Investigating the Impact of Usage of Geogrid in Increasing the Pavement Bed Bearing

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Abstract— **In the recent years, the use of the geosynthetic productions has increased as an effective element in many constructions and environmental projects. In this essay, the impact and the amount of effectiveness of the Geogrid networks buried at different depths in the level of road building technics has been modeled according to the machines loading in the road bed. For this purpose, first the numerical model has been extended by the finite element method and using the PLAXIS 2D v 8.6 software. Therefore, in this study, the road surface level considered as zero and geogrid placed in three levels and three depths of the road surface in the order (55cm and 40cm and 25cm) that has done in the order of:**
1. Between the basis layer and under basis, 2. Among the layer and under basis, 3. Between the under basis layer and the bed and analysis. Geogrids and soils' grains shows such a kind of being mobilized against the forces exerted on the levee that caused the resistance and bearing of the soil layers becomes more against the exerted forces and the life and durability of the road's levee increase.

Index Terms— **Modeling, Tensile Strength, Reinforced soil, Geogrid, Road Bed.**

I. INTRODUCTION

According to the definition, geosynthetic ASTM0439[1] is such a flat product that produced from polymeric materials and be used along with soil, stone, field or the most of materials related to the geotechnical engineering as an integral part of the project, construct and with the system built by the human. (Müller and Saathoff, 2015)[2]. Geogrids as one of the types of geosynthetic are such a polymeric product that usually builds in a form of regular reticulated networks in one or two directions. Without a doubt, one of the inherent advantages of geogrids rather than the most of geosynthetics, is their significant inhibitory resistance. According to definition, the inhibitory resistance include of geogrid's resistance against pulling them out from the environment in the soil or aggregates. The fossa between them caused that the soil's grains or stone material be involved well with them. Therefore, employed geogrid in the levee layers acts like the resistant elements against the tension and can harness the forces and transformations well in it in such areas which tensions and tensile deformations arise in the soil. (Bouazza, 2008)[3]

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Also in such a condition that CBR in the dry manner being smaller than 3 and in the flooding manner being smaller than 1, it can be expected that the geogrid acts as its most important application namely backup, reinforcement and separator layer (Heibaum, 2011)[4]. Due to the existence of the large springs in the geogrid networks, this possibility exists that the inhibitory resistance of geogrids becomes more from their inhibitory resistance that placed on the soil layer. Spring's dimension is variable between 10 to 100Mm. (Bouazza, 2010)[5]
According to studies the use of geogrids to strengthen the roads was actually started from 1970. In this regard, studies increased in the field of geogrid's application on the roads in that years. These works include of Modeling of the finite element of the flexible sidewalks under the fixed loading (Howard and Warren ,2009)[6], experimental mechanism of modeling and development of the design of geosynthetic modeling of the flexible sidewalks reinforcement of the Montana department of transportation (Perkins,2001)[7], ministry of transport of federal bureau of highway- study of geogrids on the reinforcement of the flexible roads' system.
(Perkins, 2002)[8] the geosynthetic material association ''united states of America'', reinforcement with geogrid and its impact on the flexible pavement Perkins (Perkins et al)[9].
Different studies assessed well the impact of geosynthetic reinforcement for the construct of the paved roads by the laboratory method and studied numerical modeling approaches.(Berg, R. R et al 2000)[10]
The impact of the reinforcement of geogrid place in improvement of the paved road has been studied using the expansion FE PLAXIS program. The paved layer and geogrid, modeled as a linear isotropic elastic material while the Mohr-Coulomb material model used to simulate the granular soil layers. They show that the reinforcement of the geosynthetic placed in the down of the asphalt layer leads to the highest deviation decrease of the sidewalk in the vertical mode.(Miura et al 1990)[11].
The results coming from the analysis on the unreinforced asphalt with the reinforced one with its geogrid also in the same geometry and material properties have been compared and showed that with the inclusion of the geogrid layer, permanent deformation decrease only for 20 percent of the load of one cycle. This level of improvement is related to the geogrid flexural stiffness which was from the presentation of the model used by the authors(Leng and Gabr, 2005)[12]

