Extended Abstract | DOI: Not Included | Open Access

Site Characterization Using Passive Seismic Measurements at Dhaka University, Bangladesh

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Received: August 1, 2025, Accepted: October 15, 2025

Abstract: Dhaka is one of the most densely populated cities of the world with rapid urban expansion. The city is mostly covered by soft sediments of Holocene and Pleistocene origin. The depressed areas are filled up by artificial fill to meet the growing demand of land in the capital city. In the GICU project, the Geological Survey of Bangladesh has started to unveil the fundamental frequency with technical support of BGR and instrumental support from the Disaster Science and Climate Resilience department of Dhaka University. We determined resonance frequency from seven ambient noise measurements (recording duration 30-40 minutes) inside and near the Dhaka University campus in the southern periphery of the city using OYO McSEIS-NT NEO seismographs (200 Hz to 10 s frequency response). The survey was done over Pleistocene and Holocene sediments, mostly composed of unconsolidated clayey silt and silty sand. The most reliable "output" from microtremor horizontal-to-vertical spectra ratios is the lowest frequency peak which is interpreted as the site fundamental frequency (f_0). The results show variations of natural frequency between 0.85 and 1 Hz with an amplitude of the H/V ratio of 2.4 to 3.

Keywords: ***Microtremor, Predominant frequency, Dhaka University.***

Introduction

Seismic noise is the ambient vibration of the Earth's surface, produced at low frequency (<~ 1 Hz) by natural microseisms and at higher frequency (>~1Hz) by anthropogenic microtremors (Bonnefoy-Claudet et al., 2006, Landes et al., 2010). The single-station microtremor horizontal-to-vertical spectral ratio (MHVSR) method involves recording seismic ambient noise and dividing the combined horizontal by the vertical spectra. The main objective of the study is to determine the natural frequency of a small area of the mega city Dhaka.

Farazi et al. (2023) analyzed the H/V data from a seismic station at Dhaka University and determined the shear wave velocity applying diffuse field theory. The HVSR curve shows the fundamental frequency for Dhaka University at 0.6 Hz, whereas the shear wave velocity is 760 m/s at 200 m depth, which is considered as engineering bedrock. Helaly and Ansary (2021) have determined the fundamental frequency at 500 sites in Dhaka city; frequencies vary from 0.23 Hz to 7.6 Hz but in most of the area, the frequency is between 0.23 and 1.2 Hz. Ansary and Arefin (2020) estimated that the predominant frequencies vary from 0.4 to 1.6 Hz for the relatively loose/soft alluvium valley fill, artificial fill, Holocene alluvium and Pleistocene deposit. Data of Rahman et al. (2021) reveal that in two boreholes the bedrock (Vs > 760 m/s) found above 200 m depth, but in most areas the bedrock lies at a depth of greater than 200 m in Dhaka City. VS_{30} near the mapped area in Pleistocene sediments is 271 m/s (Rahman et al., 2018). Singh et al. (2016) analyzed seismic station data of teleseismic events in a joint research program between Dhaka University, Bangladesh and Lamont Doherty Earth Observatory (LDEO) of Columbia University at New York and found that sedimentary thickness is lower than 16 km in the deep Bengal Basin, whereas shear-wave velocity is about 4 km/s at 16 km depth. Shear-wave velocity increases from 1 km/s to 2.5 km/s at 4km depth.

Methodology

The resonance frequency of each measurement was manually determined in Geopsy software (version 3.5). The H/V module of Geopsy computes the Fourier spectra of the horizontal components (with H as the root of the sum of the squared values of the E-W and N-S components) divided by the spectrum of the vertical (V) component.

Results and discussion

The H/V results from the seven stations show 0.85, 0.87, 0.91, 0.91, 0.93, 0.97 and 1.0 Hz with an amplitude of the H/V ratio of 2.4 to 3 (Figure 1). The area comprises Holocene sediments and mostly Pleistocene sediments. Within the Pleistocene sediments, there are strata of dense sand at various depth ranges. The

thickness of the Holocene sediments ranges from 0 to 6 m located on top of the Pleistocene sediments all over Dhaka City (Rahman et al., 2021). Pleistocene sediments are part of Madhupur Tract Terrace; they are slightly uplifted with respect to the Holocene sediments due to vertical tectonic movements.

