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Estimation of 2D Shear Wave Velocity Profile of Soil Layers Using Surface Wave Seismic

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Abstract： The 2D shear wave velocity profile of strata is estimated using the active and passive surface wave seismic tests. The experimental dispersion curves were obtained after the recorded signals were transformed by the slant stack procedure. The phase velocity in the relatively high frequency range can be obtained using the dispersion curves deduced from the active tests. On the other side, dispersion curves obtained from the passive tests can be used to estimate the phase velocity in the relatively low frequency range. From the higher frequency portion of the dispersion curves that stand for the fundamental mode, we obtained the phase velocities about 190 m/s for the sandy surface fill. Theoretical dispersion curves can be constructed by the thin-layer-stiffness-matrix method. For theoretical dispersion curves, the soil layers of the test site were modeled as the sandy surface fill overlying a half space soil layer. A real-parameter genetic algorithm was programmed to minimize the difference between the theoretical and experimental dispersion curves. We prove that the real-parameter genetic algorithm is capable to reduce the error between experimental and theoretical dispersion curves. The estimated 2D geometry of the sandy surface fill using the active and passive surface wave seismic tests was verified with the borehole data.

STUDY METHODS

Surface wave seismic tests

- **The study area is situated on Campus of the Chaoyang University of Technology, Taichung, Taiwan.**
- **From the result of drilled borehole, the thickness of a gray sandy silt with little gravel is 5.7 m overlaid on dark gray weathered sandstone.**
- **The 16-channel seismograph recorded the seismic data of each receiver. A linear array of 12 receivers 1 m apart aligned acquired the vertical velocity time history on ground surface. The spread of receivers were moved 1 m to northeast together along the survey line until the entire measurement process finished.**
- **In active MASW test, the impulsive source was used by a sledgehammer of 10 kg impacting a 0.2 m by 0.2 m metal plate. The recording time was only 1 s with sampling rate of 5000 samples per second.**
- **The vibration source of passive MASW test was ambient noise. Because the study area is located in playground (Fig.1), some microtremor induced by persons running or playing ball. The duration of the seismic records was set to 40 s with sampling rate of 125 samples per second.**

