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（博士課程）
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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 ）

From the 1964 Niigata earthquake, liquefaction has been recognized as a serious problem in geotechnical engineering. Liquefaction has usually caused severe damage to embankment structures such as levees, earth dams, levees and dykes, supported on a loose sandy ground. In order to mitigate the damage caused by liquefaction, the most effective way is to increase the density of ground. The Sand Compaction Pile (SCP) method is a typical densification countermeasure against liquefaction, whose main purpose is to prevent liquefaction occurrence or reduce settlement. Generally, when the SCP method is adopted for the foundation ground of an embankment structure, the foundation ground is improved to a target density before the embankment is constructed. However, the ground with an existing embankment cannot be improved by the SCP method with vertical sand piles. It was reported that the major cause of the embankment settlement and/or failure is the lateral deformation of liquefied foundation soil below the embankment towards the free field. In the current design guide of liquefaction countermeasure for existing embankment, the soil under embankment toes is improved by the SCP method or the deep mixing method, aim at mitigating crest settlement by providing containment for the deformation of the liquefiable foundation soils below the embankment. With advancements in machinery, a new type of SCP method has been recently developed, which enables the vertical installation of sand piles or the installation of sand piles at a specific angle into the ground. Thereby, compacted sand piles can be formed in any direction underneath an embankment. The geometric form of the improvement zones may affect the response and deformation behavior of the improved ground and embankment. However, these influences are not well investigated and incorporated into the current design precisely. Therefore, the main purpose of this study is to investigate the performance of an embankment improved by the SCP method with various geometric forms including the angle and the extent of the SCP improvement zone.

This study consists of three parts to achieve the purpose. In the beginning, a series of dynamic centrifuge experiments and finite element analyses are conducted to evaluate the effectiveness of SCP improved ground with various geometric improvement forms in terms of embankment settlement, and to investigate the effects of the geometry of the improved zone on the ground response and deformation mechanism of embankments and foundation ground. In the centrifuge test program, the focus is on the angle of the improvement zone, which is defined as the angle between the SCP improvement form and the ground base, in which the angle is 50, 60 and 90 degrees. It is found that the lateral displacement beneath the embankment toes is mitigated by the presence of the improvement zone installed in the foundation ground. In particular, the case with a 50° improvement zone is more effective and contributes to the lower settlement of the embankment.

In order to evaluate the SCP improvement angle in a wide range as much as possible in practice, in the second part of this study, the deformation mechanism of embankments supported on a liquefiable ground improved by the SCP method with 30 to 90 degrees was investigated. Accordingly, the investigation of liquefaction induced deformation of embankment on various ground condition (i.e., various SCP improvement angle) was carried out by a series of finite element analyses. Effects of the SCP improvement angle on ground deformation and embankment settlement were compared and analyzed. It was found that by making the improvement angle smaller than 60 °, the excess pore water pressure in the foundation ground could be suppressed, and the amount of settlement is also reduced.

In the third part of this study, the effect of the extent of SCP improvement was investigated by a FEM analyses in chapter 6. In the design of the SCP method as a liquefaction countermeasure, in addition to the improvement angle, the improvement extent must also be determined. The extent of the SCP improvement must satisfy two main aspects: (a) Stability of slip failure of embankment and ground, and (b) the amount of settlement should be kept below an allowable value. In this study, the former

condition (i.e., ensuring stability) was set to be satisfied in all cases, and then the focus is on the effect of the extent of the SCP improvement on the liquefaction-induced embankment settlement. It was found that as the extent of the SCP improvement increases, the excess pore water pressure ratio generated in the ground below the embankment tends to increase. Nevertheless, increasing the extent of the SCP improvement was very effective for reducing the lateral deformation of the foundation ground under the embankment, resulting in smaller embankment settlement.