Velocity profile report at the seismic station IT.ASP - ASCOLI PICENO

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Subject: **Final report illustrating measurements, analysis and results for station IT.ASP**	

Convenzione DPC-INGV 2018, Allegato B2: Obiettivo 1 - TASK B: "Caratterizzazione siti accelerometrici" (Coord.: G.Cultrera, F. Pacor)

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1. Introduction

In this report, we present the geophysical measurements and the results obtained in the framework of the 2018 agreement between INGV and DPC, called *Allegato B2: Obiettivo 1 - TASK B: Caratterizzazione siti accelerometrici (Coord. G. Cultrera, F. Pacor).* In this report, the results for station IT.ASP, belonging to the Italian Strong Motion Network (RAN-DPC), are presented.

Geophysical measurements consist in a 2D array in passive configuration that provide results in terms of dispersion curves of surface waves. These curves are inverted to obtain a shear-wave velocity (Vs) profile that is suitable for assigning the soil class according to the current Italian seismic code (NTC 2018) and the current Eurocode (EC8).

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2. Geophysical investigations

Figure 1 shows the location of the stations used for the 2D array and Tab. 1 the corresponding geographic coordinates.

Figure 1: Map of the geophysical measurements performed at the IT.ASP site. The yellow points are the nine stations of the 2D array in passive configuration (all stations are equipped with Reftek-130 digitizer and Lennartz 3D-5sec velocimetric sensors). The red triangle indicates station IT.ASP.

staz	Lat (°)	Lon (°)	El (m)
ASP1	42.84798	13.64895	80
ASP2	42.84794	13.64913	79
ASP3	42.84806	13.64903	79
ASP4	42.84784	13.64925	84
ASP5	42.84787	13.64897	82
ASP6	42.84781	13.64909	83
ASP7	42.84807	13.64917	75
ASP8	42.84792	13.64931	81
ASP9	42.84802	13.64928	83

Tab. 1: array stations coordinates (WGS84)

2.1 Array measurements results

A 2D array was performed using nine seismic stations equipped with Reftek 130 digitizers and Lennartz 3D-5s velocimetric sensors. The noise recording lasted about 2 hours.

A view of the 2D passive array survey is shown in Figure 2.

The seismic sensors were positioned in a circular geometry with a radius of 15 m, as shown in Figure 1 and 2.

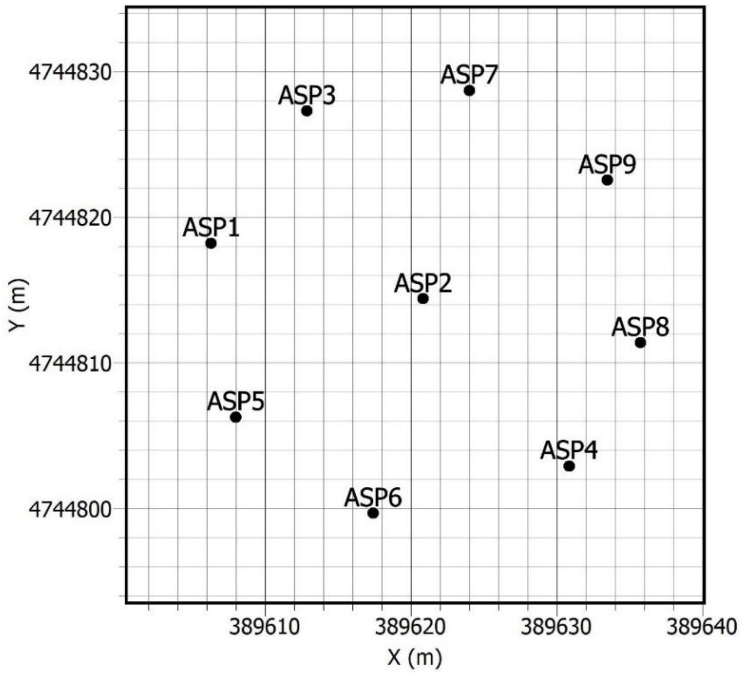

Figure 2: Top: example for the installation of an array station. Bottom: 2D Array geometry with UTM coordinates.

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The geometry of the array controls the response in terms of theoretical transfer function as shown in Figure 3.

