COMPARISON OF SEISMIC INTERFEROMETRY AND MULTICHANNEL ANALYSIS OF SURFACE WAVES FOR ESTIMATION OF S-WAVE VELOCITY IN LANDSLIDE COLLUVIUM

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Introduction

Geophysical subsurface characterization of slopes prone to mass movements is crucial in landslide hazard evaluation (Harba and Pilecki 2017, Pilecki 2017, Whiteley et al. 2019). Multichannel analysis of surface waves (MASW) is widely known to estimate shear wave (S-wave) velocity of landslide's subsurface. Seismic interferometry (SI) has been recently developed to assess time-spatial changes of S-wave velocity on Just-Tęgoborze landslide (Harba and Pilecki 2017). In case of high seismic noise generated by high traffic on the road, active seismic data from commonly used methods is difficult to interpret. However, such conditions are favorable for SI method. Therefore, the comparison of SI and MASW applications in high seismic noise conditions is significant in case of estimation of S-wave velocity in landslide colluvium.

Methodology

Study was carried out on Just-Tęgoborze landslide which is located on the south of Poland in Małopolska voivodship. The landslide is crossed by the state road no. 75 of high traffic density. Geologically, the Just-Tegoborze landslide lies in Magura Nappe in the Outer Carpathians. Landslide bedrock (flysch bedrock) is made of shales, variegated shales and sandstones and it is covered discordant by clayey colluvium. Failure surfaces, which were indicated on the study area, can be distinguished at about 10 and 12 m depth within colluvial deposits and at about 14 to 17 m depth between colluvial deposits and flysch bedrock (Harba and Pilecki 2017).

Seismic acquisition was carried out along two profiles which crossed at the point of the 3I/P borehole on 29th June 2015 (MASW) and on 9th July 2015 (SI). The main difference in methodology was seismic source. In MASW method, seismic energy was released in a metal plate using a 5 kg sledgehammer, however, local high-frequency seismic noise generated by intense vehicle traffic was the seismic source in SI method. It was recorded with use of 12 Güralp CMG-6TD three-component broadband seismometers installed along profiles. Moreover, data processing varied significantly between MASW and SI. MASW data needed to be filtered due to high seismic noise generated by high traffic on the state road. However, SI methodology was based on cross-correlation of seismic noise which led to obtain series of empirical Green's functions for Rayleigh surface wave. Next steps of processing and interpretation for both methods were carried out according to the same methodology of dispersion analysis, inversion and model visualization.

Results

S-wave velocity seismic sections were visualised as a result of data processing and interpretation both from MASW and SI methods (Fig. 1). S-wave velocity varies between 130-330 m/s (MASW) and 150-400 m/s (SI). Subsurface medium is characterized by the lowest values of S-wave velocity (up to about 270 m/s) which are correlated to the most weakened zone of landslide colluvium. Such zone is the most exposed to changes of infiltration and water content which affect medium's rigidity and consequently S-wave-velocity. According to MASW results, it reaches about 8 m depth. However, on the sections from SI it reaches deeper (about 10 m depth). It can be explained by the enlargement of weakened zone due to strong storm rainfalls which had taken place before SI data acquisition.

Probable lithological boundary between clayey colluvium and the flysch bedrock, which is indicated as a slip surface, can be marked on the S-wave velocity section from SI method. It has the S-wave velocity about 340 m/s on the depth between 12-15 meters. However, MASW method on the study area cannot allow to distinguish that slip surface due to limited depth range. Failure surfaces in colluvial deposits are not observed neither from SI nor MASW S-wave velocity sections.

