DIFFRACTION OF MULTIDIRECTIONAL RANDOM WAVES BY A GROUP OF RECTANGULAR SUBMARINE PITS

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Study of wave interaction with submarine pits (or trenches) has important application to the coastal and harbor engineering. A three-dimensional (3D) modeling of multidirectional random-wave diffraction by a group of rectangular submarine pits is presented in this paper. The fluid domain is divided into N interior regions representing the pit area and an overall exterior region separated by the imaginary pit boundaries. In this study, a discrete form of the Pierson-Moskowitz (P-M) frequency spectrum in terms of both frequency and direction is formulated to represent the incident random-wave condition. Superposition of 3D diffraction solutions of regular waves with inputs of a finite number of decomposed wave components is performed to obtain the overall velocity potential and wave elevation under random-wave conditions. The approach of basing on the boundary integral and Green's function for regular waves propagating past a 3D rectangular pit [1] is extended to derive the solution formulations for the cases of multiple pits. In application of Green's second identity to the exterior region of constant water depth, a vortex distribution based 3D Green's function proposed by Wehausen and Laitone [2] is adopted to provide integral equations which link the velocity potentials and their normal derivatives on the fluid interfaces between the regions. Also, the velocity potential in the interior region may be expressed in an analytical form as a Fourier-series expansion with unknown coefficients determined from a series of boundary integral equations. The analytical formulation provides diffraction solutions with higher-accuracy for the interior region of the plane rectangular pits.

Numerical results for the cases of regular waves and random waves are presented to examine the influences of the pit geometry and incident wave condition on the overall wave field. Generally, the diffraction pattern of alternate bands of increase and decrease of relative wave height in front of the pit system can be clearly observed and in the shadow region, the reduction of the relative wave height can be achieved. For both cases of regular and random waves, the results indicate that the pit has major influence on the wave field in, in front of and behind the pit area. By increasing the number of pit (e.g., 3 pits in series), the relative wave height in the shadow region can be substantially reduced (e.g., up to 60% for the cases of regular waves). However, major increase of the relative wave height within the pit area and in front of the leading pit can be observed. It is noticed that under the random-wave conditions the level of increase or decrease of the relative wave height due to the existence of submarine pits is found to be less pronounced than that observed from results in regular-wave conditions. The present 3D numerical model may be extended to apply with confidence for many coastal engineering applications.

References

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