Evaluation of Site Effect Using Ambient Noise Survey (A Case Study: Babol City)

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Extended Abstract

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Introduction

Every year, numerous casualties and a large deal of financial losses are experienced due to earthquake events. The losses incurred by an earthquake vary depending on local site effect. Some well-known examples include the earthquake in Caracas 1967, Mexico city 1985, Kalamata 1986, Loma Prieta 1989, Roodbar 1990, Bam 2003, Jammu and Kashmir 2005, Sichuan 2008 and Haiti 2010. Therefore, in order to conquer drastic effects of an earthquake, one should evaluate urban districts in terms of the local site effect. Various methods are available for the evaluation of site effect. One of the most common methods includes ambient noise survey. Today, this approach is being used as fast, applicable, cost-effective method. Ambient seismic noise are feeble ground motions with displacement amplitudes of about 0.1–1 μm and that can be detected by seismograph with high magnification. Many investigations have been conducted to determine the nature of ambient noise. One of the possible sources of ambient noise can be human activity, such as traffic, industrial noises and nature activity, such as wind, ocean waves. The Babol city is one of the largest cities in the north of Iran (Mazandaran province). It lies on alluvium beds in the region presenting a high seismic potential. Therefore, comprehensive studies are necessary to introduce suitable solutions for minimizing earthquake damage and loss of life. For this reason, in Babol city, ambient noise survey has been performed at 60 stations and the obtained data were analyzed with Nakamura or H/V method (1989). The results were compared with local geological,

geotechnical and seismic data to confirm their reliability for a seismo-stratigraphic.

Methodology and data collection

The analysis of ambient noise was initially proposed by Kanai and Takana (1961). Since then, many researchers have used ambient noise for site effect evaluation. As it is said before, one of the most popular techniques for estimation of site effects in the regions with low seismicity is ambient noise survey by Nakamura or H/V method (1989). Based on the literature review, the Nakamura method (1989) has been used in many places. Many theoretical and experimental studies show that, this method has the capability of estimation of fundamental frequency. Ambient noise survey was carried out at 60 stations in Babol city. Ambient noise was recorded using a velocity meter SARA. Two horizontal and a vertical components of ambient noise at each location are recorded for duration of 15 min with 100 samples per second. Because the environmental noise has an effect on ambient noise they are recoded between 10 p.m. to 6 a.m. The locations were determined by using GPS at the sites. The ambient noise survey in this study was made in compliance with the guidelines of SESAME (2004).

Results and discussion

The maximum and minimum values of fundamental frequency of the present research are 11.4 and 0.65 Hz, respectively. Also, the maximum and minimum values of amplitude of H/V peaks have been calculated as 3.71 and 1.19, respectively. The most significant point is that the fundamental frequency of the major part of Babol city is smaller than 1 Hz in agreement with the previous knowledge of the city's geological setting. Another relevant point is the presence of some stations with very high (> 5 Hz) fundamental frequencies. In these cases, ambient noise recording and data analysis were repeated, but similar results were obtained. Considering the lack of sufficient geotechnical data (in some stations), the above phenomena need to be integrated with other methods. For this purpose, the data of electrical resistivity tomography (ERT) were used. The ERT showed that small regions of the north-west, west, and south areas have high resistance

values probably related with the presence of hard deposits in the shallow subsoil. Babolrood river diversion in the west part and its return to the previous direction in the northern section is possibly due to the existence of these relatively hard deposits. By comparing these two tests, we observed that the ERT results correlate with the ambient data analysis. ~~So~~ Therefore, we can conclude that the high-frequency peaks measured are reliable, but we need direct investigation to associate them to a specific shallow geological layer. To validate the results, fundamental frequencies obtained from ambient noise survey were compared with geotechnical data, numerical analysis and seismic data in the study area. A general review shows that the geotechnical data, equivalent-linear analysis results and seismic data have an acceptable conformity with the results of ambient noise survey.

Conclusion

The results show minimum and maximum fundamental frequencies 0.65 and 11.4 Hz, respectively. Assessment also reveals that the major parts of Babol city have the fundamental frequencies less than 1 Hz, which are in conformity with that of previous research. According to the results of seven cross sections, it can be concluded that fundamental frequency variations are in line with the geotechnical and geological data in the study area. It means that this method is the appropriate way to assess the local site effect in the Babol ~~C~~city. It is also observed that besides the soil layers, the soil stiffness and its shear wave velocity are effective factors in changing the fundamental frequency. Site frequencies were also estimated by preliminary 1-D site modeling using the equivalent-linear method. In general, a reasonable correspondence between the methods was obtained. Using seismic data, the HVSR of two strong ground motions have been calculated and the results have been compared with the nearest ambient noise recording station. Analyzing the spectral ratios demonstrates that the value of the fundamental frequency obtained by the H/V method (1.06 Hz) is very close to that of frequencies obtained by the seismic data (0.95 and 0.90 Hz).

Keywords: Site effect, H/V spectral ratio, Ambient noise, Fundamental frequency, Amplification factor

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