



## Modeling of the cyclic behavior of shallow foundations resting on geomesh and grid-anchor reinforced sand

A.H. Boushehrian<sup>1</sup>, N. Hataf\*, A. Ghahramani<sup>2</sup>

Department of Civil Engineering, Shiraz University, Shiraz, Iran

### ARTICLE INFO

#### Article history:

Received 13 March 2010

Received in revised form

23 November 2010

Accepted 24 November 2010

Available online 16 December 2010

#### Keywords:

Reinforced sand

Shallow foundations

Cyclic loading

Field study

### ABSTRACT

Storage tank foundations with frequent discharges and filling or road embankments under repeated traffic loads are examples of foundations subjected to the cyclic loading with the amplitude well below their allowable bearing capacity. The concern exists for the amount of uniform and non-uniform settlement of such structures. The soil under such foundations may be reinforced with geosynthetics to improve their engineering properties.

This paper deals with the effects of using the new generation of reinforcement, grid-anchor, for the purpose of reducing the permanent settlement of these foundations under the influence of proportion of the ultimate load. Unloading-reloading field tests were performed to investigate the behavior of a square footing on the sand reinforced with this system under such loads. The effects of footing size and reinforcement types on the cyclic behavior of the reinforced sand were studied experimentally and numerically by the aid of computer code. The large-scale results show that by using the grid-anchors, the amount of permanent settlement decreases to 30%, as compared with the unreinforced condition. Furthermore, the number of loading cycles reaching the constant dimensionless settlement value decreases to 31%, compared with the unreinforced condition. Another goal of this paper is to present the equations for reinforced soil under cyclic loading to prevent such complicated calculation involved in deformation analysis. According to these equations, calculation of the permanent settlement and the number of load cycles to reach this amount for each foundation with a given size on the geomesh and grid-anchor reinforced sand, without further need to carry out the large-scale test, is supposed to perform easily.

© 2010 Elsevier Ltd. All rights reserved.

### 1. Introduction

Over the past 40 years, innovative ground modification approaches have been developed to solve the soil-related problems. These approaches are often considered to be the most economical means to improve an undesirable site condition compared to traditional construction methods. One of these approaches is use of polymeric materials, known as geosynthetics.

Geosynthetics have revolutionized many aspects of geotechnical practice; in addition in some applications they have entirely replaced the conventional construction materials. In many cases, the use of a geosynthetic can significantly increase the safety factor, improve performance and reduce costs in comparison with conventional design and construction alternates.

Soil reinforcement dates back to more than 40 years when the advantages of this method in the improvement of mechanical and physical properties of soils were recognized. Since then, the type and quality of reinforcements have been changed considerably; the use of polymeric reinforcements such as geotextiles, geogrids and geocomposites has been increasingly expanded.

In the recent decades, several experimental and numerical investigations have been carried out to determine the bearing capacity of shallow foundations on different soil types reinforced by a number of methods, for example metal strips, metal bars, rope fibers, tire shred and geotextiles Akinmusuru and Akinboladeh (1981); Binquet and Lee (1975); Boushehrian and Hataf (2008); Ghazavi and Lavasan, (2008); Ghosh et al. (2005); Guido et al. (1986); Hataf and Rahimi (2006); Madhavi Latha and Amit Somwanshi (2009); Huang and Tatsuoka (1990); Noorzad and Mirmoradi (2010).

One of the most effective methods of soil reinforcement is to use geomesh reinforcement. The grid-anchor is a new type of 3-dimensional reinforcement system that is made by adding anchors at an angle of 45° with plastic belt material ending at two polymer cubes with the dimensions of 1.0 × 1.0 × 1.0 cm to an

\* Corresponding author. Tel.: +98 (711) 6133108; fax: +98 (711) 6473039.  
E-mail addresses: [ahajjani@gmail.com](mailto:ahajjani@gmail.com) (A.H. Boushehrian), [nhataf@gmail.com](mailto:nhataf@gmail.com) (N. Hataf), [aghahrama@shirazu.ac.ir](mailto:aghahrama@shirazu.ac.ir) (A. Ghahramani).

<sup>1</sup> Mobile: +98 (917) 702 8072.

<sup>2</sup> Fax: +98 (711) 8328923.