BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Publicat de
Universitatea Tehnică „Gheorghe Asachi” din Iaşi
Volumul 63 (67), Numărul 3-4, 2017
Secția
HIDROTEHNICĂ

INFLUENCE OF DEGREE OF COMPACTION AND SURCHARGE ON CBR VALUE OF GEOGRID REINFORCED CLAY AND SANDY SOILS

BY

PARVEEN KUMAR, A.K. SAHU[*] and AJEET

Department of Civil Engineering, DTU, New Delhi

Received: July 28, 2017
Accepted for publication: August 31, 2017

Abstract. In the present investigation, CBR tests were carried out on sandy and clay soils. With these two types of soils , geogrid is also used as reinforcement at different positions. Here surcharge and degree of compaction are also two variable factors. Effect on the CBR value is to be observed at increase in surcharge and degree of compaction on reinforced clay and sandy soils. It was reported that with increase in surcharge and degree of compaction CBR value of soil also increased. The optimum result comes out when, increased surcharge, degree of compaction, and geogrid in a single stage. Morphology of the soil has been studied by Scanning Electron Microscope (SEM).

Keywords: CBR; reinforced soils; surcharge; degree of compaction; Scanning Electron Microscope (SEM).

1. Introduction

Subgrade is the native material underneath a constructed road, pavement or railway track. A good quality of subgrade is not available

[*]Corresponding author: *e-mail*: pkumar@gmail.com

everywhere then either it is replaced or providing some chemical or mechanical treatment, the subgrade can be made suitable for foundation purpose. To improve the subgrade, geosynthetic materials such as geotextile and geogrid can be used. Here it is focused on three variables the degree of compaction, increment of surcharge and use of geogrid. The CBR test were conducted with combination of above three variables and find out the improvement in the soils. CBR was developed by California Division of Highway. This method is used as the classifying and evaluating the base course and subgrade soil material for the flexible pavements. This is an empirical test used to determine the material properties. It measures the strength of the soil subgrade. CBR value is extensively to be used for field correlation of the flexible pavement thickness requirement. Here CBR values are find out with varying factors such as degree of compaction, increment of surcharge and use of geogrid. Degree of compaction affects the void ratio, dry density and other soil parameters widely. As it is find out that there will be more degree of compaction or by applying more compactive efforts, then the air present in the void of soil is comes out from the pores of soil and soil will rearrange itself in a better compact structure . Surcharge is the load applied on the soil either permanently or temporary. Surcharge is also another factor that affects the behavior of soil in various conditions. Surcharge can be applied on the existing subgrade by placing a large mass of soil on it or by mechanically with the help of jacks. Geogrid are just like a net having large opening made of polymers likes as high density polyethylene and polypropylene etc. These opening are to be called as apertures. These apertures allow the geogrid to makes better interlocking with the soil and boulders such that it works as reinforcement. Geogrid are generally provided at the base of subgrade.

2. **Material Used**

Two types of soil are to be used for investigation *i.e.* sand and clay. In addition with these two soil geogrid is used as reinforcement. General physical properties of these soils and geogrid are given below as:

Table1

Physical Properties of Clay Soil

Properties	Value
Maximum dry density, [KN/m^3]	18.20
Optimum moisture content, [%]	16.00
Liquid limit, [%]	48.00
Plastic limit, [%]	26.00
Plasticity index, [%]	22.00
Specific gravity	2.63
Classification of soil	CI

Table 2
Physical Properties of Sandy Soil

Properties	Value
Maximum dry density, [KN/m^3]	17.74
Optimum moisture content, [%]	9.74
Liquid limit, [%]	NA
Plastic limit, [%]	NA
Plasticity index, [%]	NA
Specific gravity	2.67
Coefficient of uniformity (C_u)	3.34
Coefficient of curvature (C_c)	1.25
Classification of soil	SP

Table 3
Properties of Geogrid

Properties	Value
Weight/Area, [N/m^2]	3.05
Aperture length, [m]	0.04
Aperture width, [m]	0.31
Aperture thickness, [m]	0.01
Thickness at junction, [m]	0.004
Tensile strength @ 2% strain, [KN/m]	6.00
Tensile strength @ 5% strain, [KN/m]	11.80
Ultimate tensile strength, [KN/m]	19.10
Flexural stiffness, [KN/m^2]	0.75
Colour of geogrid	Black

Source: Garware Wall Ropes Limited Kirti Nagar, New Delhi.

