International Journal of Engineering, Management & Technology (IJEMT)
www.ijemt.com, Volume 1 Issue X, December 2022, PP 15-26, ISSN (Online): 2583 – 4517

Effect of Geotextile on Granular Soils

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ABSTRACT : *Geotextiles have been successfully used for reinforcement of soils to improve the bearing capacity. In this paper the geotextile as a tensional material have been used for reinforcement of granular soils. Laboratory California bearing ratio (CBR) tests were performed to investigate the load-penetration behavior of reinforced granular soils with geotextile. Samples of granular soil with different grading are selected and tested without reinforcement. Then by placing geotextile at certain depth within sample height in one and two layers, the effects of the number of geotextiles on the increase in bearing capacity of reinforced granular soils and grading on performance of geotextile is discussed. The result of these tests shows that, bearing ratio of reinforced granular soils with geotextile increases.*

KEYWORDS : *geotextile, CBR, granular soils, reinforced granular soils, grading.*

INTRODUCTION

The uses of geotextile in many engineering applications have become more apparent and have proven to be an effective means of soil improvement. In early applications in roads and airfield construction, emphasis was laid on the separation function of the geotextile. Resl and Werner (1986) carried out the laboratory tests under an axisymmetric loading condition using nonwoven, needle-punched geotextiles. The results showed that the geotextile layer placed between subbase and subgrade can significantly increase the bearing capacity of soft subgrades. Fannin and Sigurdsson (1996) carried out a full-scale field trial to observe the performance of different geosynthetics in unpaved road construction over soft ground. Numerous papers have examined the reinforcement of soil (Bergado *et al.*, 2001; Raymonda and Ismail, 2003; Park and Tan, 2005; Yetimoglu *et al*., 2005; Patra *et al.*, 2005; Varuso *et al.*, 2005); current research work mainly emphasize on the strength, mechanism and bearing capacity at the reinforced soil (Haeri*et al.*, 2000; Michalowski, 2004; Zhang *et al.*, 2006; Latha and Murthy, 2007; Williams and

* Corresponding Author: Vijay Shekhar
Published online on www.ijemt.com : Dec 13, 2022

Okine, 2008;) In this study, the CBR test carried out on nonwoven needle-punched geotextile combines with the granular soils with different grading, the geotextile reinforcement placed between three different subgrade layers and the comparison between bearing capacity of soil with and without geotextile reinforcement under axisymmetric loading condition were investigated.

DETAILS OF EXPERIMENTAL STUDY

The necessary details of the materials used, experimental set-up, tests conducted and the experimental procedures have been presented as follows.

MATERIALS

Three different compressible subgrades were used, these compressible bases were three of the five base types used by the ASHTTO(T27) standard method Granular soils with three different grading in the experimental study as founding material figure 1.

Almost all the soils consisted of granular materials. Compaction characteristics were determined in the laboratory using the standard ASTM D 698 method.

CBR TEST PROCEDURE

The soils was placed in three layers at the mold. Each of the layers was compacted by 56 blows of a 24.7N rammer dropped from a distance of 304 mm. In the tests, thickness of the compacted layers were 39 mm. A nonwoven geotextile sheet (Fibretex F-32) produced from polypropylene raw material was used at the interface (i.e., between layer) as reinforcement, provided by the manufacturers are given in Table 2.

The standard CBR test was selected, so that a comparative analysis between the current test and previous test results without the use of geosynthetic can be interpreted. Furthermore, the geotextile thickness and boundary effect can have influence on the final outcome, but any change of in condition, will make it difficult for comparative analyses.

Therefore, the current values can be treated more as a relative measurement. It is to be noted that the choice of the CBR test apparatus as the testing platform brings some inherent problems into the experimental study. Small size of the CBR test apparatus limits the size of the geotextile sheet. End effect in such a small sample size can be more pronounced than that of the other large- scale model tests when materials having maximum particle sizes greater than a certain value (i.e.,19 mm) are to be tested, the test method provides for modifying the gradation of the material the modified material may have significantly different strength proper- ties than the original material. Despite these limitations, a large experience base has been developed using the CBRtest, and some satisfactory design methods are in use based on the test results.

