Seismic Microzonation – The assessment of Local Seismic Hazard through the identification of zones with seismically homogeneous behavior. In practice, Seismic Microzonation identifies and characterizes stable zones, stable zones prone to local amplification of seismic motion and zones prone to instability. Seismic amplification is the first cause of earthquake damage, even more important than the size of the earthquake itself. A notable example of this in recent years has been in the Central Mexico on September 19, 1985, M=8. It didn't induce significant damage in the epicentral area, but caused the collapse of 400 buildings and the huge damage of many more in Mexico City, 240 km from the epicenter. Pic.1

Pic.1 Damage buildings in Mexico City which is built on a sedimentary basin with a resonance frequency of about 1 Hz.

Seismic Microzonation studies may be carried out at three levels:

- Level 1 consists of a collection of existing data that are processed to divide the investigated area into qualitatively homogeneous microzones;
- Level 2 introduces a quantitative element associated with the homogeneous zones by using additional and focused investigations (where necessary), in addition to defining the SM Map;
- Level 3 produces a Detailed Seismic Microzonation Map covering particular issues or areas.

The microzones indicated on the map are classified according to 3 categories:

A) stable zones, where no significant local effects of any nature are assumed (outcropping geological bedrock with flat or slightly inclined morphology – slopes with a gradient of less than 15 degrees);

B) stable zones prone to local amplification, where the amplification of seismic motion is expected (as a consequence of local litho-stratigraphic and morphological conditions);

C) zones prone to instability, where expected and predominant seismic effects may be ascribed to permanent deformations of the investigated area. The main types of instability are:

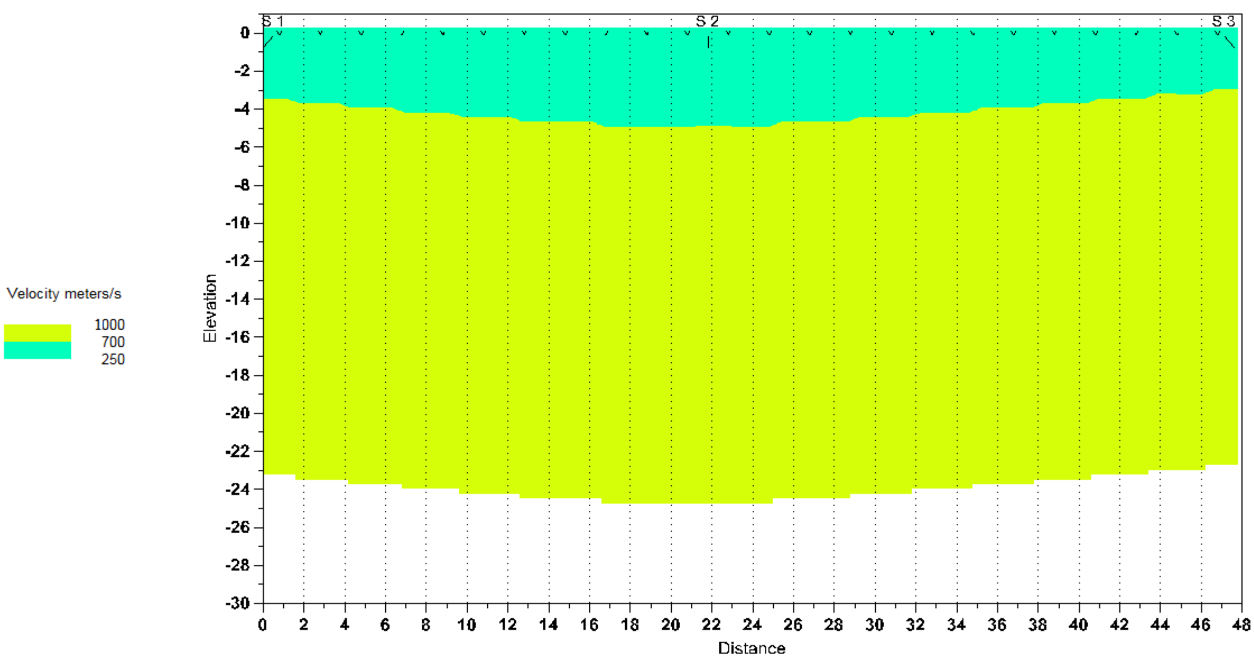
- slope instability;
- liquefaction;
- active and capable faults;

• differential settlements.