3. Experimental Investigation

3.1. Introduction

The scope of the investigation was to study the influence of degree of compaction and surcharge on CBR value of geogrid reinforced clay and sandy soils. Therefore a total 42 numbers of CBR tests were conducted on reinforced and unreinforced soils. The laboratory tests performed included CBR test, light and heavy compaction test, direct shear test etc.

CBR test conducted on reinforced and unreinforced soils. Methodology used to carried out these tests is such as:

1. To find out the general properties of subgrade soil (*i.e.* clay and sandy soil) and Geogrid.
2. Find MDD by Standard Proctor test.
3. Find out CBR value for soaked and unsoaked sample at different surcharge load *i.e.* 5 kg, 7.5 kg and 10 kg.

4. Find out CBR value Geogrid reinforced sample at different location at different surcharge.

5. Variable quantities are:

– Surcharge.
– Methods of compaction.
– Position of geogrid (At 0.50 H and 0.67 H from the top of mould).
– Soil (sandy and clay)

Draw the different curve for CBR and analyses them.

3.2. California Bearing Ratio (CBR) Test

CBR test was developed by California Division of Highway. This method is used as the classifying and evaluating the base course and subgrade soil material for the flexible pavements. This is an empirical test used to determine the material properties. It measures the strength of the soil subgrade. It consist of a standard piston of area 0.1962 m^2 (diameter is 50 mm) is penetrate in the soil at the standard rate of 1.25 mm/min. CBR value is equal to the ratio of load carried by the specimen at 2.5 mm or 5 mm penetration to the load carried by the standard specimen. The standard loads of crushed stones are 1,370 kg (7,000 KN/m^2) and 2,055 kg (10,500 KN/m^2) at 2.5 mm and 5 mm penetration respectively.

CBR value as percentage of actual load cause penetration of 2.5mm or 5mm to the standard load is shown below as:

$$\text{CBR} = \frac{\text{Load carried by the specimen}}{\text{Load carried by standard specimen}} \times 100.$$

In most of the cases the CBR value decreased as we increased penetration. Generally CBR value at 2.5 mm is to be taken but if it comes out greater at 5mm than at 2.5 mm then to conform it test is to be repeat again. CBR measures the resistance of material against the penetration of standard plunger in controlled moisture and density condition.

3.3. Test Results and Discussion

3.3.1. *Scanning Electron Microscope (SEM) Results*

SEM is performed at three scales (5 µm, 10 µm, 20 µm) and at two scales (200 µm, 500 µm) for clay and sand. From the Figs. 1,…,5 it is observed that soil particles are angular in nature and have some silica in case of sand and in case of clay soil particles are plate like structure and having more surface area.

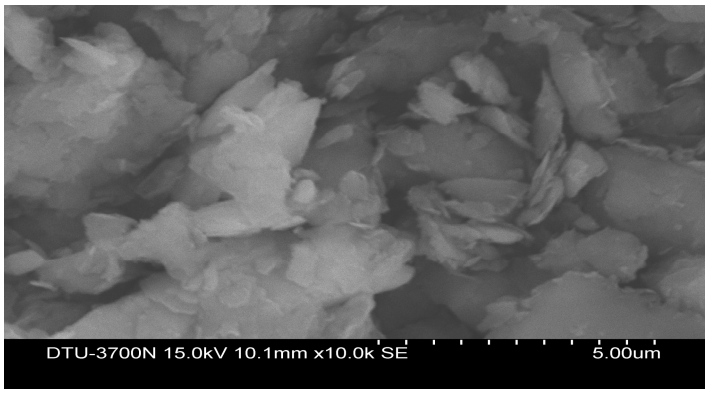

Fig. 1 – SEM of clay at 5µm.

