

SEISMIC SURVEY METHODS

Seismic surveys are used in geology and geotechnical engineering to: a) define the depth of the bedrock; b) investigate the landslide areas, c) check the structural condition of dams, detected, landfills, etc.. D) define the seismic classification of the soils (VS30): e) evaluate the deformability characteristics of soils



Seismic surveys are based on the measurement of the velocity of propagation of seismic waves, generated artificially, in the ground or inside structures. The elastic waves are created by means of hammers (2) or controlled explosions (3).



The seismic signal is detected by special sensors (geophones), and determines a deformation of the ground or structure in relation to their elastic properties of the medium. The geophones used for seismic surveys have different resonance frequencies and the choice of the sensor is related to type of investigation: the seismic refraction geophones are used to 10 or 40 Hz, while for surface waves (MASW and REMI), using low-frequency geophones (4.5 Hz), often mounted on streamer (4). In seismic transparency and, in general, to investigate structures, using 100 Hz geophones (5).

The data acquisition is performed with the seismograph modular Daq Link III, the 24-bit Seismic Source Ltd (1), composed of units connected in series to 24 channels (up to 5 units available, for a total of 120 channels simultaneously).

The instrument is equipped with a standard network connection 10/100 (RJ45 base); for communication with the laptop it is installed a dedicated program (VibraScope[®]) that handles the display, analysis and storage of seismic data.

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SEISMIC REFRACTION METHOD

The seismic refraction methodology is widely applied in geology and engineering to define the geological characteristics of the subsoil. In particular, it is particularly suitable for:

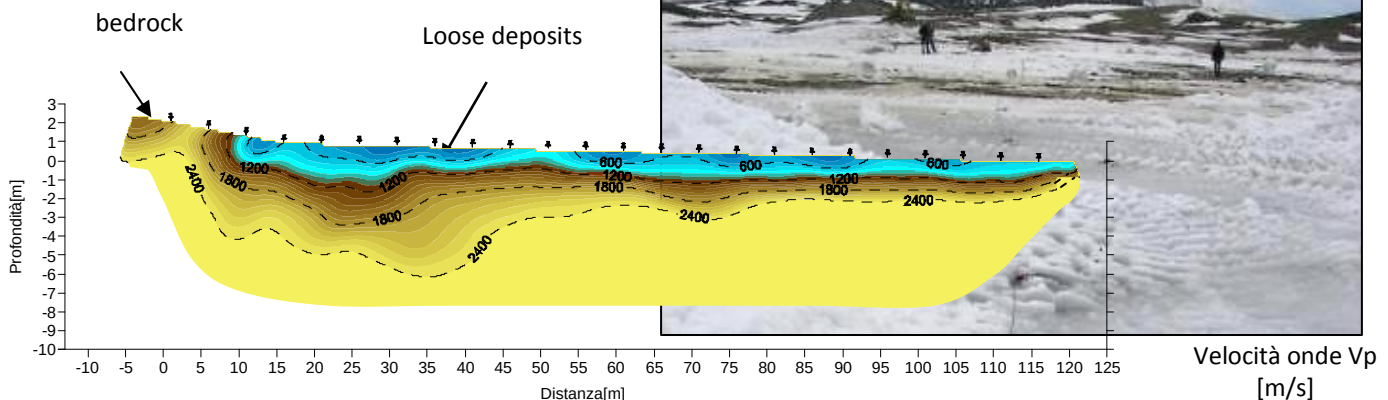
- 1) Estimating the depth of the stone substrate (Example 1)
- 2) Verification of landslide areas (Example 2)
- 3) Assessment of ground deformability parameters (soil density of embankments, landfill thickness, etc)

For seismic surveys we use one or more 24 channels Units of Seismic Source (DAQLink III System - 24-bit Acquisition System). The energy source is obtained by means of different techniques, depending on the length of the line, the characteristics of the site and the dispersion of the signal :

