BEARING CAPACITY ANALYSIS OF RING FOOTING ON CLAY WITH SAND TRENCH.

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Abstract: Ring footings are usually used for symmetrical buildings like silos, chimney, and oil storage. One of the most important problems are to construct these footings on marine deposits of very soft clay which extends in Egypt in the northern of the delta and the north of the Suez gulf. Replacing the soft clay soil with granular mixture is the most famous and cheapest techniques to increase the bearing capacity of these soils. The aim of this research is to introduce a technique using sand trench to reinforce the soft clay below the ring foundation. Laboratory investigation has been performed to study this combination. The effect of different factors such as the width, the thickness of sand trench, and the presence of stone piles below it have been examined. Dimensions of sand trench appeared to be an important factor in improving ring footing behavior on soft clays. Bearing capacity of ring footings on sand has been studied by laboratory model tests but in this study the numerical analysis is done. The analysis is done using PLAXIS 2D software. The effects of the depth, internal friction of sand and the ratio of the inner to the outer diameter of the ring footing have been studied.

Keywords: *Bearing Capacity, Ring Footing, Sand trench, Stone Piles, Soil Improvement.*

I. INTRODUCTION

Ring footings generally known as ring foundations, in geotechnical or geoengineering approach are frequently used as foundations for axisymmetric structures i.e. either on shore or off shore. They are habitually used for wind turbines, annular platforms, transmission towers, water tanks and silos and many other offshore and on shore axisymmetric structures. The priority is given to this foundation because these are the foundation with internal opening and are considered to be more economic than the mat foundations. The loading conditions, soil conditions and footing geometry influence the interaction of the foundation with the s+r4upporting medium. For the structures having circular cross section and are axisymmetric in nature the ring footings are the most effective and economic solution. The need of the investigation of behavioral characteristics of these footings has become more important with the increase in the use of these foundations. The load displacement response and the ultimate bearing capacity comprise of the behavioral characteristics of the ring footing. Reduction in the amount of volume in comparison to circular footing, reduction in the construction cost, and increase in the stabilizing moment as compared to circular footing with same area and acts as anchorage against slip under dynamic loads in comparison to the circular footings are the factors which influence the choice of the ring footings over the circular footings. In most of the cases the soil is considered to be homogeneous but that is not true. Soil exists in multiple layers we generally assume it be homogeneous. The full utilization of the soil capacity with less or no tension under the foundation is accomplished by using ring footing.

II. LITERATURE REVIEW

A large amount of literature is present on the stabilization of the soft clay with various stabilizing agents but however a very limited literature is available on the soft clay reinforced with sand trench. Vaibhav Sharma and Arvind Kumar (2018) carried out a research with the aim to study the behavior of the ring footing resting on loose sand or well compacted and randomly distributed fiber reinforced sand. The study was carried out for subjection to eccentric loading i.e. at 0B, 0.05B, and 0.1B where B is the outer diameter of the ring footing and inclined loading i.e. at 0˚,5˚,10˚,15˚,-5˚,-10˚and -15˚ and eccentric –inclined loading by using finite element software. Behavioral characteristics of the footing are studied introducing a dimensionless factor called reduction factor. Rana M. Al-Khaddar, Omar K. Al-Kubaisi (2017) used PLAXIS software to evaluate the behavior of ring footing on two layered soil subjected to inclined loading. The soil was modeled as an elastoplastic material with the use of Mohr- Coulomb model. The following are the findings of the research: For the same inner and outer radii with the increase in the angle of inclination, both normalized vertical and horizontal stresses are same. For the same inclination angle when the ratio of inner radii to outer radii increases and (x/R_{out})-0 there is increase in the horizontal stresses while the vertical stresses decrease Moayed, R. Z. et al. (2012) computed the bearing capacity of ring footing, using ABAQUS software, rests on a two layered soil in which the upper were soft clay while the second layer was cohesion less sand. The effect of the clay layer thickness and the radius ratio were investigated and the following conclusions have been made: The bearing capacity of the soil decreases as the radius ratio increases. An increment in the depth of the clay layer reduces the bearing capacity gradually. A. H. Boushehrian and N. Hataf (2008) in this paper, Laboratory and numerical investigation using the finite element computer code, P have been performed. The effects of different factors such as the distance to the first layer of reinforcement, vertical distances between layers, and the number of reinforcing layers, the optimum depth of the reinforcement and the stiffness of the reinforcements on the increase of the bearing capacity ratio, of circular and ring foundation have been examined. Al-Sumaiday, H. G. and Al-Tikrity, I. S. (2013) evaluated the bearing capacity of ring and circular footings on sand by laboratory model tests and study the effect of changing the radius ratio on it. The effects of the depth, internal friction of sand and the ratio of the inner to the outer diameter of the ring footing have been studied.

