Eceentrically loaded Rectangular footing on Geogrid-reinforced silty sand

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ABSTRACT

In many cases foundation subjected to eccentric load which results in reduction of bearing capacity of soil. The paper investigate the reduction factor for silty sand which is reinforced by geogrid under the effect of eccentric load. for the present study two type of rectangular footing are used. Two, three and four numbers of geogrid layers are provided and three type of eccentric load are used for present study i.e. e/B equals 0.05, 0.10 & 0.15. from the laboratory test results, the reduction factor and also called empirical relationship which is the ratio of ultimate bearing capacity of eccentrically loaded footing to that of centrally loaded footing have been determine.

Keyword: - *Eccentric load, Geogrid, Rectangular footing, Silty sand*

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1. INTRODUCTION

The ultimate bearing capacity of shallow footing resting over the reinforced soil under the axially loading have been investigated by analytical method, FEM or computer programing several test were carried out on the unreinforced soil (Meyerhof 1953, Vesic 1973) to investigate the load bearing capacity of soil. Several laboratory model test results that are currently available in the literature related to the improvement in the load- bearing capacity of shallow foundation supported by sand reinforced with various materials such as metal strips (Binquet & Lee 1975, Fragaszy & Lawton 1984, Huang & Tatsuoka 1990) metal bars (Huang & Tatsuoka 1990), geotextiles (Guido et al 1986) and geogrid (Guido et al 1986, K.H.Khing1992, B. M. Das 1992) some test of these test were conducted with model square foundation (Akinmusuru & Akinbolande 1981, Guido et al 1986) some of these were on the circular foundation (Rea & Mitchell 1978) and rectangular footing (T. yetimoglua 1994) and the others with strip foundation ((Binquet & Lee 1975).

In addition to vertical loads, foundations are frequently subjected to moments due to lateral forces acting on the structures from earthquakes, water, wind and in the case of footing located at property line, machine foundation , portal frame building. It is knows from literature that as eccentricity increases, ultimate load decreases. Many researchers (Meyerhof 1953, Prakash & saran 1971) worked on footing subjected to the eccentric loading.

2. LABORATORY MODEL TEST

For the present study, the model tank was fabricated of size 900mm x 300mm x500mm with two sides (one is longer size and second one is shorter size) with acrylic sheet. The inside surface of model tank is polished to reduce the friction between the soil and surface. rectangular was used in experimental work with size of 60mm x 120mm (i.e.

B=0.5L)and 60mm x 180mm (i.e. B=0.33L). to reduce the friction between the bottom of footing and sand, epoxy glue used as coating on the footing surface. Silty sand is ued for the study. Direct shear box test give the friction angle 33˚ and the cohesion 1 kN/m. soil used for the study is well graded. The density achieved during the test is 16.6 kN/m^3. Geogrid is used as reinforcement material in the experimental work. The property of the geogrid material is shown in table 1

TABLE 1 PROPERTIES OF THE GEOGRID

Parameters	**Value**
Polymer	Polypropylene Pp
Tensile strength	50 *KN/m*
Aperture size (W)	40*40 mm
Aperture shape	Square
Rib width (w)	6 mm
Junction strength	95%

After referring many research papers the optimum spacing of the geogrid layers are decided. Below figure 1 shows the arrangement of geogrid layers.

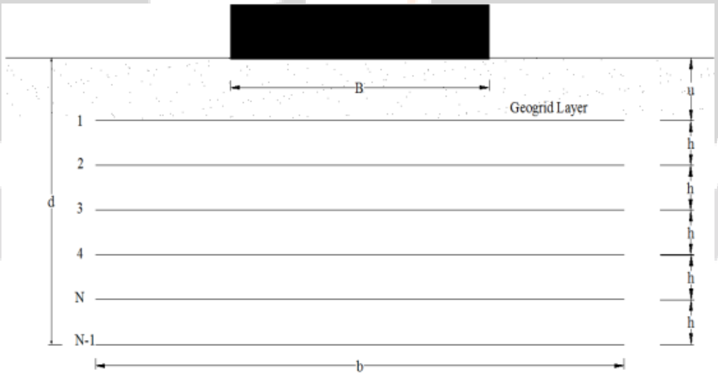

Figure 1. Cross-section showing sand bed with multiple number of reinforcement

Where u is equals to spacing between the bottom of footing and first layer of geogird. , h is spacing between secsesive grogrid layers, N is total numbers of geogrid layers and b is width of geogrid layers.

