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EXPERIMENTAL STUDY ON SETTLEMENT BEHAVIOUR OF CLOSELY SPACED RECTANGULAR FOOTINGS RESTING ON GEOGRID REINFORECED SILTY SAND

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ABSTRACT- *In Geotechnical Engineering, the bearing capacity and settlement are two main criteria that control the design and performance of footings. Due to heavy loads and non-availability of good construction sites, so engineers are usually required to place footings at close spacing. Therefore, the footings in the site generally interact with each other to some extent. There is a need for a technique which will allow the geosynthetics to increase the bearing capacity of soil without the occurrence of huge settlements. To decrease the objectionable influence of interference on the performance of the closely spaced footings, the foundation soil is reinforced by geo-grid layers. A number of investigations have been performed numerically as well as experimentally to determine the interference effect of two nearby shallow foundations subjected to vertical load with unreinforced and reinforced soil. The aim of present research work is to investigate the behaviour of settlement of two closely spaced rectangular footing resting on unreinforced silty sand and reinforced silty sand with different spacing ratio(S/B), loading condition that is concentric loading and . The model tests have been conducted using rectangular footing at different spacing ratio. The average relative density kept up throughout all the tests. The silty sand is reinforced by multiple layers of geogrid. The settlement of silty sand with rectangular footing will compute by Load- settlement curve.*

KEYWORDS- Settlement, Bearing capacity, Rectangular footing, Geogrid, Silty sand, Inteference factor

1. INTRODUCTION

In the design of foundations, the shallow foundation is the first option where the top soil has sufficient bearing strength to carry the superstructure load without any significant total and differential settlements to prevent damage to infrastructure and superstructure. However, in the last decades, the need for highrise buildings and high loaded superstructures has been increased rapidly, even in the lands with poor subsoil conditions. So, the need for foundations with higher bearing capacity and showing low settlement values, both total and differential settlement has also been increased. These types of foundations can be constructed as a shallow foundation after the application of ground improvement techniques.

For the soil reinforcement, geosynthetics have been widely used as construction materials in civil engineering projects such as slopes, retaining walls, landfills, foundations, embankments, earth retaining structures, reservoirs, canals, dams, bank and coastal protection, airfields, railroads, subgrade improvement, and reinforcement to base courses of road sections etc. since the 1970s. Today, there are many types of geosynthetic products (e.g., geogrid, geotextile, geocell, geomembrane, geonet, geopipe, geofoam, and geocomposite etc.) available in the market. Each product is designed for solving a specific type of civil engineering problems.

2. MATERIAL

A Silty Sand

The silty sand was taken from the dharnidhar at Ahmedabad, Gujarat below 1m from the natural ground level. The quantity of silty sand required was approximate 1500 kg for the testing.

B. Geo-grid

Uniaxial geogrid was procured from CTM Technical textile Ltd.

A geogrid was obtained having ultimate tensile strength 40KN/m in machine direction and 20Kn/m in cross-machine direction from manufacturing company.

TABLE 1

Properties	Value
Aperture size	20mmx20mm
Ultimate tensile strength	40kn/m
Creep reduction factor	1.49
Partial factor –installation damage	1.11
Partial factor-Environmental effects	1.15
Pull-out interaction coefficient	0.8

3. METHODOLOGY

A. FABRICATION OF TANK

As per IS 1888-1962, the minimum size of footing should be 5D, where D is the diameter of the footing to develop the full failure zone without any interference of side. For Cohesionless soil, Chumar (1972) proposed that the maximum extension of failure zone will be 2.5D below the footing. Keeping those criteria in mind, tank size of 0.75 width and 0. 75 m height is used. The thickness of tank is 8 mm. The tank was placed on bottom plates of load frame for uniform distribution of load.

