Proceedings of The Seventh (2007) ISOPE Ocean Mining Symposium
Lisbon, Portugal, July 1-6, 2007

ISBN 978-1-880653-69-2; ISBN 1-880653-69-9

Seafloor Displacement Monitoring by Double Integral Technique Using Servo-accelerometer System

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ABSTRACT

In order to monitor the seafloor stability during methane hydrate productions, a monitoring system continuously measuring seafloor displacement is required. We have been developing a system that mainly consists of a 3-component servo-accelerometer and gimbaled mechanism in a pressure chamber. The observed acceleration waveform data are used to calculate displacements by double integrals with noise reduction. After testing the performance of the servo-accelerometer, a prototype model of the system was created and tested in laboratory with soil samples and at an onshore landslide site. As the results of those tests, we confirmed that the monitoring by servo-accelerometer is practical.

KEY WORDS: Methane; hydrate; seafloor; displacement; monitoring; servo-accelerometer; integral.

INTRODUCTION

In order to monitor the seafloor stability during methane hydrate productions, it is required to measure seafloor displacement continuously. In the case of onshore landslide site, ground displacement monitoring of the landslide movement is usually done by such instruments as the slide sensors, borehole tilt meters, etc. These instruments measure the relative displacements between a fixed point and measuring points in the landslide mass. However, those can not be used for displacement monitoring at the seafloor where it is difficult to set a fixed reference point.

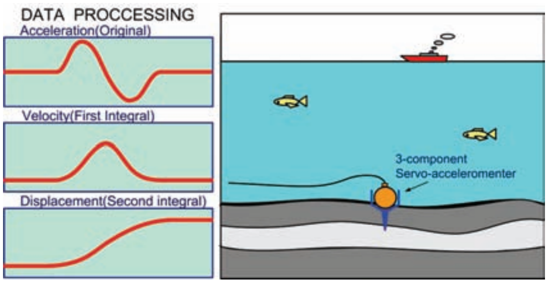

Fig.1 Basic concept of displacement monitoring at the seafloor

In this study, we propose a new method to monitor the seafloor displacement by using a 3-component servo-accelerometer system. The basic concept of the proposed method is to calculate displacements from the acceleration waveform records obtained at the seafloor by a 3-component accelerometer (Fig.1). The basic calculation is simple double integrals applied to the acceleration waveforms to obtain displacement waveforms. One of the most important points for the data processing is to reduce noises, especially long period trends, which produce much error in the integral calculations.

In this paper, we will first describe the outline of the prototype monitoring system. Next, the test results of servo-accelerometers and gimbaled mechanism will be explained. Then, we will introduce how to obtain displacement signals from the servo-accelerometer data, including data acquisition system and data processinGalgorithm. Then, we will demonstrate some results of performance tests for the servo-accelerometer in the laboratory. In addition, we will show a result of a shearing test for a soil sample in the laboratory and a monitored data at an onshore landslide site. Finally, we conclude the results and discuss about applicability of the system and future works.

OUTLINE OF THE PROTOTYPE MODEL

Schematic diagram of the prototype model is shown in Fig.2. The system consists of power supply, personal computer, data logger and a pressure chamber which contains three servo-accelerometers, three geophones, two tilt meters, two compasses and one thermometer. Servo-accelerometers and geophones are placed on a gimbaled mechanism so that the sensors can be kept horizontally at the seafloor environment. The other sensors are fixed in the pressure chamber.

Dynamic range of the servo-accelerometer is more than 150 dB, and the resolution of acceleration amplitude is about 30 μGal when used with this data logger. Voltage sensitivity of geophone is 1.0v/kine, and its resonance frequency is 4.5 Hz which is much higher than usual seismometer for observing natural earthquakes. We employ this high frequency geophone because it is smaller and stronger than the usual low frequency ones. Sensitivity of the tilt meter is the highest in the other commercially available sensors. Resolution of this tilt meter with the data logger is 1×10-6 radian. The compass is called "MI (magnetic impedance) sensor" which is developed recently, having high sensitivity 0.15V/40,000T. The data logger has 24 bit A/D converter.