Journal of Geology & Geophysics

Boaga, J Geol Geophys 2017, 6:3
DOI: 10.4172/2381-8719.1000e122

Editorial Open Access

The Use of Surface Waves in Geotechnical Engineering, which Future?

Jacopo Boaga

Department of Geosciences, University of Padua, Italy

***Corresponding author:** Boaga J, Department of Geosciences, University of Padua, Italy, Tel: +39 049 827 5111; E-mail: jacopo.boaga@unipd.it

Received date: May 17, 2017; **Accepted date:** May 22, 2017: **Published date:** May 29, 2017

Editorial

The use of surface waves (SW) in seismology is well known since the pioneering works after the First World War in the 1920s and 1930s. In the 1950s and 1960s, thanks to computer and instrumental improvements, surface waves started to be intensively adopted in global seismology [1-3]. Engineering applications started shortly after, but for their diffusion we have to wait the work of Stokoe and colleagues which introduced the SASW method (Spectral Analysis of Surface Waves) [4,5]. After the introduction of multi-channels methods, Multi channels Analysis of Surface Waves, SWs rapidly become standard practice in engineering geophysical prospecting. Nowadays surface wave methods are the most powerful and used tools for in situ shear wave velocity estimation, basing on the dispersive properties of the layered media [6-8].

Despite the scale difference from global seismology and site geotechnical characterization, the basic principles are in fact the same. The core of the measurement is based on the geometrical dispersion, which makes SW velocity frequency dependent in vertically heterogeneous media. If we measure the properties of surface wave propagation frequency by frequency (e.g. Rayleigh waves frequency dispersion properties) and we apply a correct procedure for the inversion of the extracted dispersion feature, we can obtain the subsoil physical properties that affect the wave field propagation (which is mainly the shear wave velocity-*vs.*-profile). The possibility to retrieve easily *vs.* profiles is the main reason of the of SW methods diffusion in geotechnical engineering. It is in fact well known that the shear wave profile is one of the most important parameter in site characterization, from the seismic response analysis to dozens of others geotechnical design purposes [9,10].

As a matter of fact, for common geotechnical engineering needs, SW method nowadays replaced the classic shear wave prospecting (e.g. SH reflection and refraction surveys). SW methods are in fact easier than the classical SH surveys that present higher logistic demands, especially in terms of source generation and relative depth of exploration. In the last decades the development of passive surface wave analysis as the REMI method (Refraction Microtremor) found more appealing applications, especially in urban and logistically complex sites [11]. The use of seismic noise allows in fact exploring very low frequencies (and then deeper structures) that are difficult to reach with controlled seismic sources. Can we image the modern SW methods as the final remedy for the geotechnical engineering characterization requirements?

The answer is obviously no because surface waves methods are, as all the geophysical prospecting, affected by a number of limitations. The most common (and neglected) is the low resolution we have in limited length arrays describing the dispersion properties (e.g. modes misidentification). Modes misidentification can easily bring to wrong inversion assumption and then to totally wrong site characterization [12]. On the other hand the very appealing passive SW arrays are moreover affected to site dependent unknowns, as directional noise problems [13].

The use of passive linear arrays, in case of preferential noise path, can lead to a huge over-estimation of the seismic velocity profile. In addition, some local geological conditions, as low velocity layers or very hard impedance contrasts, can make particularly difficult the interpretation of the common SW analysis [14]. These evidences clearly point out as the SW methods cannot be considered as an overall remedy and that rigorous and careful analysis are always mandatory. Despite the growing popularity of SW methods, an expert analysis should suggest that in several practical cases other classic geophysical prospecting techniques are still preferable.

