

PAPER DETAILS

TITLE: JEOTEKSTİL TABAKALARININ ÇAKIL-SILT KARISIMLARININ TASIMA KAPASI-TESI
ÜZERİNDEKİ ETKİLERİ

AUTHORS: Keramat SADEHGI AZAR,Rouzbeh DABIRI

PAGES: 61-69

ORIGINAL PDF URL: <https://dergipark.org.tr/tr/download/article-file/389887>

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

Keramat SADEGHI AZAR¹, Rouzbeh DABIRI²

¹Department of Engineering Geology, Ahar Branch, Islamic Azad University, Ahar, Iran

²Department of Civil Engineering, Tabriz Branch, Islamic Azad University, Tabriz, Iran

Corresponding author's email: rouzbeh_dabiri@iaut.ac.ir

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 subgrade 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 arasında 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, geogrids, 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).

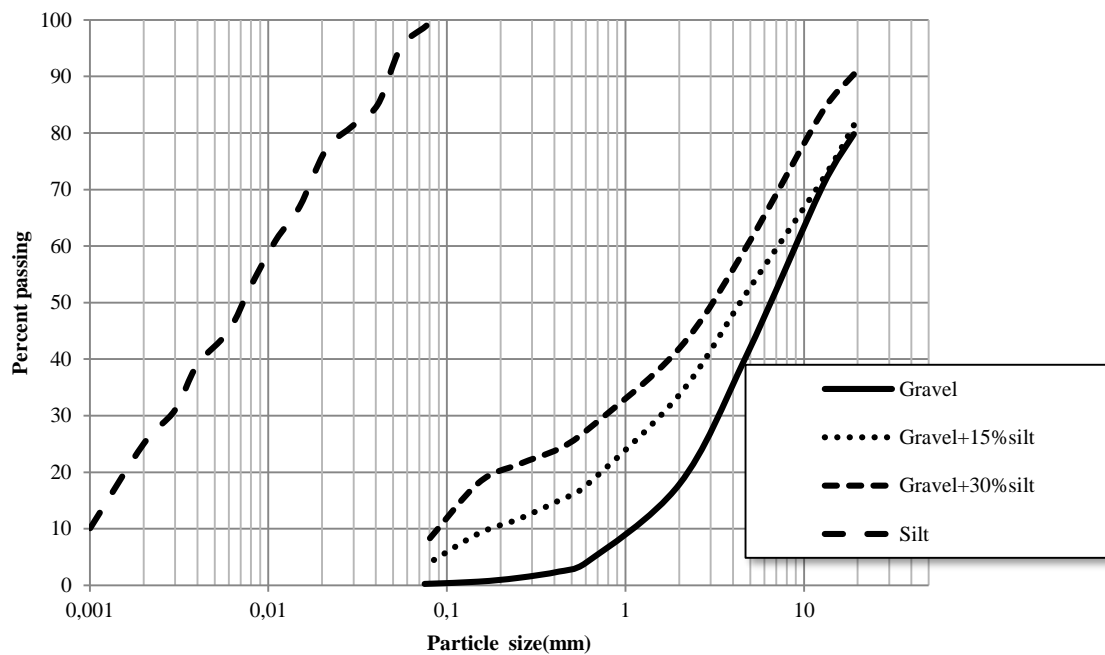


Figure 1. Grain size distribution for soils used in this study (Sadeghi azar et al., 2010).



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 $C_c=0.69$. The Atterberg limit of the silt was $PI=5$ according to ASTM D4318-95a. Moreover, the values of special weight (G_s) 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 |
|----------|--------|------------------|------------------|------|
| G_s | 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 |

