Velocity profile report at the seismic station IT.PTV - PONTEVICO

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

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.PTV, 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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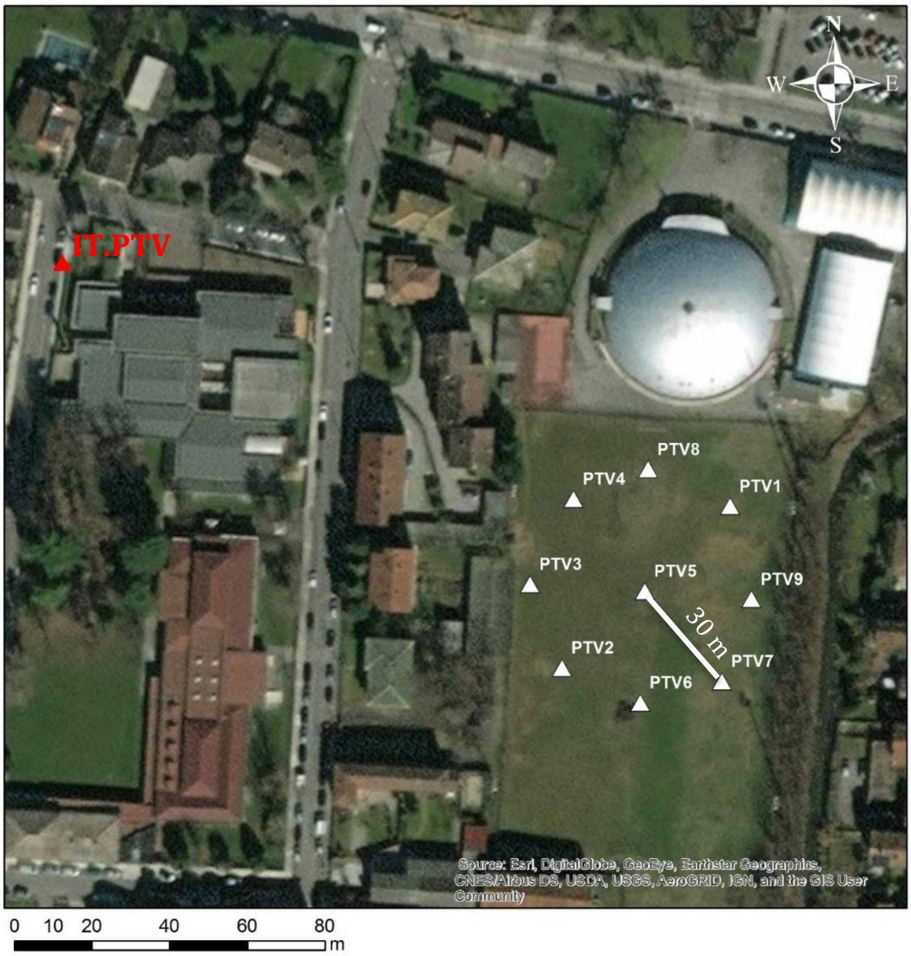
2. Geophysical investigations

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



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 1: Map of the geophysical measurements performed at IT.PTV site. The white triangles 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.PTV.

staz	Lat (°)	Lon (°)	El (m)
PTV1	45.27351	10.09009	45
PTV2	45.27314	10.08953	44
PTV3	45.27334	10.08942	44
PTV4	45.27354	10.08957	47
PTV5	45.27332	10.0898	44
PTV6	45.27306	10.08978	44
PTV7	45.27311	10.09005	40
PTV8	45.2736	10.08982	44
PTV9	45.2733	10.09015	46

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 30 m, as shown in Figure 1 and 2.

