Torre Pellice valley (Italy)

In the following we briefly summarized the main activities developed in order to define the seismic response of the Pellice valley as a joint cooperation among University of Genova, Politecnico di Milano, and the local representatives of Piemonte region.

Situation of the valley

Figure 1: Val Pellice valley

Geography

Orientation: E - W
General shape: V shape
Length: 35 km
Main width: 2 km
Thickness of quaternary deposits: 10 to over 180 m (northern side)
Elevation above sea level: 400 m to 1000 m (main towns)

History

General geological evolution: Lacustrine deposits at the bottom of the valley, with alternating fluvial sequences. Over are fluviatile and torretial deposits. To a lesser extent, some glacial deposits. Glacial effects have been very small in this valley.
Past lake: YES
Over-digging (approx. depth): NO
Past glacier: YES
Seismic activity (intensity, magnitude)   Max I-MCS=VIII

Human activity

Urbanization: about 10% of the surface, Torre Pellice town nearly 5000 inhabitants
Industry: YES, marginal; in particular, main industrial activities connected with “Pietra di Luserna” extraction and processing and disused textile industrial activities;

Geology

Bedrock type: Micaschiste, gneiss, schiste, prasinite, amphibolite, serpentinite, calcschiste
Bedrock slope (sides): 7° to 60°

Bedrock outcrop inside the valley: YES
Type of quaternary deposits: Alluvial (gravels and sand) , Lacustrine (silts, clays), Torrential and fluviatile (sandy gravels with pebbles), Morainic (very rare traces in the upper valley only)
General dip direction: gently towards E
Mud flow channel: NO
Fan delta: YES
Lacustrine delta: YES
Marsh / peat bog: NO
Collapse zone: YES
Landslide, creeping: YES
Rockfall activity: YES
Scree deposits on sides: YES
Lateral water streams, torrent, valley: YES
artificial fills: NO
Others: About shape: double paleo-bedriver (V-shape). Some erratic rocks in the upper valley.

State of art of the instrumentation and measurements in the valley at the beginning of the project

Boreholes:	31 boreholes and wells stratigraphies
Gravimetry:	4 gravimetric electric sections
Seismic data:	13 seismic refraction data
Ambiant vibrations	
Others:	5 magnetic sections, 50 s.e.v.

Instrumentation and measurements realised in the valleys during the project

Boreholes	4 boreholes (continuous core sampling, depths variable between 30m and 73m, equipped with plastic tubes for down-hole tests); n. 10 SPT tests; collection of n. 3 undisturbed samples for laboratory tests.
Gravimetry	
Seismic data	- 4 DH tests - 2 surface geophysical surveys by hybrid seismic techniques (reflection seismic methods associated to refraction tomography for P waves), realized along 2 rather-parallel profiles, perpendicular to the valley axis, for a total length of about 1700m (880m + 820m), with high resolution systems (geophone distance not longer than 2 m and total number of channels equal to 240); - 4 tests by Surface Wave Method (S.W.M.)
Ambiant vibrations	2 S.W.M. with passive technique
Others	laboratory tests in dynamic conditions *(*Resonant Column/Torsional Shear Test, RCTS) on 3 undisturbed samples

