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A Study on Bearing Capacity of Circular Footing Resting on Geogrid Reinforced Granular Soil

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ABSTRACT: This study has been conducted to investigate the effect of reinforcing on the bearing capacity of circular footing resting on granular soil. For this purpose, a total number of seven large-scale plate load tests were carried out on a circular plate with a diameter of 300 mm. In order to prepare specimens, a portable curtain rain system is used which is calibrated by 60 raining tests. In the current designed and developed experimental system, a new method is used to measure the normal pressure at footing base. In all loading experiments on soil reinforced with geogrid, only one geogrid layer is used and the effect of depth of this layer from footing base is investigated. The results showed that with provision of geogrid, the bearing capacity of circular footing increases up to 1.56 times of unreinforced mode. In addition, it is shown that by increasing the ratio of u/D_F, the slope of load-settlement curve (stiffness) decreases. For values of $u/D_F>0.67$, the effect of this parameter (dimensionless depth of geogrid) on bearing capacity of the footing is constant, which indicates that the reinforcing mechanism has been changed and the failure occurs at the upper soil mass (above the geogrid). Also, the results showed that with increasing of the distance from center of the footing, the value of normal pressure applied at footing base reduces.

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1- Introduction

The ground bearing capacity is determined to ensure that shear failure doesn't occur in the supporting soil and the settlements do not exceed the tolerable limits. Soil reinforcement with geogrid elements is one of the ground improvement techniques used for increasing the bearing capacity of sand deposits. In some structures such as cooling towers, radar stations, storage tanks, chimneys and TV-towers, circular footing is the best option. Only a few experimental studies have investigated the effects of soil reinforcement with geogrid elements on the performance of circular footings [1-7].

This paper presents the results of seven large-scale load tests performed on circular footing resting on unreinforced and geogrid reinforced sand beds. The testing program was designed to investigate the effect of the depth of the first layer of geogrid reinforcement. For this purpose, a developed experimental setup is designed and constructed.

2- Experimental setups and program

The experimental setup which is designed to investigate the reinforcement effects on bearing capacity of circular foundations, consists of five main parts: footing model, soil tank, raining system (portable curtain rain system), loading system, and data acquisition system.

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The circular model footing used in the present study is made by aluminum and consists of four main parts: upper circular plate, lower circular plate, five stiff elements connecting the plates, and three S-type load cells. Load cells are located between the upper and lower plates to measure the soil pressure at the bottom of the footing in three different locations from its center (50, 75 and 100 mm). The diameter and thickness of the upper and lower plates are 300 mm and 30 mm, respectively (according to that suggested in ASTM D 1194-94). The rigidity of the circular footing has been also proved by the equation given by Naseri and Seyedi Hosseininia [8].

The soil tank is circular in plan, 1400 mm in diameter and 900 mm in height. The tank is made of 2.5 mm thick steel plate, stiffened by some vertical elements to avoid the lateral expansion. To reduce the effects of side friction during the tests, the inside face of the plate is polished smooth.

The portable curtain rain system (PCRS) is used to deposit sand in the soil tank with a specified relative density [9]. PCRS consists of the sand storage box, the flexible hose, the hopper, the rigid tube, and the curtain rainer with different opening width. During air pluviation, sand particles fall from the hopper into the curtain rainer and then pour into the tank in 25 mm high layers. Different opening width of the curtain (2 to 4.5 mm) and height of fall (100 to 1000 mm) were used to achieve different values of relative density (RD). To control RD of the specimens during raining, some cylindrical molds installed at different locations in the testing tank. For all tests of this study, the opening width of the curtain rainer and height of fall are adopted 4.5 mm and 320 mm, respectively to prepare specimens with RD = 55 %.

The loading system designed and developed in this study, uses hydraulic pressure as power supply which is controlled by proportional directional valve to adjust the loading rate at 1 kPa/s up to a settlement of 100 mm (0.33 diameter of the footing). In the close loop control system, the data acquisition card reads the output of flow and pressure sensors and converts them into digital signals. The computer receives these signals and uses a C language code developed in this study to compute the required command for proportional valve. The data acquisition card converts this command into analogue signals and sends it to the proportional hydraulic valve.

The data acquisition system is capable of recording up to 16 channels at a rate of 100 Hz (100 data per second from each channel). This system records signals from two LVDTs and four load cells.

3- Materials

A sand used for all the experimental work undertaken herein is a uniformly graded, round shaped sand. The physical and mechanical properties of sand, at which results have been obtained, were determined by standard tests. A geogrid was used to reinforce the granular soil and its physical and mechanical properties were measured by standard experiments.

4- Results and discussion

One of the key parameters which is received attention by engineers, is the optimum depth of the geogrid layer beneath the footing base (u_{opt}).
For studying the effect of u on the performance of circular footings, seven large-scale load tests were carried out. The ratios of the depth of the geogrid layer to the footing diameter (u/D_F) are considered to be 0.17, 0.33, 0.50, 0.67, 0.87 and 1, respectively.