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Figure: CBR Test apparatus and filling soil sample with geotextile layer

FIGURE AND TABLES

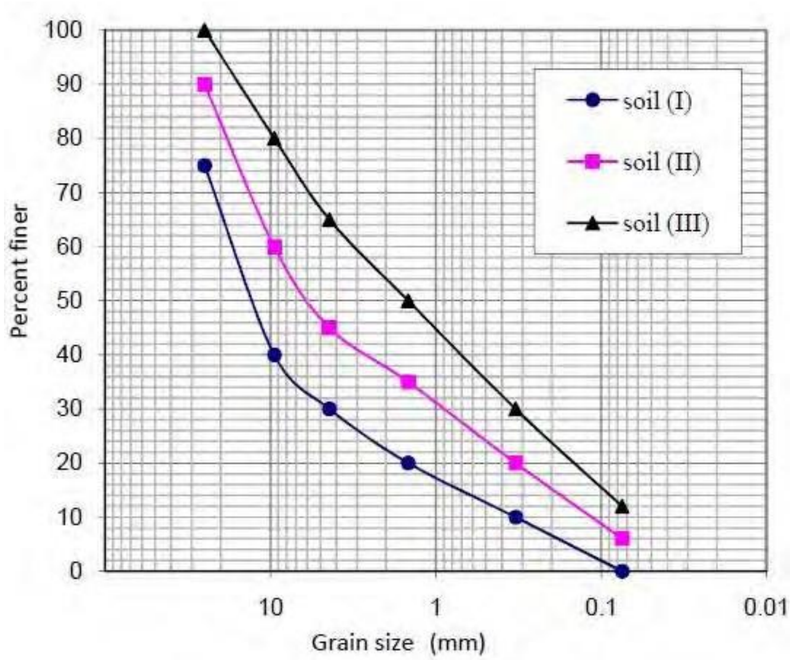


Figure: Grain size distribution of the Granular soils

Table 1: Properties of soil

	Soil (I)	Soil (II)	Soil (III)
Optimum moisture content (%) Dry	6.5	7.2	7.4
unit weight of soil (kN/m^3)	19.38	22.65	22.6

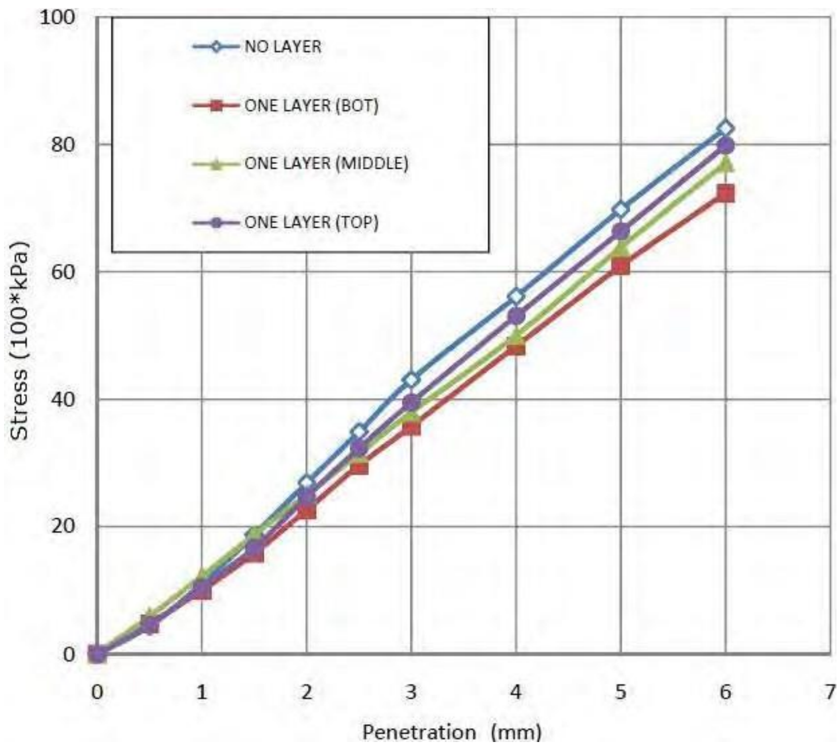
Table 2: Engineering and index properties of geotextile

