Velocity profile report at the seismic station IT.ISD - ISOLA DELLA SCALA

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

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.ISD, 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.

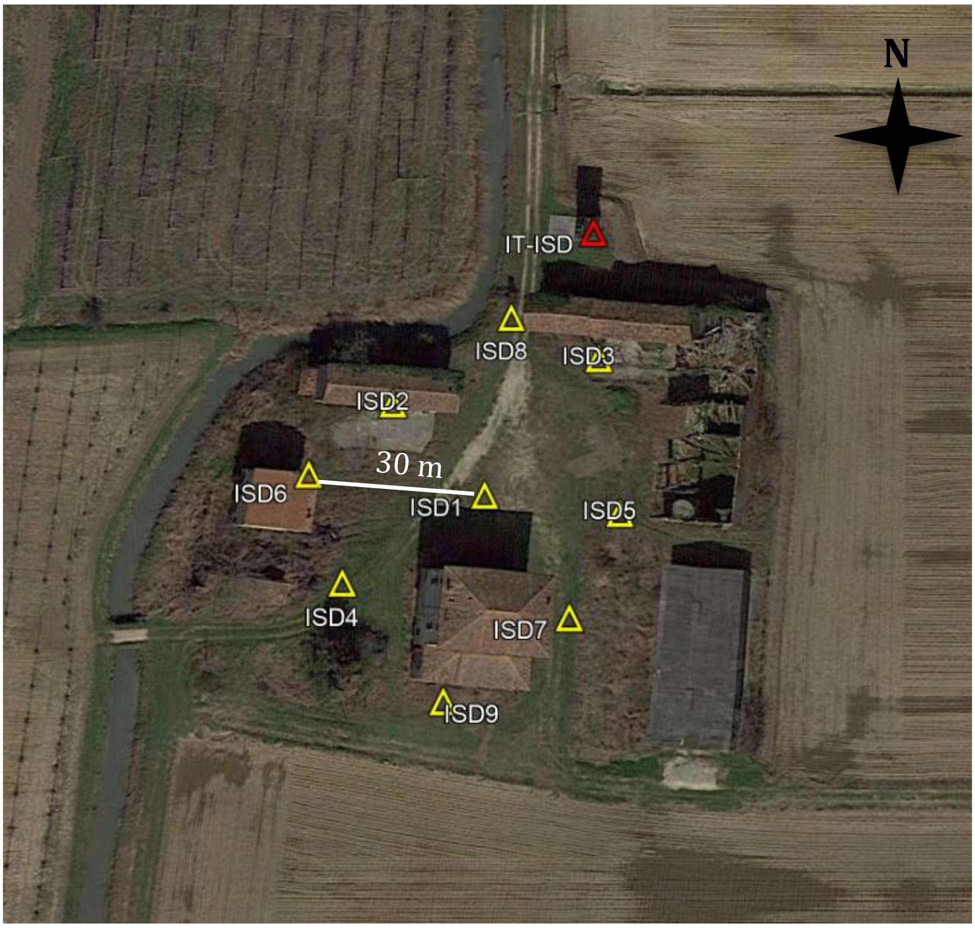

Figure 1: Map of the geophysical measurements performed at IT.ISD site. The yellow triangles are the nine stations of the 2D array in passive configuration (all stations are equipped with Reftek-130 digitizer and Lennartz 3D-5sec velocimetric sensors). The red triangle indicates station IT.ISD.

staz	Lon (°)	Lat (°)	El (m)
ISD1	10.95998	45.27296	22
ISD2	10.95977	45.27311	24
ISD3	10.96023	45.27318	24
ISD4	10.95968	45.27282	24
ISD5	10.96027	45.27293	28
ISD6	10.9596	45.27299	24
ISD7	10.96017	45.27277	15
ISD8	10.96003	45.27325	26
ISD9	10.9599	45.27264	25

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 subcircular geometry, with an average radius of 30 m, as shown in Figure 1 and 2.

