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Appendix: Reference Shear-wave Velocity Rock Model for the 2015 Swiss Hazard Model (SuiHaz15)

This appendix provides a brief summary of the reference shear-wave velocity model for use with the 2015 Seismic Hazard Model (SuiHaz15, Wiemer et al 2015). Specifically, such reference provided the basis to adjust the ground motion equations to a common site condition for use with the hazard estimates for Switzerland. The development of the reference shear-wave velocity model is described in detail by Poggi, Edwards and Fäh (2011) and summarized hereinafter.

The method is based on the comparison of measured average shear-wave velocities at specific seismic stations with the corresponding amplification obtained from spectral modeling of small magnitude events (e.g., Edwards et al., 2008). To relate the frequency-dependent amplification functions (Figure 1) to the velocity information, the quarter-wavelength approximation (Joyner at al., 1981) is used. With this approach, we can estimate the average seismic parameters (shear-wave velocity and density) up to a depth that corresponds to one quarter of the wavelength of interest. The advantage of such a procedure is the possibility of relating the depth over which the average velocity is computed to a specific frequency (Figure 2). As such, each average velocity estimate (versus depth) will be uniquely associated to a specific amplification factor at a defined frequency.

For the calibration, 27 seismic station locations in Switzerland were investigated to characterize shear-wave velocity as function of depth. The stations are part of the Swiss Digital Seismic Network (SDSNet) and the Swiss Strong Motion Network (SSMNet). From the ensemble of all measured sites, amplification versus average velocity relationships (log-loglinear correlations) were computed for a set of discrete frequencies between 1 and 15 Hz (Figure 3).

Then, assuming that the reference profile is defined by a lack of any relative amplification, the expected quarter-wavelength average velocities corresponding to relative "unitary" amplification were extracted and collected from these relations separately. By collecting the average velocity estimates at the different frequencies, a quarter-wavelength representation of the reference velocity profile can then be established (Figure 4a). A representation of the shear-wave velocity profile versus depth is required to define the rock reference profile. This can be obtained through an inversion procedure (Figure 4b).

The functional form (Equation 1) and the corresponding coefficients (given in table 1) can be used to compute the reference shear-wave velocity rock profile for Switzerland according to the method in Poggi et al. (2011) and Edwards et al. (2009).

$$Vs(z) = \left(Vs_{max} - Vs_{min}\right)\left[1 - a^{\left(\frac{z_{top} - z}{b}\right)}\right] + Vs_{min}$$

Equation 1. *Proposed functional form of the reference S-wave velocity rock profile.*

a	b	v-min (m/s)	v-max (m/s)	z-top (m)
1.3047	78.1674	1000	3200	0.5

Table 1. *Coefficients of the reference S-wave velocity rock profile equation.*

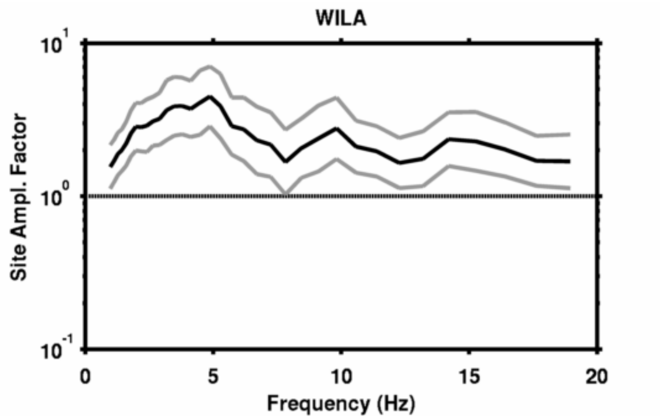


Figure 1. *Example of empirical amplification for the station WILA, obtained by spectral modelling. The amplification function is referenced to an unknown site condition, which is later defined by the proposed method.*

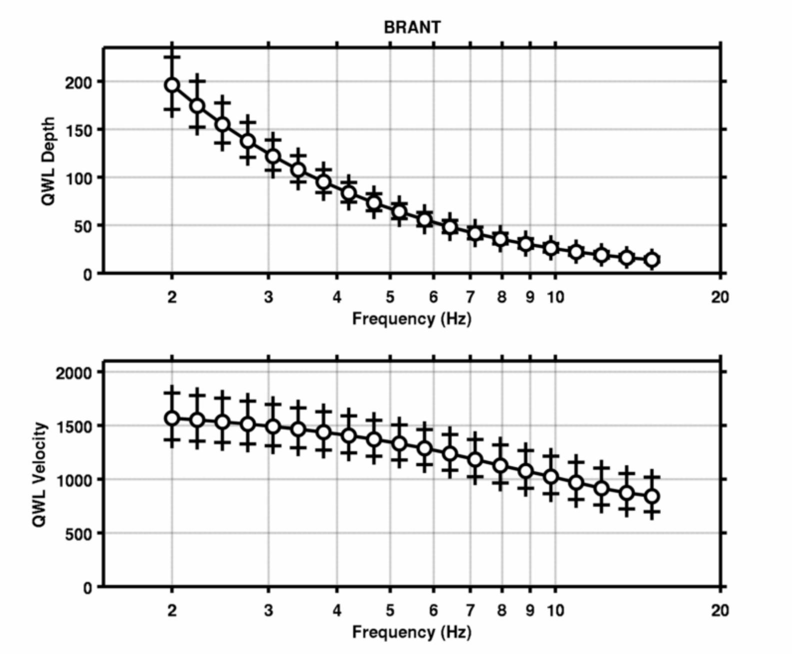


Figure 2.*Example of quarter-wavelength representation of the Vs velocity profile at the station BRANT. Site characterization was performed by Multichannel Analysis of Surface Waves (MASW).*