The most important geophysical tests to define the velocity of propagation of seismic waves inside soils and help reconstruct the geometry of deep bodies are as follows.

• Seismic refraction tests use a set of geophones to record the time of arrival of the first seismic wave generated by an energy source. The placement of the geophones and sources at the surface allows for the obtainment of linear seismic profiles. Pic.2

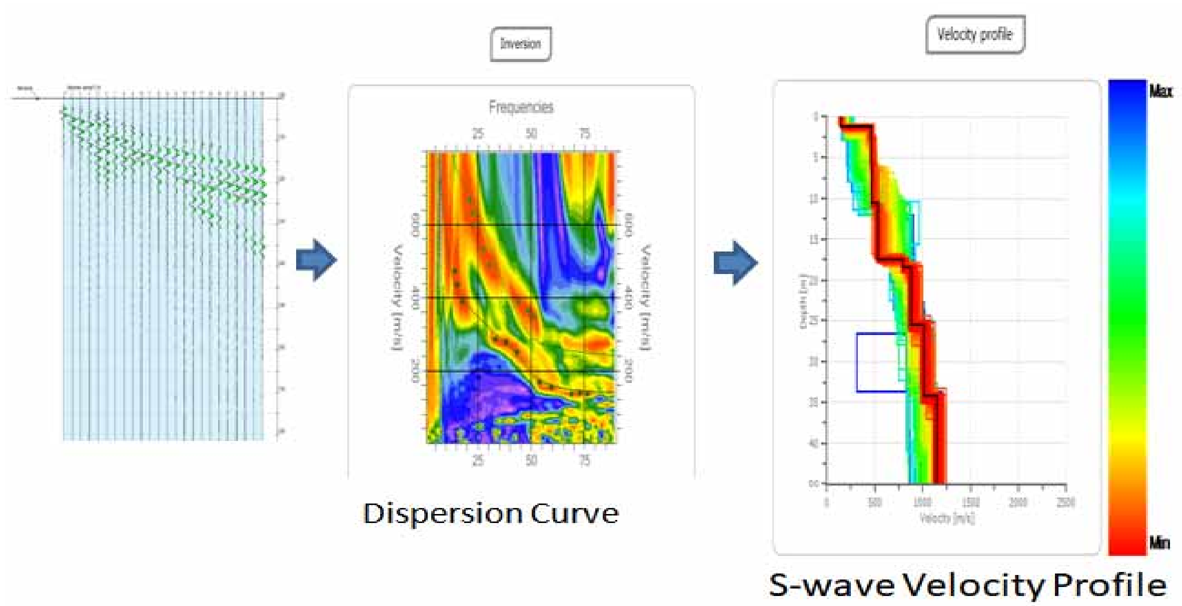
Pic.2 seismic refraction tests with RAS-24 multi-channel survey, for using 4.5 Hz vertical geophones.



Shot point depth computation

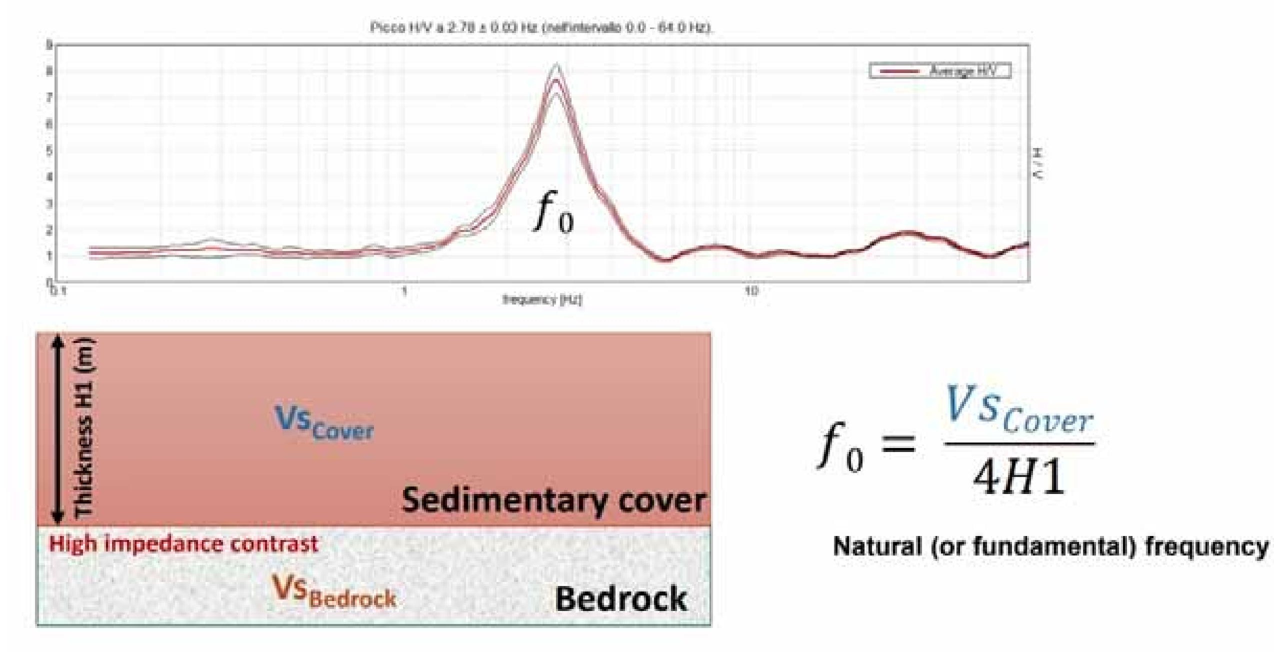
Pic.3 Vs – Seismic velocity profile, for assessment of subsoil category of Eurocode 8.