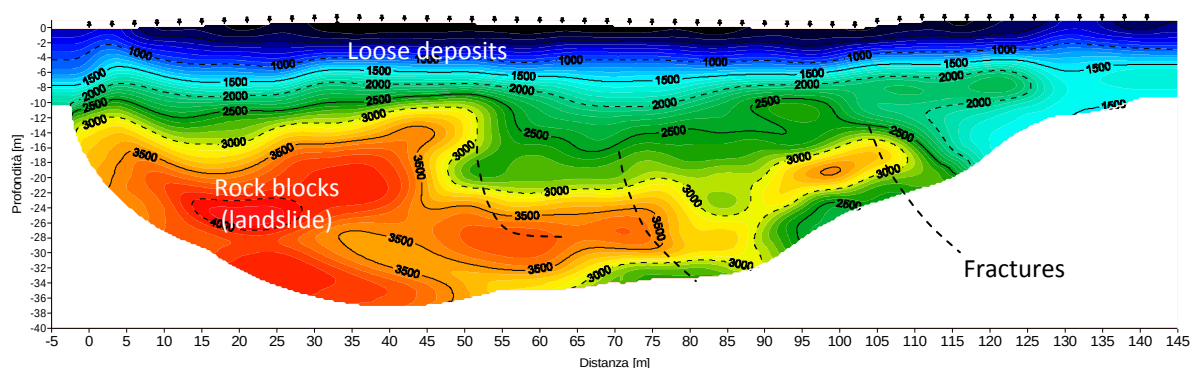
- energization with sledge hammer from 4 kg to 8 kg, near surface investigations
- energization with 35-kg heavy hammer, for medium depth surveys (40-50 m)
- energization with a special rifle or explosives for deeper investigations (> 50 m)

The seismic traces are processed with the computer code RAYFRACT™. Based on the "picking" manual or automatic first arrivals of P waves, the software generates the initial model of velocity that is used during the 'numerical inversion (Wavepath eikonal Traveltime Tomographic inversion WET). Rayfract allows modeling of seismic sections with rugged topography and the identification of geological features such as faults, lateral and vertical variations of velocity (www.rayfract.com)..

ESEMPIO 1 – Seismic survey to determine the thickness of loose deposits for the excavation of an artificial lake .
Cime Bianche (AO)



ESEMPIO 2 – Seismic refraction on a landslide area. Santo Stefano d'Aveto (GE)



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(MASW – MULTICHANNEL ANALYSIS OF SURFACE WAVES)

The investigation techniques based on dispersive properties of Rayleigh waves (surface waves), are very commonly used in geological prospections, according to the new procedures of measurement and interpretation of data. The seismic data are subjected to a stage of processing that enables to estimate the dispersion characteristics of the site, ie the phase velocity of Rayleigh waves as a function of frequency. The process of numerical inversion of points distributed on the curve that best fits the distribution of points, allowing the definition of stiffness profile (profile of shear wave velocity to depth).

The distribution of shear wave velocity along a vertical profile allows

- 1) A fast way to assess the model of the subsurface stratigraphy
- 2) Determine the parameter VS30 (required by the current seismic code for the seismic classification of soils)

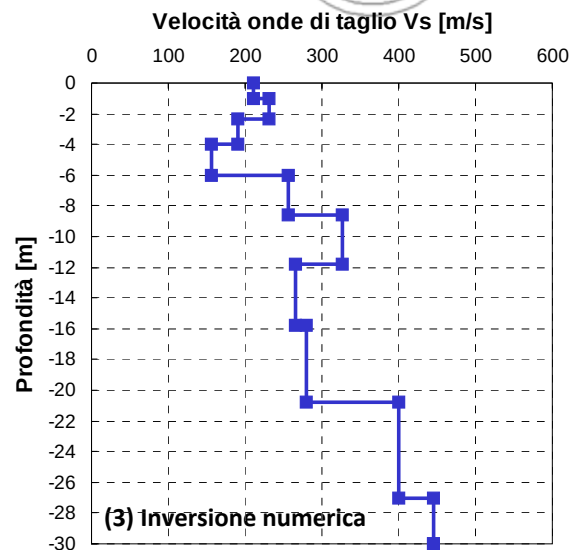
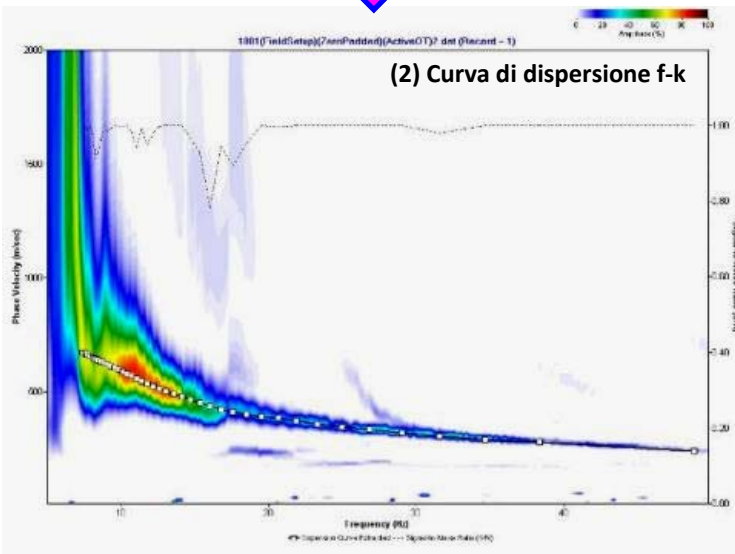
The acquisition of multiple profiles side by side along an alignment allows the definition of a 2D model (4) which has several advantages:

