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STUDIES ON GEOSYNTHETIC REINFORCED SOIL FOR COST EFFECTIVE FOUNDATION

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1. ABSTRACT

The geosynthetic reinforced foundation soils are being used to support footings of many structures including ware houses, oil drilling platforms, bridge abutments, platforms of heavy industrial equipment etc. In usual construction practice, one or more layers of geosynthetic (geotextile, geogrid, geocell or geocomposites) are placed inside a controlled granular fill beneath the footings. Such reinforced foundation soils provide improved load bearing capacity and reduced settlements by distributing the imposed loads over a wider area of weak subsoil. In the conventional construction technique, without any use of reinforcement, a thick granular layer is needed which may be costly or may not be possible, especially in sites of limited availability of good quality granular materials. In general the improved performance of a geosynthetic reinforced foundation soil can be attributed to an increase in shear strength of the foundation soil from the inclusion of the geosynthetic layers. The soil-geosynthetic system forms a composite material that prevents development of the soil failure wedge beneath shallow spread footings. In order to observe physically the behavior of prestressed reinforced granular beds overlying weak soil, extensive experimental investigations are carried out. A series of laboratory scale model tests are carried out on square footings resting on unreinforced granular bed (GB), reinforced granular bed (RGB) and prestressed reinforce granular bed (PRGB). The details of experimental setup, test methodology, material used and parameters studied are explained.

Keywords: Geosynthetic Reinforced Foundation, Unreinforced Granular Bed, Reinforced Granular Bed, Prestressed Reinforce Granular Bed

1.1 INTRODUCTION

The decreasing availability of proper construction sites has led to the increased use of marginal ones, where the bearing capacity of the underlying deposits is very low. The conventional method is to provide deep and costly foundation on such weak deposits. The necessity to develop cost effective solutions has made ground improvement a major research area. As a cost-effective foundation system, the use of geosynthetics has proven to improve the settlement performance and bearing capacity of shallow foundations. Geosynthetic improves the ability to use shallow foundations as a substitute to expensive deep foundations in normal ground conditions which is done either by replacing the poor soils with stronger granular fill or by reinforcing cohesive soil directly in combination with geosynthetics reinforcement.

1.2 OBJECTIVE

By lying a compacted granular bed over weak soil the bearing capacity & settlement can be improved. By reinforcing the granular bed with single or multi-layers of geosynthetics (Fig 1.1) the bearing capacity can also be improved. The geosynthetics that are used in the granular beds improves the ultimate bearing capacity in the reinforcement by mobilizing tensile forces.

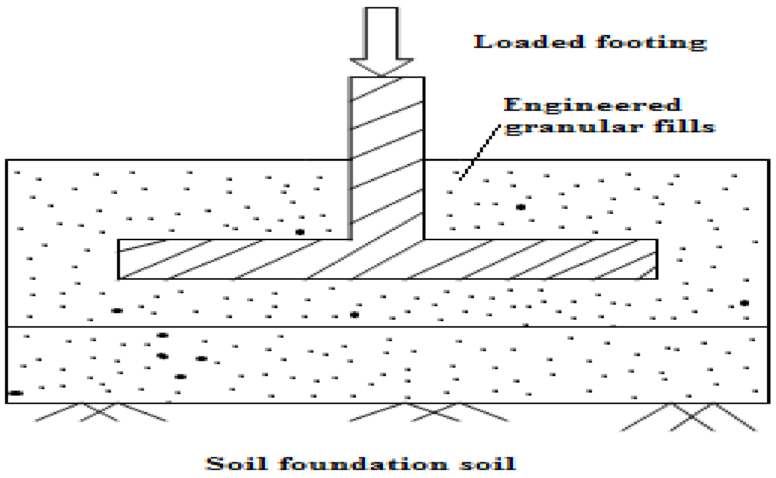

Fig.1.1 Footing supported on Reinforced Granular Bed

By the method of providing geosynthetic reinforced granular bed over the weak soil the bearing capacity of footings is improved. Hence in this study an attempt is made to improve the bearing capacity of square footings supported on geosynthetic reinforced granular beds overlying weak soil and evaluating the effects of prestressing the reinforcement.

