USE OF TRIAXIAL GEOGRID TO STUDY THE IMPROVEMENT IN BEARING CAPACITY OF SAND

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Abstract : Laboratory model tests for the determination of ultimate bearing capacity of square foundations supported by multi layered geogrid reinforcement have been presented. The present study aims at investigation of the enhancement in the bearing capacity of a poorly graded sand by placing triaxial Geogrids (TX160) at different depths. In the present study, the number of geogrid layers used and the distance between various geogrid layers is varied and the optimum number of geogrid layers and optimum distance is determined. Different model tests were being performed on a square footing resting on the top of the soil reinforced with geogrid to establish the load versus settlement curves of unreinforced and reinforced soil. The model tests have been conducted using square model footing made of mild steel plate with dimensions 10×10×2.5 cm. The average relative density to be adopted throughout all the tests is 65%.The results show that on addition of geogrid to the sand below foundation, the ultimate bearing capacity of foundation was increased and the settlement was decreased. It was also observed that the ultimate bearing capacity depends on the number of geogrid layers and the spacing between geogrid layers. The optimum number of geogrid layers obtained from the laboratory testing is 3 and the optimum distance between the layers of reinforcement used is 0.5 times the width of footing.

Keywords **: Bearing capacity, settlement, geogrid.**

I. INTRODUCTION

Sandy soils introduce various problems for geotechnical engineers. Usually, their low shear strengths and the magnitude of the proposed loads require the soil to be stabilised. Several techniques are available for ground stabilisation, e.g. grouting, freezing, dewatering, compacting, etc. Most, however, are site specific, often costly and time consuming. One of the fastest growing techniques in the field of geotechnical engineering is reinforcing the soil below shallow foundations with geosynthetic reinforcement like Geogrids etc.

A conventional method to improve the bearing capacity of the soil is to remove a part of the existing weak soil and replace it by soil with more bearing capacity. Now a days the use of geosynthetic materials like Geogrids are being used to improve the bearing capacity and settlement performance of shallow foundation. According to several researches the ultimate bearing capacity and the settlement characteristics of foundation soil can be enhanced by the inclusion of reinforcements in the soils below footings. The bearing capacity of soil can be changed with various factors like type of reinforcing materials, number of reinforcement layers, h/B (the vertical spacing between consecutive reinforcement layers/width of foundation). Generally, all these studies are ultimately related to the improvement in the bearing capacity of soil using reinforcing materials and are related to the effect of various parameters on bearing capacity. The improvement in the bearing capacities is normally expressed in a non-dimensional form as BCR (Bearing Capacity Ratio). The present study investigates the bearing capacity of poorly graded sandy soil with varying the number of triaxial geogrid layers and the distance between multiple geogrid layers while keeping other parameters constant.

During the last 15 years, several papers have been published as related to the beneficial effects of soil reinforcement on the ultimate bearing capacity of shallow foundations. The results of most of these studies reported so far in the literature are based on laboratory model tests. The reinforcing materials used for these studies have been metal strips (Binquet and Lee 1975; Fragaszy and Lawton 1984; Huang and Tatsuoka 1988, 1990), rope fibers (Akinmusuru and Akinbolande 1981), metal bars (Huang and Tatsuoka 1990), geotextiles (Guido et al. 1985), and geogrids (Guide et al. 1986). All of the laboratory model test results with geosynthetic reinforcement available at this time have been conducted with square foundations. The purpose of this note is to present and compare the results of some recent laboratory model tests on square and strip foundations supported by sand reinforced by layers of geogrid.

The main objectives of the study include:

1. To determine the bearing capacity of a given sand using a model square footing.
2. To study load-displacement characteristics of unreinforced sand.
3. To determine the enhancement of bearing capacity and load-displacement characteristics using triaxial geogrid layers.
4. To determine the variation of load-displacement characteristics with changing parameters such as
    a. Number of geogrid layers
    b. Spacing between layers.