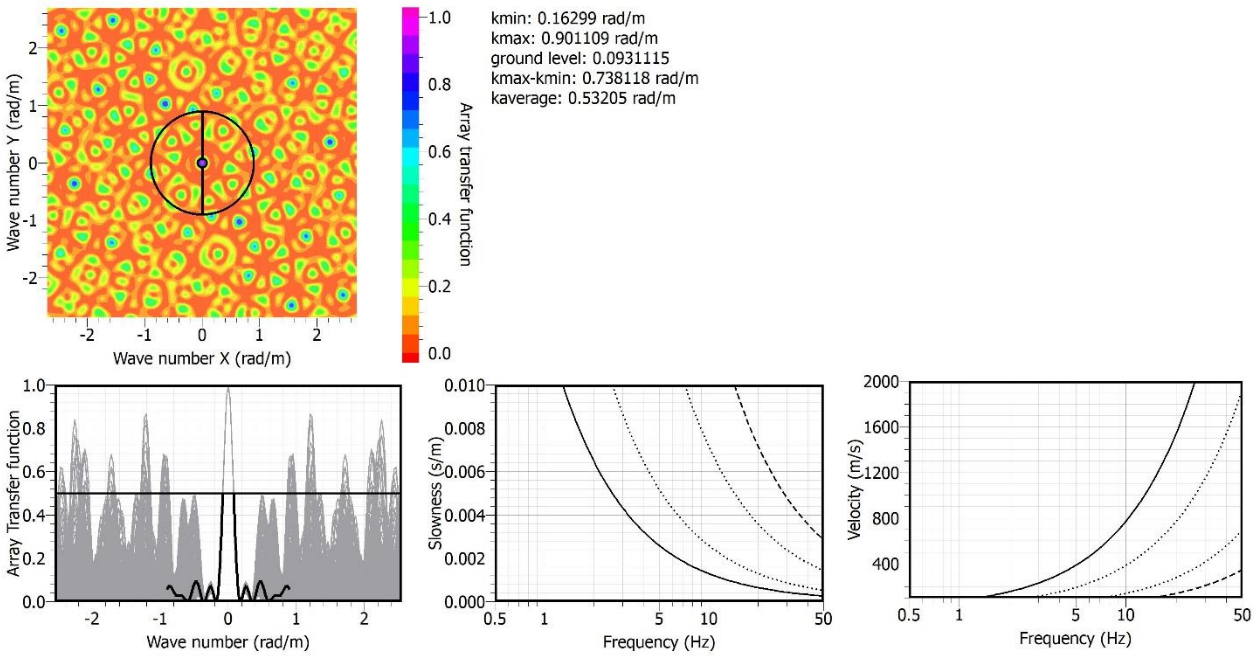

Figure 3: Theoretical Array Transfer function for the 2D array at IT.ASP

In Figure 4, the H/V curves of the nine stations are superimposed on each other. The average H/V curve is reported in red. All the H/V curves present a good agreement, with an instability at low frequency (< 0.4 Hz) probably due to the sensor-ground coupling on the synthetic football field. Despite the low frequency instability, all the average H/V curves highlight a peak at 0.6 Hz (Figure 4).

