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# Strength Characterization of Lateritic Soil with Geogrid Inclusion

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***Abstract:-*** **Soil reinforcement is one of the most popular ground improvement techniques. One of the method i.e., Geogrid reinforcement is gaining acceptance as an effective way of improving on the properties of naturally occurring soils for foundations and pavements. Geogrid is defined as the fabric material placed to enhance water movement and retard soil movement also as a blanket to add additional support to the reinforcement and it fixed in between the soil and pipes, gabion or retaining wall. A geogrid should consist of a stable network that retains its relative structure during handling, placement, and long-term service. A study is made to determine the strength and bearing capacity of the layered soil by the application of geogrid in different layers. Structures constructed on the weak soil fail due to insufficient bearing capacity and excessive settlement of the underlying soil. Supporting strength of soil or rock is called as its bearing capacity.**

***Keywords:*** **Bearing capacity, Geosynthetics, Geogrid, Settlement, Lateritic soil, Reinforced soil.**

## I. INTRODUCTION

Transportation by road is the most important facility in moving men and material. It contributes to the economic, industrial, social and cultural development of a region or state of nation. It helps primarily in linking production and consumption centers. As a result, raw and finished goods are utilized in far away places from their centers of production. By moving people across the country, transportation brings about national integration and an understanding of different cultures. Most suitable for short haul passenger and freight movement in the highway transport. It is most suitable for bulk commodity transportation. The growth of the population has created a need for better and economical vehicular operation which requires good highway having proper geometric design, pavement condition and maintenance.

When subjected to vertical loads, a reinforced soil mass typically exhibits higher load carrying capacity than the soil mass without reinforcement at maximum dry density (MDD) and Optimum Moisture Content (OMC) of soil. The general objective of this project work is to study the effect of geogrid on various engineering properties of soil. The local laterite soil and one type of geogrid was selected for this study.

The main aim is to reduce load bearing problem by reinforcing the soil using coated yarn geogrid. Thus by applying geogrid soil reinforcement (coated yarn type) in layers, more strengthening is carried out. Thus this is a ground improvement technique for locally available problematic soil.

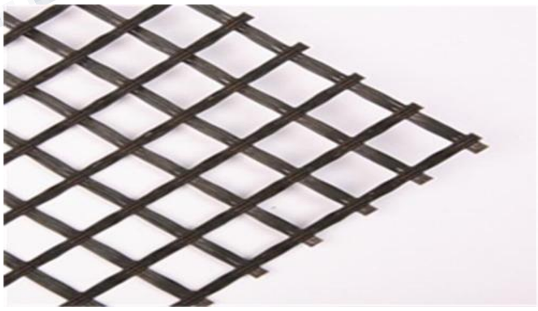

*Fig 1: Coated Yarn Geogrid*

## II. MECHANISM OF THE GEOGRID REINFORCEMENT

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. The soil particles move into the apertures and are interlocked when the size of group of particles are greater

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than the aperture size which does not allow the further movement of soil laterally. This lateral confinement to the soil allows the soil to take up heavier loads without any further settlement of soil.

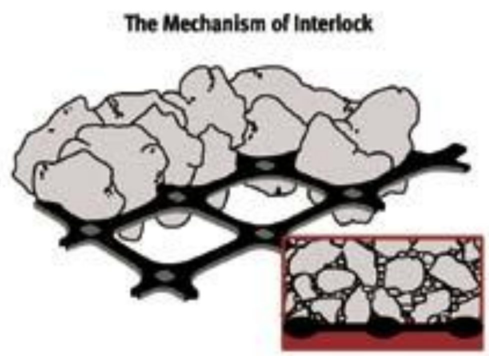


*Fig 2: Mechanism of Geogrid Reinforcement*

## III.APPLICATION OF GEOGRIDREINFORCEMENT

Geogrids are widely used for the reinforcement of soft soil. There are bundle of areas where geogrids are applied successfully. These are widely being used for reducing the settlement, enhancing the bearing capacity and shear strength of soft soil under the different types of civil engineering structures. Geogrids have been now used for different structures like embankments, foundations, retaining walls, and also for slope stability. The review on the application of the geogrid reinforcement is presented in the following sections.