II. MATERIALS AND METHODOLOGY

The experimental program has been designed to study the bearing capacity of axially loaded square footing on unreinforced and geogrid reinforced sand bed. For this purpose, the laboratory model tests were conducted on square footings at a particular density. Load tests were performed to evaluate the effects of single and multiple layers of geosynthetic reinforcement placed below shallow square footing. Triaxial geogrids are evaluated for the purpose of study. Parameters of the laboratory model tests consist of the spacing between individual reinforcement layers, number of reinforcement layers.

Materials used

Sand

Locally available river sand obtained from ganderbal kashmir was used as granular bed during the testing program. The relevant properties of the materials were determined following Indian standard test procedures. The sand used in the experimental program has been mined from the river bed of River Jhelum.

Geogrid

Based on the stress transfer, triaxial geogrid TriAX (TX160) was used as reinforcement. The properties of triaxial geogrid are given in table 2 as obtained from the tensar international.

Equipment Used

The load tests were conducted in a tank measuring 0.45 m × 0.40 m × 0.50 m and made up of mild steel of 12 mm thickness. A model footing of mild steel of size 100 mm×100 mm was adopted for this tank size. The model footing was made of a mild steel plate having thickness of 25 mm. Square footing was used so that the dimensional effects are minimized.

Testing Procedure

A series of laboratory model footing tests were conducted on geosynthetic reinforced sand foundation (ASTM 1196, IS 1888). Triaxial geogrid TX160 made of polymers was used as reinforcement inclusions in these tests. The footing was placed in position in the test tank. Load was applied through the load gauge and was maintained manually. Load was measured with the proving ring.

Testing Program

Various experimental studies were done in order to obtain the load-settlement characteristics of a model square footing resting on unreinforced and reinforced granular beds. The parameters studied in this research were the effect of vertical spacing between layers and the number of reinforcement layers. From the laboratory model tests, settlement ratio versus bearing pressure response of footings is brought out for all the cases. The research was conducted in two phases as outlined below

Test series A

This phase consisted of the test for evaluating the response of model footing placed on unreinforced soil. These tests were conducted on unreinforced sand to determine the number of geogrid layers. Based on the load per unit area versus settlement plots obtained from the bearing-capacity tests conducted on the model square foundations,

Test series B

The primary purpose of Phase B was to evaluate the effect of different reinforcement spacing with respect to footing size (h/B) and to determine the optimum spacing between the geogrid layers for the maximum enhancement in bearing capacity.

III. RESULTS AND DISCUSSION

Load tests have been performed on model square footing of size 10cm× 10cm resting over unreinforced as well as reinforced sand bed. For preparing reinforced sand bed, a single layer or the multiple number (1, 2, 3, 4) of geogrid layers have been introduced. Settlement corresponding to each load increment is noted and the test result is plotted in terms of load-settlement curve. The bearing capacity for each test is determined from load-settlement curve. Bearing capacity results are then analyzed to determine the optimum values of h/B and N.

The mild steel plate of dimensions 10cm × 10cm × 2.5cm was used as model square footing. All experiments are conducted at same relative density of 65%. The average unit weight of sand at this relative density is 1.59g/cc and internal friction angle is found out to be 34.29 by direct shear test at this relative density. The characteristics of sand used in research work and the grain size distribution is listed in table 1 and figure 1 respectively.

Table 1 : Properties of sand.