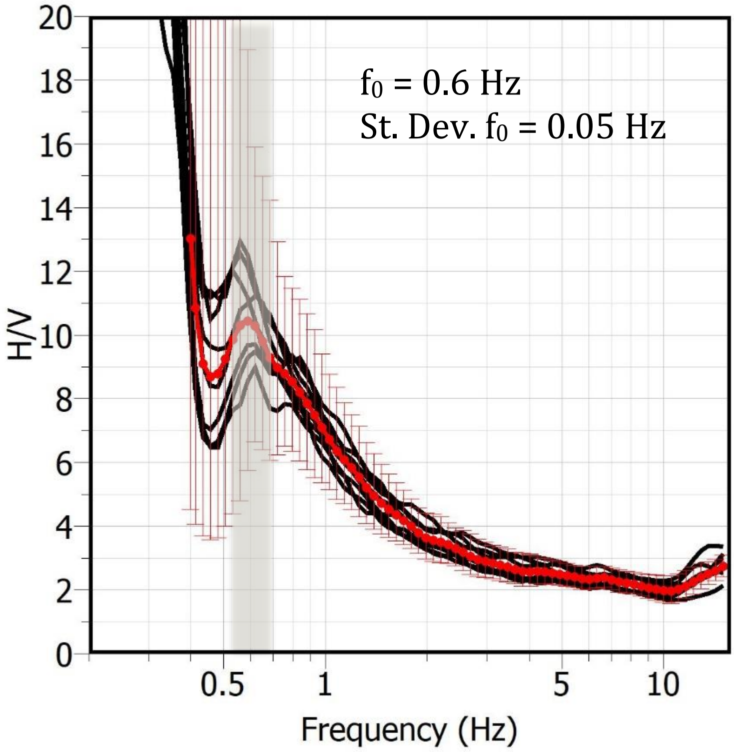

Figure 4: H/V curves of the nine stations. The red curve is the average H/V and the red bars estimate the uncertainty of the average H/V.

Data from the 2D array have been analysed in terms of FK analysis and high-resolution FK analysis. Because the two techniques lead to similar results, hereinafter we consider only the high-resolution FK method. For the analysis, we use the code GEOPSY (http://www.geopsy.org). The dispersion curve is shown in Figure 5.

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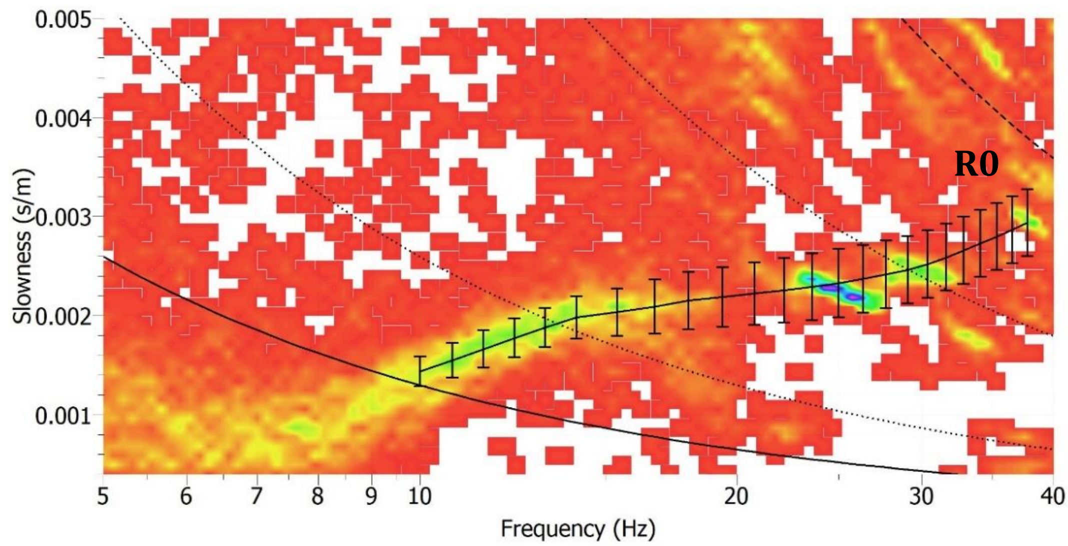
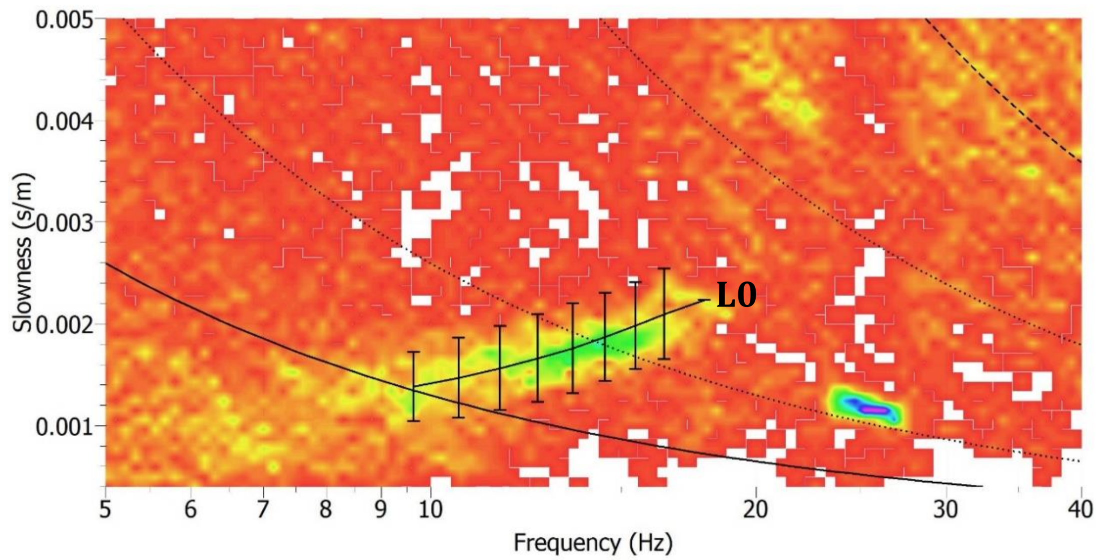


