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Soil liquefaction in Tokyo Bay area during the 2011 Great East Japan Earthquake

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The 2011 Great East Japan Earthquake caused severe liquefaction in the Tokyo Bay area. Immediately after the earthquake, the authors investigated the liquefied sites for about 10 days. A tentative map of liquefied zones was drawn based on this first stage investigation. As the liquefaction-induced damage were serious, Kanto Regional Development Bureau of the Ministry of Land, Infrastructure, Transport and Tourism, intended to make joint research with JGS to identify liquefied sites. Figure 1 is the map of liquefied zones thus estimated which is slightly modified from the tentative map. As shown in this map, severe liquefaction occurred in reclaimed lands from Shinkiba in Tokyo through Urayasu, Ichikawa, Funabashi and Narashino cities to Chiba City. Total liquefied area from Odaiba to Chiba City reached about 41 km2 which is wider than the liquefied area in Christchurch during the 2011Christchurch, New Zealand earthquake. These lands were constructed after around 1966 by soils dredged from the bottom of the bay. The dredged and filled soils must have been liquefied by the earthquake.

Seismic intensities in the liquefied zones were not high, 5- to 5+ by the JMA scale or 160 to 230 cm/s2 in peak surface acceleration, though the liquefied ground was covered by boiled sands. According to the questionnaires to inhabitants, starting time of the boiling of muddy water are quite different at place. This must imply the depths of liquefied layer and/or water table are different at place. Some inhabitants testified boiling did not occur during main shock but occurred during aftershock. It can be said that very long duration of the main shock and an aftershock 29 minutes later should have induced the severe liquefaction.

Two remarkable characteristics of the liquefied grounds were observed: i) much boiled sand and large ground subsidence, and ii) the buckling of sidewalks and alleys. The former must have occurred because the liquefied soils were very fine. The latter might have been induced by a kind of sloshing of liquefied ground. Sewage pipes meandered or were broken, joints were extruded from the ground, and pipes were filled with muddy water. Many manholes were sheared horizontally and filled with muddy water, whereas few manholes were uplifted. This remarkable damage to buried pipes and manholes might have occurred due to a kind of sloshing of liquefied ground.

About 27,000 houses were damaged in the Tohoku and Kanto districts of Japan due to liquefaction caused by the earthquake. About half of the damaged houses are located in the Tokyo Bay area. In Urayasu City, where houses were seriously damaged, 3,680 houses were more than partially destroyed. Houses settled substantially and tilted seriously

Keywords: Great East Japan earthquake, Liquefaction, reclaimed land, house, sewqage pipe

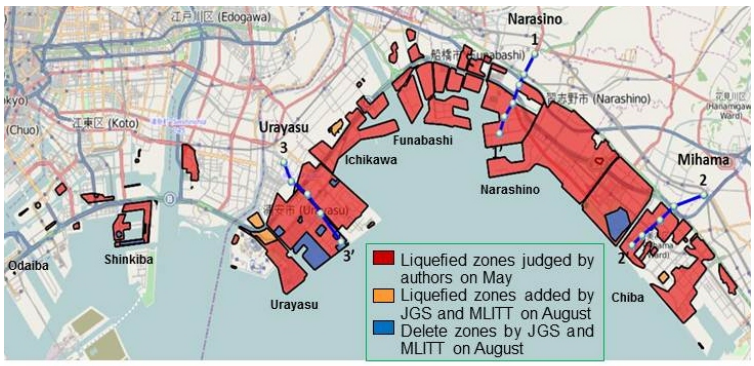

Figure 1 Liquefied area from Odaiba in Tokyo to Chiba City (Joint research by Kanto Regional Development Bureau of the Ministry of Land, Infrastructure, Transport and Tourism and JGS)