



Controlled Curved Drilling Technique in the Permeation Grouting Method for Improvement Works of an Airport in Operation

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Abstract

Improvement of the ground under existing structures against liquefaction is not easily possible. A new controlled curved drilling method is developed to apply the permeation grouting of chemicals to the liquefiable ground under existing structures. This method is employed for the improvement work of Tokyo International Airport. Details of application of this new method are presented in this paper. The precise monitoring system during the improvement work for prevention of any potential accident during the improvement work is also demonstrated. The post-improvement investigations showed that application of permeation grouting method by means of controlled curved drilling technique can effectively and safely improve the ground.

Keywords: Airport; Liquefaction Mitigation; Controlled curved drilling; Permeation grouting method

1 Introduction

Tokyo International Airport is one of the busiest airports in the world. Besides, it is expected that the airport resume its operation after 3 days of occurrence of a great earthquake around that area. Therefore, as part of improvement work, it was planned to improve the soil under the airport's runway to increase the liquefaction resistance of the runway without disturbing its normal daily operation.

Application of silica stabilizers for prevention of liquefaction which is called Permeation Grouting Method (PGM) dates back to late 1990's. Different technical aspects of this method have been investigated in previous studies (Hayashi et al. 1996, Yamazaki et al. 2005, and Zen et al. 2014). In addition, the practical applicability of this method has also been verified by conducting full-scale tests, 1-g model experiments and centrifuge modelling investigations (Gallagher et al. 2007, Kawamura et al.

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2004, Miyamoto et al. 2000, and Conlee 2012). In this method, low viscose solvent-type silicate based material diluted by water is injected into ground. Because of its low viscosity, the solution provides high permeability for sandy soils. By replacing the existing pore water in the ground with injected chemical and forming a permanent gel after the solidification of the chemicals which binds soil particles, it reduces the potential of liquefaction in the soil.

Conventionally, PGM has been applied to the ground through vertical boreholes. A new controlled curved drilling method has been developed to avoid most of the problems caused by the conventional vertical drilling of boreholes. In the new method the curved injection bores are drilled from the sides of the runway. In this way of application the runway's normal operation is not disturbed by improvement work. This method was partially employed in the improvement works of Fukuoka Airport project for the first time in Japan (Rasouli et al. 2016). The successful application of this method verified its feasibility in a practical project. However, because of being the first application of this method, several additional safety measures were imposed during the improvement work. For example, the improvement work was mainly conducted during the limited night time when the runway's traffic was ceased. As the second experience, this method was employed for the improvement work of Tokyo International Airport. The non-stop operation of improvement work without disturbing the airport's regular traffic on the runway accelerated the project considerably in terms of duration and safety.

In this paper, details of the ground improvement under the runway of Tokyo International Airport are reported. About 200 m length of the runway has been improved by the controlled curved drilling method. The pre-treatment experiments such as correlating the gel time with the chemical's pH values and measuring the chemical diffusion in different injection time secured the improvement of ground in the desired zone. In addition, the post-treatment investigations confirmed the achievement of the designated improvement in the ground.

2 Controlled Curved Drilling Method

2.1 Background of the Controlled Curved Drilling Method

Permeation Grouting Method (PGM) of silicate based chemicals is one of the mitigations against liquefaction-induced damages to existing infrastructures. This method was initially applied by drilling vertical boreholes and injection of chemicals through these holes. In case of improvement of the soil under existing structures, significant preparation and recovery efforts such as stopping the operation of facilities and removing some parts of structures are required. In such cases, the conventional method may not be a preferable choice from the view points of the construction time and cost. To solve these shortcomings, a controlled curved drilling method is developed. By means of this technique the ground under existing structures and operating facilities can be improved without any disturbance to their normal daily operation.

After the Great East Japan Earthquake in 2011, soil improvement projects under critical existing infrastructures have increased considerably. In particular, Ministry of Land, Infrastructure, Transport, and Tourism (MLIT) of Japan required the main 13 airports of the country to be resumed within only three days after great earthquakes. In this regard, the runway of Tokyo International Airport was scheduled to be improved against liquefaction-induced damages. After considering different possible mitigations, PGM by controlled curved drilling method was selected to be employed for this improvement work. Fig. 1 shows schematically the application of the controlled curved drilling method under an airport runway during its operation.

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