The [10th] International Conference on Coasts, Ports and Marine Structures (ICOPMAS 2012)
Tehran, Iran, 19-21 Nov. 2012

Experimental Study on VIV Dynamics of a Flexible Cylinder in Uniform Cross-Flow

[بیژن صناعتی BIJAN . SANAATI]
[ناومی کاتو Naomi . Kato]

Keywords: *Vortex-induced vibration (VIV); Flexible cylinder; Hydrodynamic forces; Vibration amplitude; Pre-Tension; axial Stiffness.*

Abstract

In this paper we present the experimental results of a study on the effects of pre-tension and axial stiffness on vortex-induced vibration (VIV) of a horizontally mounted flexible cylinder. The parameters examined included vibration amplitude and its suppression, mean and fluctuating tensions, frequency increase rate, drag and lift coefficients, and in-line (IL) and cross-flow (CF) harmonics. The test model was selected with a low bending-stiffness, low mass ratio (cylinder's mass/mass of replaced water), and high aspect ratio (length/diameter=162). The tests were conducted in the subcritical Reynolds number regime (Re=2000-20000). The effects of pre-tension and axial stiffness were studied for five different cases in which these parameters were varied. Our results showed that high pre-tension, which reduces vibration amplitude, can significantly raise the lift coefficient. Specifically, a four-fold increase in pre-tension from 73.5 N through 294 N was found to correspond to an increase of approximately 57% in lift coefficient and a decrease of approximately 30% in vibration amplitude. We also observed that the lock-in bandwidth of amplitude response narrowed with increase in pre-tension, whereas, it broadened with axial stiffness. In contrast to the vibration amplitude bandwidth, the lift bandwidth increased with increase in pre-tension. The ratio of dominant IL-to-CF frequency was almost 2.0 except for the IL lock-in and upper branch regions. In the IL lock-in region the ratio was found to be 1, and in the upper branch the ratio reached 4.0 for the highest pre-tension (294 N), accompanied by broadening of the region in which this ratio is over 2.0.

1. Introduction

The vortex-induced vibration (VIV) of risers, tensioned leg platform (TLP) tendons and subsea pipelines subjected to ocean currents has been a serious concern for ocean researchers and engineers because it imposes high additional costs on projects and the risk of environmental catastrophe if not properly mitigated. The production of oil, gas, and minerals has extended to deeper oceans in which the risers show very high-coupled torsional, axial and lateral flexibility. This flexibility leads to the sudden inclusion of higher harmonics in dynamic and vibration responses at frequencies higher than those caused by ocean waves and top-end motions of platforms. Therefore, these higher modal responses may lead to earlier stress-caused fatigue damage to the riser.

Due to large number of parameters involved with this phenomenon, there is still great uncertainty in VIV design of these structures. Amongst the parameters not yet comprehensively studied are pre-tension and axial stiffness. In most real applications to prevent large deflections in the in-line (IL) direction of a riser motion due to drag force and to compensate for a riser