a)



b)

Figure 5: Picked dispersion curves in the slowness domain with the high-resolution FK analysis. a) vertical components, R0 = Rayleigh wave fundamental mode ; b) transverse components, L0 = Love wave fundamental mode.

We interpret and assume that the dispersion curve obtained with the vertical components of the array stations is relative to the fundamental mode of the Rayleigh dispersive waves (Figure 5a). On the other hand, we interpret the dispersion curve obtained with the transverse components of the array stations as relative to the fundamental mode of the Love dispersive waves (Figure 5b).

3. V_S Model

At the IT.ASP site, the high-resolution FK analysis allows to define the dispersion curves relative to the fundamental mode of Rayleigh wave and Love wave.

The fundamental mode of Rayleigh wave is defined between 10 and 37.7 Hz, whereas the fundamental mode of Love wave is defined between 9.5 and 17.9 Hz.

The dispersion curves, adopted for the inversion process, are shown in Figure 6.

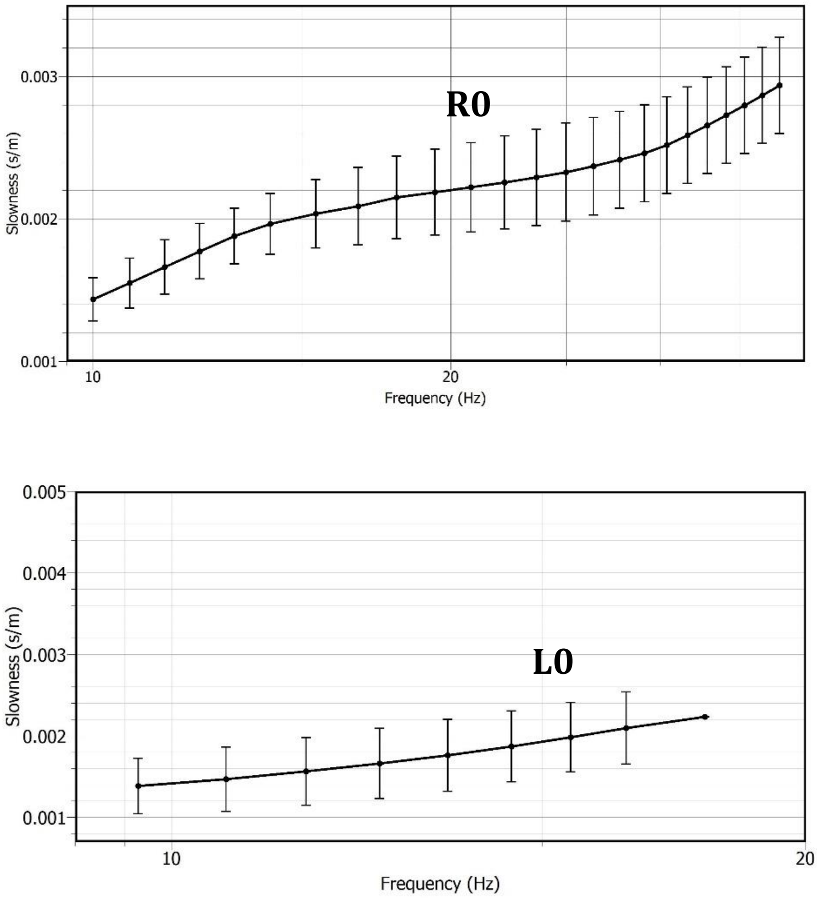


Figure 6: Top: Rayleigh wave dispersion curve relative to the fundamental mode (R0). Bottom: Love wave dispersion curve relative to the fundamental mode (L0).

