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Experimental Validation of Directional Wave Maker Theory with Side Wall Reflections

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ABSTRACT

Dalrymple recently developed a directional wave maker theory capable of simulating a desired oblique planar wave train at any predetermined cross-section in a wave basin. This theory, which uses intentional reflections from side walls, can be used to significantly enlarge the testing area in the basin over which the sea state is expected to be homogeneous. A numerical validation of this theory was recently undertaken at the Hydraulics Laboratory of the National Research Council of Canada. The findings were published in Mansard et al. (1992). This paper reports the results of an extensive series of experimental investigations undertaken to further validate this theory for the case of a basin with a sloping bottom.

INTRODUCTION

Although the technique of generating multidirectional waves by the snake principle has been known for nearly four decades, its application has only become feasible in the last 15 years due to the proliferation of fast and economical computer technology. There are now nearly 30 institutes around the world capable of testing their offshore and coastal models using multidirectional waves. Research is also under way in many of these institutes to develop improved techniques for multidirectional wave simulation, as the optimal testing area produced by the conventional snake principle is limited. This limitation is principally due to the diffraction and reflection processes that occur in a basin because of its physical boundaries. The Dalrymple model discussed in this paper is capable of simulating a given sea state, at any predetermined cross-section in a multidirectional wave basin using intentional reflections from the side boundaries. An example of the capability of this model can be seen in Fig. 1, which depicts the reproduction of a uniform oblique wave field at the target position. It is interesting to note the intentional reflections, in the righthand corner of the figure, required for this purpose.

The objective of this paper is to demonstrate the validity of this numerical model by means of an extensive series of experimental investigations.

BACKGROUND OF DALRYMPLE'S MODEL

A brief description of Dalrymple's model is outlined here; a detailed presentation of its theoretical background and capabilities can be found in Dalrymple (1989).

The model provides a technique by which an oblique planar wave train of any angle of incidence can be generated across the full width of the basin, at any predetermined distance from the wave machine by using intentional reflections from the two side walls of the basin. The basin may have either constant depth or a mildly sloping bathymetry.

The theory is based on the treatment by Dalrymple and Kirby

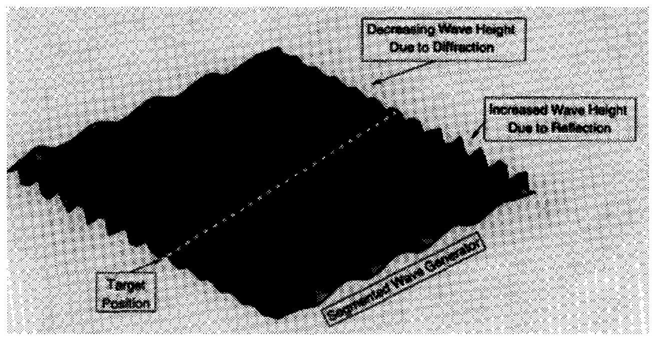

Fig. 1 Water surface elevation of an oblique wave train generated by Dalrymple's model

(1988) for combined diffraction and refraction of waves on sloping beaches. Wave motion, assumed to be linear, is described by a velocity potential satisfying the mild slope equation. On the side walls of the basin, the boundary condition of zero normal flow is imposed. A splitting procedure is used in the analytical solution to determine the wave field as a function of the distance from the generator. At a specified distance from the wave machine, the velocity potential is set to match an oblique planar wave extending across the full width of the basin. This wave is then propagated backwards to the position of the wave machine, taking into account diffraction, reflection from the side walls, and refraction by the mild slope equation. The wave machine segment motions required to generate the desired oblique wave are then obtained by setting the vertically integrated wave paddle velocity to match the normal derivative of the calculated velocity potential at the centre of each segment.

The X-axis is defined to be normal to the face of the wave generator and the desired oblique planar wave is specified by θ and X_T, where θ is the angle of propagation relative to the X-axis and X_T is the target distance from the wave machine at which the oblique wave is to be reproduced. The target wave position, X_T, can be at any distance from the paddle. If partial side walls are used in a basin, the wave field beyond the end of the side walls cannot be estimated with the present technique. Although other models can predict the wave field for the partial side wall situation, the validation undertaken in this study is only up to the limit

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