# Improvement In Bearing Capacity Of Soil Using Geogrid: A Review

**Nishant Kumar[1], Nishank Mishra[2], Mr. Divakar Singh[3]**
[1, 2] Dept of Civil Engineering
[3]Assistant Professor, Dept of Civil Engineering
[1, 2, 3] Bansal Instituite of Engineering and Technology,Lucknow,India

***Abstract***- *The enhancement of soil bearing capacity through geogrid reinforcement has emerged as a crucial aspect of geotechnical engineering, offering sustainable solutions to support the growing demands of infrastructure development. This review paper provides a comprehensive analysis of the myriad techniques and methodologies employed to improve soil stability and load-bearing capabilities using geogrids. Drawing from an extensive body of literature and case studies, it elucidates the effectiveness and versatility of geogrids across various geotechnical applications. Geogrids serve as a robust tool in increasing soil load-bearing capacity, mitigating issues such as settlement, enhancing slope stability, and bolstering resistance to lateral forces. Their application extends to diverse scenarios, encompassing road construction, embankment stabilization, and foundation support. Nonetheless, the successful utilization of geogrids necessitates careful consideration of factors like design, material selection, and installation techniques.*

***Keywords***- Geogrid reinforcement, Settlement, Bearing Capacity, Soil Stability.

## I. INTRODUCTION

Soil is a combination of four basic types such as gravel, sand, clay and silt. It generally has low tensile and shear strength. Its characteristics may depend on the environmental conditions. Reinforcement consists of incorporating certain materials with some desired properties within other materials which lack those properties. Thus soil reinforcement is used to improve the characteristics of soil such as compressibility, density, shear strength and hydraulic conductivity. So, the primary purpose of reinforcing soil is to increase its bearing capacity, to improve its stability, to reduce settlement, lateral deformation, rutting, etc. The reinforced soil behaves as a composite material in which fibers of high tensile strength or embedded in a matrix of soil. The reinforced soil is defined as the soil mass that contains randomly distributed, discrete elements.

## II. LITERATURE REVIEV

**Zornberg and Gupta et al. (2009)** studied the effect of geogrid reinforcement in mitigation of longitudinal cracks induced in pavements constructed over highly plastic, expansive clay subgrades. Three field evaluations are done on pavements constructed in the Forth Worth-Dallas area, Texas. It was found that geogrid reinforcement in FM 1915, Milam County, Texas significantly reduces the longitudinal cracks in the reinforced portion. In FM 542, Leon County it was observed that cracks are present outside the reinforced area and in FM 1774, Grimes County cracks developed even in the reinforced zone due to low junction efficiency of geogrid.

**Naeini and Moayed et al. (2009)** studied the effect of reinforcement and variation in plasticity index (PI) on CBR values. The soil sample used was collected from Khatoon Abad, Iran and was classified as clay of low plasticity (CL). The geogrid used was GS-50 made of low density polyethylene fibers having a weight of 300GSM with 2mm aperture size. It was found that the CBR values for both unsoaked and soaked specimens decreased with increase in plasticity index. It was also found that single layer reinforcement in unsoaked condition and double layer in soaked condition was more effective with improvement of 40% and 35% in CBR values respectively for soils having different plasticity index values.

**Hossein Moayedi et al. (2009)** provides geo-grid reinforcement into paved road to improve the performance of the transportation. He in his experimental work provides Geo-grid reinforcement at three different positions (i.e. at a distance of 0.5m, 0.25m and at 0.05 from the bottom of the model. He found that maximum shear stress and normal stress increases when the geo-grid is placed at a distance of 0.5m from the bottom. He also observed that the vertical deflection under the centre of the load reduces with the use of geo-grid just under the asphalt layer and hence concluded that the effectiveness of geogrid is more pronounced when it is placed at the bottom of the asphalt concrete improved if an effective bending is maintained between the asphalt concrete and geogrid. The author had used FEM model for AC pavement and did not show any analytical correlation for the obtained results. The Author has not validated results by testing it on sub-grade soil nor it has been experimentally verified using tests like California Bearing Ratio.

