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Near-surface S-wave velocity measured with six-degree-of-freedom seismic sensor Rotaphone

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An essential parameter in seismic engineering is the near-surface S-wave velocity. Rotaphone, a six-degree-of-freedom seismic sensor can be used with advantage to retrieve it from collocated rotational and translational measurements. Rotaphone consists of highly sensitive geophones connected to a conjoint datalogger. The geophones are mounted in parallel pairs to a rigid (metal) ground-based frame. The instrument is designed to measure short-period translational ground motion (velocity) and, in addition, differential motion between the paired geophones. The records of those differential motions are used to obtain rotational components. In-situ calibration of individual geophones is performed simultaneously with each measurement, which enables to reach high sensitivity and accuracy of rotational measurements.
In our method we utilize seismic waves produced by anthropogenic source - a generator of S waves and rotational ground motions. The generator contains a fixed part (anchored to the ground), a revolving part and a braking mechanism for immediate braking of the rotational part, in which rotational seismic motions are generated by immediately stopping the revolving part, whereby energy is transmitted into the rock massive. The generator produces repeatedly identical source pulses. Due to identity of the source pulses, we can suppress noise by means of stacking data from many generator actions and thus increase the depth range and resolution. The phase velocity retrieval is based on matching relevant acceleration and rotation rate components. Thanks to a near-source distance and high-frequency content of the source pulses, well-known equations for plane-wave approximation must be replaced by more adequate equations relating the individual rotation rate components to the translational ones. These equations are derived under an assumption of spherical wave. The resulting S-wave phase velocity is compared to the value obtained by standard profile measurements. The advantage of our approach in comparison to the profile method is that the resulting velocity is obtained from a single-point measurement.