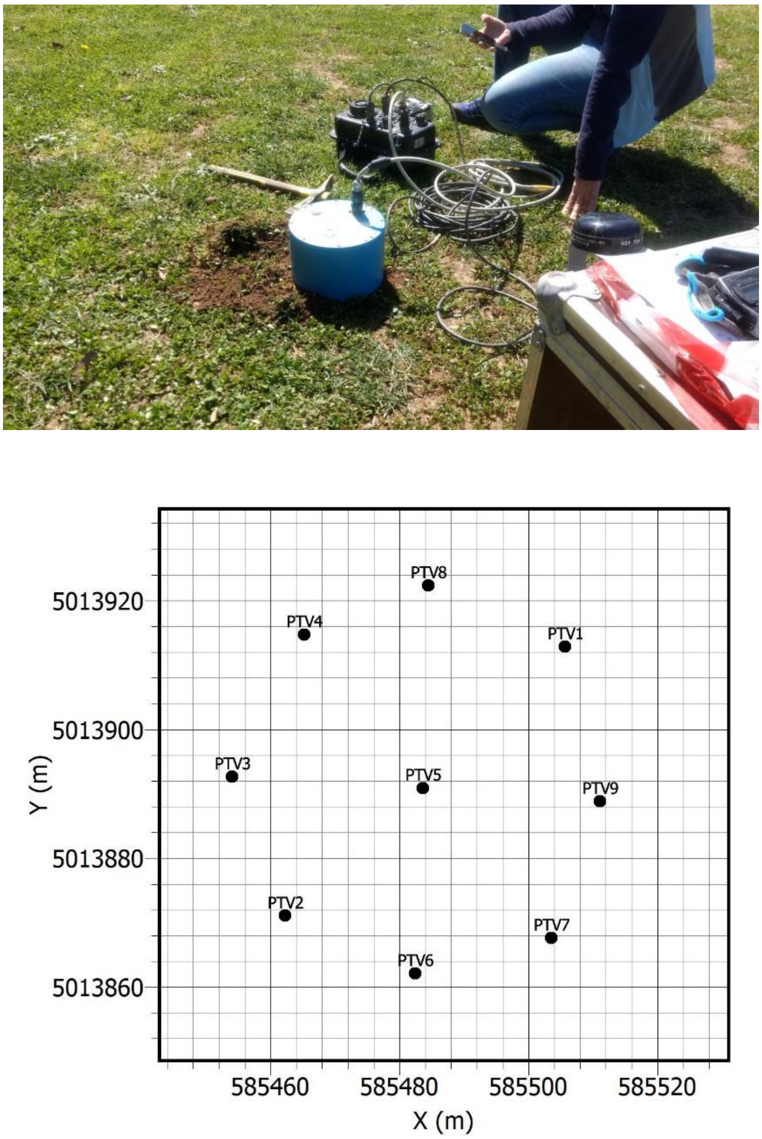


Figure 2: Top: example for the installation of an array station. Bottom: 2D Array geometry

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

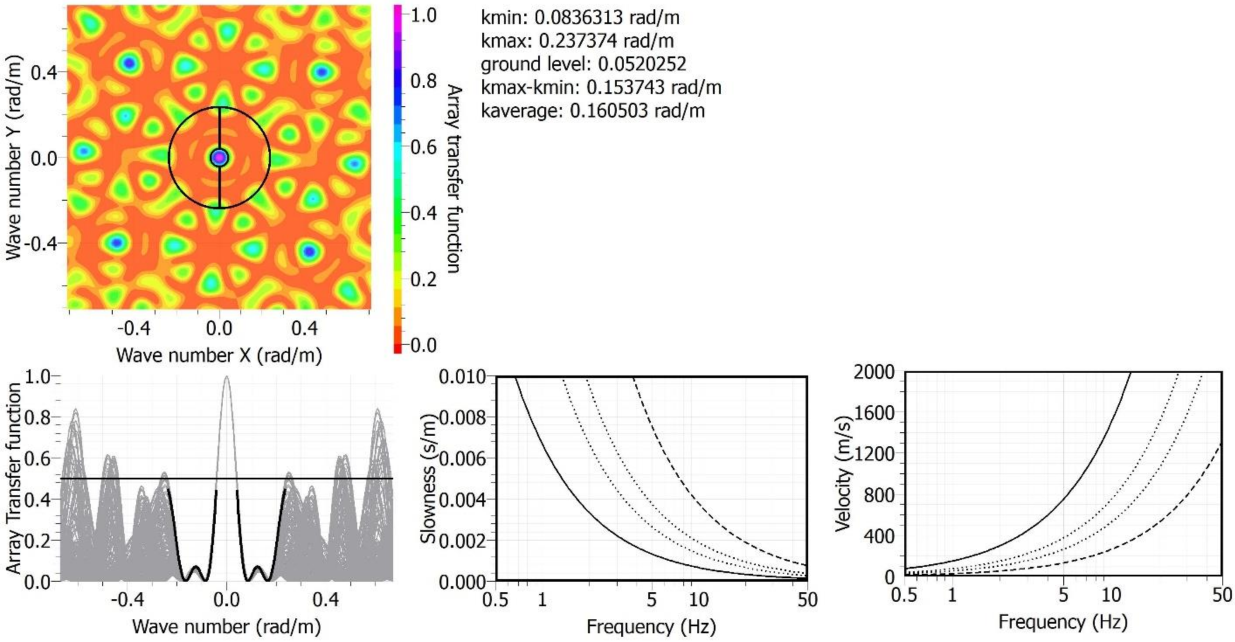


Figure 3: Theoretical Array Transfer function for the 2D array at IT.PTV

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. The agreement between all the H/V curves is very good.