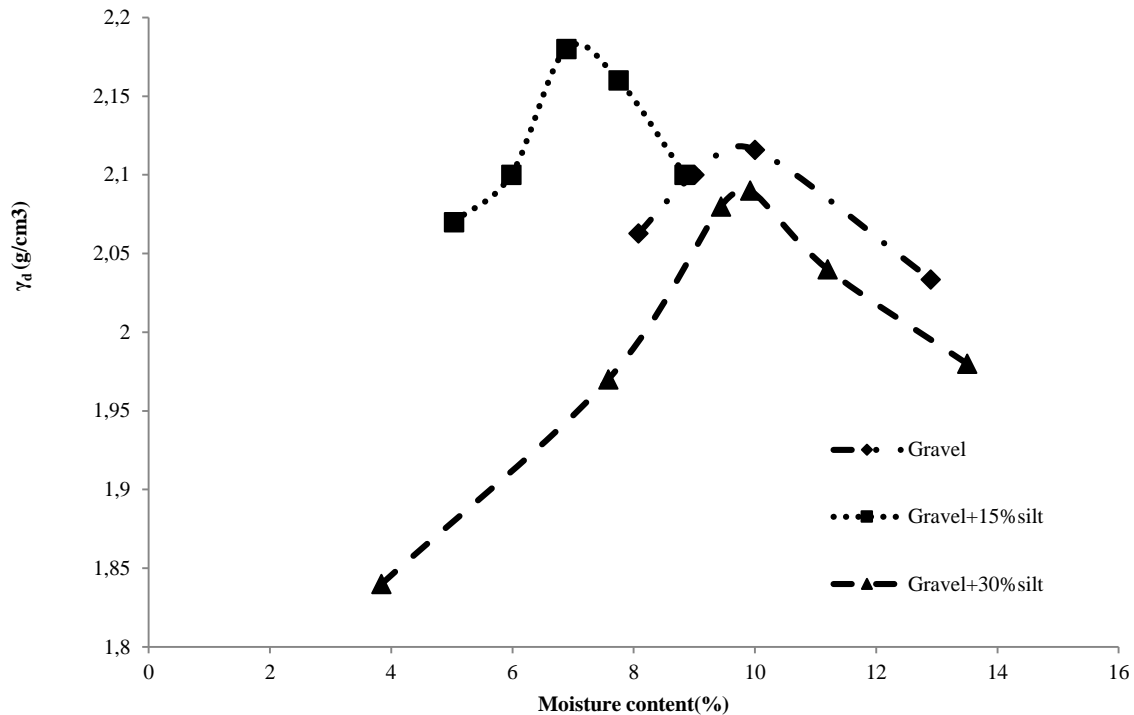


Figure 3. Dry weights values versus moisture content for soils used in this study (Sadeghi azar et al., 2010)

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)

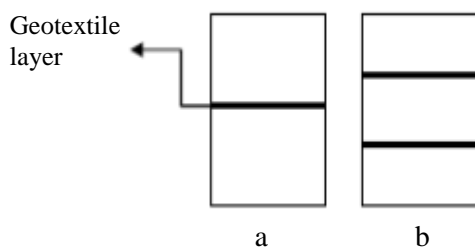


Figure 4. Geotextile positions in this study: a- one layer, b- two layers (Sadeghi azar et al., 2010)

CBR TESTS RESULTS

The results of CBR tests on reinforced and unreinforced soil specimens with different non-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.