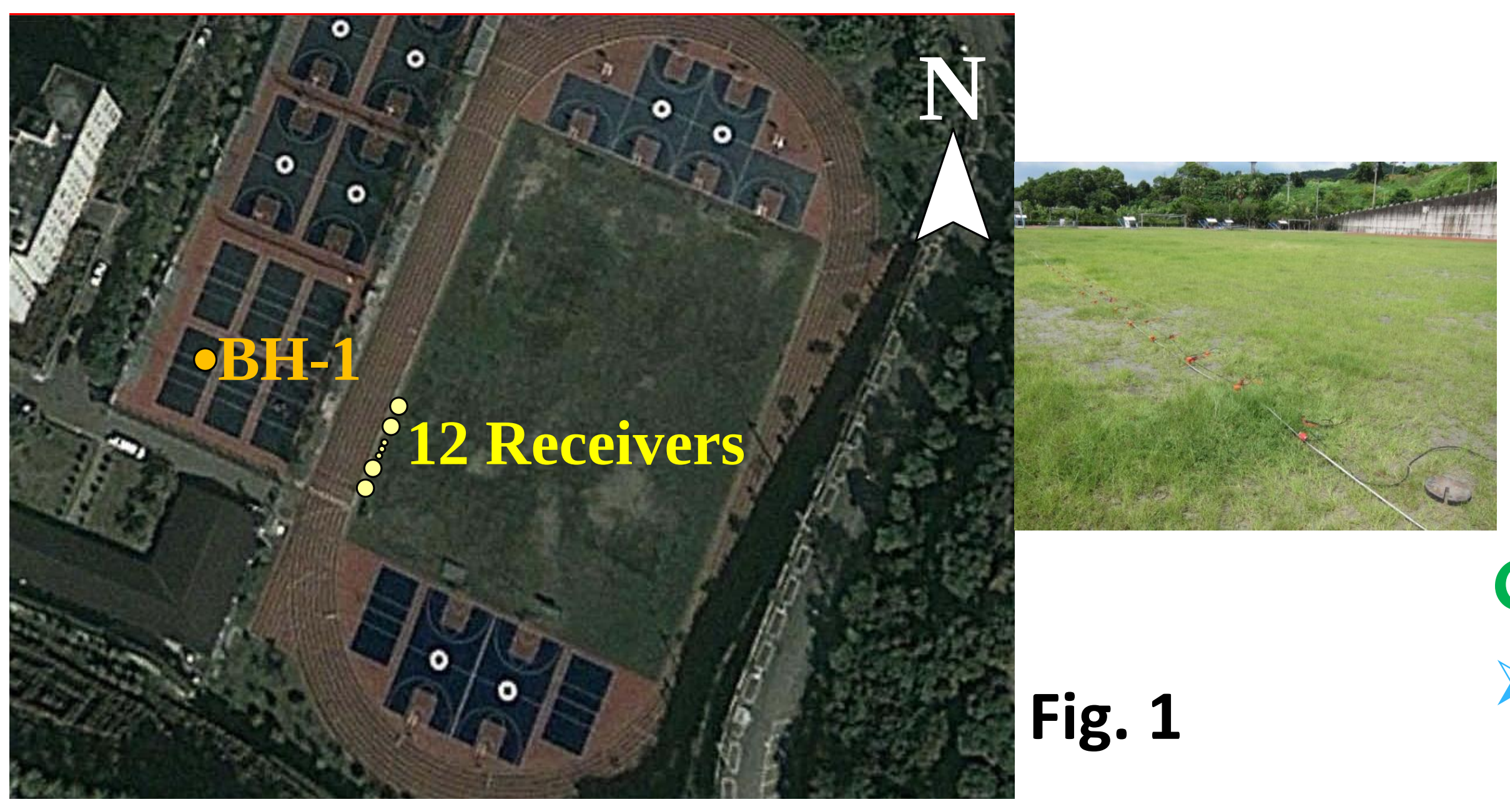

Fig. 1

Analysis of experimental dispersion curve

- **The experimental dispersion curves for active MASW tests were obtained by Ryden et al.[1)] proposed method. The peak of amplitude in an active MASW spectrum is assumed on the dispersion curve.**
- **The ambient noise or microtremor ubiquitous were transformed to the slowness-frequency (p-f) domain and stacked prior to dispersion analysis, as described by Louie[4)]. The experimental dispersion curve can be extracted from the lower limit of higher amplitude in the passive MASW spectra.**

STUDY RESULTS

Active MASW test

- **The evaluated dispersion curves are represented by a dashed white line with circle symbols and they are shown in the Fig. 2.**
- **The seismic station number is sequentially assigned from south to north.**
- **The asymptotes at high frequencies approach the phase velocities of 190 m/s.**

