STERENGTHENING OF EXPANSIVE SOIL TO REDUCE SETTLEMENT

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Abstract

Stabilization is the main aim, to reduce the bearing capacity of expansive soil by using coated yarn geogrid. The supporting power of a soil or rock is referred to as its bearing capacity. Reinforced earth is a composite material, a combination of soil and reinforcement suitably placed in layers to resist tensile stresses. In case of soft soils geogrid is one which redistributes the stresses internally with locally available backfill materials. Ground improvement technique using geosynthetic material i.e. geogrid is done below foundation .Using this technique; we can improve stability of available expansive soil, and increase the load bearing capacity. With this it also controls the earthquake vibrating forces. Reinforcement of soil to improve the ground (weak soil) using a polymeric geosynthetic material i.e. coated yarn geogrid is applied below a square footing. To reduce the foundation settlement, bearing capacity of soil increased. This can also be implemented to many such weak places as road, railway ballast, airways, slopes, tunnels, etc. in various ways.

Geotechnical engineers often deals with the soil bearing capacity and compaction quality of soils and non-cohesive sub-bases, as well as for soil improvement applications. Built-in soil layers can easily be tested without load abutment, facilitating quick assessments of test lots even under limited space conditions. Strengthening is carried out and the results of this method is measured and tabulated. The test results indicate that the soil reinforced by gogrid is very much effective to increase the load bearing capacity of soft soil.

Keywords: *soil reinforcement, bearing capacity, geosynthetics, geogrid, expansive soil, settlement, foundation.*

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1. INTRODUCTION

Expansive soils are considered to be unsafe with reference to safety of the structure in serviceability aspects, and needs to be tackled in a well engineered manner, if it should be used as a foundation soil .Soil is a particulate material consisting of soil grains and as a result it cannot withstand tensile stresses. Therefore, soils are unstable below the foundation and undergo deformations under loads. A variety of reinforcing materials are used for reinforced earth applications. They include natural materials, metallic strips and geosynthetics [3]. A reinforced soil mass is a soil mass containing reinforcement layers placed at appropriate locations in proper directions. The bearing capacity of black cotton soil is increased with the help of geogrid soil reinforcement [1]. The geogrid usd for this test is coated yarn geogrid. This is biaxial geogrid[8]. For avoiding cracks, due to vertical loads, dynamic loads, earthquake forces, etc. strengthening is very much essential for the expansive soil. Geogrid is chosen for its high load carrying capacity, ant corrodible, easily available, and cheap also. For road base, it is widely applied everywhere. But for settlement in case of foundation we should study here. Geogrid increases stiffnss and load carrying capacity of soil which automatically reduces the settlement of foundation.

When subjected to vertical loads, a reinforced soil mass typically exhibits higher load carrying capacity than a soil mass without reinforcement. The present research has to study the effect of geogrid reinforcement on maximum dry density (MDD), Optimum Moisture Content (OMC), California Bearing Ratio (CBR) of soil. The clayey type of soil and one type of geogrid were selected for this study [4]. This method can be implied to: Road construction, railway construction, earth works, pipe & canal construction, examination of foundation fillings. The main aim is to reduce load bearing problem by reinforcing expansive soil using coated yarn geogrid. Thus by applying geogrid soil reinforcement (coated yarn type) in layers such that more stability strengthening is carried out. This is applied below the footing. Square footing is chosen here for this study. Thus this is a ground improvement technique for locally available problematic i.e. expansive soil.

2. THEORY

This presentation shows weaker soils are generally clayey and expansive in nature which are having lesser strength characteristics. Technique of improving the soil with geogrid increase the stiffness and load carrying capacity of the soil through fractional interaction between the soil and geogrid material improving black cotton soil. Reinforcement can be done with the implement of bars, rods, jutes, fibers, meshes, nets, pipes, textiles, etc. made by polymeric materials[1]. Polymeric materials are polypropylene, polyethylene, etc. These can be got from wastes i.e. by recycling it. This may be

an advantage us to control environmental pollution, also it saves cost.

