Weak sub-grade soil reinforced with Geogrid material - A Review

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Abstract. Pavement design on weak subgrade soils is to a certain extent challengeable and challenging for transportation and geotechnical engineers. Weak soil is vastly compressible clayey soils so the life of the pavements is less and effect of the weakening of the paved or unpaved surface. The development of such soil are substitutes such as replacement and excavation of unsuitable soils, compaction, Mechanical and chemical stabilization, Pre-compression and reinforcement of soil, etc., are used typically at such locations. During the recent historical utilization of reinforcement of soil by various methods has been increased to progress the strength properties and bearing capacity of poor subgrades. Field signals indicate that geosynthetic reinforcements will expand pavement performance. From this, the employment of various geosynthetics to pavement surface is testified by several researchers. Geosynthetics has numerous applications such as separation, reinforcement, filtration, drainage, and containment, etc. This paper targets to study the conclusions from various studies on weak subgrade soils using reinforcement.

Keywords—Ground improvement, Reinforced soil, weak subgrade soil, Geosynthetics, Geogrid

1. Introduction

The Pavement design and construction work are aiming to get reliable pavement by reducing maintenance and reduction in thickness of the pavement layers. The subgrade is the in-situ material, which should support all the load coming from the road structure. The lower layer of pavement is the foundation material in pavement performance. Pavement performance depends upon the subgrade’s characteristics such as its load-bearing capacity, its stiffness. weak subgrade soil can have exchange and remove with a stronger subgrade or stabilized with cement, lime, fly ash to decrease the layer thickness of the pavement. Geo-synthetics help strengthens the weak soil and to construct pavement economically with good quality and less periodical maintenance. Geo-synthetics are found to be a worth operative substitute to improve weak sub-soils in such a location where there may be a poor quality of soil and non-availability of good soils with applications in the geotechnical engineering projects such as highway pavement, railway, and airport. Geo-synthetics includes a large number of products with reinforcement function solve many geotechnical and transportation problems. Major applications of reinforcement in improving weak soil subgrades.

2. Material

Geosynthetic materials are successfully used in pavement design, separation, filtration, reinforcement.
Geosynthetics also perform filtration function by controlling the movement of soil particles from subgrade to base materials. Various types of geosynthetics such as geotextiles, geogrids, geocomposites, and geomembranes. Geogrid gaining more acceptance for improving road pavement construction. Geogrids improve the pavement system performance by lateral restraint of base and subgrade or increase bearing capacity in the system. For applications wherever higher reinforcement strength is needed, polymeric Geo-grids is also used. According to [1] geogrids are used as a geo-synthetic material consisting of polymeric material made up of many polymers like polyethylene, polyvinyl alcohol, polypropylene, etc. The open apertures of geo-grids between ribs permit interlock the fine soil with the coarse soil over them, and providing bond of the overlaying material due to the tensile strength and stiffness. There are different varieties of geogrids as discuss below.

Geogrids are classified by manufacture into three types:

2.1 Uniaxial geo-Grids-These are usually carrying high tensile load applied in one direction and made up by punching and drawing a homogenous polymer sheet called high-density polyethylene. This unidirectional product no need for coating weaving to maintain structural reliability. Uniaxial geogrids offer superior junction strength hence best for use where the stresses applied only in one direction, like in retaining wall, Basal reinforcement, and embankment slopes.

![Fig -1 Uniaxial geo-grids](image1)

2.1 Biaxial geo-grids –These are made from high polymer material represented in two dimensions longitudinal and transverse. It offers good load carrying capacity and good resistance to long term degradation. Biaxial geogrids display high tensile strength in both two directions, this makes them appropriate for soil stabilization and subgrade, subbase course reinforcement application for roads.

![Fig -2 Biaxial geo-grids](image2)
2.2 Triaxial geo-grids – These are the advanced geosynthetic product in the market and multidirectional properties for reinforcement. Its triangular geometry can provide an enhanced bearing system, which can reduce the pavement thickness. Triaxle geogrid effectively prevents cracking, ground rutting, and subsiding. Triaxial Grogrids can provide uniform tensile resistance in all three directions as compare to traditional biaxial geogrids. Therefore, triaxial geogrids are more effective in uniform stress and strain distribution.

![Triaxial geo-grids](image1)

Fig -3 Triaxial geo-grids

3. Uses of Geo-Grid

3.1 Applications of Geo-Grid in Subgrade Soil

Geo-synthetic includes large products use for improving the poor subsoil in the adverse location where there may be non-availability of ideal soils. The drastic growth in the use of geosynthetics found in the last few decades as an outcome of worldwide research on the reinforcement.

*Moustafa Ahmed Kamel, Satish Candra & Praveen Kumar (2004)* – Two important features have been examined while studying. Initially, the learning was completed on the optimum positioning of only one geogrid layer and strength property of the subgrade and the second thing was the illustration of reinforced subgrade soil under cycling loading condition. The most favorable point was selected after studying the strength rate, failure deviator stress, and the modulus of elasticity. Based on CBR and E-values rise with reinforcement and give the uppermost values when geo-grid is located at a distance between 72% and 76% from the topmost layer of the subgrade. The test results of cyclic triaxial tests implicit that in unreinforced soil 35% decreased of resilient strain as reinforcement soil. Additional, geo-grids are important in the control of the rut formation in the pavement design as the permanent strain in reinforced samples is less than unreinforced samples by 44%.