For experimental work values have been taken as u=0.35B , h= 0.25B, b= 5 B and N=4. Model test sequences shows in Table 2.

Table 2 MODEL TEST SEQUENCES

Number of Test	Number of Geogrid Layer (N)	B/L	Number of Geogrid Layer (N)
1-8	0.00	0.5 , 0.33	0
9-16	0.05	0.5 , 0.33	2
17-24	0.10	0.5 , 0.33	3
25-32	0.15	0.5 , 0.33	4

3. METHODOLOGY:

After preparation of reinforced or unreinforced sample, footing is placed over the top of silty sand bed in such a way so that footing is parallel to the wall of test tank. And the distance between the tank wall and the footing should be equal to or greater than 2.5 times the width of footing. Proving ring of desired capacity is attached with the cylindrical shaft of static loading unit and brought into contact with footing through metallic ball in between shaft and footing. Before making contact between shaft and footing, ensure that shaft is vertical. Two dial gauge of same specification is placed at the diagonally opposite corner of the footing. The arrangement is shown in figure 2

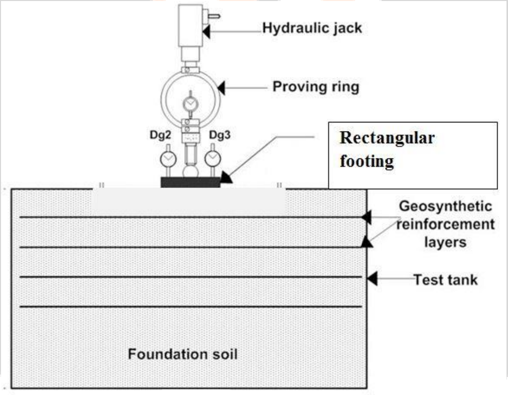

Figure 2 Equipment setup

4. RESULTS AND DISCUSSION

Bearing capacity of reinforced and unreinforced soil is determine by tangent method from the load settlement graph for each test. As per Patra el. al , the reduction faction is the function of the eccentricity to width ratio e/B and d_f/B. below figure shows the graph for rectangular footing B/L=0.5.

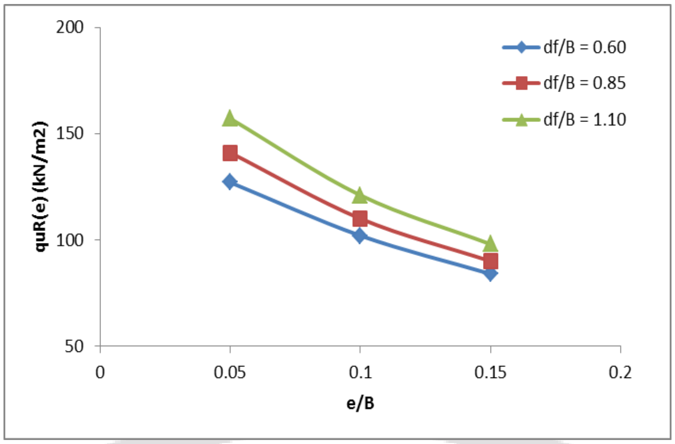

Figure 3 $q_{uR(e)}$ vs e/B with B/L=0.5

Figure 3 shows the bearing capacity values for each test of footing B/L= 0.5 for each eccentric load ing. Figure 4 shows the relation between the reduction factor and d_f/B for each eccentric load. The reduction factor (R_{kR}) is the function of d_f/B which is shown in below equation 1

$$R_{kR} = \left(\frac{d_f}{B}\right)^{\alpha_1} \tag{1}$$

Where, α_2 average value of slope line. Form the figure 4 the value of α_2 is 0.23 . thus,

