Analysis of a Near-field Earthquake Record at the Deep Underground Research Tunnel

Kwan-Hee Yun[a*], Dong-Hee Park[a], Taek-Mo Shim[b]
[a]*Korea Electric Power Research Institute, 65 Munji-Ro, Yuseong-Gu, Daejeon, 305-380*
[b]*Korea Institute of Nuclear Safety, 34 Gwahak-Ro, Yuseong-Gu, Daejeon, 305-338*
[*]*Corresponding author: kyun@kepri.re.kr*

1. Introduction

On October 29, 2008, a moderate earthquake (M=3.4, 36.35 N 127.25 E) occurred near the city of Daejon where an underground testing facilities called 'KURT (**K**AERI **U**nderground **R**esearch **T**unnel)' was located inside KAERI. Even though this earthquake did not trigger a seismic monitoring system of the mock-up Nuclear Power Plant of Hanaro, it was large enough not only to provide nation-wide earthquake data of good quality but also to be widely felt by the people uncomfortably around Daejon. In addition, this earthquake provides a good chance to obtain a near-field broadband seismogram of frequency up to 200Hz recorded at the three-component geophones at the deep underground tunnel of the KURT (-90m). So we compared the seismic records from the KURT with other records from the nearby national seismic network to evaluate the earthquake ground-motion characteristics at the underground facilities for future engineering application. Table 1 lists the three nearby seismic stations of the national seismic network jointly operated by **K**orea **M**eteorological **A**dministration (KMA), **K**orea **I**nstitute of **G**eoscience **A**nd **M**ineral Resources (KIGAM), KEPRI, and KINS.

Table 1: list of seismic Stations and information

ID	Geographical Cord.		Dist. (km)	ETC	Provider
	Long.	Lat.			
TEJ	127.3712	36.3681	10.39	Daejeon provincial branch office of KMA	KMA
TJN	127.3638	36.3775	10.07	KIGAM site	KIGAM
KOJ	127.1448	36.4708	17.27	Kongju Nation Univerty	KMA
HNR	-	-	13.09	KURT	KAERI

2. Preprocessing of the seismic data

Seismic records are the result of combining effects of seismic source, wave propagation, site amplification, and instrumental response. In order for the seismic records to be properly compared, these effects should be properly taken into account for in preprocessing the records. Since we are dealing with the same earthquake, the source-effect is not a concern. The KURT data can be considered to be without site-effect since it is located in deep underground. So, in this study, the KURT data was only corrected for the instrument response while the records from the nearby national seismic stations are corrected for the site-effect. The wave propagation effect was not considered because the nearby stations are within 5km in distance to the KURT.

2.1 KURT data

The current vibration recording system (GeoSpace GS-14-L9 model) at the KURT is a geophone type and not designed for the purpose of earthquake recording. So the instrumental correction has been done by using the technique of [1] in the time-domain by convolving the corresponding filter for the short-period seismometer with the parameters of f_n (natural frequency) = 28Hz and damping = 0.28 ([2]) an in Fig. 1. The right figure of Fig. 1 shows the amplitude response of the geophone which distorts the response below 100Hz. In particular, this geophone suppresses the response below the natural frequency of 28Hz, the main frequency range of earthquake data. Usually the frequency band below the natural frequency of geophone records is usually abandoned. But in this case, because of short distance, large ground-motion, and the main frequency of this earthquake of 4.6Hz ([3]), the seismic energy at this frequency range is considered to be enough to be recovered by the instrumental correction.

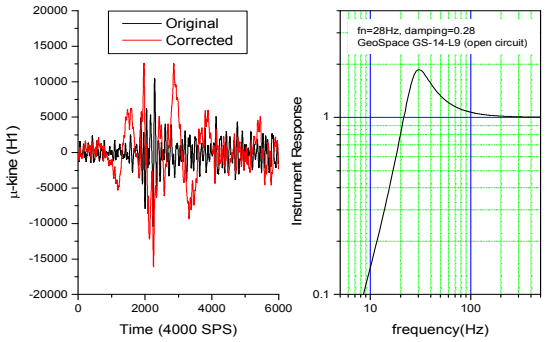

Fig. 1 Result of instrumental correction (left) and the instrument response of the geophone at the deep underground testing facilities of KURT (right).