The specific objectives of the study are to observe the following

1. Effect of number of layers of prestressed geosynthetic reinforcement.
2. Effect of type of geosynthetic reinforcement.
3. Effect of size of prestressed geosynthetic reinforcement.

2. EXPERIMENTAL SETUP

The load tests are conducted in a combined test bed and loading frame assembly. The test beds are prepared in a ferrocement tank which is designed keeping in mind the size of the model footing to be tested and the zone of influence. The dimensions of the tank are 750mm length x 750mm width x 750mm depth. The model footing is a rigid mild steel plate of 100mm x 100mm size and 20 mm thickness.

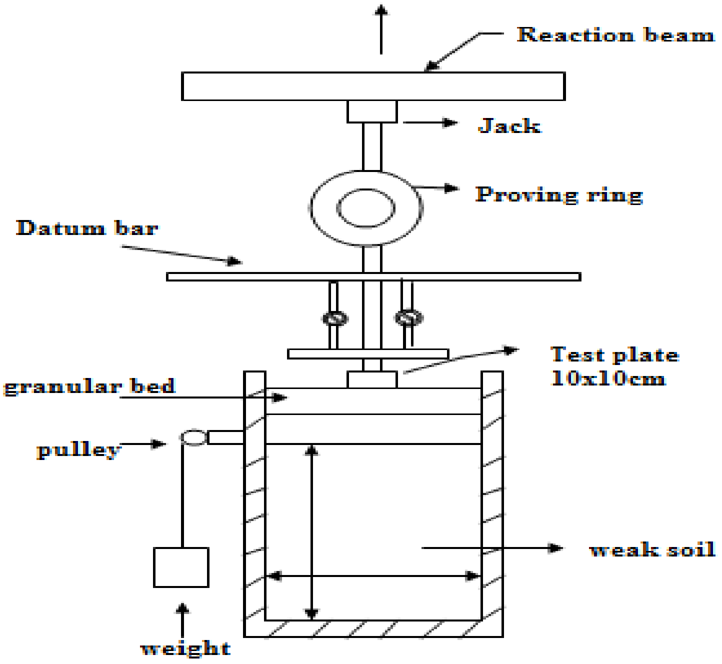

Fig.2.1 Test setup

The footing was loaded by a hand operated jack of 10KN capacity supported against a reaction frame. The load is measured using a proving ring and deformation using two dial gauges placed diametrically opposite to each other. The details of the test setup are shown in Fig.2.1 and photograph in Fig.2.2. The arrangement for measuring loads and deformations are shown in Fig.2.3

