Performance of Twin-Pontoon Floating Breakwaters

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ABSTRACT

The paper presents a numerical and experimental assessment of the hydrodynamic performance of a moored twin-pontoon floating breakwater made up of either rectangular or circular section pontoons and subjected to regular normally incident waves. The numerical model includes a hydrodynamic analysis and a mooring analysis which are linked by an iterative procedure involving consistency in the wave drift force. Comparisons with experimental measurements of transmission and reflection coefficients, breakwater motions, and mooring line tensions show satisfactory agreement. The effects of relative draft, pontoon spacing, mooring line slackness and pontoon cross-section are discussed and a comparison with a single pontoon breakwater is presented.

KEY WORDS: coastal structures, floating breakwaters, hydrodynamics, moorings, wave transmission, waves.

1 INTRODUCTION

Floating breakwaters are being used increasingly at coastal locations where open water wave conditions are not unduly severe and water depths are relatively large. A range of floating breakwater concepts have been developed, including concrete caisson breakwaters with various configurations, A-frame breakwaters, scrap-tire breakwaters, log bundles and more recently twin-pontoon breakwaters. A survey of floating breakwaters, covering topics ranging from analytical models of breakwater behaviour to in-situ experiences with particular designs, was given by Cammaert et al. (1994) and an overview of the criteria used for floating breakwater design and of the associated design process has been given by Isaacson (1993).

Numerical methods for the hydrodynamic analysis of wave interactions with floating structures are generally based on potential flow theory and have been reviewed, for example, by Sarpkaya and Isaacson (1981) and Chakrabarti (1987). Floating breakwaters are most commonly restrained by mooring lines, and the analysis of the mooring system must be carried out in conjunction with a hydrodynamic analysis. Isaacson and Baldwin (1996) have provided a general review of the analysis of moored structures in waves and currents, and reviews of the analysis of mooring system behaviour have been given by Leonard (1988) and Triantafyllou (1994).

A number of interesting results have been found for the specific case of a twin-pontoon breakwater. Numerical results indicate the occurrence of negative added mass in heave and an associated sharp peak in the damping coefficient at intermediate wave frequencies (Leonard et al., 1983; Wu and Price, 1987), which are generally attributed to oscillations of the fluid between the pontoons (Vinje, 1989). For the case of a fixed breakwater, a corresponding minimum in the reflection coefficient has been predicted by Williams and Abul-Azm (1996). This phenomena has been confirmed in laboratory tests but has not been extensively investigated experimentally.

The purpose of the present paper is to develop a numerical model for predicting the performance of a moored floating breakwater which links the hydrodynamic and mooring analyses in a consistent manner; and to compare predictions of the method with experimental results for the specific case of a twin-pontoon breakwater.

2 NUMERICAL METHOD

The numerical model used is based on two component analyses: a hydrodynamic analysis which treats the problem of normally incident waves interacting with the breakwater; and a mooring analysis, which provides the mooring line configurations, mooring line tensions and anchor forces. These are summarized in turn.

2.1 Hydrodynamic Analysis

The hydrodynamic analysis is carried out for normal or obliquely incident regular waves on the basis of two-dimensional linear wave diffraction/radiation theory (e.g. Sarpkaya and Isaacson, 1981), in which the breakwater is treated as a pair of rigidly connected infinitely long horizontal cylinders as shown in Fig. 1. The fluid is assumed incompressible and inviscid, and the flow irrotational so that potential flow theory is used. The velocity potential \( \Phi \) of the flow is considered to be made up of components associated with the incident waves, scattered waves, both these components being proportional to the incident wave height \( H \), and forced waves associated with each mode of motion of the cylinder, corresponding to sway, heave and roll (see Fig. 1). The latter potentials are proportional to the corresponding amplitudes of the motion. Thus, for normally incident waves, the total velocity potential \( \Phi \) is expressed in the form: