International Journal of Offshore and Polar Engineering (ISSN 1053-5381)

Vol. 15, No. 3, September 2005, pp. 235–240

Effect of Soil Compaction Piles on Settlement Reduction in Soft Ground

Sung-Min Cho
Incheon 2nd Bridge Construction Office, Korea Highway Corporation, Incheon, Korea

Byoung-Ill Kim and Young-Uk Kim
Department of Civil and Environmental Engineering, Myongji University, Yongin, Gyeonggi, Korea

Seung-Hyun Lee
Department of Civil Engineering, Sunmoon University, Chonan, Chungnam, Korea

Centrifuge tests were carried out to investigate the settlement reduction effect of a sand compaction pile (SCP) and a gravel compaction pile (GCP). Numerical analyses by the finite element method (FEM), which simulate the test conditions, also were carried out to compare the test results with those of the analyses. Settlements of SCP and GCP were measured during the centrifuge test for the area replacement ratio of 30%, 40%, 50%, 60% and 70%, respectively. Also examined were the coefficient of settlement reduction, the stress concentration ratio and the coefficient of stress concentration. The results of the study show that GCP was more effective than SCP in terms of settlement reduction.

INTRODUCTION

The sand compaction pile (SCP) method, which forms a composite ground by driving the pile made of compacted sands into soft ground, is one of the commonly used soil improvement techniques in South Korea. Recently, the price of sand has been increasing, and the need for new material that can substitute for sand has been increasing as well. In fact, the SCP method has advanced and found a wider application in Japan (Barksdale and Takefumi, 1991; Enoki et al., 1991). In the Western world, the stone column method—gravel compaction pile (GCP) method—has been used to improve soft ground since the 1970s (Baumann and Bauer, 1974; Hughes et al., 1975).

The SCP and the GCP methods can be applied to both sandy and clay ground. When they are applied to clay ground, the improved clay is called composite ground. SCP or GCP behave as piles in soft ground and can carry a total load greater than soft ground can without SCP or GCP. At the same time, they also work as vertical drains to accelerate consolidation of clay grounds. In addition, they prevent liquefactions.

In this study, centrifuge tests on SCP and GCP were conducted to investigate the settlement reduction effect of these piles. Al-Khafaji et al. (1998), Jung et al. (1998) and Kitazume et al. (1998) investigated the behavior of SCP-installed ground using centrifugal model tests. Numerical analyses, which simulate the test conditions, also were carried out to compare the test results with those of the analyses. Settlements of SCP and GCP were measured during the centrifuge tests for the area replacement ratio of 30%, 40%, 50%, 60% and 70%, respectively. Also examined were the coefficient of settlement reduction, the stress concentration factor and the coefficient of stress reduction.

Received July 10, 2004; revised manuscript received by the editors May 31, 2005. The original version was submitted directly to the Journal.
KEY WORDS: Centrifuge tests, coefficient of settlement reduction, coefficient of stress concentration, gravel compaction pile (GCP), sand compaction pile (SCP).

CHARACTERISTICS OF COMPOSITE GROUND

Basic Concept

In the development of a theory for the SCP method, many researchers have tried to simplify the problem of analysis by neglecting the interactions between the sand piles, and they have come up with the basic concept of SCP ground as shown in Fig. 1 (Murayama, 1962; Ichmoto and Seumatsu, 1982).

When a uniform stress by fill operation is applied to an area with sand (gravel) piles, a stress concentration occurs due to the difference in the stiffness between the columns and the surrounding soil (Fig. 1). The stress concentration ratio (m) is defined as follows:

$$m = \sigma_s/\sigma_c \tag{1}$$

where σ_s = stress in the column, and σ_c = stress in the surrounding soil.

The relationships for σ_s and σ_c are defined by the following:

$$\sigma_s = \sigma\left[\frac{m}{1+(m-1)a_s}\right] = \mu_s\sigma \tag{2}$$

$$\sigma_c = \sigma\left[\frac{1}{1+(m-1)a_s}\right] = \mu_c\sigma \tag{3}$$

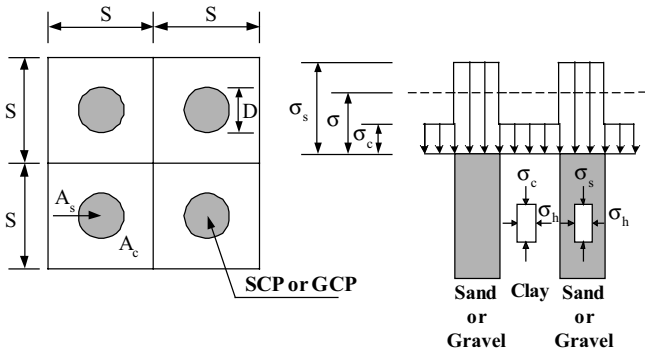

Fig. 1 Basic concept of SCP ground