Reduction of Wave Penetration into Harbors by V-Shaped Approach Channel

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ABSTRACT.

A new wave-control method is proposed in order to achieve a high level of tranquility in harbors without hindering ships' navigation. In this method, harbor approach channel is deeply excavated in V-shaped cross-section in order to effectively disperse incoming waves. It then has an effect to refract the waves like a concave lens so that the wave penetration into harbor entrance is reduced. The applicability of the method has been examined numerically and experimentally. Both the numerical and experimental results have shown remarkable effects of the proposed method in attenuating the incident waves to port entrance.

KEY WORDS: Wave control; refraction; approach channel; V-shape; harbor tranquility; wave attenuation; trench.

INTRODUCTION

It is important to improve tranquility in approach channels and harbors for safety navigations of ships. For this purpose, optimum layouts of breakwaters are generally pursued during design processes of harbors. Nevertheless, port entrance is often exposed to high waves, since the entrance is an open mouth of shelters. Accordingly several methods have been proposed in order to reduce penetrations of waves into harbor entrance without hindering ships' navigation. In the past, air-bubble breakwaters (Kobus, 1968; Green, 1961), liquefied sand bed wave barriers (Kang et al., 1997) and others have been proposed. The practical applications of these new methods are, however, still scarce due to the various factors such as their limited validity, economic disadvantages, and/or construction difficulties.

In principle it is possible to disperse incoming waves by locally dredging the area of navigation channels and/or harbor entrance. The changes in bottom topography then have an effect to refract the incident waves like a concave lens so that the wave penetration into harbor entrance is reduced. This kind of wave control method is expected to be effective as a new option in harbor design since it does not hinder ships' safe navigation.

From this point of view, a new wave-control method is proposed in this study. The basic concept of our study is to effectively utilize the refraction effects of navigation channel as a wave control method. In this method, harbor approach channel is deeply excavated in V-shaped cross-section (hereafter called as 'V-channel') in order to disperse incoming waves. The alignment of the channel is parallel to the principal direction of incident waves. It then has an effect to refract the waves like a concave lens so that the wave penetration into harbor entrance is reduced (Fig. 1). This study examines the applicability of the method by means of numerical simulations and laboratory experiments.

LITERATURE REVIEW

In the past, various researchers have attempted to control wave direction by the artificial change of bottom topographies. Typical examples were related to the formation of artificial shoals (e.g. Nochino et al. 1990; Takewaka et al. 1994; Suzuki et al. 1995). These studies aimed at concentrating incoming waves by the bottom refraction effects like a convex lens. The formation of artificial shoals is, however, considered to be inappropriate for approach channels and harbors, since