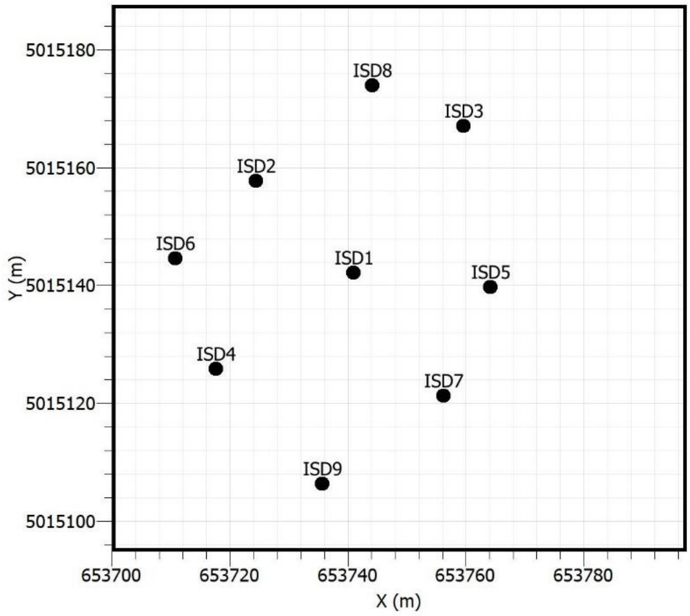

Figure 2: Top: example for the installation of an array station. Bottom: 2D Array geometry with UTM coordinates.

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

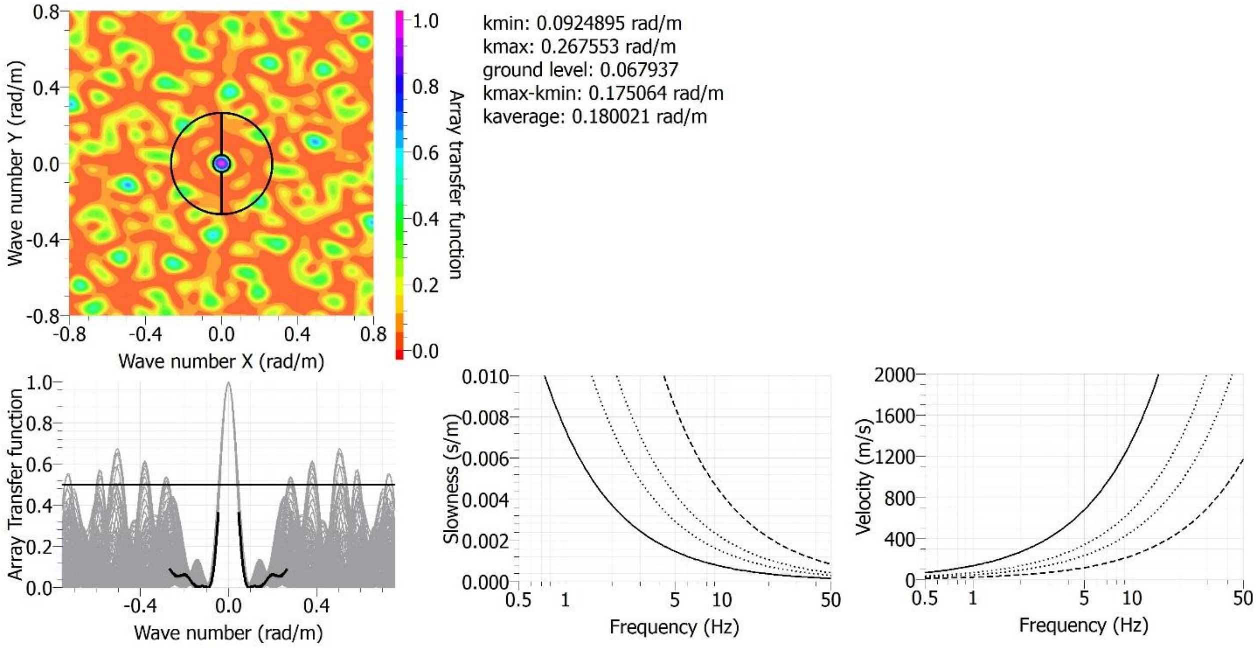

Figure 3: Theoretical Array Transfer function for the 2D array at IT.ISD

In Figure 4, the H/V curves of the 9 stations are superimposed on each other. The average H/V curve is reported in red. All the H/V curves present a good agreement, except for station ISD6 that shows an amplitude decay at low frequency.

