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OBSERVATION OF STRONG EARTHQUAKE MOTION AT PUBLIC WORKS BY NILIM

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Abstract: National Institute for Land and Infrastructure Management (NILIM) administers the observation of strong earthquake motion at public works throughout Japan. This paper describes current status of the observation at road and river facilities by NILIM and examples of utilization of observed records.

1. INTRODUCTION

The observation of strong earthquake motion at public works was initiated in 1957, when a SMAC-type strong motion accelerometer was installed at Sarutani Dam. Strong motion accelerograms recorded during the 1964 Niigata earthquake greatly contributed to study of damage caused by the earthquake, especially liquefaction of sandy soil, demonstrating necessity of the strong earthquake motion observation.

Therefore, a nationwide instrumentation plan of SMAC-type accelerometers was drawn up and has been steadily implemented by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) and other organizations. National Institute for Land and Infrastructure Management (NILIM) has been in charge of collection, processing, and analysis of the strong motion records and conducts research on seismic design and earthquake disaster mitigation using the accumulated records.

Currently, NILIM administers two types of strong earthquake motion observation, in addition to supervising the MLIT Seismograph Network. Table 1 shows outlines and objectives of these strong motion observation systems. Locations of the observation stations at river and road facilities and those for dense instrument array observation are shown in Figure 1. Strong earthquake motion observations at national dams and ports are mainly conducted by dam work offices and Port and Airport Research Institute, respectively.

2. OBSERVATION AT RIVER FACILITIES

65 observation stations were installed at river facilities: 56 stations are at levees, 8 at weirs, and one at a sluice gate. A typical configuration of instruments at levee sites is shown in Figure 2. Accelerometers are located at the crown of the levee, on the ground surface nearby, and in the bedrock layer, while piezometers are set in the sandy soil layer.

Some stations have specific purposes such as observing influence of microtopography and examination of soil improvement. Figure 3 shows locations of accelerometers and piezometers at Nakashimo station, right-bank of Naruse River, Miyagi prefecture. The sensor arrays were installed at the berm, where liquefaction strength had been improved by the sand compaction pile (SCP) method, and near the crown, where no liquefaction remediation had been conducted.

Table 1 Outline of strong-motion observation administered by NILIM

Type of observation	Description of observation	Number of stations
Strong motion observation at public works	1) River facilities (levees, weirs, sluice gate) 2) Road facilities (bridges, embankments, slopes, retaining wall, common ducts) 3) Ground surface	123 stations (65 river facilities, 30 road facilities, 28 ground surface)
Dense instrument array observation of strong motion	Observation of amplification or attenuation characteristics caused by variations of local topography and geological conditions	92 stations in 9 areas
MLIT Seismograph Network	The stations are installed on ground surface with intervals of 20 to 40 km along rivers and national highways administered by MLIT. The observed data are sent to responsible sectors by telecommunication network for estimating seismic intensity distribution.	718 stations (http://www.nilim.go.jp/japanese/database/nwdb/index.htm)