Weight (g/m^2)	175
Thickness (mm)	0.9
static puncture (CBR-test) *N*	2000
Dynamic Cone drop (mm)	28
Tensile strength (kN/m)	13
Elongation at peak stress (%)	45–50

RESULT AND DISCUSSION

The experimental moisture content and the dry densities were the result achieved during the compaction of the soil samples for the determination of the CBR using the geosynthetic material. The CBR test was conducted on each soil sample as close to the optimum moisture content (OMC) as possible. Samples for the CBR were compacted according to ASTM D 698 (MethodsB and D). After the CBR test, the CBR values were obtained by computing the penetration stressin kPa, and plotting a curve of penetration resistance (stress) vs. penetration for un-reinforcement and reinforcement samples. Figures 2–10, respectively illustrate the stress-penetration curves for the three soil samples.

Figure 2: Stress vs. penetration for reinforced soil (I) in no and one layers states



The curves for both the un-reinforcement and reinforcement were plotted on the same graph to facilitate comparisons. The penetration resistance for 2 mm, 5 mm and 5 mm were obtained from the curve and the corresponding CBR for both the un-reinforcement and reinforcement samples calculated by dividing the penetration stresses by the standard stresses' of 1000 psi (6900 kPa) and 1500 psi (10,300 kPa) respectively and multiplying by 100. The desired CBR value was chose as the greater of the computed values at 2.5 mm and 5 mm penetration. The calculation of the CBR is based on the following equation.

$$CBR = \frac{\text{Stress (kPa)}}{\text{Standard Stress (kPa)}} \times 100$$

The load–penetration curves obtained from the CBR tests for unreinforced and reinforced system with the geotextile are shown in Figure 2-10. The mobilization of soil strength via reinforcing geosynthetic material is based on the general lateral restrains caused by the frictional inter- action and interlocking between soil sample and geosynthetics. The strength mobilization due to the inclusion of geosynthetics was very unique in the soil samples with very low CBR.This is noticeable for both the soil(II) and soil(III) samples. In the case of the soil(II) sample the highest increase in the CBR was recorded by sample of (one layer bot.), when reinforced with geosynthetic material which has the lowest CBR of 97.5%(no layer). In the case of the soil (III) sample, the highest CBR when reinforced with geosynthetic material was recorded by sample of (one layer middle), which has the lowest CBR of 43.8% (no layer).

CBR TEST APPARATUS

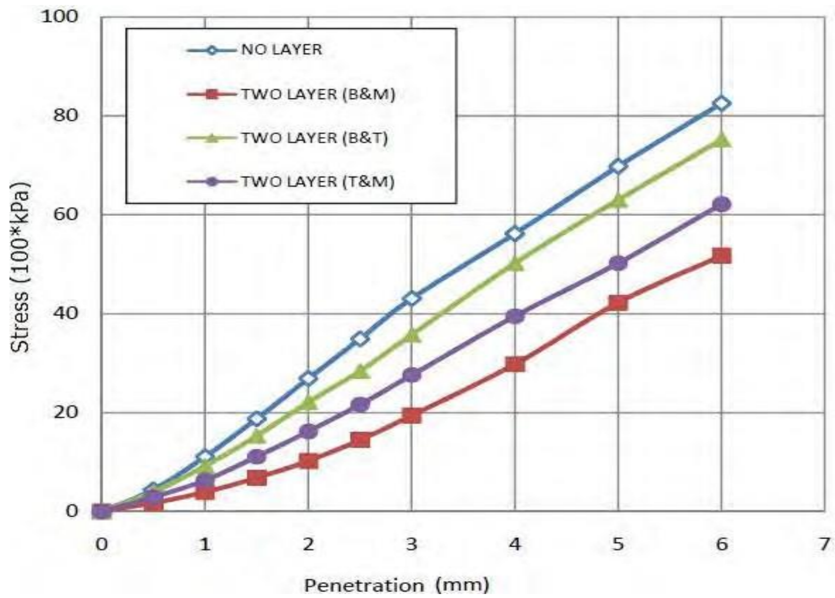


Figure 3: Stress vs. penetration for reinforced soil (I) in no and two layers states