$$R_{kR} = \left(\frac{d_f}{B}\right)^{0.23} \tag{2}$$

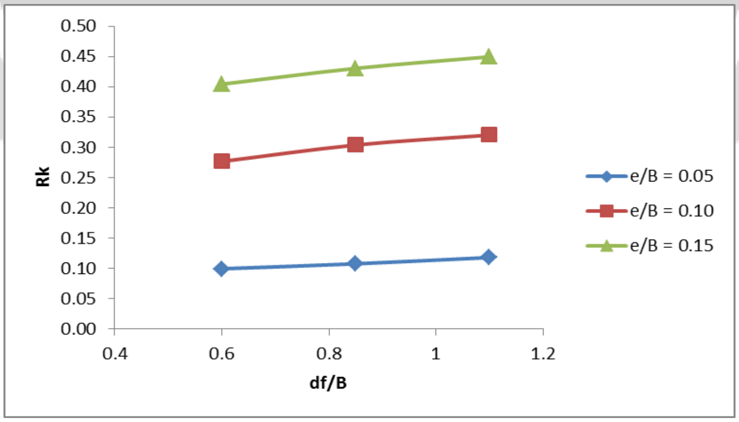

Figure 4 R_k vs d_f/B with B/L= 0.5

Figure 5 shows the relation between the reduction factor and e/B for each eccentric load. The reduction factor (R_{kR}) is also the function of e/B which is shown in below equation 3

$$R_{kR} = \left(\frac{d_f}{B}\right)^{\alpha_3} \tag{3}$$

Where, α_3 average value of slope line. Form the figure 4 the value of α_3 is 1.23 . thus,

$$R_{kR} = \left(\frac{d_f}{B}\right)^{1.23} \tag{4}$$

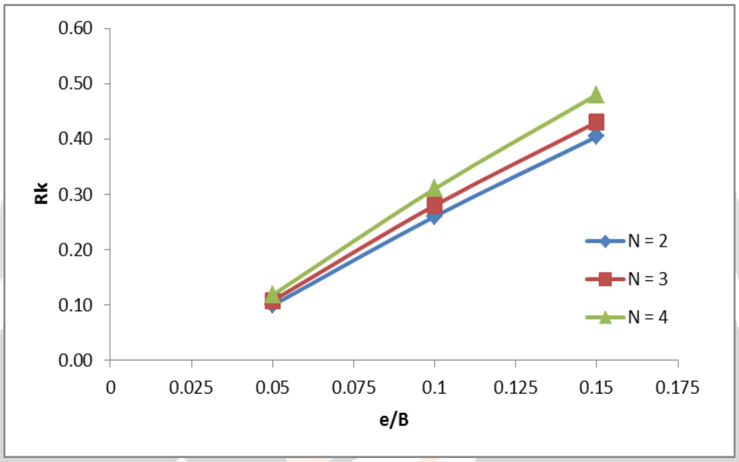

Figure 5 R_k vs e/B with B/L=0.5

So, reduction factor will be,

$$R_{kR} = \alpha_1\left(\frac{d_f}{B}\right)^{0.23}\left(\frac{e}{B}\right)^{1.23} \tag{5}$$

Value of α_1 were calculated from the equation 5 and plot the graph α_1 vs e/B. from the figure 6 the average value of α_1 is 4.82.

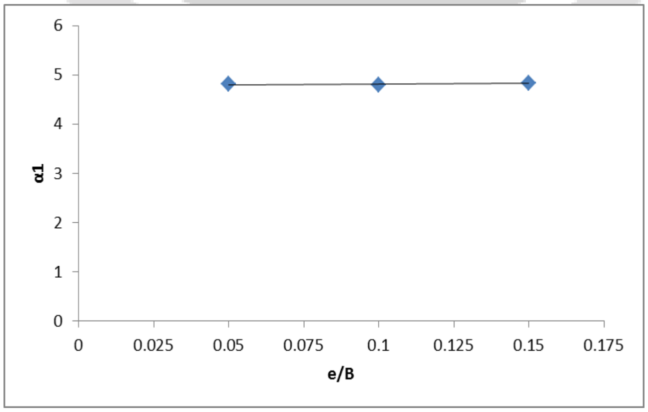

Figure 6 α_1 vs e/B

Equation 6 shows the final equation of reduction factor for B/L = 0.5.