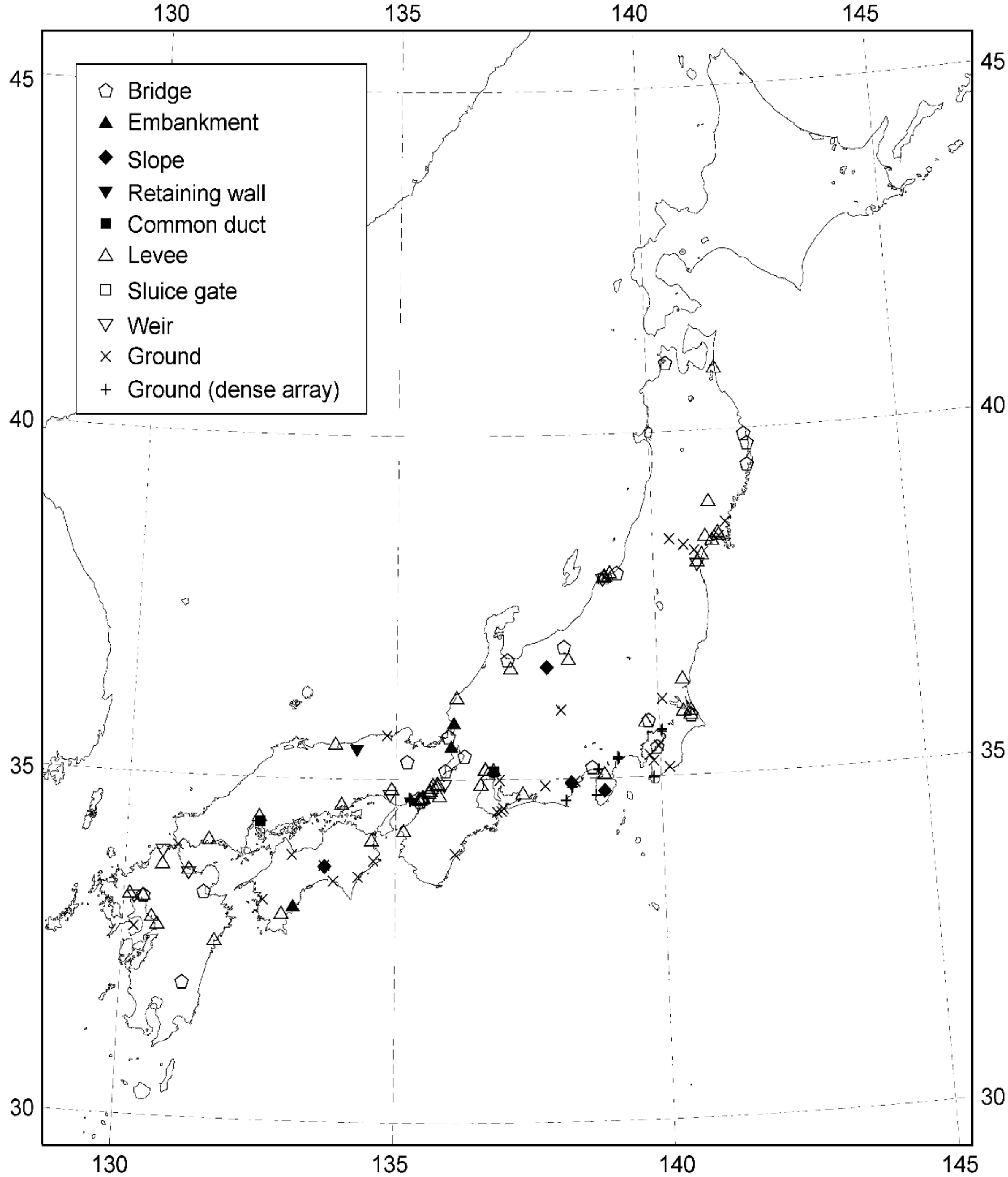


Figure 1 Strong motion observation stations at road and river facilities and those for dense instrument array observation.

Time history records of ground acceleration and pore water pressure were obtained at the station during northern Miyagi earthquakes on July 26, 2003. Figure 4 shows those recorded during the main shock (M6.4). Though the pore water pressure at 9m below the crown exceeded the maximum measurable value, 101.3[kPa]=1[atm], remarkable difference can be seen between the pore water pressure in the improved and non-improved soils. Liquefaction strengths of the improved and non-improved sandy soils were estimated using these observed records based on the accumulated damage analysis (Kataoka *et al.*, 2010). Cyclic triaxial strength ratios (R_L) of soils where the piezometers are located were estimated 0.34 and 0.40 for SCP-improved soil and 0.26 for non-improved soil.

These values are larger than R_L calculated from the equations in Specifications for highway bridges (Japan Road Association, 2002). Since the equations are used for liquefaction judgment in the seismic performance evaluation of river facilities (River Improvement and Management Division, 2007), this result can be used to reduce the cost for liquefaction remediation.

