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Trakya University Journal of Engineering Sciences, 16(2): 61-69, 2015
ISSN 2147–0308
Araştırma Makalesi / Research Article

THE EFFECTS OF GEOTEXTILE LAYERS ON BEARING CAPACITY OF GRAVEL-SILT MIXTURES

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Abstract: Soil stabilization methods to modifying and improving the physical and engineering features of the soil for achieving a set of previously determined goals. In many engineering applications, the use of geotextiles is regarded as an effective method for soil improvement. Research results indicate that, when geosynthetics placed between the sub-grade and sub base layers, increase the bearing capacity in fine grain subgrades. The main purpose of the present study was evaluating a laboratory study of the effect of geotextile layer and its number of layers on the bearing capacity of the gravel of Til region of Shabestar city, which includes 15 to 30 percent of silt. It should be noted that the mentioned tests were performed in three relative densities of 90, 95, and 100%, and the effect of geotextile layer was studied in two positions. In the first position, one geotextile layer was placed in the middle part of the soil sample, and in the second position two geotextile layers were alternatively placed in the samples. The results of laboratory studies show that putting one geotextile layer in samples helps modify and improve the bearing capacity. This increases were observed in the gravel and the gravel with 30% silt. However, putting two geotextile layers in the soil alternatively decreases resistance and bearing capacity of the samples.

Keywords: Gravel, Silt, California Bearing Ratio (CBR) Test, Soil Stabilization

Jeotekstil Tabakalarının Çakıl-Silt Karışımlarının Taşıma Kapasitesi Üzerindeki Etkileri

Özet: Toprak stabilizasyonu önceden belirlenmiş hedeflere ulaşmak için toprağın fiziksel ve mühendislik bir dizi özelliklerini değiştirmek ve geliştirmek anlamına gelir. Birçok mühendislik uygulamalarında, jeotekstil kullanımı toprak ıslahı için etkili bir yöntem olarak kabul edilir. Araştırma sonuçları, geosentetik alt zemin ve alt taban katmanları arasına yerleştirildiğinde, ince taneli zeminin dayanma kapasitesini artırmak ta olduğunu göstermektedir. Bu çalışmanın temel amacı, bir laboratuvar çalışma da jeotekstil tabakasının etkisi çakıl kapasitesine ve katmanların sayısını değerlendirmektir. %15 ila 30 oranında silt içeren çakıllar, Şebister şehrinin Till bölgesinden elde edilmiştir. Denemeler üç farklı (%90, 95 ve 100) göreceli yoğunlukta gerçekleştirilmiş ve jeotekstil tabakanın etkisi iki farklı konumda incelenmiştir. İlk pozisyonda, bir jeotekstil tabakası toprak numunesinin orta kısmında yerleştirilmiş ve ikinci konumda iki jeotekstil tabakası alternatif olarak toprak numunesine konulmuştur. Laboratuvar çalışmalarının sonuçları numunelere bir jeotekstil tabakası konulmasının taşıma kapasitesinin geliştirmesine yardımcı olduğunu göstermiştir. Meydana gelen artışlar, çakıl ve % 30 silt içeren çakılda gözlenmiştir. Ancak, toprak içine alternatif olarak iki jeotekstil katmanı koyulması numunelerin taşıma kapasitesi ve direncini azaltmaktadır.

Anahtar kelimeler: Çakıl, Silt, Kaliforniya Taşıma Oranı (CBR) Deneyi, Toprak Stabilizasyonu

INTRODUCTION

Road pavement, as a part of road structure, has a very important role in road performance and in constructing safe and smooth surfaces. Subgrade layer of the road can be compacted layer of dyke, the available natural or corrected soil. Material of subgrade is prepared according to geotechnical properties and the first layer of the pavement is built over it. Subgrade which is ultimately considered as the pavement foundation and tolerates the entire load from the pavement body and the vehicles. Therefore, making pavements with high bearing capacity and life duration as well as keeping them in suitable functioning conditions is of utmost importance. Pavement body is usually composed of several layers including the subgrade, sub-base, base and asphalt (Yoder and Witczak, 1975). The first attempts for soil improvement were made long ago by putting tree branches and leaves in the marshlands and sand plains. After a while, with putting the tree branches and leaves, a mass was formed around them and the bearing capacity of the soil increased. As a result, the mentioned places could be used as passages used for passing through. In late 1940's and 1950's, geo-synthetics were used in America, and in 1970's their use became widespread in Europe. Different types of geosynthetic materials include: geotextiles, geogrides, geonets, geomembranes, geopipes, and geocomposites. Resl and Werner (1986) conducted a laboratory study on un-weaved geotextile layer in asymmetric loading conditions. The results of their study indicated that the geotextile layer between the soil bed and sub base can increase the bearing capacity of the soft soil subgrade. Fannin and Sigurdsson (1996) conducted a study at real scales on the pavement and geotextile layers. The results of their study indicated that geotextile layer increases the loading capacity of the pavement layers. In this regard, the studies by Bergado et al. (2001), Raymond and Ismail (2003), Park and Tan (2005), Yetimoglu and Salbas