To achieve the economy and for proper performance of foundation, it is necessary to improve the soil. This study demonstrates the study of ground improvement techniques. Developmental activities in cities have lead to increased building construction. The main objective of this work is to study the behavior of square footing on expansive soil bed with and without reinforcement, and to find out improvement in bearing capacities. The settlement decrease for square footing on reinforced siol bed is also found out. Parameters varied for the study are number of reinforcing layers, width of reinforcement and depth of first layer reinforcement. Ultimate bearing capacity can be found to increase, even with single layer reinforcement for the footing. The effectiveness of geosynthetic reinforcement in improving the bearing capacity is attributed to location and width of the reinforcement in the case of single layer reinforcement whereas in multilayer reinforcement, spacing of reinforcement play significant role apart from loading applied for reinforcement. Provision of first layer of reinforcement at a depth beyond the width of footing is not effective in improving the bearing capacity. Geosynthetics: is defined as a planar product manufactured from polymer material used with soil, rock, earth, or other geotechnical engineering related material as an integral part of a manmade project, structures or system.Types of Geosynthetics covers:1. Geogrids, 2.Geocomposites, 3.Geomembranes,4. Geotextile, 5.Geopipe, 6.Geonet,7. geofoams etc. Geogrids are used: 1.To performs better.2.To reinforce economically.3.To be more economical than using traditional materials and solutions. A geosynthetic material consisting of connected parallel sets of intersecting ribs with apertures of sufficient size to allow strike through of surrounding soil, stone or other geotechnical material. The primary function of geogrids is clearly reinforcement [10]. Reasons are: They are quality control manufactured in a factory environment, they can be installed readily, they generally replace raw resources, and they generally replace difficult designs using soil or other construction materials.

2.1 Types of Geogrid

1. Polyester strap geogrid, 2.Coated Yarn geogrid, 3.Unitized polyolefin geogrid.

2.1.1 Polyester Geogrid

Made from high tenacity PET or polypropylene rods or straps. Different rib layout patterns give rise to different styles of unidirectional and bidirectional products.

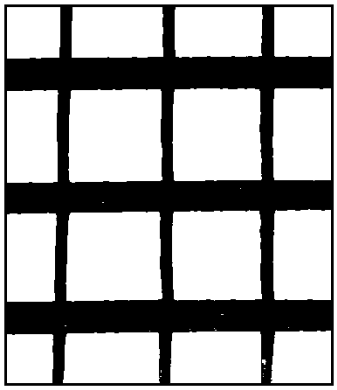


Fig.1 polyester geogrid

2.1.2 Coated Yarn Geogrid

Fig.2 coated yarn geogrid

The yarns are bundles of high tenacity polyester (PET) filaments. Strength can be varied. The geogrids are coated, usually by spraying and then dipping in bitumen, latex or PVC is done.

2.2Objectives.

To find out settlement of expansive soil in different loading system, It is observed that there is considerable reduction in the settlement using geogrid.If we compare geogrids polyester geogrid & coated yarn geogrid, coated yarn geogrid is very effective. Using different width size of geogrid estimate the settlement of expansive soil. Compare geogrid results with plane soil without geeogrid .Compare settlement for different spacing's of geogrid.

2.3 Problem Identification

It is observed that many structure (load bearing) constructed on expansive soils will have settlement cracks. It is very difficult to completely reduce the settlement cracks by conventional methods. Hence to achieve economy

strengthening of expansive soil is very much essential. Geosynthetics, - Geogrid thus can be used in foundation settlement to reduce the percentage of settlement.

2.4 Basic Mechanism of Reinforced Earth

Fig.3 basic mechanism of reinforced earth

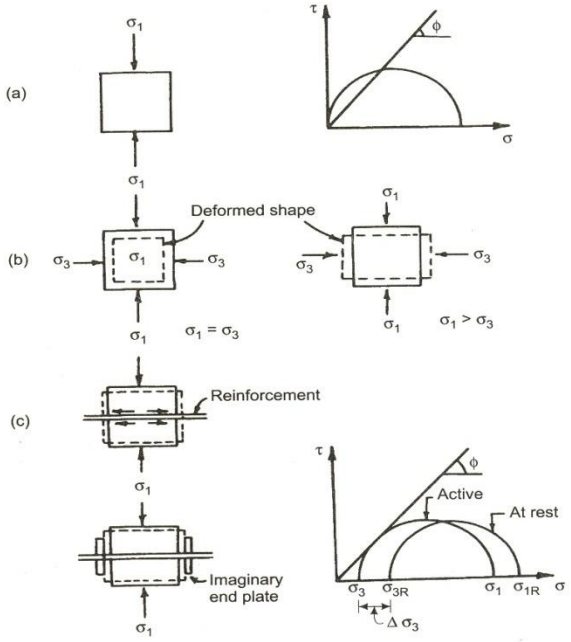


Fig.4 reinforced earth mechanism

Geogrids are plastics formed into a very open, grid like configuration i.e., with large apertures between individual ribs in the machine and cross machine directions. Grids formed from polymers are known as geogrids and are normally in the form of an expanded proprietary plastic product.

