International Journal of Offshore and Polar Engineering
Vol. 5, No. 4, December 1995 (ISSN 1053-5381)

Visualization of Flow Around Cylinder in Irregular Waves

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INTRODUCTION

The measurements made by Longoria et al. (1991) of the force coefficients showed significant differences between regular, sinusoidal flows and irregular oscillatory flows (Fig. 1). It was suggested in that study that possible disruption of regular vortex-flow regimes accounted for these differences. This note presents the results of a flow visualization study where the vortex-flow regimes are studied systematically in irregular oscillatory flows, to see if the flow regimes (known from the regular oscillatory flow) are disrupted under irregular oscillatory flow conditions.

EXPERIMENTAL SETUP

The tests were carried out in a water tank 1.50 m long, 0.50 m wide, and 0.60 m deep. The carriage technique was used in the experiments to simulate the two-dimensional oscillatory flow around a cylinder. The cylinder was mounted to a carriage which oscillated by means of a hydraulic system. Three smooth-surface cylinders 9, 3 and 1.5 cm in diameter were used. The aluminium powder technique was used to visualize the flow. The motion of vortices was videotaped. Two kinds of tests were conducted: the irregular oscillatory flow tests, and the regular (sinusoidal) oscillatory flow tests (the reference case). The control signal for the hydraulic system corresponded to regular or irregular displacements of the cylinder. The irregular signal was obtained by scaling the magnitude and frequency content of a user-supplied signal which corresponded to the measured in-situ water elevation spectrum for North Sea storm conditions. This spectrum was well-described by the JONSWAP wave spectrum with relevant parameters $\alpha = 0.0081$ and $\gamma = 2.5$. Two input displacement control power spectra have been used in the experiments: one broad-banded with $\varepsilon = 0.56$ and the other narrow-banded with $\varepsilon = 0.25$, where ε is the spectral width parameter defined by:

$$\varepsilon = \left(1 - m_2^2/(m_0 m_4)\right)^{1/2}, \quad m_n = \int_0^\infty f^n S(f)\,df \tag{1}$$

where f is the frequency, $S(f)$ is a one-sided power spectrum, and m_n is the spectral moment of the n-th order.

The length of test runs corresponded to about 150 cycles for the regular oscillatory flow, and 350 zero up-crossing periods for the irregular oscillatory flow.

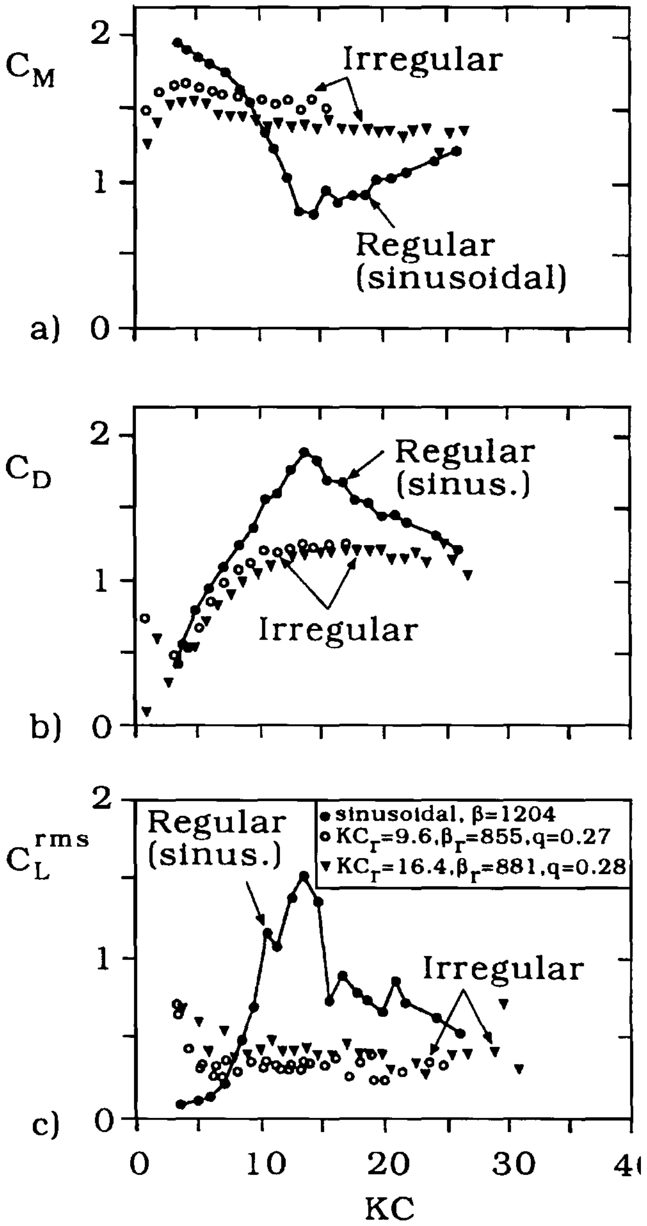

Fig. 1 Hydrodynamic coefficients versus temporal Keulegan-Carpenter number, *KC*, after Longoria et al. (1991). Note that q = 0.27 - 0.28 corresponds to broad-band spectrum of present study, namely that with $\varepsilon = 0.56$.

The following definitions of the Keulegan-Carpenter number, KC_r, and the Reynolds number, Re_r, have been adapted for the irregular oscillatory flow:

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Received January 19, 1994: revised manuscript received by the editors July 24, 1995. The original version (prior to the final revised manuscript) was presented at the Fourth International Offshore and Polar Engineering Conference (ISOPE-94), Osaka, Japan, April 10-15, 1994.

KEY WORDS: Irregular waves, forces, vortex motion, flow visualization.