(2003), Patra et al. (2005), and Varuso et al. (2005) can be mentioned. Regarding the bearing capacity of the improved soils, and the bearing capacity of the armed soils, the studies by Haeri et al. (2000), Zhang et al. (2005), Latha and Murthy (2007), and Williams and Okine (2008), Naeine et. al (2008 AND 2009) and Senthil Kumar et al. (2012) can be mentioned. The main purpose of the present research was laboratory study of the effect of the number of geotextile layers on the bearing capacity of the gravel materials containing 15 and 30% silt. It should be mentioned that California Bearing Capacity (CBR) test was done in three relative densities of 90, 95, and 100 percent, and the effect of geotextile was studied by putting one geotextile layer in the middle of the soil sample and two geotextile layers in distances of one third in the soil sample.

MATERIALS AND METHODOLOGY

As already mentioned, the purpose of the present study was examining the effect of the number of geotextile layers on the bearing capacity of the grained soils containing 15 and 13% silt using California Bearing Ratio (CBR) Test. To achieve the mentioned purpose, it was necessary to identify the geotechnical properties of materials and the physical features the geotextiles. Finally, the laboratory equipment used in the study were described (Gohari et al.,2010).

In the present study, the gravel and silt in Til region of Shabestar City was used (Figure 2). The gravel in this area is sub angular type since its length is three times as much as its width, and it is wedge-shaped. The chemical analysis of the mentioned materials by ASTM C25 standard shows that their amount of lime is so little, but the amount of iron is high, and the utilized materials do not contain organic materials. The grading of the gravel containing 15% silt, the gravel containing 30% silt, and pure silt was determined using ASTM D421 and ASTM D422, which are shown in Figure 1 (Sadeghi azar et al., 2010).

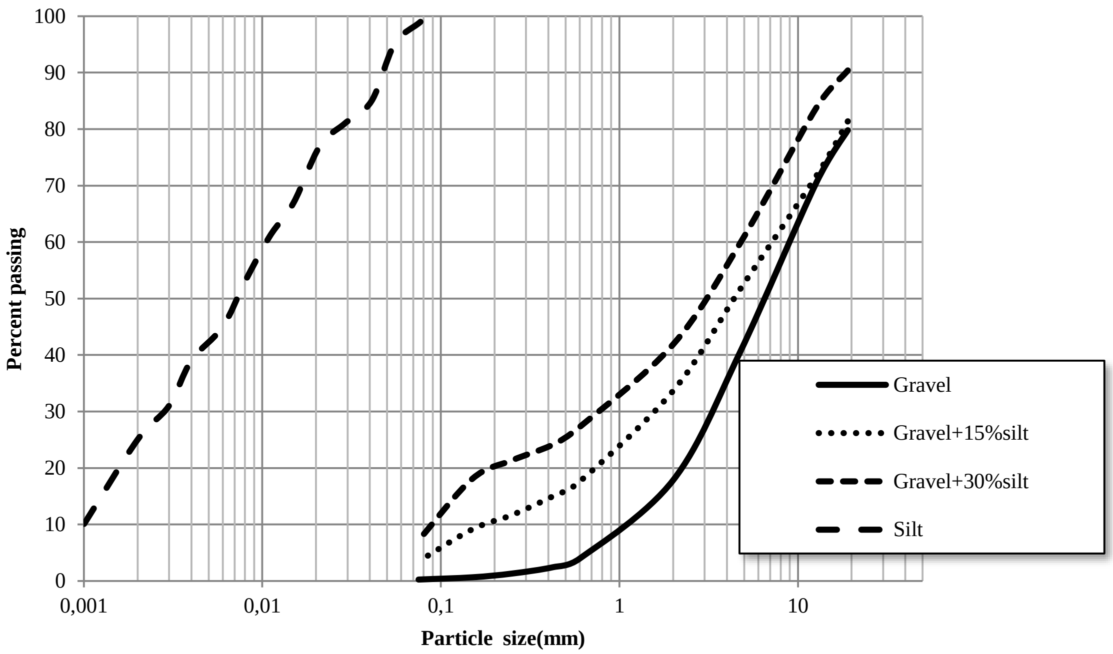

Figure 1. Grain size distribution for soils used in this study (Sadeghi azar et al., 2010).