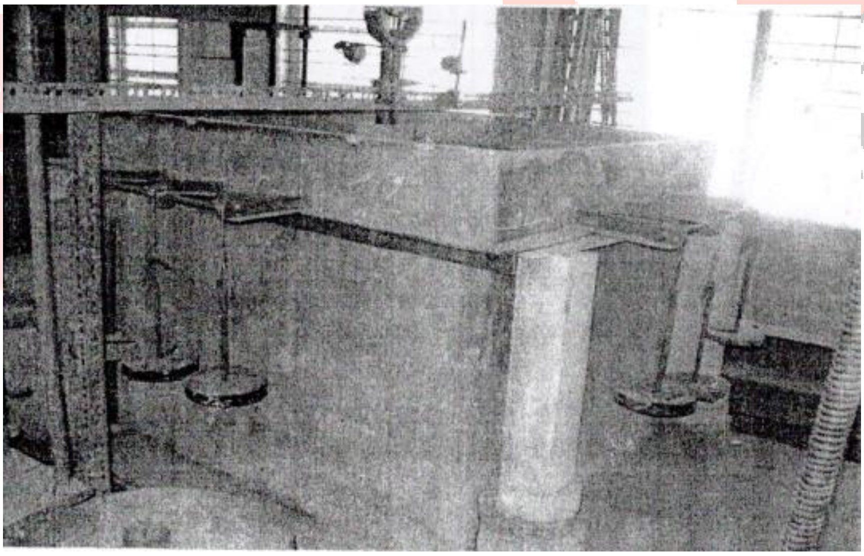

Fig.2.2 View of test setup

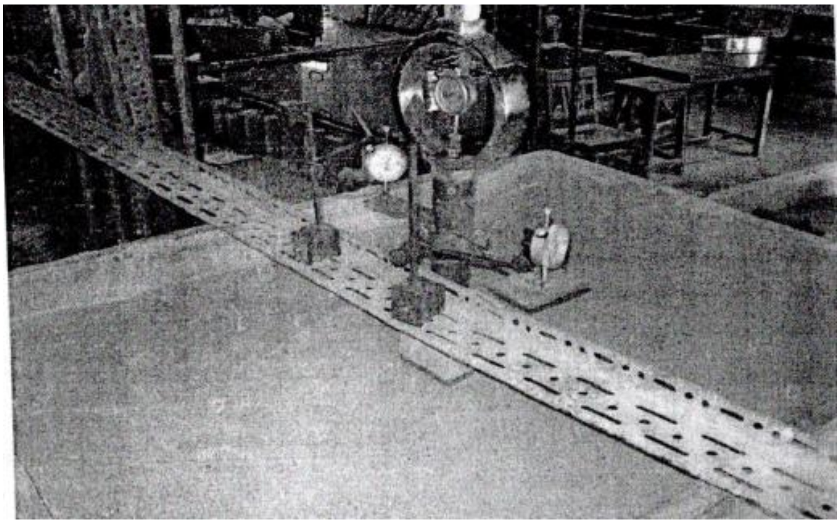

Fig.2.3 Arrangements for measuring load and deformation

2.1 PREPARATION OF TEST BED

At first the weak soil is filled in the ferrocement tank to the required level with compaction done in layers, to achieve the pre-determined density. Then sand is filled up to the bottom level of reinforcement and compacted. The reinforcement is then placed with its centre exactly beneath the jack, and the prestress is applied. Then sand above the reinforcement is placed and compacted to the pre-determined density.

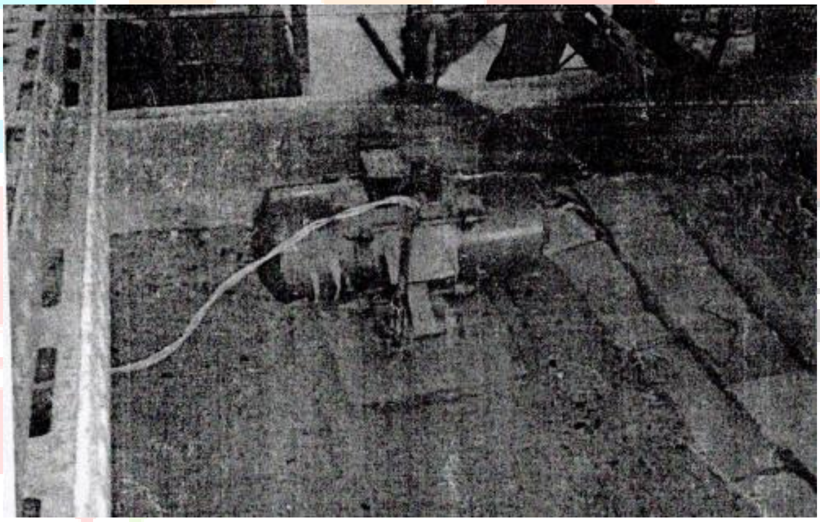

Fig.2.4 Compaction of sand using Plate Vibrator

The densities to which the soils were compacted are indicated in Tables 2.1 and 2.2. The compactive effort required to achieve the required density of both the soils is determined by trial and error. Preparation of underlying soil in all the tests involved compaction of soils using a rammer. In the preparation of granular bed, the sand was compacted using a small plate vibrator as shown in Fig.2.3.

2.2 THICKNESS OF GRANULAR BED

Tests are carried out for two thicknesses of granular bed equal to B and 2B, where B is the width of the model footing (Fig.2.5)