2.5 Properties of Geogrid:

Physical properties: These include the type of structure, junction type, aperture size and thickness. Other properties are density, mass per unit area etc.

Chemical properties: Polyolefin, polypropylene, polyethylene and polyesters used in geogrids have high excellent resistance to a wide range of chemicals.

Geogrids are formed in various ways:1) stretched in one or two directions for improved physical properties,2) made on weaving or knitting machinery by standard and well established methods and 3) made by bonding rods or straps together. There are many application areas, however, and they function almost exclusively as reinforcement materials. The primary function of geogrids is clearly reinforcement. The pressure bulb found below the square footing is as below.

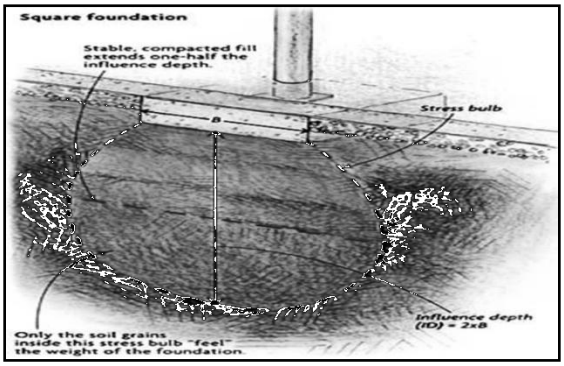


Fig.5 pressure bulb of square footing

2.6 Materials Used:

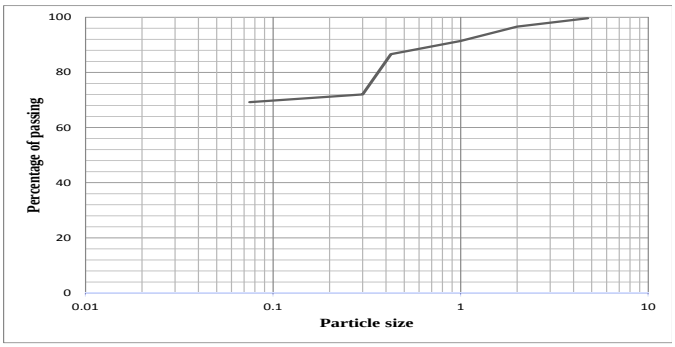
2.6.1 Black Cotton Soil (Expansive Soil)

Photograph of black cotton soil.

The B.C. soil used for the present work is collected fro BKIT Bhalki, district Bidar. The soil is collected at a depth of 1m from ground level at the sites.

Physical properties of black cotton soil

2.6.1.1 Sieve Analysis Results



Graph1: sieve analysis

Table 1: sieve analysis

Is Sieve no.	% of passing by weight
4.75mm	99.6
2mm	96.6
1mm	91.4
425mic	86.6
300mic	72
75mic	69.2

2.6.1.2 Index Properties of Black Cotton Soil

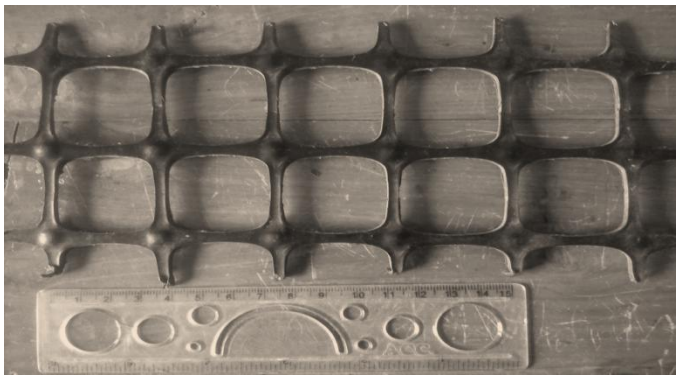
The index properties of the collected soil are studied by conducting various laboratory tests conforming to Indian Standard codes.