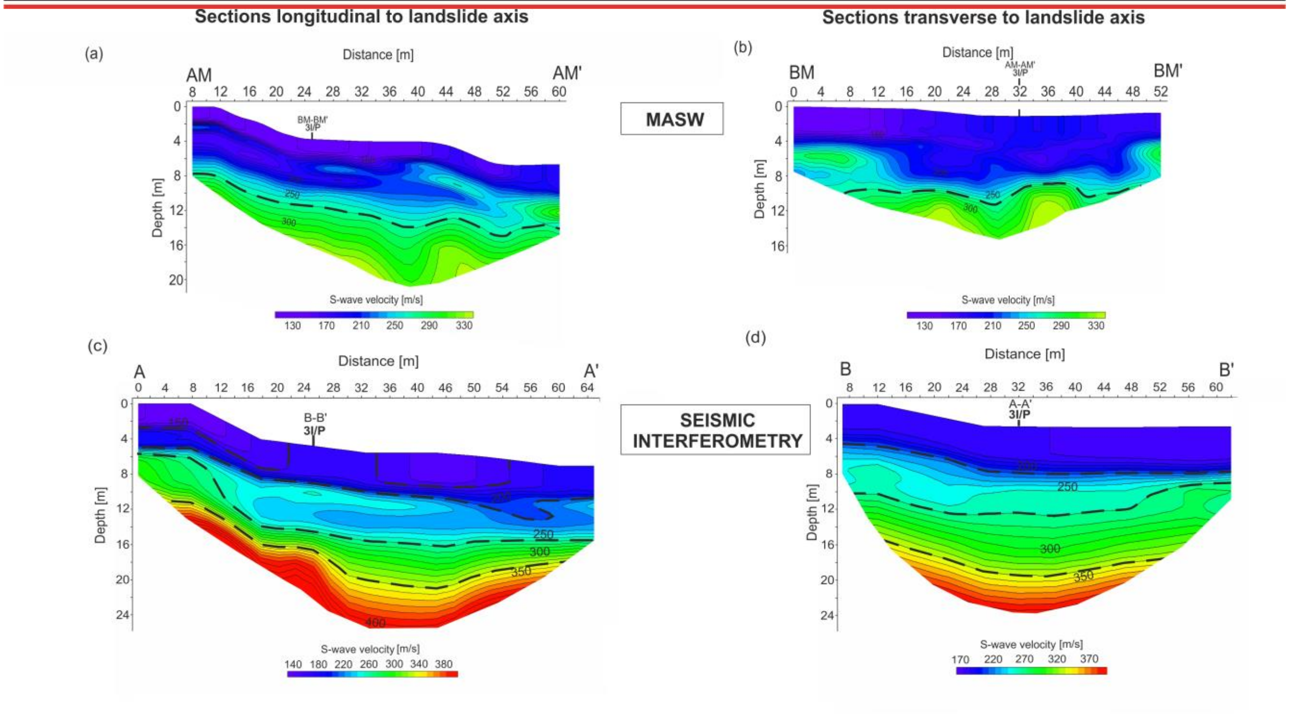

Figure 1. *S-wave velocity sections from MASW (a,b) and from seismic interferometry (c,d) obtained for longitudinal (a,c) and transverse (b,d) sections to Just-Tęgoborze landslide axis. 3I/P – borehole/crosspoint.*

Conclusions

Both MASW and SI methods allowed to estimate S-wave velocity in Just-Tęgoborze landslide colluvium. Probable changes of water content in the colluvium has the great influence on S-wave velocity. If they increase, the medium's rigidity and S-wave velocity decrease. The shallowest depth range can be observed for MASW method. However, lateral resolution is higher for MASW method where intervals between geophones are smaller than intervals between seismometers in SI method. Only results obtained from SI allow to distinguish probable slip surface located deeper, i.e. between colluvial deposits and flysch bedrock.

Data on seismic records from MASW was very noisy. Seismic noise, generated by high traffic on the state road, interfered with useful signal and made it difficult to analyze dispersion curves in MASW method. However, high frequency seismic noise used as a seismic source in SI method allowed to compute empirical Green's functions for Rayleigh surface wave and then to obtain S-wave velocity sections.

References

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