An Estimation of Torsional Motion Using Dense Array Data and Its Effect on the Structural Response

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ABSTRACT

The importance of torsional motion in seismic analysis and design of structures have been already indicated by some of the researchers. Many structural failures and damage caused by earthquakes can be linked to differential translational and/or torsional ground motions. However, dynamic response estimation of structures subjected to earthquake-induced base excitations is often simplified by ignoring the torsional motion in engineering practice. One of the main reasons can be attributed to the lack of the observed torsional motion due to the instrumental limitations. The recent development in sensors and optical instruments such as ring laser gyros has increased an interest to directly observed torsional component of ground motions. However, these instruments are in developing stage and still have some technical limitations. Meanwhile, the data from 2D or 3D dense arrays may provide a unique opportunity to estimate the torsional ground motions as they occur in place.

In this paper, the data of Chiba 3D dense array in Japan, which the separation distances among accelerometers in different azimuths vary from 5 m to 320 m, are utilized to evaluate torsional ground motion. The torsional motion is estimated using two different approaches. In the first approach, the torsional motion is estimated from spatial difference of two translational records in an array of stations on the ground. As a second approach, we used the 1986 Ghafory-Ashtiany and Sing method that expressed the torsional motion in terms of time derivative of translation components and site shear wave velocity. While the estimated torsional motions seem to be similar in small separation distances, they reveal a large variation as a separation distance increases. An attempt is made to explain the reasons of observed phenomena at the sites. Furthermore, the effect of torsional motion on structural response is investigated by estimating torsional response spectra. The variation of torsional response spectra with different separation distances were examined for both approaches.