III. ANALYTICAL STUDY

The numerical modelling was done in PLAXIS 2D in axis symmetry. The geometry is 10m by 8m horizontal by vertical in dimensions. The internal and external radius of the footing is 1m and 2m respectively. The load is applied in the form of prescribed displacement (100 mm) and the analysis was carried out in two stages the first one was carried out for the virgin clay and the second one was done for the clay with the sand trench.

(a) MATERIAL USED

TABLE 1 Properties of Clay

PARAMETER	NAME	CLAY	UNIT
Material model	Model	Mohr-coulomb	-
Type of material behavior	Type	Drained	-
Soil unit weight above phreatic level	$\gamma_{unsat.}$	10	KN/m^3
Soil unit weight below phreatic level	$\gamma_{sat.}$	12	KN/m^3
Poisson's ratio	N	0.35	-
Young's modulus (constant)	E_{ref}	10000	KN/m^2
Cohesion (constant)	c_{ref}	5.0	KN\m^2
Friction angle	Φ	28	◦
Dilatancy angle	Ψ	0.0	◦

TABLE 2 Properties of Sand

PARAMETER	NAME	SAND	UNIT
Material model	Model	Mohr-coulomb	-
Type of material behavior	Type	Drained	-
Soil unit weight above phreatic level	$\gamma_{unsat.}$	17	KN/m^3
Soil unit weight below phreatic level	$\gamma_{sat.}$	20	KN/m^3
Poisson's ratio	N	0.3	-
Young's modulus (constant)	E_{ref}	40000	KN/m^2
Cohesion (constant)	c_{ref}	1.0	KN\m^2
Friction angle	Φ	35	◦
Dilatancy angle	Ψ	0	◦

The footing was shown with plate element.

TABLE 3 Parameters of plate

PARAMETER	NAME	VALUE	UNIT
Normal stiffness	EA	1.884E+09	KN/m
Flexural rigidity	EI	1.570E+08	KNm^2/m
Equivalent thickness	D	1.000	M
Weight	W	25.000	KN/m/m
Poisson's ratio	V	0.000	-

The testing was done for 4 models. The first model geometry was created for ring footing on virgin clay. The second, third and fourth model was created for the ring footing resting on clay with partial sand replacement. The replacement depth is calculated based on the following parameters:

TABLE 4 Ratio for the Depth of Replacement

H (depth of the sand trench)	b (external radius of the footing)	H/b
1	2	0.5
2	2	1
3	2	1.5
4	2	2

IV. RESULTS AND DISSCUSSIONS

The results of all the analysis done on different models for different geometry are stated below. Five model geometries were created for the analysis. The first geometry was for the analysis of ring footing on virgin clay, the second, third, fourth and fifth model was for the analysis of ring footing on clay with sand trench of different dimensions i.e. 2m by 1m, 2m by 2m, 2m by 3m and 2m by 4m respectively.