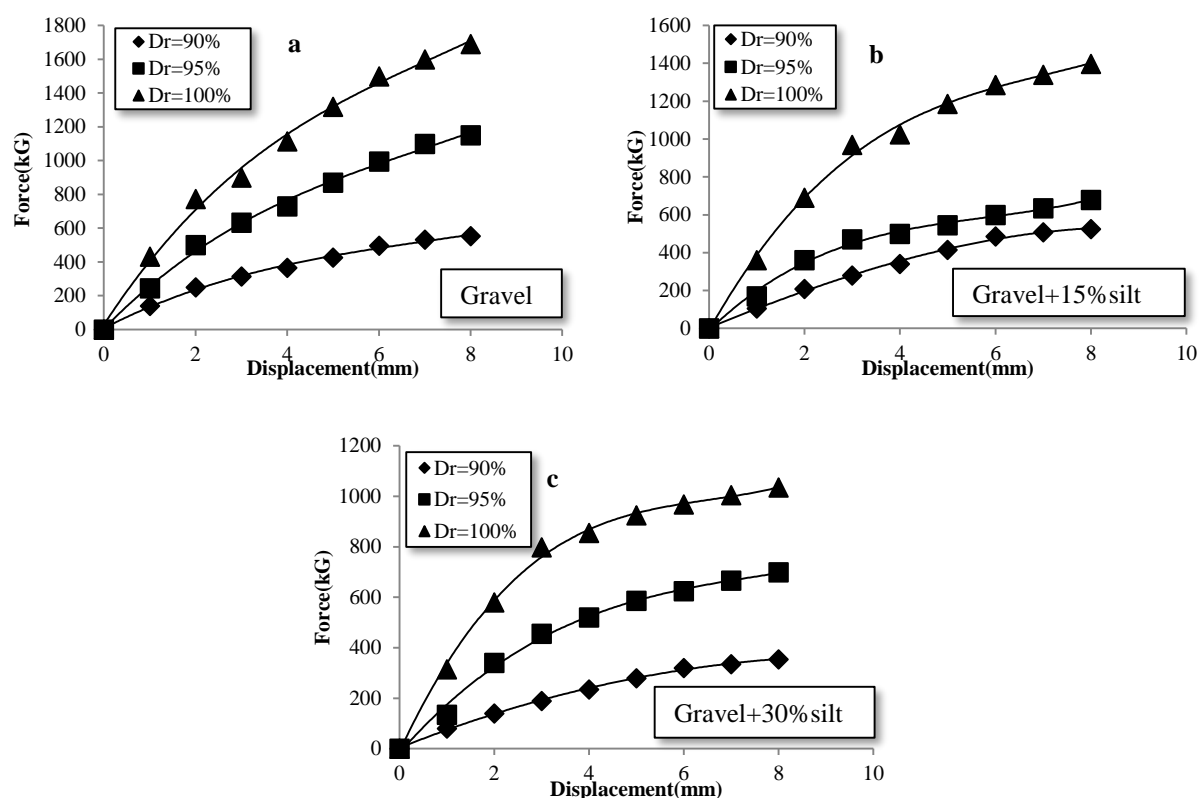


Figure 5. Effects of fines contents on bearing capacity of specimens without geotextile layer in several relative densities (Sadeghi azar et al., 2010)

