Liquefaction damage of the 2016 Kumamoto earthquake

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On April 16, 2016 at 1:25 am local time in Japan, a Japan Metrological Agency Magnitude (M_{JMA}) 7.3 earthquake struck the Kumamoto Prefecture on the island of Kyushu in southwest Japan. This earthquake followed the M_{JMA} 6.5 earthquake, which struck on April 14 at 9:26 pm local time. They were the most severe earthquakes to affect Japan since the 2011 Tohoku earthquake. The hypocenters of the strike-slip M_{JMA} 6.5 foreshock and M_{JMA}7.3 main shock and its M_{JMA} 4.5-6 aftershocks were widely distributed along the Futagawa and Hinagu active faults. Both the earthquakes registered a reading of 7 on the Japan Metrological Agency seismic intensity scale (I_{JMA}), which is the highest reading on the I_{JMA}, in the town of Mashiki approximately 6.5 and 5.5 km from the hypocenters of the main shock and foreshock, respectively.

The earthquakes elicited a strong response and significantly damaged houses and infrastructure: fifty-five people were killed and 392 people were seriously injured; almost 8300 houses in the Kumamoto Prefecture were destroyed and numerous landslides occurred in the Mt. Aso area approximately 30 km northeast from the main shock hypocenter. Our liquefaction reconnaissance surveys and interpretation of the high-resolution aerial photographs taken immediately after the earthquakes revealed that the earthquakes induced liquefaction at a significant number of locations in an 80-km long zone extending along the faults in the 18 cities, towns, and villages in the Kumamoto Prefecture. At approximately 6500 locations, occurrences of sand boiling were obtained, and one third of them occurred in Aso City located in the outer crater of Mt. Aso. Nearly 1800 grid cells, whose size is approximately 250 m × 250 m, identified to be containing liquefied sites Serious damage was caused to houses, pipelines, levees, agricultural land, and facilities because of the liquefaction. The intensities of the ground motion of the liquefied grid cells were examined, and approximately 99.5 % of liquefied grid cells were found distributed in the areas where the I_{JMA} exceeded 5 upper, which corresponds to VIII to IX on the modified Mercalli (MM) intensity scale, during the main shock. This paper presents the distribution of the liquefied sites and their effects on the structures during the earthquake, and the site-specific ground conditions of severely damaged liquefied sites are discussed.