GNSS Data Processing and Analysis for Earthquake Disaster Prevention Monitoring

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ABSTRACT

This article describes how an earthquake with highest magnitude 5.8 on the Richter scale occurred in the Gyeongju area on Sep. 12, 2016 since the first seismological observation. In addition, continuous aftershocks have occurred. There is a pressing need for proper earthquake monitoring and prevention systems. This article is intended to apprehend the dislocation and location change of Continuously Operating Reference Station (CORS) caused by earthquake by means of data on CORS of the National Geographic Information Institute (NGII) and suggest effective seismic monitoring methods. Through Precise Point Positioning (PPP) over earthquake occurrence locations, it was possible to determine the dislocation aspects of CORS for TEGN and CHSG near the seismic epicenter. The nationwide Relative Positioning processing of data for 58 CORS from Sep. 1 to Sep. 30 suggested that CORS had not transitioned coordinates due to the earthquake. For the sake of more efficient earthquake observation and monitoring, it is believed that highly frequent GNSS data acquisition and the additional installation of observation devices such as seismometers is required.

KEYWORDS
CORS, Earthquake, GNSS, Monitoring, Precise Point Positioning, Prevention

1. INTRODUCTION

At 7:44 p.m. and 8:32 p.m. on Sep. 12, 2016, there were two devastating earthquakes of magnitude 5.1 and 5.8 on the Richter scale occurred in succession (Korea Meteorological Administration, 2017; Ministry of Land, Infrastructure and Transport, 2017; Korea Institute of Geoscience and Mineral resources, 2017). This earthquake was recorded as the highest magnitude since the first seismological observation in 1978 in Korea (Kim & Lee, 2015, pp. 181-192; Cho, 2015, pp. 485-495; Park et al., 2013, pp. 2481-2486); this earthquake made a shock that was discernable nationwide and continuous aftershocks developed national anxiety. The Yangsan fault where Gyeongju is located caused many discussions about earthquakes because it is an active fault (Yang & Lee, 2014, pp. 17-27; Kim & Lee, C.K., 2015, pp. 181-192; Nam & Song, 2015, pp. 305-316). As a fault in the Korean Peninsula, the Yangsan fault starts from Yeongdeok-gun, Gyeongsangbuk-do, goes to Yangsan-si, Gyeongsangnam-do and ends at the mouth of the Nakdonggang River in Busan Metropolitan City. It is an active fault with the highest probability of seismic outbreak in Korea and it is a strike–slip fault about 170 km in length and is named the Yangsan fault or Eonyang fault on geological maps. As fragmental zones are accompanied inside bedrock and the dislocation distance is huge, it is known as a geologically important fault zone in Korea (Park et al., 2015a, pp. 247-254; Senapati et al., 2011, pp. 29-48; Park et al., 2015b, pp. 215-224; Park & Kim, 2016, pp. 9-14). Earthquake monitoring requires analyzing the dislocation due to earthquake and detecting crustal movements in areas with high probabilities.

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of seismic outbreaks. GNSS is a positioning technology using satellite signals developed for military purposes, but is now widely used in navigation, geophysical research, and surveying (Li et al., 2015, pp. 607-635; Song, 2009, pp. 535-544; No et al., 2012, pp. 529-533; Power et al., 2006, pp. 373-376; Lee et al., 2005, pp. 242-255; Park & Um, 2016, pp. 567-572). The GNSS positioning technology has become a core technology not only in various mobile navigation fields, but also in location information based information fusion applications such as ITS (Intelligent Transportation System), LBS (location based system) and telematics. The accurate determination of the time using GNSS provides precise time information to the field of mobile communication and the related fields of electronic information such as electronic finance, electronic commerce, and ubiquitous, newly emerging according to the development of communication network and mobile environment (Hong, 2015, pp. 123-129; Lee et al., 2015, pp. 537-545; Wang et al., 2013, pp. 656-667; Yang et al., 2000, pp. 783-788). This research used GNSS data of national CORS to investigate seismic dislocations caused by the Gyeongju earthquake, to analyze the location change of CORS, and to suggest a measure of efficient seismic monitoring for earthquake disaster prevention monitoring. Figure 1 shows the study flow. In data acquisition, collects NGII’s CORS data for the month in which the earthquake occurred. And Data Processing, the PPP method is used to calculate dislocation aspects caused by the earthquake and the relative positioning method is used to investigate the effects of national seismic events. In the analysis, the displacement and CORS changes due to the earthquake are examined.

2. STUDY AREA AND DATA ACQUISITION

2.1. Study Area

This research used GNSS data to analyze the displacement by earthquake and coordinate transition of nationwide CORS. Daegu CORS near the seismic epicenter was selected for the analysis of seismic dislocation, and 58 CORS were selected as research objects to analyze the coordinate transition of CORS across the nation. Figure 2 shows the seismic epicenter and study area (United States Geological Survey, 2017; National Geographic Information Institute, 2017).

2.2. Data Acquisition

Seismic occurrence data at Daegu(TEGN) and Cheongsong(CHSG) near the seismic epicenter was acquired to investigate seismic dislocation. The coordinate transition of nationwide CORS due to this earthquake was monitored using 24-hour data of 58 CORSs nationwide for Sep. 1–30. Table 1 shows the seismic displacement observation data.

3. DATA PROCESSING AND ANALYSIS

3.1. Precise Point Positioning

The seismic occurrence data of TEGN and CHSG CORS was processed by Precise Point Positioning (PPP). The Canadian Spatial Reference System (CSRS)-Precise Point Positioning (PPP), which is used by the Canadian government, was used for data processing. As CSRS-PPP is an online data processing service that supports static positioning and kinematic positioning for GNSS observation data, this research processed the observational data from the primary and secondary earthquakes in the TEGN and CHSG areas to investigate the seismic dislocation by means of a kinematic positioning method. Figures 3–6 show the results of data processing.

The primary earthquake was estimated at magnitude 5.1 on the Richter scale; it caused at most an approximately 5.2 cm dislocation in TEGN and CHSG. The secondary earthquake was magnitude 5.8 on the Richter scale and created a maximum approximately 5.5 cm dislocation; the seismic dislocation was calculated from this data processing. Nevertheless, it is considered that data of higher observed interval and seismometer observation source are also required when observing a high frequency earthquake shock of over 10 Hz via GNSS.
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