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Strain Changes due to Groundwater Migration after Earthquakes Observed at Rokko-Takao Station

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The 2011 off the Pacific coast of Tohoku Earthquake on March 11, 2011 caused the step-like increase of groundwater discharge by 250ml/s as well as the step-like changes of strain by about 10^{-7} at Rokko-Takao station. In this study, we estimated the effect of groundwater migration and deformation in the fracture zone due to the great earthquakes such as the 2011 off the Pacific coast of Tohoku Earthquake by using the observational data of strain changes, groundwater discharge and groundwater level.

Rokko-Takao station is located in the emergency evacuation road for the Shin-Kobe tunnel, and crosses Manpukuji fault with the east-west strike. In the station, three components strainmeter (ST1:N81^{o}W, ST2:N39^{o}E, ST3:N21^{o}W), the groundwater discharge meter and the groundwater level meter were installed. The observation has been performed continuously with the sampling interval of 0.5 second.

The ordinary seepage rate of groundwater at the station is about 550ml/s. The groundwater discharge rate increased to 800ml/s just after the earthquake. After the earthquake, the groundwater discharge rate decreased to 300ml/s in a few days and recovered to the original rate in a few months. Strain steps due to the earthquake at the station showed the positive dilatation about 10^{-7}, which was calculated by using the fault model of Geographical Survey Institute. In general, positive dilatation causes decrease of groundwater discharge as well as decrease of pore pressure. However, the groundwater discharge at the station increased just after the earthquake. It is considered that the increase of groundwater discharge was caused by the outflow of groundwater through the groundwater channel formed by the seismic movement. As a result, the groundwater discharge decreased in a few months after the earthquake and the contraction of lateral strain was caused by the decrease of groundwater loading.

The maximum and the minimum principal strains of strain steps observed at the moment of the 2011 off the Pacific coast of Tohoku Earthquake were +0.9x10^{-7} and -3.8x10^{-7}, respectively, although the maximum and the minimum principal strains calculated by using the fault model were +1.7x10^{-7} and -0.9x10^{-7}, respectively. The observed and the calculated direction of the maximum principal strains were N31^{o}E and N54^{o}E, respectively. The observed principal strains of the strain steps have some discrepancies compared with those calculated theoretically by using the earthquake fault model as follows: the absolute values of principal strain observed are about two times larger than those calculated theoretically, and the directions of principal axes differ by about 20 degrees from those calculated theoretically. It is considered that these discrepancies were caused by the contraction of the fracture zone and the increase of pore pressure in the surrounding crust. If the fracture zone was contracted by 10^{-7} and the pore pressure increased by 9kPa, the calculated strain changes due to the earthquake could agree to the observed strain steps.

The strain changes were caused by the groundwater migration and pore pressure changes at the various earthquakes. In this study, we reported the effect of groundwater on strain changes due to the great earthquake over M7.

Keywords: strain change, groundwater discharge, Rokko-Takao station, 2011 off the Pacific coast of Tohoku Earthquake