S.No	Property	Value
1.	D_{10}	0.275
2.	D_{30}	0.63
3.	D_{60}	0.915
4.	D_{50}	0.82
5.	Coefficient of curvature (Cc)	1.577
6.	Coefficient of uniformity (Cu)	3.32
7.	Specific gravity (G)	2.67
8.	Maximum dry unit weight (KN/m^3)	16.8
9.	Minimum dry unit weight (KN/m^3)	14.5
10.	Friction angle (ϕ)	34.29
11.	E_{max}	0.84
12.	E_{min}	0.589

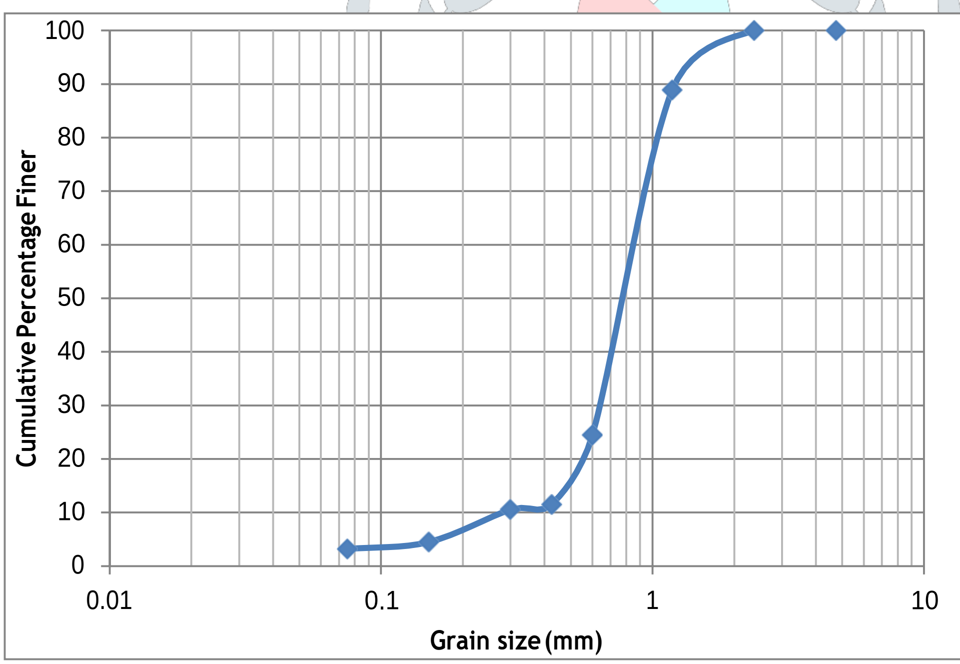

Figure 1 : Grain size distribution curve of sand.

Based on the stress transfer, triaxial geogrid TriAX (TX160) was used as reinforcement. The properties of geogrid used are tabulated in table 2

Table 2 : Properties of triaxial geogrid (TX160)

Properties	**Value**
Rib shape	Rectangular
Aperture shape	Traingular
Radial stiffness at low strain	300 KN/m2
Junction efficiency	93%
Aperture stability	3.6 kg-cm/deg
Tensile strength at low strain	1.5 KN/m2
Resistance to chemical Degradation	100%
Resistance to UV lighty and Weathering	100%

Table 3 and table 4 shows the improvement in bearing pressure with respect to unreinforced sand for a settlement ratio equal to 6% as determined from double tangent method from load settlement curves, as the vertical spacing of the geogrid layers and number of geogrid layers was varied keeping Relative Density= 65%. Figure 3 and figure 5 represents the variation of bearing capacity ratio with respect to changing N value and spacing between geogrid layers obtained at a settlement of 6% of the footing width for each grade of geogrid.