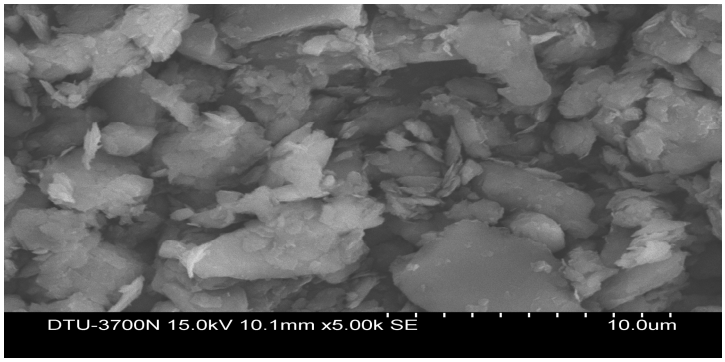

Fig. 2 – SEM of clay at 10 µm.

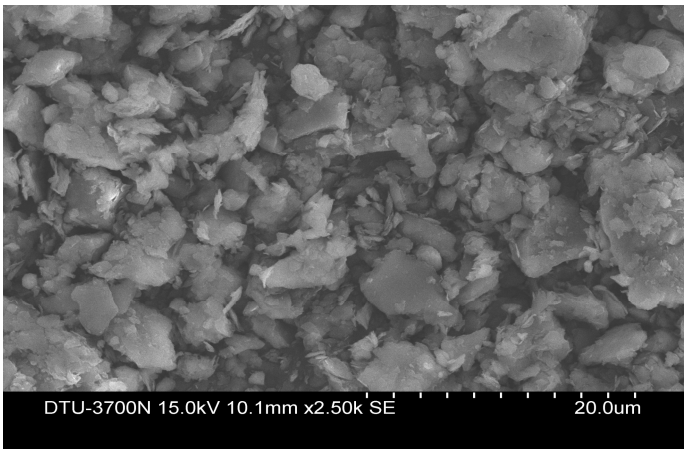

Fig. 3 – SEM of clay at 20µm.

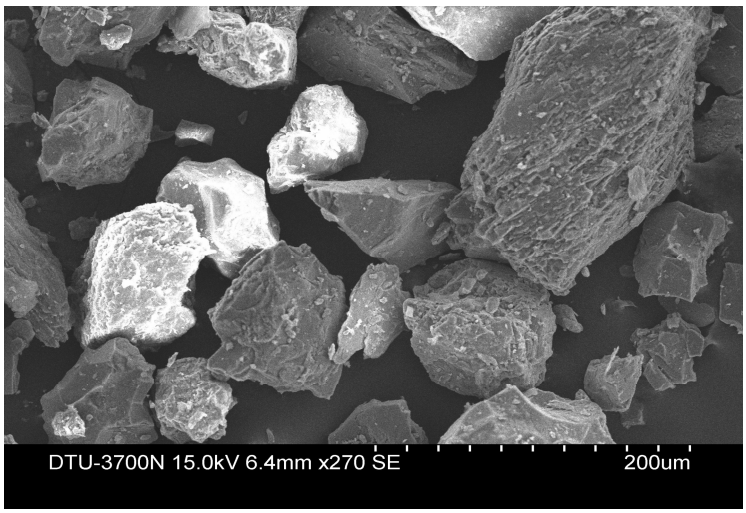

Fig. 4 – SEM of sand at 200µm.

