Bragg Reflection of Water Waves over Tripe Composites of Rectangular Bars

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ABSTRACT

In this paper, Miles’ (1981) theory is employed to derive formulae for describing the Bragg scattering of water waves for multiply composite artificial bars. We carried out a series of studies by adjusting the layout of multiply composite artificial bars including groups, spacing, the number of bars and incident wave conditions. Based on the theoretical analysis and calculations, we intend to study the particular effect of the bar spacing and combination mode, and investigate their influence on the Bragg resonance.

KEY WORDS: Bragg reflection; primary resonance; artificial bars; resonance bandwidth; group number of bar.

INTRODUCTION

The surface waves scattering by undulated seabed has been studied through theoretically, experiments and numerical models over the past decade. Following the early results of Davies and Heathershaw (1984), the phenomenon of Bragg resonance occurs when the wavelength of incident waves is equal to twice of the wavelength of bottom undulation. It means that reflected waves will return strongly when the surface wavenumber \( \bar{k} \) is equal to one half of bed wavenumber \( K \), i.e. \( 2\bar{k}/K = 1 \). To this point, Miles’ (1981) theory was used to compare the results of Bragg scattering, as induced by sinusoidal bars, with numerical model or experiments. The theory was derived on the basis of linear wave conditions to estimate Bragg reflection coefficient over small undulation bed.

Davies and Heathershaw (1984) and Mei (1985) used the physics theory and experiments to examine the reflective mechanism of the Bragg resonance. Davies et al. (1989), O’Hare and Davies (1993) and Zhang et al. (1999) also demonstrated that the superposition of two sinusoidal bottoms having different wavenumbers, the sub-harmonic and higher-harmonic resonances will occur. Hsu et al. (2003) developed an Evolution of Mild-Slope Equation (EEMSE) by extending PMSE (Parabolic Mild Slope Equation) (Hsu and Wen, 2001) and HM (Zhang et al., 1999) to study the Bragg resonance by doubly composite artificial bars. Kirby and Anton (1990) applied previous theories for Bragg reflection of surface waves by parallel bars to the case of artificial bars placed discretely on the seabed. Wen and Tsai (2008) applied EEMSE model to investigate the characteristics of the Bragg reflection under various conditions of incident wave and seabed. Bailard et al. (1990) and Tsai and Wen (2010) explored the feasibility of the Bragg reflection of artificial bars placed offshore on a natural beach. Their results concluded that the Bragg reflection of artificial bars might have merits as an appropriate shore protection method.

Miles’ (1981) theory provides a simple method to calculate the Bragg reflection coefficient than any other complex numerical methods. The Bragg reflection coefficient could be obtained in an easy way after integrating a formula for any undulation bottom. For the application of Miles’ (1981) theory, the major studies in the earlier stage focused on the singly and doubly sinusoidal bed or artificial bars. However, all aforementioned studies haven’t studied the Bragg reflection under more than two groups of combined artificial bars. In this paper, we extend Miles’ (1981) theory to investigate Bragg scattering of monochromatic water waves over multiply composite artificial bars with varying key parameters. By varying the key parameters of multiply composite artificial bars, such as the number of bars, bar spacing, formula derived from Miles’ (1981) theory is examined in the present study. We attempt to adjust the composition of artificial bars in order to achieve the enhancement of bandwidth and intensity of the primary Bragg resonance. Moreover, EEMSE model (Hsu et al., 2003) was used to verify some particular phenomena of the Bragg resonance caused by multiply composite artificial bars.

THEORETICAL FORMULATION

Miles (1981) presented an integral equation of wave reflection due