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Effect of Geocell on Bearing Capacity of Shallow Foundations Under Inclined Load and Determination of Optimum Layout using the Three-Dimensional Finite Element Method

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ABSTRACT: Effect of Geocell on Bearing Capacity of Shallow Foundations Under Inclined Load and Determination of Optimum Layout using the Three-Dimensional Finite Element Method

Nowadays, the lack of suitable ground in urban areas has raised and solving the problems in loose areas is one of the main concerns of geotechnical engineers. In recent years, the use of polymeric reinforcements such as geocells in geotechnical engineering has increased significantly. In the present study, the effect of geocell on the bearing capacity of the shallow foundation located on sandy soil under inclined load (VH) has been investigated using PLAXIS 3D finite element software. Thus, after verifying the numerical model, the effect of parameters such as the presence of shear force as well as the optimal arrangement of the reinforcing layer on the bearing capacity of the foundation has been studied. The results of the analysis are plotted in the form of diagrams and based on that, the optimum dimensions, as well as the optimum depth of geocell reinforcement layer, are determined. The results of the analysis indicate that, with the addition of the geocell layer, the bearing capacity of the foundation under the inclined load increases significantly. The extent of this effect depends on the arrangement of the reinforcing layer. Also, the optimum placement depth, width and height of the reinforcing layer to obtain the maximum bearing capacity in the inclined load condition in the present study are equal to 0.025B, 4B and 0.6B, respectively.

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1- Introduction

Demand for land has growing sharply in recent decades due to urbanization and industrialization, followed by an increase in infrastructure construction. For this reason, engineers have come up with solutions to the use of previously unusable land. Factors such as high compressibility and low bearing capacity increased the risk of using such areas. Soil reinforcement using geocells and with the aim of improving its bearing capacity is one of the important issues in the field of geotechnical engineering. Although, in recent years, several studies have been conducted to increase the bearing capacity of reinforced soils, but most of these studies have considered only vertical load and few studies have been done in the field of combined loading. For this reason, the present study investigates the effect of geocell on the bearing capacity of shallow foundation under inclined loading.

In 2004, Dash et al. reviewed a laboratory model on circular foundations located on reinforced geocell sand. The model was subjected to uniform loading by circular foundations. Their results show that the use of geocells increases the bearing capacity and also reduces the settlements. They also obtained the optimum width of the geocell layer five times the diameter and the optimal height equal to two times the foundation diameter [1]. Pokharel et al. (2010) examined soil reinforced with single geocell and finally found that circular geocells have a higher bearing capacity than oval-shaped geocells [2]. In 2012, Dash et al. investigated the effect of geocell type on the bearing mechanism of reinforced foundations. They used different geogrids to construct the geocell. Protected soil is introduced and thus, performance is further improved, and bearing capacity is increased due to increasing the strength of cellular materials [3]. In 2014, Hedge and Sitaram examined the effect of a type of geocell filler on its performance and found that the bearing capacity of geocell-reinforced foundations was increased 13 times compared to the unreinforced foundation for sandy soil. Also, the settlement reduction in the sand due to geocell reinforcement was equal to 78% [4].

Swaraj and Shakti (2015) conducted a review article on studies of geocell-reinforced foundations that examine the function of geocells as a foundation reinforcement [5]. In 2016, Sanji and Silva conducted a three-dimensional numerical study to simulate the behavior of geocell-reinforced sand using PLAXIS 3D software. Numerical modeling of geocells is very difficult due to their curved shape and most researchers use the equivalent composite method for modeling. The soil used in the laboratory model was SP sand. The maximum bearing capacity was observed in u/B ratio between 0.1 and

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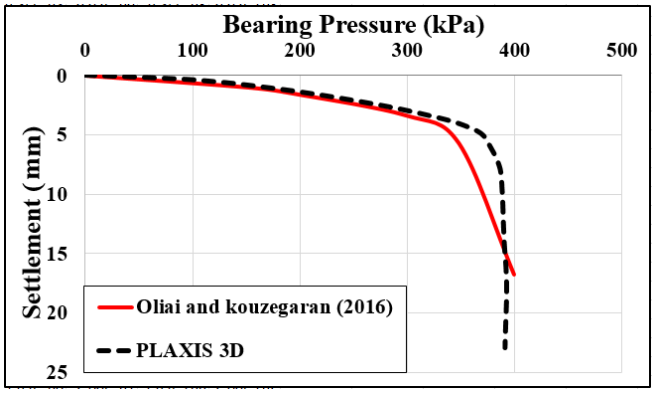