Figure 2. Position of Til (mine of material) west of Shabestar City (www.earthgoogle.com)

As shown in Figure 1, the Gravel is in accordance with unified classification in group GW, and the silt is ML. The uniformity coefficient is C_U=9>4, indicating good grading gravel. Moreover, curvature coefficient is obtained by Cc=0.69. The Atterberg limit of the silt was PI=5 according to ASTM D4318-95a. Moreover, the values of special weight (Gs) of the materials was determined by ASTM D854 standard as given in Table 1. According to the results of XRD test, the gravel under study had a very low amount of lime, a high amount of quartz, and a little clay. The clay minerals included Kaolinites and illites. The geotextiles used in the study is one of the modern geotextiles used in geosynthetics (Secutex) industry, which is made of completely artificial fabric for long term resistance and is of un-weaved needled type. The geotextile mechanical properties used in the study are given in Table 2 (Sadeghi azar et al., 2010).

In the present study, California Bearing Ratio (CBR) were used for the tests. These tests were conducted based on ASTM D1883. Also, compaction test was performed on material according to ASTM D 698. The results of compaction tests are shown in diagrams of Figure 3.

Table 1. Specific gravity of materials in this study (Sadeghi azar et al. 2010)

Material	Gravel	Gravel+ 15%Silt	Gravel+ 30%Silt	Silt
Gs	2.72	2.68	2.6	2.63

Table 2. Engineering and index properties of geotextile reinforcement (Sadeghi et. al, 2010)

Properties	Values
Weight (g/m^2)	163
Thickness (mm)	0.9
Static puncture (CBR-test) N	2200
Dynamic cone drop (mm)	28
Tensile strength(kN/m)	15
Elongation at peak stress (%)	45-55

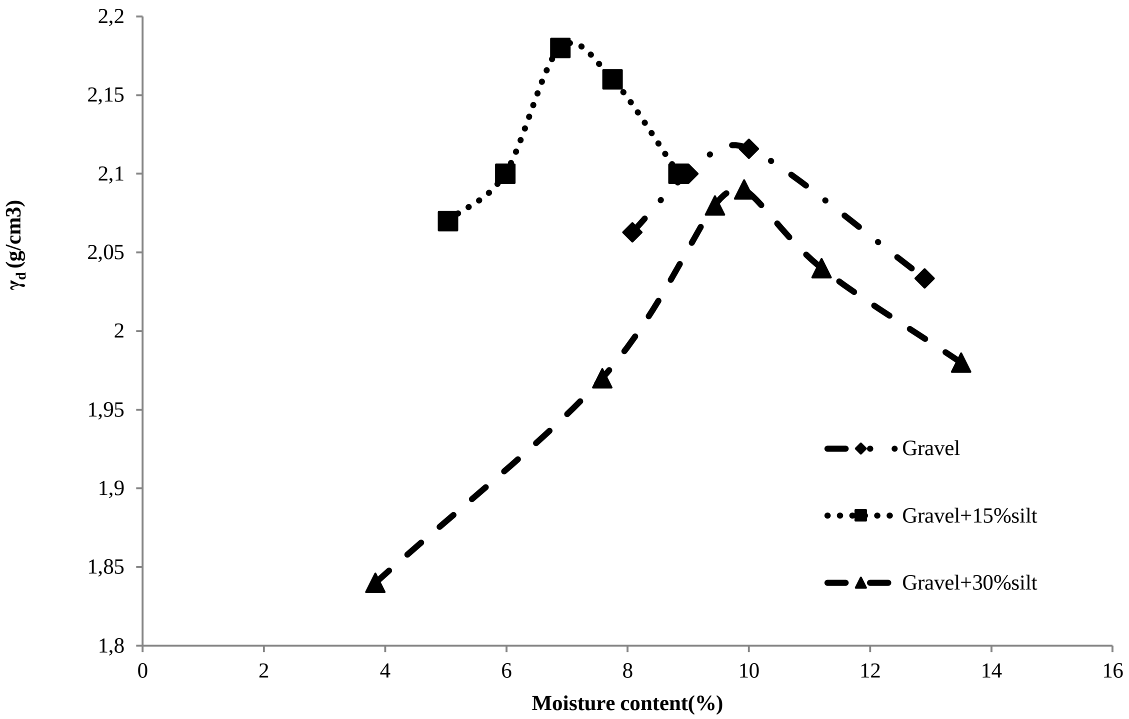

Figure 3. Dry weights values versus moisture content for soils used in this study (Sadeghi azar et al., 2010)

