International Journal of Offshore and Polar Engineering
Vol. 5, No. 1, March 1995 (ISSN 1053-5381)

Wave Field in a Laboratory Wave Basin with Partially Reflecting Boundaries

Michael Isaacson*
Department of Civil Engineering, University of British Columbia,
Vancouver, British Columbia, Canada

ABSTRACT

The present paper describes a numerical method for predicting the wave field produced by one or more segmented wave generators in a laboratory wave basin which may contain fully or partially reflecting walls or structures. The approach used is based on linear diffraction theory and utilizes a point source representation of the generator segments and any reflecting boundaries that are present. The method involves a partial reflection boundary condition which is discussed. Numerical results are presented for the propagating wave field in a rectangular basin containing two segmented wave generators whose motions correspond to specified wave parameters applied to the snake principle. Cases which are considered include fully absorbing and partially reflecting beaches along the basin sides, and a fully reflecting circular cylinder located in the test area of the basin. The method appears able to account adequately for the effects of wave diffraction and partial reflections, and to predict the generated wave field realistically.

INTRODUCTION

In the operation of laboratory wave basins, the efficient determination of the motions of a segmented wave generator required to produce a specified wave field is generally required. In almost all cases, the required generator motions have been obtained on the basis of the "snake principle." This is based on the concept that a spatially sinusoidal, monochromatic "wave-like" motion of an infinitely long segmented generator produces a regular wave train propagating obliquely to the generator face. Superposition of such motions for wave trains of different frequencies and directions will then correspond to a specified regular or random directional wave field. The snake principle was initially introduced by Biesel (1954), and other contributions to its use include those given by Gilbert (1976) and Sand (1979). Its extension to incorporate the use of reflecting side-walls has been described by Funke and Miles (1987). The snake principle method is widely used in the laboratory generation of directional waves, and thus has been reasonably well tested. However, this method is unable to account for reflections within the basin or for wave diffraction effects along the edge of a wave train which are associated with the finite length of a generator.

On the other hand, the corresponding prediction of the wave field due to specified generator motions is also of interest. This may be used to assess alternative wave basin layouts and generator designs. Apart from the application of the snake principle for this purpose as well, an alternative method for predicting the resulting wave field was given by Takayama (1984). He obtained a closed-form solution to the wave field generated by a single generator segment oscillating in an infinitely long straight wall. A suitable superposition of this solution allows the case of a full segmented generator to be treated. The effects of both diffraction and full reflection in a wave basin have been treated by Dalrymple (1989). His method is based on the mild slope equation, so that a varying bottom depth may also be modeled. Results are presented for the instantaneous water surface elevation of planar wave trains in a rectangular basin, including one case in which the basin has a sloping bottom.

Another method of predicting the wave field produced by specified motions of a segmented wave generator was indicated by Isaacson (1989). This is based on linear diffraction theory and utilizes a point source representation of the generator surfaces and the basin walls. The method was originally developed for application to a wave basin with sides that are either fully reflecting or absorbing, so that the boundary condition along these sides is relatively straightforward to apply. The wave field predicted by this method has been numerically evaluated and compared with experimental measurements (Hiraishi et al., 1992), and has generally been found quite reasonable. However, in many circumstances significant partial reflections invariably arise in a wave basin, and the present paper describes an extension to the earlier method to take this into account.

In the approach used, linear diffraction theory is used to formulate the problem in terms of a distribution of sources around the generator faces and other fully or partially reflecting walls or structures within the basin. The required wave field may be taken to correspond either to specified generator motions or to specified wave field parameters applied to the "snake principle." The evanescent component to the wave field is also considered and the region where this is negligible is indicated. The corresponding computer program calculates the free surface elevation, wave height, and wave phase within a specified area of the wave basin. Results of the program are presented for the propagating wave field in a rectangular basin containing two segmented wave generators whose motions correspond to specified wave parameters applied to the snake principle. Cases which are considered include fully absorbing and partially reflecting beaches along the basin sides, and a fully reflecting circular cylinder located in the test area of the basin. The corresponding results are described by plots of surface elevation, corresponding to an instantaneous view of the wave field, as well as contours of wave height and wave phase. The method appears able to account adequately for the effects of wave diffraction and partial reflections, and to predict

*ISOPE Member.
Received March 25, 1993: revised manuscript received by the editors October 3, 1994. The original version (prior to the final revised manuscript) was presented at the Third International Offshore and Polar Engineering Conference (ISOPE-93), Singapore, June 6-11, 1993.
KEY WORDS: Coastal engineering, hydrodynamics, ocean engineering, offshore structures, potential flow, wave basins, wave reflection.