- 1) Favorable ratio between line length versus depth reached
- 2) Detection of reverse velocity (alternance of layers of "slow" and "fast" velocity)

(1) Data acquisition with a streamer length 0.46 m

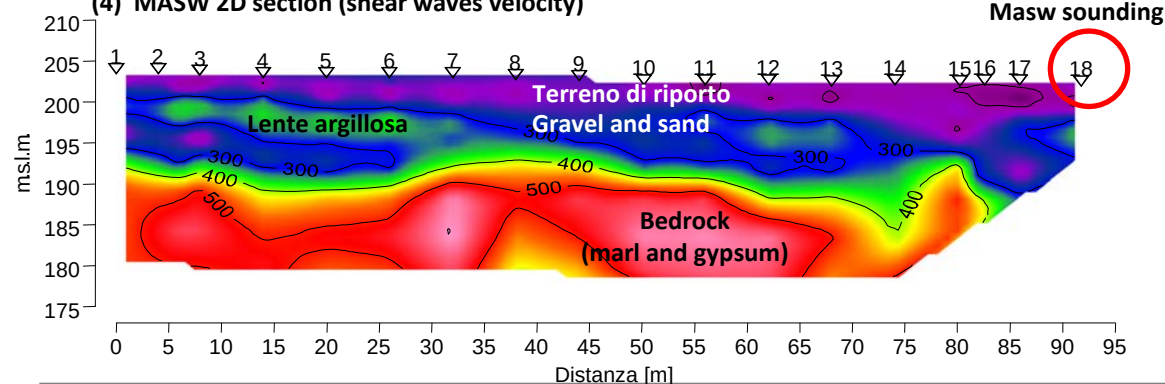


(2) Curva di dispersione f-k



(3) Inversione numerica

(4) MASW 2D section (shear waves velocity)