As mentioned above, tests were performed in three relative densities of 90, 95, and 100 percent and the effect of geotextile layer was studied in two position. In the first state, one geotextile layer was placed in the middle of the soil sample, and in the second position two geotextile layers were placed alternatively at equal distances in the sample soil. These position are observed in Figure 4. (Sadeghi azar et al., 2010)

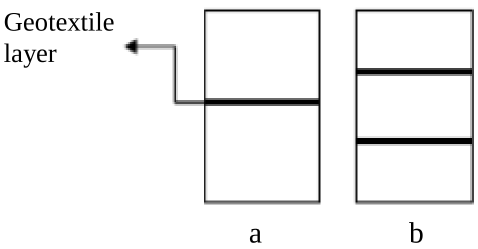

Figure 4. Geotextile positions in this study: a- one layer, b- two layers (Sadeghi azar et al., 2010)

CBR TESTS RESULTS

The results of CBR tests on reinforced and unreinforced soil specimens with different no plastic fines contents are presented below:

1) The amount of the force needed for the piston to penetrate into the specimens was studied without geotextile layers are shown in Figure 5. The results of tests indicated that the bearing capacity of specimens with different compounds increases with an increase in the relative density of the soil. Moreover, with an increase in the amount of non-plastic fines contents in the gravel, the bearing capacity decrease in general.
2) In continue, with placing a geotextile layer in the middle part of the materials, and two geotextile layers at a distance of one third in the sample soils under study. The results of tests are shown in Figures 6, 7, and 8.