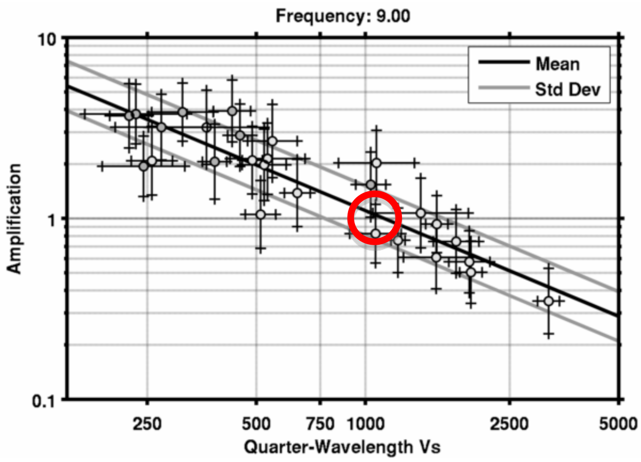
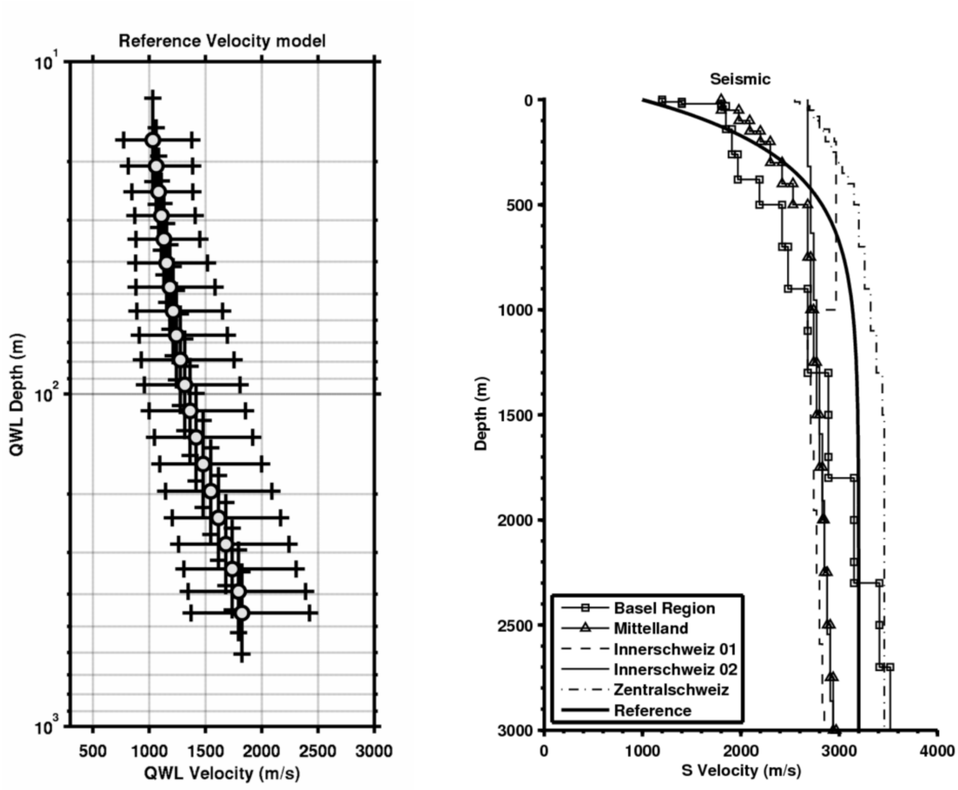


Figure 3. *Correlation between quarter-wavelength (Qwl) average velocities (MASW with dots in light grey, ambient noise in dark grey) and amplification factors from spectral modelling of earthquake spectra (here an example at 9Hz). A linear least-squares regression is applied in log-log scale to estimate parameter correlation. The red circle indicates the Qwl-velocity at unitary amplification.*



A) B)

Figure 4. *A) Quarter-wavelength representation of the reference velocity profile obtained from the correlations between quarter-wavelength average velocities and amplification factors. B) Inverted reference velocity profile in comparison with previous references from independent studies in Switzerland (Campus and Fäh, 1997).*

References

Campus, P. and D. Fäh (1997).Seismic monitoring of explosions: A method to extract information on the isotropic component of the seismic source. Journal of Seismology, 1, 205-218.

Edwards, B., A. Rietbrock, J. J. Bommer, and B. Baptie (2008). The Acquisition of Source, Path and Site Effects from Micro-earthquake Recordings using Q Tomography: Application to the UK, Bull. Seismol. Soc. Am., 98, 1915–1935.

Edwards, B., B. Allmann., D. Fäh and V. Poggi (2009), Stochastic Model for Switzerland, Swiss Seismological Service Technical Report: SED/PRP/R/006/20091130, for the swissnuclear Pegasos Refinement Project.

Joyner, W. B., R. E. Warrick, and T. E. Fumal (1981). The effect of Quaternary alluvium on strong ground motion in the Coyote Lake, California, earthquake of 1979, Bull. Seism. Soc. Am. 71, 1333-1349.

Poggi, V., B. Edwards, and D. Fäh., (2011).Derivation of a Reference Shear-Wave Velocity Model from Empirical Site Amplification, *Bull. Seis. Soc. Am.*__101__, 258-274.