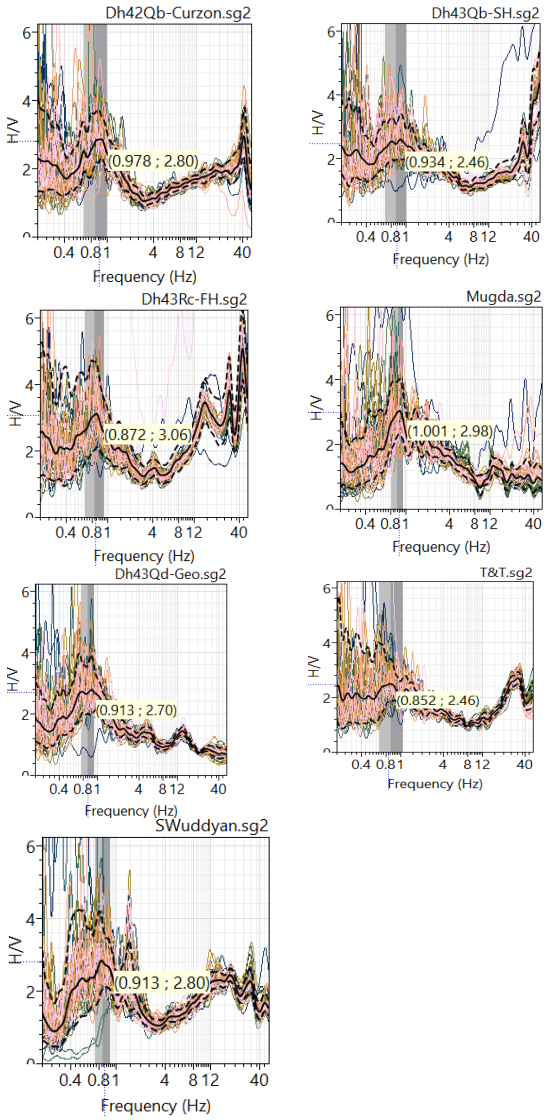

Figure 1, H/V fundamental frequencies from records at Dhaka University campus and nearby.

Conclusion

The amplification of seismic waves varies significantly in Dhaka city. The impact of the deep seismic bedrock and the engineering bedrock on the site effects of Dhaka city needs to be evaluated properly to identify the earthquake effect on buildings. Higher frequency and lower frequency zones can be differentiated through high resolution microtremor data acquisition. We recommend performing array measurements for the determination of shear-wave velocity profiles in different geomorphic units of the city. By SPAC and frequency-wave number methods, shear-wave velocity can be determined to analyze the subsurface geological structure beneath the city. Site characterization can help foster the urban planning and sustainable development of Dhaka city.

Acknowledgement

The authors acknowledge the German–Bangladesh technical cooperation project Geo-information for the Implementation of a Climate-Change-Resilient Urbanization (GICU), funded by BMZ (Germany) and MPEMR (Bangladesh), jointly implemented by BGR and GSB, and thank the students at the University of Dhaka for their assistance.

References

Ansary, M. A., and Arefin, M. R. (2020). Assessment of predominant frequencies in Dhaka city, Bangladesh using ambient vibration. Asian Journal of Civil Engineering, 21(1), 91–104. https://doi.org/10.1007/s42107-019-00194-2

Bonnefoy-Claudet, S., Cotton, F., and Bard, P. (2006). The nature of noise wavefield and its applications for site effects studies: A literature review. Earth-Science Reviews, 79(3–4), 205–227. https://doi.org/10.1016/j.earscirev.2006.07.004

Farazi, A. H., Hossain, M. S., Ito, Y., Piña-Flores, J., Kamal, A. M., and Rahman, M. Z. (2023). Shear wave velocity estimation in the Bengal Basin, Bangladesh by HVSR analysis: Implications for engineering bedrock depth. Journal of Applied Geophysics, 211, 104967. https://doi.org/10.1016/j.jappgeo.2023.104967

Helaly, A. L., and Ansary, M. A. (2021). Assessment of seismic vulnerability index of RAJUK area in Bangladesh using microtremor observations. Soils and Rocks, 44(2), e2021057420. https://doi.org/10.28927/SR.2021.057420

Landes, M., Hubans, F., Shapiro, N. M., Paul, A., and Campillo, M. (2010). Origin of deep ocean microseisms by using teleseismic body waves. Journal of Geophysical Research, 115, B05302. https://doi.org/10.1029/2009JB006918

Rahman, M. Z., Hossain, M. S., Kamal, A. S. M. M., Siddiqua, S., Mustahid, F., and Farazi, A. H. (2018). Seismic site characterization for Moulvibazar town, Bangladesh. Bulletin of Engineering Geology and the Environment, 77, 1451–1471. https://doi.org/10.1007/s10064-017-1031-6

Rahman, M. Z., Siddiqua, S., and Kamal, A. S. M. M. (2021). Site response analysis for deep and soft sedimentary deposits of Dhaka City, Bangladesh. Natural Hazards, 106, 2279–2305. https://doi.org/10.1007/s11069-021-04543-w

Singh, A., Bhushan, K., Singh, C., Steckler, M. S., Akhter, S. H., Seeber, L., and Biswas, R. (2016). Crustal structure and tectonics of Bangladesh: New constraints from inversion of receiver functions. Tectonophysics, 680, 99–112. https://doi.org/10.1016/j.tecto.2016.04.046