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On the system correction for CCA method using simple moving coil type seismometers

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It has been known that CCA method (Cho et al. 2006; Tada et al. 2006; etc.) can determine the dispersion relation of Rayleigh waves, of which wavelength is tens or hundreds time the radius of the miniature array deployed for microtremor observation. It is easily imagined that accurate detection of phase and amplitude difference among signals from different seismometers in case of observation using a miniature array. Unfortunately the characteristics of simple moving coil type seismometers are not so accurately regulated by manufacturers as required for observation using miniature arrays. It is also recommendable to take very local amplification effect of the shallowest soil just below seismometers and also the effect of installation condition of seismometers into account. I will show the formulation shown below for the system correction using microtremor records themselves and those of huddle test, and also some results of field experiments to validate it. It is imagined that this formulation can perform the system correction if the following two conditions are fulfilled: i) All seismometers have common power spectra of input ground motion except very local amplification effect, ii) The phase difference among channels due to the installation situation and the very local amplification effect is negligible. The latter suggests that a careful installation of seismometers, e.g., using horizontal table with spirit level, is necessary in field observation. It is imagined that the abrupt change of phase characteristics around the natural period should be suppressed using appropriate shunt resistance because in site nothing but tubular or bull's eye spirit level is available tool to adjust seismometers.

Keywords: Microtremor, Miniature Array, System Correction, Dispersion Curve, coherence

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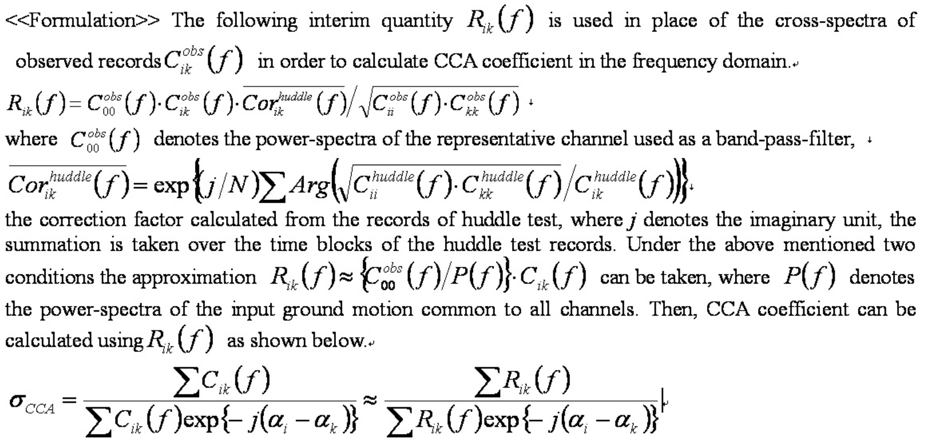

<<Formulation>> The following interim quantity $R_{ik}(f)$ is used in place of the cross-spectra of observed records $C_{ik}^{obs}(f)$ in order to calculate CCA coefficient in the frequency domain.

$$R_{ik}(f) = C_{00}^{obs}(f)\cdot C_{ik}^{obs}(f)\cdot \overline{Cor_{ik}^{huddle}(f)} \Big/ \sqrt{C_{ii}^{obs}(f)\cdot C_{kk}^{obs}(f)}$$

where $C_{00}^{obs}(f)$ denotes the power-spectra of the representative channel used as a band-pass-filter,

$$\overline{Cor_{ik}^{huddle}(f)} = \exp\left\{(j/N)\sum Arg\left(\sqrt{C_{ii}^{huddle}(f)\cdot C_{kk}^{huddle}(f)} \Big/ C_{ik}^{huddle}(f)\right)\right\}$$

the correction factor calculated from the records of huddle test, where j denotes the imaginary unit, the summation is taken over the time blocks of the huddle test records. Under the above mentioned two conditions the approximation $R_{ik}(f) \approx \left\{C_{00}^{obs}(f)/P(f)\right\}\cdot C_{ik}(f)$ can be taken, where $P(f)$ denotes the power-spectra of the input ground motion common to all channels. Then, CCA coefficient can be calculated using $R_{ik}(f)$ as shown below.

$$\sigma_{CCA} = \frac{\sum C_{ik}(f)}{\sum C_{ik}(f)\exp\{-j(\alpha_i - \alpha_k)\}} \approx \frac{\sum R_{ik}(f)}{\sum R_{ik}(f)\exp\{-j(\alpha_i - \alpha_k)\}}$$