### *a Embankment*

The soft soil often poses design, construction and maintenance hazards to civil engineering structures founded on them. Construction of embankment over soft soil or weak soil is very difficult work. Some soils are so weak that they can't take the load of construction equipments. Problems may arise during the construction stage due to the inability of the soft soil to provide adequate support to the construction equipments. Post construction, the excessive settlement and insufficient bearing capacity of the soft subgrade may lead to loss of stability of the overlying structures. Rotational slip failure of embankments, crackingand differential settlement of soil under embankments are some of the failures associated with construction of structures on soft soils.

In such condition generally upper layer of weak soil is removed and some strong soil is used. The depth of removal of weak soil depends upon the load coming on the soil and strength of the soil. This process governs the overall construction cost of embankment. Use of geogrids mattress over the soft soil can reduce the settlement and increase the load carrying capacity (Zhang et al. 2010). Geogrid act as rigid mattress and it distribute the applied load over larger area due to which pressure intensity on the soft soil decreases (Dash et al. 2007). Johnson (1982) reported the use of geogrid mattress at Greatham Creek Bridge, England. The mattress was placed under a 5 meter high embankment over soft silt which was 7 meter deep. The lateral strain reported was small and the vertical settlement was found to be reduced by 50%. The author attributed the reduction in settlement to the lateral restraint offered by the geogrid material that prevents the material from spreading and hence reduces the stresses coming onto the soft sub grade. Similar type of performance was found by Cowland and Wong 1993 for road in Hong Kong when Geogrid mattress was used under the embankment. Use of geogrid increases the stiffness of embankment and it can also reduce cost up to 30% (Bush et al. 1990).

*Fig3: Geogrid for Embankment*

### *b Retaining Wall*

Use of geogrid in the retaining wall is very popular now. In such retaining wall concrete panel is not required. Vegetation can also be grown in such reinforced wall. Geogrids are used to confine the soil which results in the increase of shearing strength and preventing the failure of the structure. So there are lot of applications of geogrids in reinforce wall. It has been seen that deformation settlement on both wall and backfill is increased with increasing the facing angle and surcharge. In facing type walls displacement and settlement is more as compare to the gravity type because of its light weight. While in gravity type two modes of failure often seen are failure due to sliding and failure due to overturning. So to avoid these circumstances reinforcement of retaining walls is required. Geogrid reinforced retaining walls are also performed better in case of earthquake loading. Due to geogrid reinforcement

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the deformation in such retaining wall can be suppressed effectively.

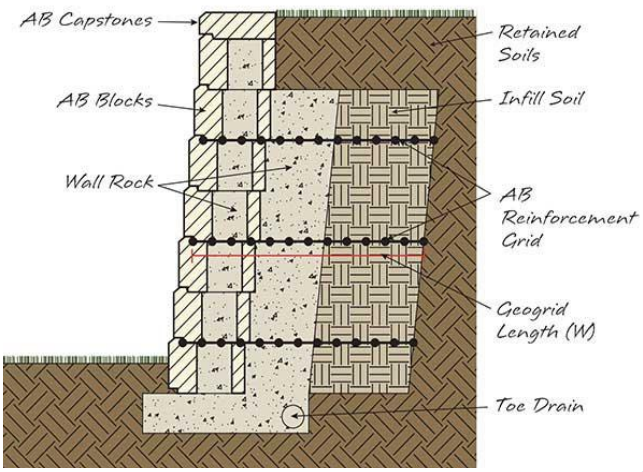


***Fig 4 Geogrid for Retaining Wall***

***c Slope Stability And Erosion Control***

Slope stability and erosion control are important for the condition when structure is situated near to flowing water. Conventionally use of vegetation is and effective way of slope stability and soil erosion. It helps to bind the soil particles as one but in some places like steep slopes and region of high intensity rainfall trees are not enough to prevent these two problems. So to overcome these problems geogrids are used to hold the soil particles as a unit.