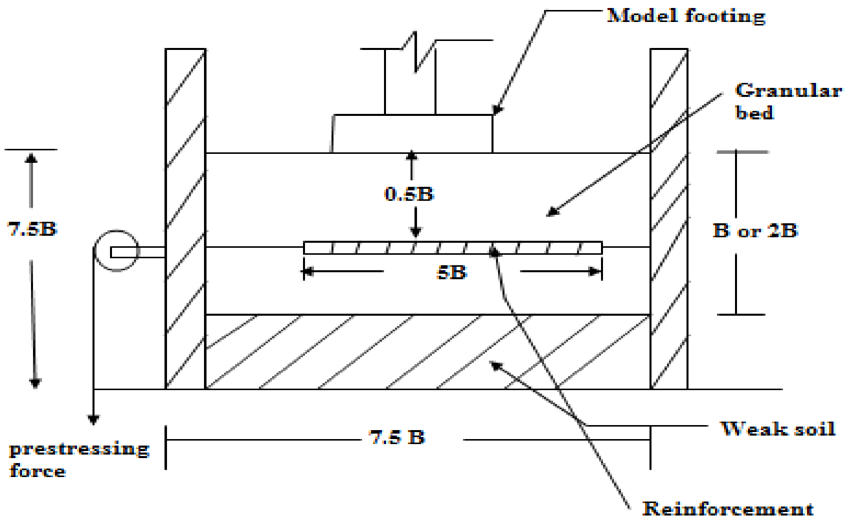

Fig.2.5 Details of granular bed

In all the tests, the reinforcement was kept at a depth of 0.5B from the base of the footing. When the thickness of granular bed is B, reinforcement is at the middle of granular bed and when the thickness of granular bed is 2B, reinforcement is at the top quarter point.

2.3 MAGNITUDE OF PRESTRESS

In order to investigate the effect of magnitude of prestress in the behavior of prestressed reinforced granular bed, tests are carried out with three different magnitudes. Prestress applied are equal to 1%, 2% and 3% of the tensile strength of the reinforcement. The prestressing force is distributed over three pulleys as shown in Fig.2.6.

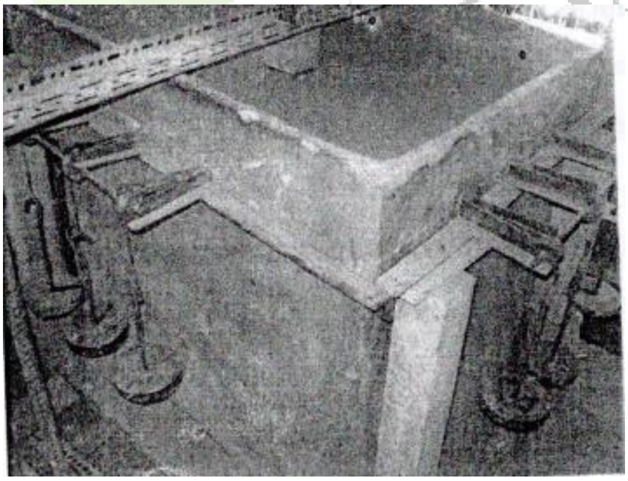

Fig.2.6 Prestressing force applied through three pulleys

Prestress is applied to the reinforcement through light steel cables attached to thin mild steel flats bolted to the edges of the reinforcement. This arrangement is shown in Fig.2.7.

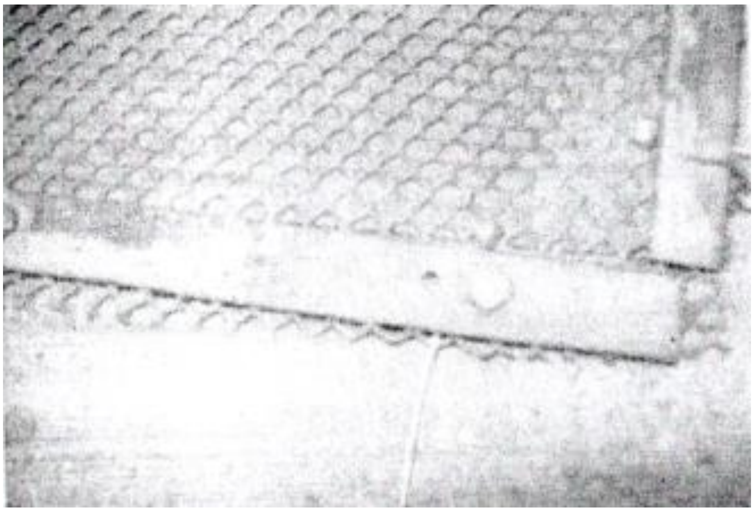

Fig.2.7 Application of prestress to reinforcement

2.4 DIRECTION OF PRESTRESS

To determine the relationship between the direction of prestress and improvement in bearing capacity, tests are carried out with two directions of prestress, viz. uniaxial and biaxial. In uniaxial prestressing the prestress is applied only in the X-direction as shown in Fig.2.8.