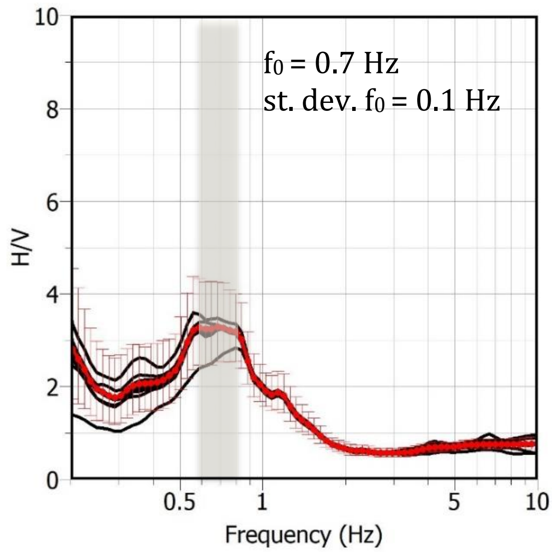

Figure 4: H/V curves of the nine stations. The red curve is the average H/V curve. The red bars estimate the uncertainty of the average H/V.

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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.

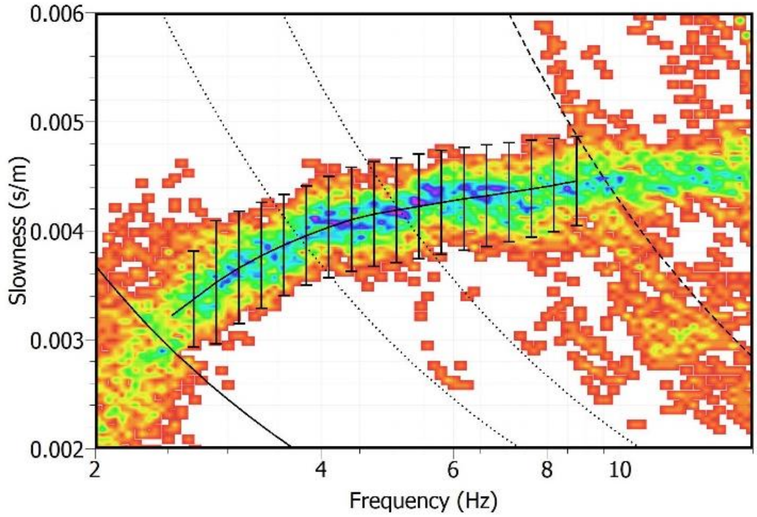
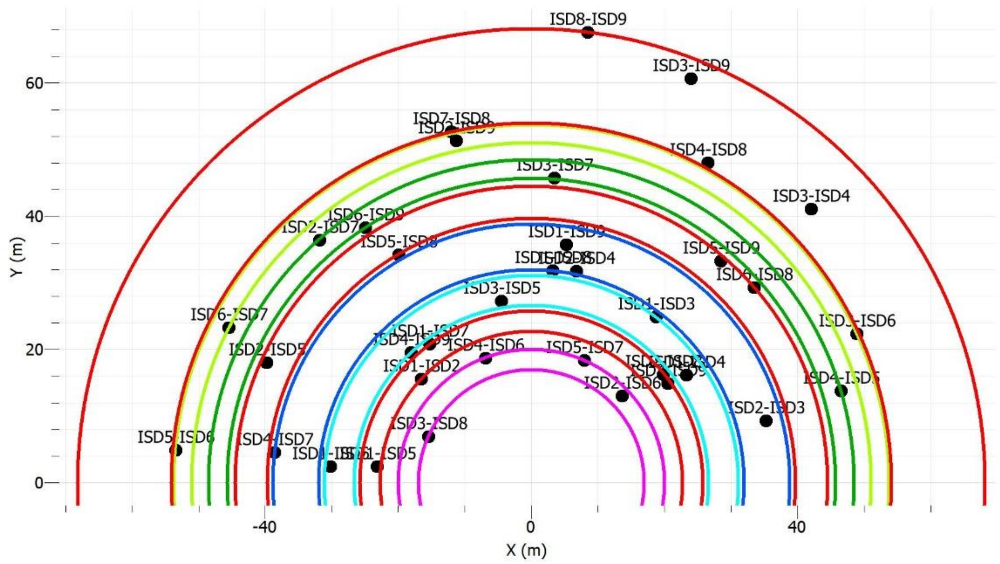


Figure 5: Picked dispersion curve in the slowness domain with the high-resolution FK analysis.