Economical and Environmental concerns lead to the increasing use of geosynthetics materials for the purpose of reinforcement of soil to prevent soil erosion due to surface runoff. In most of the places soil erosion on slopes take place due to high intensity rainfall. Soil erosion takes place due to detachment of particles, and flowing of particles with surface runoff. So to prevent this cause geogrids are used, it assists to slow down the surface runoff and hold the soil particles in their cells. The geogrids are used to avoid the mass sliding of soil by providing the confinement to the soil.

***Fig 5: Geogrid for Slope Protection***

***d Pavement***

The unique lateral confinement of this material separates it from other geosynthetic reinforcing material, such as woven geotextile, geofoam, etc. The local soil or granular material show better structural properties when confined in geogrid with a proper manner. The incorporation of geogrid in pavement layers facilitates a better load distribution and reduction in vertical stresses underneath the pavement structure. The CBR increases and hence a significant thickness reduction is possible by using this lateral confinement technology in flexible pavements. There has been a lot of literature published to incorporate the reinforcing effect of geotextile and geogrids in paved and unpaved pavements. Geocell in various layers of flexible pavement is installed for better distribution of load by the traffic to prevent excessive deformation. The durability of pavement can be increased by laterally confining the soil which in turn counter acts against impact, wear and tear of the surface course.

***Fig 6: Geogrid for Pavement***

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## IV. METHODOLOGY

- 3 samples of laterite soil form the college campus are taken for the test.
  - Sample 1 – Behind the civil block.
  - Sample 2 – Besides the boys hostel.
  - Sample 3 – Behind the library block.

- The preliminary tests conducted are;
  - Water Content determination
  - Specific gravity
  - Grain size distribution
  - Liquid limit
  - Plastic Limit
  - Shrinkage Limit
  - I.S. Compaction

| TESTS | Sample 1 | Sample 2 | Sample 3 |
|---|---|---|---|
| Initial moisture content (%) | 2.63 | 2.04 | 1.96 |
| Plastic limit (%) | 30 | 26 | 26 |
| Liquid Limit (%) | 31.4 | 30.2 | 29.8 |
| Specific Gravity | 2.711 | 2.423 | 2.453 |
| MDD (gm/cc) | 2.3 | 1.95 | 1.925 |
| OMC (%) | 10 | 10.5 | 11.5 |
| Dry Density by sand replacement (gm/cc) | 1.6 | 1.8 | 1.7 |
| Classification of soil as per USC (ASTM-2487) | Poorly Graded Sand with Gravel | Poorly Graded Sand | Poorly Graded Sand with Gravel |

***Table 1: Preliminary Test Results***

- Foundation soil model is prepared in a mild steel box of nominal size 0.6m*0.6m*0.6m by compacting it in 3 layers with 50 blows per layer using a rammer of 11.5kg at optimum moisture content (OMC).

***Fig 7: Foundation Model***

### *4.1 Loading of soil*

- Prepared soil model is placed below the loading frame and wooden footing of size 12"*12"*1" is placed on the model to transfer the load to determine its Bearing capacity and Settlement without Geo-Grid.
- At the beginning 0.1 ton of load is applied and the settlement is recorded, when the rate of settlement is less than 0.002mm/minute. Further the loading of 0.2 ton, 0.4 ton, 0.6 ton and so on upto 3 tons is applied and settlement are checked respectively. Results are tabulated.
- Similar soil model is prepared by application of Geo-Grid at half the depth and load is applied. Results are tabulated and compared.
- Strengthening is carried out and it reveals that the application of Geo-Grid will improvise the Bearing capacity and reduce the Settlement of soil when compared to plane soil.

***Fig 8: Setting of LVDT***

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*Fig 9: Loading arrangement of Soil*

