La Salle (Val d'Aosta, Italy)

In the following we briefly summarized the main activities developed in order to define the seismic response of the La Salle fluvial fan as a joint cooperation among University of Genova, Politecnico di Milano, and the local representatives of Valle d'Aosta region.

Situation of the valley

Figure 1: La Salle (Val d'Aosta)

GEOGRAPHY	
Orientation	**NE-SW**
General shape	**Triangular alluvial fan**
Length	**1.5 km**
Main width	**2 to 2.5 km**
Thickness of quaternary deposits	**max 200 m**
Elevation above sea level	**850 to 1100 m**
HISTORY	
General geological evolution	**During the Quaternary, succession of alluvial fan deposits, made up of medium to coarse grainsize, on deposits of glacial enviroment.**
Past lake	**NO**
Over-digging (approx. depth)	**YES**
Past glacier	**YES**
Seismic activity (intensity, magnitude)	**Max I-MCS= V**
HUMAN ACTIVITY	
Urbanization	**<1800 inhabitants**
Industry	**not relevant**
GEOLOGY	
Bedrock type	**Micaschistes, gneiss, amphibolites and generally high-grade metamorphic rocks.**
Bedrock slope (sides)	**10° to 50°**
Bedrock outcrop inside the valley	**NO**
Type of quaternary deposits	**Alluvial conoid deposits(sand, gravel,stone).Polygenic slivers, stones and blocks (3-4 cm to meter scale)**
General dip direction	**gently towards SW**
Mud flow channel	**NO**
Fan delta	**YES**
Lacustrine delta	**NO**
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**

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

Boreholes	**5 pre-existing boreholes (SPT Tests) + 2 new boreholes (Downhole Tests) not yet available**
Gravimetry	**NO**
Seismic data	**2 deep reflection profiles**
Ambient vibrations	**YES (25 points)**
Others	**NO**

Instrumentation and measurements realised in the valleys during the project

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 a preliminary gravimetric investigation on the area and a hybrid seismic survey.

The hybrid seismic investigation revealed for the fluvial fan a typical morenic deposit configuration in which three reflectors characterized by materials with a growing seismic velocity appears; the crystalline substratum seems to be cut by numerous faults. As regards the bedrock formation underlying the fluvial fan, the hybrid seismic survey revealed a simple geometry, which, as shown in the following, justifies the use of simple numerical modelling techniques.

For the optimal design of the temporary seismic network, a preliminary noise survey was carried out in the area of La Salle and, since May to September 2005, a temporary network composed by four velocimetric stations (Lennartz 3D – 5s/MarsHD) and three accelerometric stations (K2–Kinemetrics digital recorders coupled with Episensor FBA ES-T accelerometers) has been installed in the municipal area of La Salle. The network was deployed to encompass regions inside the fan with different thickness, as indicated by seismic and gravimetric profiles, and one velocimetric station (used as the reference site in the following) was installed on outcropping rocks composed by arenaceus micaceous carbonic phylladic schists with antracite's levels, in the area of Fenetre. From May to September 2005, more than 40 low energy seismic events ($2 < Ml < 3.5$) and some regional events have been recorded by the seismic temporary network installed in La Salle. Using all local events selected for each station, RSM (Reference Site Method) and HVSR techniques were applied. For what concerns RSM method, being installed on outcropping schists, Lsv5 was used as a reference station. RSM and HVSR techniques were also applied to regional events recorded by velocimetric stations in order to better investigate seismic response at low frequencies.

Results of the work done in the valley

The HVSR results from all accelerometric and velocimetric stations do no show particular amplification effect. Nevertheless the application of RSM techniques points out different seismic response between the reference station and the other ones located on the fan. In particular it is evident that the stations installed on the alluvial fan (Lsa2, Lsv4, Lsa4, Lsv6), near La Salle village, show relevant site amplification effects in a wide frequency range starting from about 1 Hz.

The RSM results (Figure 2) indicate that the seismic signal recorded in the alluvial fan is clearly amplified with respect to the reference station and the amplification level of the peaks at frequencies greater than 1 Hz increases from Lsv1 station towards Lsv6 station. The seismic response of the fan, as indicated by RSM technique application, seems to be dominated by a wide amplification band in which several amplification peaks appear for the frequencies 2, 4-5, 7-8 Hz.

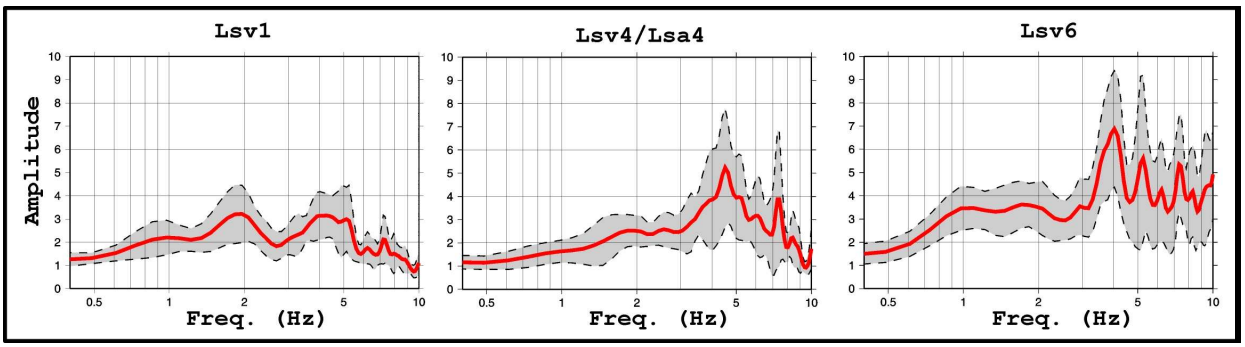

Figure 2: RSM results; mean value of the RSM curves (red line) and ±1σ area (grey) computed averaging NS and EW component, considering the best quality data (local and regional) and taking Lsv5 as reference site.

The support of 2D numerical simulations performed by Dept. Structural Engineering (Politecnico di Milano) has been useful to highlight that the fundamental resonance frequency of the fan is expected to be around 2 Hz, in reasonable agreement with the observations during the local events in La Salle. While more complicated and detailed modelling assumptions can be adopted, assuming for example a 3D geometry for the fluvial fan deposit in order to investigate source-site azimuth dependence of the seismic response, we believe that the results presented here can be a useful starting point to address from a quantitiative point of view an issue that is often disregarded in seismic hazard studies.