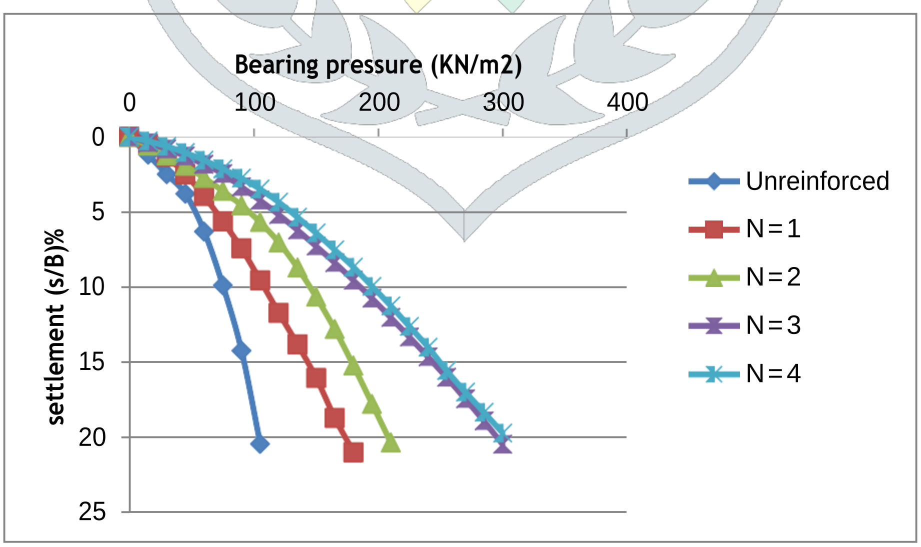

Figure 2 : Plot of bearing pressure vs settlement ratio at varying N(No. of geogrid layers)

Table 3 : Bearing capacity ratios at different no. of geogrid layers.

N	Bearing pressure for unreinforced soil ,qu (KN/m2)	Bearing pressure for reinforced soil ,qr (KN/m2)	Bearing capacity ratio (BCR)	Increase in bearing capacity (%)
1	58.2	78.12	1.342	34.22
2	58.2	108.61	1.866	86.61
3	58.2	132.07	2.27	126.92
4	58.2	144.28	2.48	147.91

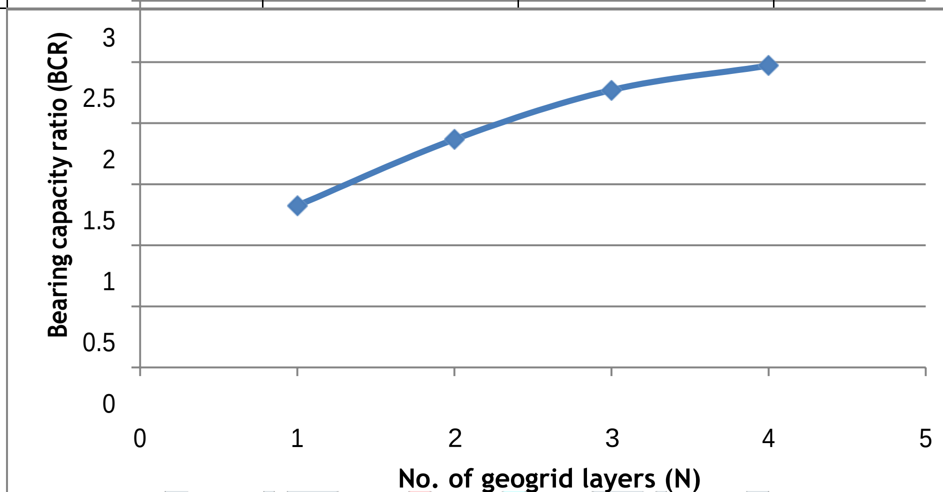

Figure 3 : Variation of Bearing capacity ratio with No. of geogrid layers.