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In this case, in order to focus on the shallow (first tens of meters) Vs model, we invert the Rayleigh and Love wave dispersion curves in Figure 6, not considering the low frequency H/V peak at 0.6 Hz. Therefore, just the surface wave dispersion curves at high frequency (10-37.7 Hz) are considered.

Figure 7 shows the comparison between the experimental targets and the ones expected for the best models coming from the inversion process.

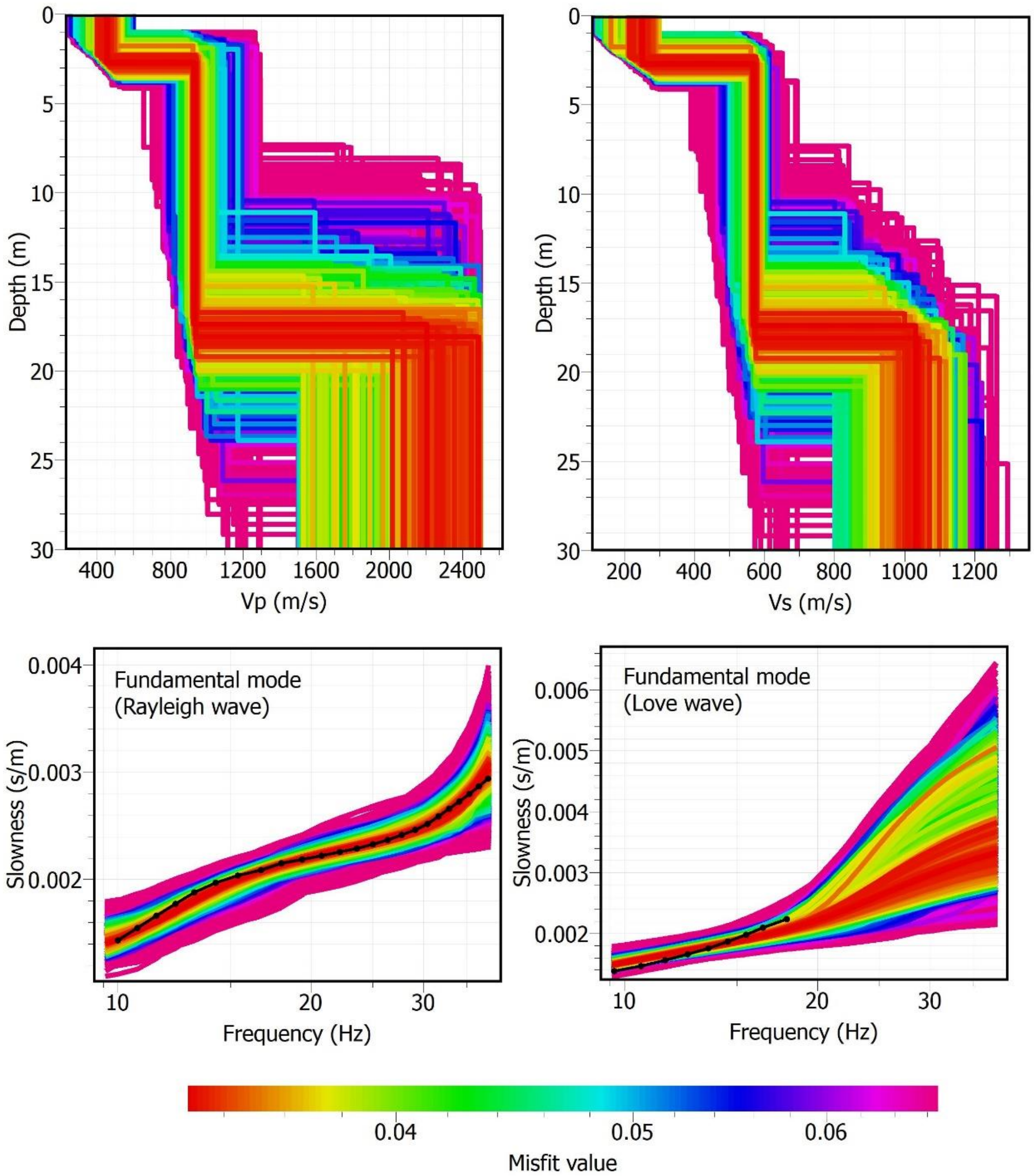

Figure 7: Inversion of the dispersion curves obtained with the 2D passive array.

