Ground motion prediction equations for PGA and PGV at the S-net seafloor sites and their application to the KiK-net sites on northeast Japan

Yadab P. Dhakal, Hisahiko Kubo, and Takashi Kunugi
National Research Institute for Earth Science and Disaster Resilience
ydhakal@bosai.go.jp, hkubo@bosai.go.jp, kunugi@bosai.go.jp

S-net is a large-scale cable-linked seafloor observation network for earthquakes and tsunamis around the Japan Trench area, consisting of 150 stations equipped with seismometers and pressure gauges. Out of the 150 stations of S-net, 41 stations in the shallow-water regions (water depth < 1,500 m) were buried approximately one meter below the seafloor, whereas the other stations in the deeper-water regions were laid freely on the seafloor. Due to the different site and path conditions for the majority of stations of S-net compared to the stations on land, it is desirable to develop ground motion prediction equations (GMPEs) specific to the seafloor sites. Because the main objective of the network was to enhance the Japan Meteorological Agency (JMA) earthquake early warning (EEW) and tsunami early warning systems, it is also desirable to develop the ground-motion prediction method for EEW using the S-net data. Here, we achieved the both objectives of obtaining the GMPE for seafloor sites and also extending the results to predict the values at the stations on land partially.

Data from about 70 earthquakes of magnitudes between Mw 5.5 and 7.4 and focal depths ranging between about 5 and 90 km were used recorded between 2016 and 2023. The construction of the GMPEs for horizontal peak ground accelerations (PGAs) and peak ground velocities (PGVs) was achieved in two steps. First, regression analysis was carried out for each event data using the distance only parameter taking account of the both geometrical and anelastic attenuation. Then, mean site residual was obtained over the available records at each S-net site. The mean site residuals serve as proxies to site condition parameters because the measured site parameters such as the S-wave velocities are unknown at the S-net sites. Secondly, the data were adjusted by the mean site residuals obtained in the first step above, and stratified regression analysis, which decouples the source and path factors, was performed. The source factors were further decomposed in to the tectonic types and focal depths. Finally, we applied the GMPEs to predict PGAs and PGVs at the KiK-net sites on land, where measured Vs30 values were available. We found that the residuals at the KiK-net sites were systematically biased with Vs30. We obtained correction factors for the bias and showed that the PGAs and PGVs at the KiK-net sites could be predicted reasonably well. The prediction had smaller standard deviation for PGVs than PGAs fort both land and S-net datsets. The standard deviation for PGV at the land sites was smaller than the one using the relations based on land-based data only.