• ESAC - Extended Spatial Autocorrelation or SASW – spectral analysis of Surface Waves tests measure the velocities of surface waves, from which the velocity of S waves is derived. Pic.4

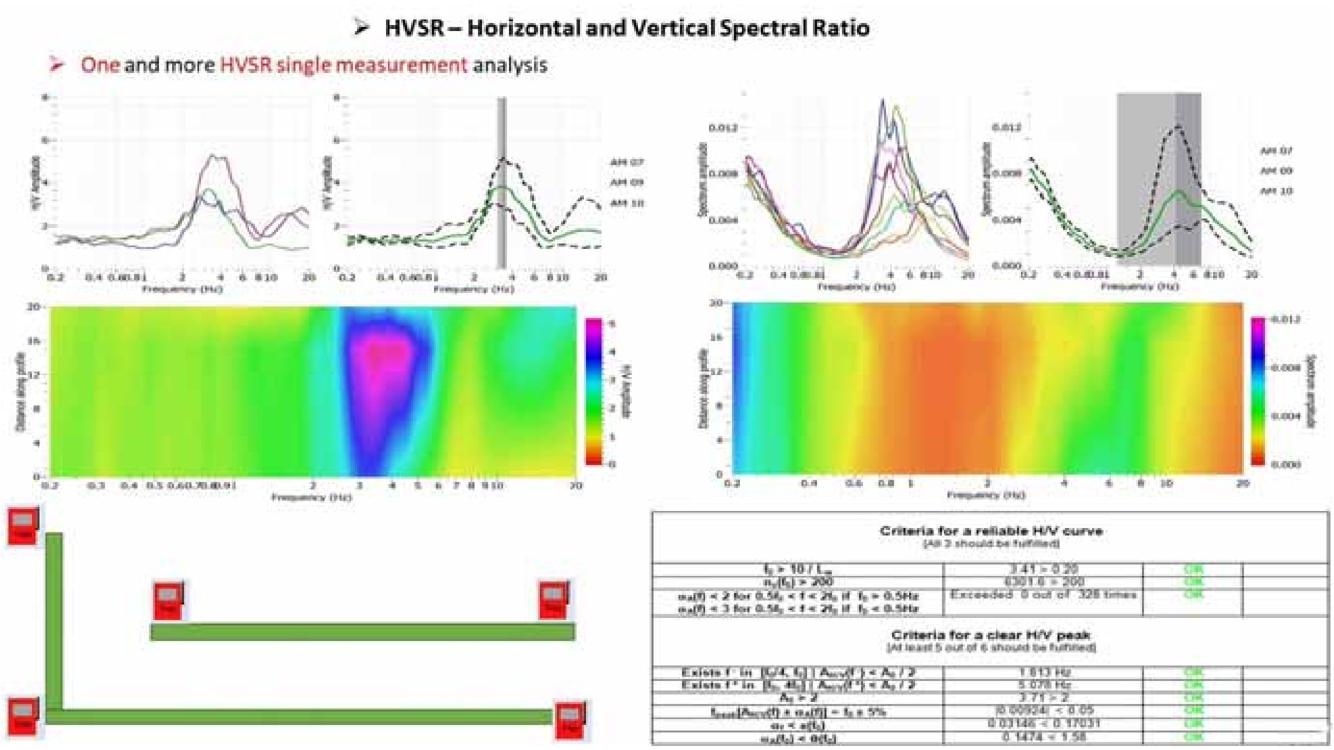


Pic.4 SASW – Data processing to evaluate S – wave velocity on the shallow and dipper part of soil.