**Dr. D.S.V. Prasad et al. (2010)** prepared a model of flexible pavement consisting of expansive soil sub-grade of 0.5m at bottom compacted in 10 layers and gravel sub-base laid in two layers, each of 0.07m compacted thickness using a layer of different reinforcing material like Geo-grid, bitumen coated chicken mesh, bitumen coated bamboo mesh for reinforcement with waste plastic and waste tire rubber was mixed uniformly throughout. The sub-base material on which two layers of WBM-II each of 0.075m compacted thickness was laid. To find the best alternative reinforcement in flexible pavement, the cyclic plate load test was carried out. It was found that the total and elastic deformation values of the flexible pavement system are decreased by the provision of providing different reinforcing material. The maximum load carrying capacity followed by less value of rebound deflection obtained for geo-grid reinforcement is more than any other reinforcement provided. The work of the author essentially is about the usage of geo-grid along with other reinforcing elements like chicken mesh, bamboo mesh and waste plastic. The results, thus obtained are not giving a clear picture about which reinforcing elements contributed towards the improvement in strength of the sub-base.

**Azadegan and Pourebrahim et al. (2010)** studied the effect of geogrid reinforcement on UCS and elastic modulus of cement/lime treated soil. The soil sample was collected from Kerman, Iran. The geogrid used was made from polypropylene material. The amount of lime varies from 4.5 to 6.8% and cement varies from 4.5 to 5.6% by weight of dry soil. A single layer geogrid was placed at the centre of the sample. It was found that as the cement/lime ratio increases there is increase in compressive strength and modulus of elasticity of soil.

**Omid Azadegan and Gh. R. Pourebrahim et al. (2010)** studied the effect of geo-grids on compressive strength and Elastic Modulus of Lime/ Cement treated soil in order to find out the effect of geo-grid applications, on the geotechnical behavior of lime /cement treated soil used as base, sub-base or structural foundation materials. Study has been performed on compressive treated soil sample with or without geo-grid layers and found that when there is an increment in modulus of elasticity and the cohesion, produced by pozzolanic reaction of lime and cement, side deformation of the cylinder decreases and therefore the tension produced in reinforcement and the confinement.forces would decrease too. To have appropriate interaction the mix design should comprise enough ductility and side deformation for which, L/C ratio should be greater must be selected and total amount of applied cement must be lower than 5 percent. The author has used Unconfined Compression Test using cylindrical sample and observed that the deformation prior to the reinforcement of the geo-grid and did not correlate with California Bearing Ratio.

**A.K. Choudhary et al. (2011)** placed multiple layers of reinforcement namely geo-grid and jute geo-textile within the sub-grade. He found that the expansion ratio decreases when the soil is reinforced with single layer and goes on decreasing with an increase in number of reinforcing layer, but this decrease is significant in case of jute Geo-textile and marginal in the case of Geo-grid which means the insertion of reinforcement controls swelling of the soil. The California Bearing Ratio value of the soil also increases with increase in number of reinforcing layers. It is found that geo-grid offer better reinforcing efficiency than jute geo-textile but it can be gainfully exploited in low cost road project.

**Rakesh Kumar and P.K.Jain et al. (2013)** in their study of ground improvement techniques found that the construction of granular piles in expansive soil improves the load carrying capacity of the soil. They further made an attempt to investigate the improvement of load carrying of granular pile with and without geo-grid encasement through Laboratory model tests and found that the load carrying capacity of granular pile increases by casing the pile with geo-grid.

**Prof Mayura Yeole and Dr. J.R. Patil et al. (2013)** carried out a laboratory California Bearing Ratio test on granular soil with or without geo-textile which was placed in one or two layer in the mould. The single layer of geo-textile was placed at the depth of (25, 50, 100mm) from the top of the mould , the maximum California Bearing Ratio obtained was at 25mm and when the geo-textile was placed in two layers at { (25 &75 mm),(50 &75 mm), (50 &100 mm)} California Bearing Ratio was increased and it was maximum at 25 & 75mm geo-textile layer by 38.21% when compared with the California Bearing Ratio of no geo-textile.