II. THE EFFECT OF THE GEOGRID APPLICATION ON THE CBR BED IMPROVEMENT

One of the characters which we can distinguish the main performance domain of the geotextile layers from each other in the road building affairs and also do the necessary design using it. The California bearing ratio (CBR) index is bed. The values of this index can be measured by the experiment with

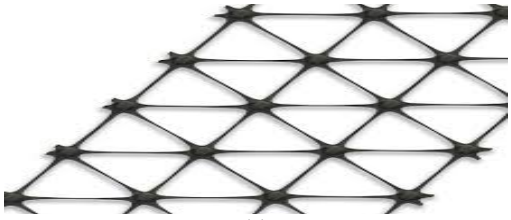
this name and according to the ASTM-D1883 [1] instruction for the different materials. In table 1, the range of each of the main performances of the geotextile layer in road building presented according to the characteristic resistance of the natural earth's bed that cited in terms of the results of the California bearing ratio (CBR). According to table 1, in the event that natural bed CBR is more than 8 in the dry mode and in the flooding manner is more than 3, the main expected performance from geotextile, is the separation layer performance (for the purpose of preventing the grains merge of the under basis layers in the bed layer). Also in such condition that CBR is smaller than 3 in the dry manner and smaller than 1 in the flooding mode, it can be expected that the the geotextile acts as the strengthening, reinforcing and separating layer.

Table 1. Effects of CBR on the geotextile application [3].

CBR bed values		geotextile performance
Flooding	DRY	
≥ 3	≥ 8	Layer's separation
3-1	8-3	consolidation (including separation, drainage and filtration in some cases and somewhat reinforcing)
≤ 1	≤ 3	reinforcement and separation

III. The Effect of the Geogrid Application on the CBR Bed Improvement

There are some of current geogrids in figure 1. In this study, biaxial geogrid (b) that is shown in figure 1 is used to reinforce the levee.



(a)

(b)

(c)

Figure 1. Three sample of the conventional three-axis (a), two-axis (b) and single-axis geogrid.(c)

A. Mechanical properties

1) Tensile creep: long time behavior of geogrids against the tensile forces that exert on them from the environment or materials around and in many conditions has a constant and uniform value.
2) Tension relief: due to the geogrid's creeping behavior and deformations resulted from it, existed tensions in the longitudinal and transverse of geogrids gradually release and the geogrid piece make itself release gradually from the exerted tensions field.
3) Exhaustion: due to the abnormal factors and out of the defined range in below, these factors include: environment temperature, oxidation, chemical solutions, radioactive waves, sunlight, cracking due to the tensile exertion.
Final Stage

B. .Characteristics of the geogrid's durability

Geogrids are from the petroleum products which have shown resistance somewhat against the different factors, including physical and chemical to some extents, these networks naturally somewhat have shown stability against the different condition and in the case of exerting allowed excess tensions will be worn-out and their performance will decrease.
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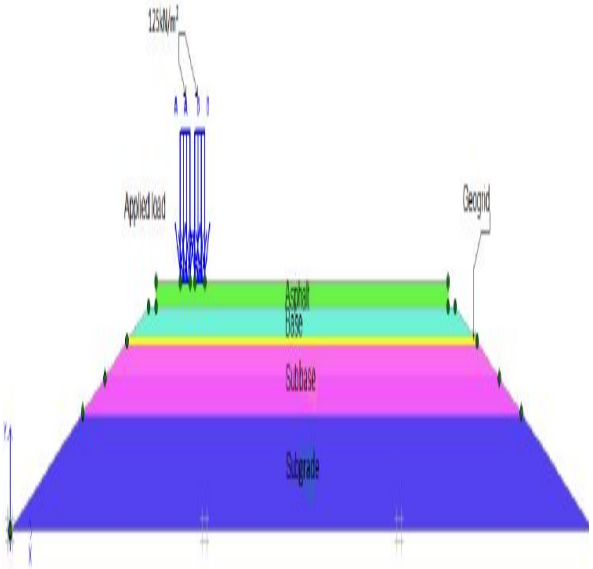
C. Different applications of the Geogrid Networks in levees and sandy Soil

Geogrid network can be used directly in reinforcing and separating the levees' layers and road's pavement layers because of having the outstanding characteristics like suitable tensile strength and significant flexibility. Also in the special condition that the dimensions of the geogrid spring be small enough or the use of these networks is performed along with the geotextile layers, they can be used also as the drainage or filtering layers. In the case of using these networks between the infrastructure and pavement, we can decrease the thickness of the embankment or the pavement segments.