The relation between the Vs profile and the H/V analysis is tested performing a forward modelling (Figure 8). The theoretical H/V curve, computed from the Vs profile, shows a good agreement with the experimental curve at high frequency, in correspondence with the H/V peak at 18 Hz.

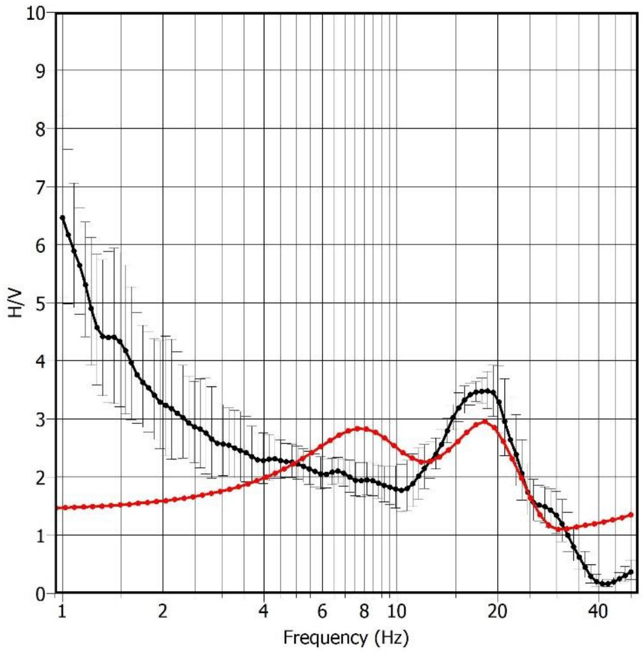

Figure 8: comparison between the experimental H/V curve (black line) at high frequency (1-50 Hz), with the theoretical H/V curve obtained performing a forward modelling of the Vs profile.

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The best fit models of V_p and V_s are represented in Figure 9 and reported in Tab. 2.

