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Liquefaction Phenomenon in the Kathmandu Valley during the 2015 Earthquake of Nepal

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Abstract : The Gorkha Nepal earthquake of moment magnitude (Mw) 7.8 struck the central region of Nepal on April 25, 2015 with the epicenter about 77 km northwest of Kathmandu Valley . Peak ground acceleration observed during the earthquake was 0.18g. This motion induced several geotechnical effects such as landslides, foundation failures liquefaction, lateral spreading and settlement, and local amplification. An aftershock of moment magnitude (Mw) 7.3 hit northeast of Kathmandu on May 12 after 17 days of main shock caused additional damages. Kathmandu is the largest city in Nepal, have a population over four million. As the Kathmandu Valley deposits are composed mainly of sand, silt and clay layers with a shallow ground water table, liquefaction is highly anticipated. Extensive liquefaction was also observed in Kathmandu Valley during the 1934 Nepal-Bihar earthquake. Field investigations were carried out in Kathmandu Valley immediately after Mw 7.8, April 25 main shock and Mw 7.3, May 12 aftershock. Geotechnical investigation of both liquefied and non-liquefied sites were conducted after the earthquake. This paper presents observations of liquefaction and liquefaction induced damage, and the liquefaction potential assessment based on Standard Penetration Tests (SPT) for liquefied and non-liquefied sites. SPT based semi-empirical approach has been used for evaluating liquefaction potential of the soil and Liquefaction Potential Index (LPI) has been used to determine liquefaction probability. Recorded ground motions from the event are presented. Geological aspect of Kathmandu Valley and local site effect on the occurrence of liquefaction is described briefly. Observed liquefaction case studies are described briefly. Typically, these are sand boils formed by freshly ejected sand forced out of over-pressurized sub-strata. At most site, sand was ejected to agricultural fields forming deposits that varied from millimetres to a few centimeters thick. Liquefaction-induced damage to structures in these areas was not significant except buildings on some places tilted slightly. Boiled soils at liquefied sites were collected and the particle size distributions of ejected soils were analyzed. SPT blow counts and the soil profiles at ten liquefied and non-liquefied sites were obtained. The factors of safety against liquefaction with depth and liquefaction potential index of the ten sites were estimated and compared with observed liquefaction after 2015 Gorkha earthquake. The liquefaction potential indices obtained from the analysis were found to be consistent with the field observation. The field observations along with results from liquefaction assessment were compared with the existing liquefaction hazard map. It was found that the existing hazard maps are unrepresentative and underestimate the liquefaction susceptibility in Kathmandu Valley. The lessons learned from the liquefaction during this earthquake are also summarized in this paper. Some recommendations are also made to the seismic liquefaction mitigation in the Kathmandu Valley.

Keywords : factor of safety, geotechnical investigation, liquefaction, Nepal earthquake
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