THE NECESSITY OF 2D/3D SITE EFFECT STUDIES IN BIG CITIES OF IRAN: PREMILINARY RESULTS OF TEHRAN EXPERIMENT

Saeid SOLTANI
Ph.D. Candidate, IIEES, Tehran, Iran
s.soltani@iiees.ac.ir

Ebrahim HAGHSHENAS
Associate Professor, IIEES, Tehran, Iran
haghshen@iiees.ac.ir

Bertrand GUILLIER
Ph.D., Universite Grenoble Alpes, Grenoble, France
bertrand.guillier@ird.fr

Cecile CORNOU
Ph.D., Universite Grenoble Alpes, Grenoble, France
cecile.cornou@univ-grenoble-alpes.fr

Keywords: 2D/3D Site effects, Surface Waves, Ambient noise, Tehran

Iran is one of the most seismically active countries in the world due to the collision between the Arabian and Eurasian plate. According to the 4th version of Iranian seismic building code (BHRC, 2016) 14 out of 18 metropolises of Iran (Metropolis in Iran defined as the large city which is a signifiant economic, political, and cultural center with over 1 million (or sometimes 500,000) inhabitants.) are located in areas with high and very high seismic risk hazard. Most of these cities are located along valleys on soft unconsolidated sediments, a very common example of a 2D structure.

Based on many numerical studies, these structures can cause amplifications significantly higher than the corresponding 1D value (e.g. Bard & Bouchon, 1985). That means even moderate earthquakes can make causality for more than 25 million peoples living in these areas.

In recent years, a series of studies have been conducted in metropolises such as Tabriz (Haghshenas et al., 2006) and Mashhad (Akbari et al., 2011). However none of these studies have taken into account the 2D/3D effects. These effects are strongly depends on the geometry of the valley. In shallow valleys, the wave-field is dominated by laterally propagating surface waves generated at the valley edges while in deeper valleys the interference between surface waves with vertically propagating waves gives rise to the evolution of a 2D resonance pattern (Roten et al., 2006). Any study without consideration these multidimensional site effects could lead to an underestimation of ground motions.

Tehran, is an alluvial basin lies on a seismically active zone of northern Iran. As a road map for such studies in Iran, we started to evaluate 3D modeling of Tehran alluvial deposits with ambient vibration techniques. Since the impact of an earthquake is strongly linked to the seismic wave velocity in the subsurface structure, shear wave velocity represents the most important parameter of the geophysical model. In this regard, surface wave methods of ambient vibration techniques are very common techniques to retrieve the shear-wave velocity profiles. For using these methods, new campaigns of noise measurement in Tehran Started from 2017 and up to now 26 arrays and around 300 single station measurements have been carried out in the city. The single station measurements has been carried on following the SESAME H/V user guidelines (SESAME, 2004) to verify preliminary evaluation about soil behavior in Tehran. Also in places with deep impedance contrast, single station measurements could be able to extracted absolute value of the ellipticity in a restricted frequency range (Hobiger et al., 2009).

Arrays measurements are processed in the frequency-wavenumber domain by using two beamforming methods. HRFK and RTBF (Wathelet., 2018), actually the last one would improve the ellipticity resolution and also gives the ellipticity angle that can be used as complementary observation for inverting dispersion curves.

It is also recommended to use MASW method (park et al., 1999) for shallow depths because combination of active and passive methods can provide an experimental dispersion curve over a broad frequency band from surface to maximum reached depth (Maximum depth is about 1 / 2.5 of the maximum available experimental wavelength). The preliminary results in the phase velocity – wavelength domain shows that the velocity exceeded 1000 m/s in most of the arrays at mid-depth range in stations with good knowledge about shallow depths (MASW method), mid depths (arrays method) and deep depths (ellipticity or earthquake data) we reached the velocity contrast at 750 m/s that is in accordance with previous studies (Shabani et al., 2010) (Figure 1). However, according to the proposed geological models for Tehran sedimentary layers (e.g. Engalenc., 1968), the Plio-quaternary alluviums of Tehran consists of homogenous cemented conglomerates estimated up to 1200 m. Thus, it is necessary to deploy larger arrays or, if possible, using the large earthquakes to investigate the deeper parts.