Fig. 1. Comparison of the PLAXIS 3D results, obtained in this study, with Oliaei and Kouzegaran (2016)

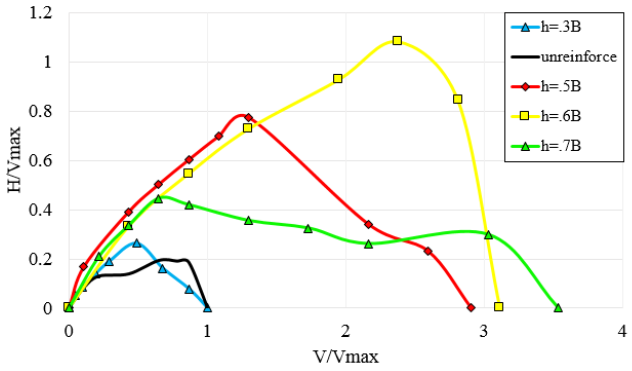

Fig. 2. Dimensionless diagram for the VH loading space for different heights of the reinforcement layer

0.5 [6]. Oliaei and Kouzegaran (2016) examined the effect of geocells on reinforced foundations to determine the optimum depth, width and height of the reinforced layer using FLAC 3D software and finally found that the optimum height of the layer in clay was 30% to 50% of the width of the foundation. The result was 30% to 40% in sand, and when using the geocell, the required depth of placement is 0.055 of the foundation width in clay and 0.045 of the foundation width in sandy soil [7]. Shadmand et al. (2018) in a study examined the load-settlement characteristic under square footings by performing large-scale loading experiments on reinforced and unreinforced geocell soils. They concluded that the load-settlement behavior of the foundation depends on the effect of scale on the geocell reinforced soil, and generalization of the results of small-scale experiments to large-scale experiments leads to unconservative estimates [8].

In the present study, the effect of geocell on the bearing capacity of the shallow foundation located on sandy soil under inclined load has been investigated using PLAXIS 3D finite element software.

2- Methodology

In order to construct the model of the present study and to investigate the effect of geocell with three-dimensional geometry on the surface bearing capacity under inclined loading, PLAXIS 3D finite element software was used. For this purpose, a model with a height of 8 m and a length and width of 30 m and a 1 m square concrete foundation with a height of 0.25 m on the ground in the center of the model has been created. The fine-grained mesh was selected for the model. Also, in order to model the soil behavior, the Mohr-Columb failure criterion was used. Sandy soil characteristics have been selected from the tables in the literature. The PLATE element has been used for modeling the foundation materials.

The results of the study of Oliaei and Kouzegaran (2016) [7] were used to verify the numerical model. They numerically investigated the use of geocell to improve the bearing capacity of the foundations using the finite difference method. A comparison of the PLAXIS 3D results, obtained in this study with Oliaei and Kouzegaran (2016) was depicted in Figure 1.

3- Results and Discussion

The aim of this study is to determine the optimum values of geocell parameters (u: depth from the foundation, h: height of the geocell layer and b: width of the geocell) in order to obtain the maximum bearing capacity under inclined loading.

Figure 2 shows the dimensionless diagram for the VH loading condition for different heights of the geocell layer. As it can be seen, by using geocell, the bearing capacity of the foundation under inclined load is increased significantly.

4- Conclusion

In the present study, the effect of geocell on the bearing capacity of the surface on sandy soils under inclined load has been investigated using PLAXIS 3D finite element software. The main results of the present study are the following:

1- The addition of the geocell layer has increased the bearing capacity of the foundation under inclined load 500%.

2- The optimum depth of placement of the reinforcing layer in the VH loading space is equal to u=0.025B.

3- The optimum width of the geocell reinforcement layer in VH loading condition is equal to b=4B.

4- The optimum height of the reinforcing layer in was determined to be h=0.6B.

5- By placing the geocell layer in its optimal location, the bearing capacity has increased by about %500 compared to the unreinforced case.

Based on the results of this study, it was found that the addition of geocell layer to the soil has significantly increased the bearing capacity of the soil against inclined load. To achieve the maximum bearing capacity, it is better to use the reinforcing layer in the optimum arrangement.

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