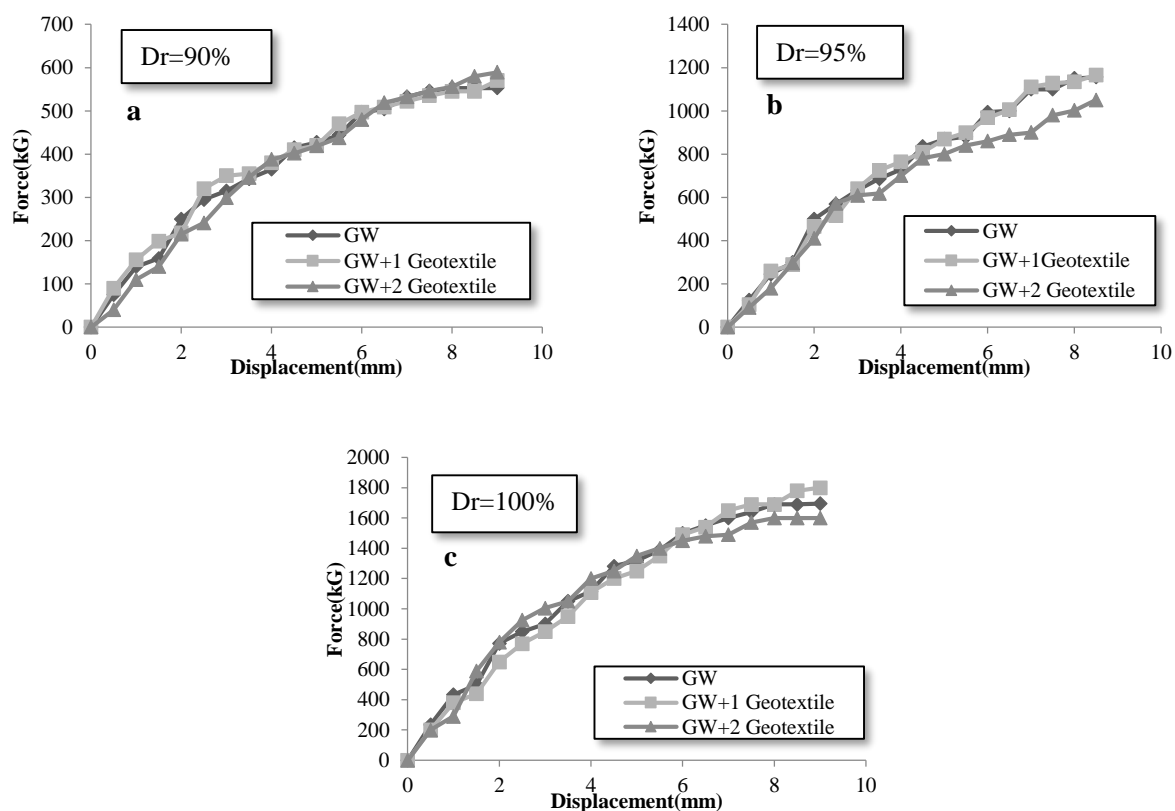


Figure 6. Comparison of gravel bearing capacity in reinforced and unreinforced position in several relative densities (Sadeghi azar et al., 2010)

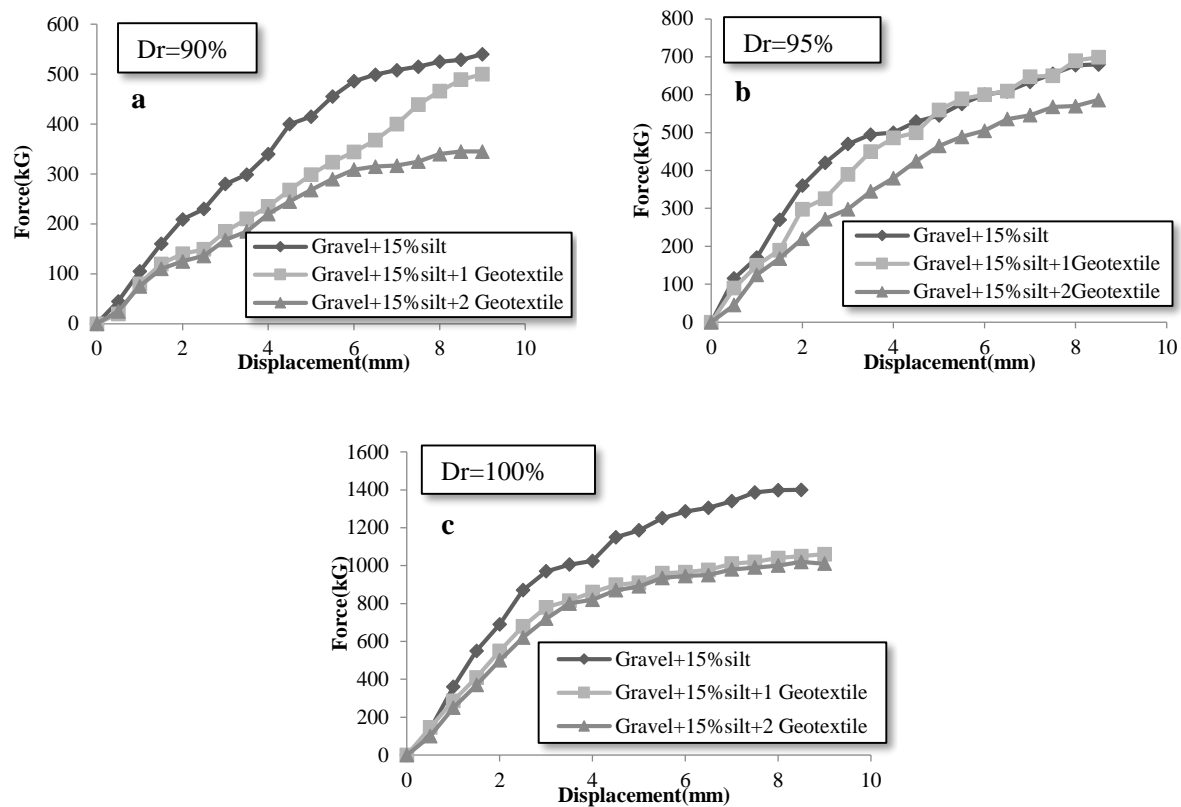


Figure 7. Comparison of gravel+15% silt bearing capacity in reinforced and unreinforced position in several relative densities (Sadeghi azar et al., 2010)

