

Hydrodynamic Forces on Partly Buried Pipelines in Waves/Current

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ABSTRACT

In this study, the forces on a cylinder, laid on, or partly buried in the sea bed, were determined by measuring the pressure distribution on the cylinder surface in the case of steady current, pure wave and combined waves and current. Force coefficients were obtained for the ranges of $Re = 0.8 - 2 \times 10^4$, $KC = 1-10$, the current-to wave-velocity ratio = 0;3;6; and infinity (current) and for the burial-depth-to-the diameter ratio = 0-0.7.

KEY WORDS: Hydrodynamic forces, buried and unburied pipelines, steady current, wave, coexisting flow

NOMENCLATURE

c_p	: Pressure coefficient
C_D	: Drag coefficient
C_M	: Inertia coefficient
$C_L, C_{L,max}$: Lift coefficient corresponding to maximum lift force away from bottom for pure wave and coexisting flow
D	: Pipe diameter
e	: Burial depth
F_x	: In line force
F_y	: Lift force
KC	: Keulegan-Carpenter number
k	: Roughness height of cylinder surface
$p(p_0)$: Total (hydrostatic) pressure
Re	: Reynolds number
T	: Period of wave
t	: Time
U_c	: Steady current flow velocity
U_m	: Maximum value of wave flow velocity
α	: Current-to-wave-velocity ratio
ν	: Kinematic viscosity

INTRODUCTION

The effect of the sea bed on the forces on the cylinder has been the subject of several investigations in recent decades. Various authors have developed theoretical models of potential flows around a cylinder,

such as Milne-Thomson (1962) for a cylinder on a plane boundary, and Yamamoto et al (1974) for a cylinder close to a plane wall. Fredsøe and Hansen (1987) gave modified description of the potential flow in which the lift force on the cylinder was evaluated.

Various authors, reported qualitative and quantitative observations of the flow around a circular cylinder and forces placed near a wall where the cylinder was towed at constant velocity in still fluid.

Bearman and Zdravkovich (1978) measured pressure distribution around a circular cylinder on and near a wall and also along the wall in steady currents. They also conducted a spectral analysis of hot-wire signals received from both sides of the cylinder wake. From their spectral analysis, they found out that regular vortex shedding persisted for cylinders with gap-to-diameter ratios larger than 0.3. This result was later confirmed by the measurement of Grass et al (1984).

The case where the cylinder is subjected to an oscillatory flow has also attracted much attention, in view of its application to marine pipelines exposed to waves. The first investigation was the research work of Sarpkaya (1976). Jacobsen et al (1988), Justesen et al (1987) and Sumer et al (1991) have reported measurements regarding the effect of the wall on force coefficients on and flow around cylinder exposed to oscillatory flow.

The studies of Sarpkaya and Storm (1985), Sumer et al (1992), Çokgör and Avcı (1997) are related to the determination of the forces on a cylinder, if both the wave and current exist. In the former two studies, the coexisting flow is obtained with the sinusoidally oscillating motion of the cylinder. In the latter two studies, the forces on a cylinder are determined by obtaining the pressure distribution with the pressure transducers placed on the cylinder. On the other hand, the study of Sumer et al (1992) covers the determination of the forces on a structure such as the cylinder on the wall or at various distances from the wall under the and coexisting flow. Jacobsen et al (1989) have determined the forces on the partly buried pipelines, pipelines in open trenches and pipelines sliding on the seabed.

The purpose of this study is to investigate, the forces effecting the pipelines laid just on, or partly buried in the sea bed for cases of steady current, pure wave and combined waves and current.