Effect of Geogrid Reinforcement on Soil : A Review

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Abstract- *Geogrid reinforcement refers to the integration of geogrid materials, which are net-like structures made of polymers, into soil and other materials to increase their structural strength and stability. This technology is widely utilized in civil engineering applications, especially in road construction, embankments, retaining walls, and slopes to mitigate the risks of soil displacement and failure. Geogrids, due to their unique design, enhance the mechanical interlock between the granular or cohesive soil particles. When soil is compacted over geogrids, the tensile strength of the geogrid resists deformations that can be caused by various loads. This interaction improves load distribution, reduces settlement, and enhances the lifespan of civil structures. With growing urbanization and infrastructural needs, the application of geogrid reinforcement is becoming essential to ensure the sustainability and safety of engineering projects. Future advancements in geogrid materials, including eco-friendly and biodegradable options, promise an even broader application spectrum for this vital civil engineering tool.*

Keywords- Geogrid Reinforcement, Soil, Stability, Geogrid

I. INTRODUCTION

Soil, the fundamental material in many civil engineering projects, can exhibit a range of behaviors depending on its composition, moisture content, and compaction. However, in many situations, its natural state may not meet the requirements for the intended application. This is where soil improvement techniques come into play, and among the most innovative and effective of these techniques is the use of geogrids. Geogrids, constructed primarily from polymers, are net-like structures designed to interlock with soil particles, enhancing their mechanical properties. By introducing these grids into soil layers, engineers can significantly enhance the soil's load-bearing capacity, stability, and resistance to deformations. This technology has ushered in a revolution in the fields of road construction, slope stabilization, and many other areas of civil engineering. This paper delves into the mechanisms through which geogrids bolster soil properties, the various types of geogrids available, and the breadth of their applications in modern engineering projects.

II. LITERATURE REVIEW

Yetimoglu, et al. (1994) investigated the bearing capacity of rectangular footing on sand reinforced with geogrid both by experimental and finite element analysis. The parameters that were investigated were vertical spacing from footing base to geogrid first layer, width of reinforcement, number of reinforcing layers. From both experimental and finite element analysis, it was observed that optimum embedment depth is at which bearing capacity was highest was when single layer of reinforcement was used. The bearing capacity also increased with increase in number of reinforcing layers and width of reinforcement when placed in effective zone. It was also concluded that beyond a certain value increase in stiffness of reinforcement would not increase the bearing capacity.

Mandal & Gupta et al. (1994) carried experimental investigation on soft clayey soil using geocell as a reinforcement to find reinforcement effect on the soft soil. Laboratory model tests were conducted on marine clay overlaid by a sand layer to obtain the bearing capacity in reinforced and unreinforced condition. Strip footing was used as footing. It was concluded that up to a settlement ratio of 5-10% geocell layer exhibit beam action and after 20% it exhibits membrane action. The stiffness of the sand layer increased due to geocell layer. bearing capacity increases with increase in thickness and opening of geocell. For maximum profit at low settlement, geocell of smaller opening should be used and at higher settlement, geocell of large opening should be used.

Kumar & Saran et al. (2009) performed a total of 74 tests on closely spaced strip and square footing on sand reinforced with Geogrid to study the effect of spacing between footings, reinforcement size and continuous and discontinuous reinforcement layers on bearing capacity and tilt of footing. It was concluded that there was insignificant effect of interference on bearing capacity and settlement of closely spaced square footing in comparison to isolated footing on reinforced sand. Improvement in tilt of adjacent square footing was also observed. Also, improvement in bearing capacity, tilt and settlement was also observed in closely spaced strip footing.

Sharma, et al. (2009) formed analytical solutions for the ultimate bearing capacity of geogrid reinforced sandy soil and silty clay soil. Proposed analytical solution was verified by large scale model test and the data reported in the literature. The predicted bearing capacity values from analytical solutions are in good agreement with the test results.

Latha & Somwanshi et al. (2009) presented laboratory model test result and numerical stimulation on square footing resting on sand to evaluate bearing capacity and effect of reinforcement. Parameter studied were type and tensile strength of geosynthetic material, amount of reinforcement, layout and configuration of geosynthetic layers below the footing. Steel tank of size 900×900×600mm was used and four different type of geogrid were used as reinforcement. Test result of unreinforced and reinforced footing was compared. Result showed that effective depth of reinforcement is twice the width of footing and optimum spacing of geosynthetic layers is half the width of the footing. It was also observed that layout configuration of footing also plays an important role in bearing capacity improvement.

