

## **Effects of the Interaction with the Seafloor on the Fatigue Life of a SCR**

*Ali Nakhaee and Jun Zhang*

Ocean Engineering Program, Zachry Department of Civil Engineering,  
Texas A&M University  
College Station, Texas, USA

### **ABSTRACT**

The fatigue life of a Steel Catenary Riser (SCR) near its touch-down zone is substantially affected by its interaction with the seafloor. Hence, accurate estimate of its fatigue life requires the understanding and realistic modeling of the interaction between them. The interaction depends on many factors, such as soil properties, riser characteristics, and the development of trenching at the seafloor. Existing approaches for modeling the seafloor in interaction with a SCR approximate the seafloor soil by a linear or nonlinear spring and a dashpot which respectively represent the stiffness and damping of the soil. However, they do not take into account certain phenomena resulting from plastic deformation or degradation of the seafloor soil, such as trenching. In this study, a more realistic approach is developed for simulating the interaction between a SCR and the seafloor soil. In addition to the use of a realistic P-y curve (where P stands for the supporting or resistance force of the seafloor and y for the vertical penetration of the riser into the soil) to simulate the soil deformation during its interaction with a riser, it considers the development of a trench caused by continuous poundings of a riser on the seafloor and then its feedback effect on the variation of the bending moment along the riser. It has been found that trenching may decrease the maximum variation of the bending moment of a riser near its touch-down zone. Since the variation of the moment dictates the fatigue damage to a SCR, the results based on this approach indicate that the trenching development at the seafloor may increase the fatigue life of a SCR and hence it may have important application to the design of a SCR.

**KEY WORDS:** riser; SCR; soil stiffness; fatigue life; seafloor; trenching.

### **INTRODUCTION:**

The use of Steel Catenary Risers (SCRs) increased significantly in recent years with oil and gas production moving to deep and ultra-deep waters. SCR's are more cost-effective in deep water comparing with the other types of risers and were widely used in oil fields all over the world.

One of the critical issues in design of a SCR is to estimate the fatigue life near its Touch Down Zone (TDZ), where a SCR starts to contact the seafloor. A SCR connecting to an oscillating floating structure at its upper end experiences oscillations in and near its TDZ that are constrained by and interact with the seafloor soil. Existing riser models that approximate the seafloor by a rigid, or elastic, or even non-degradation boundary condition fail to consider the complicated process of trenching development on the seafloor. This study extends an existing program for the dynamic analysis of risers and mooring lines, CABLE3D, to allow for a more realistic behavior of the seafloor soil in contact with the riser. A degradation P-y curve presented by Aubeny et al. (Jiao, 2007) is used to determine the trench development at the seafloor near the TDZ of a SCR experiencing regular heave at its upper end. The trenching development is then considered in the computation of the bending moment along a riser, especially near its TDZ. It is found the trenching development described by the degradation P-y curve (P stands for soil resistance and y for the penetration of a riser into the soil) results in a smaller maximum bending moment near the TDZ of a riser. In turn, it results in a reduction the maximum variation of bending moment and hence dynamic stress near the TDZ of a riser.

### **RISER-SOIL INTERACTION:**

A non-degradation P-y curve was proposed earlier to model the interaction between a riser and the seafloor, which was based upon laboratory tests and numerical simulations (Dunlop et al., 1990; Willis et al., 2001; Giersten et al., 2004; Aubeny et al., 2006). The curve describes important phenomena occurring in the interaction between a riser and the seafloor soil, such as elastic rebound, riser-soil separation, reversal of deflection direction and plastic penetration. In a cycle of large loading-unloading-reloading, the P-y curve may be distinguished into four different steps (see Fig. 1). In the first step (loading), the backbone curve from point 0 to 1 depicts the penetration of an initially suspended riser into the virgin soil. The penetration (y at point 1) is determined by equating the penetrating force, W (usually the submerged weight of the riser per unit length) to the soil resistance, P, governed by the backbone curve (Bridge et al, 2004). The initial penetration is usually much smaller than that of the field observations made in the Gulf of Mexico. The observation indicated that the maximum penetration of a riser is in the range of 4-5 riser diameters a few months after the installation (Willis and West, 2001; Theti and