

## Distribution of average S-wave velocities by small-scale (5 to 15 meters) microtremor arrays in and around Hue City, Thua Thien-Hue province, Vietnam

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We are promoting earthquake hazard assessment for safe operation of hydroelectric power generation and protection of world cultural heritage for Hue City, Thua Thien-Hue Province, Vietnam. This is a collaborative research with Dr. Nguyen Anh Duong at Vietnam Academy of Science and Technology (VAST). As a part of this research project, we conducted multiple small-scale microtremor array observations in that area and evaluated the distribution of shallow average S-wave velocities.

We began this microtremor research with providing a technical support to researchers at VAST. First, the authors conducted a microtremor array observation at four sites in and around the Hanoi City on 20th and 21st October, 2017, as a practical training of microtremor observation. On the premise of applying the SPAC method, we deployed linear-shaped arrays with a length of about 30 m using a three-component servo-velocimeter. We recorded microtremors for 1 to 2 hours at each site. Since the authors brought two seismometers (three-component servo-accelerometers) from Japan, we deployed two-point arrays along with their array at intervals of 5 to 30 m, and compared the analysis results with those from the VAST observation apparatuses.

On the next step, the VAST research team and the authors conducted microtremor array observations at seven sites in Hue City on 17-19th March, 2018. At each site we deployed triangle-shaped arrays with side lengths of 5 m and 15 m. We also deployed a linear array with a length of 12 m. Those arrays consisted of 4.5 Hz vertical geophones. In addition to this, we deployed two-point arrays with two seismometers brought from Japan. We set the observation durations from about 30 minutes to 1 hour at each site. There were existing subsurface data by refraction surveys at these sites, and therefore, we compared our analysis results with them. As a result, the analysis results of microtremors were consistent with those existing data.

Through the above preparatory period, the VAST research team conducted microtremor array observations at 126 sites in and around the Hue City (observation area of about 11 km x 14 km) in a period from June to July 2018 (19 days in total). More specifically, they deployed triangular arrays with side lengths of 5 m and 15 m at 89 sites and a linear array with a length of 12 m at 37 sites. Vertical 4.5Hz geophones were used to consist seismic arrays. The observation duration was set to 30 minutes at each site.

We applied the SPAC method to the array data thus obtained and identified the Rayleigh-wave phase velocities. We read the phase velocities with the wavelengths of 13 m, 25 m and 40 m and interpreted them as average S-wave velocities to the depths of 10 m, 20 m, and 30 m, respectively. The spatial distribution of average S-wave velocities thus obtained is consistent with the geological map in and around the Hue City. In near future, we will improve the accuracy of soil evaluations by adding H/V spectral data at each site of array observation.

Keywords: microtremor, array, surface wave, Vietnam