D204

Near-surface S-wave Velocity in Mountainous Regions Depending on Topography, Geology, and Geomorphology

〇Koichi HAYASHI, Esteban CASTANEDA and Hayato ISHIDA

1) Introduction

Near-surface S-wave velocity (Vs) model is indispensable information in various geotechnical and earthquake engineering aspects, such as liquefaction, landslides, and site amplification. Many researchers have studied the Vs model in flat areas for years. For example, AVS30 (time-averaged Vs to 30 m deep) is widely used to evaluate site amplification for building design in many countries, and a relationship between the AVS30 and geomorphology was well established in Japan. In contrast, the near-surface Vs model at mountainous regions is not well known compared with the flat area. To understand near surface Vs characteristics in mountainous regions, we are collecting near surface Vs data and developing a database. This article briefly introduces data collection, the outline of the database, and preliminary findings in Japan.

2) Data collection

We carried out active (Multi-Channel Analysis of Surface waves: MASW (Park et al., 1999)) and passive (Microtremor Array Measurements: MAM (Okada, 2003)) surface wave methods at investigation sites mainly in Japan to obtain near-surface Vs models. Four to ten single (vertical) components or three components velocity sensors (geophones) were deployed with 2 to 10 m spacing intervals. We used a 10 kg sledge hammer for MASW and recorded 30 minutes of ambient noise (microtremors) for MAM processing and horizontal-to-vertical spectral ratio (H/V or HVSR). A non-linear inversion estimated 1D Vs profiles from dispersion curves to at least 30 m deep at each site.

3) Database

We registered all observed data (dispersion curves, H/V spectra, etc.) and processing results (Vs profiles, etc.), in a relational database together with other site information, such as coordinate, elevation, topographic relief, slope angle, geomorphology (JSHIS, 2026), geology (AIST, 2026), etc. The database also contains the data that we have collected for years mainly obtained at flat areas. Table 1 summarizes the number of sites in Japan used in this study, by geological age and geomorphology. The following section compares time-averaged Vs at three depths, 3 m (AVS3), 10 m (AVS10), and 30 m (AVS30) between flat area and mountainous regions as preliminary analysis.

Table 1. Number of sites by geological age and geomorphology.

	Holocene	Pleistocene	Neogene	Paleogene	Mesozoic	Paleozoic	Total
Abandoned river channel	33	1	0	0	0	0	34
Alluvial fan	131	8	2	0	0	0	141
Back marsh	336	5	0	0	0	0	341
Delta and coastal lowland	222	0	0	0	0	0	222
Dry river bed	16	0	0	0	0	0	16
Filled land	94	0	0	0	0	0	94
Gravelly terrace	33	173	6	4	2	1	219
Hill	3	21	0	6	0	0	30
Lowland between coastal dunes and/or bars	1	0	0	0	0	0	1
Marine sand and gravel bars	30	0	0	1	0	0	31
Mountain	3	1	6	18	4	4	36
Mountain footslope	0	0	6	4	0	0	10
Natural levee	142	0	0	0	0	0	142
Reclaimed land	56	0	0	0	0	0	56
Sand dune	2	0	0	0	0	0	2
Terrace covered with volcanic ashsoil	65	778	1	1	0	0	845
Valley bottom lowland	86	53	1	0	0	0	140
Volcanic footslope	4	2	0	0	0	0	6
Total	1257	1042	22	34	6	5	2366

4) Time-averaged S-wave velocity

Figure 1 compares the time-averaged Vs for three depths by geomorphologies (a) and geological ages (b). The time-averaged Vs varies depending on both geomorphology and geology. It is interesting that the time-averaged Vs increases rapidly with depth as geological age gets older.

Figure 2 shows the time-averaged Vs as functions of elevation (a) and slope angle (b). Although the variation of the data is large, the regression lines indicate that the time-averaged Vs increases with both elevation and slope angle increase. Note that the amount of data in the mountainous region is much less than that in the flat area. Even considering the difference in the amount of data, the preliminary analysis implies that the Vs in the mountainous region depends on topography, geology, and geomorphology, and it is possible to statically estimate a regional Vs model in mountainous regions based on the topography, geology, and geomorphology.

References

National Institute of Advanced Industrial Science and Technology (AIST), 2026, Seamless geological map of Japan at a scale of 1:200,000 V2, https://gbank.gsj.jp/seamless/.

Japan Seismic Hazard Information Station (J-SHIS), 2026. https://www.j-shis.bosai.go.jp/.

Okada, H., 2003, The microtremor survey method. Society of Exploration Geophysicist, Tulsa.