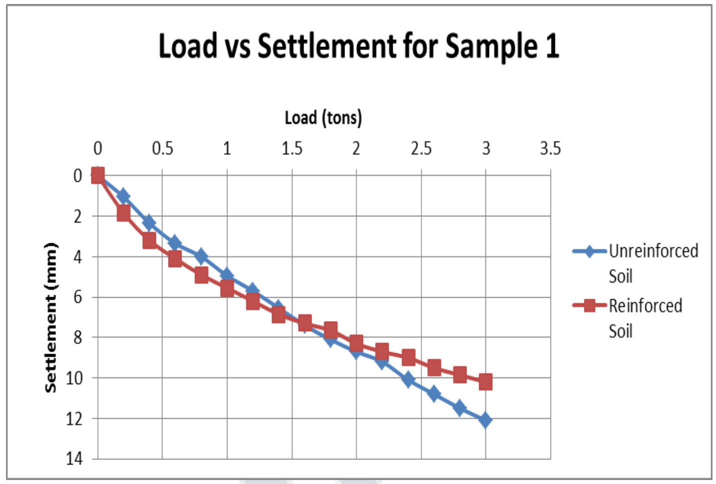


*Fig 10: Load vs Settlement Curve for Sample 1*

## V. LOADING RESULTS

The inclusion of Geogrid into the soil has to improve the bearing capacity of the soil. The increase in the bearing capacity of soil in this project is observed in terms of reduction in the soil settlement. The present project includes observations and discussions of the experiments carried out to examine.

- Improvement of bearing capacity
- Settlement reduction

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 settlement and then the load is applied.

### *5.1 Sample 1*

| Load (tons) | Unreinforced soil Settlement (mm) | Reinforced soil Settlement (mm) |
|---|---|---|
| 0 | 0 | 0 |
| 0.2 | 1.05 | 1.85 |
| 0.4 | 2.35 | 3.2 |
| 0.6 | 3.35 | 4.1 |
| 0.8 | 4 | 4.9 |
| 1 | 4.95 | 5.55 |
| 1.2 | 5.7 | 6.2 |
| 1.4 | 6.55 | 6.85 |
| 1.6 | 7.4 | 7.3 |
| 1.8 | 8.1 | 7.65 |
| 2 | 8.7 | 8.3 |
| 2.2 | 9.2 | 8.7 |
| 2.4 | 10.1 | 9 |
| 2.6 | 10.8 | 9.5 |
| 2.8 | 11.5 | 9.85 |
| 3 | 12.1 | 10.2 |

*Table 2: Load vs Settlement value of Sample 1*

### *5.2 Sample 2*

| Load (tons) | Unreinforced Soil Settlement (mm) | Reinforced Soil Settlement (mm) |
|---|---|---|
| 0 | 0 | 0 |
| 0.2 | 1 | 0.75 |
| 0.4 | 1.55 | 1.2 |
| 0.6 | 1.95 | 1.3 |
| 0.8 | 2.35 | 1.6 |
| 1 | 2.7 | 2.05 |
| 1.2 | 3.05 | 2.3 |
| 1.4 | 3.35 | 2.7 |
| 1.6 | 3.85 | 3 |
| 1.8 | 4.15 | 3.3 |
| 2 | 4.45 | 3.7 |
| 2.2 | 4.8 | 4.35 |
| 2.4 | 5.1 | 4.8 |
| 2.6 | 5.4 | 4.85 |
| 2.8 | 5.95 | 5.4 |
| 3 | 6.4 | 5.7 |

*Table 3: Load vs Settlement value of Sample 2*

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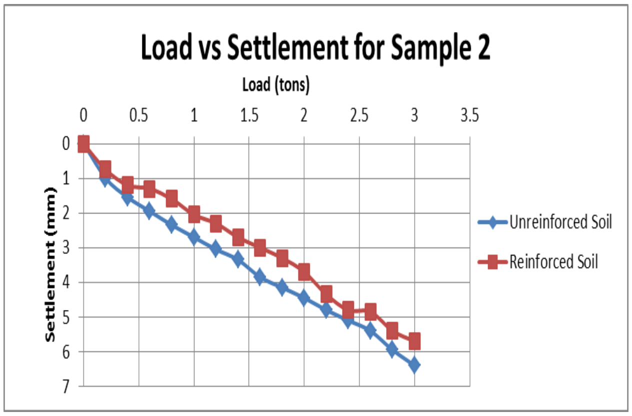