**Adams et al. (2014)** studied the effect of triaxial geogrids on the CBR value of soil. The soil sample was taken from Kumasi, Ghana and was classified as sandy silt (SM) as per USC. Two different types of triaxial geogrids are used, namely TriAx Tx 130s and TriAx Tx 170 and both are placed at the layer 3 level. An increase of 11% and 12% was observed for soaked and unsoaked condition when TriAx Tx 130s was placed at layer 3 level, whereas this increase was 72% and 135% respectively for TriAx Tx 170. It was concluded that TriAx Tx 170 shows a much greater improvement in CBR value especially in the soaked condition where its effect was about 60% more than that of the TriAx Tx 130s

**Tiwari and Vyas et al. (2017)** studied the effect of geogrid reinforcement on strength behaviour of black cotton soil. The soil sample was collected from Govindpura near Bhopal and classified as clay of intermediate compressibility (CI) as per ISC. Laboratory CBR tests are conducted with and without reinforcement. The geogrid sheets are placed in single layer at various depths (i.e. 0.2H, 0.4H, 0.6H and 0.8H) from top of specimen. It was observed that geogrid placed at 0.2H depth showed maximum improvement. The CBR value increased from 4.77% to 13.13% for soaked condition and from 6.53% to 19.66% for unsoaked condition.

By extending the available literature and techniques the authors have done the work on the stabilization of soil having poor in-situ engineering properties for further application of geogrid to improve the strength.

## III. SOIL REINFORCEMENT

Soil reinforcement is a technique which is used to improve the strength and stiffness of soil. Different engineering techniques are used to enhance the strength of soil, like geogrid and geotextile. It is a combination of earth fill and reinforcing strips. They are capable of bearing large tensile strength. Soil reinforcement is a modern technique which is employed in various projects to prevent the failure of slopes of soil and it improves the bearing capacity of the soil.

A geogrid is geosynthetic material used to reinforce soils and similar materials. Soils pull apart under tension. Compared to soil, geogrids are strong in tension. This fact allows them to transfer forces to a larger area of soil than would otherwise be the case. There are three types of geogrids:-

### TYPES OF GEOGRIDS

There are three types of geogrids namely-

- Homogeneous/ Utilized Geogrids
- Coated Yarn Geogrids
- Bonded Rod/ Strap Geogrids

### HOMOGENEOUS/UNITIZED GEOGRIDS

The polymers used to manufacture unidirectional homogeneous geogrids are high density polyethylene (PE), whereas polypropylene (PP) is used for bidirectional and tridirectional products. Holes are punched in polymer sheet and passed over rollers to get the desired shape. Uniaxial products are stretched longitudinally, whereas biaxial products are stretched in both longitudinal and transverse directions thus improving strength in both the directions.

**Fig 1: Utilized PE or PP Geogrids**

### COATED YARN GEOGRIDS

These geogrids are formed by weaving high tenacity polyester yarn bundles on conventional textile machinery. The junctions are knitted together to connect transverse and longitudinal ribs together. By varying the number of filaments per yarn in machine and cross machine direction, strength can be varied giving rise to uniaxial and biaxial products. These geogrids are coated with polyvinyl chloride, latex or bitumen for durability, dimensional stability and resistance to installation damage.

**Fig 2: Coated Yarn Geogrids**

### BONDED ROD/STRAP GEOGRIDS

These geogrids are formed from high tenacity polypropylene or polyethylene rods or straps. The individual rods are 1mm thick and 10mm wide. The junctions formed by overlapping machine and crossmachine direction ribs are connected by laser or ultrasonically. They are stiffest of all types of geogrids.

**Fig 3: Bonded rod/Strap geogrids**

## IV. OBJECTIVES

- To support bearing capacity without excessive settlement of failure.
- To identify the variation in shear strength of reinforced soil.
- To find the effect of reinforcement on various placement height.
- To determine the stress strain behaviour of Reinforced soil.

## V. CHARACTERISTICS

- **High Tensile Strength:** Geogrids are designed to have high tensile strength in both the machine and cross-machine directions, allowing them to effectively distribute loads and provide reinforcement to the soil.
- **Chemical Resistance:** Geogrids are often chemically resistant, making them suitable for use in soils with varying pH levels and chemical compositions.
- **UV Resistance:** Geogrids are designed to withstand exposure to ultraviolet (UV) radiation and other environmental factors over extended periods without significant degradation.
- **Load Distribution:** Geogrids improve load distribution by spreading applied loads over a wider area, reducing the potential for soil settlement and improving the performance of pavements and embankments.
- **Environmental Benefits:** The use of geogrids can minimize excavation and reduce the need for natural resources, making them an environmentally friendly option for construction projects.
- **Biological Resistance:** Geogrids are generally resistant to biological factors such as fungi and microorganisms, which can be important in long-term applications.