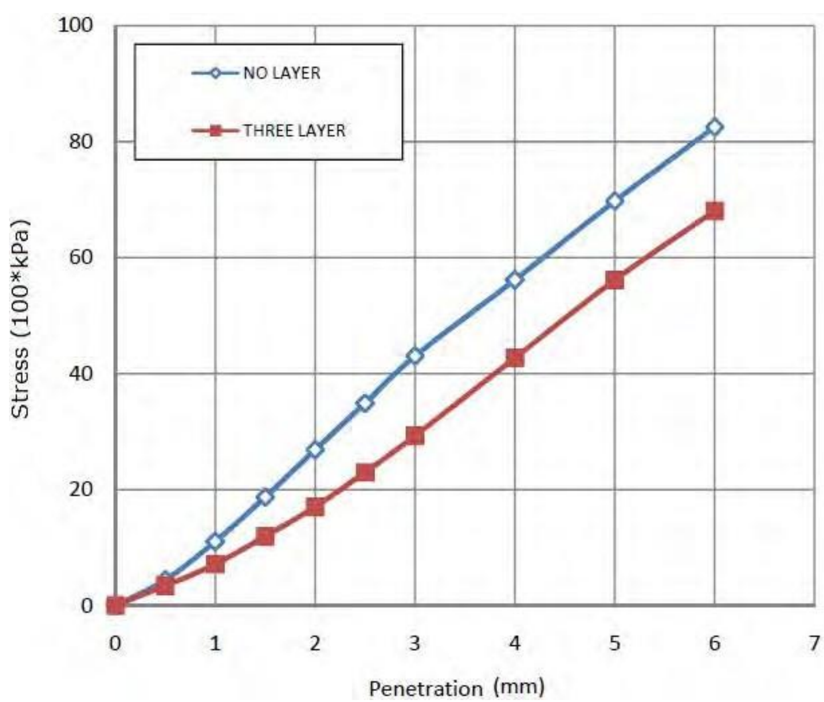


Figure 4: Stress vs. penetration for reinforced soil (I) in no and three layers states

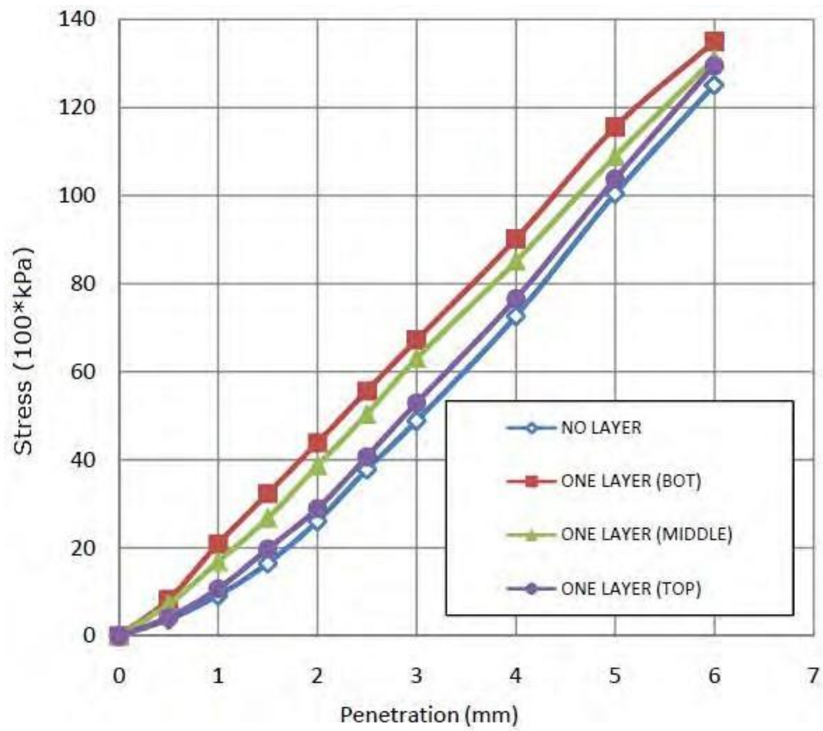


Figure 5: Stress vs. penetration for reinforced soil (II) in no and one layers states