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)

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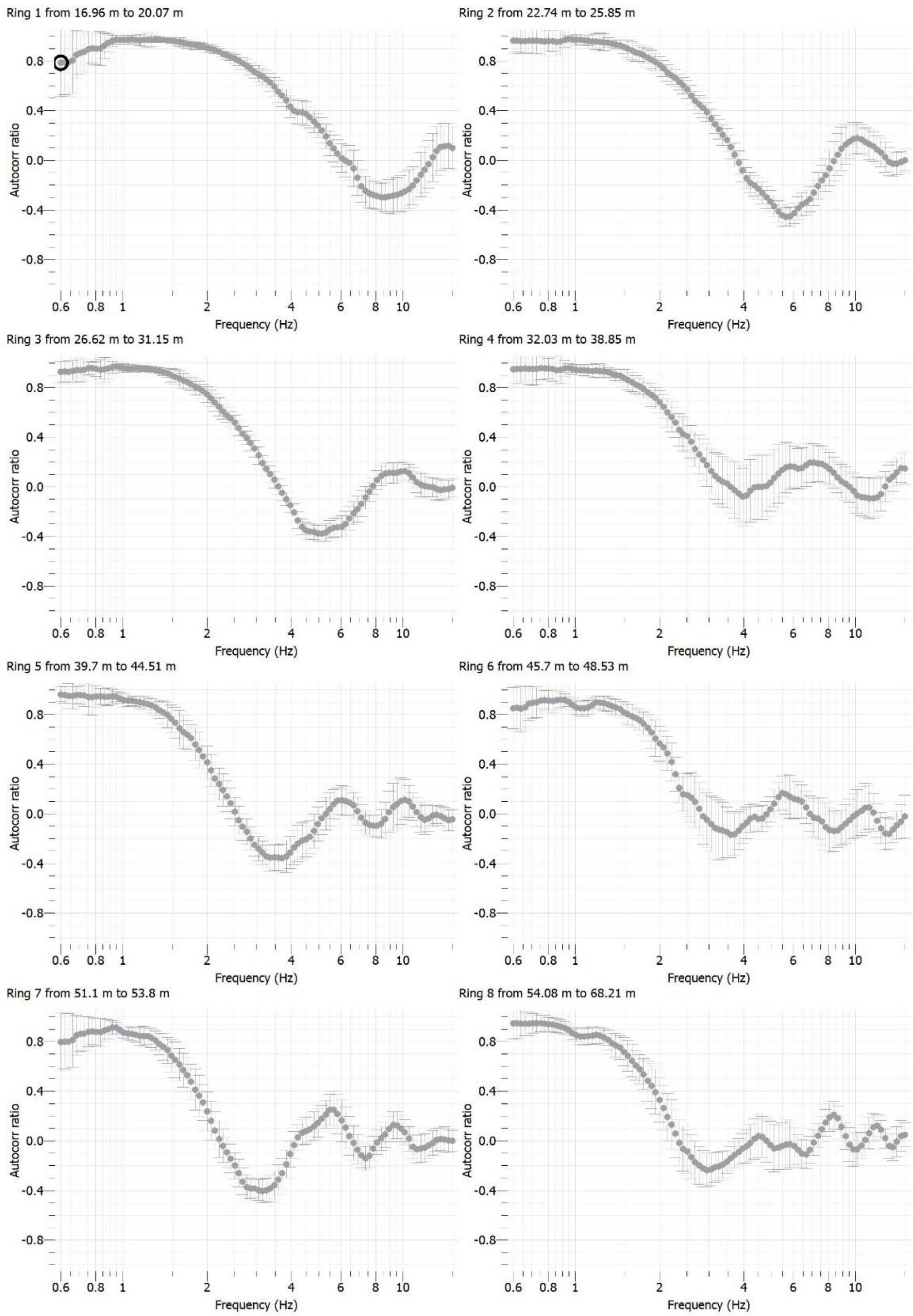

b)