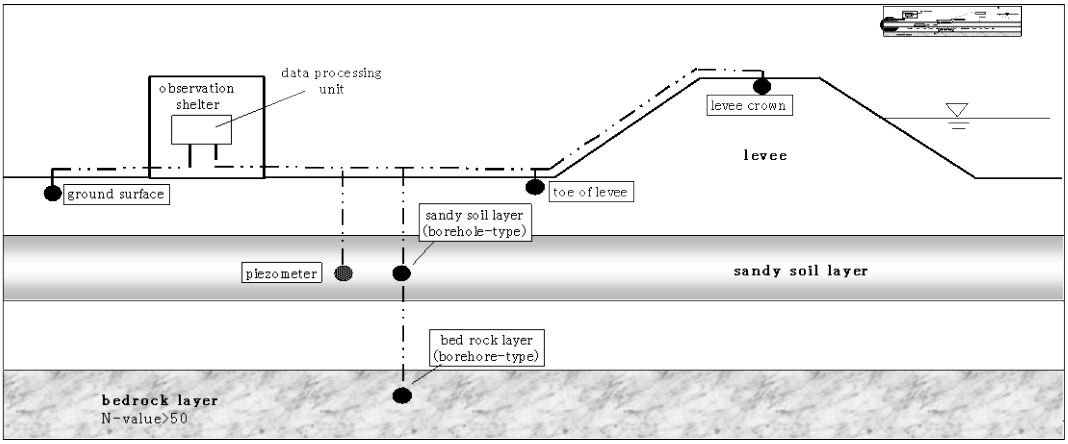


Figure 2 Typical configuration of instruments at a levee site.

