SECOND EUROPEAN CONFERENCE ON EARTHQUAKE ENGINEERING
AND SEISMOLOGY, ISTANBUL AUG. 25-29, 2014

SITE EFFECTS IN ALPINE REGIONS FROM SYSTEMATIC SITE CHARACTERIZATION AT STRONG MOTION STATIONS

Clotaire MICHEL[1], Benjamin EDWARDS[2], Valerio POGGI[3], Jan BURJANEK[4], Carlo CAUZZI[5] and Donat FÄH[6]

Switzerland is currently upgrading its strong motion network (SSMNet). 30 new permanent stations were installed over the period 2009-2013. In the framework of this project a site characterization procedure has been developed and systematically applied (see Michel et al., 2014 for more details). The main goal of the procedure is to retrieve realistic 1D velocity profiles for each site hosting a strong motion station.

The retrieval of 1D velocity profiles, mostly based on the analysis of surface waves, is achieved through the following procedure:

- collection of available data;
- ambient vibration array measurements and, if necessary, active seismic experiments;
- single station processing (H/V ratios to retrieve the ellipticity of Rayleigh waves, polarization analysis to highlight 2D effects);
- 3-component array processing to retrieve dispersion curves of Rayleigh and Love waves;
- combined inversion of ellipticity and dispersion data into 1D velocity profiles;
- computation of secondary parameters such as Vs_{30} and SH transfer functions.

In addition, the retrieved SH transfer functions are compared to amplification functions obtained through spectral modelling (ESM) of recorded events at the strong motion station (Edwards et al., 2013). Both amplification functions are computed with respect to the Swiss reference rock model. This comparison process allows us to discard unrealistic profiles and eventually modify the assumptions in the site characterization.

The procedure proved to be very efficient in retrieving realistic profiles and the obtained amplification functions match well for a large number of sites. Fig. 1 presents the Vs_{30} of the study-sites with respect to the maximum amplification in the ESM function. More than the obvious correlation between Vs_{30} and the amplification, the figure shows the instrumented site types, typical of the alpine environment. Glacial-lacustrine sediments with low Vs_{30} corresponding to ground type C EC8 (CEN, 2004) and high amplification up to a factor of 15 are recognized at 6 sites. No sites of ground type D were found. Glacial-fluvial sediments, corresponding to ground type C, constitute the majority of sites with amplification factors of 2 to 8. Various rock sites, from sandstones in the foreland to hard rock from the Alps, are also present. Only one site falls into the definition of type E.

[1] Dr., Swiss Seismological Service, ETH Zurich, clotaire.michel@sed.ethz.ch
[2] Dr., Swiss Seismological Service, ETH Zurich, ben.edwards@sed.ethz.ch
[3] Dr., Swiss Seismological Service, ETH Zurich, valerio.poggi@sed.ethz.ch
[4] Dr., Swiss Seismological Service, ETH Zurich, jan.burjanek@sed.ethz.ch
[5] Dr., Swiss Seismological Service, ETH Zurich, carlo.cauzzi@sed.ethz.ch
[6] Prof. Dr., Swiss Seismological Service, ETH Zurich, donat.faeh@sed.ethz.ch

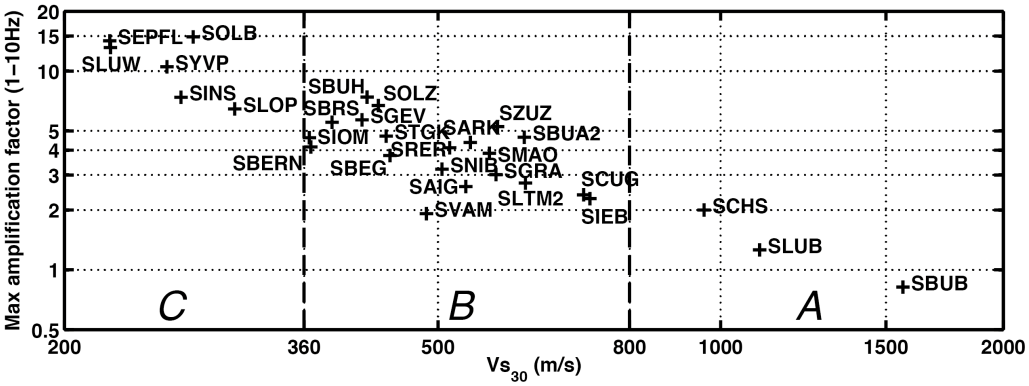

Figure 1. Vs_{30} of sites with new strong motion stations with respect to maximum observed site amplification from ESM of earthquake recordings in the frequency band 1-10Hz. EC8 ground types are also displayed.

