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Experimental Study on Wave-induced Motion of Offshore Observation Buoy

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ABSTRACT

An offshore observation buoy employing GPS data has been developed in Japan. The buoy system observes the offshore waves with the period range of swells to long period waves including tsunami components in the deep sea. The water depth at the station is about 1000m. For such deep-sea condition, several technical problems are under consideration. One of the important subjects is the relation of buoy motion and wave profiles.

In this paper an experiment measuring the motion of buoy in the deep-sea condition is described. The elastic spring is implemented in the experiment to reproduce the mass gravity of mooring chain under water. Experimental results reaveal the performance of buoy system installed in the deep-sea and the correlation between the buoy motion and wave profile.

KEY WORDS: GPS buoy, hydraulic experiment, mooring tension, buoy-motion, wave observation.

INTRODUCTION

An offshore observation buoy employing GPS data has been developed in Japan. Photograph 1 shows an example of offshore buoy station to measure the wave condition off the west island (Shikoku) in Japan. The heaving motion of buoy is obtained by GPS (Global Position System) and recorded in a main station located on the main island. The GPS buoy system becomes a tool suitable to measuring offshore waves in the ocean. Nagai et al. (2006) have proposed the offshore tsunami monitoring network employing several GPS buoys. The wave data obtained in deep water may be also useful to the integrated ocean observation system as the real time data is combined with other meteorological information like salinity, temperature, current etc. (NOAA, 2008).

Meanwhile long period waves induced by the nonlinear infra-gravity waves bounded in offshore swells and tsunamis due to earthquakes on the continental plate boundary give great risk to the Japanese coast lines (Hiraishi, 2006, Okumura et al., 2007). The offshore wave station becomes much important because the coastal residents are able to prepare the mitigation or evacuation before the target waves reach at the shore by using the offshore data. The completion of GPS buoy network is planned to mitigate the risk of tsunamis and long period waves in the coastal residential areas.

Two observation buoys have been just installed in the Japanese northern coastal area this year. The buoy system observes the offshore waves with the period range of swells to long period waves including tsunami components. The distance of observation station where the buoy is located is about several hundreds kilo-meters from the shore and its water depth is about 100 to 200m. In order to raise the safety in the coastal area, the observation in deeper water area becomes necessary.

To catch the signal of the tsunamis and long period waves at least 1 hour before their arrival, another buoy system will be installed in a deeper area near from an isolated coral island in near future. The water depth at the station is about 1000m. For such deep-sea condition, several technical problems are under consideration. One of the important subjects is the relation of buoy motion and wave profiles.

The buoy is moored to the sea-bed employing a nylon hawser and anchor chains and the total mass of mooring line become very heavy because the water depth is 1000m. The long mooring line may become an obstacle reducing the displacement of buoy-heaving motion. The reduction of heaving motion has to be accurately evaluated because the heaving displacement of the buoy measured in GPS is counted as the wave height. If the GPS' heave motion perfectly agrees with the water surface elevation, the error in the measured wave height becomes very small. Therefore investigation of buoy motion, especially of heave motion is important to ensure the accuracy of analyses wave data in the GPS buoy system.

In this paper an experiment measuring the motion of buoy in the deep-sea condition is described. The elastic spring is implemented in the experiment to reproduce the mass gravity of mooring chain under water. Experimental results demonstrate the performance of buoy system installed in the deep-sea and the correlation between the buoy motion and wave profile. Of course, the satellite signal should have no error when the buoy heaving motion is sent to a ground base to analyze the wave height with high accuracy. The reliability of total system