Effect of Geo Grid Reinforcement on Pavement Sub Grade

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Abstract—A pavement structure consists of a number of layers for the purpose of transmitting and distributing traffic loads to the sub-grade. Rutting is one form of pavement distresses that may influence the performance of road pavements. Soft sub-grade soils are distinguished by their low un-drained shear strength and high compressibility. Thus, such type of sub grade is required to improve by either replacing the existing soil, which is not a practical and feasible option, thus it is required to stabilize the soil and improve its strength. Nowadays reinforcement has been provided to get the desirable strength of sub grade. This dissertation work deals geo-grid reinforcement which are nothing but planar, polymeric (synthetic or natural) materials used in contact with soil/rock and/or any other geotechnical material, for Filtration, drainage, Separation, Reinforcement, Protection, Sealing and Packing. This work describes the useful effects of reinforcing the sub-grade layer with one layer of geo-grid at completely different positions and thereby determination of optimum position of reinforcement layer. The optimum position determined depend on CBR value test was conducted to determine the optimum position of geo-grid. The CBR of a soil increases by 50-100% when it is reinforced with a single layer of geo-grid. The amount of improvement depends upon the type of soil and position of geo-grid. CBR of sub-grade soil is 6.53% without reinforcement and when geo-grid was placed at 0.2H from the top, The CBR value increased to 19.66%. Soaked Condition CBR of sub-grade soil is 4.77% without reinforcement and when geo-grid was placed at 0.2H from the top, The CBR value increased to 4.46%.

Key words: Geo-grid, California Bearing Ratio (CBR), Maximum Dry Density (MDD), Optimum Moisture Content (OMC), Sub-grade soil

I. INTRODUCTION

In pavements, sub-grade is native material beneath created road, pavement or railway track. It additionally referred to as formation level. Sub-grade is usually compacted before the development of a road, pavement or railway track.

The sub-grade should be ready to support load transmitted from the pavement structure. This load

Bearing capacity is usually affected by degree of compaction, moisture content, and soil type.(Dr.Vijay Kumar, Ms P.Lavnya Rekha,2016) A sub-grade that may support a high quantity of loading while not excessive deformation is taken into account sensible. these days Engineers face the issues throughout construction with soil, that don't posses decent strength to support the masses obligatory upon them either throughout construction or throughout the services of life of the structure. Many areas in India consist of soils with high silt content, low strength and minimum bearing capacity. These poor soil performance characteristics are generally attributed to the nature and quantity of the fines present in the material. The engineering performance of such soils is very poor and has forced engineers to stabilize these poor quality soils. Stabilization of soils is the best method for improving the properties of soil. The objectives of any stabilization techniques are to increase the strength and stiffness of the soil. There are various methods that could be used to improve the performance of poor quality soils. The choice of a selected technique depends principally on the sort of soil to be improved; its characteristics, the sort and degree of improvement desired in a very specific application and financial considerations.

For any construction work, like building works, road works etc, type of soil and its condition plays a very vital role as it is one of the important foundation materials. For any road construction work, minimum value of California Bearing Ratio (CBR) of the soil must be more than 3 %. In many areas of the subcontinent like India, the sub grade soil having more than 3% California Bearing Ratio (CBR) is not available. For such areas, either we need to borrow sub grade soil from some other areas or alternatively, soil strength needs to be improved by various soil stabilizing methods. Soil stabilization may be a procedure wherever natural or synthesized additives are accustomed improves the properties of soil. Within the past, several analysers have carried out their research work for raising the strength of sub grade soil using different additives/stabilizing materials. The present dissertation work deals with the reinforcement of soil using Geo-grids.

A. Geo-grid:

Geo-grids represent a little however speedily growing phase of the geo-synthetics space. It works in two ways: reinforcement and separation which are the techniques of humanizing soil having expansive in nature with geo-grid, to increase the stiffness and load carrying capacity of the soil through frictional interaction between the soil and geo-grid material.

B. Soil Reinforcement:

To allow reinforcement to the soil there are 3 strategies. 1st is by physical technique that is completed by vibration, thermo-electrical solidify and thaw. Second is by mechanical technique exploitation fibrous materials from Geo-synthetic family (Geo-grid, Geo-textile, Geo-composite, Geo-net, and Geo-cell). The third is by chemical technique exploitation standard materials, enzymes & chemical compound resins. Reinforcing soil may be a terribly recent and effective technique.

