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The development and evaluation of sensors for long-term borehole monitoring system at C0002 site in Nankai Trough

Toshinori Kimura[1*], Eiichiro Araki[1], Hiroyuki Takayama[2], Kazuya Kitada[1], Masataka Kinoshita[1], Yasuhiro Namba[1], Masanori Kyo[1]

[1]JAMSTEC, [2]JMA

In this presentation, we report the development and evaluation of sensors for Long-Term Borehole Monitoring System (LTBMS) installed at C0002 site, the first LTBMS observatory in the Nankai Trough. The suite of LTBMS sensors includes a broad-band seismometer, volumetric strainmeter, tiltmeter, geophone, accelerometer and thermistor array. The set of sensors was designed to collect broad-band dynamics with wide dynamic range to understand the mechanism of mega-earthquake occurred along the plate boundary faults. The purpose of this study is to develop high accuracy and reliable sensors that can obtain valuable scientific data and to develop sensors that have anti-vibration mechanism that is sufficient to resist against Vortex Induced Vibration (VIV) caused by the strong ocean current, ”Kuroshio”.

In our development scheme for sensors, broad-band seismometer, CMG3TB, tiltmeter, LILY and thermistor digitizer, SAHF were developed by customizing general products. The volumetric strainmeter was developed from scratch. We developed some printed circuit boards (PCBs) for telemetry, A/D conversion and calibration. Geophone, GS-11D and accelerometer, JA-5H200 were integrated to our PCBs. We added anti-vibration mechanism to all sensors.

After development was completed, noise evaluation, vibration and shock test were conducted using tiltmeter, geophone, accelerometer and thermistor digitizer. The purpose of these tests is to confirm that our anti-vibration mechanism is working well by comparison of sensor response before and after vibration and shock tests. Noise evaluation test was conducted in Matsushiro Seismological Observatory of JMA. Because of the very low-noise and stable environment, minimal change of amplitude or phase response that occurred during vibration and shock test can be detected. We can also confirm long-term stability of sensors. The vibration test was conducted with a sweep vibration from 3 to 15 Hz in frequency, and from 0.25 to 2.0 G in acceleration calculated from accelerometer data measured on IODP Exp. 319. The shock pulse test was conducted with 90 G shock pulse and 2 ms pulse width. After these tests were completed, we installed all sensors to Matushiro Seismological Observatory and re-start noise evaluation test. As for the volumetric strainmeter, we only conducted vibration test using each small components. As for the broad-band seismometer, vibration test was conducted by Guralp Systems Ltd. in U.K. with same parameters as our test. After delivered, noise evaluation test was conducted in Matsushiro.

Power spectral density (PSD) was calculated using background noise for sensor evaluation. We confirmed that PSD plots have same response before and after these tests. The peak of microseism around 0.2Hz can be clearly confirmed in the PSD plot of the geophone,and tiltmeter. In the PSD plot of accelerometer, a peak in microseism was not found because the accelerometer was adjusted for strong motion. However, there were no differences of internal noise level before and after these tests. The broad-band seismometer was also installed to same place after delivered. PSD plots of broad-band seismometer, geophone, accelerometer and tiltmeter were compared with reference sensor, CMG3T general package. Finally, we confirmed that the responses of these sensors have good coherence with that of the reference sensor and this result is consistent with each specification of sensors.

After final noise evaluation test was completed, all of sensors were loaded to D/V Chikyu. In IODP Exp. 332, these sensors were installed to C0002 site successfully. These sensors are planned to connect to a seafloor recorder and to start continuous recording in KY11-04 cruise by R/V Kaiyo. In this presentation, we report the preliminary result of KY11-04 cruise and evaluation of acquired data as well.

Keywords: Long-term borehole monitoring system, Nankai Trough, development of sensors, vibration and shock test, noise evaluation test