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Analytical and numerical analysis for unbonded flexible risers under axisymmetric loads

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Abstract. Due to the structural complexity, the response of a flexible riser under axisymmetric loads is quite difficult to determine. Based on equilibrium conditions, geometrical relations and constitutive equations, an analytical model that can accurately predict the axisymmetric behavior of flexible risers is deduced in this paper. Since the mutual exclusion between the contact pressure and interlayer gap is considered in this model, the influence of the load direction on the structural behavior can be analyzed. Meanwhile, a detailed finite element analysis for unbonded flexible risers is conducted. Based on the analytical and numerical models, the structural response of a typical flexible riser under tension, torsion, internal and outer pressure has been studied in detail. The results are compared with experimental data obtained from the literature, and good agreement is found. Studies have shown that the proposed analytical and numerical models can provide an insightful reference for analysis and design of flexible risers.

Keywords: flexible riser; axisymmetric response; analytical model; numerical model; gap between the layers

1. Introduction

As the exploitation of the oil-gas resource advances into deeper waters and harsher environment, flexible risers are more and more widely used, serving as the essential channel transiting oil-gas from the wellhead to the offshore rig (Do 2011, Huang *et al*. 2013, Zou 2011). The main advantage of flexible risers is that they are compliant and highly deformable in bending, while maintaining enough tensile stiffness to enable them to undergo large deformations induced by currents, waves, vortex-induced vibrations, and the motion of floating vessels. However, due to their elaborate structure, the design and analysis of flexible risers is a complex and difficult topic.

Because of their importance in the offshore industry, unbonded flexible risers have been the subject of intensive research in last 15 years. Among the analytical works, Feret and Bournazel (1987) analyzed the behavior of high-pressure unbonded flexible risers. They derived simple formulas for the stresses and the contact pressures between layers in flexible risers under axisymmetrical loads. Witz and Tan (1992) proposed an analytical nonlinear model for predicting

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