Park, C.B., Miller, D.M., and Xia, J., 1999, Multichannel Analysis of surface waves. Geophysics, 64, No.3: 800-808. https://doi.org/10.1190/1.1444590.

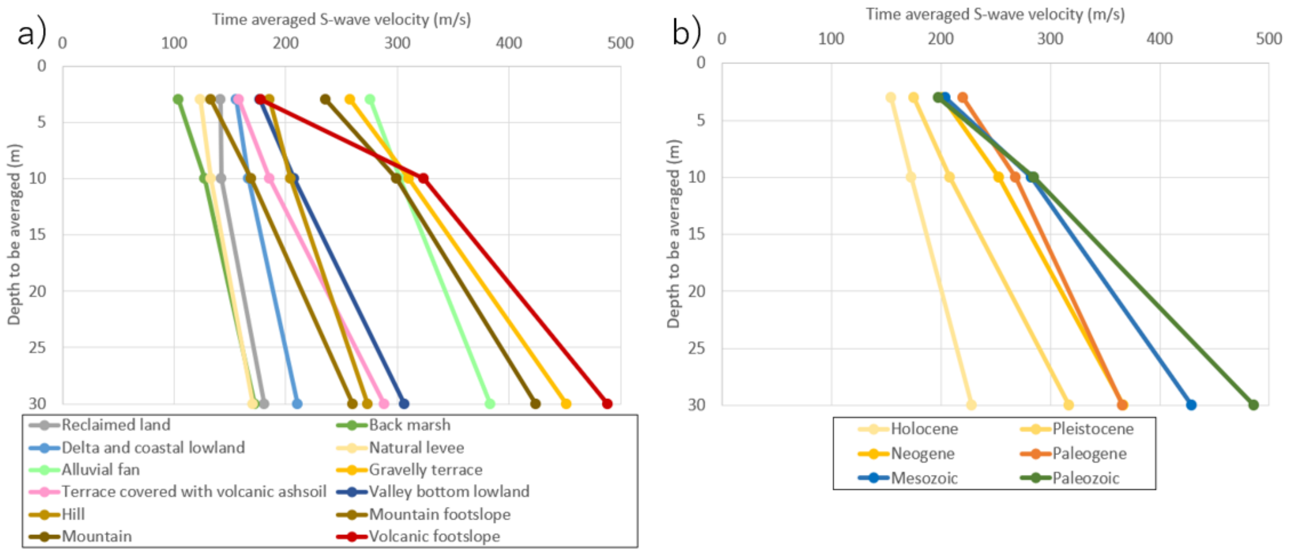

Figure 1. Time-averaged Vs for three depths by geomorphologies (a) and geological ages (b).

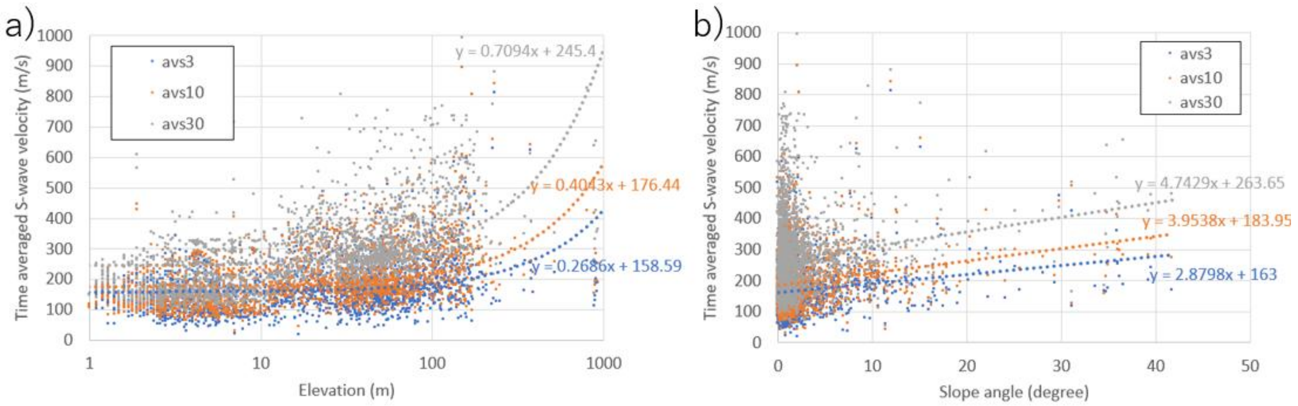

Figure 2. Time-averaged Vs as functions of elevation (a) and slope angle (b).