C. Properties of black cotton soil

Black cotton (BC) soils are extremely clayey soils, grayish to blackish in color, meet a good space of 30,000 sq. metric linear units across many states of India i.e. in MP, Maharashtra, Karnataka, Andhra Pradesh, and Tamil Nadu and UP. The BC soils contain clay mineral montmorillonite
clay mineral that has high expansive characteristics. The liquid limit and malleability index values ranges from forty to 100 percent and 20 to 60 severally. BC soils have a low shrinkage limit between 10 to 15 and high OMC of 25 to half-hour. Of these properties render the soil to be sensitive to wetness changes, extremely compressible and plastic in nature. The strength of the soil terribly is extremely incredibly low and contains a very low bearing capability.

D. Problem summary
From the stabilization purpose of view, the following are the most issues encountered within the case of BC soil:

- It is very difficult to pulverize the soil because the dry lumps are difficult to break as a result of high, dry strength and therefore the wet soil is simply too sticky and unmanageable.
- There is excessive variation in volume and stability with variation in water content.
- They undergo considerable shrinkage on drying, leading to the formation of intensive cracks. BC soil compacted at OMC jointly shrinks once dried because the shrinkage limit is way below the OMC.
- The BC soil exerts high swelling pressure on being soaked.

The BC soils are terribly poor and undependable sub-grade material. Typical behavior of those soils beneath completely different climate has created the development and maintenance of roads not solely expansive, however conjointly troublesome. The pavements created in BC soils areas are found to suffer from early failures. In versatile pavement with serious traffic, excessive unevenness, ruts, waves and corrugations are shaped virtually once each monsoon season, leading to serious value of maintenance once a year. These properties of BC soil create its stabilization obligatory before it will be used for any construction work. An effort has been created during this study to stabilize the BC soil by using geo-grids.

E. Functions of Geo-grids in Civil Engineering and Construction Works
- Reinforcement of sub-grade soil.
- Basal reinforcement to support the soil reinforced structure.
- To avoid mixing and reducing mechanical performance geo-grid provides Separation between the in-situ soil and the imported soil.
- Filtration behind all hydraulic structures.
- For collecting seepage water coming from the outer side of embankment to avoid contamination of structural fill geo-grid provides control of drainage at top 8 m.
- Geo-grid work as erosion control blanket to protect the slope at the top.

II. LITERATURE REVIEW
A.K. Choudhary et.al (2011) placed multiple layers of reinforcement specifically geo-grid and jute geo-textile among the sub-grade. He found that the enlargement quantitative relation decreases once the soil is bolstered with single layer and goes on decreasing with a rise in variety of reinforcing layer, however this decrease is critical just in case of jute Geo-textile and marginal within the case of Geo-grid which implies the insertion of reinforcement controls swelling of the soil. The American state Bearing quantitative relation worth of the soil conjointly will increase with increase in variety of reinforcing layers. It’s found that geo-grid provide higher reinforcing potency than jute geo-textile however it is gainfully exploited in low value road project.

Chander Bhal Roy (2015) analyzed the report for the stabilization of soil of Indian origin. Scrap tyres square measure being created associated accumulated in large volumes inflicting an increasing threat to the atmosphere. In order to eliminate the negative impact of these depositions and in terms of property development there is nice interest among the usage of these nonhazardous wastes. The potential of exploitation rubber from worn tyres in many technology works square measure studied for over twenty years, Tyre wastes is employed light-weight weight material either among the shape of powder, chips, sliced and as a complete. Applications of tyre rubber tried to be effective in protecting the atmosphere and protecting natural resources. They’re used beyond and below water. The utilize application for tyre is but the tyre square measure method primarily fenced shredding, removing of metal reinforcing and extra shredding until the required materials square measure achieved a automotive tyre contains some twenty sixth atomic number 6. Forty seventh natural rubber, unit of time of caoutchouc, Bharat is fabricating one a hundred thousand MT of recycle rubber that’s sold-out @ Rs seventy per metric weight unit.