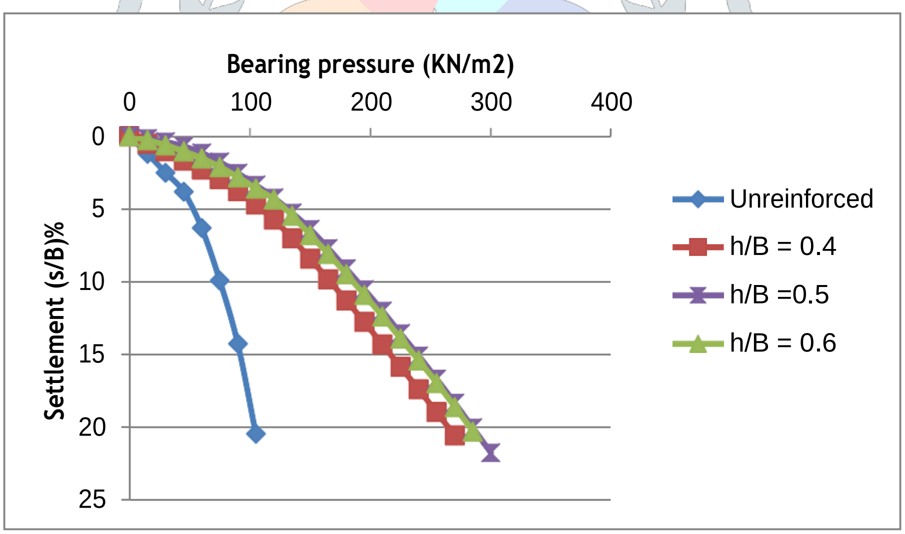

Figure 4 : Plot of bearing pressure vs settlement ratio at various h/B ratios.

Table 4: Bearing capacity ratios at various h/B ratios

h/B	Bearing pressure for unreinforce d soil ,qu (KN/m2)	Bearing pressure for reinforced soil ,qr (KN/m2)	Bearing capacity ratio (BCR)	Increase in bearing capacity (%)
0.4	58.2	123.23	2.1	111.73
0.5	58.2	141.22	2.4	142.65
0.6	58.2	145	2.49	149.14

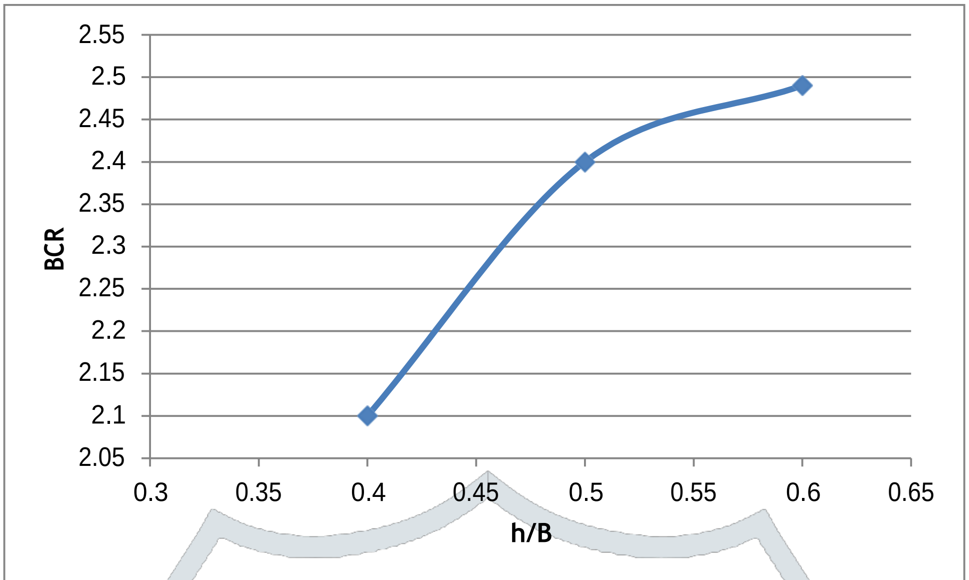

Figure 5 : Variation of bearing capacity ratios at various h/B ratios.

IV. CONCLUSIONS

Based on the test results obtained, the following conclusions can be made:

1. The inclusion of geogrid in the soil makes the relationship between the settlement and applied pressure of the reinforced soil almost linear. At a particular settlement, the bearing capacity will be more in case of reinforced condition than unreinforced case.
2. For the same soil and geogrid configuration, the ultimate bearing capacity increases with the increase in the no. of layer of geogrid N. Maximum improvement was found at N=3.
3. The spacing between the individual reinforcement layers (h) affects the improvement in bearing capacity. The improvement is maximum for h/B = 0.5 for TX160.

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