Within the scope of the Sismovalp project, a thorough subsoil exploration was undertaken with the aim of defining the physical-mechanical parameters of the superficial lithotypes as well as providing information about the geometry and the depth of bedrock structures. The investigation survey included: 4 boreholes, 4 seismic down-hole, 4 SASW tests and 2 hybrid seismic profiles. For optimally designing the temporary seismic network a preliminary noise survey was carried out in Val Pellice. The HVSR technique was applied on microtremor observations, collected using Marslite acquisition units coupled to Lennartz 3D seismometers: the results from 15 measurement points clearly revealed peaks in the frequency response ranging 1.2 - 1.5 Hz along the riverbed and suggested the presence of amplification phenomena between 2 Hz and 3 Hz all over Torre Pellice town alluvial terraces. Then, since June to November 2004, a temporary network composed by six accelerometer stations was installed in the municipal area of Torre Pellice. K2-Kinemetrics digital recorders were used, coupled with (external or internal) Episensor FBA ES-T accelerometers. Moreover, a velocimeter (Lennartz 3D-5s/MarsHD) was installed in the town centre in order to detect teleseismic events, useful to better investigate seismic response for frequencies lower than 1 Hz. The network was deployed following roughly the two seismic profiles in Torre Pellice, both perpendicular to River Pellice. Two accelerometer stations (PE01-PE07) were installed in the riverbed, three on the alluvial terraces (PE04-PE05-PE06) in Torre Pellice town centre, one on alluvial fan (PE02) and one on outcropping gneiss (PE03). Between November 2004 and December 2004 four velocimeter stations (PE08-PE09-PE10-PE11) were installed in order to better investigate the seismic response of both the lower part of the fluvial fan and the riverbed. During the month of December 2004 all residual receivers were removed and three velocimeter stations were installed at the sites previously adopted for PE03 PE06 and PE07. These stations were removed at the end of March 2005.

Using more than 170 low energy seismic events (2 < Md < 3.5) and several regional and teleseismic events recorded by installed accelerometers and velocimeters, RSM (Reference Site Method) and HVSR techniques were applied. For what concerns RSM method, being installed on outcropping gneiss, PE03 was used as a reference station.

RSM and HVSR techniques were also applied to teleseismic events recorded by velocimetric stations in order to better investigate seismic response at low frequencies. Results from spectral analyses pointed out the presence of relevant site amplification effects involving both Torre Pellice town and the surrounding areas. Starting from information derived using both RSM and HVSR techniques it is possible to recognize four main zones characterized by different seismic response:

- the riverbed zone, showing significant spectral amplifications in the frequency range 1-2 Hz;
- the ancient terraced fluvial deposits zone, characterized by relevant spectral amplifications in the frequency range 2 - 3 Hz;
- the fluvial fan zone, showing a wide band amplification pointed out through the calculation of RSM spectral ratios; in this case no site amplification phenomena have been recognized by using HVSR method;
- the zone located where the gneiss formation outcrops, where no amplification effects have been detected.

Results of the work done in the valley

Observed amplification effects may depend on the presence of lacustrine deposits, mainly characterized by clay and sand, located in depth between alluvial gravel shallow deposits and altered bedrock formations (till). These deposits present, considering a section orthogonal to the river, both variable thickness and low values of shear waves (300 m/s < Vs < 450 m/s, on the basis of down-hole experiments performed by Politecnico di Torino) with respect to the underlying geological formations (bedrock formations). The reliability of the analyses performed at different sites is confirmed by the substantial agreement among results coming from both HVSR (Figure 2) and RSM (Figure 3) techniques, applied for each considered station using noise, local earthquakes, regional and teleseismic events as input signal.

