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# Numerical Simulation of Morison Coefficient Estimation

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## ABSTRACT

**Numerical simulations of a random wave force record are used to study the accuracy of alternative methods of estimating Morison coefficients from random data. The simulated wave record corresponds to a two-parameter Pierson-Moscowitz spectrum and the corresponding force is calculated using the Morison equation with specified force coefficients. In order to provide a more realistic representation of measured forces than occurs with the use of constant force coefficients, the force coefficients are instead taken to vary through a force record. In this way, the influence of experimental errors and theoretical approximations which inadequately account for effects such as vortex shedding, wave nonlinearities, unknown currents, and so on can be determined in an indirect yet controlled manner. A least squares fit of the wave force time series is found to be the simplest and most accurate method by which constant force coefficients may be estimated from measured data in random waves.**

## INTRODUCTION

The evaluation of wave forces on slender members of offshore structures has traditionally been based on the Morison equation, which involves empirical drag and inertia coefficients. These force coefficients have been determined from accurate experiments for the idealized case of a uniform sinusoidal flow (Sarpkaya and Isaacson, 1981). For the more general case of random waves, a considerable number of studies have been carried out both in the laboratory and the ocean (Moe and Overvik, 1989). However, a great deal of scatter is observed in published values of the force coefficients, and suitable values for these force coefficients in random waves remain uncertain. The scatter is generally attributed to experimental errors and an inadequate accounting of various effects such as vortex shedding, unknown currents, wave nonlinearities, wave directionality, and so on. The degree of scatter is also influenced by the selection of the method used to estimate the force coefficients. However, because of the uncertainties associated with measured data, it has been difficult to isolate this source of scatter.

Numerical simulation of random waves has proved to be a useful tool in offshore engineering design (Goda, 1985). A variety of different simulators exist, and comparisons of these and the distortions associated with each are given by Tuah and Hudspeth (1982) and Medina et al. (1985). An early application of numerical simulation to study the accuracy of Morison coefficient estimation was described by Borgman (1969). A random wave force record was simulated numerically, and since uncertainties associated with the applicability of the Morison equation, the accuracy of the predicted kinematics and general experimental errors were avoided, discrepancies between the estimated and specified coefficients could be attributed solely to the method of analysis. It was thereby shown that the estimation of the force coefficients using a deterministic approach is generally unsuitable for random data and in fact introduces artificial scatter in the estimated coefficients.

A number of methods exist for estimating the force coefficients in random waves. Many of these have been summarized by Borgman (1972) and all involve some kind of best fit between the measured and predicted wave force. The method of fitting usually involves a least squares procedure or the method of moments and may be applied to (i) the time series, (ii) the spectral density or covariance function, or (iii) the probability density of the force. The most common methods used are:

(i) Least squares fit of the force time series
(ii) Least squares fit of the force spectrum
(iii) Method of moments applied to the force probability distribution
(iv) Least squares fit on a wave-by-wave basis

Other methods involve fits to measurements of force maxima. In addition it is possible to estimate frequency dependent coefficients from the cross-spectral density between the free surface elevation and the wave force. However, this has not been widely used in practice, and the interpretation of the force coefficients as functions of frequency remains a matter of speculation.

In a recent study by Isaacson et al. (1990), numerical simulations were used to investigate the accuracy of a number of different methods. An artificial force record was generated by applying linear wave theory and the Morison equation with constant coefficients to a simulated wave record. This allows most methods to be studied adequately. However, an exception is the least squares fitting of the force time series, because the simulated force leads to the specified force coefficients exactly. On the other hand, the other methods introduce scatter into the estimated coefficients from one random simulation to the next. This scatter is due to the variability associated with sampling a random process as the statistics of the sample are necessarily only an estimate of the statistics of the entire process, and as these vary with different samples, so then do the estimates of the force coefficients. In particular this scatter is quite large with the method of moments, and it was concluded that this is not a practical method for estimating the force coefficients. Least squares fitting of the force spectrum was found to be a suitable method only when the force is predominantly inertial, since it is otherwise too sensitive to sampling variability and also to the linearization of the drag component in the expression for force spectral density.

In practice a measured force record in random waves will not correspond exactly to the Morison equation with constant coefficients. In order to utilize a more realistic force record and thereby

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