$$R_{kR} = 4.82\left(\frac{d_f}{B}\right)^{0.23}\left(\frac{e}{B}\right)^{1.23} \tag{6}$$

For the rectangular footing B/L=0.33 the graph are shown in figure 7 to 10. And reduction factor is in equation 7.

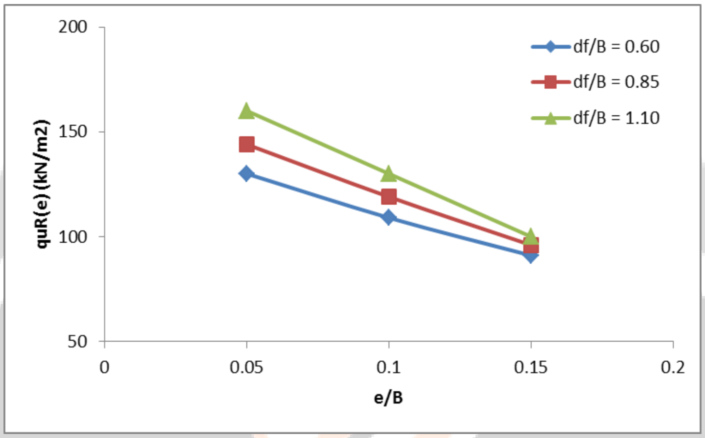

Figure 7 $q_{uR(e)}$ vs e/B with B/L=0.5

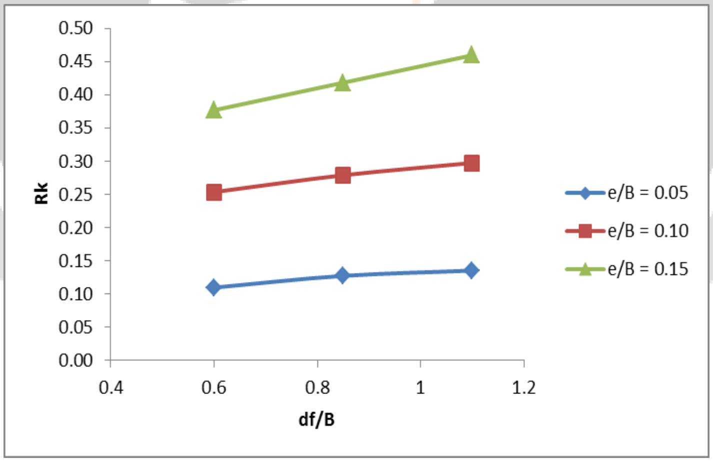

Figure 8 R_k vs d_f/B with B/L= 0.5

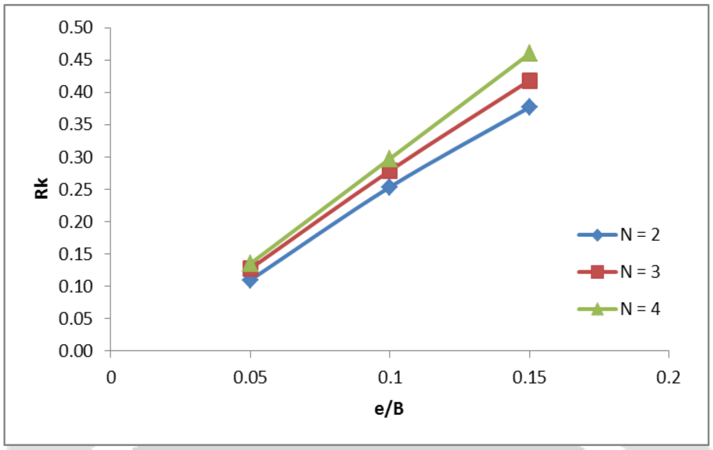

Figure 9 R_k vs e/B with B/L=0.5

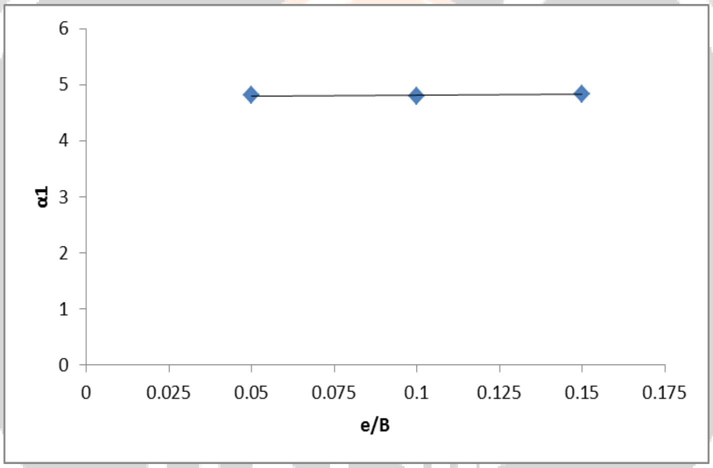

Figure 10 α_1 vs e/B

$$R_{kR} = 3.82\left(\frac{d_f}{B}\right)^{0.39}\left(\frac{e}{B}\right)^{1.17} \tag{7}$$

From the equation 6 and 7 the generalized value can be written as per below

$$R_{kR} = 4.5\left(\frac{d_f}{B}\right)^{0.3}\left(\frac{e}{B}\right)^{1.2} \tag{8}$$

5. CONCLUSION

From the results of laboratory model test for bearing capacity of eccentrically loaded rectangular footing supported by reinforced silty sand has been presented. From limited number of model test the reduction factor were determine as shown in equation 8. And comparing the value of the bearing capacity determine by experimental work and from equation 8 it noted that the variation is 4.7%.

6. REFERENCES

[1] Basudhar, P. K., Dixit, P. M., Gharpure, A., Deb, K. (2008). "finite element analysis of geotextile-reinforced sand-bed subjected to strip loading." *Geotextiles and Geomembranes,* 26, pp. 91-99.