D.S.V. Prasad et.al (2010) ready a model of versatile pavement consisting of expansive soil sub-grade of zero.5m inside compacted in ten layers and gravel sub-base ordered in 2 layers, each of 0.07m compacted thickness employing a layer of various reinforcing material like Geo-grid, hydrocarbon coated chicken mesh, hydrocarbon coated bamboo mesh for reinforcement with waste plastic and waste tire rubber was mixed uniformly throughout. The sub-base material on that 2 layers of WBM-II evry of zero.075m compacted thickness was ordered. to search out the most effective various reinforcement in versatile pavement, the cyclic plate load check was administered. it absolutely was found that the entire and elastic deformation values of the versatile pavement system square measure faded by the availability of providing totally different reinforcing material, the most load carrying capability followed by less worth of rebound deflection obtained for geo-grid reinforcement is over the other reinforcement provided. The work of the author basically is concerning the usage of geo-grid beside different reinforcing parts like chicken mesh, bamboo mesh and waste plastic. The results, therefore obtained don’t seem to be giving a transparent image concerning that reinforcing parts contributed towards the advance in strength of the sub-base.

III. SOIL AND ITS REINFORCEMENT: GEO-GRID
A. Sub Grade Soil:
The sub grade soil used was obtained from Govindpura, Bhopal. The soil sample was collected after removing the top soil by 200 mm depth. The soil was air dried, pulverized and sieved with 4.75 mm Indian Standard as for the requirement of the various laboratory test.
B. Reinforcement Material

1) GEO GRIDS

Geo-grids are planar, polymeric structures consisting of a regular open network of integrally connected tensile elements, which may be linked by bonding or interlacing, openings of which are larger than the constituents. In civil engineering applications geo-grids are used in contact with soil or rock and/or any other geotechnical material. These openings are called as apertures, which allow sand particle to come in to direct contact on either side of the mounted geo-grid which increases the interaction between the geo-grid and sand increasing the tensile strength of sand fill. Features of the geo-grid vary in polymer type and cross-sectional proportions. When the soil strains in response to applied loads, tensile forces are generated in the geogrid because of the frictional interaction between the geo-grid and the soil. The tensile forces developed in the reinforcement keeps the reinforced soil mass in stable equilibrium. The mechanism of Bi-axial geo-grid is shown in figure below.

![Biaxial geo grid](image)

Fig. 3.3: Biaxial geo grid

IV. METHODOLOGY

A. Introduction

Soil can be defined as the upper layer of the earth consisting of air, water and solid particles is generally produced by disintegration of rocks. Abundantly available soil is the cheapest construction material in most of the regions of the world. The properties of the soil vary from point to point and place to place. Cohesive soil causes great engineering problems due to its poor strength, high compressibility and low permeability. It covers large and extensively located areas of India and also many parts of the world. Silty soil extends in massive stretches and construction of pavements and different structures on such type of soils is a problem. To set right these issues it is substantially necessary to treat these soils. There area unit such a big amount of methods for the treatment of those soils. Some of them are very costly and some are very tedious.

B. Atterberg Limits (IS:2720(PART 5)-1985)

The Atterberg limits are basic amount of the acute water content of the fine-grained soil, such as plastic limit and liquid limit. As a dry, clayey soil takes on increase amounts of water, it undertake affect and distinct variation in behavior and consistency. Depending on the water content of the soil, it may come into in four states:

C. Heavy Compaction Test (IS: 2720 (PART 7)-1980)

Compaction is that the most typical and necessary technique of soil improvement, within the construction of engineering structures like highway embankments or earth dams, for example loose fill are required to be compacted to extend the soil density and improve their strength characteristics. Compaction typically results in a rise in shear strength and helps improve the stability and bearing capacity of soil. It conjointly reduces compressibility and permeability of the soil.

1) Importance of compaction test

Compaction is a important method of building if performed improperly, settlement of the soil might occur and result in excess maintenance prices or structure failure.

- The principal reason for compacting soil is to reduce resulting settlement below operating hundreds.
- Compaction will increase the shear strength of the soil.
- Compaction reduces the voids magnitude relation creating it harder for water to flow through soil. this can be vital if the soil is getting used to retain water like would be needed for associate earth dam.
- Compaction will stop the build from massive water pressures that cause soil to liquefy throughout earthquakes.

