Impact of Seismic Velocity Change on Ground Motion Modeling

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Temporal change of seismic velocity is well observed after strong shaking of large earthquakes. Seismic velocity drop is generally observed, indicating possible stress change due to water-saturated cracks and related reasons. It resulted in larger seismic intensity than conventional seismic hazard estimates. This impact is also expected to ground motion modeling and time-dependent seismic hazard assessment to the 1923 Kanto earthquake sequence with the mainshock and more than five M7-class aftershocks, the 2011 Tohoku earthquake sequence with the mainshock and three M7.5-calss aftershocks, and the Nankai Trough megathrust sequence associate with the M8 events with two-year delay in 1944 and 1946 and two-day delay in 1854. In addition, as seen in the 2016 Kumamoto earthquake sequence and the 2019 Ridgecrest earthquake sequence, the mainshock with largest ground motion is associate with the foreshock with strong shaking.

We quantitatively investigate the impact of seismic velocity change on ground motion modeling. Using the coda interferometry method by Chen et al. (2017), the seismic velocity change more than 5% with respect to the average S-wave velocity was observed for both the 2003 Tokachi-oki earthquake and the 2018 Hokkaido Eastern Iburi earthquake at the KiK-net IBUH03 station (e.g., Taira et al., 2019; Chen et al., 2020). The seismic velocity drop occurred near surface between the sensors at uphole and at downhole with 153 m deep with S-wave velocity of 520 m/s. We estimate the seismic velocity drop made the increment of 0.15 at maximum on the JMA seismic intensity scale. Since the increment of seismic intensity is proportional to the input ground velocity at the engineering bedrock, the temporal velocity change is not negligible in time-dependent seismic hazard assessment for aftershock forecasting with significant ground motion, and has a potential to over the threshold as a final push.

Keywords: seismic hazard, ground motion, velocity change