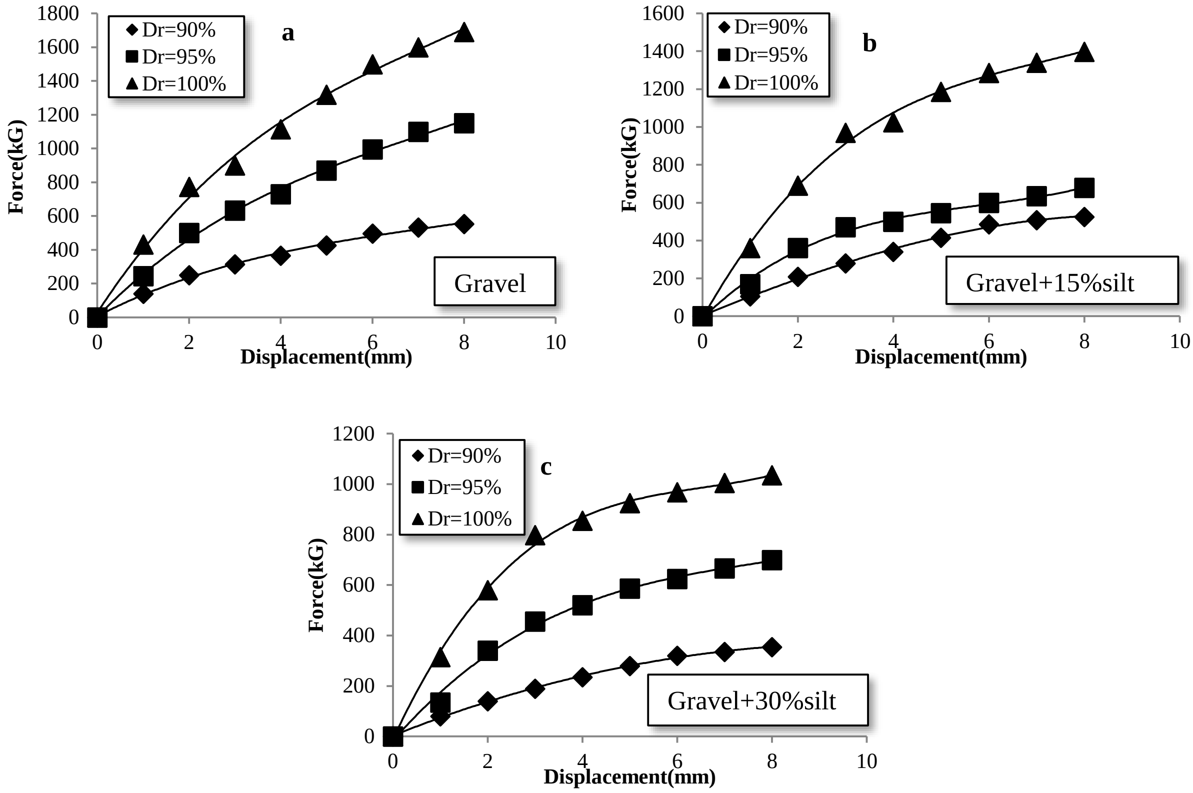

Figure 5. Effects of fines contents on bearing capacity of specimens without geotextile layer in several relative densities (Sadeghi azar et al., 2010)

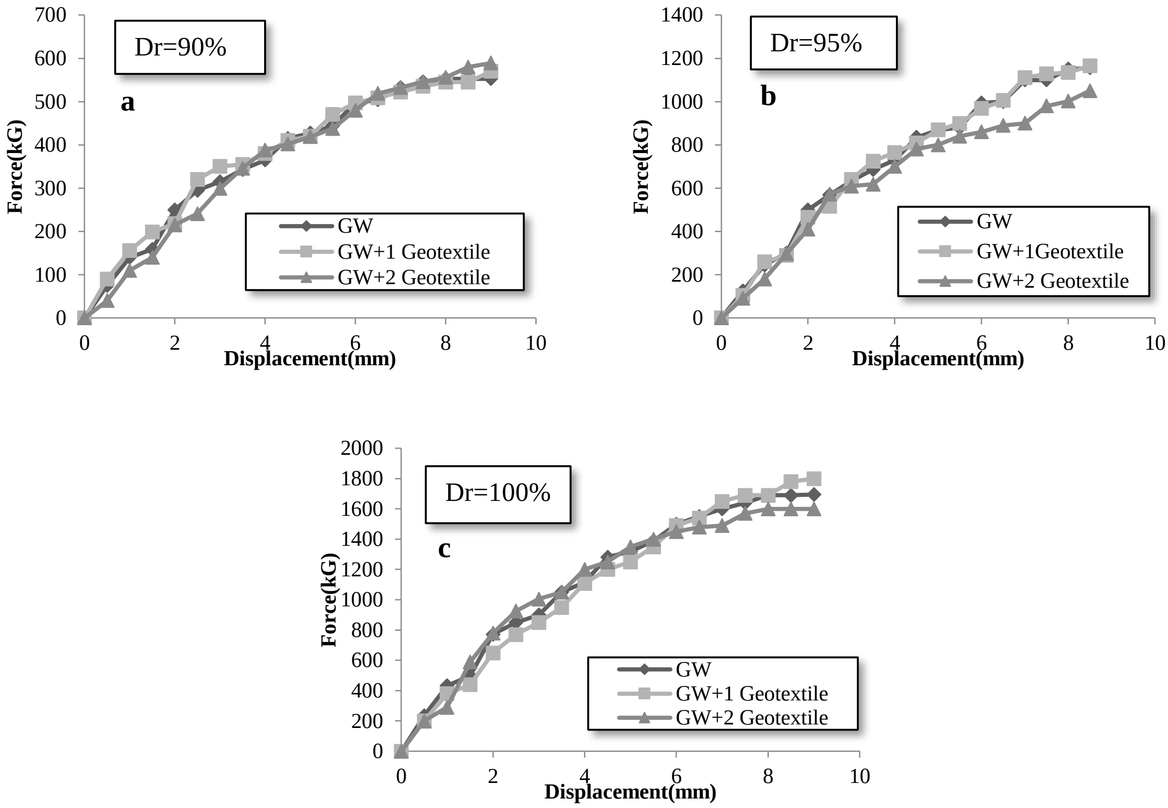

Figure 6. Comparison of gravel bearing capacity in reinforced and unreinforced position in several relative densities (Sadeghi azar et al., 2010)