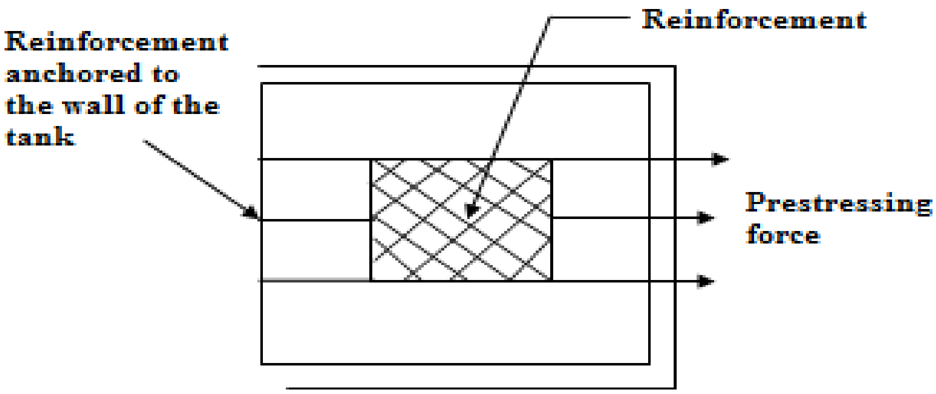

Fig.2.8. Uniaxial Prestressing

In biaxial prestressing, the prestress is applied in both X and Y directions as shown in Fig.2.9.

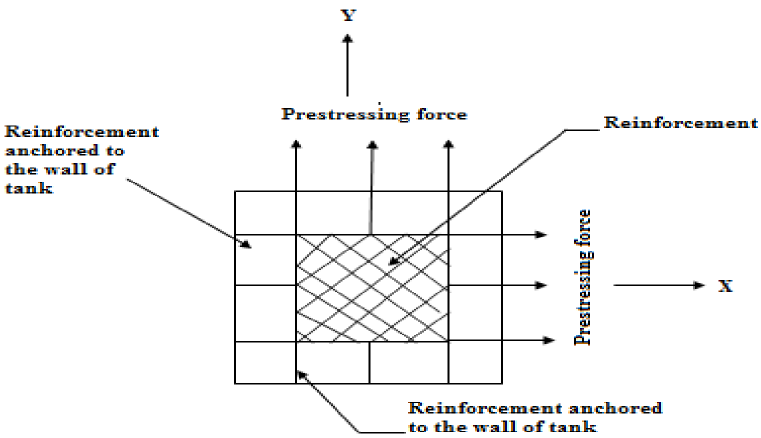

Fig.2.9 Biaxial prestressing

3. GEOSYNTHETIC REINFORCEMENT

3.1 NUMBER OF LAYERS OF REINFORCEMENT

To assess the improvement in bearing capacity due to an increase in the number of layers of prestressed reinforcement, tests are carried out with single and double layers of prestressed reinforcement. The test setup for double layer reinforcement is shown in Fig.3.1. In the literature, it is reported that optimum depth of placement of the first layer of reinforcement is 0.2B to 0.5B (B is the width of footing) (Sharma et al. 2009). The depth of reinforcement from the base of footing is adopted as 0.5B for all the tests with single layer reinforcement. In case of double layer reinforcement, the depth of top layer is 0.25B from the base of footing and that of bottom layer is 0.5B from the base of footing. The arrangement of reinforcement for double layer is shown in Fig.3.1.