Sarika Dhule et.al (2011) in her experimental work tries to modify the properties of weak sub-grade soil and soft murrum by addition of geo-grid in different percentage i. e. 1%, 2%, 2.5% and 3% separately and found that the California Bearing Ratio value increases with addition of geo-grid. Again with addition of this work she also found the effect on California Bearing Ratio value of murrum with 2% cement and different percentage of geo-grid. The California Bearing Ratio value found by addition of 2.5% geo-grid is more. The author used compacted soil for further California Bearing Ratio tests. The author also mentioned that the shear strength and low permeability are the affecting properties on compaction characteristics. Therefore, the results are dependent on compaction of the soil under consideration.

Pradeep Singh and K.S. Gill et al. (2012) carried out experimental work to determine the optimum position of providing geo-grid reinforcement in sub-grade soil by conducting California Bearing Ratio test and unconfined compressive test . He found that by providing geo-grid reinforcement at 0.2H from top give considerable improvement in California Bearing Ratio value and stress strain behavior of sub-grade soil.

GEOGRID

Geogrid is the one which is used as reinforcement in the soil. Geogrid is a planar, polymeric structure having regular opening for proving tensile strength, bonding has a uniformly distributed array of apertures between their longitudinal and transverse elements. The polymeric materials from which geogrid are generally made are high-density polyethylene, polyester, and polypropylene. These materials are the important component in the design of geogrid. It has stiffness and tensile strength which make it widely usable as a reinforcing material.

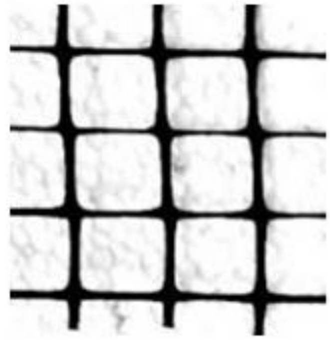

Fig:Geogrid

III. MANUFACTURING OF GEOGRID

The grids of the geogrid are formed by the ribs which are properly intersected by the manufacturer along two directions. The first direction is the machine direction (MD), which is the direction in the manufacturing process. The second direction is called the cross-machine direction (CMD), which is perpendicular to the machine direction. The ribs of the geogrid form a matrix structured material. The open area between the perpendicular ribs is known as aperture. The size of aperture varies from 2.5cm to base on the arrangement of the ribs in longitudinal and transverse direction.

The three most used methods for the manufacturing of Geogrid are as follows.

1) **By Extruding:** In this method of manufacturing of geogrid, flat plastic sheets are extruded into required configuration. The material used in the manufacturing can be a high-density polyethylene or high-density polypropylene. Then the punching pattern is placed above these sheets to give the sheet desired shape and form proper grids. The punching in the sheet will form pattern of holes known as apertures. Now the material is stretched in longitudinal as well as transverse direction to develop tensile strength in the geogrid.

Fig:Geogrid sample manufactured by Extruding

2) **By Knitting or Weaving:** In this method of manufacturing, polyester or polypropylene material yarn undergoes the process of either weaving or knitting to form flexible junction. These materials have high tenacity so that geogrid manufactured is having tensile strength and other basic properties. Then these geogrids are coated with bitumen or latex or polyvinyl.

Fig: Geogrid sample manufactured by Knitting

3) **By Welding and Extrusion:** This is the latest developed method of manufacturing of geogrid. in this method polyester or polypropylene sheets are extruded by passing them through roller. This is done in a machine which adjusts automatically and runs at different speed, which stretches the ribs of geogrid and this increases its tenacity.

IV. FUNCTIONS OF GEOGRID

- **Stabilize Soil Mass:** The geogrid serves the objective of holding the particles together whether it is a soil or an aggregate. This interlocking helps in mechanically stabilizing the earthwork. The aperture helps in proper interlocking between the soil and aggregate.
- **Improvement of Bearing Capacity:** Installation of geogrid helps in the reduction of lateral movement of aggregates. This would further result in the elimination of stresses. Geogrid possess frictional resistance which resist the lateral movement of the subgrade. Thus, improving the bearing capacity of soil due to the formation of inward stresses.
- **Lateral Restraining Capability:** Due to the wheel load on the pavement, results in lateral movement of aggregate, which disturbs the stability of the aggregates . The geogrid here acts as a restraining agent, which restrains the aggregate movement.

V. ADVNATAGES

- **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.

VI. 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.

VII. CONCLUSION

Geogrids are a valuable technique in geotechnical engineering, improving soil bearing capacity. They enhance load-bearing capacity, providing innovative solutions for civil engineering projects. Geogrids increase soil stability, offer cost-effectiveness, ease of installation, and long-term performance. They help mitigate foundation failures, control soil erosion, and support structures. Their success in soil improvement opens new possibilities for tackling geotechnical challenges in construction and infrastructure development. As geosynthetic technologies continue to advance, the future holds exciting possibilities for further performance and efficiency.

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