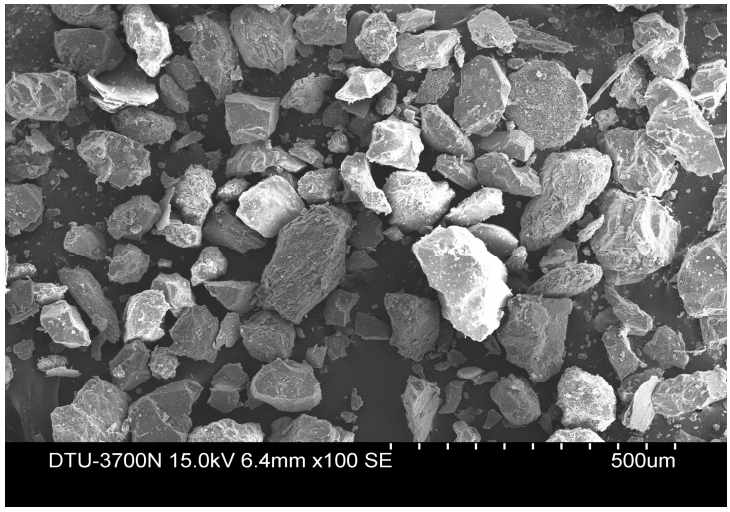

Fig. 5 – SEM of sand at 500µm**.**

3.3.2. *CBR Test Results*

Results of variation of CBR of clay and sand with three variables surcharge (At 5 kg, 7.5 kg and10 kg.) degree of compaction (Light and heavy compaction) and at different layers of geogrid (Single and doubled layer).

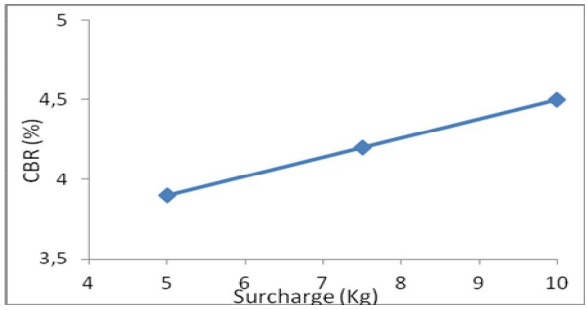

Fig. 6 – Variation of CBR of clay with increasing surcharge.

With increase in the surcharge up to 10 kg at heavy compaction in clay results 15.4% increase in the CBR value.

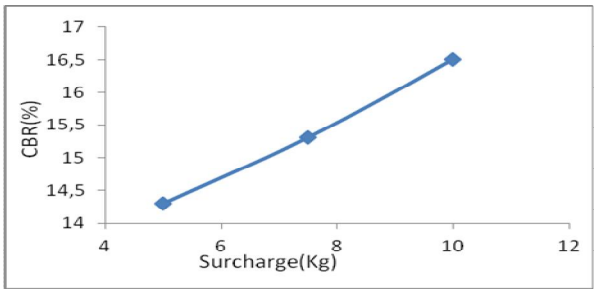

Fig. 7 – Variation of CBR of sand with increasing surcharge.

With increase in the surcharge up to 10 kg at heavy compaction in clay results 15.3% increase in the CBR value.

With increase in the surcharge CBR value going to increase it may be due to as increase in the surcharge the air void in the soil will decreases that results in increase in the density of soil i.e. more will be the compact soil more will be the CBR value.

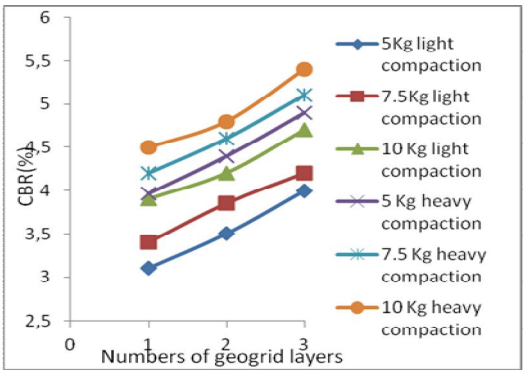

Fig. 8 – Effect of placement of geogrid on CBR value of clay with high degree of compaction and surcharge.