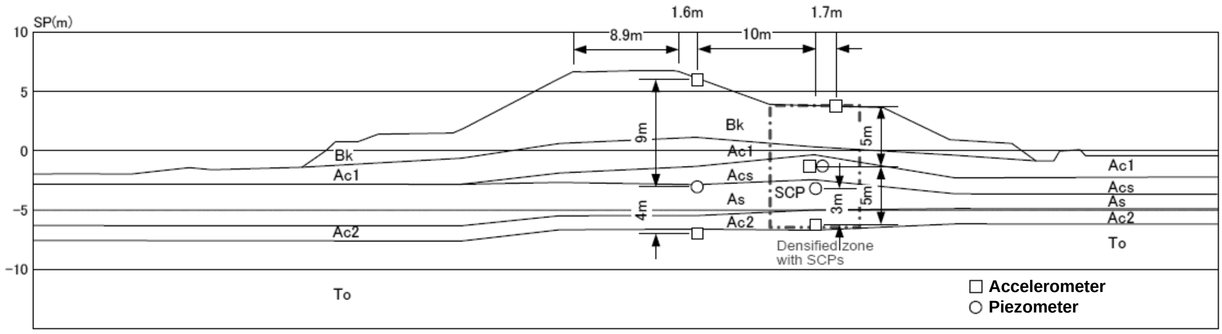
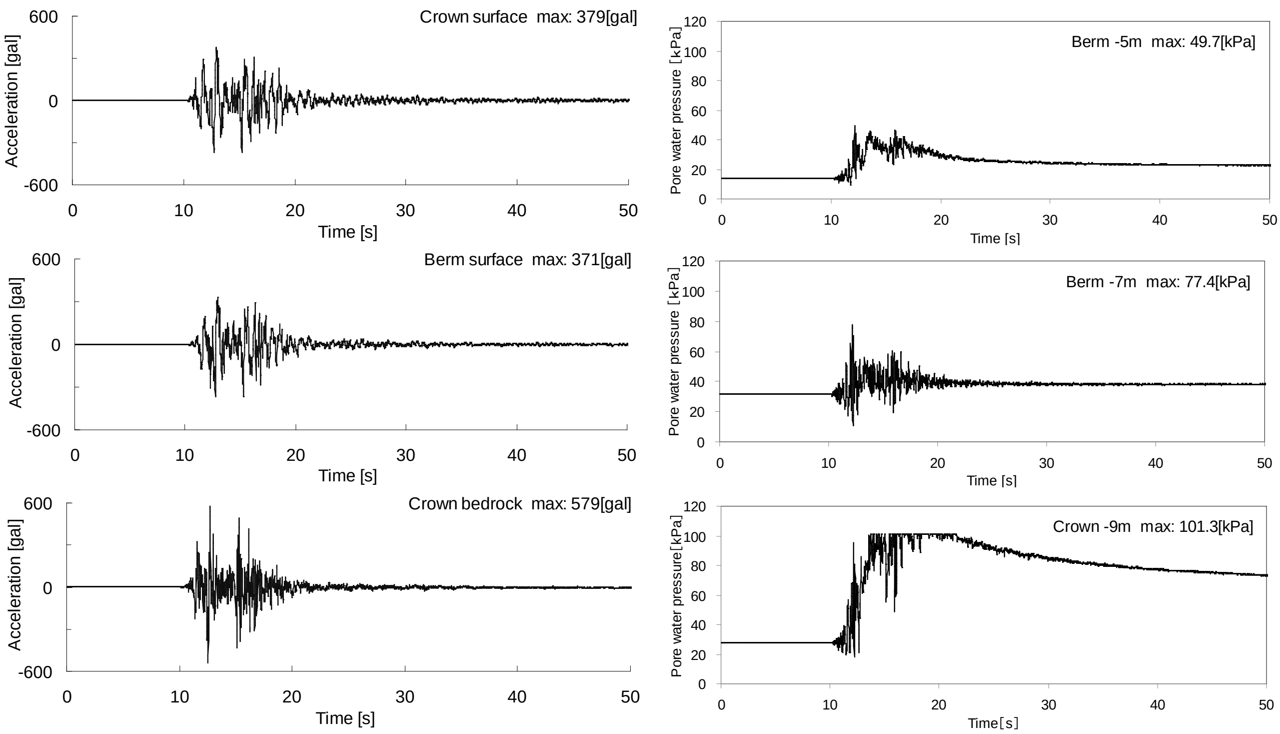


Figure 3 Locations of accelerometers and piezometers at Nakashimo station.



(a) Acceleration (b) Pore water pressure

Figure 4 Time history records observed at Nakashimo station during the main shock (M6.4) of the northern Miyagi earthquakes on July 26, 2003.