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

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

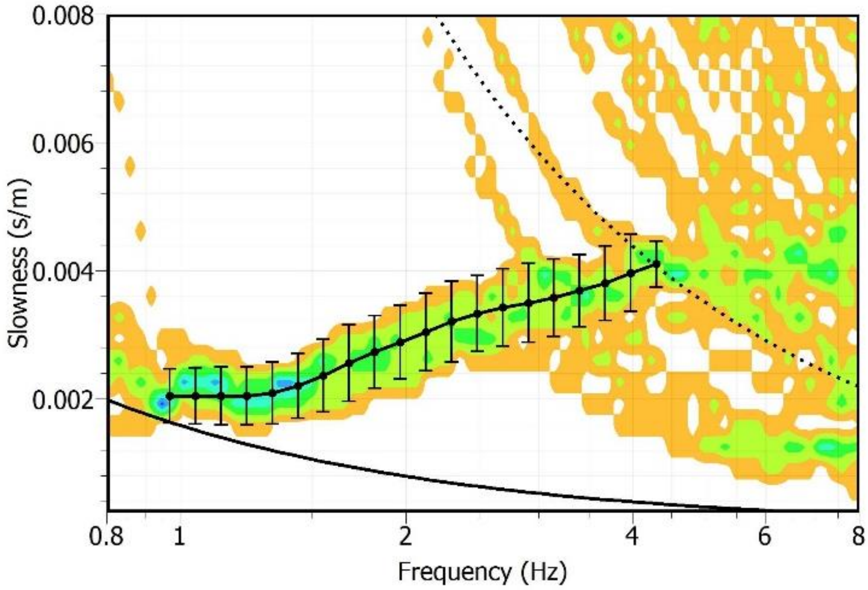

Figure 7: Picked dispersion curve in the slowness domain with the MSPAC method.

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 at higher frequency (2.5-9 Hz) whereas the MSPAC dispersion curve extends at lower frequency (1-4 Hz).

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

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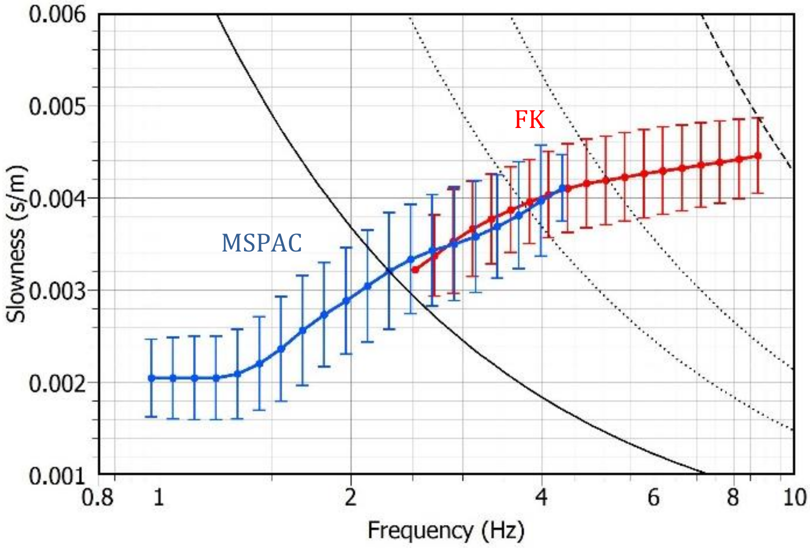
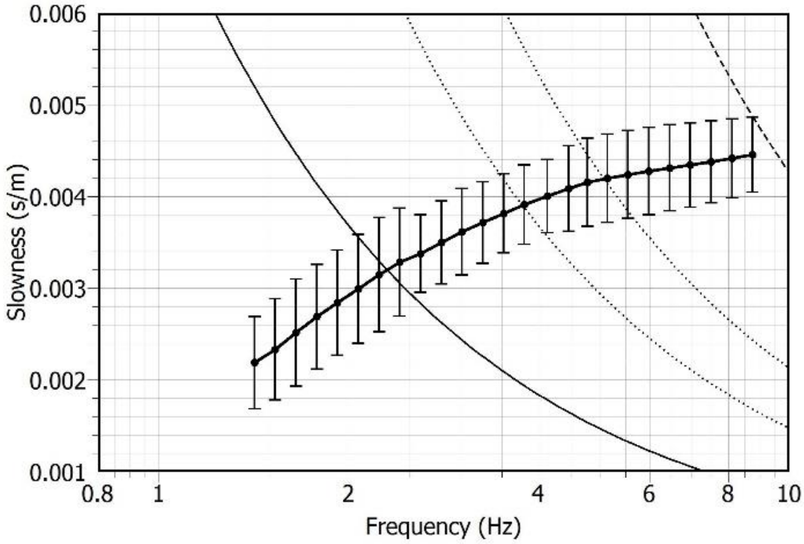


a)



b)

Figure 8: a) superimposed FK and MSPAC dispersion curves; b) dispersion curve adopted for the inversion process.

To proceed with the inversion, we estimate the ellipticity curve from the H/V curve, considering 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).