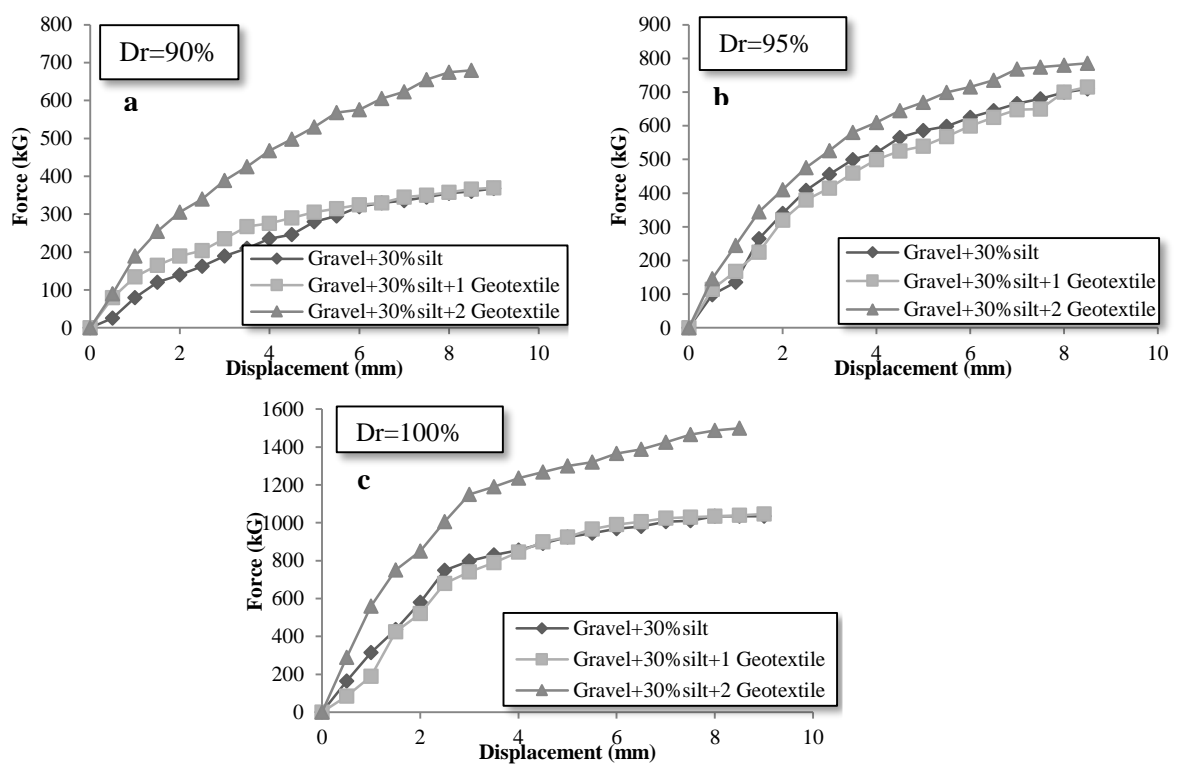


Figure 8. Comparison of gravel+30% silt bearing capacity in reinforced and unreinforced position in several relative densities (Sadeghi et al., 2010)

The Figures are given above indicate that:

- 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.
- With an increase of 15 and 30 percent of non-plastic fine contents in the gravelly soils, the bearing capacity of the soil decreases gradually.
- In gravelly specimens, at equal relative densities, the bearing capacity of specimen a little increases. But, with placing two geotextile layers resistance decrease.
- 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.
- 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.
- 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.

- 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.

