

## PC-Based Computation for Second-Order Wave Loads on Large-Volume Multi-Column Structures

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### ABSTRACT

An efficient and reliable PC-based computer program for the computation of second-order sum- and difference-frequency wave excitations and wave drift damping on large-volume multi-column structures, such as tension leg platforms (TLPs), has been developed, and its theoretical background and some numerical results are presented here. The first-order diffraction and radiation potentials for deep-draft multiple circular cylinders are first obtained in analytic forms. The second-order potential force is then calculated by the indirect method using an assisting radiation potential. The second-order force component from the quadratic products of first-order quantities is obtained in closed forms. A rational approximation method for the cylinder bottom and pontoon contributions is developed based on the asymptotic expression of the second-order potential at large depths. The method is validated through comparison with existing data. The present method is especially powerful when the number of cylinders is large, for which the use of existing panel programs seems not feasible. The developed first- and second-order programs are an order of magnitude faster and require much less memory space than existing panel programs, and can thus be routinely run on personal computers. In addition, it is free of grid generation and requires minimum human effort for input preparation and convergence test; hence it is particularly suitable for the parametric study in the preliminary design stage.

### INTRODUCTION

Offshore platforms often consist of a number of large-diameter vertical columns that are in many cases connected by pontoons at large depths. Typical examples are TLPs and deep draft floaters (DDFs) (Herfjord and Nielsen, 1988). This kind of multi-column multi-module system can also be used as an offshore airport or floating bridge. As the size and number of columns increase, the interaction between waves and arrays of columns becomes increasingly important. The resulting wave loads as well as the free-surface elevation can be surprisingly large for a particular arrangement of columns, which should be avoided in the design stage.

The interaction of waves with multi-column structures can in principle be computed by three-dimensional boundary element or finite element programs. However, as the number of columns increases, the use of the discretization-based three-dimensional

codes becomes practically not feasible. Recently, the first-order analytic diffraction/radiation solutions for arrays of bottom-mounted vertical circular cylinders were obtained by Linton and Evans (1990) and Kim (1992a). In view of the exponential decay of wave particle motions with depth, those explicit solutions can also be used to approximately compute wave loads on arrays of deep-draft truncated cylinders, such as TLPs. At low frequencies, however, the deeply submerged cylinder bottoms or pontoons can be felt, and therefore rational cylinder bottom and pontoon corrections need to be employed. The performance of the numerical scheme for the first-order and mean drift wave loads on and responses of various column-based platforms was demonstrated in Kim et al. (1993).

Encouraged by our first-order results, the PC-based computation for the second-order sum- and difference-frequency wave excitations and wave drift damping was tackled. The second-order potential force was calculated by the indirect method using an assisting radiation potential. The second-order force component from the quadratic products of first-order quantities was obtained in closed forms. A rational approximation method for the cylinder bottom and pontoon contributions was developed based on the asymptotic expression of the second-order potential at large depths. Wave drift damping was calculated from the formulas suggested by Clark et al. (1993), which were proven to pro-

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KEY WORDS: PC-based, second order, multi-column, wave loads, analytic solution, pontoon correction, wave-drift damping.