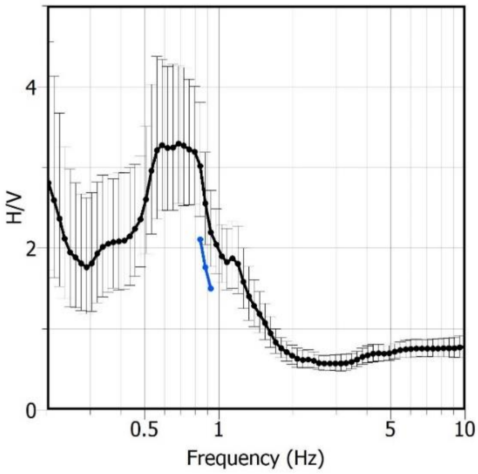


Figure 9: estimation of the ellipticity curve (blue) from the average H/V curve (black).

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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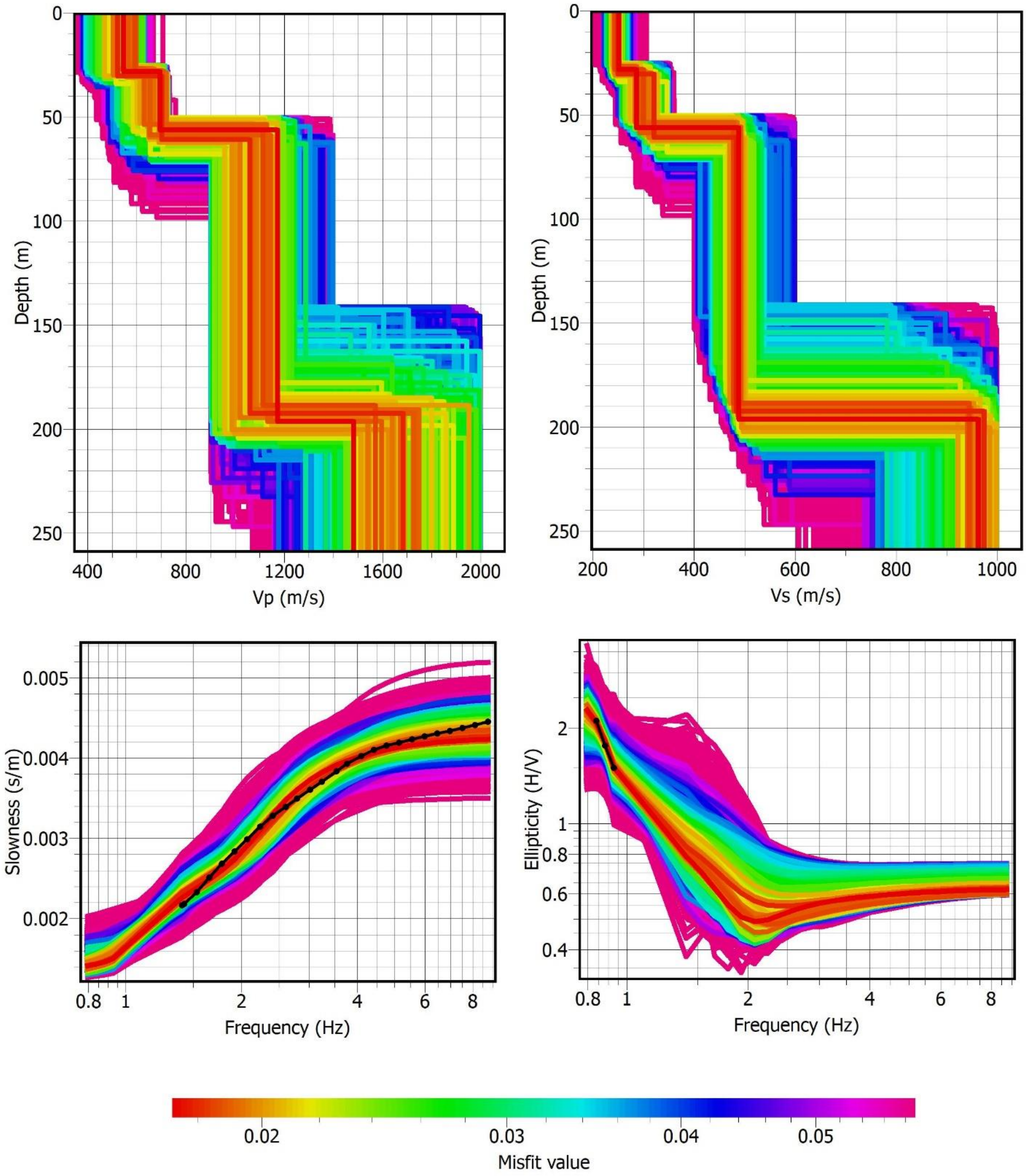

Figure 10: Inversion of the dispersion curve obtained with the 2D passive array, constrained with the H/V results.