• Microtremor tests measure the period and amplitude of soil vibrations, (environmental seismic noise or microtremor). HVSR (Horizontal and Vertical spectral Ratio) application to indentify Resonance frequency (f0,Hz) of subsoil and the thickness (H) of sedimentary cover of the bedrock and resonance interfaces. Pic.5



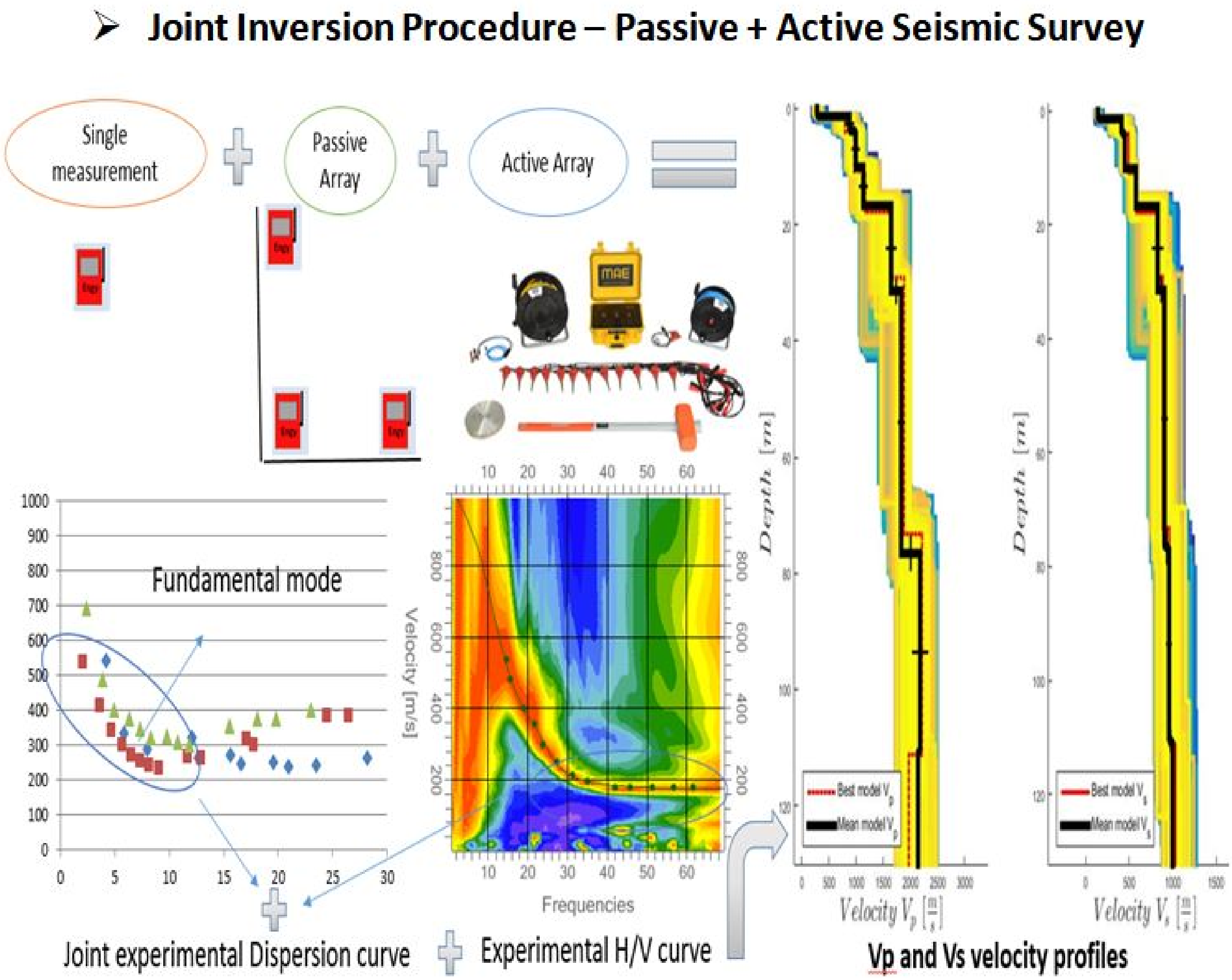
Pic.5 The basic case with one main subsoil Resonance frequency