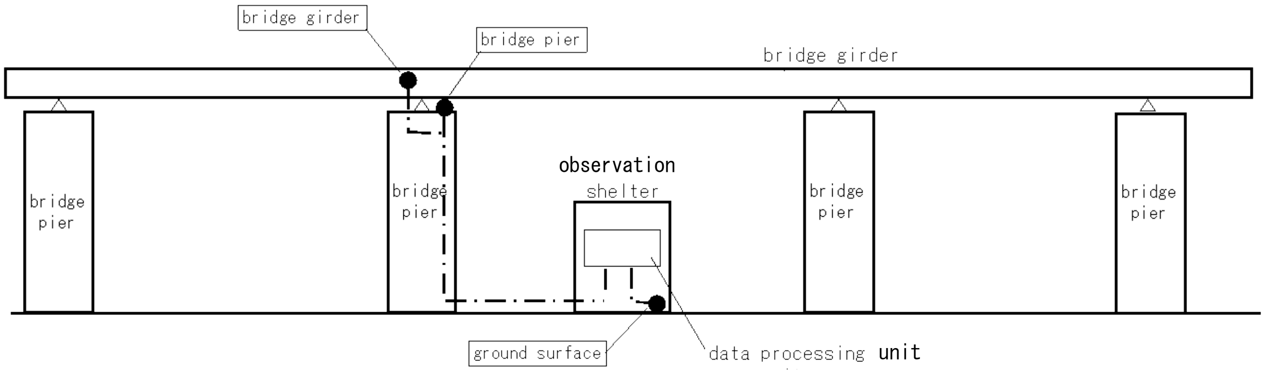
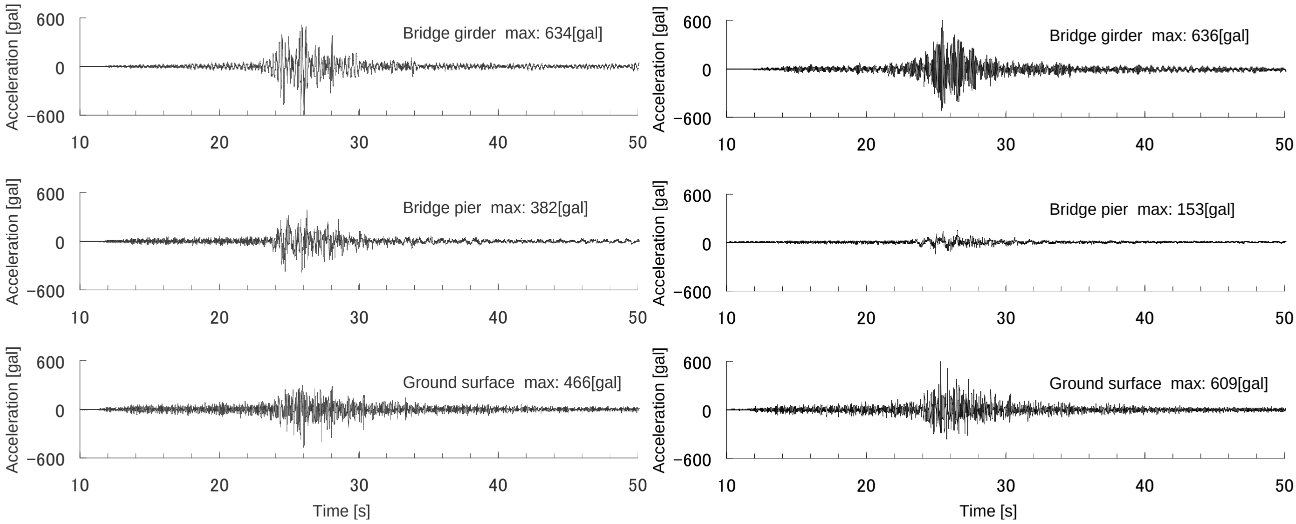


Figure 5 Typical configuration of instruments at a bridge site.



(a) Longitudinal direction (b) Transverse direction

Figure 6 Accelerograms recorded at Yamada viaduct during the northern Iwate coast earthquake (M6.8) on July 24, 2008.

3. OBSERVATION AT ROAD FACILITIES

30 observation stations were installed at road facilities: 20 stations are at bridges, 4 at slopes, 3 at embankments, 2 at common ducts, and one at a retaining wall. A typical configuration of instruments at bridge sites is shown in Figure 5. Accelerometers are located at the girder, pier, and on the ground surface nearby.

Figure 6 shows accelerograms recorded at Yamada viaduct during the northern Iwate coast earthquake (M6.8) on July 24, 2008. Horizontal force distribution structure was adopted for the viaduct, 470.7m long with two 4-span continuous steel box girders, using multi-layered rubber bearings. We conducted dynamic response analysis of the viaduct using the observed records and found the earthquake response of the viaduct cannot be reproduced well by a simple model (Matsuhashi *et al.*, 2010). We have been investigating the reason that causes the difference between observed and analytical responses.

4. CONCLUDING REMARKS

NILIM has been intent on maintenance of the strong earthquake motion observation systems and utilizing the observed records for improving seismic design and earthquake disaster mitigation. We will be working on further development of the observation systems and improvement of the data utilization.

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