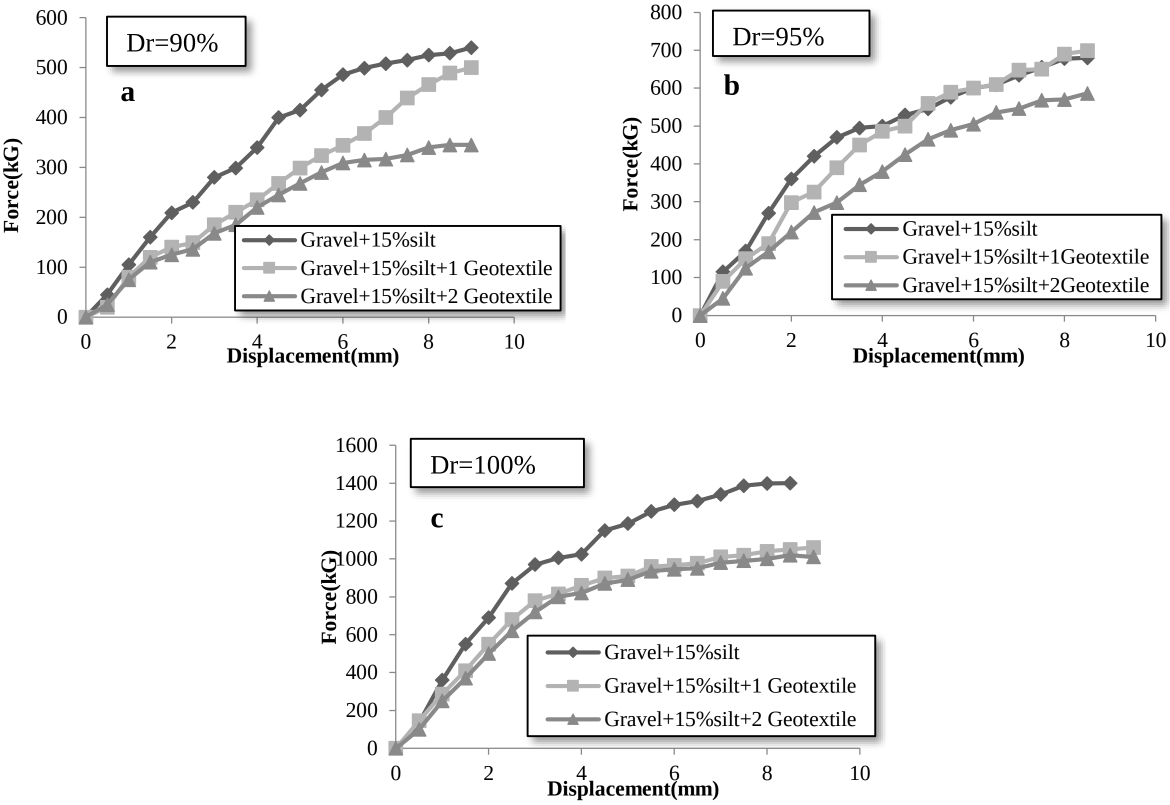

Figure 7. Comparison of gravel+15%silt bearing capacity in reinforced and unreinforced position in several relative densities (Sadeghi azar et al., 2010)

