbilical layout components are: the straight section from the TDP to the start of the curved section (L), the radius of the curved section (R), and the angle of the curved section (ϕ). Umbilical embedment depth into the seabed (H) is shown as a ratio (k) of its diameter (D). The bottom tension load (F) is applied at the TDP.

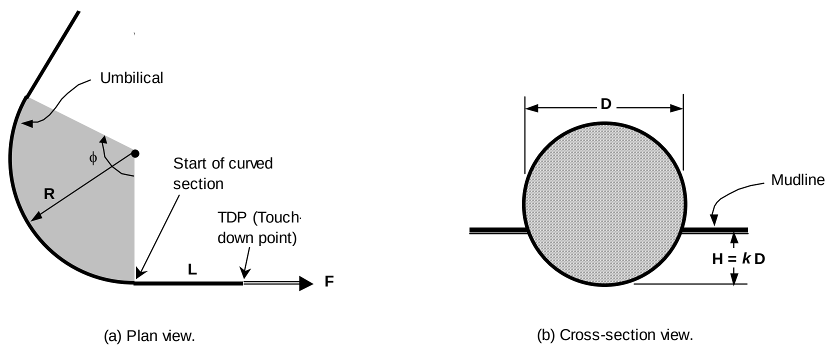

Figure 1. Schematic representations of a subsea umbilical lying on seabed: (a) primary layout components in plan view, and (b) embedded into seabed in cross-section view.