Table 2: basic properties

Properties	Tests carried out as per IS	results
Liquid limit wL (%) (>45%)	IS 2720 part V,1985 [23]	69.5%
Plastic limit wP (%) (>25%)		48%
Optimum moisture content, wOMC (%)	IS: 2720, Part VII— 1980 [25]	18.5%
Maximum dry density, γdmax(gm/cm3)		1.6gram per cc
Specific gravity (G)	IS 2720 part III/Sec-1,1980 [22]	2.4

2.6.2 Geogrid

Coated yarn (2 inch aperture geogrid) Used as Reinforcement in Soil.



Photograph of coated yarn

2.6.2.1 Physical Properties of Geogrid

Table 3 physical properties of geogrid

Physical properties	Coated yarn geogrid
Aperture size	50.8mm
Thickness	2mm
Density	1.12gm/cm3
Mass per unit area	0.1gm/cm2

Without using geogrid material and using geogrid material and tested in loading frame as per procedure given below.

2.7 Search Strategies

Expansive soil is checked for settlement of without geogrid, and with geogrid. The tests are carried for different spacing's as 0.5B, 1B, 1.5B, 2B, 3B. Also, these spacing's are checked at various load intervals for calculating graph analysis. High Performance, high water permeability and gas permeability, high tensile strength and tearing resistance, aging resistance, anti-corrosion

3. PROPOSED METHOD FOR SETTLEMENT AND LOADS

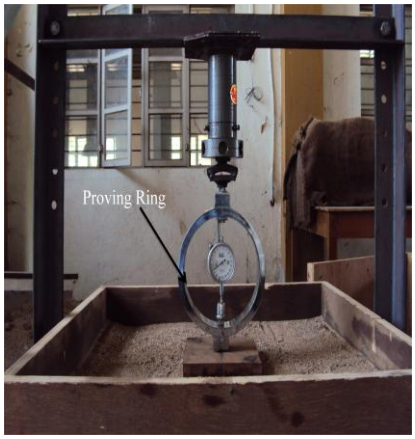
The foundation model is prepared of size 0.6m * 0.6m * 0.5m.Without using geogrid material and using geogrid material and tested in loading frame as per procedure given below:

A. Types of model prepared: Without using geogrid material, using coated yarn 2″ aperture geogrid .

First, without geogrid is tsted. Prepared model is placed below the loading frame and wooden footing of size 3″ * ″3 * ″ 1" is placed on the model to transfer the load. Simultaneously the displacement cell and digital data reader setup is made to note the settlement and then the load is applied. At the beginning 40.00kg load is applied and the settlement is recorded, when the rate of settlement is less than 0.002mm/minute. Further the

loading of 80.00kg, 160kg, 280kg, 360kg, 450kg & 530.kg are checked respectively.

4. EXPERIMENTAL RESULTS



4.1 Evaluation

Equipments Used: Displacement cell with capacity of ± 20mm is used to measure the settlement. Metal loading frame with lever arm of length 0.56m. A metal fabricated box,weighing machine, shovel tray, digital data reader with least count 0.001, weights ,12.125kg rammer .

4.1.1 Experimental Investigation.

In this project, use of geogrid material in between the soil layers acts as reinforcing material to the foundation model. The foundation model is prepared of square size (square footing also) without using geogrid material and using geogrid material. Load is applied and settlement is noted.

4.1.2 Preparation of Foundation Bed

Soil which is free from lumps is taken for one set of reading consisting of same kg of soil in each layer. It is mixed homogenously with the calculated amount of water on the basis of OMC. Soil is spread in the box and compacted with the rammer from the height of 15-20 cm to get maximum density and the next layer is spread and the same procedure is continued till the required height is achieved. A square wooden footing of was used for conducting the load test on prepared soil bed without geogrid. The foundation bed is tested in loading frame under constant loading condition. A load cell and digital data reader each were employed for measuring the load and settlement respectively. Similar type of bed is prepared by using two different types of geogrids, placed horizontally at different depths of 0.5B, 1B, 1.5B, 2B, 3B.

(B= width of footing).

