BEARING CAPACITY OF SQUARE FOOTING ON GEOGRID-REINFORCED LOOSE SAND TO RESIST ECCENTRIC LOAD

Prof. Dr. Mosa J. Al-Mosawe
Civil Engineering Department, College of Engineering, University of Baghdad.

Dr.A′amal A. Al-Saidi

Civil Engineering Department, College of Engineering, University of Baghdad

Faris W.Jawad.
Civil Engineering Department, College of Engineering, University of Baghdad.

ABSTRACT

This research presents and discuss the results of experimental investigation carried out on geogrids model to study the behavior of geogrid in the loose sandy soil. The effect of location eccentricity, depth of first layer of reinforcement, vertical spacing, number and type of reinforcement layers have been investigated. The results indicated that the percentage of bearing improvement a bout (22 %) at number of reinforced layers N=1 and about (47.5%) at number of reinforced layers N=2 for different Eccentricity values when depth ratio and vertical spacing between layers are (0.5B and 0.75B) respectively.

الخلاصة :-

نستعرض هنا النتائج لدراسة مختبريه لتقدير قابلية التحمل لتربة رملية مفككة بعد تسليحها بال (geogrid) وقد تمت دراسة تأثير بعض العوامل لغرض الحصول غلى التصرف العام للتربة المحسنة بال (geogrid) وتشمل هذه العوامل قيمة انحراف الحمل عن المركز عمق الطبقة الأولى من التسليح ، والمسافة العمودية بين طبقات التسليح ,عدد طبقات التسليح و نوع طبقة التسليح. وقد بينت النتائج أن نسبة التحسين قد وصلت إلى (22%) لطبقة تسليح واحدة و (47.5%) عند استخدام طبقتين من التسلح مع تغير موقع انحراف الحمل عن المركز عندما تكون عمق أول طبقه والمسافة العمودية بين الطبقات مثبته لكل الفحوص (0.75B and 0.5B)على التوالي.

INTRODUCTION

The use of reinforced earth is a recent development in the design and construction of foundations and earth-retaining structures. Several authors studied strip foundations but reinforced with different materials such as steel bars (Milovic, 1977; Bassett and Last, 1978; Verma and Char, 1986), steel grids (Abdel-Baki et al. 1993), geotextiles (Das and Shin, 1994) and geogrids (Ismail and Raymond, 1995). All of these researchers concluded that reinforcement increased the bearing capacity and reduced the corresponding settlement of the foundations compared to the unreinforced soil.

The present study was undertaken to investigate the bearing capacity of square footings on geogrid-reinforced sand. The parameters that are investigated include;

- Eccentricity value (e)
- Depth Ratio of first layer (u/B=0.75), where u and B are depth of first reinforced layer and footing width respectively.
- Vertical spacing between layers (z/B=0.5), where z and B are vertical distance between layers and footing width.

And Br/B=3 for tests where Br and B reinforcement layers width and footing width.

The symbols of the geometric parameters used in the present paper are shown in Figure (1).