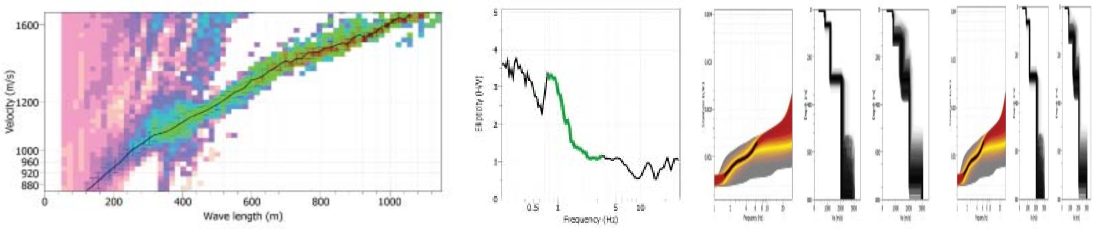

Figure 1. a) The velocity – wave length curve for Pardisan station, west of Tehran, b) ellipticity of Rayleigh waves, c) Inversion of array dispersion curve, d) 1D Shear Wave velocity.

REFERENCES

Akbari, M., Ghafoori, M., Moghaddas, N.H., and Lashkaripour, G.R. (2011). Seismic microzonation of Mashhad city, northeast Iran*, Annals of Geophysics*, 54(4), 424-434.

BHRC (2014). *Iranian Code of Practice for Seismic Resistant Design of Buildings*. Standard 2800 (Edition 4), Building and Housing Research Center (in Persian).

Bard, P.Y. & Bouchon, M. (1985). The two-dimensional resonance of sediment filled valleys. *Bulletin of the Seismological Society of America*, 75, 519-541.

Engalenc, M. (1968). Contribution a la Geologie, Geomorphologie, Hydrologie de la Region de Tehran (Iran), C.E.R.H.

Haghshenas, E., Jafari, M., Bard, P.-Y., Moradi, A.S., and Hatzfeld, D. (2006). Preliminary results of site effects assessment in the city of Tabriz (Iran) using earthquakes recording, *ESG 2006*, Bard P.-Y., Chaljub E., Cornou C., Cotton F. & Gueguen P. (eds.), LCPC, Paris, 993-1001.

Hobiger, M., Bard, P.-Y., Cornou, C., and Le Bihan, N. (2009). Single station determination of Rayleigh wave ellipticity by using the random decrement technique (RayDec). *Geophysical Research Letter,* 36, L14303.

Park, C.B., Miller, R.D., and Xia, J. (1999). Multichannel analysis of surface waves (MASW). *Geophysics*, 64, 800-808.

Roten, D., Cornou, C., Fah, D., and Giardini, D. (2006). 2D resonances in Alpine valleys identified from ambient vibration wavefields. *Geophysics Journal International*, 165, 889-905.

SESAME (2004). Guidelines for the implementation of the H/V spectral ratio technique on ambient vibrations: measurements, processing, and interpretation. SESAME European research project, WP12—Deliverable D23.12.

Shabani, E., Haghshenas, E., Mirzaei, N., and Eskandari-Ghadi, M. (2010). Application of noise wavefield to assign velocity model in site effects studies-A case study in Tehran. *The Fourth National Conference on Civil Engineering Tehran*, Iran.

Wathelet, M., Guillier, B., Cornou, C., and Ohrenberger, M. (2018). Rayleigh wave three-component beamforming: signed ellipticity assessment from high-resolution frequency-wavenumber processing of ambient vibration arrays. *Geophysical Journal International*, 215(1), 507-523.