Characteristics of Long-Period Ground Motions and Responses of High-rise Buildings in Metro Manila during 2019 Central Luzon Earthquake

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Metro Manila is surrounded by several seismic generators and is situated within Central Luzon Basin. Due to the presence of deep sedimentary basin in this area, it has the potential to generate long period strong ground motions that can impose damage to long period structures such as high-rise buildings (Grutas and Yamanaka, 2011). This phenomenon was observed during the 2019 Central Luzon earthquake with surface wave magnitude (Ms) of 6.1. During this event, a 53-storey building in Binondo, Metro Manila located more than 80km away from the epicenter, had water spillage from the top of the building due to the long-period ground shaking. There were no other recorded damages in adjacent low-rise buildings in the area. In this study, the characteristics of strong ground motion records of the event were evaluated, and the building response was analyzed based on captured videos.

To understand the characteristics of long-period ground motion that caused shaking in Metro Manila, strong ground motion records of acceleration data were retrieved from 23 sites of Philippine Strong Motion Accelerograph Arrays. The frequency spectra of waveforms for each site were plotted and analyzed to understand the time-invariant features of the waveforms, and the corresponding displacement response spectra were calculated to investigate the building response on the site.

To analyze the response of the 53-storey building, the building period is estimated using an empirical equation based on the total height of the building. Additionally, three videos capturing the water spillage from the top of the building were retrieved online. These recorded video data were analyzed to estimate the building period based on periodic water surge and based on tracking the building movement in consecutive video frames using computer vision techniques. The five main steps to estimate the building natural-period from the video data are: 1) extracting video frames, 2) setting points for tracking, 3) optical flow tracking, 4) relative displacement calculation, and 5) dominant frequency identification. The estimated building period from this method is compared to the estimated natural-periods based on the building height and the periodic water surge on top of the building. Finally, the amplitude of the building displacement from the video analysis is compared to the displacement response of the corresponding SDOF system using the actual strong ground motion data near the site of the building.

The results of this preliminary study will be utilized in the simulation of long-period ground motion in the three-dimensional structural model of the deep sedimentary layers in Metro Manila.

Keywords: Metro Manila, long-period ground motion, strong motion network, response of high-rise buildings