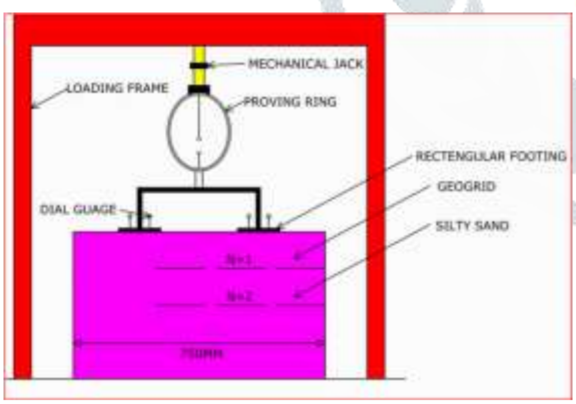

Figure 1 Schematic diagram of test setup

B. EXPERIMENTAL SETUP FOR COMPRESSION TESTS

A model load settlement test has been conducted at the geotechnical laboratory, Applied Mechanics, L.D. College of Engineering, Ahmedabad on the silty sand. The prototype foundation used isrectangular in shape, the size of 80mm length &40mm width and 10mm thickness is used. The test model was prepared by compacting the sand in layers, each of 100 mm thick up to 450 mm height. The sand was compacted at a relative density of 55%. The accuracy of the sand density inside the tank was checked by conducting three preliminary density tests. The variation of the sand relative density was found to be 55%± 0.50%. The geogrid layer is placed at the desired height and location on the compacted level surface. The model footing is placed, centrally on the top surface of the silty sand and the dial gauge was placed on the footing. The verticality of the hydraulic jack and horizontality of the footing model were set up with the help of plumb bob. After taking the zero loading, the load was applied in small increments and the dial gauge recorded the footing settlement at the end of each increment until failure. The experimental program consists of carrying out fifteen load bearing tests on the rectangular model footing. The study investigated the effect of BCR value and settlement ratio soil-footing response. A rectangular footings are placed at different spacing at centre to centre that is

40mm,60mm,80mm,100mm.

Figure 2 Experimental setup for modal test

4. RESULTS& DISCUSSION

A. *Material property*

The index and engineering properties of silty sand used for the study are shown below:

Table 2: Index and engineering properties of silty sand

Sr. No	Test	Description	Determination
1	Specific Gravity	Density bottle method (IS: 2720-3)	G= 2.63
2	Standard Proctor	Standard Proctor as per (IS-27207)	OMC =12.5% & MDD = 18.8 KN/m3
3	Relative density	Vibratory table (IS:2720-14)	Pdmax =19.81KN/ m^3 Pdmin =13.40 KN/ m^3
4	Direct Box Shear	Square shear box as per (IS:2720-13)	C= 8 KN/m3and Φ= 34º
5	Liquid Limit	Liquid limit as per (IS 2720-5)	25.47
6	Plastic Limit	plasticlimit as per (IS 2720-5)	21.52

B. *Laboratory test result*

Load-settlement curves from twelve tests carried out on centrally loaded circular footings in both reinforced and unreinforced conditions. The ultimate bearing capacity of foundation on soil under axial loadings isobtained from the loadsettlement curves.In curves with the double tangent method, the ultimate bearing capacity and settlement at failure load are taken at the peak point. In the present research, a dimensionless parameter called bearing capacity ratio (BCR), is used to measure the effect of improvement utilizing reinforcement layers on increasing the bearing capacity. This parameter is defined as the ratio of the ultimate bearing capacity in reinforced soil to that in unreinforced soil condition. To analyze the footing settlement, the settlement ratio (SR) is proposed and defined as the ratio of footing settlement in reinforced soil to that in unreinforced soil condition.

$$BCR = \frac{qu(reinforced)}{qu(unreinforced)}$$

$$SR = \frac{su(reinforced)}{su(unreinforced)}$$

Where qu is the ultimate bearing capacity, and Su is the footing settlement.