4.1.3 Testing of Foundation Bed:

Prepared model is placed below the loading frame and wooden footing is placed on the model to transfer the load. Simultaneously the displacement cell and digital data reader setup is made using proving ring to note the settlement and then the load is applied. At the beginning a load is applied and the settlement is recorded. Without using geogrid material, using 2″ aperture geogrid (Coated yarn). The main aim is to reduce settlement problem by using geogrid is carried out and the results of this method is measured and tabulated.

4.2 Expected Results

Table 4 shows the settlement at different loadings using geogrid and without geogrid.

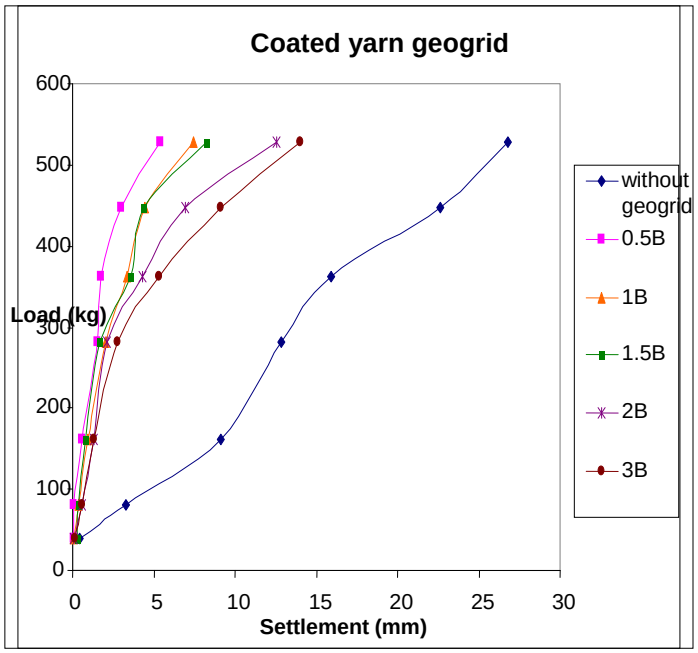
Table4: without geogrid

LOAD KG	SETTLEMENT IN MM
40.00	0.399
80.00	3.125
160.00	8.9
280.00	12.835
360.00	13.9
450.00	23.3
530.00	27.02

Table 5 Shows the settlement at different loadings using with Coated yarn geogrid at different depths

Table5: with geogrid

Load kg	Settlement in mm				
	0.5B	1B	1.5B	2B	3B
40	0.0	0.04	0.28	0.102	0.135
80	0.0612	0.42	0.395	0.605	0.662
160	0.493	0.922	0.431	2.150	2.009
280	1.664	2.112	2.005	1.992	3.642
360	1.882	3.401	3.445	4.031	6.715
450	3.188	4.511	4.008	5.990	8.983
530	5.451	8.110	8.806	13.461	13.902



Graph 2 Graph showing the variation of Load with Settlement comparison.

5. SCOPE OF THE WORK

1. Beneath or within aggregate in unpaved roads.
2. Beneath or within ballast in rail road, railways, airfields construction.
3. Beneath or within surcharge fills or temporary construction sites.
4. As mechanically stabilized earth for a variety of walls:as embankments, retaining structures, reservoirs, dams, canals.
5. Repairing slope failure and land slide,bank protection.
6. As lateral confinement to stone for constructing stone column.
7. As inserts between geotextiles and geomembranes.
8. To reinforce landfill to allow for vertical and lateral expansion.
9. As three-dimensional mattresses for land bearing capacity.

6. CONCLUSIONS

After carrying the tests, the following conclusions are observed. It was observed that there is considerable reduction in the settlement using geogrid. This coated yarn biaxial geogrid is very effective. At lower loading use of geogrid at 1B depth is more effective; at higher loading use of geogrid at 0.5B depth is more effective. Thus, boundary forces, earthquake resistance and gravity forces can also minimized by this layer system.

FUTURE ENHANCEMENT

Any type of soil can be used for results instead of black cotton and CBR can be studied using googrid. For combined footing also tested. Circular or rectangular footing may be studied. Another type of geosynthetics can be used for expecting results at that particular situation. Geoocomposites i.e. combination of geogrid and geotextile can be applied. This study can be applied to sloped footing also. Instead of this , plate load test can be studied using any type of geogrids.

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