Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 29-30, 2014

Site response assessment using borehole seismic records

Park, Dong-Hee*, Chang, Chun-Joong, Choi, Weon-Hack
KHNP Central Research Institute, 1312, Yuseongdaero, Yuseong-gu, Daejeon, Korea, 305-343
**Corresponding author email: dpark@kjnp.co.kr*

1. Introduction

Deep geological disposal is currently accepted as the most appropriate method for permanently removing spent nuclear fuel from the living sphere of humans. For implementation of deep geological disposal we need to understand the geological changes that have taken place over the past 100,000 years, encompassing active faults, volcanic activity, uplift and subsidence, which as yet have not been considered in assessing the site characteristics for general facilities, as well as to investigate and analyze the geological structures, fracture systems and seismic responses regarding deep underground.

In regions with high seismic activity, such as Japan, the Western United States and Taiwan, borehole seismometers installed deep underground are used to monitor seismic activity during the course of seismic wave propagation at various depths and to study the stress changes due to earthquakes and analyze the connection to fault movements.

The Korea Meteorological Administration (KMA) and the Korea Institute of Geology and Mining (KIGAM) have installed and are operating borehole seismometers at a depth of 70~100 meters for the precise determination of epicenters. Also, Korea Hydro & Nuclear Power Co., Ltd. (KHNP) has installed and is operating 2 borehole seismic stations near Weolseong area to observe at a depth of 140 meters seismic activities connected to fault activity. KHNP plans to operate in the second half of 2014 a borehole seismic station for depths less than 300 and 600 meters in order to study the seismic response characteristics in deep strata.

As a basic study for analyzing ground motion response characteristics at depths of about 300 to 600 meters in connection with the deep geological disposal of spent nuclear fuel, the present study examined the background noise response characteristics of the borehole seismic station operated by KHNP. In order to analyze the depth-dependent impact of seismic waves at deeper depths than in Korea, seismic data collected by Japan's KIK-net seismic stations were used and the seismic wave characteristics analyzed by size and depth.

2. Data and Processing Method

2.1 Background Noise Analysis Utilizing Borehole Data

The background noise analysis method presented in McNamara & Nuland[1] allows one to analyze the background noise level by using the data collected without removing or differentiating waveforms caused by earthquakes or data damages due to momentary mechanical malfunctions. Since most seismic observation data contain background noise, the density is probabilistically high; and because false signals due to signal or instrument errors during an earthquake are generally temporary, the frequency is probabilistically low. If a probability density function based on such statistical characteristics is used in background noise analysis, the characteristics of the major background noise recorded at a seismic station can be determined, and it is useful in the analysis or automated analysis of data collected over a long period.

To analyze the characteristics of the data from the borehole seismic station operated by KHNP, in the present study we installed a portable seismic observations on the upper part of the borehole observation and diagrammed the background noise for each data as depicted in Fig. 1 and 2. As these figures show, the background noise characteristics depending on frequency were observed at the same level at the borehole and deep underground. Hence, it is deemed that with respect to analyzing borehole seismic observation data in the future, this method can be applied to differentiate seismic signals in order to study the seismic response characteristics of the borehole and data through background noise analysis using the PDF (Power Density Function).

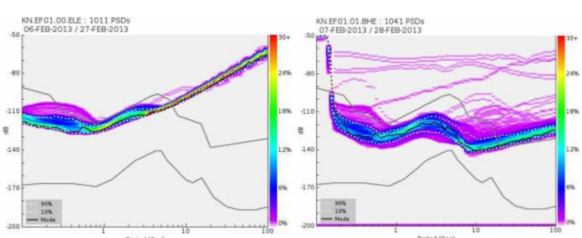

Fig. 1.(a) Power Density Function of Borehole seismometer (EF01) (b) Power Density Function of Free-field seismometer (FF01)

2.2 Analysis of Japan's KIKnet Observation Data

As discussed above, since the number of seismic stations is limited domestically to underground depths of less than about 150 meters, we used recorded observation data from Japan, where many seismic stations of various depths are distributed, in the analysis to study the characteristics of seismic response depending on depth.

Seismic data from the free-field and borehole seismometers(depths : 100 ~ 1,000 m) in the Kiban-Kyoshin Net and KlK-net operated by the NIED (National Research Institute of Earth Science and Disaster) were obtained and peak ground acceleration (PGA) was analyzed by depth and size. The results showed that, compared to the borehole depths observation data, the PGA of the seismic waves recorded in free field tended to decrease (Fig. 3), and it was confirmed that particularly at shallow depths this depth-dependent decreasing tendency became more pronounced. Also, even if the seismic data were observed in the same borehole-free field, depending on the size, their ground motion characteristics showed differences, and the greater the seismic size and amplitude, the extent of decrease depending on depth was shown to be gradual.

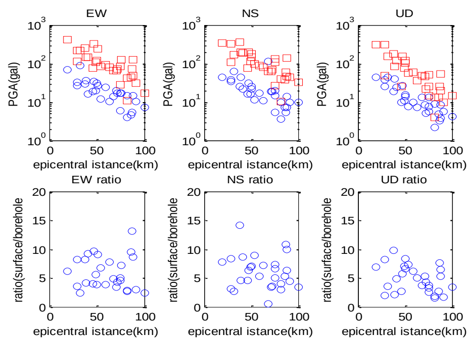

Fig. 3. Seismic response characteristics(PGA, Peak Ground Acceleration) by magnitude of the earthquake from Sendai region of Japan.

3. Conclusion and Discussion

In order to analyze the borehole seismic observation data from the seismic station operated by KHNP, this study analyzed the background noise characteristics by using a probability density function. Also, based on the analysis of the observation data of KIK-net operated in Japan, the study showed that even in bedrock of the same depth, affected by various factors such as the condition of the rocks or soil at the top part and fracturing formations, differences depending on ground motion characteristics due to depth appear to be quite diverse.

Together with the ground motion data recorded by the borehole seismometer that will be installed domestically at a depth of 600 meters or less, the analysis results of this study can be utilized as basic data for seismic response characteristics studies with regard to spent nuclear fuel disposal depth and as the input data for seismic hazard assessment that distinguishes response by depth.

REFERENCES

[1] D.E. McNamara, R. P. Buland, and H. M. Benz, An assessment of the high-gain STS2seismometer for earthquake monitoring in the United States, USGS Open-File Report, No. 2005-1437, p. 25, 2005

ACKNOWLEDMENT

This work was supported by the Radioactive Waste Management of the Korea Institute of Energy Technology Evaluation and Planning(KETEP) grant funded by the Korea government Ministry of Trace, Industry & Energy(2012171020001C)