Pic.6 One and more HVSR single measurement analysis, to evaluate reliable H/V curve and H/V peak

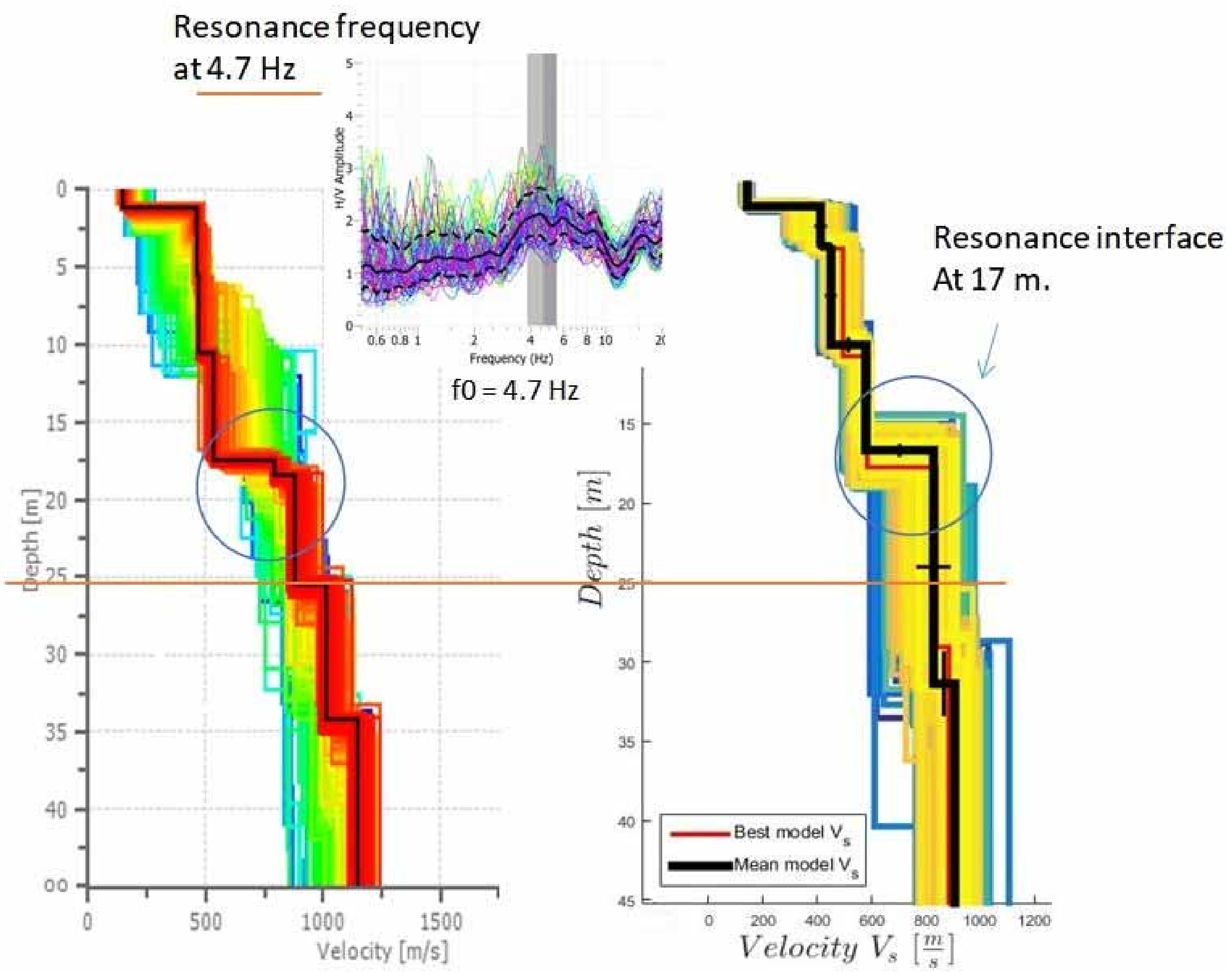
Pic.7 Seismograph Tromino 3G, Seismic noise measurement.