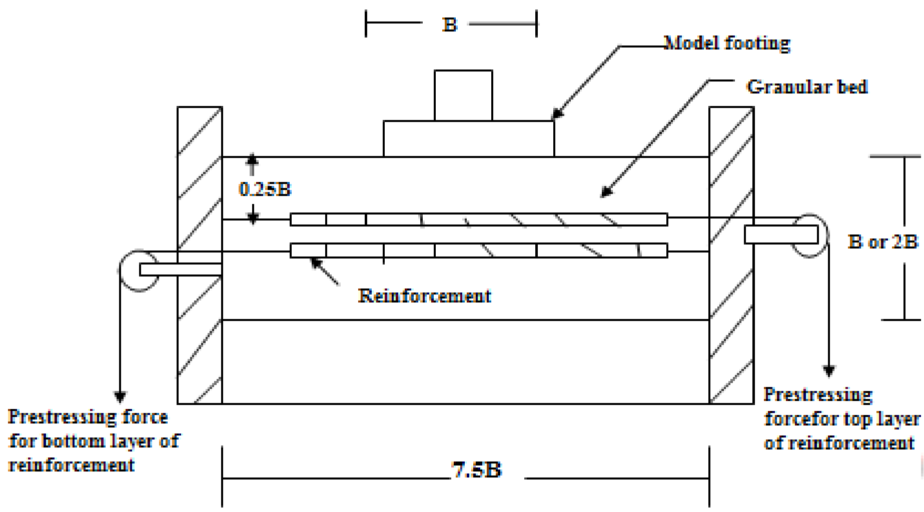

Fig.3.1 Arrangement of double layer reinforcement

3.2 SIZE OF REINFORCEMENT

Previous studies have shown that for footings supported on reinforced soil, the optimum size of reinforcement is equal to 5 to 7 times the width of square footing (Lee et al. 1999). In order to investigate the effect of size of prestressed reinforcement in improving the bearing capacity, tests are carried out with two sizes of reinforcement. The sizes of reinforcement used for the tests are 5B and 2B, where B is the size of square footing.

3.3 TYPE OF GEOSYNTHETIC REINFORCEMENT

Table 3.1 Properties of geogrid used for the investigation

Property	Value
Mass per unit area (gm/m^2)	730.00
Aperture size (mm)	8 x 6
Thickness (mm)	2.30
Tensile Strength (KN/m)	7.68
Extension at maximum load (%)	20.20
Colour	Black
Polymer	HD-Polethylene

The improvement in bearing capacity attained will depend upon the properties of geosynthetic reinforcement used. In order to investigate the effect of the type geosynthetic on the performance of prestressed reinforcement, tests are carried out with two types of geosynthetics, viz. geogrid and geotextile. The properties of geogrid used are given in Table 3.1 and that of geotextile in Table 3.2.

Table 3.2 Properties of geotextile used for the investigation

Property	**Value**
Mass per unit area (gm/m^2)	206.00
Thickness (mm)	0.58
Breaking strength – Warp (5 x 20 cm)(Kg)	257.7
Breaking strength – Weft (5 x 20 cm)(Kg)	181.90
Extension at break (%) – Warp	36.90
Extension at break (%) – Weft	30.20
Interfacial friction angle with sand (°)	30.50
Style (Quality No:)	P.D. 381
Material	Polypropylene

The experimental setups are summarized in Table 3.2.

Table 3.2. Experimental Setup

Series	Type	Number of layers of reinforcement	Size of reinforcement	Reinforcement type	Thickness of granular bed	Direction of prestress	Magnitude of prestress
A	Reinforced GB on weak soil 1	1 & 2	5B & 2B	Geogrid & Geotextile	B & 2B	-	-
B	Prestressed RGB on weak soil 1	1 & 2	5B & 2B	Geogrid & Geotextile	B & 2B	Uniaxial & biaxial	1%, 2% & 3%
C	Reinforced GB on weak soil 2	1 & 2	5B & 2B	Geogrid & Geotextile	B & 2B	-	-
D	Prestressed RGB on weak soil 2	1 & 2	5B &2B	Geogrid & Geotextile	B & 2B	Uniaxial & biaxial	1%, 2% & 3%

4. RESULTS & DISCUSSIONS

4.1 Effect of Number of layers of reinforcement

To determine the effect of the number of layers of prestressed reinforcement, investigations were carried out with single layer and double layer geogrid reinforcement. in general double layer reinforcement gave better BCR than single layer reinforcement.

It is observed that at 1% and 2% prestress, granular bed of thickness B with biaxially prestressed double layer reinforcement gives more improvement than granular bed of thickness 2B with uniaxially prestressed double layer reinforcement. It is also observed that granular bed of thickness 2B with biaxially prestressed single layer reinforcement gives more improvement than granular bed of thickness 2B with uniaxially prestressed double layer reinforcement.

