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Description of partial sandy layers of dredged clay deposit using penetration resistance in installation of prefabricated vertical drains

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Abstract

The dredged soil dumped into a reclamation facility is generally heterogeneous. If the reclamation is executed using hydraulic transportation through pipes, large particles will be deposited around their outlets, and fine particles will be deposited apart from those outlets, resulting in significant grain size segregation. Therefore, ground improvement by applying a preload or vacuum to the dredged soil deposit with prefabricated vertical drains (PVDs) may result in an unexpected differential settlement. In the present study, partial sandy layers in a dredged soil deposit were identified as three-dimensional information using the penetration resistance of the mandrel in the PVD installation, which was recorded as dense information for a wide region. It was clarified that the depth profile of the penetration resistance of the mandrel in the PVD installation was useful for investigating the soil stratigraphy, because it is closely related to the depth profile of the tip resistance in cone penetration tests (CPTU). The relative penetration resistance, defined as the penetration resistance eliminating the data trend that reflects the effects of the overburden stress, shear strength, sleeve friction and buoyance, is useful for identifying the partial sandy layers in a dredged soil deposit. A classification equation was proposed for identifying the partial sandy layers. Firstly, the depth profile without the sandy layer was approximated, and then the threshold value of 1.0 MN/m^2 was used to identify the partial sandy layer. To verify the availability of this proposed method, the depth profiles were compared with the results of CPTU tests. In addition, the predicted settlement, calculated on the basis of the stratigraphy obtained using the penetration resistance of the PVDs, was compared with the ground surface profile leveled after vacuum consolidation.
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Keywords: Penetration resistance; Mandrel; Prefabricated vertical drain; PVD; Partial sandy layer; Differential settlement; Ground survey

1. Introduction

Dredged soil mainly consists of clay and silt and is generally in an ultra-soft state with a very high water content. To use the dredged soil deposit as a foundation ground, prefabricated vertical drains (PVDs) (or plastic board drains, PBD) are installed for ground improvement, and then a preload or vacuum is applied. Typical examples of projects using preload technology to accelerate consolidation include the offshore expansion of Tokyo Haneda Airport (Nakada et al., 1997) and the construction of the new Kita-Kyushu Airport (Terashi and Katagiri, 2005). Recently, in some waste reclamation facilities, vacuum consolidation technology has been applied to dredged soil deposits to increase their volumetric capacity.

The dredged soil dumped into a reclamation facility is generally heterogeneous. If the reclamation is executed using

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Photo 1. PVD installing machine on work vessel.

hydraulic transportation through pipes (pipeline), large particles are deposited around their outlets, and fine particles are deposited apart from those outlets, resulting in significant grain size segregation. Therefore, ground improvement by applying a preload or vacuum to the dredged soil deposit may result in an unexpected differential settlement. In most cases, however, no information on the location of these outlets during infilling has been recorded.

As a part of construction management, the hydraulic pressure applied to operate the mandrel in the PVD installation is recorded with a data acquisition system. However, the recorded data are generally not used when no execution problems are encountered. The PVD-installing machine on a work vessel used in this study is shown in Photo 1 and its operation system with a hydraulic motor is illustrated in Fig. 1. The mandrel is penetrated through the friction rollers driven by the hydraulic motor. High and low pressures are measured by pressure transducers and recorded to calculate the difference between these two values corresponding to the penetration resistance.

In consideration of the dense arrangement of the PVD installation pitch and the continuity of the data in the depth direction, if the data set can be used to find partial sandy layers, caused by the grain size segregation, the data set can then be transformed into a three-dimensional stratigraphy of the dredged soil deposit. This is equivalent to conducting cone penetration tests (CPTU) in a very dense arrangement. Such a three-dimensional description of the stratigraphy of partial sandy layers can be employed as very useful information on the prediction of differential settlement derived from the consolidation.

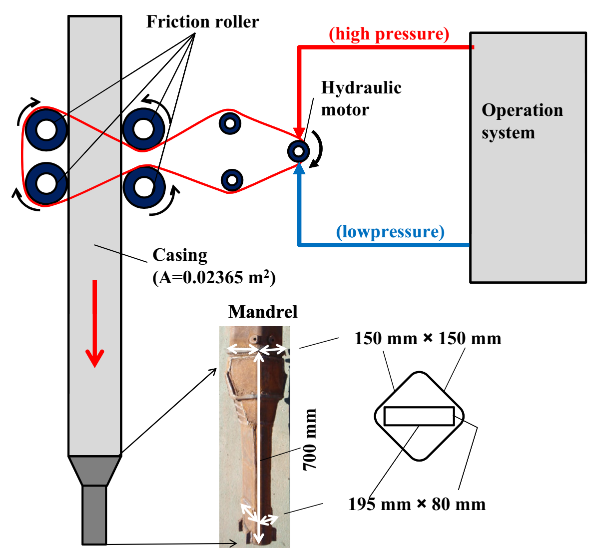

Fig. 1. Illustration of measurement of hydraulic pressure in PVD installation and details of mandrel.

In the present study, the PVD installation for the vacuum consolidation conducted in a reclamation facility for dredged soil was examined. The data set of the hydraulic pressure for the mandrel penetration was transformed into the depth profile of the penetration resistance to find the partial sandy layers in the dredged soil deposit and to describe the three-dimensional stratigraphy of the dredged soil deposit. To verify the availability of the proposed method, the depth profiles of the penetration resistance were compared with the CPTU results. In addition, the ground surface profile, leveled after the vacuum

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