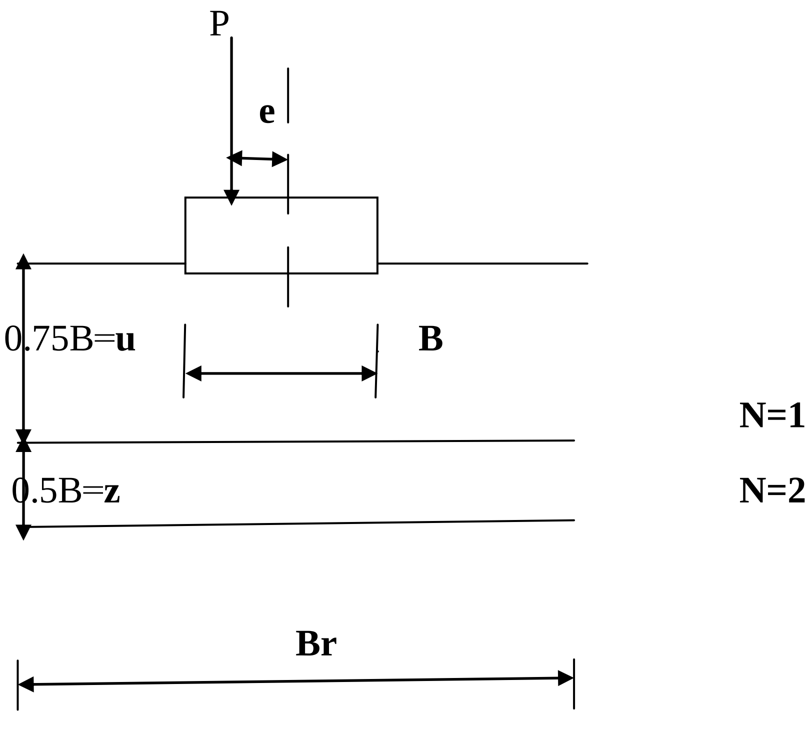


Figure (1) Geometric Parameters of Reinforced Foundation.

EXPERMENTAL TESTS:-

A series of model loading tests were conducted inside steel box of 600 X 600mm x 700mm in size the box was made of steel plate of 3mm thickness, stiffened with angle sections, as shown in Plate (1). The internal faces of the box were covered with polyethylene sheets in order to reduce the slight friction which might be developed between the box surface and soil. Static vertical loads were applied using electrical hydraulic pump. Loads transferred from the pump to a hydraulic jack were carefully recorded by proving ring installed between the jack and the tested footing.

The footing was loaded at a constant loading rate to failure. The ultimate bearing capacity was defined as the state at which either the load reached a maximum value where settlement continue to without further increase in load or where there was an abrupt change in the load –settlement relationship. Settlement of the footing was measured using two dial gauges fixed in the middle and edge of footing.

The test footing was a square steel plate 60mm in plane and 5mm thick.

Plate (1) General View of Testing Equipments

SOIL PROPERTIES:-

Clean, oven-dried, uniform quartz sand (Kerbela sand) was used in the tests. The sand was placed in the test box at unit weight of approximately 15.2 kN/m^3 (relative density is 31%). Some properties of the sand are given in Table (1).

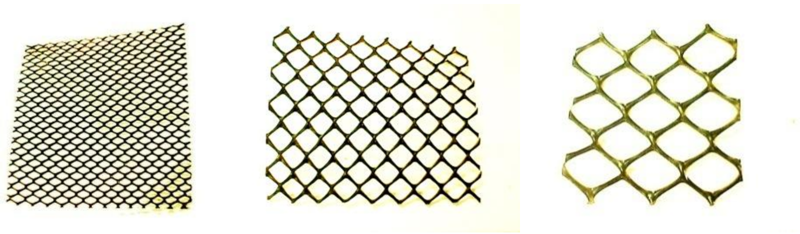
Table (3.1) Sand Properties.

Property	Values
Specific Gravity	Gs= 2.63
Void Ratio and Dry Unit Weight	e_{max}=0.82, γ_{dmin} =14.4 kN/m^3 e_{min}=0.59, γ_{dmax}=17.39kN/m^3 e_{used}=0.75, γ_{dused}=15.2 kN/m^3
Relative Density	Dr=31%
Angle of Internal Friction	Ø=29°

The value of (Ø) was obtained from the direct shear test

REINFORCEMENT PROPERTIES.

The reinforcement used in the research is polymer geomesh. The general view for three types used in tests described, Plate (2). The dimensions of the geogrid samples used in this study were listed in Table (2), the physical chemical properties for sample used were listed in Table (3) and the technical properties for sample used were listed in Table (4).



Geogrid No.1 Geogrid No.2 Geogrid No.3

Plate (2) The Reinforcement Used.

Table (2): Dimensional properties for geogrids used (Latifia Georgid).

Property	Unit	Data for geogrid No.1	Data for geogrid No.2	Data for geogrid No.3
Aperture Size	mm	6x10	26x26	39x39(±2)
Mass Per Unit Area	g/m^2	700	520(±%)	770(±40)
Roll Width	m	2.0	1.0	2.5
Roll Length	m	20	20	30
Roll Diameter	m	0.40	0.43	0.50
Cross Roll Weight	kg	28.0	10.4	57.75

Table (3): The physical, chemical and biological properties for geogrids used (Latifia Georgid)..