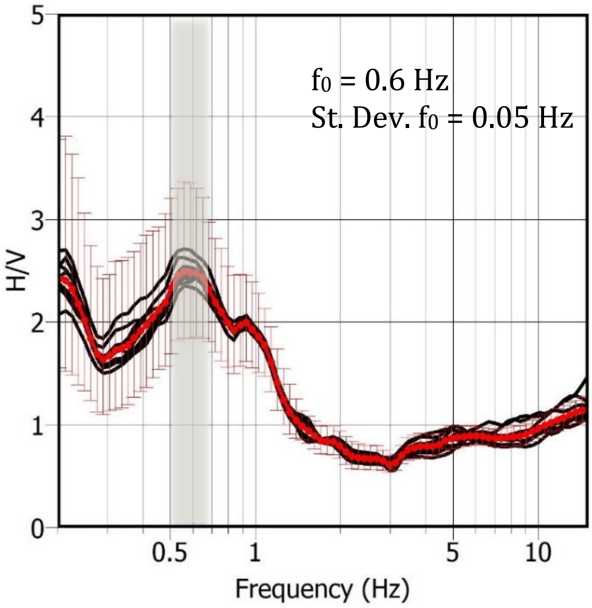


Figure 4: H/V curves of the 9 stations. The red curve is the average H/V and the red bars estimate the uncertainty of the average H/V.

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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 used the code GEOPSY (http://www.geopsy.org). The dispersion curve is shown in Figure 5.

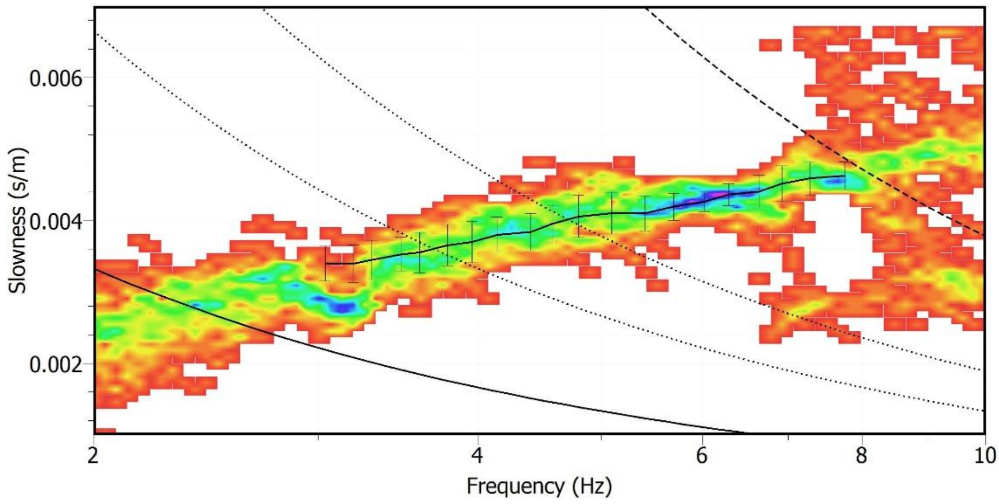
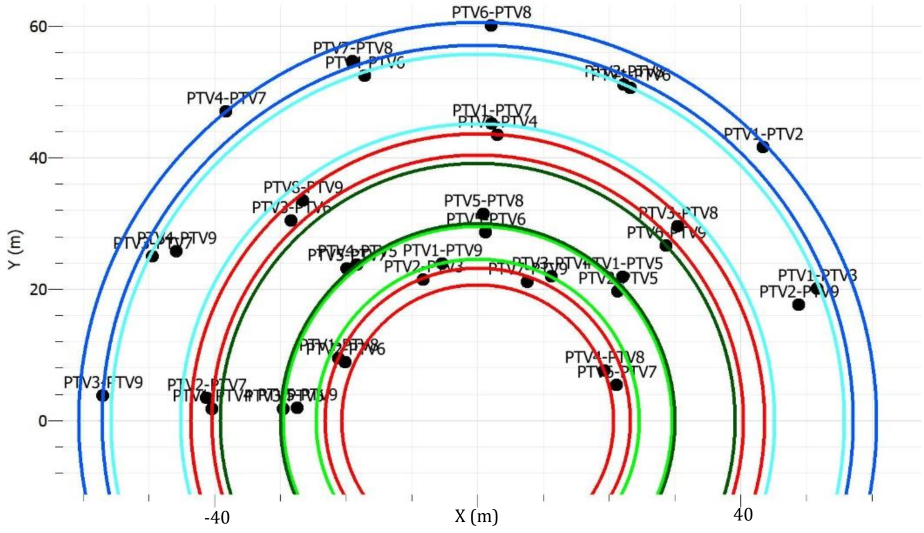


