Preliminary analysis of amplified ground motion in Bangkok basin using HVSR curve from recent moderate to large earthquakes

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1. INTRODUCTION

The Bangkok Basin has been known from non-instrumental observations of the local population to be subject to ground motion amplification due to the deep alluvial sediments and basin geometry. This study analyzes available seismic data to confirm that basin effects are significant in the Bangkok Basin. The paper contributes to the evaluation of basin effects by characterizing the engineering ground motion parameters and HVSR curves for the Bangkok basin which produce lengthening of ground motion duration with respect to nearby rock sites, albeit with very low ground motions. For this purpose, we analyzed ground motion records from seismic stations located within the Bangkok alluvial basin from 2007 to 2021. Recorded peak horizontal ground acceleration (PGA) for seismic stations inside the basin always exceeded 1 cm/s2 during eight earthquakes with Mw ≥ 5.5. Of these, two were intraslab events and six were shallow crustal earthquakes. These recorded ground motions shook high-rise buildings in Bangkok even though their epicentral distance exceeded 600 km.

2. GROUND MOTION RECORDS

All ground motion within the Bangkok basin considered in this study shook high-rise buildings in central Bangkok causing panic and mass evacuations of people from skyscrapers. The recorded ground motion considered in the current study was obtained from Thai Meteorological Department (TMD). Accelerometer stations outside the Bangkok basin including SRDT equipped with TSA-100 model of Nanometrics and PRAC installed with 24-bit PA-23 model of Geotech.Inside Bangkok basin with a vertical array consisting of two PA-23 accelerometers on the ground level (TMDA) and in the borehole (TMDB) at 47-m depth located in the seismological bureau, Thai Metrological Department in Bangkok has been operating since 2007. However, only ground motion data from 2008 and 2009 events could be recovered from TMDB due to system malfunction in 2010. Furthermore, Thailand's seismic stations have been upgraded since 2018 with a further seven strong motion stations located within the Bangkok basin operated with the CMG-5TC Guralp sensors (i.e. DONA, PWSA, PWNA, BKSI, SIRA, PTNA, and KMUT), Figure 3b.

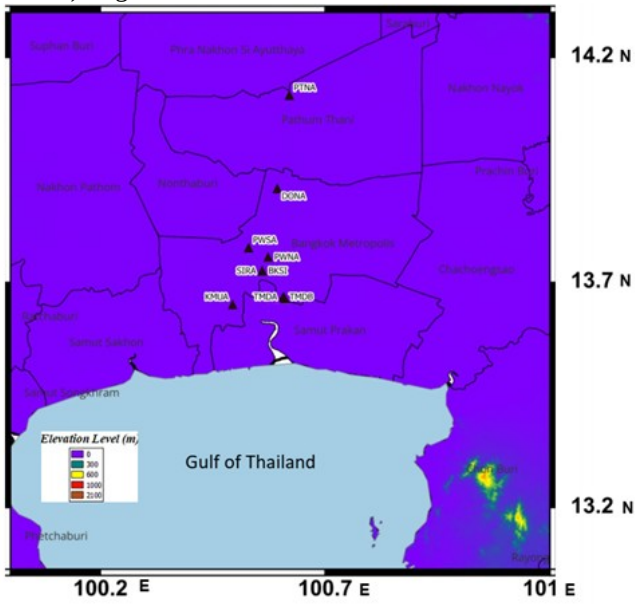

Figure 1. The SRTM elevation model of Thailand and surrounding regions developed by Reuter et al. (2007) is shown. b) Black triangles represented permanent seismic stations operated by TMD in Bangkok. It is worth mentioning that only TMDA and TMDB have operated since 2007.

3. TIME & FREQUENCY DOMAIN

Several time and frequency domain analyses are used on the ground motion records in the Bangkok basin to determine the frequency content of recorded ground motion and to demonstrate the significance of surface waves induced by the deep basin in altering the engineering ground motion amplitudes.