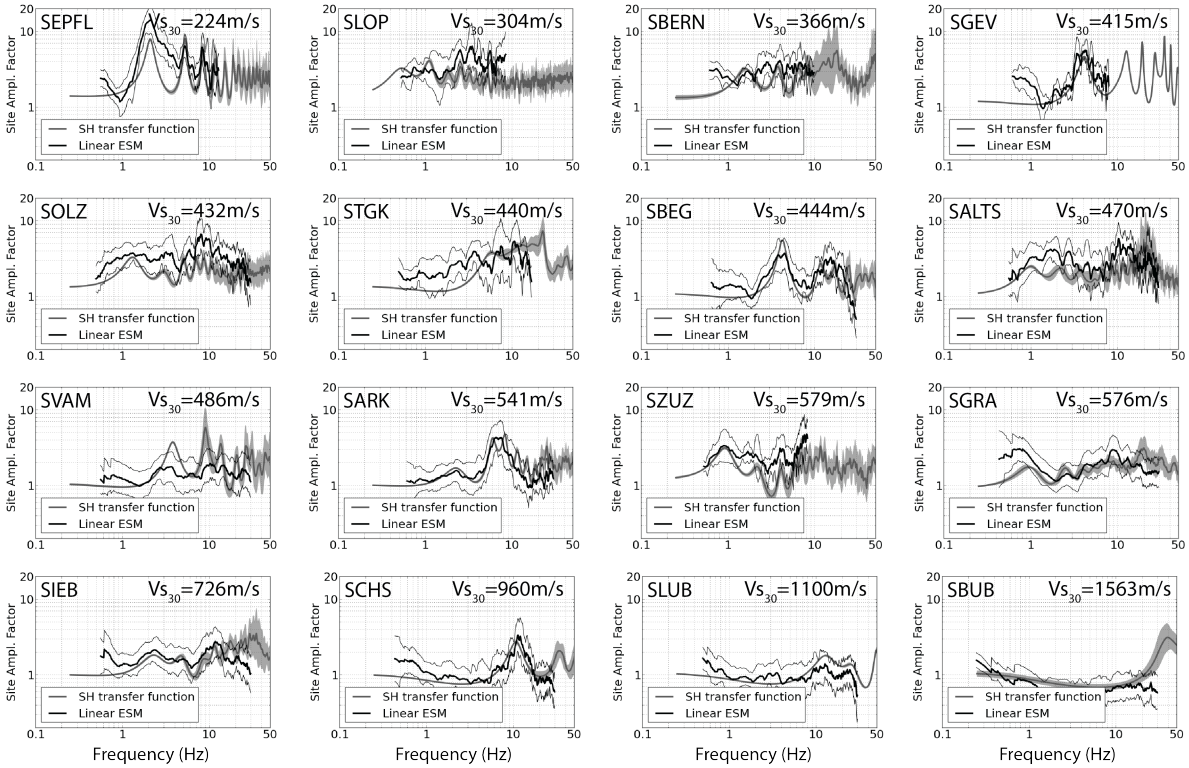

Figure 2. Comparison of ESM amplification (black) and SH transfer function from the site characterization (grey) for sites showing a 1D behaviour, ordered by increasing Vs_{30}.

Fig. 2 presents the comparison of ESM amplification functions with SH transfer function computed from the retrieved velocity profiles for sites with 1D behaviour. In many cases, 1D assumption is perfectly valid and sufficient to represent site effects.

Moreover, 2D/3D effects could be highlighted with this procedure (Fig. 3). The generation of surface waves at the edges of basins (EGSW, local effect) and the 2D resonance (global effect) are recognized at number of sites of the newly installed stations. EGSW are recognized from the comparison between ESM and 1D SH transfer functions as flat large amplifications above the resonance frequency of the site. 2D resonance is recognized by polarization of the surface waves in the direction of the valley axis, or the perpendicular direction. However, in several cases, these criteria are not unequivocal and these cases are classified as “unclear” in Fig. 3. 2D resonance is recognized in the large basins of the Rhone, the Aar and Rhine but also in smaller structures such as alluvial fans and alpine valleys. EGSW are clearer in basins with low Vs_{30} and in the Rhine graben.