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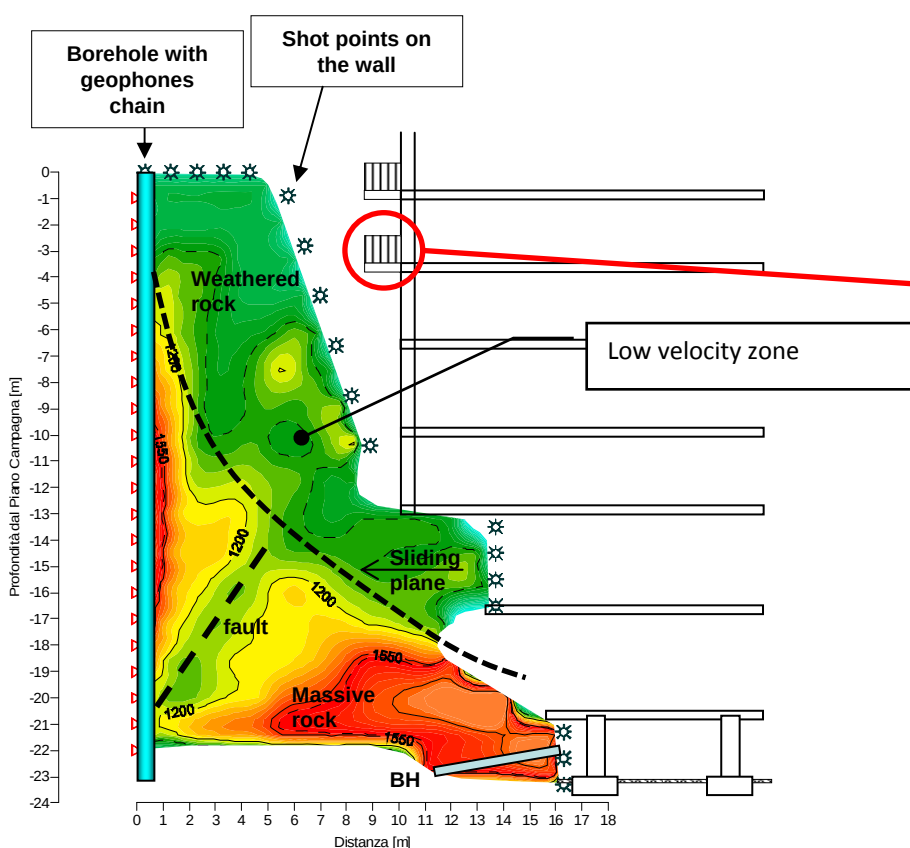
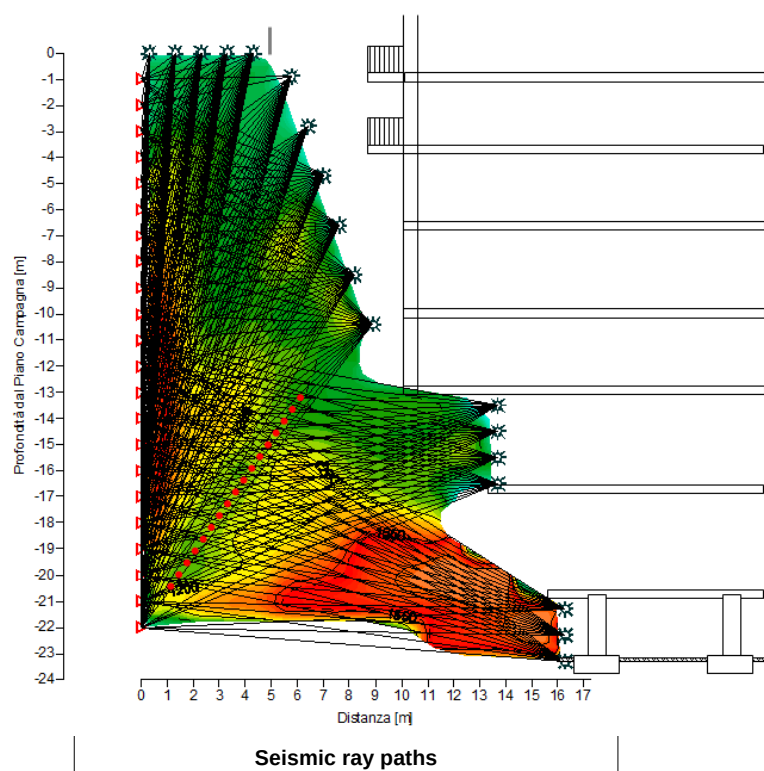
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SEISMIC TOMOGRAPHY - SIRT

The measurements of seismic tomography with direct traces are obtained by placement of sensors (receivers) on a side of a structure and the shot points on the opposite side (direct seismic rays). These array (also used for cross-hole tests in the holes) allow to obtain 2D and 3D distribution of the compression wave velocity in concrete structures (dams, bridge piers or walls). From the data of the first arrival of seismic ray paths, the calculation algorithm SIRT (Simultaneous Iterative Reconstruction Technique) is obtained a model of initial velocity (the wave velocity V_p model). According to the high degree of resolution resulting from the dense network of seismic rays, tomographic models of the compression waves allow to highlight the details of the characteristics of deformation structures (directly related to the rate of compression waves), and any structural defects (deteriorated, fractures, etc..)