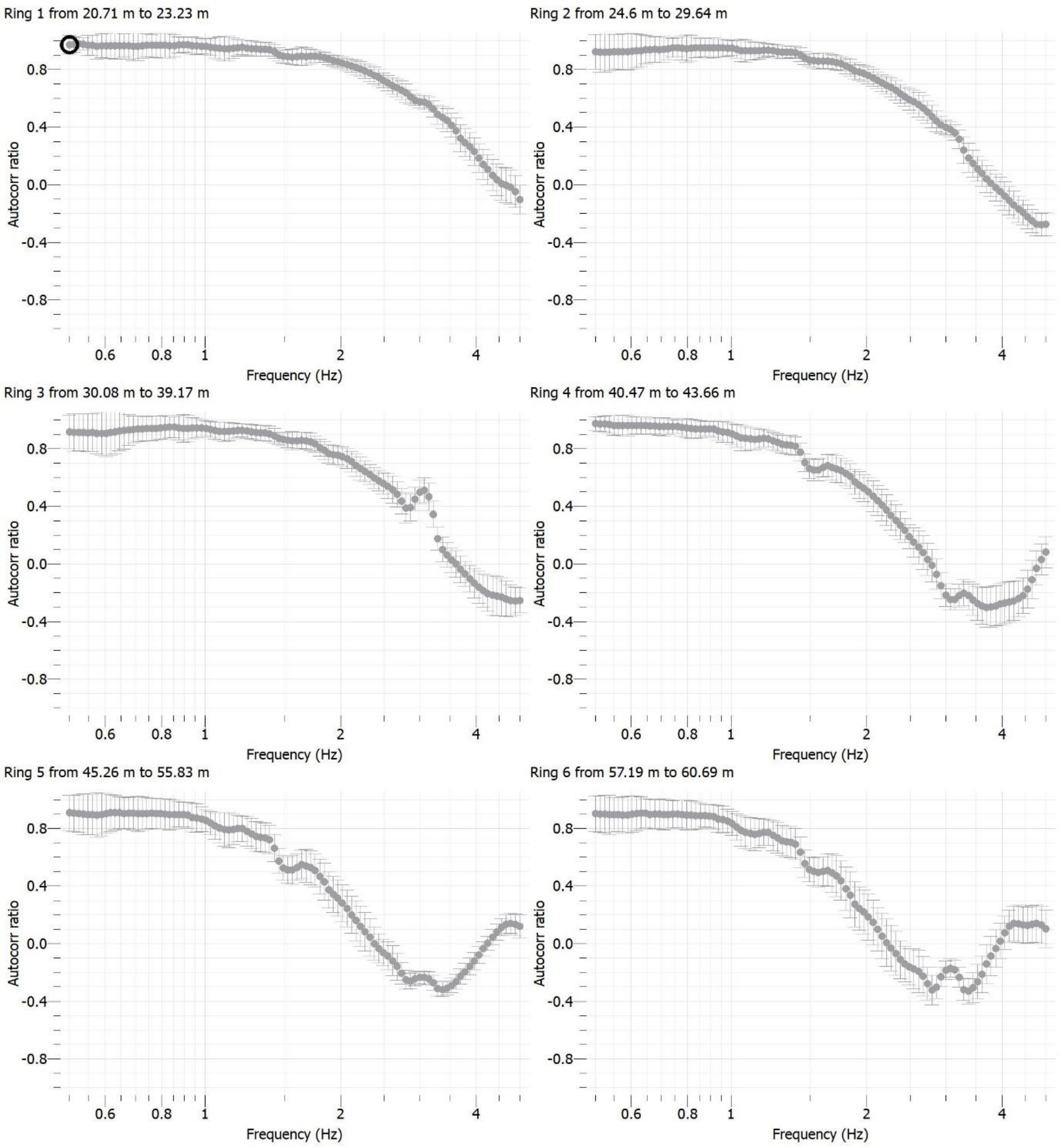
Figure 5: Picked dispersion curve in the slowness domain with the high-resolution FK analysis.