Joint inversion procedure of ESAC, SASW and HVSR application to evaluate depth part of subsoil Pic.8



Pic.8 Seismic wave velocity profiles (Vp and Vs) at 130 m depth.

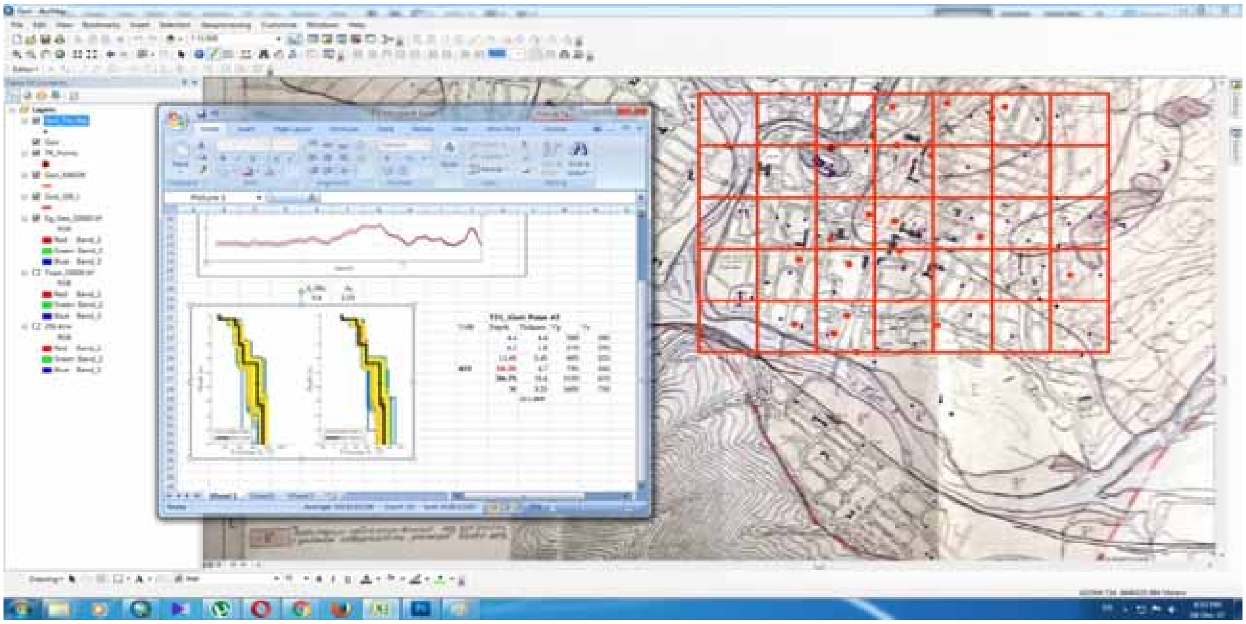
Pic.9 Estimation of resonance interface and and Seismic S - wave velocity profile.



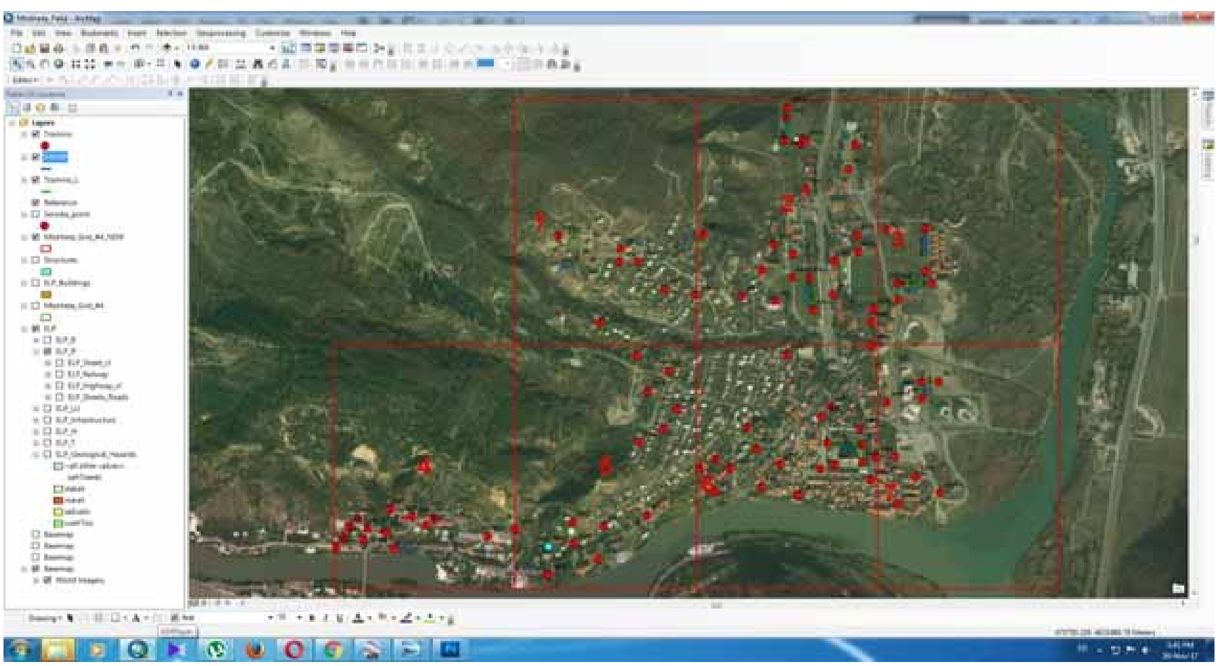
a) Vs velocity profile derived from MASW/SASW method.