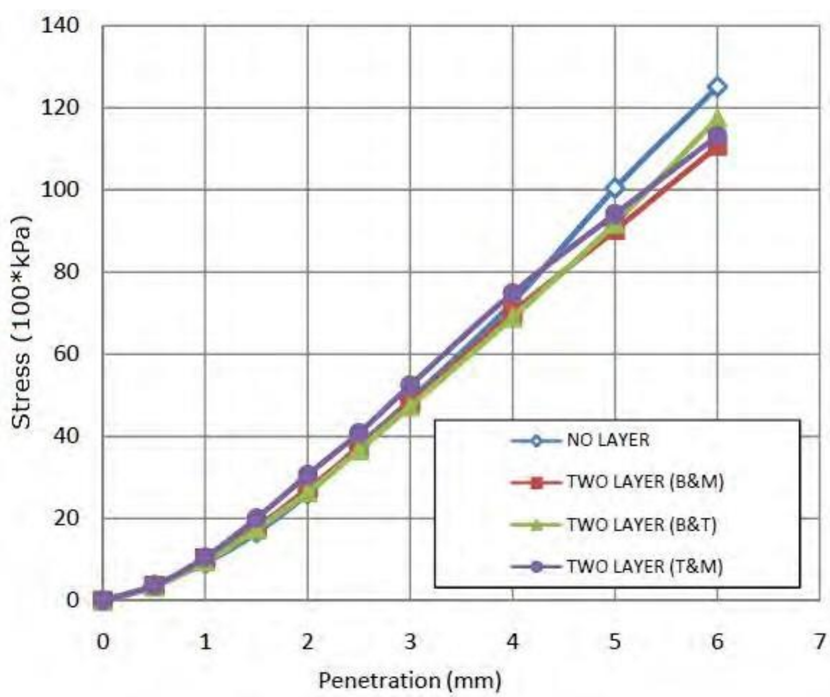


Figure 6: Stress vs. penetration for reinforced soil (II) in no and two layers states

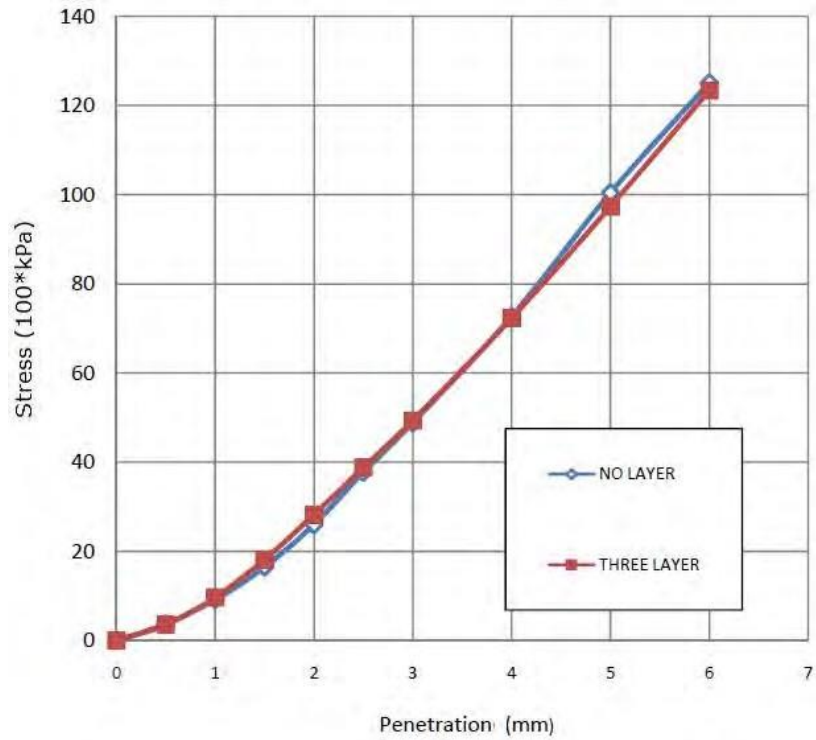


Figure 7: Stress vs. penetration for reinforced soil (II) in no and three layers states