[2] Behera, R. N. (2012). "behaviour of shallow strip foundation on granular soil under eccentrically inclined load." *Ph.D Thesis,* NIT Rourkela.

[3] Balla, A. (1962) "bearing capacity of foundations." *J. Soil Mech. and Found. Div.,* ASCE, 88(5), pp. 13-34.

[4] Dash, S. K., Krishnaswamy, N. R., Rajagopal, K. (2001). "bearing capacity of strip footings supported on geocell-reinforced sand." *Geotextiles and Geomembranes,* 19, pp. 235-256.

[5] Das, B. M., Omar, M. T. (1994). "the effect of foundation width on model tests for the bearing capacity of sand with geogrid reinforcement." *Geotechnical and Gelogical Engineering* 12, pp133-141.

[6] Das, B. M., Shin, E. C.,Omar, M. T. (1994). "the bearing capacity of surface stripfoundations on geogrid-reinforced sand and clay – a comparative study." *Geotechnical and Gelogical Engineering* 12, pp1-14. 59

[7] Das, B. M., "Shallow Foundation, Second Edition." *CRC Press.*

[8] Erol Sadoglu, Evrim Cure, "ultimate loads for eccentrically loaded model shallow strip footings on geotextile-reinforced sand" , Geotextiles And Geomembranes , 27 (2009) 176-182

[9] C. R. Patra, B. M. Das, "eccentrically loaded strip foundation on geogrid-reinforced sand" international journal of Geotextile and Geomembranes , Technical note.

[10] Patra, C.R., Das, B.M., Bhoi, M., Shin, E.C. (2006). "eccentrically loaded strip foundation on geogrid-reinforced sand."*Geotextiles and Geomembranes,* 24, pp. 254–259