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The best-fit Vp and Vs model are represented in Figure 11 and Tab. 2.

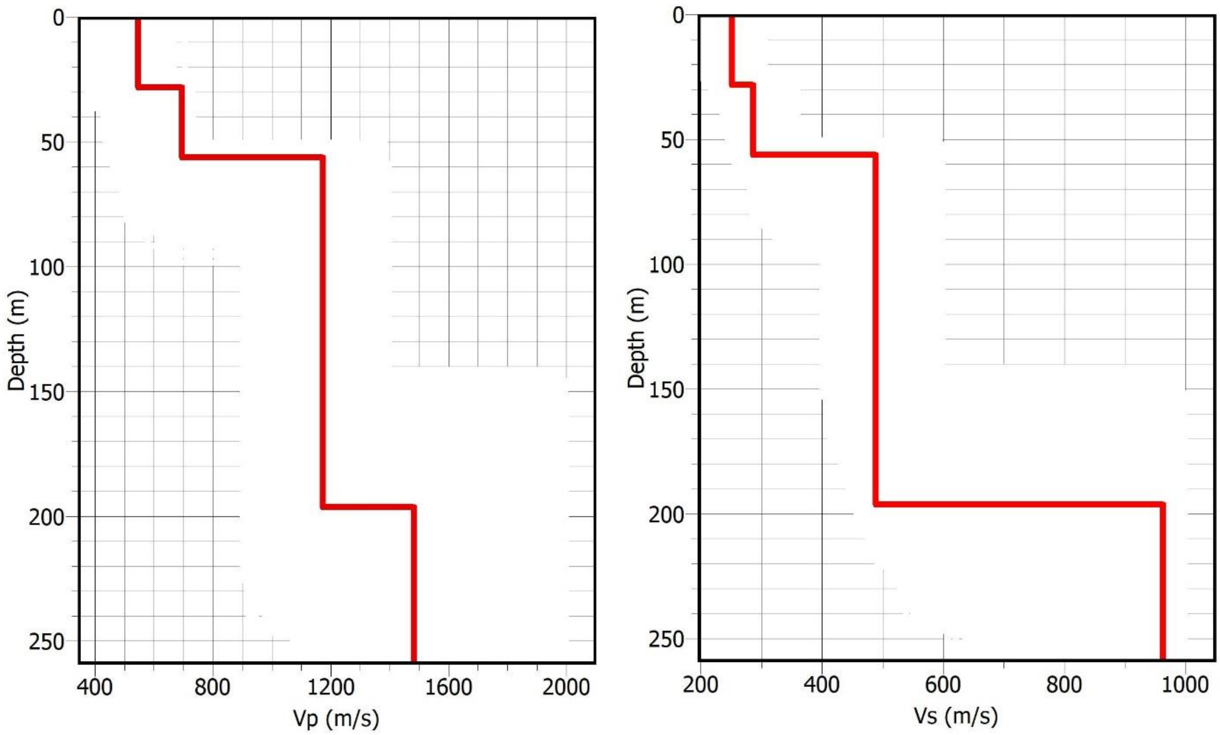

Figure 11: Best-fit model of Vp (left panel) and Vs (right panel) values

From	*To*	*Thickness (m)*	*V_S (m/s)*	*V_P (m/s)*
0	27	27	249	547
27	57	30	285	694
57	197	140	488	1167
197	?	?	962	1479

Tab. 2: Best-fit model

4. Conclusions

The H/V analyses performed with the array recordings show a main H/V peak at about 0.7 Hz, in good agreement with the H/V analysis from ambient noise at the IT.ISD seismic station (http://itaca.mi.ingv.it).

This H/V peak can possibly be related with the top of the bedrock (Vs>800 m/s; NTC 2018) at 197 m depth. The Vs of the bedrock retrieved from the inversion is presumably high because poorly constrained. The inversion process of the array data is poorly constrained also 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 252 m/s (Tab. 3); therefore IT.ISD 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)***
252	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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