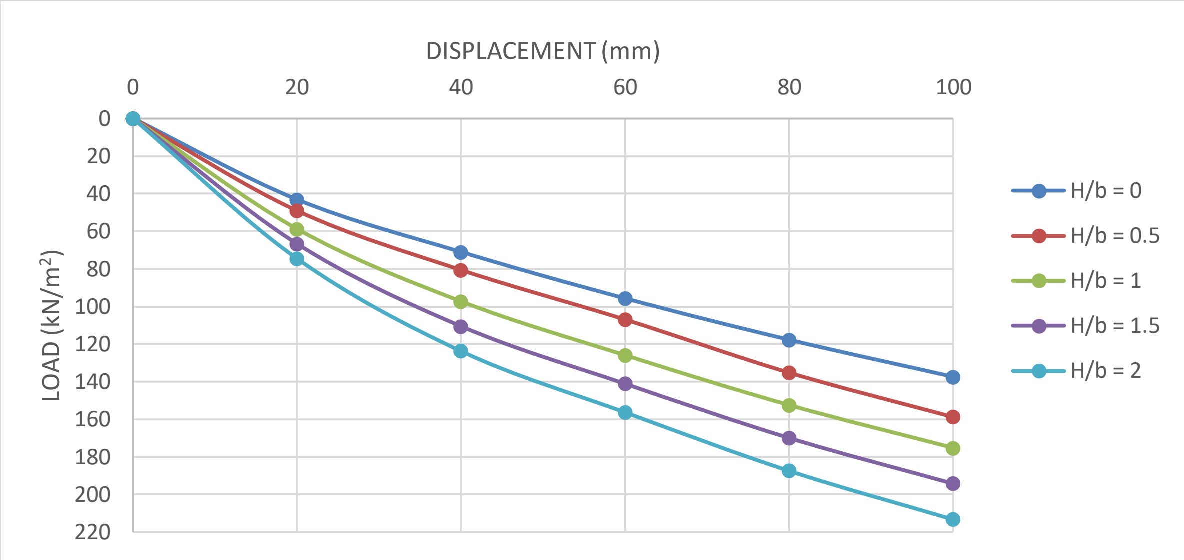

Figure 1 Load versus Settlement Variation for All the Four Cases

Table 4 Load Carrying Capacity for 40 mm Settlement in All the Cases.

CASES	LOAD CARRYING CAPACITY (kN/m^2)
H/b = 0	71.06
H/b = 0.5	80.57
H/b = 1	97.39
H/b = 1.5	110.55
H/b = 2	123.71

The load bearing capacity for 4o mm settlement in all the five cases have been depicted above. From the above readings it can be seen that in comparison to virgin clay (i.e. H/b ratio 0) there is 13.38 % increase in case 2 (H/b = 0.5), 37.05% increase in case 3 (H/b = 1), 55.57% increase in case 4 (H/b = 1.5) and 74.09% increase in case 5 (H/b = 2).

V. CONCLUSIONS:

The bearing capacity of the virgin clay has increased with the introduction of sand trench. The following conclusions have been made:

1. In comparison to the virgin clay the bearing capacity has increased remarkably.

2. The bearing capacity for the sand trench stabilized soil for H/b = 2 is maximum for 40 mm settlement i.e. 123.71 kN/m^2.

3. In comparison to the virgin soil the sand trench stabilized soil shows the increment in the bearing capacity by 13.38%, 37.05%, 55.57% and 74.09% respectively.

S4. The sand replacement method is cheaper than other stabilizing techniques and can be used very effectively.

VI. REFRENCES:

• Vaibhav Sharma, Arvind Kumar "Behavior of ring footing resting on reinforced sand subjected to eccentric-inclined loading" Journal of Rock Mechanics and Geotechnical Engineering 10 (2018) 347-357

•K. Al-kubaisi Rana, Al-khadaar Omar2017 "Evaluating the Behavior of ring footing on two-Layered Soil Subjected to Inclined Load" Journal International Journal of Science and research Volume 6 Issue 4 Pages125-129

•A.H.Boushehrian, N. Hataf "Bearing capacity of ring footings on reinforced clay" *Proceedings of the 4th Asian Regional Conference on Geosynthetics* June 17 - 20, 2008 Shanghai, China

•Al-Sumaiday Israa S. Hussain Al-Tikrity "Experimental Investigation of the Bearing Pressure for Circular and Ring Footings on Sand" Tikrit Journal of Engineering Sciences **ISSN**: 1813162X 23127589 **Year**: 2013 **Volume**: 20 Issue: 3 **Pages**: 64-74

•*R. Ziaie Moayed, V. Rashidian, and E. Izadi "Evaluation on Bearing Capacity of Ring Foundations on two-Layered Soil" World Academy of Science, Engineering and Technology International Journal of Civil and Environmental Engineering Vol:6, No:1, 2012*