We interpret and assume that the dispersion curve obtained with the 2D array is relative to the fundamental mode of the Rayleigh dispersive waves.

The spatial auto-correlation technique (MSPAC) has also been applied to the passive data to obtain the auto-correlation curves (Figure 6).



a)



b)

Figure 6: a) selected rings for the MSPAC analysis; b) autocorrelation curves for the six rings.

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The auto-correlation curves in Figure 6b have been inverted to obtain the relative dispersion curve (Figure 7) that we assume as relative to the fundamental mode of the Rayleigh dispersive waves.

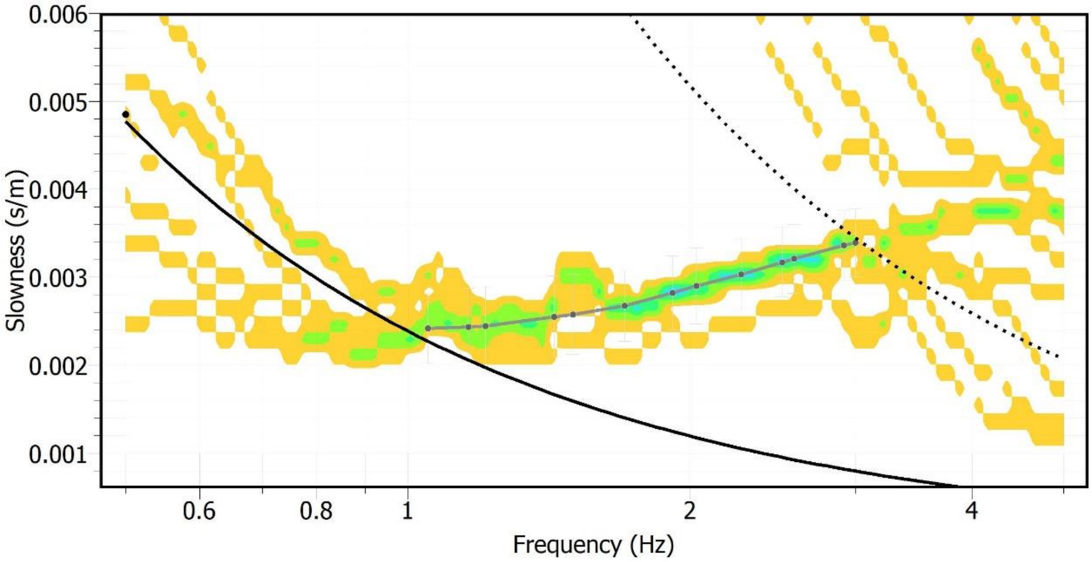

Figure 7: Picked dispersion curve in the slowness domain with the MSPAC method.

3. V_S Model

Comparing the dispersion curves obtained with the FK and MSPAC methods, we observe a good consistency. In particular, the FK dispersion curve extends to higher frequency (3-7.5 Hz), whereas the MSPAC dispersion curve extends to lower frequency (1.2-3 Hz).

The FK and MSPAC dispersion curves are superimposed in Figure 8a and the final dispersion curve, adopted for the inversion process, is shown in Figure 8b.