## VI. ADVANTAGES OF USING GEOGRIDS IN SOIL

- **Improved Bearing Capacity:**Geosynthetic material offers a superior frictional resistance against soil that helps minimize subgrade lateral movement.
- **Environmental Durability:**Geo-grid is known for its longevity and efficiency, especially due to its exceptional environmental durability.
- **Cost-Effective:**Geo-grid is also as kind to your wallet as it is to the environment. Since geosynthetics provide an adequate solution to erosion, you won’t spend a ton of money on replacing problematic soil.
- **Landscape Flexibility:**By nature, a geo-grid is highly adaptable to its surrounding landscape. It is applicable in any situation, including sloped/warped surfaces
- **Safety:** Ultimately, the safety of your property and the individuals living/working there is your number one priority when combating erosion. Soil erosion can tank the value of a property and even render land uninhabitable! Furthermore, damaged soil can cause injuries to people due to tripping and slipping.

## VII. DISADVANTAGES

- Long-term performance of the particular formulated resin being used to make the geosynthetic must be assured by using proper additives including antioxidants, ultraviolet screeners, and fillers.
- The exposed lifetime of geosynthetics, being polymeric, is less than unexposed as when they are soil backfilled.
- Clogging or bioclogging of geotextiles, geonets, geopipe and/or geocomposites is a challenging design for certain soil types or unusual situations. For example, loess soils, fine cohesionless silts, highly turbid liquids, and microorganism laden liquids (farm runoff) are troublesome and generally require specialized testing evaluations.
- Handling, storage, carrying and installation must be assured by careful quality control and quality assurance.

## VIII.CONCLUSION

This review paper explores the use of geogrid reinforcement to improve soil bearing capacity. Geogrids are a versatile solution for improving soil stability and load-bearing capabilities, offering benefits like reduced settlement, improved slope stability, and increased resistance to lateral forces. They are versatile in various geotechnical applications, such as road construction and embankment stabilization. Geogrids are eco-friendly, reducing excavation and material use, making them a promising alternative to traditional methods. With proper planning, design, and execution, geogrids can lead to more resilient, cost-effective, and environmentally responsible construction practices. The bearing capacity for the soil increases with an average of 16.67% using one geogrid layer at interface of soils with equal to 0.667 and the bearing capacity increases with an average of 33.33% while using one geogrid in middle of sand layer with equal to 0.33.

## REFERENCES


[1] J.G. Zornberg and R. Gupta, Reinforcement of pavements over expansive clay subgrades, 17th International Conference on Soil Mechanics and Geotechnical Engineering, 2009, 765-768.

[2] S.A. Naeini and R.Z. Moayed, Effect of plasticity index and reinforcement on the CBR value of soft clay. International Journal of Civil Engineering, 7(2), 2009, 124-130.

[3] Hossein Moayedi, Sina Kazemian, Arun Prasad, Bujang B. K. Huat (2009) “Effect of Geo-grid Reinforcement Location in Paved Road Improvement” EJGE Vol. 14.

[4] Dr.D.S.V.Prasad and Dr M. Anjan Kumar (2010) “Behavior of reinforced sub bases on expansive soil sub-grade” GJRE Vol. 10.

[5] O. Azadegan and G.R. Pourebrahim, Effect of geogrids on compressive strength and elasticity modulus of lime/cement treated soils, EJGE, 15, 2010, 1571-1580.

[6] Omid Azadegan and Gh.r.Pourebrahim (2010) “Effect of geo-grid on Compressive strength and Elasticity modulus of Lime/ Cement treated soil” EJGE Vol.15.

[7] A.K.Choudhary, K.S.Gill and J.N.Jha (2011) “Improvement in CBR values of expansive soil sub-grades using geo-synthetics” IGC J-233.

[8] Rakesh Kumar and P.K. Jain(2013) “Expansive soft soil improvement by geogrid encased granular pile”.IJET

[9] Prof. Mayura M. Yeole and Dr. J.R.Patil (2013) “Geo-textile can be worth their cost in Pavement.” IOSRJEN Vol.3

[10] C.A. Adams, N.Y. Amofa and R.O. Boahen, Effect of Geogrid Reinforced Subgrade on Layer Thickness Design of Low Volume Bituminous Sealed Road Pavements, IRJES, 3(7), 2014, 59-67.

[11] S. Tiwari and M. Vyas, Effect of Geogrid Reinforcement on Pavement Subgrade, International Journal for Scientific Research and Development, 5(5), 2017, 183-186.