Apart from the well-established described role of SW techniques, what can we expect from surface wave analysis development in the future? The frontier and most promising fields in SW studies are the multi-dimensional characterization and the improvement of attenuation studies. 3D and 2D surface waves analysis are nowadays realities in rapid growing (e.g. MOPA analysis [15,16]. These approaches are able to provide sections and volumes of properties as the shear modulus that can dramatically help the geotechnical design. Moreover the successful applications of SW analysis for extended multi-dimensional profiles are increasing their popularity in the oil and gas industries interested in deep explorations. SW studies are in fact successfully adopted as support to statics correction [17].

In some cases the SW acquisition can be done with the same arrangement of the reflection surveys, with a huge logistically advantages and a relevant improvement in information. On the other hand the evaluation of damping and attenuation effects from the SW analysis is the most recent promising tools for site estimation of energy dissipation [18]. The possibility to evaluate quickly on site the dynamic dissipation of energy, to be compared with the classical laboratory tests, is in fact of crucial interest for earthquake engineering.

It was recently demonstrated as, in some geological conditions; the damping characteristics of the site can play a greater role then shear wave velocities profile affecting seismic local response [19]. It is author's opinion, considering the already well-established role of some techniques and the promising recent researches about this topic, the surface waves methods will play again a key role in the next future for geotechnical engineering characterization.

References

1. Levshin L, Pisarenko A, Pogrebinsky D (1972) On a frequency-time analysis of oscillations. Ann Geophys 28: 211-218.
2. Aki K, Richards PG (1980) Quantitative seismology: Theory and methods. Freeman.
3. Ben-Menhaem A (1995) A concise history of mainstream seismology: Origins, legacy and perspectives. Bull Seism Soc Am 85: 1202-1225.

4. Jones RB (1958) In-situ measurement of the dynamic properties of soil by vibration methods. Geotech 8: 1-21.
5. Stokoe KH II, Wright SG, JA Bay, JM Roesset (1994) Characterization of geotechnical sites by SASW method. Geophysical Characterization of Sites.
6. Tokimatsu K (1995) Geotechnical site characterization using surface waves. First international conference on earthquake geotechnical engineering, Tokyo.
7. Foti S (2000) Multistation methods for geotechnical characterization using surface waves. Politecnico di Torino pp: 229.
8. Socco LV, Strobbia C (2004) Surface wave methods for near-surface characterisation: A tutorial. Near Surface Geophys 2: 165-185.
9. Kramer SL (1996) Geotechnical earthquake engineering. Prentice Hall, New York.
10. Woodward J (2005) An introduction to geotechnical processes. CRC Press.
11. Louie J (2001) Faster, better: Shear-wave velocity to 100 meters depth from refraction microtremor arrays. Bull Seismol Soc Am 91: 347-64.
12. Boaga J, Vignoli G, Deiana R, Cassiani G (2014) The influence of subsoil structure and acquisition parameters on surface wave mode misidentification. J Environ Eng Geophys 19: 87-99.
13. Strobbia C, Boaga J, Cassiani G (2016) Double-array refraction microtremors. J Applied Geophys 121: 31-41.
14. Boaga J, Cassiani G, Strobbia LC, Vignoli G (2013) Mode mis-identification in Rayleigh waves ellipticity as a cause and a cure. Geophys 78: 17-28.
15. Strobbia C, Foti S (2006) Multi-offset phase analysis of surface wave data (MOPA). J Applied Geophys 59: 300-313.
16. Vignoli G, Cassiani G (2010) Identification of lateral discontinuities via multi-offset phase analysis of surface wave data. Geophys Prospect 58: 389-413.
17. Socco L, Mabyalaht G, Comina C (2015) Robust static estimation from surface wave data. SEG Technical Program Expanded pp: 5222-5227.
18. Zhang Y, Xia XJ (2011) Analysis of dispersion and attenuation of surface waves in poroelastic media in the exploration-seismic frequency band. Geophys J Int 187: 871-888.
19. Boaga J, Renzi S, Deiana R, Cassiani G (2016) Soil damping influence on seismic ground response: A parametric analysis for weak to moderate ground motion. Soil Dyn Earthq Eng 79: 71-79.