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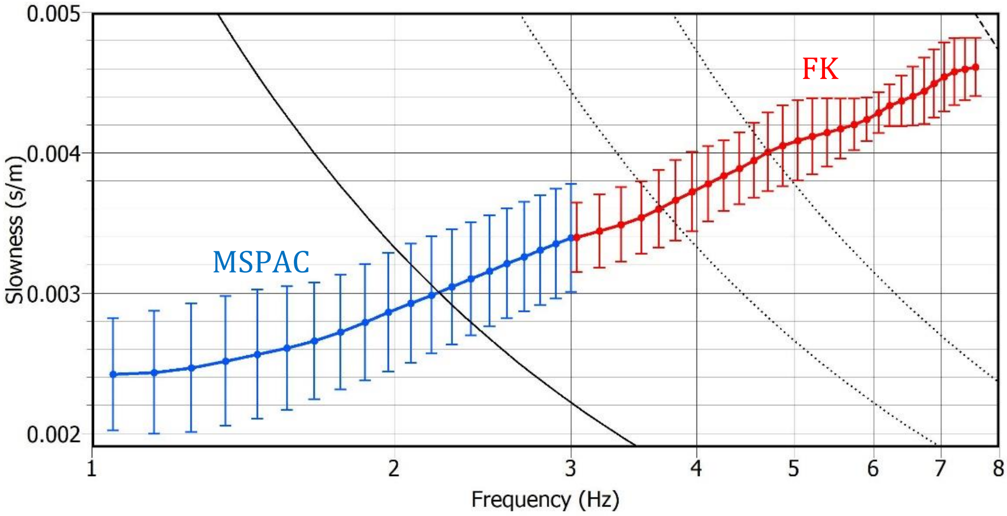
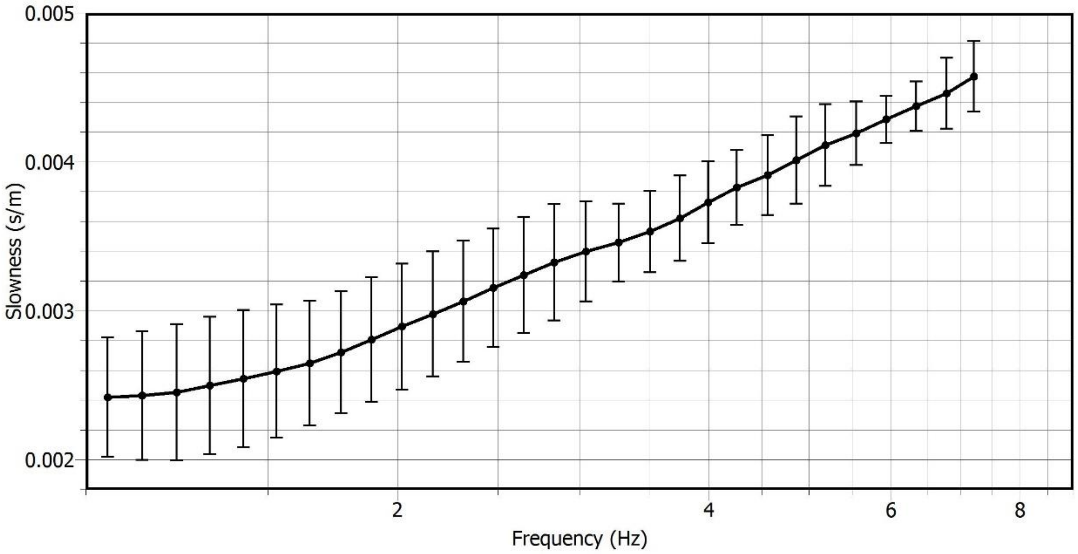


a)



b)

Figure 8: a) Superimposed FK and MSPAC dispersion curves, with the validity limits of the FK analysis. b) Dispersion curve adopted for the inversion process.

To proceed with the inversion, we estimate the ellipticity curve from the H/V curve, considering in particular the right flank of the H/V peak, where the influence of the Rayleigh waves is higher. Moreover, to reduce the contribution of the other waves in the H/V flanks, a common practice consists in reducing the H/V amplitude for the square root of 2 (Figure 9).

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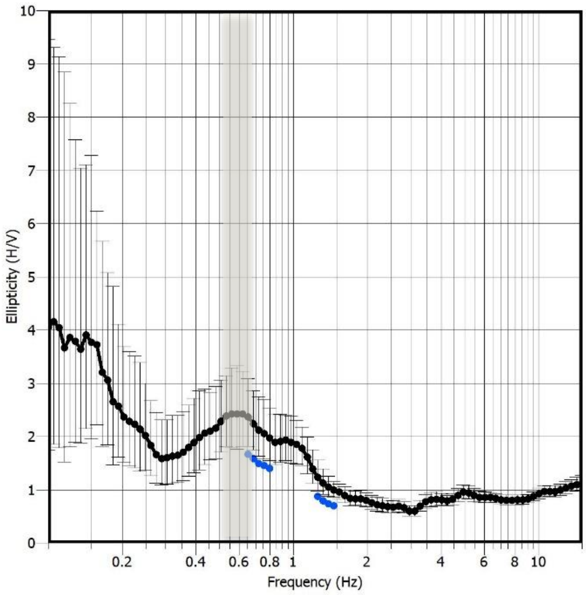

Figure 9: estimation of the ellipticity curve (blue) from the average H/V curve (black).