The tests results which are shown in Figure 1 indicate that the bearing capacity of the circular foundation decreases with an increase of u/D_F. It is considerable that for settlement ratios $s/D_F \leq 0.05$, the variation of u/D_F doesn't have a significant effect on the bearing capacity, while for settlement ratios s/DF > 0.05, increase of the bearing capacity is more obvious.

Furthermore, it is found that for depth ratios $u/D_F > 0.67$, the reinforcement doesn't have a significant effect on the bearing capacity of the circular footing which is due to a change in the reinforcement mechanism. Soil pressures measured at the footing base indicated that the contact pressure decreases with increase of the distance from the center of the footing.

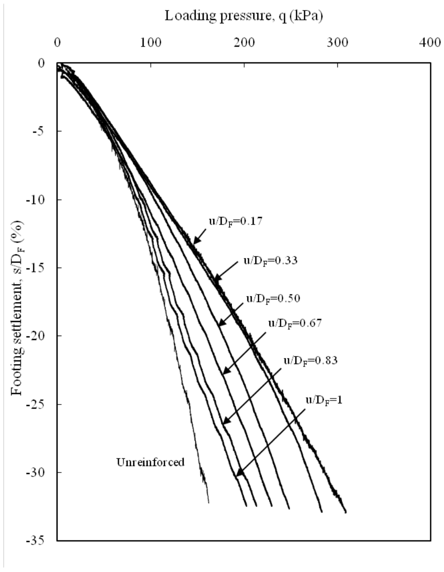

Figure 1. Load- settlement curve for footing resting on unreinforced and reinforced sand

5- Conclusions

This research was undertaken to study the bearing capacity of a circular footing on geogrid reinforced sand bed. For this object, a developed experimental setup was designed and constructed, and a total number of seven large-scale load tests were performed on circular footing placed on unreinforced and geogrid reinforced sand beds. Based on the large-scale load tests results, the following main conclusions were made:

1. The footing model which is designed and developed, is capable of measuring the soil contact vertical pressures at three different locations on the footing base.
2. The constructed portable curtain rainer system (PCRS) is able to prepare uniform huge sand specimens with a wide range of relative densities.
3. The optimum depth of the geogrid layer is less than or qual to $0.17D_F$ beneath the footing base and is smaller than the values reported for other shapes of footing.
4. Increase of the geogrid depth, decreases the bearing capacity of the circular footing and for depths greater than $0.67D_F$, a sudden decrease happens which is due to the change in reinforcement mechanism.
5. Soil reinforcing technique has a significant effect on the bearing capacity of granular soils, because one geogrid layer at optimum depth increases the bearing capacity by about 56 % relative to the unreinforced case.

6- References

[1] S.K. Dash, S. Sireesh, T.G. Sitharam, Model Studies on Circular Footing Supported on Geocell Reinforced Sand underlain by Soft Clay, Geotextiles and Geomembranes, 21(4) (2003) 197-219.

[2] J.H. Boushehrian, N. Hataf, Experimental and Numerical Investigation of the Bearing Capacity of Model Circular and Ring Footings on Reinforced Sand, Geotextiles and Geomembranes, 21(4) (2003) 241-256.

[3] P. Basudhar, S. Saha, K. Deb, Circular Footings Resting on Geotextile-Reinforced Sand Bed, Geotextiles and Geomembranes, 25(6) (2007) 377-384.

[4] S. Sireesh, T.G. Sitharam, S.K. Dash, Bearing Capacity of Circular Footing on Geocell–Sand Mattress overlying Clay Bed with Void, Geotextiles and Geomembranes, 27(2) (2009) 89-98.

[5] J. Lovisa, S.K. Shukla, N. Sivakugan, Behaviour of Prestressed Geotextile-Reinforced Sand Bed Supporting a Loaded Circular Footing, Geotextiles and Geomembranes, 28(1) (2010) 23-32.

[6] A.A. Lavasan, M. Ghazavi, Behavior of Closely Spaced Square and Circular Footings on Reinforced Sand, Soils and Foundations, 52(1) (2012) 160-167.

[7] A. Demir, A. Yildiz, M. Laman, M. Ornek, Experimental and Numerical Analyses of Circular Footing on Geogrid-Reinforced Granular Fill underlain by Soft Clay, Acta Geotechnica, 9(4) (2014) 711-723.

[8] M. Naseri, E.S. Hosseininia, Elastic Settlement of Ring Foundations, Soils and Foundations, 55(2) (2015) 284-295.

[9] A. Tabaroei, S. Abrishami, E.S. Hosseininia, Comparison between Two Different Pluviation Setups of Sand Specimens, Journal of Materials in Civil Engineering, 29(10) (2017) 04017157.

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