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Re-Assessment of P-Y Curves for Soft Clays from Centrifuge Testing and Finite Element Modeling

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Abstract

The paper focuses on the results of centrifuge testing on a laterally loaded conductor. The conductor was installed to simulate jetted conditions and lateral transfer curves (so called P-Y curves) were generated for monotonic and cyclic conditions. The influence of a previous set of cyclic loads on the subsequent behavior of the pile when subjected to additional cyclic loads was investigated. The paper focuses on the determination of P-Y curves tangent and secant moduli since there are the key input parameters for structural software in determining the lateral displacements of the conductor and therefore the cyclic fatigue-generating stresses in the conductor. Results show that the P-Y curves as recommended by API RP2A (2000) can be conservative, with moduli and ultimate unit pressures less than what test data and theoretical modeling suggest. The centrifuge tests validated theoretical curves derived via Finite Element Analyses (FEA) and described by Templeton (2009). Equations are proposed to generate the backbone P-Y curves and to calculate the secant modulus to the P-Y curves to analyze the cyclic loading of interest to this paper.

Introduction

Roadmap for the paper

The paper is divided into the following parts:

- It first describes the problem of interest and defines the jetted conductor loading conditions that were studied.
- It then describes the theoretical Finite Element Analyses (FEA) that were performed and the obtained P-Y curves,
- After which the centrifuge tests performed to calibrate the FEA derived P-Y curves are detailed.
- An extensive comparison of the P-Y curves from the FEA analyses and the P-Y curves is presented,
- And new equations to derived backbone P-Y curves for soft clays are proposed.
- Last, conclusions from centrifuge pile head load displacement curves are listed, along with implications for pile design.

Loads on jetted conductor for top tension risers

The study work reported herein focuses on the evaluation of lateral small-displacement soil-structure interaction for jetted conductor fatigue analysis. The conductor is assumed to be connected to a floating structure via a top-tensioned production riser. As the riser responds to the platform motions and to the sea currents, it imparts loads on the well head and the conductor. These loads are being applied simultaneously but, as a simplification, these loads are assumed to be applied independently, when calculating fatigue life.. A large fatigue safety factor covers this non-conservative assumption. The loads, which are assumed to be collinear, that induce fatigue damage in the conductor can be divided into three categories: Vessel Motions (VM), Hull Vortex Induced Hull Motion (VIM), Riser Vortex Induced Vibration (VIV) (Fig. 1):

- Vessel Motions: The platform, or vessel, motions are separated in motions caused by the wind and waves first. These are the "vessel motions or VM". A finite element model of the hull, the mooring the risers and well foundations are subjected to various sea and wind conditions for 3 hours. From these 3 hours simulations, the fatigue rate of the connector is calculated. The total VM fatigue rate is the metocean condition frequency weighted sum of these fatigue rates.