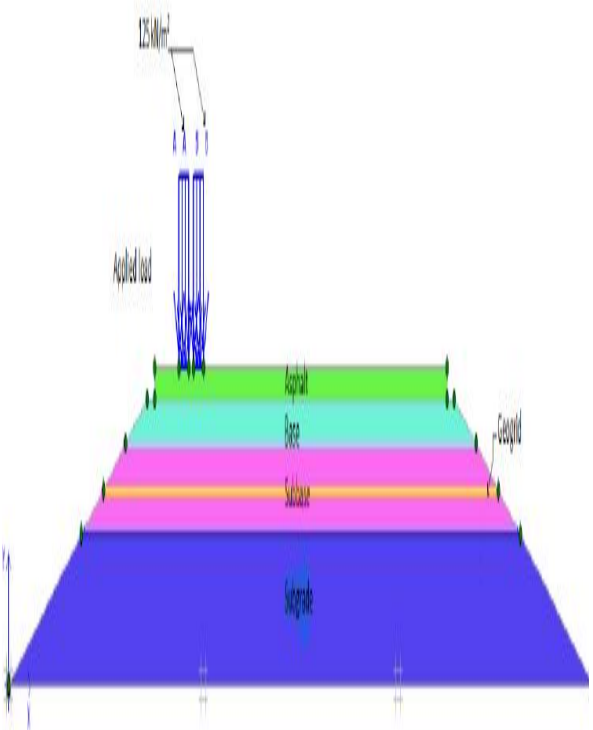
D. Developing Numerical Model, materials' information and properties

In this system that was a normal road system, road building reinforcement includes of warm asphalt layer, basis layer, under basis layer, bed layer and also geogrid reinforcement

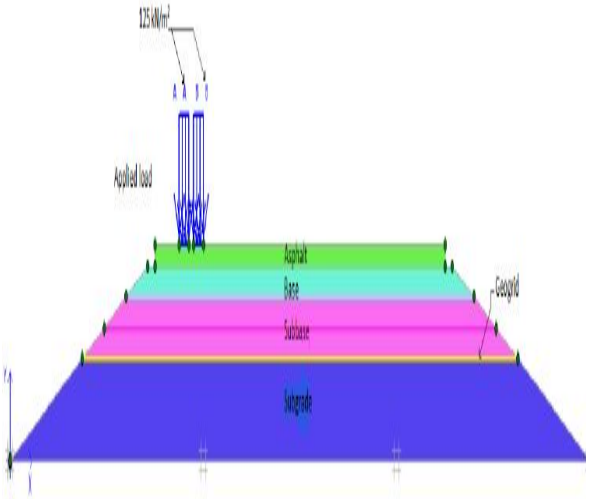
layer that is modeled as a multi-layer construct under the statistical loading.As it can be seen, in figure 1, the model is based on the Plaxic 2D FE software that the analysis of the road constructs is expanded as the reinforced and unreinforced using the geogrid that is shown in (a), (b), (c) in the order of geogrid placement in the depths of 25, 40 and 55 cm.



(a) Geogrid in the depth of 25 cm from the road surface



(b) Geogrid in the depth of 40cm from the road surface



(c) Geogrid in the depth of 55cm from the road surface

Figure 2. An overview of the road layer modeling and exerted loading on the road level and depth of the geogrid placement in the road level (a) (b) (c).

In the accomplished modeling in the article, the material models are analyzed in the linear elastic manner and special dry and saturated weight of all soil layers due to the dryness of the place, considered in the same amount and other coefficient is given in Table 2.