Finally, we jointly invert the following targets:

1) Rayleigh wave dispersion curve (fundamental mode) in Figure 8b
2) Ellipticity curve in Figure 9 (blue curve)

Figure 10 shows the comparison between the experimental targets and the ones expected for the best models coming from the inversion process.

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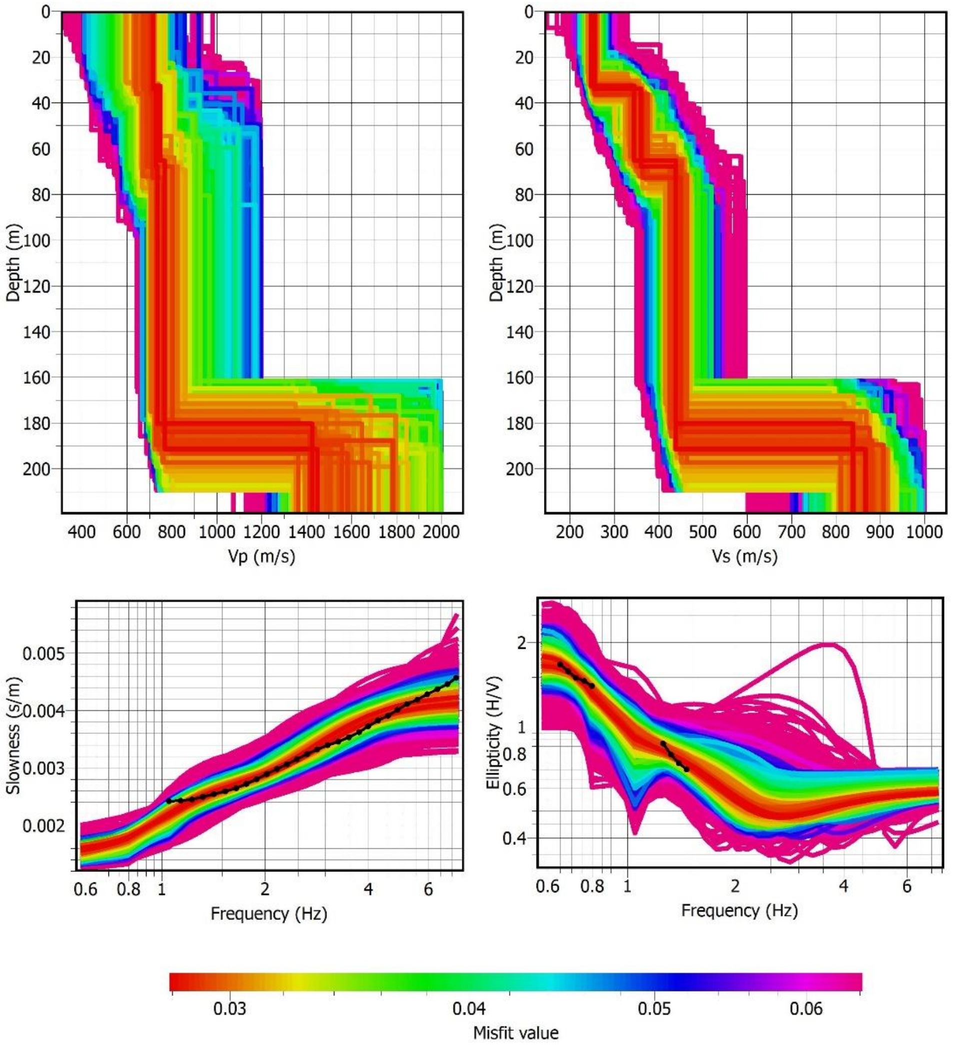

Figure 10: Inversion of the dispersion curve obtained with the 2D passive array, constrained with the H/V results.

The best fit models of V_P and V_S are represented in Figure 11 and Tab. 2.