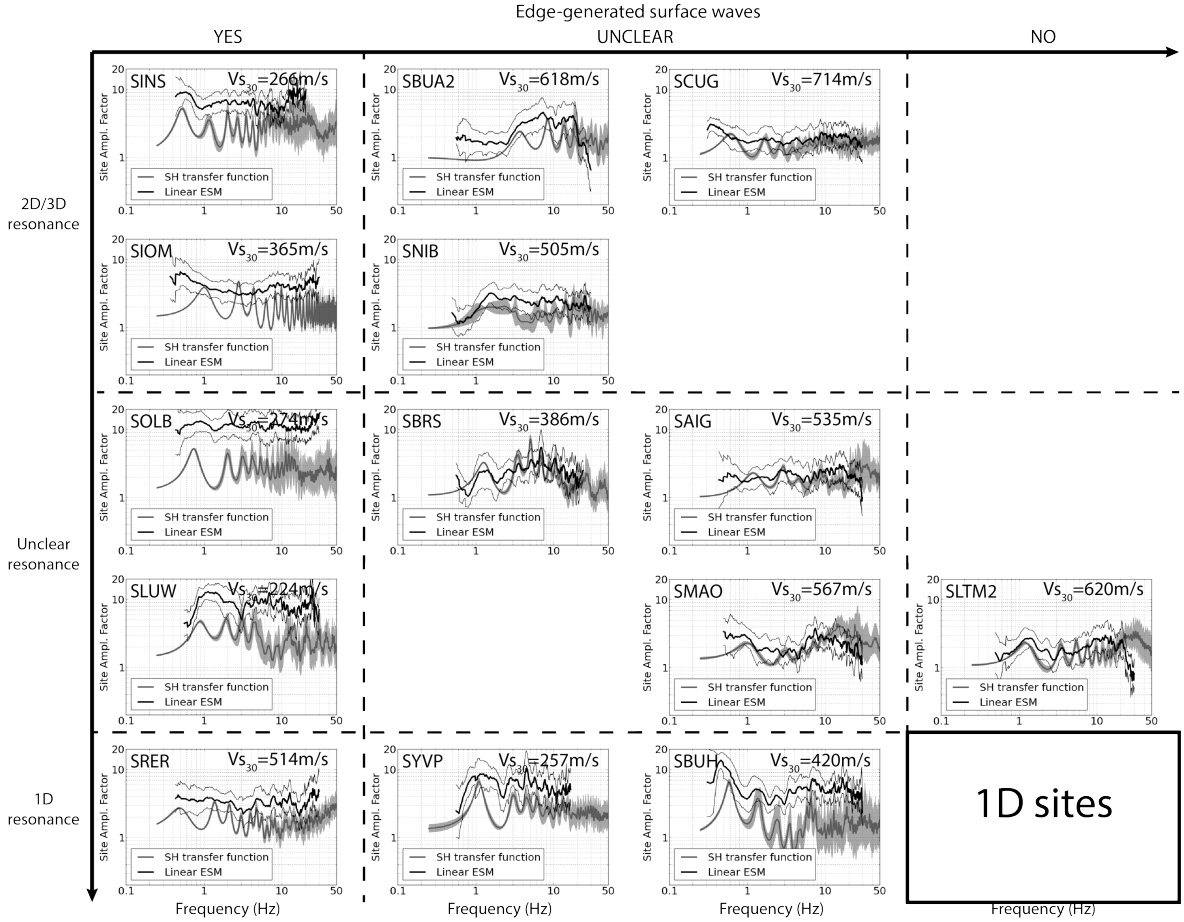

Figure 3. Comparison of ESM amplification (black) and SH transfer function from the site characterization (grey) for sites showing 2D effects.

REFERENCES

CEN. (2004). *Eurocode 8: Design of structures for earthquake resistance - Part 1: General rules, seismic actions and rules for buildings* (EN 1998-1:, pp. 1–229). European Committee for Standardization

Edwards, B., Michel, C., Poggi, V., & Fäh, D. (2013). Determination of Site Amplification from Regional Seismicity: Application to the Swiss National Seismic Networks. *Seismological Research Letters*, *84*(4), 611–621. doi:10.1785/0220120176

Michel, C., Edwards, B., Poggi, V., Burjanek, J., Roten, D., Cauzzi, C., & Fäh, D. (2014). Assessment of site effects in alpine regions through systematic site characterization of seismic stations, *submitted*.