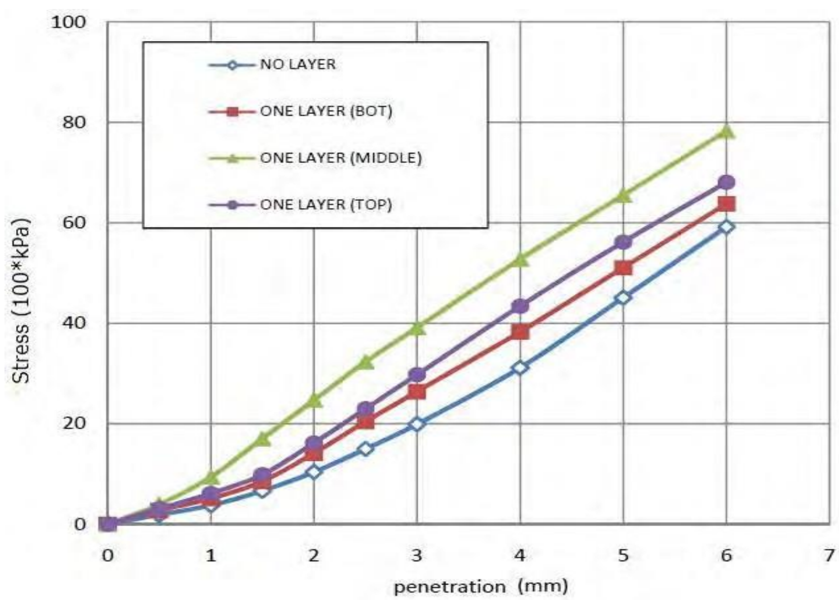


Figure 8: Stress vs. penetration for reinforced soil (III) in no and one layers state

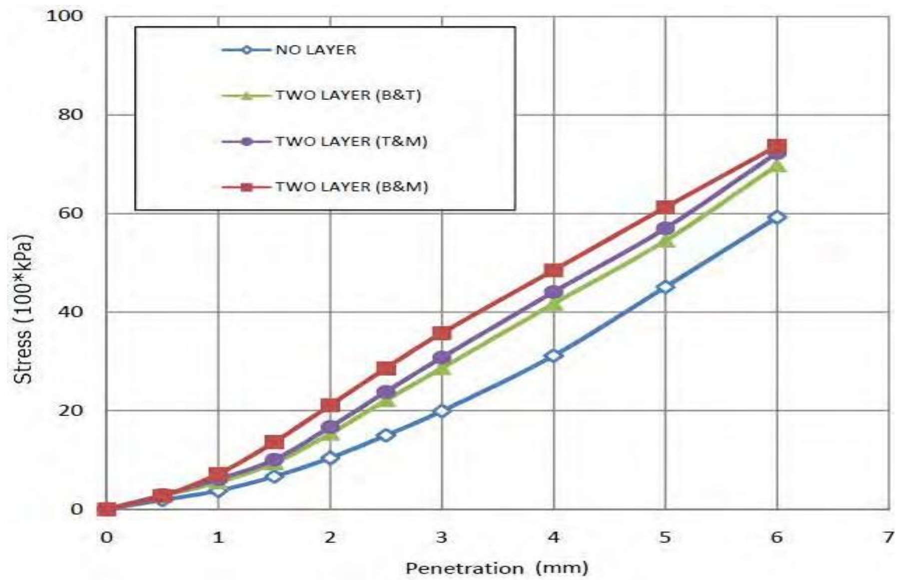


Figure 9: Stress vs. penetration for reinforced soil (III) in no and two layers states