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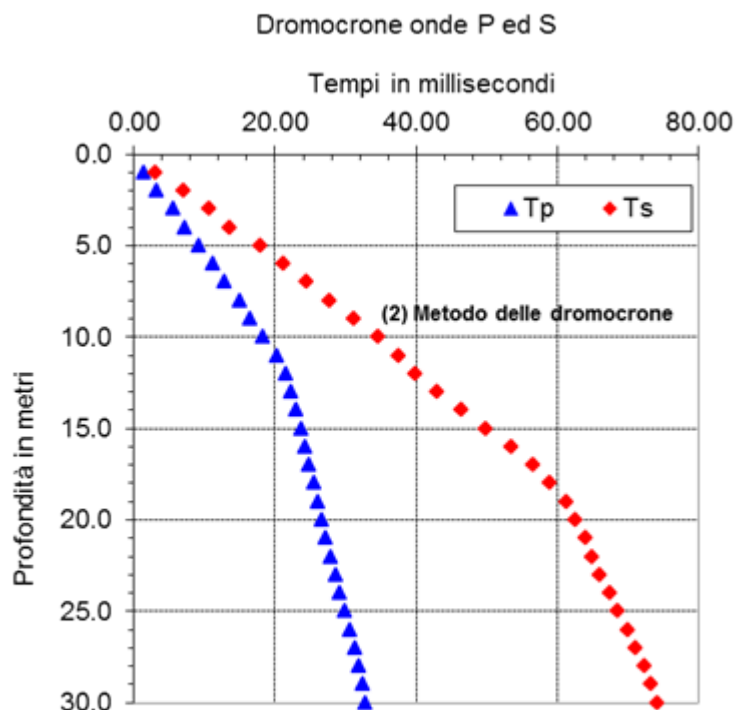
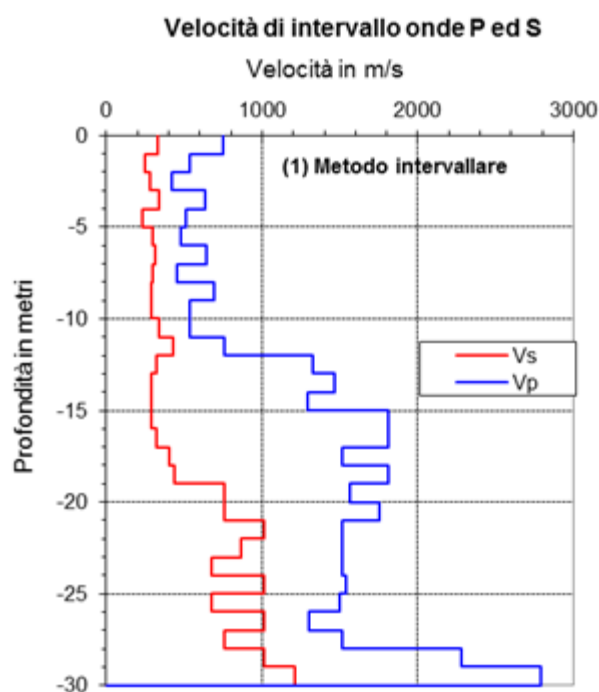
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DOWN HOLE TEST

The downhole seismic tests involve the use of a test hole and energizing external (downhole) or using a pair of holes (cross-hole).

The down-hole seismic testing involves the insertion of a borehole geophone inside a hole, and a seismic pulse (shot) out of the hole at a fixed distance (usually 2 m from the hole). Shear-wave surveys using horizontally polarized waves require horizontal hammer impacts against a rigid object (the source) that is coupled to the ground surface.

These are then used to produce total velocity profiles from which interval velocities and the various elastic moduli can be calculated (in conjunction with density data from geophysical logging of the borehole).



Strato (m)	Vp m/s	Vs m/s	g g/cm ³	n	E Mpa	G Mpa	K Mpa
1 - 4	584	300	2.00	0.32	475.77	180.13	442.2
5 - 14	738	310	2.00	0.39	535.27	192.14	833.0
15 - 23	1621	570	2.00	0.43	1855.72	649.05	4390.9
24 - 30	1777	908	2.00	0.32	4366.23	1649.78	4117.8

5/5

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