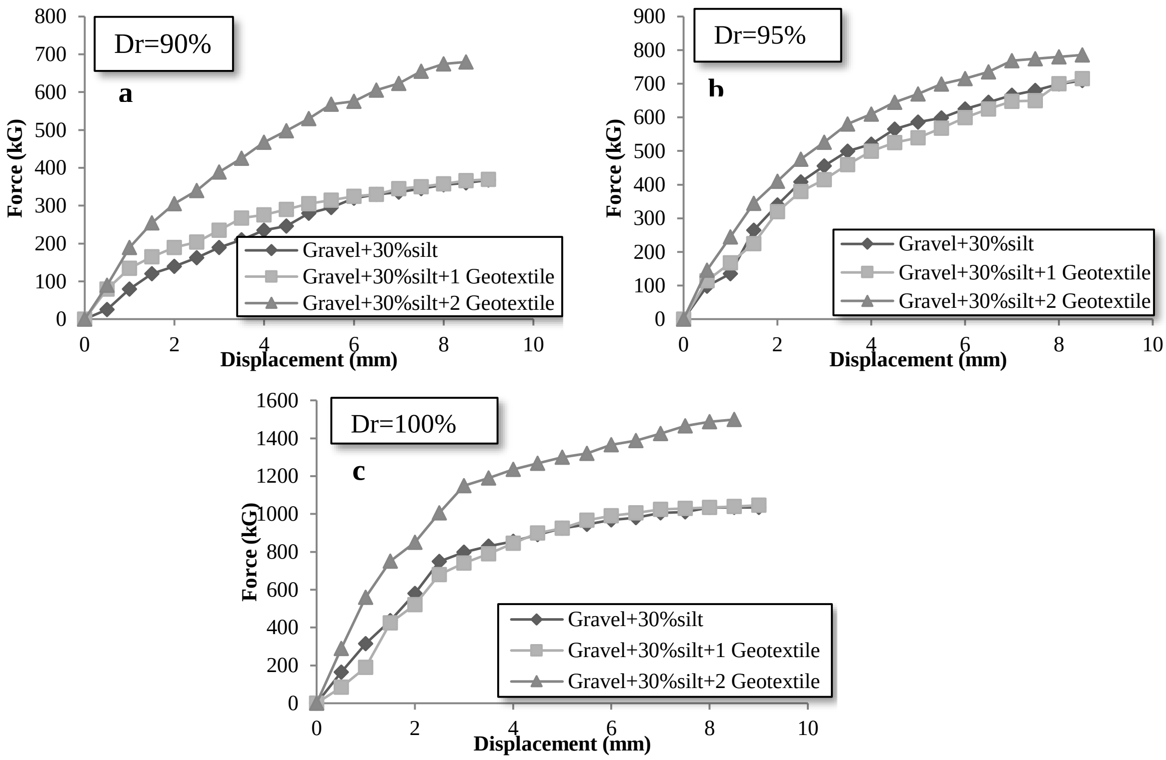

Figure 8. Comparison of gravel+30%silt bearing capacity in reinforced and unreinforced position in several relative densities (Sadeghi et al., 2010)

The Figures are given above indicate that:

a. With an increase in the relative density of the reinforced and unreinforced specimens, the amount of the force needed for the piston to penetrate increases.

b. With an increase of 15 and 30 percent of non-plastic fine contents in the gravely soils, the bearing capacity of the soil decreases gradually.

c. In gravely specimens, at equal relative densities, the bearing capacity of specimen a little increases. But, with placing two geotextile layers resistance decrease.

d. In the gravel+15% silt mixture, at equal relative densities, it is observed that by placing one and two geotextile layers, the bearing capacity of the soil decreases alternatively.

e. In the gravel+30%silt mixture, at equal relative density, it is observed that by placing one and two geotextile layers, the bearing capacity increases, indicating that the bearing capacity of the soil has improved.

f. Generally, with comparing the results, it can understand that at equal relative densities, by placing one and two geotextile layers in the soil specimens, the bearing capacity of the soil increases in comparison with the state in which geotextile layer is not inserted.

3) California Bearing Ratio (CBR) has been evaluated based on ASTM D1883 for the soil specimens and results are observed in Figures 9 and 10. Figure 9 indicates that California Bearing Ratio (CBR) decreases with an increase in the percentage of non-plastic fines content in the gravel. This trend is observed in all relative densities.

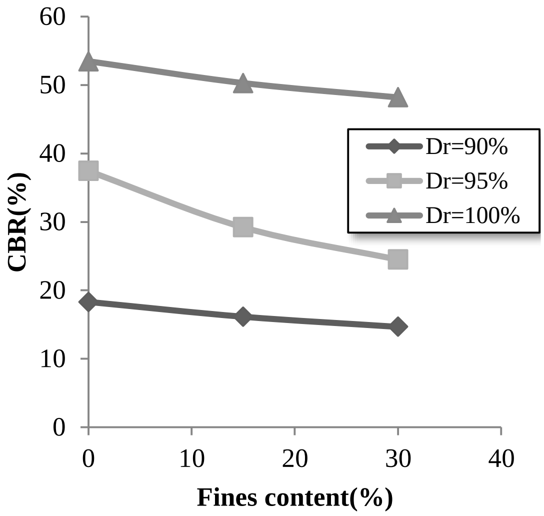

Figure 9. CBR values for various fines content in unreinforced specimen (Sadeghi et al., 2010)

