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国際共同研究(一般)

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**Comparative study of influences on site response
in Japan, U.S., and Italy:
the effect of shallow subsurface stratigraphy on
site amplification using machine learning**

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Project Title : Comparative study of influences on site response in Japan, U.S., and Italy: the effect of shallow subsurface stratigraphy on site amplification using machine learning

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Research Period : 1 April 2024—31 March 2026

Research Location : Japan

Number of the Participants in the Project: 8 (DPRI: 3/ non-DPRI: 5)

Anticipated Impact on Research and Education

This research has the potential to improve the state of knowledge on near subsurface structures that control seismic site effects through the in-situ measurements conducted during the research period.

Research Report

(1) Purpose

Study influence of site conditions on site response in Japan.

(2) Summary of Research Progress

In September 2024, a team of geotechnical engineers and geophysicists conducted field visits to several accelerometer stations in Japan to assess site conditions and their potential influence on recorded earthquake ground motions. The stations included KNG013 in Odawara, KNG014 and KNGH22 in Yamakita, and KYTH07, KYTH08, and KYT013 in Kyoto. The team's objective was to evaluate geological and structural factors that could affect seismic data that are expected to contribute to improvements in earthquake monitoring and hazard assessment.

For the Odawara and Yamakita visits, the team was comprised of Dr. Ken Hudson of Hudson Geotechnics, Inc., and Mr. Alan Yong of the United States Geological Survey (USGS). For the Kyoto visits, Dr. Shinichi Matsushima of the Disaster Prevention Research Institute (DPRI) at Kyoto University and Dr. Tara Nye of the USGS joined the team, bringing additional expertise in seismic site characterization and geophysical analyses. This collaborative effort ensured a comprehensive evaluation of each site's unique characteristics.

At KNG013 in Odawara, the team observed a flat site located approximately 5 meters from a 6-story, base-isolated building. The proximity to this structure raises concerns about potential soil-structure interaction effects, where the building's dynamic response could influence ground motion recordings. Such interactions are critical to consider, as they may alter the amplitude and frequency content of seismic

signals, affecting data interpretation for earthquake engineering applications.

In Yamakita, KNG014 is situated within an east-west trending valley, characterized by geological conditions that may induce shallow three-dimensional basin effects. These effects can amplify ground motions due to wave trapping or resonance within the basin, potentially amplifying or attenuating seismic records. KNGH22, also in Yamakita, is located on a hill surrounded by steep slopes and adjacent to a 6-meter-tall structure. The team noted that topographic effects, where the hill's geometry could focus or scatter seismic waves, and soil-structure interaction from the nearby building, could produce complicated station recordings.

In Kyoto, KYTH07 is positioned five meters from the crest of a three-meter-high steep slope which descends to a creek. The nearby free-face slope and a potentially shallow groundwater table could influence recorded ground motions. These conditions increase the risk of liquefaction, cyclic softening, and lateral spreading during seismic events, which would alter the site's seismic response. KYTH08, located three meters from a road and a four-story building, faces challenges from traffic noise and soil-structure interaction. Machinery on the ground surface near the downhole array may further contribute noise, degrading the quality of seismic data. KYT013, situated in a park at the base of a five-meter-tall steep hill within a larger, gently sloping hill, may experience topographic effects. The hill's geometry could modify wave propagation, impacting the station's recordings.

Dr. Hudson also presented the next generation liquefaction (NGL) recently developed models for liquefaction susceptibility, triggering, and manifestation to the DPRI at Kyoto University during his visit. Following Dr. Hudson, Dr. Nye presented her findings on the effects of seismic path attenuation on earthquake recordings.

