INVESTIGATING POLARIZATION OF RAYLEIGH WAVES IN SINGLE METHOD MEASUREMENTS BASED ON THE REVISED RAYDEC

Naimeh MOGHADASI
Ph.D. Student, Department of Seismology, Institute of Geophysics, University of Tehran, Tehran, Iran
n.moghadasi@ut.ac.ir

Elham SHABANI
Assistant Professor, Department of Seismology, Institute of Geophysics, University of Tehran, Tehran, Iran
eshabani@ut.ac.ir

Manuel HOBIGER
Researcher, Swiss Seismological Service (SED), ETH Zürich, Zürich, Switzerland
manuel.hobiger@sed.ethz.ch

Keywords: Seismic noise, Ellipticity, Rayleigh wave, RayDec, HVTFA

The knowledge of the site effects is important to the assessment of seismic hazard studies. The horizontal-to-vertical spectral ratio (H/V) method (Nakamura, 1989) has been introduced as a convenient technique to estimate the fundamental frequency of soft deposits. The ellipticity curve analysis can be described as the elliptical motion of Rayleigh waves using a single seismic station. Since Love and body waves are present in the wavefield as well, the H/V curve would not completely correspond to the ellipticity curve. The effect of Love and body waves should be minimized or removed before considering the H/V spectral ratio.

Horizontal-to-Vertical Time-Frequency Analysis (HVTFA) method can reduce the SH-wave influence by identifying P-SV wavelets from the signal and computing the spectral ratio from these wavelets (Fäh et al., 2009).

The RayDec method was proposed to determine the Rayleigh wave ellipticity curve emphasizing the effect of Rayleigh waves and minimizing other types of waves based on the random decrement technique (Hobiger et al., 2009). The random decrement technique was introduced at NASA (Cole, 1973) as an alternative to the FFT algorithm. The principle is to estimate random decrement functions by averaging time segments of the measurements, which have been selected under certain conditions (Asmussen, 1997). The RayDec includes applying narrow-band Chebyshev filter on the three components of a signal. The vertical component is considered as a master trigger using zero crossings with positive slope triggering condition for all time steps. Where this condition is hold, a signal of given length could be stored for all the three components. In order to compensate the phase shift of between vertical and horizontal components, both of the horizontal signals are shifted. For each stored signals, the horizontal components are projected into the direction which maximizes the correlation between the horizontal and vertical components. Then, the obtained signals are stacked together and the ratio between the horizontal and vertical motions is estimated by analysing the energy content of the vertical and horizontal stack. The final ellipticity measurement is then obtained by averaging the RayDec results of these time windows. In this method, the length of the buffered signal Δ and the width of the frequency filter can be chosen arbitrarily.

In this study, we revised RayDec method named as R-RayDec to improve the process of filtering and triggering conditions. The different ways of filtering including the classical IIR (Infinite Impulse Response) filters and FIR (Finite Impulse Response) filters and the various triggering conditions are investigated. The four most well-known triggering conditions are level crossing, local extremum, positive point and zero-crossing with positive slope conditions. The auto random decrement function defined as the mean value of a stochastic process itself on condition *T*,

$$\ddot{a}_{xx}\left(\tau\right)=E\left(X\left(t+\tau\right)|T_{X(t)}\right) \tag{1}$$

where is the auto random decerement function, is a stochastic stationary process, *t* is time, *E* is the expectation value, i.e. the averaging operator in our case, and T is a triggering condition.

It is important which triggering condition should be used because the obtained number of triggering points controls the convergence in the estimation process of random decerement functions. On the other hand, an appropriate triggering level that minimizes the variance of the estimated random decrement functions can play an important role in the results.

The different types of filters and triggering conditions are investigated and the suitable parameters are chosen to be used in R-RayDec method. In order to compare the results of the RayDec and R-RayDec method, two types of data include synthetic and real seismic noise data recorded in the Dargahan-Qeshm Island are used. It is clear in Figure 1-a that the estimated peak frequency and the right flank of synthetic data using R-RayDec shows a good accordance with its theoretical curve. According to Figure 1-b, the estimated peak frequency using R-RayDec and HVTFA methods are in agreement with the theoretical curve, while RayDec and H/V overestimate the peak. Furthermore, the obtained right flank of the peak frequency using RayDec and R-RayDec methods reveal different trends. To sum up, in comparison with RayDec method, R-Raydec gives better results regarding the misfit.

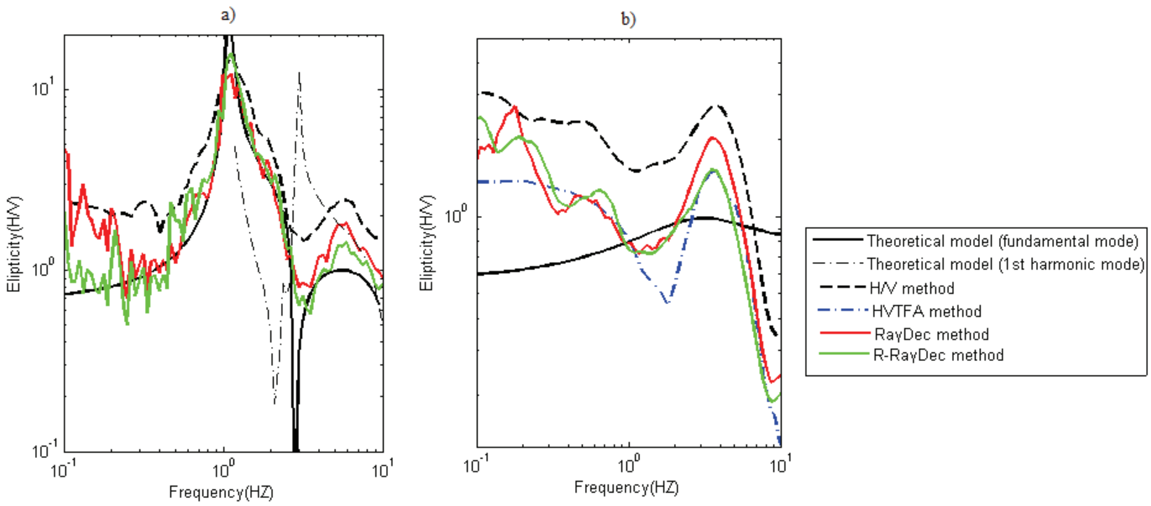

Figure 1. Ellipticity curves related to (a) synthetic noise data based on complex shallow model, (b) real ambient seismic noise recorded in the Dargahan-Qeshm Island. The theoretical ellipticity model, H/V and HVTFA method are used to compare RayDec and R-RayDec methods.

REFERENCES

Asmussen, J.C. (1997). *Modal Analysis Based on the Random Decrement Technique*. Ph.D. Dissertation. University of Aalborg, Denmark.

Cole, H.A. (1973). On line failure detection and damping measurements of aerospace structures by random decrement signature, NASA, *Tech. Rep*. CR-2205.

Fäh, D., Wathelet, M., Kristekova, M., Havenith, H.-B., Endrun, B., Stamm, G., Poggi, V., Burjanek, J. & Cornou, C. (2009). *Using Ellipticity Information for Site Characterization*, NERIES JRA4 “Geotechnical Site Characterization”, taskB2-D4, final report.

Hobiger, M., Bard, P.-Y., Cornou, C., & Le Bihan, N. (2009). Single station determination of Rayleigh wave ellipticity by using the random decrement technique (RayDec). *Geophy. Res*. Lett., *36*.

Nakamura, Y. (1989). A method for dynamic characteristics estimation of subsurface using microtremor on the ground surface. *QR RTRI*, *30*, 25-33.