ESC2016-108, 2016
35th General Assembly of the European Seismological Commission

A Multimethod Approach for Acquiring Shear-wave Velocity Data (Vs30) for Seismic Hazard Site Characterization Within the Urban Environment

Jack Odum (1), William Stephenson (2), Robert Williams (3), and Theodora Volti (4)

(1) U. S. Geological Survey, Golden, Colorado, United States (odum@usgs.gov), (2) U. S. Geological Survey, Golden, Colorado, United States (wstephens@usgs.gov), (3) U. S. Geological Survey, Golden, Colorado, United States (rawilliams@usgs.gov), (4) Geoscience Australia, Canberra, Australia (Theodora.Volti@ga.gov.au)

The use of site-specific shallow shear-wave velocity (Vs) to assess site response is an important parameter in urban seismic hazard investigations, building codes, and in design applications by the earthquake engineering community. The need for rapid, accurate, and inexpensive collection of shallow Vs data over large urban sedimentary basins and within heavily developed cities is critical for urban hazard mapping, site amplification estimation, and earthquake-effects studies. As part of a continuing effort to evaluate the strengths and limitations of Vs acquisition methodologies in various geologic and environmental settings, the United States Geological Survey and Geoscience Australia have developed a site acquisition strategy of using co-located multi-method site surveys. Our multimethod Vs characterization approach requires the acquisition of co-located body-wave and surface-wave data during a site survey. A key advantage of this approach is that it captures independent wave-field propagation effects that can yield a more robust estimate of velocity and thickness of subsurface strata. Typical methods used include active-source (4-kg sledgehammer) P- and S-wave seismic-refraction/reflection, multichannel analysis of surface-waves (MASW), and both passive-source refraction microtremor (ReMi), and passive-source spatial auto-correlation (SPAC).

Challenges to acquiring high-quality Vs data to increasingly greater depths (greater than 30 m) in urbanized areas come from inherent logistical constraints such as limited space available for sensor arrays and the signal-to-noise degradation related to buildings, infra-structure and cultural noise. Cultural noise can overwhelm the active-source signal due to its intensity and location with respect to the acquisition array and bias model results during passive-source acquisition due to inconsistency of cultural noise direction and frequency content. While it may not be possible to acquire data using all methods at every site, we typically were able to acquire data using at least three methods. Some sites selected for multi-method surveys are in the proximity of preexisting Vs-logged boreholes, allowing a comparison of up to four different acquisition methods at those sites. Vs-versus-depth profiles from sites underlain by different geologic materials are used to (1) analyze the similarities and differences in resulting Vs structure derived from the collocated multi-method data sets, (2) determine if Vs30 values from different methods significantly alter NEHRP site classifications, and (3) examine how geologic stratigraphic structure influences data quality and reliability. Additionally, in some studies first order estimates of site frequency derived from multimethod Vs data are compared to horizontal-vertical spectral ratios (HVSR) derived from recordings at nearby portable seismographs deployed in aftershock studies.

We find that co-located body-wave and surface-wave methods complemented each other for the development of Vs-verses-depth models and the determination of Vs30. Our procedure of using a multi-method acquisition approach with co-located arrays helps corroborate results, adding confidence that reliable site characterization information has been obtained. Importantly, inconsistencies in results maybe a warning sign of poor data quality and possible misinterpretation and or overestimation of surface-wave results, indicating the need for further analysis.