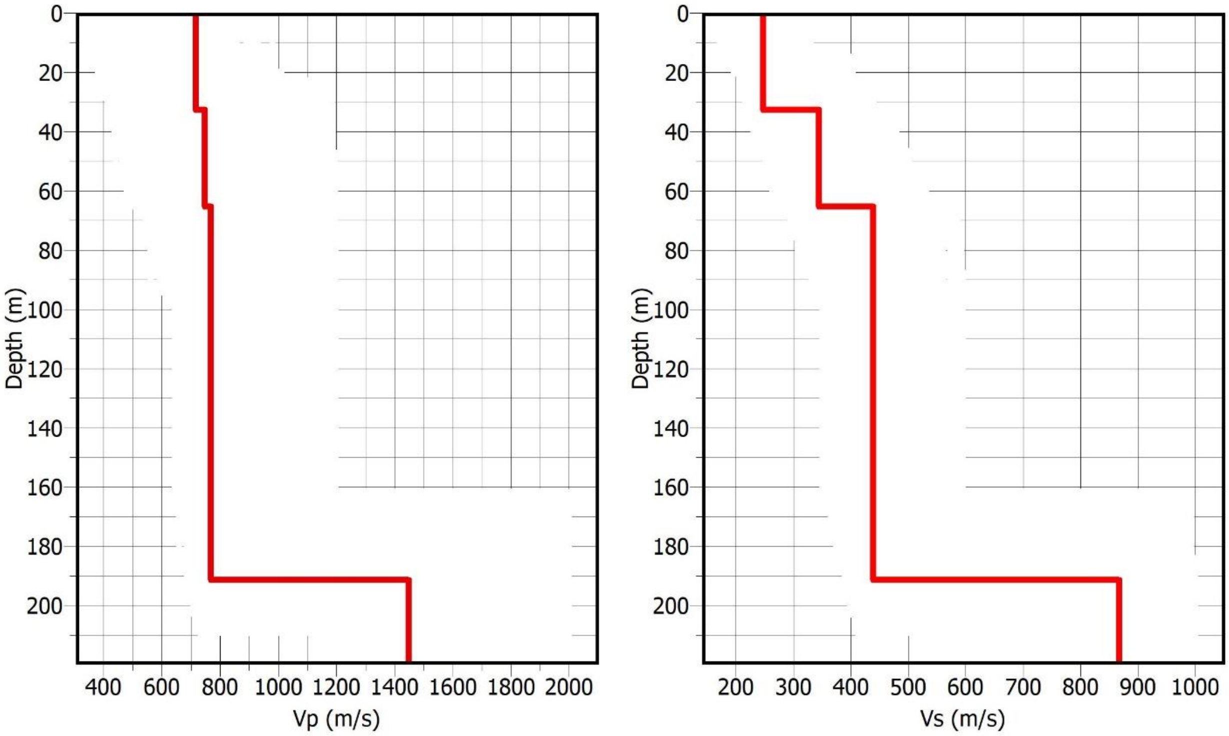

Figure 11: Best-fit models of Vp (left panel) and Vs (right panel) values

From	*To*	*Thickness (m)*	*V_S (m/s)*	*V_P (m/s)*
0	30	30	245	718
30	64	32	343	747
64	191	127	438	760
191	?	?	864	1442

Tab. 2: Best-fit model

4. Conclusions

The H/V analyses performed with the array recordings show a main H/V peak at about 0.6 Hz, in good agreement with the H/V analysis from ambient noise at the IT.PTV seismic station (http://itaca.mi.ingv.it).

This H/V peak may be related to the impedance contrast at about 191 m depth, in correspondence to the top of the bedrock (Vs > 800 m/s, NTC 2018), according to the obtained Vs profile.

However, the inversion process of the array data is poorly constrained by other independent information (i.e., stratigraphy, borehole logs etc.). Adding new available constraints, results may change.

According to the current Italian seismic code (NTC 2018), since the bedrock (V_S > 800 m/s) is > 30 m depth, the $V_{S,eq}$ is defined by the $V_{S,30}$. The $V_{S,30}$ retrieved from the inversion of the dispersion curves is 245 m/s (Tab 3); therefore IT.PTV is classified in the soil class C of NTC 2018 and EC8 seismic classifications.

$V_{s,eq} = V_{S,30}$ *(m/s)*	***Soil class (NTC 2018)***	***Soil class (EC8)***
245	C	C

Tab. 3: Soil Class

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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