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Shear-Wave Velocity Reconstruction via Unconventional Joint Analysis of Seismic Data: Two Case Studies in the light of Some Theoretical Aspects

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Abstract

In site characterisation for seismic-hazard studies, the unambiguous determination of the shear-wave velocity (V_S) vertical profile is a crucial point often accomplished via surface-wave analysis.

The determination of the dispersive properties eventually inverted for the determination of the V_S vertical profile, can be performed both via active and passive methodologies and while considering phase or group velocities.

Common techniques for determining phase velocities are the *Multichannel Analysis of Surface Waves* (MASW), ESAC (*Extended Spatial AutoCorrelation*) and FK (*frequency-wavenumber*) analysis, while for the analysis of group velocities we can name MFA (*Multiple Filter Analysis*) and FTAN (*Frequency-Time Analysis*). Considering land data, all these analyses can be performed while considering both Rayleigh and/or Love waves.

Because of its constitutive equations, Rayleigh-wave propagation is often characterized by a complex phenomenology expressed by non-trivial mode excitement, while Love waves result so-to-say simpler. As a result, Love-wave velocity spectra appear easier to interpret and, when Rayleigh-wave velocity spectra appear hard to interpret, can be proficiently adopted as valuable support capable of solving possible interpretative issues (e.g. Dal Moro and Moura, 2013).

Furthermore, the joint analysis of Rayleigh and Love waves (possibly both in their phase and group velocity manifestation) results relevant to overcome the non-uniqueness of the solution typical of any non-invasive methodology (Dal Moro and Keller, 2013). After the determination of the dispersive properties with one or more of the mentioned techniques, their inversion can be performed considering different strategies to choose according to the complexity of the data: analysis of the modal or effective dispersion curves or the Full-

Velocity Spectra (FVS) or full waveform inversion - e.g. Tokimatsu et al., 1992; O'Neill et al., 2003; Dal Moro and Moura, 2013).

After the presentation of some synthetic datasets shown with the aim of putting in evidence the above-mentioned theoretical aspects, two case studies characterized by different peculiarities are presented.

For the first case study we consider the joint inversion of Rayleigh and Love waves acquired using only horizontal geophones (Rayleigh waves are then considered in their radial component) and the inversion is performed while considering the FVS approach. Figure 1 reports both field and synthetic velocity spectra and the agreement results apparent.

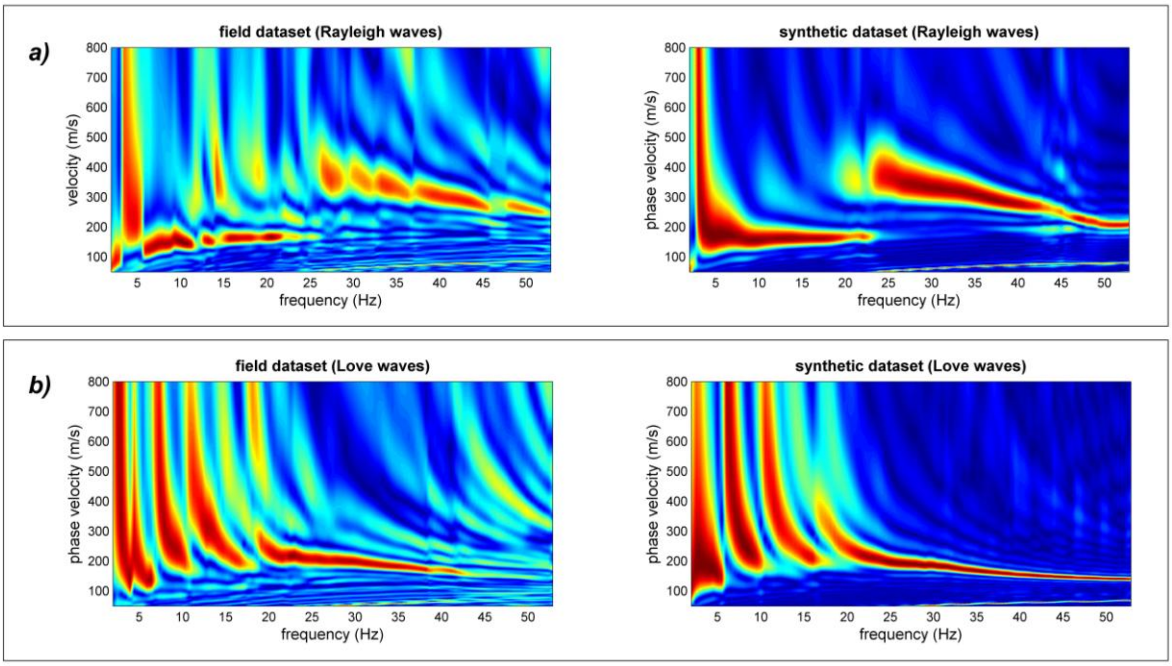

Figure 1: *Case study#1: velocity spectra of field (on the left) and synthetic (on the right) data. Upper panel: Rayleigh waves (radial component); lower panel: Love waves.*

For the second dataset we analyze Rayleigh- and Love-wave dispersion determined via MASW, ESAC and *HoliSurface™* acquisition techniques, also jointly considering HVSR (*Horizontal-to-Vertical Spectral Ratio*). The study area is located just by a lagoon channel in NE of Italy and is characterized by very soft sediments (silt and sand) that, for the first 6m, appear completely saturated thus resulting in very low shear-wave velocities. As a result, the depth actually investigated appears critical since low velocities determine short wavelengths. Under such specific conditions (low velocities and high attenuation), in the HVSR modeling (jointly considered with surface-wave dispersion) the role of quality factors appears quite relevant, resulting apparently inadequate the simple elastic solution (see also Lunedei and Albarello, 2009; Dal Moro, 2013).

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