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Riser Interference and VIV Amplification in Tandem Configuration

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Wake Induced Oscillations (WIO) and amplification of Vortex Induced Vibration (VIV) are studied for 2 risers in tandem configuration. The criticality of riser interference is first investigated in term of nondimensional numbers for different types of risers. Theoretical, numerical and experimental approaches are then used simultaneously to define similarity rules and to investigate scale effects with respect to the Reynolds number. Finally, experimental results demonstrating amplification of VIV are given.

NOMENCLATURE

- Cd : drag coefficient (also Cd_i)
- C_Y : Cauchy number ($C_Y = (Ur)^2/\mu$)
- D : riser diam (D_i for riser number i)
- f : first natural frequency (and associated pulsation ω)
- i : subscript to identify riser number
- K : structural stiffness of 1st mode
- K_c : contact stiffness between risers
- L : initial spacing between risers
- M : riser mass per unit length in air including internal fluid (also defined as m_i)
- ma : fluid added mass per unit length ($ma_i = \pi\rho D_i^2/4$)
- Sc : Scruton number (also noted A_R)
- $_T$: first natural period of riser
- Ur, V_R : reduced velocity ($Ur = V_0/\omega \cdot D$, $V_R = 2\pi Ur$)
- $V(z)$: current profile
- V_0 : effective current velocity
- X_i : position of riser i
- (x, y, z) : coordinate system (z is vertical downward)
- ρ : water density
- $\psi_n(z)$: modal shape associated to structural mode number n
- μ : reduced mass ($\mu = 4m/\pi\rho D^2$)
- $\zeta_{x,\,\mathrm{drag}}$: hydrodynamic damping due to drag in x direction
- ζ_i : structural damping of riser i
- ζ : total damping (structural and hydrodynamic)
- τ : nondimensional time ($\tau = \omega \cdot t$)

INTRODUCTION

Hydrodynamic riser interference is becoming a crucial issue as offshore technology moves into deep and ultra-deep water. The main concern about riser interference is to be able to predict the risk of collision between closely spaced risers, and eventually to design risers able to withstand possible impact with each other. Besides turbulence buffeting, hydrodynamic interference between risers can be classified in 2 categories: Wake Induced Oscillation (WIO) and Vortex Induced Vibration (VIV).

WIO, also referred to as galloping, is a classical type of instability; see e.g., Blevins (1977, 1990, 2004) and Axisa (2001) for a simplified description of the mechanism underlining the phenomenon. Basically, spatial variations of the time-averaged hydrodynamic coefficients (lift and drag) can create such instability at high reduced velocity. WIO is a low-frequency motion which arises at the first natural period of the riser. Large amplitude, which may rise up to several tens of diam, is predicted (e.g., Wu, 2001).

VIV is known to be a self-limited motion with a maximum order of 1 diam for a single riser. However, in cylinder array, measurements have shown VIV amplification of up to 2 diam. VIV frequencies may be high as they are closely correlated with current velocity through a Strouhal relationship.

A literature survey indicates that hydrodynamic riser interference has been investigated recently, e.g., by Wu (2001) and Blevins (2004). A recommended practice RP F-203 is expected to be issued by DNV, as a result of Norwegian Deepwater Program research. Clearly, the next stage consists in better understanding the hydrodynamic loads acting on a riser placed in the wake of an upstream riser.

CRITICALITY OF RISER INTERFERENCE IN DEEP AND ULTRA-DEEP WATER

In ultra-deep water, the first natural period of the riser is generally of the order of 50 to 100 s (Table 1), and the modal stiffness associated with the first natural frequency of the riser at midspan is very low, due to the riser length. Consequently, large displacements of the WIO type are likely to occur and must thus be studied. When the instantaneous distance between risers gets

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