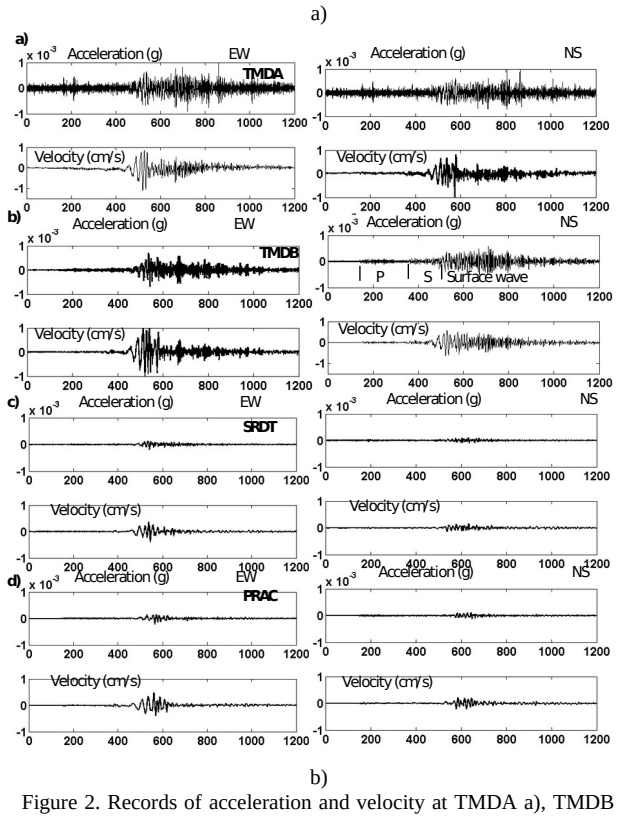

Figure 2. Records of acceleration and velocity at TMDA a), TMDB b) SRDT c), and PRAC d) stations from the Mw 7.9 12 May 2008 Sichuan earthquake. The recorded PGA and PGV at TMDA and TMDB station are much higher than other stations situated outside Bangkok basin due to the soil amplification effect.

To gain better understanding regarding the characteristics of long period ground motion recorded inside the Bangkok basin stations (i.e. TMDA, SIRA), in the current study, we analyst ground motion records from these 8 events and compute horizontal / vertical spectral ratios (HVSR) for seismic stations located inside and outside the Bangkok basin. Following original work by Nakamura (1989) and Mase et al. (2021) (using microtremor data) and Lermo and Chavez-Garcia (1993) (using recorded ground motion), the HVSR analysis has been implemented extensively to determine basin-induced amplification, using both microtremor data and ground motion recordings.

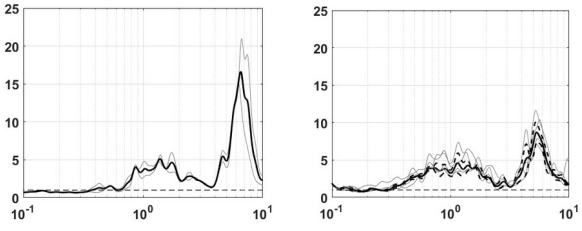

Figure 3. Average HVSR curves for recorded ground motion at (a) SIRA, (b) TMDA Solid lines indicate mean; shaded region shows each individual event. Dash black line shows one standard deviation of HVSR curve.

4. CONCLUDING REMARKS

Even though it has long been recognized that Bangkok is situated on a soft soil deposit, understanding of the site amplification periods and characterization of ground motion have been hindered by an absence of recorded ground motion. To supplement this, a preliminary comparative analysis of the recorded ground motions in BMA from recent earthquakes and the recently established seismic monitoring network have been analyzed and showed that the recorded acceleration in the Bangkok basin could increase both peak amplitude and duration compared to those stations outside basin with ratios of at least 3 for horizontal directions. The peak ground motion parameters (e.g., PGA and PGV) are mostly observed at the arrival of surface wave. Because of the high rate of seismicity surrounding Thailand, a growing volume of broadband and strong-motion data could be further used for developing site-specific basin amplification factors, the crustal quality factors.

5. REFERENCE

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