*Mostafa A.El.Sawwaf (2006)* – This study was done on the possible benefits of reinforcing a substituted layered of sand created near a sloping crest. It was decided to carry out a model test using a 75mm wide model footing with geogrids. The studied parameter includes the thickness of the changed sand layer along with the place of the footing comparative to the slope crest. The main emphasis was reinforcement configuration along with, their length, number of layers, space among layer, and thickness to the ground surface. Two-dimensional plane strain using the computer code plaxis was used to perform a sequence of finite element investigation. Created on study soil improvement of soft clay replaced with sand layer increase the load-bearing capacity of footing. Soil reinforcement not only upgraded the soft soil but also decrease the sand layer thickness at the same load level.
Eric Duncan-Williams, Nii. O.Atoh-Okine(2007) –In this investigation strength property of a different type of granular base soil strengthened with geogrid was finding out. Tests were shown on both unsoaked and soaked CBR samples with reinforcement or without reinforcement. The experiments show that the CBR of soil enhanced when reinforced with geogrid materials and hence increases the CBR value and load-carrying capacity. The addition of geosynthetics increases the soil resistance to dynamic and cyclic loading.

A.K. Choudhary, K.S. Gill, J.N. Iha & S.K. Shukla (2012) - This paper presented results of series of CBR tests as well as swell tests to calculate the effect of a single layer of geogrid and jute geotextile at various depth from the top of the CBR mold when placed horizontally. This study was concluding that single layer of geogrid control the swelling of expansive soil and depend upon the type of reinforcement or depth of reinforced layer from a top surface of subgrade soil. CBR value increase with only one layer of reinforcement and the stress-strain behavior of soil also improves.

Ahmet Demir (2011) – During this investigation, a large-scale field test was performed to conclude the potential use of geo-grid under large circular footing above clay soil. Near about 15 field tests were done to calculate the effect of replaced clay soil with a coarse grain fill layer with one or more geogrid layers under different diameters circular footing. The results were accessible in terms of subgrade modulus and bearing capacity. The results show that subgrade modulus decrease as footing diameter increase. After that, the field test results are related to analytical methods with statistical correlations.

M. Abdesssemed (2015) This experimental study was for flexible asphalt airway. Geogrid was used for reinforcement of runway and monitor behavior by measurement of deflection or tensile stresses. Finite element 3D modeling and non-destructive testing by heavyweight deflectometer was performed on the runway and conclude that with adopted optimal position improvement of the stresses and strain and decrease the propagation of the descending crack.

Ayush Mittal and Shalinee Shukla (2019) presents a laboratory test on the outcome of polyester biaxial geo-grid on the strength behavior of weak subgrade soil. The soil in this study was clay which is intermediate compressibility by IS 1498 (1970) having a considerable quantity a more percentage of fine soil and losing its strength with change in moisture content. Geo-grid sheets are used as one and many layers at different place in soil subgrade. CBR ratio and unconfined strength test are executed. The study specify enhancements in strength value in form of CBR, UCS, and axial strain at failure. Maximum enhancements of 40% in Strength value and 70%, respectively, in UCS values are detected when the subsoil subgrade from top of surface reinforced with geogrid with one and more layers. Scanning electron microscopy (SEM) is performed to evaluate the micromechanical interaction between soil and geo-grid surface. It is detected that interlocking and surface friction between soil particles and fibers of the geo-grid are responsible for the strength enhancement of weak subgrade soil.

Meenakshi Singh (2019) – In this research, unpaved road has been evaluated for CBR value. Subgrade soil performance is investigating geosynthetics reinforcement placing at a different depth in subgrade soil. An effort was made to determine the ideal depth of reinforced layers and laboratory CBR tests performed. The position of a single layer of geosynthetics in CBR mold change from middle to one third and one fourth from the upper surface of the soil. The results show a decrease in pavement design thickness with an improvement in the CBR value of subgrade soil. According to this study reinforcement soil performs better unreinforcement. The optimum location of reinforcement was found layer is placed between 0.41H to 0.62 H.
3.2 Use of Geo-Grid in the Foundation Soil

Over the past 30 years, many researchers have supported studies to investigate the role of reinforced material for improving the load-bearing capacity and settlement characteristics of foundation soil as an example [2-7]. Several laboratory model tests were showed with square, strip, rectangular or circular footing. The primary control parameters in these tests are

a) Location of topmost reinforced layer
b) The number of reinforced layers
c) Depth of the reinforced layer.

Temel Yetimoglu, Jonathan T.H. WU, Ahmet Saglamer (1994)– While studying model test was performed on a rectangular footing with geogrid and sand to determine the bearing capacity. The count of reinforced layers, the vertical spacing between reinforced sheets were investigated. The was in the increased in the bearing capacity.

C.R.Patra, B.M. Das, C. Atalar (2005)- The laboratory model test was performed for the ultimate bearing capacity of a strip foundation on multi-layered geogrid reinforced. The compression of the ultimate bearing capacity was done with the theory of Huang and Menq (1997). The ultimate bearing capacity increase with embedded ratio.

A.K. Choudhary, J.N. Jha, K.S. Gill (2010)- The study was carried out on strip footing resting on the top of geogrid reinforced fly ash slope. Many model footing tests were performing to determine the number of reinforced layer, location of footing relative to slope crest, slope angle, and width of footing. The results show that both the ultimate bearing capacity and pressure settlement increase with reinforcement.

4. Conclusions

After review of the above study, my study reveals the use of geosynthetic reinforcement can improve the engineering character of the soil. The research in reinforced soil attracted the attention of geotechnical engineers to take advantage to handle the various geotechnical and transportation engineering hurdles. All the above-discussed papers reveal that the CBR value obtained after geogrid is more than untreated soil. It helps to reduce the pavement layers’ thickness without compromising strength. This impacts the cost of the project. The same strength can be achieved by spending less amount.

The second impact of the study shows that with the use of geogrid one can get increase bearing capacity and can control the settlement of weak soil.

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