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Technical note

Wave interaction with twin plate wave barrier

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Abstract

The wave transmission and reflection characteristics and wave induced pressures on single surface plate and twin plate barriers were investigated experimentally for a wide range of wave heights and periods in regular and random waves. Seven different spacing between the plates were tested. It is found in general, hydrodynamically the twin plate is better than the single surface plate to reduce the wave transmission and increase the wave reflection. It is found that the transmission coefficient of twin plate reduced from 0.8 to 0.3 when the relative plate width is increased from 0.18 to 0.84. Transmission coefficient of twin plate barrier shows oscillating behavior, when relative plate width is increased due to blocking and pumping effect. The reflection coefficient increased from 0.25 to 0.65, when the relative width of the plate is increased from 0.18 to 0.84. The increase in spacing between the plates was also found to increase the reflection coefficient. The transmission coefficient, K_t for 98% probability of non-exceedence was found to be minimum and is about 0.60 when the relative spacing between the plate is about 0.12, compared to $K_t = 0.76$ for single surface plate. The reflection coefficient for 98% probability of non-exceedence was found to exceed 0.66 for single surface plate, whereas it is 0.73 for twin plate with relative spacing of about 0.40. From the investigation with wide range of input parameters, it is found that the twin plate barrier needs to be designed for highest 98% pressure ratio of 2.0, which is equal to the static pressure induced by the design incident wave height.

Keywords: Special breakwaters; Twin horizontal plates; Wave transmission; Reflection and energy dissipation; Wave pressures; Pile groups

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1. Introduction

Rubble mound structures are widely used around the world as breakwaters and for shore protection. Concrete caissons are adopted, when sufficient quantity and good quality rubbles are not available in the vicinity of the proposed port construction site. Both of these types are expensive in deeper waters and hence, special type of breakwaters, which requires less concrete per unit run, but at the same time, capable of transmitting less wave energy is to be invented. Since in deeper waters, most of the wave energy is concentrated near the water surface, a structure, which can be effectively intercept and dissipate or reflect this energy, is required. The presence of a horizontal plate near the free water surface reduces the wavelength over the plate, increases the wave height due to shoaling and a part of the incident wave energy gets dissipated by wave breaking, turbulence and by overcoming the friction developed on the plate surface. Along with the plate, the pile group on which the plate is fixed also dissipates a part of the wave energy by vortex shedding effects and increasing the wave reflection due to pile groups. The wave interaction problem with single plate without pile groups (pile groups are required in the field for transferring the load acting on the plate into the foundation) is widely investigated (e.g.: Patarapanich and Cheong, 1989; Neelamani and Reddy, 1992). The effect of pile groups supporting a single plate at still water level (SWL) on transmission, reflection and energy dissipation characteristics and the wave pressures on this plate needs to be investigated for foreseeing its performance as a prototype. Further, addition of one more plate may improve the hydrodynamic performance (i.e. increase in wave reflection and energy dissipation, reduction in wave transmission and reduction of wave induced pressure on the plate, etc.), but the effect of change in spacing on the hydrodynamic performance is not known at present.

Hence the main objective of the present research work is to investigate the hydrodynamic performance of a single surface plate resting on pile groups and compare the performance with twin horizontal plate barrier with different spacing between the horizontal plates (Photo 1 and Fig. 1). The main advantage of this type of breakwater is that they allow free exchange of water between the seaside and the lee side and hence the pollution level inside the harbor can be reduced. The main drawback is that this breakwater transmits wave energy, which depends on the input wave and structure condition. In deeper waters the present type of wave barrier may work out to be economical.

In Fig. 1, B is the width of the plate in the direction of wave propagation, s is the spacing between the plates, d is the local water depth, T is the wave period, H_i is the incident wave height, H_r is the reflected wave height and H_t is the transmitted wave height.

2. Literature review

The earliest study on wave interactions with a submerged, horizontal, finite plate can be traced to Burke (1964) who developed a mathematical method based on Wiener–Hopf technique but did not provide any numerical result. Dick and Brebner (1968) investigated on wave reflection and transmission characteristics of a submerged