b) Active(ras-24) and Passive (seismic noise measurement) combine data processing for estimate Vs velocity and resonance interface.

Data collecting and interpretation has been created in ArcGIS, where each study point corresponds to relevant reports. Pic. 10



Pic. 10 Mapping the subsoil resonance frequencies (H/V technique) and modeling the H/V curves



Pic. 11 Red bubbles correspond Seismic noise measurement points in the study area of Mtskheta city.

Instrumentation

TROMINO ® is a highly sensitive seismometer designed to record the background seismic noise.

• 3 velocimetric channels with adjustable dynamic range from ± 1 . 5 mm/s to ± 5 cm/s

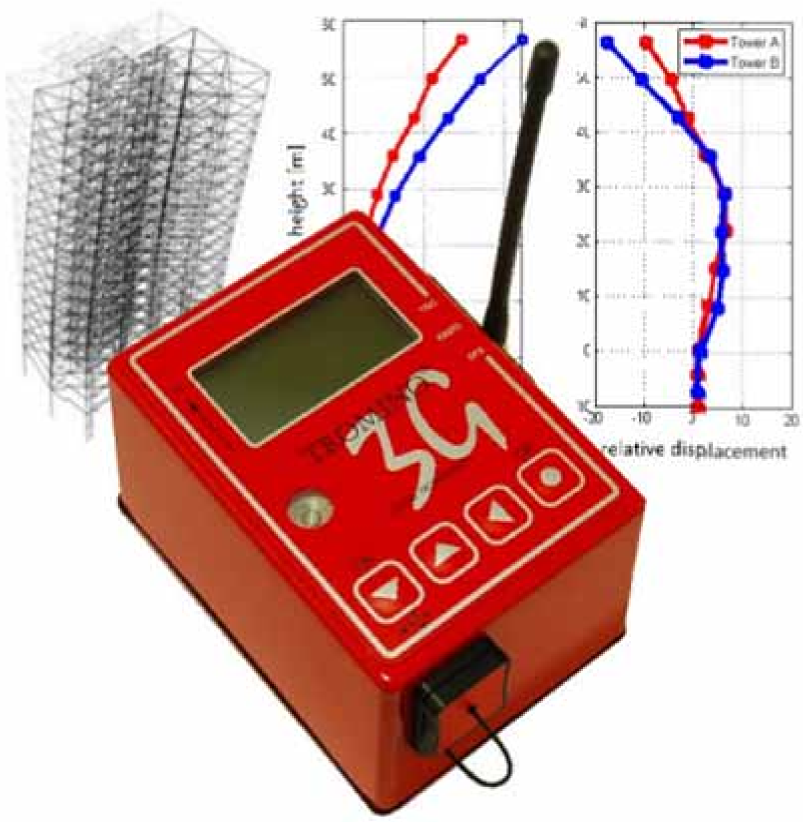
• 3 accelerometric channels

• Operating range 0 . 1 -2048 Hz on all channel

• 1 analog channel (external trigger for MASW/refraction)

• built -in GPS receiver , internal and/or external antenna for positioning and absolute timing/synchronization among different units

• built -in radio transmitter/receiver module for indoor/outdoor synchronization among different units and alarm transmission (e . g . , signal above threshold levels). Pic.11



Pic.11 Seismograph Tromino 3G.