Geotechnics — Array measurement of microtremors to estimate shear wave velocity profile

Géotechnique — Mesure en réseau des microtrémors pour estimer un profil de vitesse des ondes de cisaillement
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Introduction

This document provides the specifications on the equipment, survey and analysis procedure of array measurement of microtremors in order to estimate shear wave velocity profile.

This document is intended for use by administrators of infrastructure facilities (public sector institutions, such as national and local governments, and private institutions), building constructors, house builders, consultants, academia, and public/private research institutions. The array measurement of microtremors deliverable described in this document can be useful in various engineering fields such as the

- estimation of geotechnical site conditions for construction;
- stability assessment of foundations;
- evaluation of the risk for soil liquefaction;
- evaluation/prediction of earthquake ground motions.

Array measurement of microtremors is one of the geophysical measurements using surface waves, and it is a non-destructive testing method described in an application manual of geophysical methods to engineering and environmental problems\[^5\] for estimating S-wave velocity profile from dispersive characteristics of the surface waves. Reliability of the method has been evaluated by blind tests and numerical simulations in several international projects\[^6\],\[^12\].

The array measurement of microtremors is a passive method using natural and artificial ambient vibrations. Since power of the ambient vibrations is highly variable from one site to the other, it will possibly not be applicable to a site where the ambient vibration level is less than internal noise of measuring instruments. The array measurement of microtremors using vertical ground vibration to estimate an S-wave velocity profile by processing microtremor records based on the fundamental mode of Rayleigh waves is the most common surface wave method. In addition to the fundamental mode, including the processing of higher modes of the Rayleigh waves improves the reliability of the estimated S-wave velocity profile. However, a procedure for identifying the higher modes from observed microtremors is not authorized in academics yet. Hence, analysing the higher mode of the Rayleigh waves is out of scope in this document. Love waves is another type of surface waves extracted from horizontal ground vibration. Joint use of the Rayleigh waves and the Love waves also improves the reliability of the estimated S-wave velocity profile. However, the surface wave method using Love waves is not widely used in practice. Hence, the measurement and the analysing of the Love waves are out of scope in this document. Therefore, the array measurement of microtremors using vertical ground vibration and the data analysis of the microtremor records with an assumption of the fundamental mode of Rayleigh waves are described in this document.

This method provides a vertical S-wave velocity profile. The depth range of the S-wave velocity profile varies depending on the wavelength of observed surface waves. The profile estimated using surface wave has an uncertainty caused by estimation errors of the observed phase velocity. Therefore, it is important to include additional information from soundings [e.g. cone penetration test (CPT), standard penetration test (SPT)], borehole data and a prior geological information to reduce the uncertainty in the S-wave velocity profile by electing a reliable initial model or search area in the inversion analysis. Active method using artificial sources such as sledgehammer and weight drop is also useful to improve the accuracy of estimated S-wave velocity profile, particularly at very shallow depth of the profile from the additional phase velocity in high frequency. Additionally, horizontal-to-vertical (H/V) spectral ratio is useful to reduce the uncertainty of S-wave velocity profile estimated by the array measurement of microtremors from a peak frequency of the spectral ratio.

Regardless of the uncertainty in the estimated S-wave velocity profile, array measurement of microtremors has a great advantage in time, cost and environmental impact for the investigation compared to borehole measurements and soundings. Therefore, this method is expected to be widely applied in the field such as evaluation of soil structure and geotechnical site characteristics described above.