Expansive Subgrade Strength Improvement using Geogrid and Geotextile Layers

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Abstract: Clay is fine grained soil, which is plastic due to its cohesive nature at relative moisture content. Clay soils exhibits alternate swell and shrink in variation with moisture content and possess low CBR value. In this study, stabilization of subgrade has been done by the introducing geosynthetics as layers. Non-woven geotextiles and geogrids layers are the geosynthetics used. Engineering properties such as shear strength and CBR value and index properties such as Atterberg limits and grain size distribution of the clay specimen are evaluated. CBR Test value obtained for control sample is 3.54 %, when the geogrid were placed at top & middle, CBR Values had been increased 4 % and 5.56 % respectively. The performance of Geogrid is increased when it placed together with geotextile as combined layer. CBR test conducted over the combined layers positioned at top and middle give the value 6.31 % and 6.9 % respectively.

Keywords: Clay soil, Geotextile, Woven, Non Woven, Geogrid, CBR test, Plasticity.

1. Introduction

Transportation improvements are essential for a growing country like India in order to extend their financial growth. In the roadways construction, naturally occurring soil will perform as a foundation for the pavement. Sometimes, soil filling also required to constructing the subgrade to meet the vertical alignment. When the Expansive soils are used as a filling material to prepare Subgrade, it becomes critical, since it possess poor strength, less CBR value and swelling behavior [1,2,3,4]. Using the ground improvement techniques these problem can be rectified. There are certain ways available such as Mechanical modification, Chemical admixture, Hydraulic modification and Reinforcement. Soil becomes more stable against the loading condition by improving their shear strength[5,6]. With increase in soil stabilization properties, the bearing capacity of the soil increases. They are flaky particles with flocculent structure. In case of clay as a subgrade, one would prefer a replacement of subgrade. This method is possible for small areas but in the case of lengthy pavements, it is not possible. A Properly stabilized Subgrade can give long term performance, so that the design life of flexible pavement is increased. One of the methods, adopted these days in order to stabilize the sub
grade soil, is Reinforcement technique using Geosynthetics [1-6]. Geotextiles and Geogrids are forms of geosynthetics. Geotextiles may be made of natural fibres or synthetics. In recent years, a newer material known as geotextiles is usually made from a synthetic polymer such as polypropylene, polyester, polyethylene, and polyamide. Geotextiles are classified into further types such as woven and non-woven geotextiles. These geosynthetics function as reinforcement to the soil. In addition they also possess functions such as separation, filtration, drainage, sealing etc.

Due to the tensile resisting capacity of the geosynthetics materials, they will improve the friction angle of the soil and takes the tensile load.

2. Materials Used

2.1. Soil
The clay soil samples were taken from a depth of 1.2 m at Kuppanur, Coimbatore. In that location, 3 different points were identified with 5m spacing and the samples were collected. Then finally the samples are mixed well for the experiment.

2.2. Geosynthetic Materials

2.2.1. Geogrid
Geogrids are manufactured using polymers as the strips perpendicularly crossing each other as shown in figure 1. They are attached at the intersections. Commonly made of polymer materials, the major function of the geogrid is in the area of reinforcement to resist the tensile force. Other specifications are as provided by the manufacturer.

2.2.2. Geotextile (Non-woven)
The non-woven geotextiles are permeable fabrics made by the thermal or chemical bonding of continuous fibres and then pressed through rollers into relatively thin sheets. Woven and non-woven geotextile differ by their filtration property. 300 GSM thickness materials is used in this experiment. Other specifications are as provided by the manufacturer.

