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Prefabricated and electrical vertical drains for consolidation of soft clay

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ABSTRACT

The use of prefabricated vertical drains to consolidate soft clay is a common ground improvement method. In large projects laboratory testing of PVDs for selection and quality assurance is considered important. This paper presents a review of PVD laboratory testing. The need to provide simulated site conditions in the test is emphasized. In addition instrumented PVDs show that installation stresses in deep soft clay deposits could cause filter rupture under tensile failure. It is also shown that the maximum required discharge capacity of a PVD is obtained by equating the flow rate of the PVD under the installation and consolidation states to the maximum rate of volume reduction of the influential clay cylinder of the PVD. Consolidation can be enhanced much faster in clay soils if vertical drains manufactured with conducting polymer are used. Some laboratory tests, field tests and field applications of such electric vertical drains (EVD) are presented. A minimum current density at appropriate applied voltage is required to benefit from the electric osmosis (EO) application. EVD in dewatering clay soils, extracting heavy metals in clay soils and few other geotechnical applications are also presented.

1. Introduction

For several decades prefabricated vertical drains have been in use for consolidation of soft clay. Since PVDs are more QA/QC dependable, they are used in ground improvement projects involving thick deposits of soft clay. Many different types of PVDs are available in the market; but some of them have delivered disappointing consolidation rates. The standard laboratory tests on PVDs appear to have failed in isolating these substandard PVDs. A series of tests designed to understand and simulate field conditions reveal that discharge capacity of a PVD is subject to deformation of the PVD core and filter, clay intrusion, axial strain and kinking as well as installation stresses. The latter can cause filter rupture and completely block the flow path. The paper compiles a summary of these findings for consolidation of clay soils.

With the advent of conducting polymer, EVDs have been installed for passing DC voltages, to further accelerate the consolidation of soft clays. The electro-osmotic (EO) process is found to be quite useful for dewatering clay soils, extracting heavy metals and strengthening such soils.

2. Desired characteristics of PVDs

It is a common practice to use PVDs to accelerate the consolidation of soft clay deposits. Annually several million meters of PVDs are installed worldwide to improve soft soil deposits. In 2001, projects in Singapore recorded an annual consumption of more than 20 million meters. Rates of installation as high as 30 000 linear meters per 14-h day per machine have been reported in these projects (Choa et al., 2001). Installation rigs with mandrel insertion and withdrawal speeds exceeding 1 m/s have been developed for these projects (Cortlever and Dijst, 2002). Installation stresses need to be examined for PVD performance.

PVDs normally consist of a core and a filter (sleeve) made with polymeric materials. The core should have adequate capacity to convey the water inflowing from the consolidation of cylindrical clay defined by the tributary volume of a single PVD. The inflowing water should first transmit rapidly enough through the PVD filter. This demands a proper selection of filter criteria including its thickness. A coarse single filter will not effectively arrest clay intrusion. A filter too thin and/or of smaller modulus is prone to (tensile and puncture) failure during installation, fast clogging and consequent reduction of water flow capacity, and intrusion into grooves of the core (Koerner, 1997; Karunaratne and Chew, 2000).

3. Laboratory testing of PVD

During laboratory testing of PVDs, neither a stiff platen nor a foam rubber lining gives a discharge capacity as low as a layer of soft clay packed around a PVD, jacketed in a rubber membrane under an applied all round pressure, similar to triaxial testing procedure. This has been confirmed by Holtz et al. (1991), Loh et al.

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