

## Large Scale Soil-riser Model Testing on High Plasticity Clay

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### ABSTRACT

Offshore projects frequently use Steel Catenary Risers (SCRs) to connect floating production facilities (e.g. FPSOs) and their respective seabed systems. The fatigue life of these risers is typically lowest at the hang-off point and in the Touchdown Zone (TDZ). However, behavior in the TDZ is not fully understood and the complex soil behavior may not be accurately captured by models used within the industry. This uncertainty can have significant implications for the design and resulting project costs. Large-scale physical model testing has been used to investigate soil-riser interaction in the TDZ, although little data is available in the public domain. The Norwegian Geotechnical Institute (NGI) and Texas A&M University (TAMU) recently cooperated on a project involving large scale model testing of vertical soil-riser interaction using high plasticity clay. This paper presents key data from cyclic penetration tests together with important conclusions reached. Initial penetration shows good agreement with existing models. Strength degradation occurs rapidly during cyclic penetration, which can reduce seabed-riser stiffness.

**KEY WORDS:** SCR; seabed; TDZ; geotechnics; clay; model testing

### INTRODUCTION

The importance of soil-riser interaction has been highlighted by several authors (e.g. Aubeny et al., 2006 and Clukey et al., 2005). Offshore projects, particularly in deepwater, utilise Steel Catenary Risers (SCRs) to connect floating and subsea systems. SCRs are subjected to a multitude of cyclic loads and movements resulting from phenomena such as platform/vessel heave and Vortex Induced Vibrations (VIVs). The riser is (partially) restrained at both ends, namely the hang-off point and within the Touchdown Zone (TDZ). Typically, these locations will be subjected to the largest cyclic stresses which can lead to a significant reduction in fatigue life, as described by Hatton (2006). Behavior in the touchdown zone is complex and involves both vertical and transverse motions, creating a trench of variable depth and width. Although trench development is caused by such bi-directional motions, most research into soil-riser interaction has focused on the vertical direction only. Figure 1 presents a generalized force-displacement response curve, showing: [i] initial penetration (the so-called backbone

curve), [ii] elastic unloading, [iii] tensile resistance or suction where the riser is restrained by the seabed, [iv] detachment and [v] reloading where the riser re-penetrates the seabed. The seabed stiffness during cyclic loading-reloading is a key parameter within the structural design where a stiffer seabed may result in larger stresses in the riser and vice-versa.

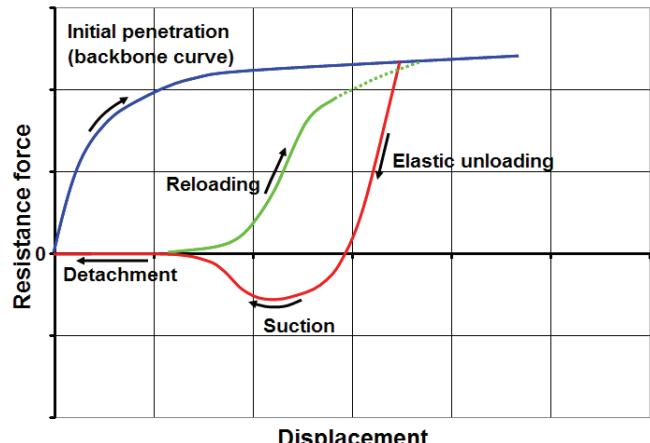


Fig. 1 Seabed-SCR interaction model

Due to the complexity of this interaction, physical model testing has been used to investigate the important issues relevant for design. Several authors have presented results and interpretation of model testing, including Dunlap et al. (1990), Bridge et al. (2004) and Giertsen et al. (2004). These previous tests were performed on 'artificial' kaolin or low plasticity soils. However many current deepwater projects are located in areas where the seabed consists of clay with much higher plasticity, such as the Gulf of Guinea, Gulf of Mexico and South China Sea. Andersen (2004) has shown that the cyclic behavior of clays is dependent on both plasticity and overconsolidation. It was therefore decided to perform seabed-riser interaction tests on a high plasticity soil taken from the Gulf of Guinea. These test results may be compared with spring models currently used within the industry to test the validity of seabed stiffness values.