2.2 Earthquake data from the national seismic network

KEPRI have recently developed a suite of digital filters for removing site-effects of all the national seismic stations in Korea and applied these in practice for routine work each time an earthquake occurred ([3]). These filters were designed with linear-phase to match the amplification of Fourier amplitude at the site amplification relative to TJN site. Fig. 2 shows the digital filters applied to the recorded data from the seismic stations TEJ and KOJ in Table 1 for removing site-effects.

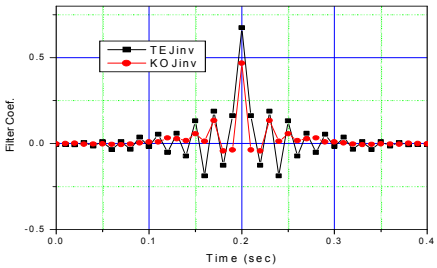

Fig. 2 Digital filters for removing the site-effect of the seismic stations TEJ and KOJ.

3. Result of the Comparative study

The preprocessed data from the KURT and the nearby national seismic networks were compared in Fig. 3. This figure shows that the underground seismic response is similar at low frequencies below 5Hz but deamplified, i.e., lower than the nearby surface seismic stations without site-effects at high frequencies above 10Hz. This result supports the expectation that the high-frequency amplification is mostly driven by the weakening of seismic impedance at the shallow underground level as the seismic wave approach to the ground surface.

High-frequency cut-off model was also developed by fitting the observed corrected Fourier spectrum of 10 to - 150Hz. As a result, Butterworth filter of order 2.5 and corner frequency of 72Hz was found to be the best fitting model for the high-frequencies. This model coupled with the κ_0 - model ([4]) can be used to simulate the near-field strong ground-motion for engineering purposes.

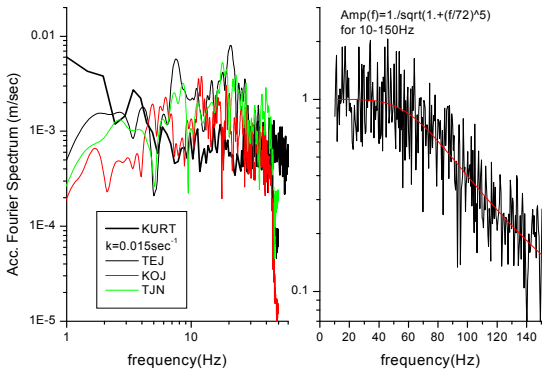

Fig. 3 Fourier spectra of the KURT data compared with those of nearby national seismic stations (left) and the best fitting model for high-frequency diminution model (right).

This deamplification feature at the deep underground is found to be comparable to the observation at the deep (-100m) borehole seismic stations of YNCB and GAHB installed adjacent to DMZ line by KMA. So the empirically corrected KURT data for the deamplification results in the similar spectral level of nearby seismic stations without site-effects as in Fig. 4.

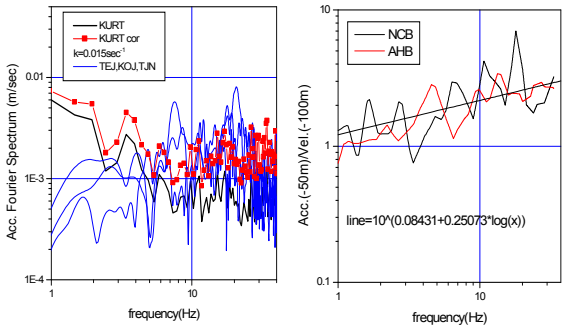

Fig. 4 Correction of the KURT data (left) by incorporating the empirical site amplifications (right) observed by the two deep borehole sites of NCB (Yon-Chon) and AHB (Gang-Hwa).

4. Conclusions

A near-field seismogram for a moderate earthquake recorded by a geophone at the deep underground testing facilities of KURT was corrected for the instrument response to be compared with the records of the nearby national seismic stations with the site-effect removed.

The KURT data show deamplified seismic response at the high-frequency (> 10Hz) compared to that of the nation-wide seismic networks at the level of free field without site-effect.

In addition, due to the high sampling rate of the KURT recording system, the high frequency diminution model for the domestic earthquakes could be suggested as $1/\sqrt{1+(f/72)^5}$.

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