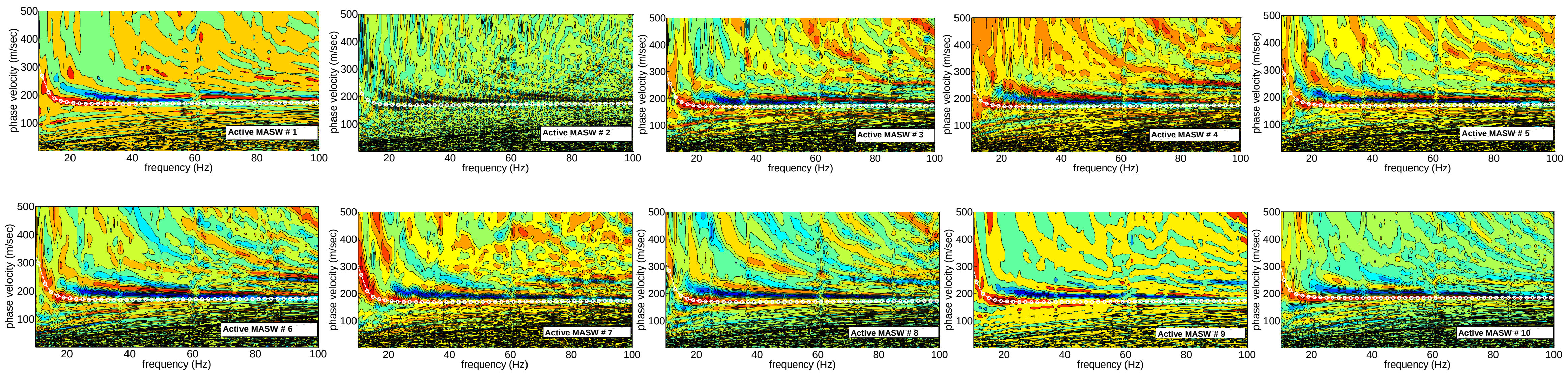

Fig. 2

Passive MASW test

- **The duration of seismic records in passive MASW test is 40 s which indicated the increment of frequency is 0.025 Hz. The resolution is enough in low frequency.**
- **The dispersion curves are represented by a dashed black line with circle symbols (Fig.3).**
- **The dispersion curves at the 10 seismic stations are slightly different. This implies the shear wave velocity profiles of soil layers are similar.**

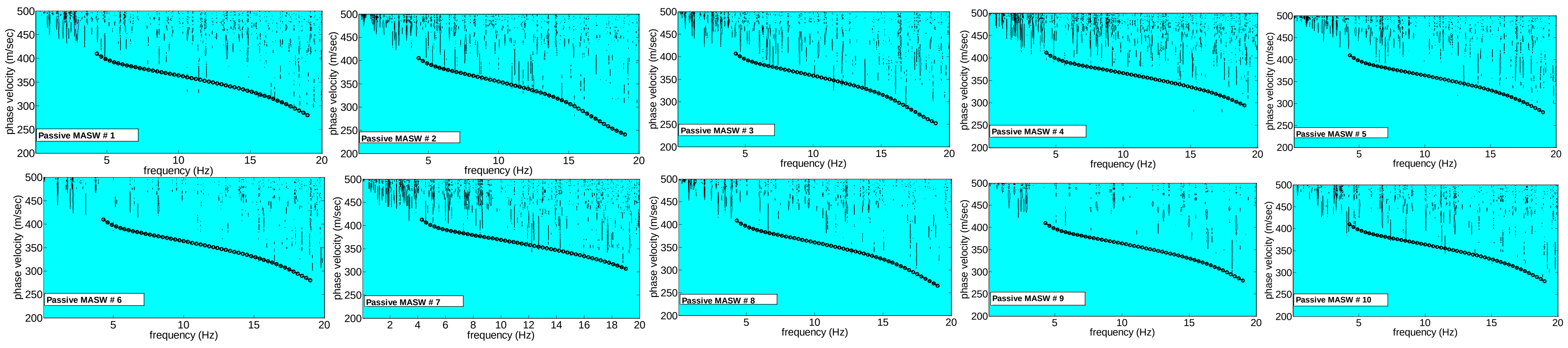

Fig. 3

Combined dispersion curves

- The dispersion curves for active and passive MASW tests are close in high frequencies, as shown in Fig. 4.
- In low frequencies (less than 40 Hz), the phase velocities for passive MASW tests are greater than that of active MASW test.