3. Experimental Investigation

3.1. Soil Properties
Basic physical properties are identified for the control sample as per IS 2720 standards as follows in table 1. [7]
Table 1 Properties of Soil Sample

| Particulars            | Value |
|------------------------|-------|
| Moisture Content (%)   | 7.14  |
| Specific Gravity       | 2.6   |
| Liquid Limit (%)       | 39    |
| Plastic Limit (%)      | 20    |
| Plasticity Index (%)   | 19    |
| BIS Classification     | Cl    |

3.2. Compaction Test

As per IS: 2720 (Part 8) 1983 the Standard Proctor test under light compaction was carried out to determine the maximum dry density (MDD) and optimum moisture content (OMC) of the control sample. The Maximum Dry Density of soil is 1.69g/cm$^3$ with corresponding Optimum Moisture Content value of 18% respectively. [8]

3.3. Unconfined Compression Test

As per IS: 2720 (Part 10) the Unconfined Compression Test conducted on the sample compacted with the optimum moisture content. The compressive stress acting on the soil sample and its corresponding axial strain is measured using proving ring and dial gauge. It is found that the sample possess the compressive strength of 120 kpa at 8% strain.
3.4. CBR Test

Laboratory CBR as per guidelines of IS-2720 (Part-16) was conducted on unreinforced sample and on the geotextile and geogrid layers placed soil. CBR test on soils were done by compacting the sample in three equal layers by giving 56 numbers of blows using 2.6 kg rammer maintaining the height of fall as 310 mm with Optimum Moisture Content in the soil as found by standard compaction test to achieve the required density. Standard compaction energy has imparted over the three layers evenly. [9]

![CBR Curve](image)

CBR Test performed on the unreinforced soil sample as per the guidelines gave the CBR Value as 3.54 % at 2.5 mm penetration for the respective stress applied 2.5 kg/cm² as shown in figure.5

For making reinforced soil specimens, the geotextile and geogrid was trimmed in the form of a cylindrical disk of diameter fit to the diameter of CBR mould. The Geosynthetics were placed in four different combinations as
1. Geogrid at Top,
2. Geogrid at Middle,
3. Geotextile and Geogrid combined placement at Top and
4. Geogrid and Geotextile combined placement at middle

Placing the Geosynthetics at the middle, refer that it is positioned at a height of H/2 from top of the sample as marked; H refers the height of the sample in CBR mould. The soil blended with OMC was filled in the mould. Weight of the sample was calculated for the desired density in order to prepare the compacted layer upto the mark. Weight of the sample was calculated for the desired density in order to prepare the compacted layer upto the mark. Then using the light weight hammer compaction was done to achieve desired dry density. So it can be easily achieved that top of the compacted soil layer merging the marked level (H/2). Reinforcing layer was placed at the marked level and the remaining soil can be filled over the reinforcement. Further Compaction process continued to achieve the density. [8][9]

4. Results and Discussion

| Soil | Material used | Position of Geosynthetics | CBR value (%) |
|------|---------------|---------------------------|---------------|
| Clay | -             | -                         | 3.54          |
|      | Geogrid       | Top                       | 4.01          |
|      |               | Middle                    | 5.56          |
|      | Combination of| Top                       | 6.31          |
Table 2 shows, CBR test results on unreinforced and reinforced soil with geotextile and geogrid. CBR Value of the specimen increased from 3.54% to 4.01% by placing the Geogrid at the top, from 3.54% to 5.54% by placing the Geogrid at the middle, from 3.54% to 6.31% by the placement of combination of Geotextile and Geogrid at the top and from 3.54% to 6.90% by the placement of combination of Geotextile and Geogrid at the middle.

4. Conclusion

The natural clay is tested for its Index and Engineering properties. UCC test is conducted to find its shear strength parameters of the virgin soil. CBR test is conducted to find its load bearing capacity. It is found that clay sample taken for this study gives lower CBR value. In the further study, CBR value of geogrid and geotextile combined placement at middle proves to be higher than geogrid at middle and geogrid at top configuration. The maximum CBR value attains at the middle position. Geotextile and Geogrid when placed together show better improvement of the strength than the placement of Geogrid alone. It is determined that combined action of geogrid and geotextile layers is highly preferable for improving the strength of weak subgrade soil.

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