IV. Analysis and the Interpretation of the Results

In fact, the accomplished study in this essay, the model which used in the analysis, is Plan Strain and is the manner of the desired elements placed for the 15 group soil. The surface level of the underground water is zero and the slope angle of levees is from 1 to 3. Under these conditions, performed loading of the results is provided in figures 3 and 4 in the manner that the placement of geogrids be changed in the soil. In the studied article, to specify the effect of the geogrid use on the soil bed, such a manner is modeled that the soil is in the unreinforced condition that its results are shown in Figure 3 in a form of tension bubbles from loading. Also in figure 3 it can be seen that how the amount of the exerted tensions can be reduced with the placement of the geogrid network in the depths less than the road level.

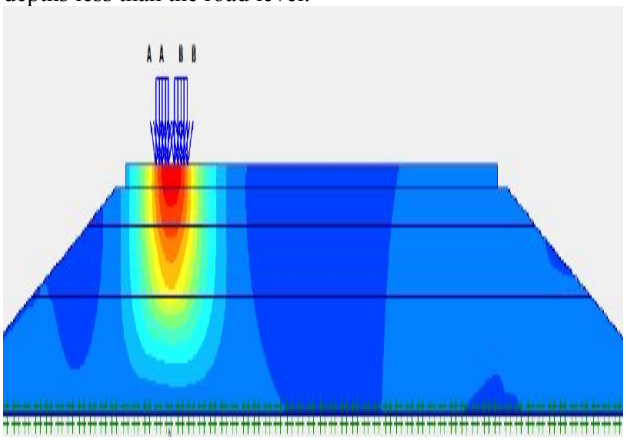


Figure 3. Vertical displacements (subsidence) around the Loading

Table 2. Parameters used in the study

Material	Asphalt	Base	Subbase	Subgarde
Material model	Linear elastic	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb
Thickness(cm)	10	15	30	50
Young Modulus(Kpa)	2100	1000	500	300
Poisson's ratio	0.45	0.35	0.3	0.3
Special dry weight (Kn/m3)	20	20	18	17
Special wet weight (Kn/m3)	20	22	20	18
Cohesion (Kn/m2)	-	30	20	-
Friction angle	-	43	40	35
Dilatancy angle	-	13	14	5
Horizontal permeability(m/day)	-	1	1	1
Vertical permeability (m/day)	-	1	1	1

As it can be seen from figure 4, the amount of the changes in a place which has been considered in the modeling of the load from the traffic, namely from the range of 3.5 to 4.0, the numerical amount of the outputs show that the amount of displacements in the Uy direction decreased significantly by exerting the geogrid coverage rather than the geogrid manner of without coverage. That these reactions are from the interaction of the soil and geogrid network. Also, it can be resulted from figure 4 that the best manner of the geogrid network placement is in the depth of 50cm and we will have fewer subsidence in the bed.

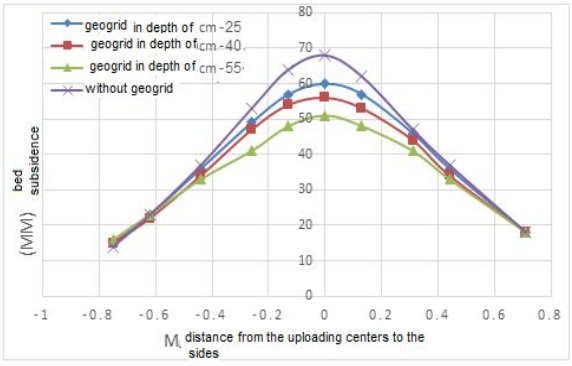


Figure 4. Comparison of the reinforced soil and unreinforced soil.

Another result that can be seen from the graph and output, is this point that if we give an example of EA coefficient in the same manner for one road building level with the same loading ratio and with the same ratio for the technical characteristics of geogrid, we In this article, geogrid is used to reinforce the weak beds in the levee. Geogrids are placed in three locations of the road building and their impact on the bed examined using the will find that whatever we consider the place of the coverage of geogrid lower, we can achieve better results in terms of displacements.

CONCLUSION

PLAXIS 2D v 8.6 software by the finite element method considering to their amount of subsidence. The results of this study are:

Geogrids caused that mobilize by overcoming to the tensile forces against this force and reduce deformations.

Whatever that the geogrid distance from the road surface become lower, it caused that better results are much more achieved rather than the deep depth.

Geogrids raise the soil bearing resistance and cause the decrease of subsidence in the levee layers.

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