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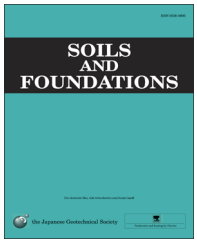

Damage to agricultural facilities

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Abstract

The 2011 off the Pacific Coast of Tohoku Earthquake severely damaged agricultural facilities in Tohoku district, damaged coastal dikes and farmland behind the embankment, and disrupted lifelines, such as irrigation systems, in districts far from the coastline.

This report introduces an outline of the damaged agricultural facilities on the basis of the investigations made during inspection visits to those facilities by National Institute for Rural Engineering (NIRE). In Fukushima Prefecture, many small earth dams, other dams, and pipelines were damaged. Among a total of 3730 dams and small earth dams in Fukushima Prefecture, 745 small earth dams were damaged by sliding failure or settlement of embankment. Small earth dams at 3 locations were breached, inflicting severe damage on the regions downstream.

The embankments of two dams for agricultural use, the Nishigo dam and the Hatori dam, located in the Tohoku region, were damaged. In parts of Fukushima Prefecture where trunk pipelines for agricultural use have a total length of 17.8 km, at 7 places pipelines were either exposed or experienced leakages, and severe deformation which did not satisfy standard values was noted at 149 locations.

This paper reports the state of damage typical to each type of facility and the restoration measures that were undertaken.

Keywords: Small earth dam; Pipeline; Earthquake; Failure; Liquefaction; Site investigation; Restoration

1. Introduction

The 2011 Off the Pacific Coast of Tohoku Earthquake caused extensive damage such as the floating and ejection of buried structures as well as the failure of some small earth dams. Mohri et al. 1995 performed a detailed survey on the state of a main agricultural pipeline that broke during the 1993 Hokkaido Nansei-Oki Earthquake, and found that the damage was focused on the ancillary structure. Koseki and Matsuo (1997), Yasuda et al. (1995), and Yamaguchi et al. (2012a) described the ground liquefaction mechanism that caused manholes and pipelines to float up to the ground surface.

In Japan, while there have been no reports of the severe failure of large dams constructed with earthquake resistant design, Yamaguchi et al. (2012b) reported on the seismic behavior of embankment dams during an earthquake. Regarding small earth dams, Hasegawa and Murakami (1996) and Tani (1996) described the damage features and mechanism of the 1995 Hyogo-ken Nanbu Earthquake. Large earthquakes have resulted in the damage of a huge number of small earth dams. For example, the 1995 Hyogo-ken Nanbu Earthquake resulted in damage to 1222 of the 51,000 small earth dams in Hyogo Prefecture, and the 1983 Japan Sea Chubu Earthquake resulted in damage at 1300 locations at small earth dams in Akita Prefecture and Aomori Prefecture. All of these small earth dams damaged by earthquake were constructed before the enactment of the seismic design standard (Ministry of Agriculture, Forestry and Fisheries, 2009), while other small

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dams constructed in accordance with the seismic design standard have been safe. However, it is not clear enough how safe they actually are from a hypothetical earthquake like a Level 2 earthquake.

The 2011 off the Pacific Coast of Tohoku Earthquake breached 0.1% of small earth dams in Fukushima Prefecture, showing that almost all of the small earth dams remained in sound condition. This paper reports on the state of the damaged earth dams and pipelines.

2. Earthquake ground motion in Sukagawa City, Fukushima

The Kumado river region is located in the west part of Sukagawa City in Fukushima Prefecture, as shown in Figs. 1 and 4. A large-diameter pipeline is installed underground, as roughly shown in Fig. 2, in soil comprised of sandy silt with an N value (Standard Penetration Test, SPT) of 10 or less at a depth of about 10 m below the ground surface, and coarse/medium sand with an N value of more than 20 at a depth of about 10 m and deeper. In the hilly and mountainous areas, the ground at the installation depth of the pipeline consists of mainly silt and clay with an N value of 5–10.