4.2 Effect of Size of reinforcement

Investigations are carried out with reinforcement of two sizes; 5B and 2B, where B is the size of square footing. The improvement in bearing capacity attained with bigger reinforcement is slightly higher than that attained with smaller reinforcement. It is observed that biaxially prestressed RGB of thickness B with reinforcement of size 2B x 2B is giving more improvement than uniaxially prestressed RB of thickness 2B with reinforcement of size 5B x 5B at 1% and 2% prestress.

4.3 Effect of type of geosynthetic reinforcement.

In order to determine the effect of type of geosynthetic reinforcement, investigations are carried out with geogrid and geotextile reinforcement. In general PRGB with geotextile reinforcement is giving better improvement than with geogrid reinforcement. the geogrid used for the study is a weak type of geogrid having a tensile strength of only 7.68 KN/m, much lesser than the tensile strength of geotextile. The reason for lesser improvement by geogrid compared to that of geotextile could be attributed to the lower value of tensile strength of the geogrid used.

5. REFERENCES

1. Alamshahi,S. and Hataf,N. (2009). Bearing capacity of strip footings on sand slopes reinforced with geogrid and grid-anchor, *Geotextile and Geomembranes*, 27 (2009) 217 – 226.
2. Azam,G., Hseigh,W. and Wang,MmC. (1991). Performance of strip footing on stratified soil deposit with void, *Journal of Geotechnical and Geoenvironmental Engineering*, ASCE, Vol.117, No.5, May, pp.753 – 772.
3. Baus,R,L. and Wang,M,C. (1983). Bearing capacity of strip footing above void, *Journal of Geotechnical and Geoenvironmental Engineering*, ASCE, Vol. 109, No.1, January, pp.1 – 14.
4. Bhat,A,K., Shivashankar,R. and Yaji,R.K.(2008), "Case study of land slide in NH 13 at Kethikal near Mangalore, India", *6th International Conference on Case histories in Geotechnical Engineering, Arlington*, VA, USA, paper no.2.69
5. Deb,K et al, 2007, Numerical analysis of multilayer geosynthetic reinforced granular bed on soft sill, *Geotechnical and Geological Engineering*, 25, 639 – 646.
6. Ghosh,C. and Madhav,M,R.(1994a), Reinforced granular fill soft soil system – membrane effect, *Geotextiles and Geomembranes*, 13(11), pp. 743 – 759.
7. Kiyosumi,M., Kusakabe,O., Ohuchi,M. and Peng,F,L. (2007). Model tests and analyses of bearing capacity of strip footing on stiff ground with voids, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 137, No. 4, April, pp. 363 – 375.
8. Lackner,C., Bergado,D,T. and Semprish,S. (2013), Prestressed reinforces soil by geosynthetics – Concepts and experimental investigations, Geotextiles and Geomembranes, 37, pp. 109 – 123.

9. Madhavilatha,G. and Somwanshi,A. (2009b), Effect of reinforcement form on the bearing capacity of square footings on sand, Geotextiles and Geomembranes, 27, pp. 409 – 422.
10. Meyerhof,G,G. (1974). Ultimate bearing capacity of footings on sand layer overlying clay, Canadian Geotechnical Journal, Vol. 11, pp. 223 – 229.
11. Sireesh,S., Sitharam,T.G. and Dash,S.K. (2009). Bearing capacity of circular footing on geocell-sand mattress overlying claybed with void, Geotextiles and Geomembranes, 27, pp. 89 – 98.
12. Tafreshi,S.N.M. and Dawson,A.R. (2010a), Comparison of bearing capacity of a strip footing on sand with geocell and with planar forms of geotextile reinforcement, Geotextiles and Geomembranes, 28, pp. 72 – 84.
13. Terzaghi,K. and Peck,R.B. (1948), Soil Mechanics in Engineering Practice, Wiley International, New York.
14. Wang,M.C. and Badie,A. (1985). Effect of underground void on foundation stability, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 111, No. 8, August, pp. 1008 – 1019.
15. Wang,M.C. and Hseigh,C.W. (1987). Collapse load of strip footing above circular void, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol 113, No. 5, May, pp. 511 – 515.
16. Yamamoto, K. and Otani,J. (2002). Bearing Capacity and failure mechanism of reinforced soil based on rigid-plastic finite element formulation, Geotextiles and Geomembranes, 20, 367 – 393.