- In case of clay in light and heavy compaction with one and two layer of geogrid the CBR values are increased by 12.9%, 29.1% and 12.8%, 25.6%.
- In case of clay at surcharge 7.5 kg in light and heavy compaction with one and two layer of geogrid the CBR values are increased by 14.7%, 23.5% and 10.0%, 21.4%.
- In case of clay at surcharge10 kg in light and heavy compaction with one and two layer of geogrid the CBR values are increased by 8%, 20.5% and 7%, 20%.
- With the application of geogrid, better will be the interlocking and it avoid shear failure. Generally soil fails in the shear, As the shear strength increases CBR value also increase.
-

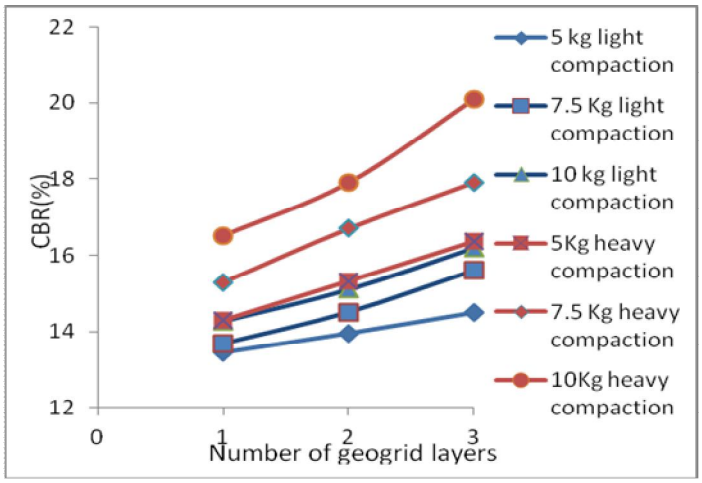

Fig. 9 – Effect of placement of geogrid on CBR value of sand with high degree of compaction and surcharge.

In case of sand in light and heavy compaction with one and two layer of geogrid the CBR values are increased by 3.77%, 7.8% and 7.31%, 14.33%.

- In case of sand at surcharge7.5 kg in light and heavy compaction with one and two layer of geogrid the CBR values are increased by 6.07%, 14.1 % and 9.2 %, 14.33 %.
- In case of sand at surcharge10 kg in light and heavy compaction with one and two layer of geogrid the CBR values are increased by 2.3%, 7.5% and 6.7%, 21.82%.
- With increase in degree of compaction CBR values for clay and sand increase by 25.8% and 6.4 %. As we apply more compactive effort then air comes out from the void that results in increase in the density of soil. *i.e.* more will be the compact soil more will be the CBR value.

4. Conclusion

On the basis of experiments on CBR test on sand and clay soil under different conditions viz. with surcharge, degree of compaction and placement of geogrid, the following conclusion may draw.

The CBR value of clayey soil increase in degree of compaction and surcharge. With these conditions the placement of geogrid in two layers, an enhancement of CBR value as observed further. The similar kinds of results were obtained in case of sandy soil also but there is more improvement as compare to that of clay soil in similar condition**.**

REFERENCES

Alemgena A .Araya, *Investigation of the Resilient Behavior of Granular Base Material with Simple Test Apparatus*, Springer -011-9790-1, 2012.

Archana Muraleedhara, *Behavior of Geogrid Reinforced Silty Sand*, Techno J. of Engng. a. Research (TJER) (2016).

Bandyopadhyar K., *Laboratory CBR Value of Fly Ash under Different Condition*, GEOTIDE, 2009.

Chakravarthi V.K., Jyotsha, *Efficiency of Overflying Coarse aggregate and Geosynthetic Separator on CBR value for Soft Subgrade of varying Plasticity-A lab Study*, Internat. J. Research in Engng. a. Technol.-2321-7308 (2014).