Property	Data for Geogrid No.1	Data for Geogrid No.2	Data for Geogrid No.3
Structure	Extruded Geogrid	Extruded Geogrid	Extruded Geogrid
Mesh Type	Diamond	Square	Diamond
Standard Color	Black	Black	Black
Polymer Type	HDPE	HDPE	HDPE
U.V Stabilized	Carbon Black	Carbon Black	Carbon Black
Chemical Resistance	Excellent	Excellent	Excellent
Biological Resistance	Excellent	Excellent	Excellent
Packaging	Rolls	Rolls	Rolls

Table (4): The technical properties for geogrid used (Latifia Georgid).

Property	Unit	Data for Geogrid No.1	Data for Geogrid No.2	Data for Geogrid No.3
Tensile Strength at 2% Strain	kN/m	5.1	2.3	4.3
Tensile Strength at 5% Strain	kN/m	9.1	4.0	7.7
Peak Tensile Strength	kN/m	16.0	7.1	13.5
Yield Point Elongation	%	20.0	20.0	20.0

STUDIED VARIABLE

Effect of Eccentric Values:-

Figure (2) illustrates the load –settlement curve for a point at the footing edge while Figure (2) shows that curve for a point at the footing center for different eccentricity values. It can be seen that increase in the load carrying for reinforced sand with decrease the eccentricity values. But settlement edge dial decrease and settlement center dial gauge increase with decrease the eccentricity values.

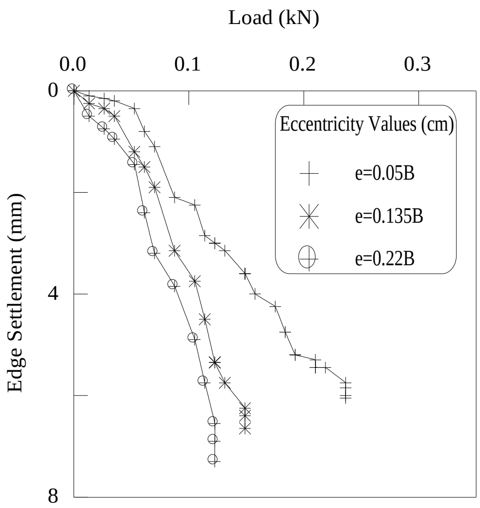


Figure (2) Load – Edge Settlement Curves for Different Eccentricity Values, u/B=0.75, Br/B=3 and Number of Reinforced N=1.

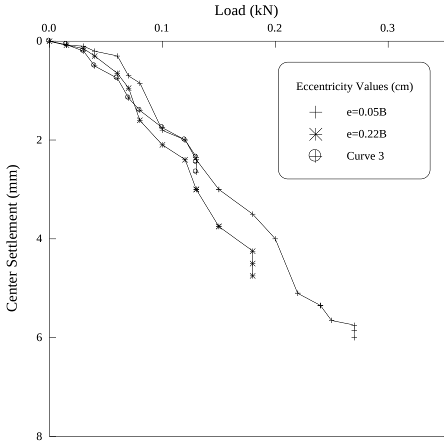


Figure (3) Load – Center Settlement Curves for Different Eccentricity Values, u/B=0.75, Br/B=3 and Number of Reinforced N=1.

The same conclusion can be drawn for figure (4and 5) when number of reinforcement layers (N=2)

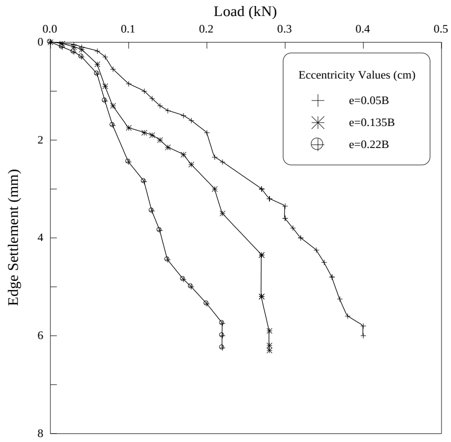


Figure (4) Load – Edge Settlement Curves for Different Eccentricity Values, u/B=0.75, z/B=0.5, Br/B=3 and Number of Reinforced N=2.

