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Use of Refraction Microtremor (ReMi) technique for the determination of 1-D shear wave velocity in a landslide area

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In the context of an ongoing study on seismic response of landslide-prone hill-slopes in Central Italy (area of Caramanico Terme), we tested the applicability of the Refraction Microtremor (ReMi) analysis technique (Louie, 2001) to obtain geometrical and physical parameters needed for numerical modelling. In particular, we used this technique to determine one-dimensional shear-wave velocity profiles (Vs) at sites located on and close to a recent landslide that mobilized 30-40 m thick Quaternary colluvium overlying Pliocene mudstones.

The use of this technique in unstable slope areas presents difficulties related to rough topography and lateral lithological heterogeneities, which prevent the extension of geophone array up to the minimum lengths (100 – 200 m) commonly adopted in standard applications. Moreover, sites distant from anthropic sources of microtremors can have unfavourable noise conditions in comparison with other well established cases of application.

To check the stability of the ReMi data in these operative conditions and the confidence level of the results, three ReMi campaigns were conducted at different times using different acquisition parameters (seismograph channel number, geophone frequency and spacing). We also tested simultaneous noise recording along orthogonal arrays to investigate a possible presence of directional variations of soil properties. The Rayleigh wave velocity dispersion data derived from picking carried out on p (slowness)-f (frequency) matrix showed the presence in noise recordings of different Rayleigh wave vibration modes (fundamental and first two higher modes), which prevail at different frequency intervals. This indicates that it is essential to correctly identify the different vibration modes to avoid erroneous data interpretation (e.g. fictitious identification of velocity decrease with depth).

An analysis of the influence of changing environmental conditions and of different acquisition parameters was conducted through the comparison of data obtained from different campaigns with equal acquisition parameters and from simultaneous acquisition with different parameters. We show that different data acquisition can give quite stable results if spatial aliasing does not contaminate the signal in the p-f matrix near the picking area. Regarding the presence of directional variations, the differences found between velocities measured in two orthogonal directions were not very large (up to 10-20 %). These differences were more probably due to an anisotropic distribution of the noise sources rather than to lateral variations in material properties.

The Rayleigh wave velocity dispersion curves, obtained from microseismic noise recording, were then inverted with the software Dinver (Wathelet, 2005) to derive shear-wave vertical distribution. This resulted in a large number of models compatible with data uncertainties estimated from measurement repetitions. The major variability characterizing the models at depth implies that this part of profiles is poorly constrained. However, if different vibration modes are recognised, the number of solutions can be considerably reduced by simultaneously inverting the relative dispersion curves and also by introducing into the models additional constraints (e.g. subsurface information from boreholes and seismic refraction data).

References

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