Charles A. Adams, *Effect of Triaxial Reinforcement on CBR value of Soil used for Pavement*, Internat. Refereed J. of Engng. a. Sci.-79-68 (2015).

Charles Anum Adam, *Effect of Geogrid Reinforced Subgrade on Layer Thickness, Design of Low Volume Bituminous Sealed Road Pavements*, Internat. Refereed J. of Engng. a. Sci.-59-67 (2014).

Fatemeh Mousavi, *Effect of Polymer Stabilization on Swelling Potential and CBR of Forest Road Material*, KSCE J. of Civil Engng.-014-0137-7 (2013).

Fisher S.Z., Horvat F., *Investigation of the Reinforcement and Stabilization Effect of Geogrid Layers under Railway Blast*, Slovak J. of Civil Engng., 3-22-30 (2011).

Krishna Rao S.V., *Laboratory Study on the Relative Performance of Silty –Sand Soil Reinforced with Linen Fiber*, Springer-011-9449-2, 2012.

Mayara Myeole, *Geotextile can be Worth their Cost in Pavements*, IOSR J. of Engng. (2014).

Nabil Al Joulani, *Effect of Powder and Lime on Strength, Compaction and CBR Properties of Fine Soils*, Jordan J. of Civil Engng. (2012).

Naveen B. Shirur, *Establishing Relationship between CBR value and Physical Properties of Soil*, IOSR J. of Mechan. a. Civil Engng.-26-30 (2014).

OLade A.K., Olaniya A.S., *Application of Geogrids on the Geotechnical Properties of Subgrade Material under Soaked Condition*, Civil and Environ. Research-224-5790 (2014).

Robert Nini, *CBR of Soaked Clay Drained by Sandy Layer*, World Cong. on Civil, Structural and Environmental Engng.-166-1002 (2016).

Saad F. Ibrahim, *Long Term Dry and Wet Effects on the Engineering Behavior of Subgrade Soil with High Amount of Soluble Salts using Low Cost Stabilizers*, J. of Civil Engng. a. Urbanization Sci. Line Publ.-492-500 (2014).

Sadok Benmebarek, *Effect of Geosynthetics on the Performance of Road Embankment over Sabkha Soil in Algeria: A Case Study*, Internat. J. of Geosynthetic a. Ground Engng.-015-0040-04 (2016).

Tao Zhang, *Engineering Properties and Microstructural Characteristics of Foundation Silt Stabilized by Lignin based Industrial by Product*, KSCE J. of Civil Engng.-1-12 (2016).

Yousif Jawad, *Effect of Compaction on the Behavior of Kirkuk Gypseous Soil*, J. of Engng. Sci., 97-104 (2006).

Zornberg, Gupta, *Geosynthetics in Pavements: NorthAmerican Contributions*, Internat. Conf. of Geosynthetic, Brazil, 2010.

INFLUENȚA GRADULUI DE COMPACTARE ŞI SUPRAÎNCĂRCARE A VALORII CBR A GEOGRIDULI DE ARMARE PENTRU ARGILE ŞI SOLURI NISIPOASE

(Rezumat)

În cadrul investigațiilor actuale, testele CBR au fost efectuate pe soluri nisipoase şi argilă. Cu aceste două tipuri de sol, geogridul este de asemenea utilizat ca armătură la diferite poziții. Aici, supraîncărcarea şi gradul de compactare sunt doi factori variabili. Efectul asupra valorii CBR trebuie să fie observat la creşterea supraîncărcării şi a gradului de compactare pe soluri argiloase şi nisipoase. S-a observat că, odată cu creşterea supraîncărcării şi a gradului de compactare, valoarea CBR a solului a crescut şi ea. Rezultatul optim apare atunci când se adaugă o creştere suplimentară, gradul de compactare şi geogrid într-o singură etapă. Morfologia solului a fost studiată prin microscopul electronic de scanare (SEM).