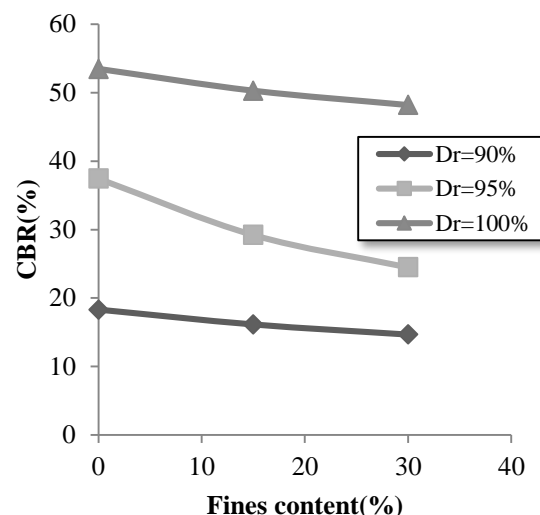


Figure 9. CBR values for various fines content in unreinforced specimen (Sadeghi et al., 2010)

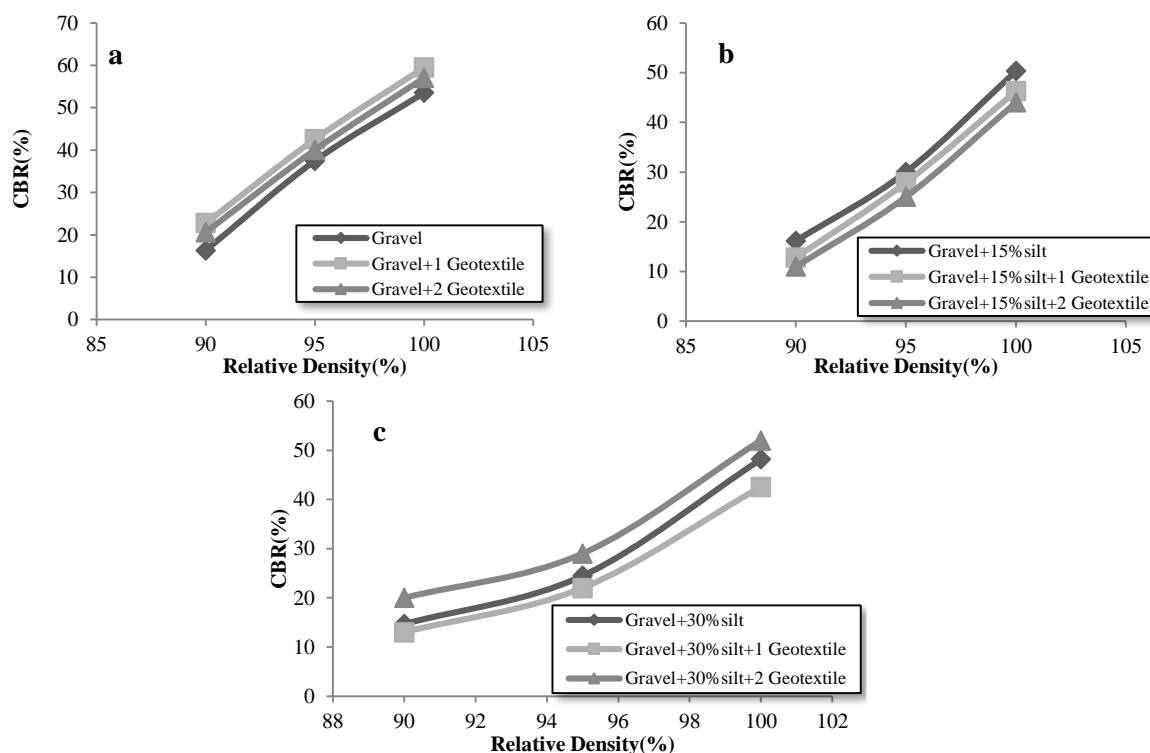


Figure 10. Effects of geotextile layers number on CBR values in specimens (Sadeghi et al., 2010)

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.