*Fig 11: Load vs Settlement Curve for Sample 2*

### *5.3 Sample 3*

| Load (tons) | Unreinforced Soil Settlement (mm) | Reinforced Soil Settlement (mm) |
|---|---|---|
| 0 | 0 | 0 |
| 0.2 | 0.5 | 0.75 |
| 0.4 | 1.15 | 1.25 |
| 0.6 | 1.55 | 1.65 |
| 0.8 | 2.15 | 2.1 |
| 1 | 2.7 | 2.35 |
| 1.2 | 3.15 | 2.8 |
| 1.4 | 3.6 | 3.15 |
| 1.6 | 4.15 | 3.55 |
| 1.8 | 4.9 | 4 |
| 2 | 5.4 | 4.3 |
| 2.2 | 6.05 | 4.7 |
| 2.4 | 6.75 | 5.05 |
| 2.6 | 7.6 | 5.55 |
| 2.8 | 8.5 | 6.2 |
| 3 | 9.15 | 6.55 |

*Table 4: Load vs Settlement value of Sample 3*

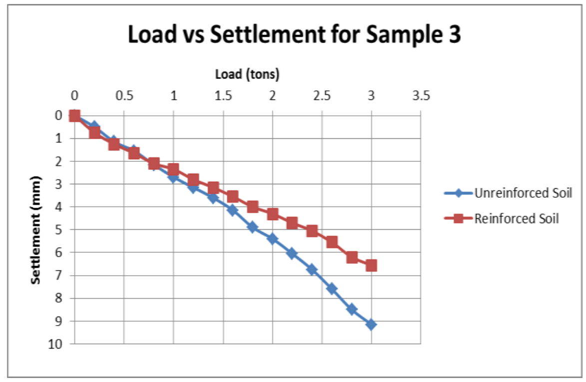


*Fig 12: Load vs Settlement Curve for Sample 3*

### *5.4 Result Comparison*

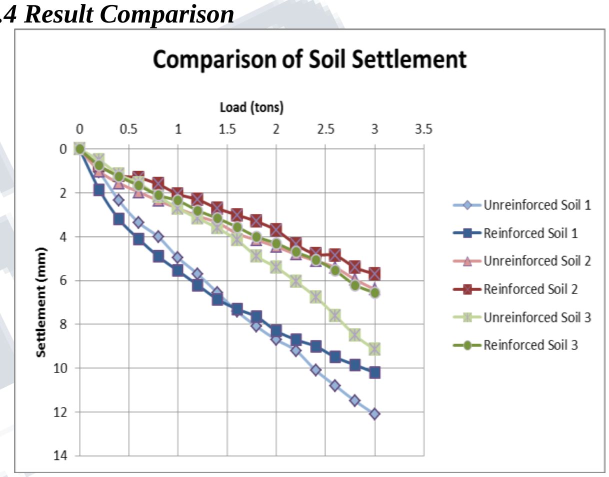


*Fig 13: Load Settlement Comparison Curve for all 3 Samples*

## VI. CONCLUSION

Use of the geo-grid reinforcement leads to better performance from the point of view of strength improvement as well as settlement reduction. The project work results suggest the possibility of developing a predictive model for strength improvement due to use of geo-grid reinforcement. As the density of the soil increases the load carrying capacity also increases. In order to get the effective utilization of geo-grid reinforcement, the soil should have higher density so that the stiffness between the soil and geo-grid reinforcement increases.

- It was observed that there is considerable reduction in the settlement using geogrid for all the 3 samples. This coated yarn biaxial geogrid is very effective.
- For sample 1 and sample 2 there is a reasonable reduction in the settlement, and sample 2 is having the least amount of settlement in both reinforced

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and unreinforced condition because of its natural strength.

- However, for sample 3 Geogrid has proven to be the most effective in decreasing the settlement.

## VII. FUTURE SCOPE

- The test can be carried out for different types of soil like shedi soil, black cotton soil etc in different areas.
- Settlement of Combined footing, Circular or rectangular footing and Sloped footing may also be studied.
- Different types of geosynthetics can be used for testing. Geo-composites i.e. combination of geogrid and geotextile can be applied.
- This work can be extended for reinforcing the soil by geogrid laid in different number of layers at different depths and settlement can be checked.
- To develop all weather resistant sub-base course for roads using newer material geogrids.

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