VERIFICATION OF THE V_{S30} AS A SITE AMPLIFICATION PROXY, CASE STUDY FROM THE WEST BOHEMIA SEISMIC NETWORK

Martin Mazanec, Faculty of Science, Charles University, Prague, Czech Republic
Jan Valenta, Faculty of Science, Charles University, Prague, Czech Republic
Jiří Málek, IRSM Czech Academy of Sciences, Prague, Czech Republic

Local site conditions play a significant role in a ground motion since it may amplify amplitudes of an incoming wave field. The average shear-wave velocity in the uppermost 30 m (V_{s30}) was initially introduced by Borcherdt (1992) to provide uniform definitions of site classes. It is now a generally accepted site classification parameter e.g., in the Earthquake Hazard Reduction Program (NEHRP), Uniform Building Code (UBC) or Eurocode 8 provision. Some authors, however, express doubts whether the V_{s30} is an appropriate parameter for evaluating a site amplification. Castellaro et al. (2008), for example, claimed that the seismic amplification is too complex to be related only to the V_{s30}. To better understand if the V_{s30} sufficiently represents the site amplification we correlated observed earthquake seismic data from eighteen seismic stations of the West Bohemia Seismic Network (WEBNET) with V_{s30} estimated by a multichannel analysis of surface waves (MASW).

The West Bohemia/Vogtland region forms the western section of the Bohemian Massif and is located in the transition zone between three distinct Variscan structural units. It is unique for its intraplate earthquake swarm activity with a frequent occurrence mostly of magnitudes ML ≤ 3.5. Using the MASW we obtained a 1D seismic shear-wave velocity (V_s) model and a V_{s30} for each of the eighteen WEBNET station locations. The active seismic acquisition consisted of 24-channels linear receiver array with 4.5 Hz vertical geophones with spacing from 3 to 5 meters according to local topographical conditions. For achieving a high signal/noise ratio, 8 vertically stacked impacts of a 10 kg sledgehammer on a metal plate were used at each shot point as a seismic source. The determined V_{s30} values range from ∼400 to 1400 m/s.

To estimate the site response (amplification ratio), we correlated the V_{s30} with observed horizontal to vertical spectral ratios (HVSR) of the M6.4 Petrinja earthquake (December 29, 2020) recorded by the WEBNET. We compared HVSR ratios of both horizontal components separately (i.e., R – radial and T – transverse) and related them to the reference station (station with the lowest amplitudes of recorded earthquake). These ratios are defined as relative amplification ratios. We chose different frequency windows (0-0.5 Hz, 0.5-1 Hz, 0.5-2 Hz, 1-2 Hz, 1-3 Hz, 2-4 Hz, 4-8 Hz, 8-16 Hz) and for each frequency window calculated the average value of relative ratios. Next, we applied polynomial regression to the datasets with a quantitative estimator of the goodness of fit – the regression coefficient R^2.

The regression analysis shows the best fit of HVSR and V_{s30} in the frequency window 1-3 Hz for HVSR-R (radial component) with $R^2 = 0.868\%$ for the third-degree polynomial and 1-2 Hz for HVSR-T (transverse component) with $R^2 = 0.869\%$ for the third-degree polynomial. With the increasing frequency the relation between V_{s30} and relative amplification amplitude degrease rapidly. Correlation indicates that for seismic stations with high shear-wave velocities the amplification is low. For stations where V_{s30} is under 600 m/s the amplification ratio is much higher and with the velocity decrease it increases significantly. Three zones are visible on the correlation of relative amplification ratios and the V_{s30}: i) high velocity zone with the V_{s30} above ∼900 m/s, here the amplification does not change significantly and the amplification difference for sites in the V_{s30} range 900–1400 m/s is minor; ii) slow velocity zone with the V_{s30} under ∼700 m/s, where the difference in velocity affects substantially the amplification; iii) middle zone – stations having low amplification despite V_{s30} being relatively low – approx. 700 m/s.

This study characterized local geology effects on the WEBNET sites using the V_{s30} and correlated this parameter with recorded far field earthquake data to see if the V_{s30} really reflects the earthquake amplification. It is evident that for the sites with a low shear velocity, the amplification is significant and can be estimated based on the V_{s30}. In contrast, the results show that there is a certain value of the V_{S30} over which the amplification does not change significantly. According to our results, the coherent rocks, where V_{S30} exceeds 900 m/s have only negligible effect on the site conditions and earthquake amplification. Despite many doubts in this case the parameter V_{s30} seems for low V_{S30} values as an effective proxy for the site amplification.