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Combination of different seismic methods and geotechnical sounding for a rapid characterization of the near-surface ground

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For economical and feasible seismic exploration of the near-surface ground, an approach has been developed for the joint application of reflection and refraction seismics as well as multi-channel analysis of surface waves (MASW). The measuring concept was tested within the research project COMEXTECH, dealing with the exploration of construction ground. Besides the overall characterization of the subsurface by refraction and reflection seismics, the MASW can be used for the derivation of relevant soil parameters such as soil stiffness. The centre of the measuring concept represents a land streamer, pulled by a vehicle equipped with the seismic source. The 24-channel land streamer may be tipped with different geophones, according to the focus of investigation.
We used three fully equipped land streamers with 72 channels at all at the test site Nauen close to Berlin, Germany. The first 24 positions of the land streamer nearby the seismic source were filled with 4.5 Hz geophones. The next two land streamers were tipped with 14 Hz geophones, respectively. The idea behind this arrangement is that the positions close to the shot point, which are not utilisable for reflection seismics, can be used for the interpretation of surface waves. The signal was given with an accelerated weight drop mounted on a cross-country vehicle. Shots were arranged every meter, and four shots per shot point were executed for an increased signal/noise ratio. Three registration units (GeodeTM by Geometrics) were connected in series for signal recording.
At the site, a profile of 164 m length was investigated in bidirectional manner in combination with geotechnical exploration technique. The purpose of bidirectional recording is to check the reliability and sensitivity of the seismic array and to increase the resolution of the image of the subsurface. By using the same shot points forth and back, a multiple overlap rate for certain common depth points (CDP) can be achieved, which is thought to result in an increased data quality. Geotechnical investigations comprise the use of Cone Penetrating Tests (CPT) for characterization of properties of the subsurface. Thereby the lithology may be derived by means of the friction ratio, which represents the ratio of the in-situ determined parameters of sleeve friction and cone resistance during CPT soundings.
First results of data processing are available for the interpolated shear wave velocities (Vs) of the analysis of the Rayleigh-type surface waves on a multichannel record (MASW) by using the program SURFSEIS. The velocities are more or less laterally layered with zones of lower velocities (<180 m/s) in the upper subsurface and in about 5 m depth at the southern part of the profile. The strong increase of shear-wave velocities in 10 m depth and below (>250 m/s) is supposed to correspondent to a glacial moraine underlying the sandy sediments. The characterization of the near-surface ground by MASW corresponds well with the results of the nearby CPT soundings. By comparing the MASW results of the forward and backward recording of the profile, however, it turns out that the methodical approach of bidirectional seismic measurements still needs some tests. The produced 2-D Vs profiles show some marginal differences in the Vs-distribution in detail. Processing of seismic refraction and reflection data are in progress yet.
In summery, the land streamer has the real advantage of fast data recording with a variable geophone array for different applications. The slight loss in quality of seismic data does not limit the use of the land streamer even on arable land. If carefully performed, geophones fitted on the land streamer still record data in an adequate quality for a feasible characterization of the subsurface, as shown in our study. Especially along long profiles the employment of a land streamer outplays stuck geophones by the fast progress in data recording due to the pulled array of geophones in a fixed geometry.