REFERENCES

1. YODER E. J., WITCZAK M. W. Principles of Pavement Design, Second Ed., Wiley Interscience, Newyork, 300-321, 1975.
2. RESL, S., WERNER, G., The influence of nonwoven needle- punched geotextiles on the ultimate bearing capacity of the subgrade, *Proceedings of the Third International Conference on Geotextiles*, Vol. 4, pp. 1009–1013, 1986, Vienna,
3. FANNIN, R.J., O. SIGURDSSON, Field observations on stabilization of unpaved roads with geosyntheticS, *ASCE Journal of Geotechnical Engineering*, 122, 7, 544-553, 1996.
4. BERGADO, D.T., S. YOUWAI, C.N. HAI, P. VOOTTIPRUEX, Interaction of nonwoven needle-punched geotextiles under axisymmetric loading conditions, *Geotextiles and Geomembranes*, 19, 299-328, 2001.
5. RAYMOND, G., ISMAIL, I., The effect of geogrid reinforcement on unbound aggregates, *Geotextiles and Geomembranes*, 21, 355-380, 2003.
6. PARK, T. and TAN S.A., Enhanced performance of reinforced soil walls by the inclusion of short fiber, *Geotextiles and Geomembranes*, 23, 348–361, 2005.
7. YETIMOGLU, T., SALBAS, O., A study on shear strength of sands reinforced with randomly distributed discrete fibers, *Geotextiles and Geomembranes*, 21,2, 103-110, 2003.
8. PATRA, C.R., DAS, B.M. and ATALAR C., Bearing capacity of embedded strip foundation on geogrid-reinforced sand, *Geotextiles and Geomembranes*, 23, 5, 454-462, 2005.
9. VARUSO, R.J., GRIESNABER, J.B. and NATARAJ, M.S., Geosynthetic reinforced levee test section on soft normally consolidated clays, *Geotextiles and Geomembranes*, 23, 4, 362-383, 2005.
10. HAERI, S.M., NOURZAD R. and Oskrouch A.M., Effect of geotextile reinforcement on the mechanical behavior of sands, *Geotextiles and Geomembranes*, 18, 6, 385-402, 2000.
11. ZHANG, M.X., JAVADI, A.A. and MIN X., Triaxial tests of sand reinforced with 3D inclusions, *Geotextiles and Geomembranes*, 24, 201-209, 2006.
12. LATHA, G.M. and MURTHY V. S., Effects of reinforcement form on the behavior of geosynthetic reinforced sand, *Geotextiles and Geomembranes*, 25, 23-32, 2007.
13. WILLIAMS, E.D. and OKINE, N. A., Effect of geogrid in granular base strength – An experimental investigation, *Construction and Building Materials*, 22, 2180-2184, 2008.
14. NAEINIE S. A. and MIRZAKHANLARI M., The effect of geotextile and grading on the bearing ratio of granular soils, *electronic journal of geotechnical engineering (EJGE)*, 13, 1-10, 2008.

15. NAEINIE S. A. and ZIAIE MOAYED R., Effect of plasticity index and reinforcement on the CBR value of soft clay, *International Journal of Civil Engineering*, 7, 2, 124-130, 2009.
16. SENTHIL KUMAR P. and RAJKUMAR R., Effect of geotextile on CBR strength of unpaved road with soft subgrade, *electronic journal of geotechnical engineering (EJGE)*, 17, 1355- 1363, 2012.
17. GOHARI M., DABIRI R. and RAZIZADEH F., Evaluation of geotextile effects on bearing capacity of granular soils based on California bearing ratio (CBR) test, MSC thesis of Engineering geology, Islamic Azad University, Ahar Branch, 2010. (In Persian)
18. ASTM C25-99, Standard Test Methods for Chemical Analysis of Limestone, Quicklime, and Hydrated Lime, Annual book of ASTM standards, 1999.
19. ASTM D421-85, Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants, Annual book of ASTM standards, 1985(reapproved 1998).
20. ASTM D422-63, Standard Test Method for Particle-Size Analysis of Soils, Annual book of ASTM standards 1963(reapproved 1998).
21. SADEGHI AZAR K., DABIRI R. and RAZIZADEH F., Study of geotextile layers effects in bearing capacity of granular soils with non-plastic fines content based on California bearing ratio (CBR) test, MSC thesis of Engineering geology, Islamic Azad University, Ahar Branch, 2010. (In Persian)
22. www.earthgoogle.com, Imagery ©2016 Digital Globe, Cnes/Spot Image, CNES / Astrium, Map data ©2016 Google
23. ASTM D 4318-95a, Standard test method for liquid limit, plastic limit and plasticity index for soils, Annual book of ASTM standards, 1995
24. ASTM D1883-93, Standard test method for CBR (California bearing ratio) of laboratory- compacted soils, Annual book of ASTM standards, 1993.
25. ASTM-D 698-00, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600 kN-m/m³)), Annual book of ASTM standards, 2000.