Proceedings of the Eighth (2008) ISOPE Pacific/Asia Offshore Mechanics Symposium
Bangkok, Thailand, November 10-14, 2008

ISBN 978-1-880653-52-4

Experimental Study of Surf Beat Generated on a Submerged Sill

Guohai Dong , Xiaozhou Ma, Yuxiang Ma and Jianwu Xu
State Key Laboratory of Coastal and Offshore Engineering
Dalian University of Technology, Dalian, China

ABSTRACT

Low-frequency waves generated on a submerged curvilinear sill by bichromatic wave groups with and without an opposing current are studied experimentally in a laboratory flume. The second-order wave maker theory is used to generate the primary waves and the spurious long waves were significantly suppressed. The generation of harmonics, wave blocking of the short waves and especially the penetration of long waves through the blocking point have been observed. The evolution of long waves before and after the blocking point is described in detail.

KEY WORDS: Surf beat; Wave blocking; Experiments; Submerged sill; Bichromatic waves

INTRODUCTION

Surf beat was first observed and termed by Munk (1949) and Tucker (Tucker, 1950) outside the surf zone. It is a wave motion at the period of 0.5 ~ 5.0 min, which is also referred as infragravity wave later in the literature. The observed long waves were believed to be generated in the surf zone as a result of a beat phenomenon induced by the primary incident wave groups. Further measurements of elevation spectra in the near shore zone show that the water motion in shallow water is dominated by infragravity energy (Huntley, 1976; Holman, 1981; Huntley et al., 1981; Thornton and Guza, 1982). The incidence of surf beat into the harbor may have a negative effect on the tranquility of the harbor (Bowers, 1977; Mei and Agnon, 1989; Smallman and Cooper, 1989) and on the cargo work on the moored ships (Nagai et al., 1994). Surf beat may also be responsible for the change of the coastal morphology and some complex topography (Holman and Bowen, 1982; Osborne and Greenwood, 1992; O'Hare and Huntley, 1994; Ciriano et al., 2005), and influence the sand transport in the nearshore (Smith and Mocke, 2002).

Wave current interaction occurs often in the real costal region. However, the low-frequency waves generated in the waves with current is rarely studied to the authors' knowledge. The low-frequency waves generated on a submerged curvilinear bar in the bichromatic waves with an opposing current are observed and analyzed in this paper.

EXPERIMENTAL SETUP

Wave flume and instrumentation

The experiments are carried out in a flume 50 m long, 3 m wide and with a maximum working depth of 0.7 m. The flume is equipped with a hydraulically driven, piston-type wave generator at one end and a passive wave absorber at the other. The origin of the x axis is fixed at the average position of wave board, pointing positive to the other end of the flume. The positive of z coordinate points upward and its origin is at still water level (SWL). The bottom profile of the bathymetry is built with sand and a cemented surface in the present experiment, shown schematically in Fig. 1. The still water depth in front of the sill slope is 0.5 m.

The bottom profile is defined by exponent and elliptical curves, which are written as

$$z+h=\begin{cases} h_s\cos\theta_1\exp\left(-\dfrac{1}{2}\dfrac{(x-x_0)^2}{a_1^2\cos^2\theta_1}+\dfrac{1}{2}\tan^2\theta_1\right), & x\le x_1 \\ h_s\sqrt{1-(x-x_0)^2/a_1^2}, & x_1<x<x_0 \\ h_s\sqrt{1-(x-x_0)^2/a_2^2}, & x_0\le x<x_2 \\ h_s\cos\theta_2\exp\left(-\dfrac{1}{2}\dfrac{(x-x_0)^2}{a_2^2\cos^2\theta_2}+\dfrac{1}{2}\tan^2\theta_2\right), & x\ge x_2 \end{cases} \tag{1}$$

where h is the still water depth; a_1, a_2, h_s and x_0 are the parameters to define the profile; x_i (i = 0, 1, 2) define the ranges of the four segments of curve; θ_1 and θ_2 are defined as θ_i=-arctan($a_i z_x(x_i)/h_s$) (i = 1, 2). In order to get a asymmetrical profile, we choose a_1 = 4.0m and a_2 = 2.5m. The highest point of the sill is located at x_0 = 20.2m, where the height of sill (h_s) is set 0.4m. The maximal slope of the sill (z_x) is located at x=x_1 and x = x_2, and z_x is set 0.125 and 0.2 at the two points, respectively.

The surface elevations on both the bathymetries are recorded with 23 capacitance wave gauges and their locations are shown in Fig. 1 with vertical lines at SWL. The first gauge (Gauge1) is located at x = 5m and