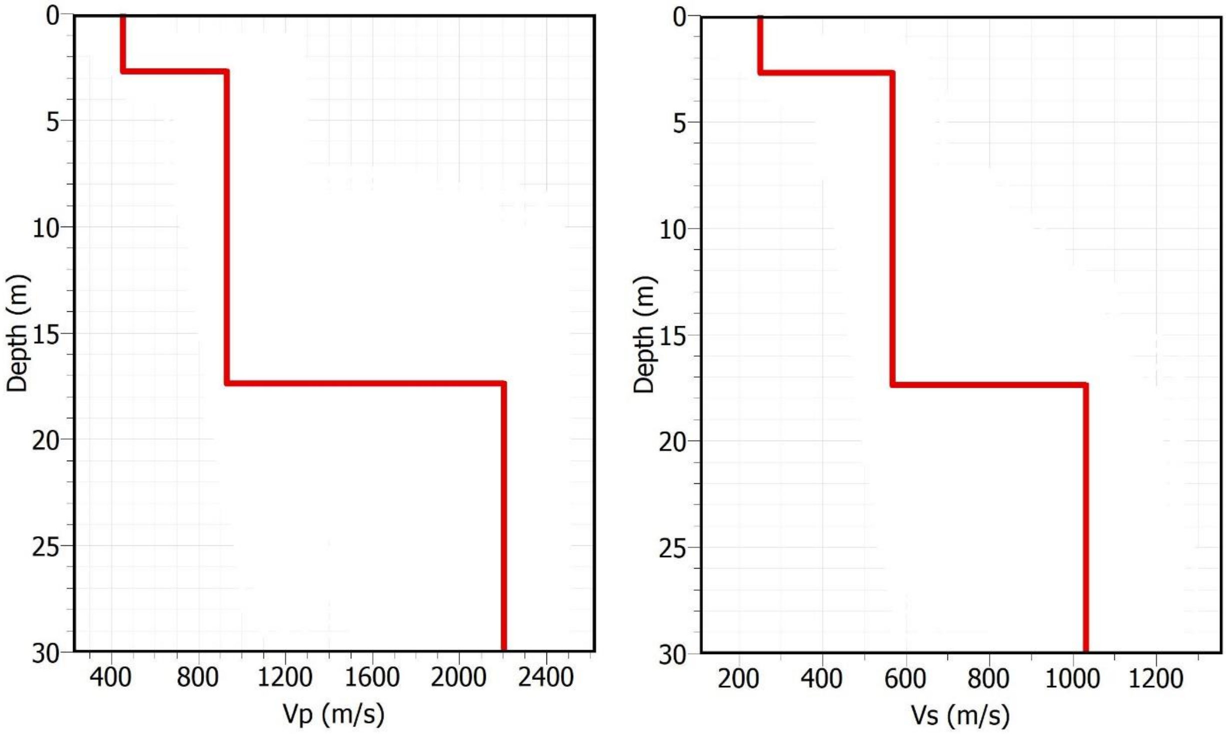

Figure 9: Best-fit models of Vp (left panel) and Vs (right panel) values

From	*To*	*Thickness (m)*	*V_s (m/s)*	*V_p (m/s)*
0	3	3	245	441
3	17.2	14.2	560	921
17.2	?	?	1028	2208

Tab. 2: Best-fit model

4. Conclusions

The H/V analyses for site IT.ASP show an instability at low frequency (< 0.4 Hz) probably due to the sensor-ground coupling on the synthetic football field. Despite the low frequency instability, all the average H/V curves highlight a peak at 0.6 Hz. However, in order to focus on the shallow Vs model of the site, this H/V peak is not considered in the analysis.

We can propose an interpretation of the velocity profile based on the geological map at 1:10.000 scale and on the nearest borehole stratigraphy at a distance of 400 m from the study site (Agreement DPC-INGV 2018, Allegato B2: Obiettivo 1 - TASK B, Geological report IT.ASP). The very first 3 meters could be linked to the presence of a superficial soil layer of sandy gravel. This thin sedimentary layer may be related to the H/V peak at 18 Hz, as highlighted by the forward modelling in Figure 8. The second layer, about 14 m thick, could be related to the alluvial deposits of the Musone Synthem (terraced alluvial deposits of Holocene age). The third layer of the Vs profile corresponds to the bedrock (Vs > 800 m/s) according to the current Italian seismic code (NTC 2018). This layer may be related to the Laga Formation (pelitic-arenaceous facies of Miocene age) that outcrops about 1 Km southwards and in the nearest borehole stratigraphy, 400 m away (Agreement DPC-INGV 2018, Allegato B2: Obiettivo 1 - TASK B, Geological report IT.ASP), is found at 19 m depth.
The $V_{s,eq}$ retrieved from the inversion of the dispersion curves is 457 m/s and the $V_{s,30}$ is 599 m/s (Tab. 3). Therefore, IT.ASP is classified in soil class B according to the NTC 2018 and EC8 seismic classifications.

***$V_{s,eq}$* (m/s)**	***$V_{s,30}$* (m/s)**	***Soil class (NTC 2018)***	***Soil class (EC8)***
457	599	B	B

Tab. 3: Soil class

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5. References

EC8: European Committee for Standardization (2004). Eurocode 8: design of structures for earthquake resistance. P1: General rules, seismic actions and rules for buildings. Draft 6, Doc CEN/TC250/SC8/N335.

NTC 2018: Ministero delle Infrastrutture e dei Trasporti (2018). Aggiornamento delle Norme Tecniche per le Costruzioni. Part 3.2.2: Categorie di sottosuolo e condizioni topografiche, Gazzetta Ufficiale n. 42 del 20 febbraio 2018 (in Italian).

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