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Riser Soil Interaction in Soft Clay Near the Touchdown Zone

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Abstract

Development of deep water fields has gathered new momentum with fresh discoveries. Many of these new discoveries are in regions where soft clay is encountered. Steel catenary risers (SCRs) are considered to be technically feasible and commercially efficient solutions in deep water, especially where high temperatures and pressures are involved. SCRs offer a more robust solution than the flexible risers but face the problem of excessive fatigue in both hang-off and touch down regions. In order to design a reliable riser system it is important to understand the riser soil interaction mechanism and establish a rational methodology for quantifying the fatigue life near the touch down zone. The riser system forms a critical part of the field architecture and needs special attention.

Riser soil interaction studies have been reported by various authors. In all these studies results from experimental programmes have been used to define riser soil interaction parameters for use in regular analyses programs. Such experimental data are not available in the public domain. In order to investigate these interactions analytically a programme of geotechnical finite element analyses involving riser soil was initiated. The aim was to formulate a procedure which could be implemented within the schedule-driven 'project environment'.

This paper reports the analyses of a riser in soft clay in 1200 m depth of water, where the dominant wave was transverse to riser axis. The riser soil interaction is studied using an ABAQUS/Explicit finite element model with an adaptive meshing technique. Embedment and large lateral ploughing movements of the riser are examined. The lateral soil resistance obtained was used to formulate the lateral friction coefficient.
Fatigue lives were computed, using the 'Rainflow Counting' technique. A comparison of fatigue lives obtained from the software packages ABAQUS and ORCAFLEX is included.

The investigations are preliminary but indicate that riser soil interaction is important and if ignored could lead to serious under-prediction of fatigue lives. An outline of the methodology adopted and numerical results is presented.

1.0 Introduction

Fatigue life prediction in SCRs is a complicated process involving many factors and has been discussed at length by Campbell (1999). Design of SCRs including fatigue, has been dealt with in several papers in the 1990s, including Karunakaran et al (1999), Chaudhury and Kennefick (1999), and Hatton and Willis (1998). The issue of riser soil interaction, however, is not dealt with in the above papers.

Fresh discoveries of deep water fields have changed the scene. Soft clay is encountered in many of these newly discovered fields (e.g. the Caspian Sea region, the Far East). This has led to a renewed surge of investigations into fatigue aspects of steel catenary risers (SCRs) involving riser soil interaction. A good, qualitative introduction to the subject of catenary riser interaction at the touch down point and the factors that are likely to govern is given by Palmer (2000). Since then soil-structure interaction has been reported recently by various authors, including Fontaine (2006), Fontaine et al (2004), Bridge et al (2004), Giertsen et al (2004), and Leira et al (2005). Experimental and analytical investigations of soil-SCR interaction under vortex-induced vibrations have been reported by Kim et al (2006).

In all these studies, results from experimental programmes have been used to define riser soil-interaction parameters for further analyses. Such experimental data are not available in the public domain. Prediction of fatigue lives where such riser soil interaction is involved is still a key area of concern.