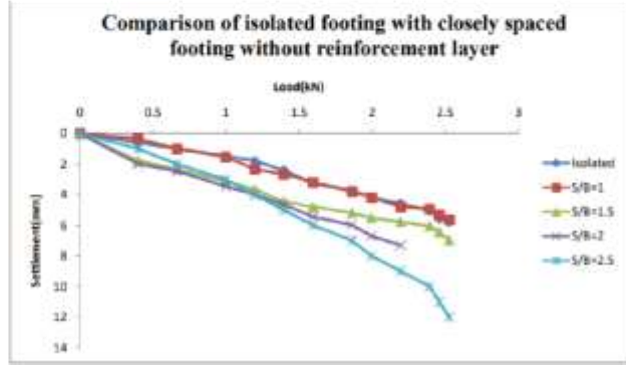

Figure 3 Comparison of isolated rectangular footing and closely spaced footing without reinforcement

From the above plots, it is observed that as spacing ratio increase pressure bulb interference of two nearby footing settlement at some extent decrease , and for S/B=1 footing act as single footing . As spacing ratio increase the effect of interference of closely spaced footing• is decrease and from 2.16 to 1.49 and settlement also decrease .

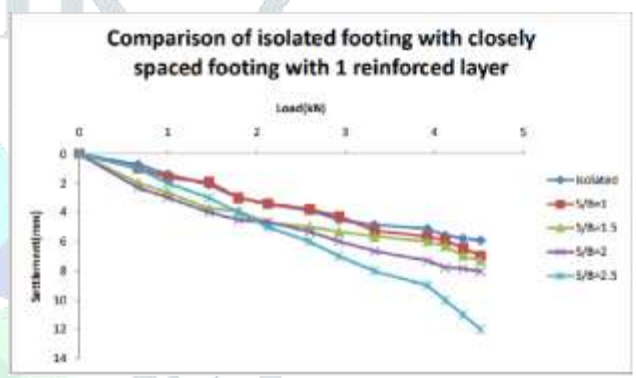

Figure 4 Comparison of isolated rectangular footing and closely spaced footing with one reinforced layer:

From the above plots, it is observed that load carrying capacity of Geogrid reinforced silty sand beds is higher than the unreinforced silty sand beds, it is because of the internal friction between geogrid to the silty sand. Provision of geogrid reinforcement in silty sand beds leads to decrement in permanent settlement. Since the decrease in the permanent settlement is marked by the presence of geogrid, thus the load carrying capacity is increased.

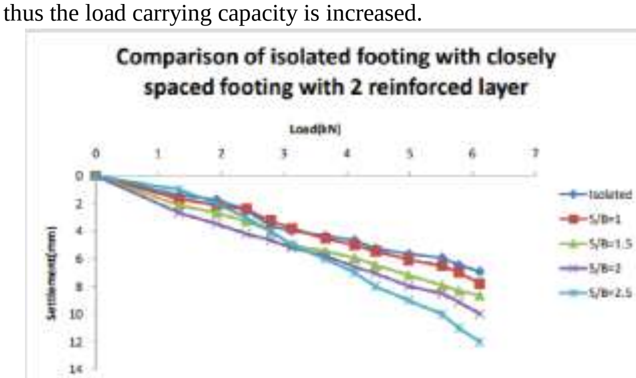

Figure 5 Comparison of isolated rectangular footing and closely spaced footing with two reinforced layer:

Table 3 experimental result comparison of settlement ratio

Rectangular Footing	Footing condition	Settlement ratio, N=1	Settlement ratio, N=2
	Isolated	1.56	1.77
	S/B=1	1.78	1.89
	S/B=1.5	1.90	1.99
	S/B=2	2.11	2.45
	S/B=2.5	2.89	2.96

5. CONCLUSION

- Considerable improvement in load carrying capacity of silty sand when reinforced with geogrid

- It is observed that the soil system with reinforced condition shows lesser settlement compared. to the unreinforced condition for the high compressive load.

- From the study,it is observed that the reinforced soil system with two numbers of layer shows lesser settlement compared to the single and without reinforced soil system.

•In practical we find interference effect is reduced due to geogrid 1.2 to 1.5 times reduceds.

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