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論 文 要 旨

THESIS SUMMARY

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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Liquefaction has been reported as a cause of severe damage to foundations of buildings, bridges and other structures, as well as to ports and buried lifelines during past major earthquakes. Previous studies that initiated following the observations from liquefaction-related damage during several past devastating earthquakes, have provided significant insights into the liquefaction phenomenon and associated failures. Initially studies were only focused on assessing the triggering factors for liquefaction in clean sandy soils. As the years passed, physical model studies on layered soil deposits evolved. It is noted that the real soil profile is complex, characterized by various patterns of layering and lensing and a soil deposit is neither uniform nor consists of continuous layers. Earthquake-induced liquefaction has become a major problem to soil embankments such as river dykes, levees, road embankments, and earth dams, supported on a cohesionless foundation soil. The widespread damage to such embankments occurred mainly due to the liquefaction of foundation soil, resulting in cracking, settlement, slumping, and lateral spreading. Previous studies have investigated the dynamic response of embankments by mainly considering uniform sand foundation and a single earthquake event. However, the foundation of an embankment consists of many sublayers of soil from liquefiable sand to relatively impermeable layer, and during earthquakes a mainshock may trigger an aftershocks before the major dissipation of excess pore water pressure (Δu), which may have the potential to cause additional damage to soil structures. Therefore, my research is focused on investigating the liquefaction mechanism of non-homogeneous soil deposits and to understand the effects of non-homogeneity on the deformation of embankments under the mainshock-aftershock sequence of ground motions.

The research was carried out in three phases. The first phase was focused on the understanding the liquefaction mechanism of non-homogeneous soil deposits. The study was carried out by a series of dynamic centrifuge tests and finite element analyses. Four types of model tests were conducted: one model test involved a uniform soil deposit; one involved a continuous layered soil deposit; and two involved discontinuous layered soil deposits, referred to as non-homogeneous soil deposits. Non-homogeneity in the tests was incorporated by including periodically distributed silty sand patches. It was found that, in non-homogeneous soil deposits, the pore water was trapped beneath or within less permeable silty sand patches due to the local migration of pore water and difference in permeabilities of the soils. The less permeable silty sand layer acted as a barrier and restricted the seepage of pore water. This indicated that the pore water found a path to drain from the high pore pressure region to the low pressure region, which revealed that the presence of the discontinuous less permeable layer could have substantial effects on the pore pressure dissipation mechanism and drainage. It was found that larger excess pore water pressure remained for a longer period of time in the discontinuous region in non-homogeneous soil deposits compared with the continuous layered and uniform soil deposits. The rapid dissipation of Δu occurred through the discontinuous part in the non-homogeneous soil deposits, manifesting a larger settlement in the discontinuous part, causing non-uniform settlements.

In the second phase, the investigation of liquefaction-induced deformation of earthen embankments on various liquefiable foundation conditions under mainshock-aftershock sequential ground motions was carried out by a series of dynamic centrifuge tests and finite element analyses. The liquefiable foundation included uniform sand foundation, continuous layered foundation, and non-homogeneous foundation. Effects of various foundation conditions on embankment deformations were compared and analyzed. In the non-homogeneous foundation, the dissipation of pore water from the underlying layer was concentrated at the discontinuous region below the embankment, inducing the larger excess pore water pressure ratios. From the results, it was found that the embankment resting on non-homogeneous soil deposits suffered more

damage compared to the uniform sand foundation of the same relative density. The results also suggested that the sequential ground motions had a significant effect on the accumulated deformation of embankment.

The stratification of non-homogeneous foundation is complex and the discontinuity in low-permeability layer may lie at any location below the embankment. Therefore, the third phase investigated the effects of position of non-homogeneity on the deformation of embankment. Parametric studies were carried out by changing the position of non-homogeneity in order to determine the critical position of non-homogeneity using finite element analysis. The position of non-homogeneity varied from the discontinuity lying exactly below the center of embankment to the toe of embankment. The parametric studies showed that larger excess pore water pressure ratio were found below the toe region for the cases where the discontinuity lay below the embankment toe. This caused the liquefaction of soil at the free field and toe region, which decreased the confining stress of foundation soil below the embankment. This might have allowed the lateral stretching of the soil below the embankment towards the free field, leading to the larger lateral deformation in the free field and toe region for the cases where discontinuity lay below the embankment toe. Furthermore, the crest settlement was found to be even and uniform when the discontinuity lay exactly below the center of embankment. However, uneven settlements occurred at the embankment crest when the discontinuity was located at the position other than the center of embankment.