D. California Bearing Ratio Test:-

California Bearing Ratio (CBR) test was developed by the California Division of Highway as a method of classifying and evaluating soil-sub grade and base course materials for flexible pavements. Standard test equipment and procedure as per IS: 2720 (part 16).1979, (Laboratory determination of California Bearing Ratio) was used in the present work to perform the CBR test. The CBR test were conducted on soil and RBI mixture in which both these material were mixed in the proportion of 100:00, 98:02, 96:04, 94:06 and 92:08 respectively. For example, to prepare a sample of 6 kg for CBR testing with 2% RBI, 5880 gm dry soil and 120 gm RBI were mixed and OMC+1% water content was added into it. The mould was then cured for 0 days, 10 days and 24 days and soaked for 4 days. After soaking this specimen was tested in CBR testing machine. A graph is then plotted between load and penetration. The value corresponding to 2.5 mm and 5 mm penetration (which is higher) is divided by standard value and that is the CBR Value in percentage.

V. RESULTS

A. Atterberg limit

<table>
<thead>
<tr>
<th>Test Type</th>
<th>Liquid Limit</th>
<th>Plastic Limit</th>
<th>OMC</th>
<th>MDD</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNSOAKED</td>
<td>42.35</td>
<td>19.01</td>
<td>20.13</td>
<td>1.75</td>
</tr>
<tr>
<td>SOAKED</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5.1: Atterberg limit and OMC & MDD

B. CBR Value Unsoaking and Soaking Condition

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Position of geo-grid from top of specimen</th>
<th>UNSOAKED CBR</th>
<th>SOAKED CBR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No geo-grid</td>
<td>6.53</td>
<td>4.77</td>
</tr>
<tr>
<td>2</td>
<td>0.2H</td>
<td>19.66</td>
<td>13.13</td>
</tr>
<tr>
<td>3</td>
<td>0.4H</td>
<td>16.64</td>
<td>8.93</td>
</tr>
<tr>
<td>4</td>
<td>0.6H</td>
<td>11.34</td>
<td>5.95</td>
</tr>
<tr>
<td>5</td>
<td>0.8H</td>
<td>8.97</td>
<td>4.46</td>
</tr>
</tbody>
</table>

Table 5.2: CBR Value Unsoaking and Soaking Condition
VI. CONCLUSION AND RECOMMENDATION

A. Conclusions

Based on the results of this study the following conclusions may be drawn:

1) The strength has been compared on the basis of CBR for virgin and geogrid reinforced soil under unsoaked and soaked conditions.

Results are mentioned in below table

<table>
<thead>
<tr>
<th>Presence of Reinforcement</th>
<th>Unsoaked CBR</th>
<th>Soaked CBR</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Reinforcement</td>
<td>6.53</td>
<td>4.77</td>
</tr>
<tr>
<td>Reinforced with Geo-grid at optimum position</td>
<td>19.66</td>
<td>13.13</td>
</tr>
</tbody>
</table>

Table 6.1: Improvement of CBR with geo-grid reinforcement

The result implies that when sub-grade is reinforced with geo-grid it’s CBR increases as for virgin soil CBR is 6.53 and it increases to 19.66 with geo-grid under unsoaked condition.

For soaked condition CBR of geo-grid as 13.33 which is higher than virgin soil CBR of 4.77 under soaked condition.

In this project soil sample of Govindpura Bhopal has been tested for following test shown in table below

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Liquid Limit Test</th>
<th>Plastic Limit</th>
<th>OMC</th>
<th>MDD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td>42.35</td>
<td>19.01</td>
<td>20.13</td>
<td>1.75</td>
</tr>
</tbody>
</table>

Table 6.2: Atterberg limits & compaction test

Interfacing soil with geo-grid material at various positions , increases the penetration resistance and hence CBR strength in both unsoaked and soaked condition while comparing the thickness (position of geo-grid) following results has been observed:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Position of geo-grid from top of specimen</th>
<th>UNSOAKED CBR</th>
<th>SOAKED CBR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No geo-grid</td>
<td>6.53</td>
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<td>4.46</td>
</tr>
</tbody>
</table>

Table 6.3: CBR value for soaked and unsoaked soil sample

From above table it has been proved that strength is maximum at 0.2 H for both soaked and unsoaked conditions.

B. Recommendations

Geo-grids have a good potential to reduce the cost of pavement layers if weak sub-grade are encountered on the alignment. On low volume paved roads, designers should consider the installation of geo-grid to improve the California Bearing Ratio,

Reduce layer thickness and increase structural number of pavement.

REFERENCES