Data on the earthquake ground motions of the 2011 off the Pacific Coast of Tohoku Earthquake is shown in Fig. 3: EW acceleration at the K-Net Sukagawa site(FKS017) recorded at Sukagawa City in Fukushima Prefecture. The maximum acceleration of the EW motion was 492.9 cm/s^2. The duration of this motion at the Sukagawa site over 50 cm/s^2 continued for 100 s despite being more than 200 km from the epicenter, which was an earthquake motion never which had been experienced. The distribution of the duration of acceleration over 50 cm/s^2 was located from the Tohoku region to Kanto region (Sasaki et al., 2012). The duration times in the Tohoku region were greater than in the Kanto region. The very long duration time of the main shock resulted in the significant deformation of the ground and soil structure, and induced severe liquefaction of soil (Yasuda et al., 2012). A detailed investigation of the river embankments throughout the Tohoku

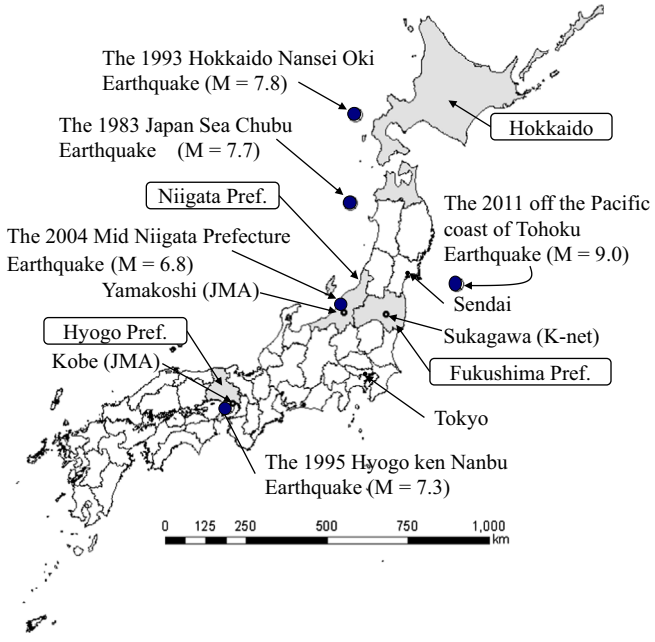

Fig. 1. Locations of earthquake epicenter and investigations.

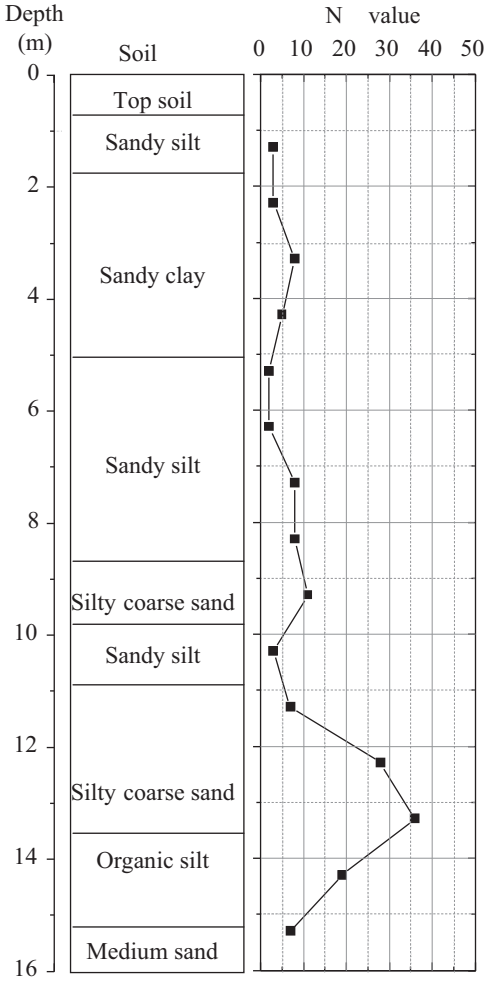

Fig. 2. Result from boring survey conducted before earthquake at Kumado region in Fukushima Pref. (at Ooikenishi Conbined Junction in Fig. 4).

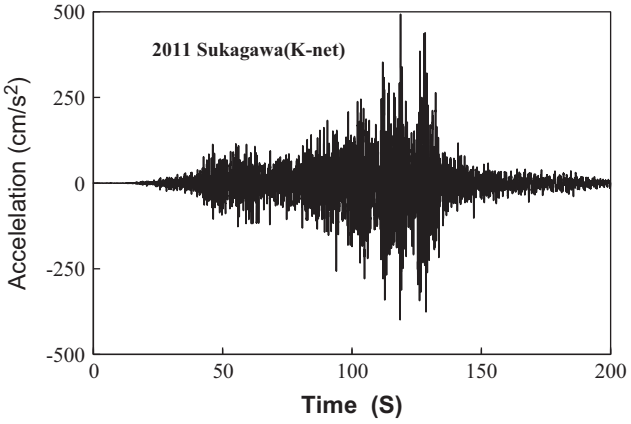

Fig. 3. Accelelation records at Sukagawa (K-net).