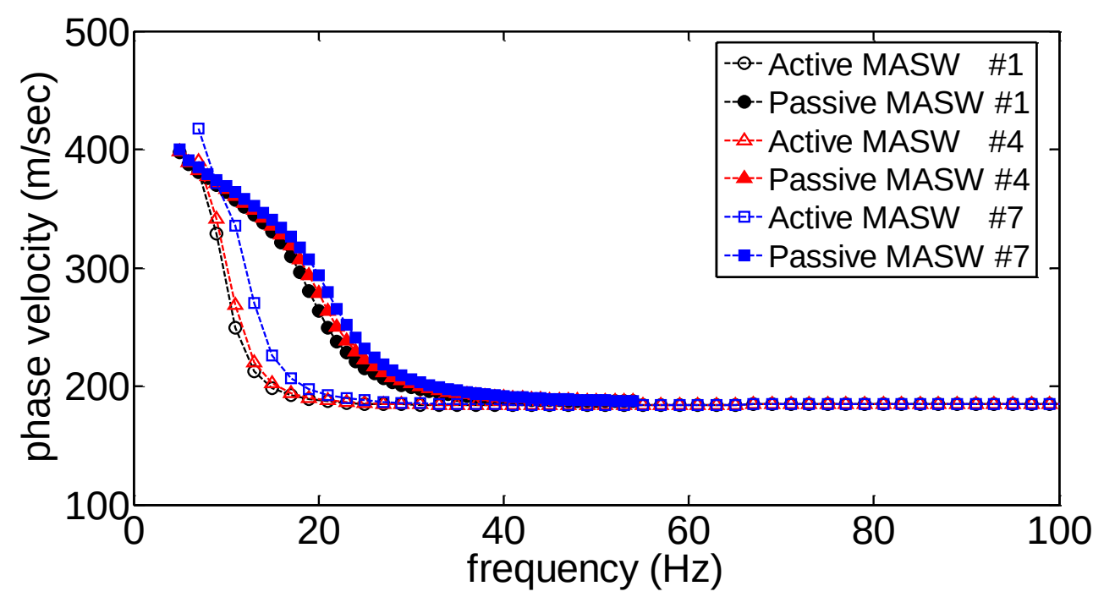

Fig. 4

Shear wave velocity profile

- There is a high resolution of dispersion curve for passive MASW test in low frequencies.
- The depth of bedrock is evaluated ranging from 4 to 4.8 m. The results of the bedrock depth are more reliable than that from active tests.
- We use the dispersion curves from passive MASW tests to evaluate the shear wave velocity and depth of weathered bedrock (Fig.5).

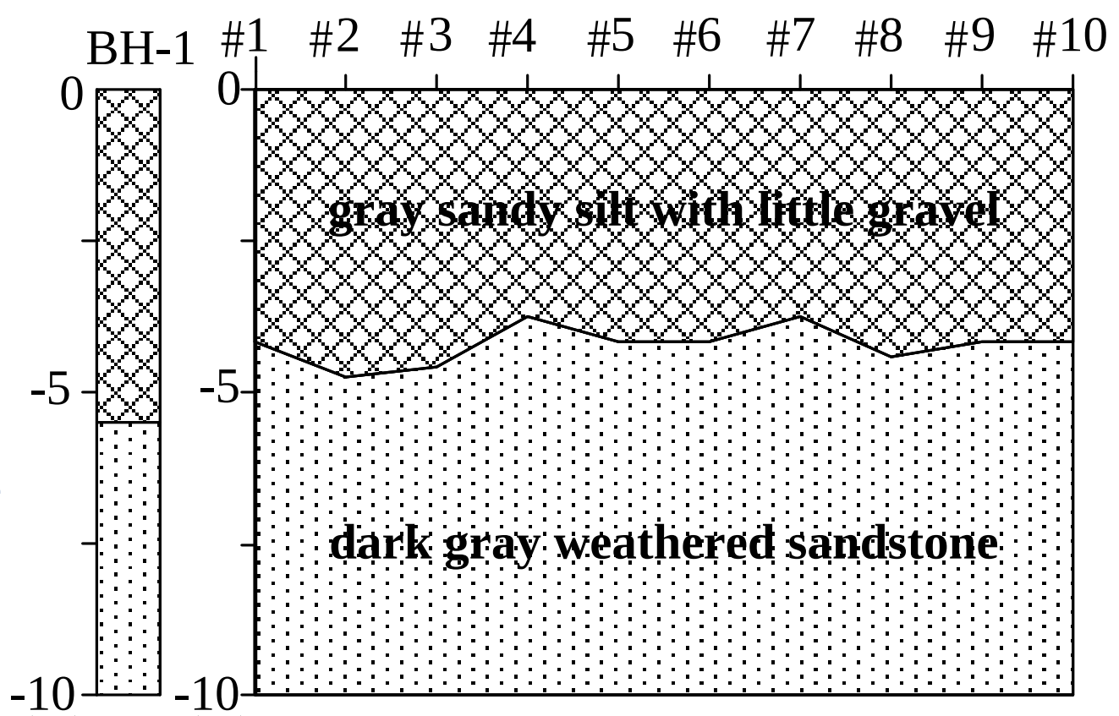

Fig. 5

Conclusions

- The asymptotes at high frequencies of the fundamental mode dispersion curve of both active and passive MASW tests are close.
- The dispersion curve for passive MASW test in low frequencies has a high resolution.
- The shear wave velocity and depth of weathered bedrock are suggested to be evaluated by the dispersion curves from the passive MASW test for this site.