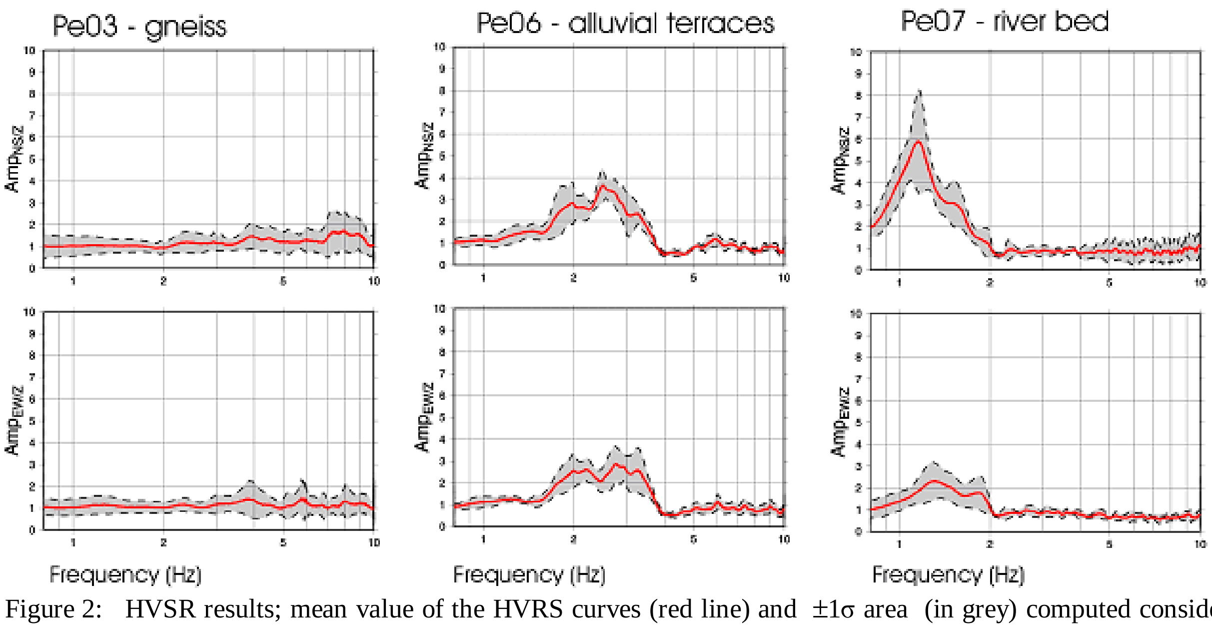

Figure 2: HVSR results; mean value of the HVRS curves (red line) and ±1σ area (in grey) computed considering the best quality data (local, regional e teleseismic events) for three representative sites

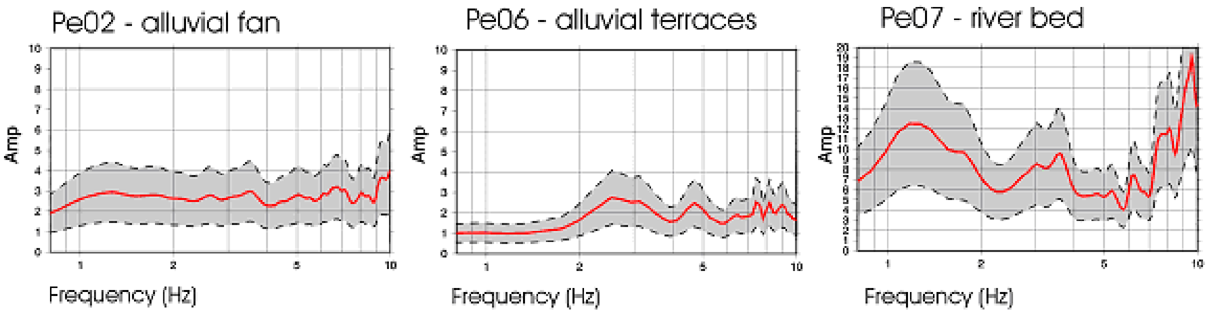

Figure 3: RSM results; mean value of the RSM curves (red line) and ±1σ area (grey) computed averaging NS and EW component, considering the best quality data (local, regional and teleseismic events) and taking PE03 as reference site

Both 1D and 2D numerical simulations of seismic response were also carried out by the Dept. Structural Engineering (Politecnico di Milano) the latter ones based on the best interpretation of the geophysical and geotechnical investigations available. Both profiles show prominent 2D effects, with some differences with respect to 1D results. The comparison with the observed amplification functions shows a reasonable agreement with the RSM results, considering the local events alone, but a significant discrepancy with the HVSR, especially in the locations where 2D effects dominate site response. The observed differences between experiments and modelling seem to be more related to geometric features of the models than to assumed mechanical properties of the different units. Although further numerical analyses are foreseen to clarify the reasons of the observed discrepancy among the numerical and experimental site amplification functions, namely by investigating the influence of different modelling assumptions, especially the geometry and the dynamic properties of the geological units at depth, we can conclude that the seismic response of a relatively narrow and complex valley such as Val Pellice is dominated by 2D effects, posing relevant problems in the interpretation of the experimental amplification functions.

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