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In-Situ Test Research on Vacuum Dynamic Consolidation Method to Improve Double-Layered Soft Ground

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ABSTRACT

A new technique named vacuum dynamic consolidation method (VDCM) to improve double-layered soft ground is presented on the basis of a harbor construction project in Shanghai. By analyzing the variation of underground water table and soil water content in shallow ground, the roles of vacuum well dewatering are investigated. The increasing and dissipation regularities of excess pore water pressure during and after dynamic compaction are also monitored. The underlying improvement mechanism of VDCM is analyzed and the method to choose the optimal construction parameters is proposed. The results of field detective tests verify the validity of VDCM to improve double-layered soft ground. This study provides an effective and economic improvement method, which can be widely used in harbors or other coastal engineering constructions.

KEY WORDS: Vacuum dynamic consolidation method(VDCM); double-layered soft ground; ground improvement; excess pore water pressure; field detective tests

INTRODUCTION

Dynamic consolidation method (DCM), also named dynamic compaction, is one of the engineering measures to improve soft ground firstly proposed by Menard Inc. (Menard and Broise, 1975; Menard, 1976). The effectiveness of DCM to improve gravelly soils, sandy soils, and collapsible soils has already been proved by many construction projects (e.g., Gamblin, 1984; Rollins and Rogers, 1994; Lee and Gu, 2003). Recently, DCM begins to be used in saturated soft clay ground treatment, but the effectiveness is not always satisfied (e.g., Vemon, 1998; Zheng and Lu, 2000; Shi et al, 2001).

As to saturated soft clay ground, when treated by conventional dynamic compaction, two main problems should be stressed. First, because of its poor properties of saturated soft clay, such as high water content and low permeability, excessive pore water pressure induced by tamping energy can't dissipate quickly. Second, the high tamping energy will over-destroy the structure of saturated soft clay in shallow surface ground and it can't restore in short time. To solve these problems, many new methods have been proposed on the basis of field and lab tests research. Merrifield and Davies (2000) introduced low-energy dynamic compaction for shallow treatment of soft clay ground, and the validity of wave-activated stiffness test in prediction of soil stiffness improvement was confirmed. Zheng and Lu (2000) analyzed the cause responsible for the failure of soft clay ground improved by traditional technique of DCM, and the plastic draining plates were introduced to accelerate the dissipation of excess pore water pressure.

In this paper, a new technique named vacuum dynamic consolidation method (VDCM) to improve double-layered soft ground is introduced on the basis of Yangshan Harbor construction project in Shanghai, China. This new technique combines the advantages of both DCM and vacuum well dewatering. By in-situ monitoring and detection, the roles of vacuum well dewatering are comprehensively studied and the different improvement mechanisms for different soil layers are emphatically discussed.

SITE CONDITIONS

The construction site is in southeast seashore in Shanghai, which is a large container pool served for Yangshan Harbor. The total area of the construction site is about 612,000 m^2. The geological conditions of the site are a silty clay layer in surface and a sandy silt layer underlying. The average thickness of the silty clay layer and the sandy silt layer are about 2m and 12 m, respectively. The depth of original underground water table is about 0.6–0.8 m.

The main physical and mechanical indices of ground soil are summarized in Table 1.

Table 1. Properties of ground soil

Soil layer	Thickness (m)	γ (kN/m^3)	e	I_P (%)	I_L	$a_{1\text{-}2}$ (MPa^{-1})
①Silty clay	1.6–2.5	18.8	0.905	13.9	1.03	0.32
②Sandy silt	11.0–14.0	19.0	0.848			0.17
③Clay	5.0–7.0	17.2	1.099	22.1	1.10	0.52