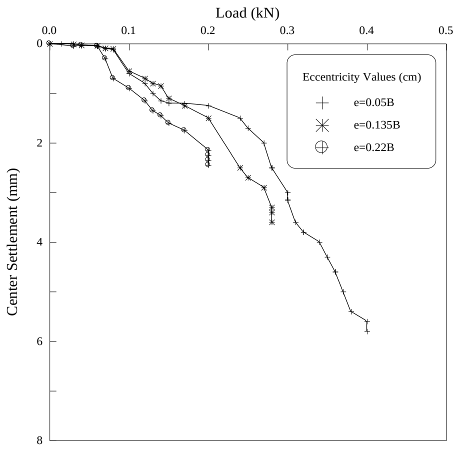


Figure (5) Load – Center Settlement Curves for Different Eccentricity Values, u/B=0.75, z/B=0.5, Br/B=3 and Number of Reinforced N=2.

Figure (6) displays load variation with eccentricity values for different reinforced number. The load indicates an increase with increase reinforced number for each value of eccentricity. For each value of eccentricity, can be find the maximum load can sand bearing.

$\ln(p) = -0.58 * \ln(e) - 1.6 \qquad e > 0$ ……………………(1)

Where p= applied load (kN)

e= eccentricity value (mm).

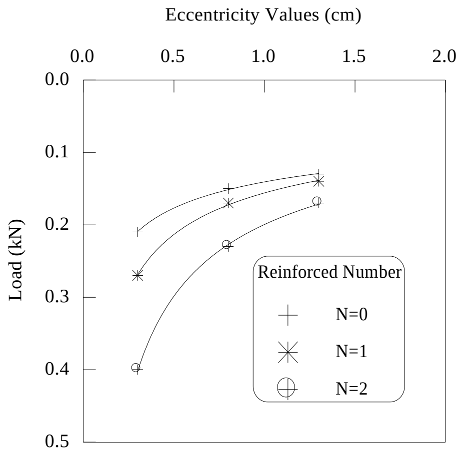


Figure (6) Load Versus Eccentricity Values for Different Reinforced Number (N), u/B=0.75, z/B=0.5, Br/B=3.

Figure (7) illustrates the variation of improvement percentage with reinforced number for different eccentricity values. The improvement percentage increases with increasing number of reinforcement layers and decreasing eccentricity values.

For each value of number of reinforced can be determined the improvement percentage.

$I = 11.7(N) - 1.5$ …………. (2)

Where: I= improvement percentage (%)

N= Number of Reinforced

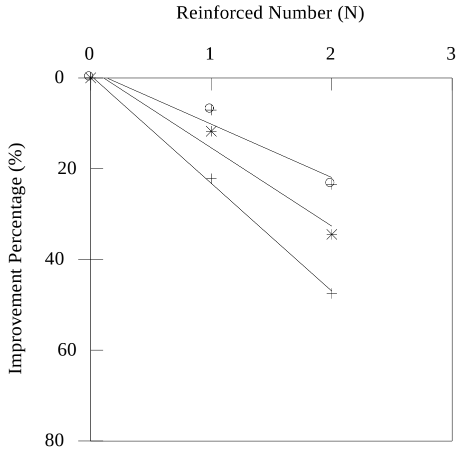


Figure (7) Improvement Percentage Versus Reinforced Number for Different Eccentricity Values, u/B=0.75, z/B=0.5, Br/B=3.

CONCLUSIONS

- For single-layer reinforced sand when the depth ratio is 0.75B, the improvement percentage increases about t(20%) for different eccentricity values.
- For two layers reinforced sand when depth ratio is u/B=0.75 and vertical spacing z/B=0.5 improvement percentage increase to (47.5%) for different eccentricity values.
- This equation can be used to calculate the maximum applied load on sand for $N \leq 2$.
- $\ln(p)=-0.58*\ln(e) -1.6 \qquad e > 0$
- This equation can be used to calculate improvement percentage for $N \leq 2$.
    - $I=11.7(N) -1.5$

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