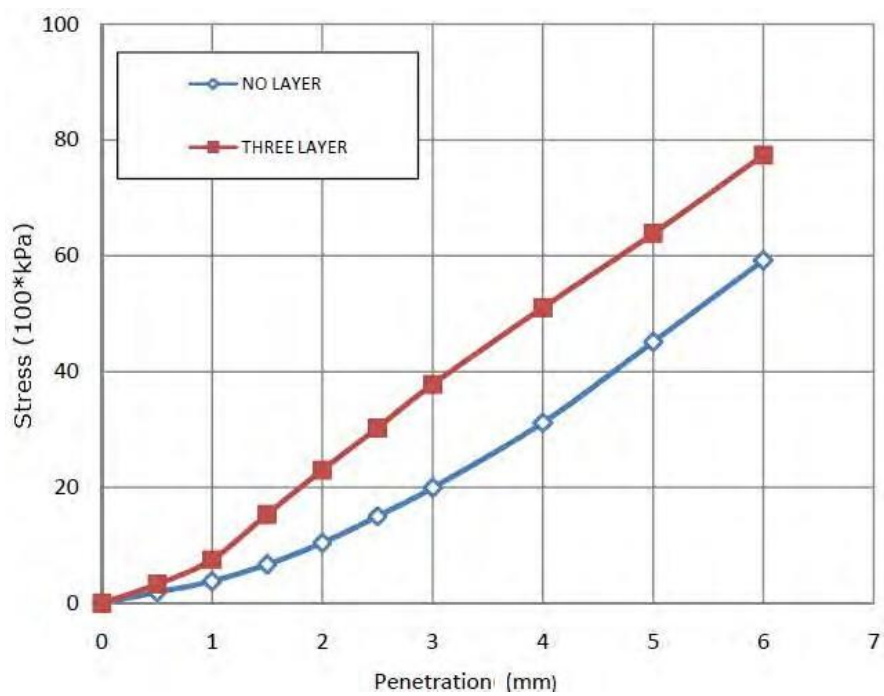


Figure 10: Stress vs. penetration for reinforced soil(III) in no and three layers states

This observation confirms the strength mobilization principle of the geosynthetic materials in general which emphasized that the strength mobilization of reinforcing geosynthetic material very much depends on the range of CBR of soil sample. The smaller the soil sampleCBR the more effective the strength mobilization effects of geosynthetic material in general.This is evident from Table 3.

Table 3: CBR test results for Soil (I), Soil (II), Soil (III) with and without geotextiles

Number of geotextile layers	Soil (I)	Soil (II)	Soil (III)
NO LAYER	67.7%	97.5%	43.8%
ONE LAYER (BOT)	59.1%	112.2%	67.7%
ONELAYER (MIDDLE)	61.9%	105.7%	89.2%
ONE LAYER (TOP)	64.4%	101%	76.3%
TWO LAYER (B&M)	40.9%	87.6%	95.8%
TWO LAYER (B&T)	61.1%	89.2%	66.1%
TWO LAYER (T&M)	48.7%	91.4%	83.1%
THREE LAYER	54.5%	94.5%	65.8%

CONCLUSION

A series of CBR test was under taken to investigate the effect of geotextile and grading on the bearing ratio granular soils. the major inclusion from this study are summarized as follows:

1. The inclusion of reinforcing geotextile materials in soils improves the CBR and therefore the strength of soils. It implies that geotextile-reinforced soils in unpaved roads will perform better than unreinforced ones and increase load carrying capacity of soils.

2. The **i**mprovement of soil strength and CBR with geotextile material depends on the soil grading. The effect is significant for soil with more fine percent.

3. The introduction of geotextile reinforcement in soils leads to decreased surface penetration and deformation and improved the stress distribution on the soil sample.

4. In a uniform deposit of granular soil (III) the introduction of a single layer of geotextile reinforcement in to the middle of soil increases signification CBR values and soil strength.

5. In soil sample (I) using of geotextile will cause interlocking between grain of soil decrease and as a result will decrease CBR value of soil.

ACKNOWLEDGEMENT

We are thankful to my guide and group member who helped and supported me during this work. I we also extend my heartfelt thanks to my family and well-wishers.

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