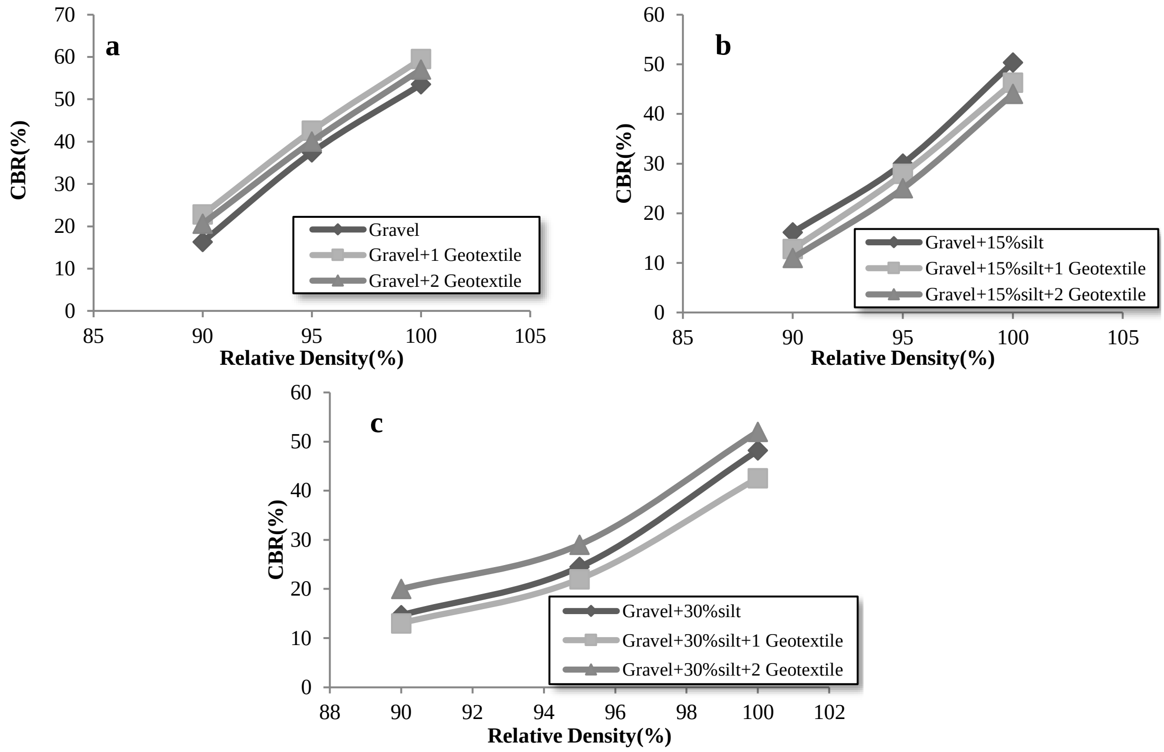

Figure 10. Effects of geotextile layers number on CBR values in specimens (Sadeghi et al., 2010)

Figure 10a show that, the value of CBR in gravelly soil increases with placing a geotextile layer. In continue, by placing two geotextile layers, California Bearing Ratio (CBR) decreases. As can be observed in Figure 10b, in gravel+15%silt mixtures, CBR decreases with placement one and two geotextile layers in specimens of soil continuously. Although, in gravel+30%silt specimens by inserting one geotextile layer the value of CBR decreases a little. But by putting two geotextile layers it increases (Figure 10c).

CONCLUSION AND DISCUSSION

The use of geotextiles in many engineering applications is an effective method in soil improvement. The Review of previous studies show that geotextiles increase bearing capacity in subgrade layer with fines content by being placed between the sub base layers and subgrade. The main purpose of the present study was the experimental study of the effect of the number of geotextile layers on the bearing capacity of the gravel with containing 15 and 30 percent of silt by using California Bearing Ratio (CBR) test. Generally, by observing the results it can be expressed that the resistance and bearing capacity of the gravelly soils containing silt depend on the ratio of gravel and silt mixture. When the percentage of the fine contents is low, and their only role is fillers between the granular particles, the existence of fine particles would not affect resistance greatly; however, if the dispersion of the fine particles is in a way that some of them work as separators between the granular particles, a rather unstable skeleton would be formed in comparison with the original skeleton of the gravel resistance and bearing capacity would decrease. With an increase in the percent of fine particles and when the granular particles are completely separated from each other, the effect of granular particles on bearing capacity of mixture can be disregarded. In this state, resistance is provided just only the fine particles. Therefore, with placement a geotextile layer in the mixture soils, the soils' improvement and increase in bearing capacity can happen. The reason is the fact that by placing one geotextile layer, the natural structure of the specimens do not change dramatically, and particles discontinuity do not happen in them. This increases the bearing capacity of the gravel and increases the resistance of the gravel with 30% of silt. However, it is recommended that further studies can be conducted on the number of geotextile layers and their arrangement in different soil compounds and specimens.

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