In 2025, in Wajima City, a municipality of the Machino-machi District within the Ishikawa Province (Japan), geophysical recordings were made to determine the subsurface structure from an earthquake engineering perspective (Yamada et al., 2025). This is important because the 2024 Noto Hanto earthquake induced heavy damage within the Machino-machi District, which is in the northern part of the Noto peninsula. Our investigation encompassed a 4 km by 1 km area along the Machino River (Fig. 1). Measurements included one-dimensional (1D) active and passive surface-wave measurements at approximately 20 sites, two-dimensional (2D) active and passive surface-wave measurements, microtremor horizontal-to-vertical spectral ratio (mHVSr) recordings at approximately 100 sites, and earthquake observation at two sites in the area. The multi-channel analysis of surface waves and the spatial autocorrelation methods were used to calculate surface-wave dispersion curves derived from active and passive data, respectively. Two seismograph instruments, one on the valley floor and the other on the mountain peak of the investigation area, were installed and recorded more than 50 earthquakes for three months.

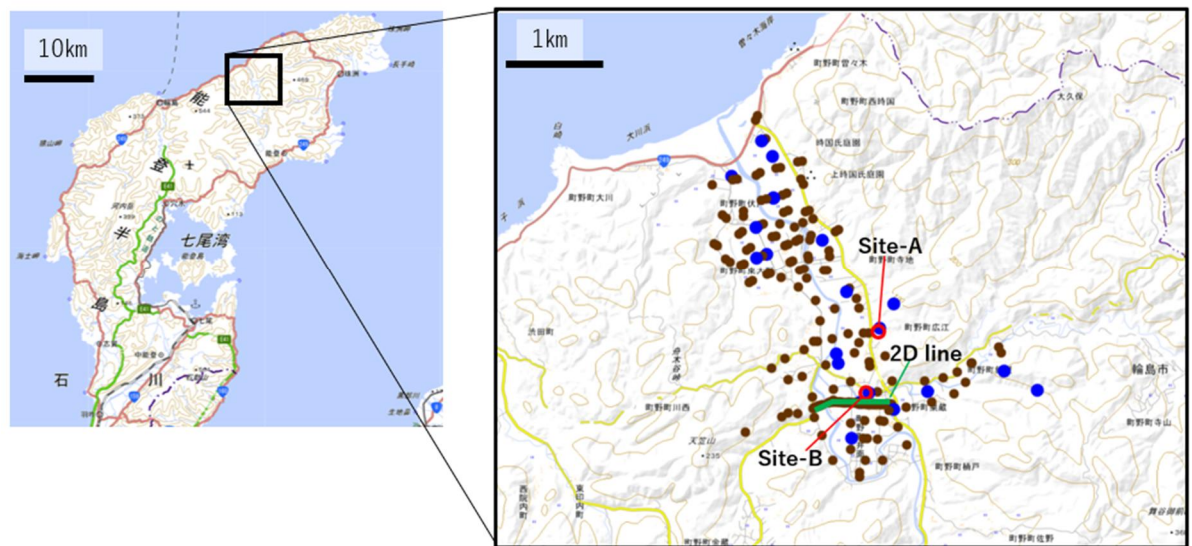


Fig. 1. Investigation sites in the Machino-machi District. Brown dots, blue dots, and a green line indicate locations of mHVSr and 2D active and passive surface-wave measurements, respectively. Site-A and Site-B indicate the locations of seismographs that recorded earthquakes for three months.

(3) Summary of Research Findings

Analyses remain in progress at the time of this report (Hayashi et al., 2026). Preliminary analyses from the investigation in Machino-machi, Wajima City roughly delineated shallow to deep 3D shear-wave velocity (V_s) models. In the shallow part, significantly low velocity layer with V_s less than 150 m/s existed extensively. In the deeper region, depth to layers with V_s of 700 m/s and 2000 m/s are approximated to be 115 m and 1000 m deep, respectively.

(4) Publications of Research Findings

Hayashi, K., Matsushima, S., Martino, A.D. Yamada, K., Nagashima, F., Chou, Y., Yadanar, T., Kaigara, T., Nishiura, H., Matsuzawa, M., and Furuya, G. 2026, Active and passive surface wave measurements at Machino-machi, Wajima City heavily damaged by 2024 Noto Peninsula earthquake, Proceedings of the 154th SEGJ Conference.

Yamada, K., Furuya, G., Hayashi, K., Doi, I., Wang, G., 2025, Active and passive surface wave methods and single station three-component microtremor measurements at Machino-machi Wajima City, Proceedings of the 152nd SEGJ Conference, 37—40.