Stabilization of Subgrade Soil using Additives - A Case Study

Athulya P.V.
M.Tech Student
College of Engineering Trivandrum

Dr R.Satheesh Chandran
Associate Professor
College of Engineering Trivandrum

Abstract:**-Subgrade soil is an essential component for design of both flexible and rigid pavement structures. The main cause of failure of pavement is the settlement of subgrade, high moisture susceptibility which leads to loss of strength of subgrade. Kuttanad soil is a type of weak soil. The pavements constructed on these type of soil are normally subjected to deterioration. In this study the soil collected from the region around Era-Valady road under construction by Pradhan Mandhry Gram Sadak Yojana (PMGSY) in Alapuzha district of 2.12 km stretch .The soil is stabilized by using terrasil and cement kiln dust. Terrasil is a commercially available chemical stabilizer and is available in concentrated liquid form. Cement kiln dust is a waste product which is obtained during the manufacture of Portland cement. CBR test, triaxial compression test, Permeability test were conducted on plain soil and the soil treated with the different additives for varying percentages for analysing the volumetric and performance properties.**

I. INTRODUCTION

The characteristic of the road depends to a large extent on the strength and shear parameter of sub grade material. The evaluation of sub grade is an important for the road pavement during design, construction and service stages. The use of CBR and elastic modulus values are mandatory parameters for pavement design and construction. Soil stabilization aims at improving soil strength and increasing resistance to softening by water through bonding the soil particles together, water proofing the particles or combination of the two.

A. Objectives of the study

The objective of the present study is to conduct experimental study and analyse the strength properties of plain soil, soil with terrasil and soil with cement kiln dust separately by conducting consistency limit test, CBR test, Triaxial test and permeability test and then to compare the effectiveness of these additives on stabilizing the weak soil.

II. MATERIALS USED FOR THE STUDY

The soil used for the study was collected from upper Kuttanad region. The PMGSY site of Era-Valady region under construction .The terrasil collected from Zydex industries .The cement kiln dust collected from Travancore Cement Kottayam. A 50.81% of CaO is present in cement kiln dust. Terrasil is a pale yellow liquid and it forms a clear solution.1.0 Kg of Terrasil is dissolved in 300 litres of water. Terrasil is nanotechtonology based organosilane material. The soil properties are shown in Table 1.

III. PREPARATION OF SAMPLES

For conducting proctor compaction mixtures of 3kg soil were prepared with 0%, 0.4%, 0.8%, 1.2%, 1.6% of terrasil and along with each terrasil percentage 1% cement is added. For conducting proctor compaction on soil with cement kiln dust soil with 4%,6%,8%,10%,16%,20% of CKD were added. For conducting CBR test the soil sample with different percentages of terrasil cured for 7 days in open air are shown in figure 3 and then soaked in water for 4 days. Soil with cement kiln dust in various percentages also cured for 7 days before undergoing four days soaking.5 kg of soil mixed with water at optimum moisture content and terrasil solution is added to the soil. The various percentages of cement kiln dust mixed with soil at optimum moisture content are tested for determining the CBR value. The elastic moduli values for soil and soil with different percentages of additives were determined by using triaxial compression test without curing.

IV. RESULTS AND ANALYSIS

The results and analysis of the test conducted are explained in the following section

A. Standard proctor compaction test

The Maximum Dry Density (MDD) value showed an increasing trend for different percentages of terrasil. The optimum moisture content and maximum dry density values for varying percentages of cement kiln dust with soil and terrasil with soil are shown in Table 2 and Table 3.

B. Atterberg limit test

The Atterberg limit values for different percentages of terrasil with soil is shown in Table 3.These values for soil with cement kiln dust for various percentages is shown in Table 4 and Table 5.

TABLE 1: PROPERTIES OF COLLECTED SOIL

Soil properties	Value
OMC	31%
Maximum Dry Density	1.26gm/cc
Clay content	30%
Liquid limit	77%
Plastic limit	36%
Plasticity Index	41%
CBR	0.8%
Elastic modulus	1716KPa
Coefficient of permeability	7.39×10^{-7}

TABLE 2: PROCTOR COMPACTION RESULTS FOR SOIL WITH CKD

Dosage	MDD(gm/cc)	OMC(%)
4	1.34	29.9
6	1.35	29.7
8	1.37	27.3
10	1.38	27.5
16	1.40	27.8
20	1.45	26.6

TABLE 3: PROCTOR COMPACTION RESULTS FOR SOIL WITH TERRASIL

Dosage	MDD(gm/cc)	OMC(%)
0.4	1.34	29.9
0.8	1.35	29.7
1.2	1.37	27.3
1.6	1.38	27.5

TABLE 4: ATTERBERG LIMIT VALUES FOR SOIL WITH TERRASIL

Dosage(%)	Liquid Limit	Plastic Limit	Plasticity Index
0	77	36	41
0.4	76	37	39
0.8	73	40	33
1.2	59	41	18
1.6	66	39	27

TABLE 5: ATTERBERG LIMIT VALUES FOR SOIL WITH CKD

Dosage	Liquid Limit(%)	Plastic Limit(%)	Plasticity Index(%)
0	74	45	29
4	64	36	28
8	60	35	25
10	57	38	15
16	55	31	24

C. California Bearing Ratio Test

The results of conducted CBR tests for soil samples with different percentages of terrasil content are shown in Figure 1. Terrasil solution is applied on top of compacted soil at 3 liter per sqm in mould in order to make the soil surface impervious. Then put the mould in Terrasil solution for one minute for waterproofing bottom soil of the mould to simulate stopping of the bottom capillary rise .The treated mould kept for air drying for 7 days before soaking in water for four days. .The increasing trend of CBR values by increasing terrasil content is observed upto 1.2%.For 1.2% terrasil content the CBR value obtained was 29 and the CBR value decreased to 22% for 1.6% terrasil .The CBR value obtained for different percentages of CKD with soil. The values showed an increasing trend upto 16% and then the value reduced for 20% CKD. The load penetration graph for different percentages of CKD content and plain soil are shown in Figure 2.

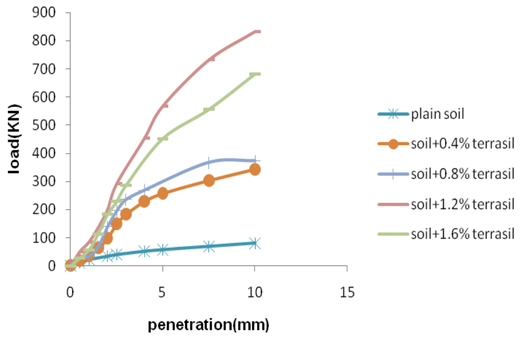

Figure 1: Load penetration graph for soil with Terrasil

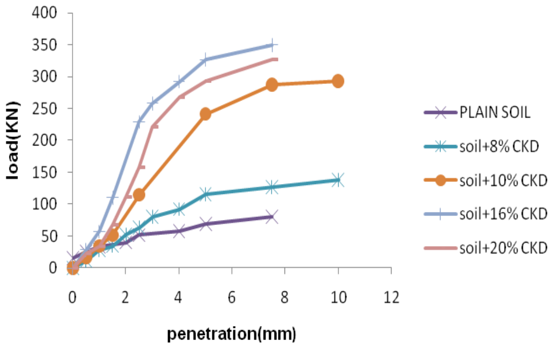

Figure 2: Load penetration graph for soil with CKD

D. Triaxial Compression Test

The triaxial test is carried out in a cell on a cylindrical soil sample having a length to diameter ratio of 2. The usual sizes are 76 mm x 38 mm and 100 mm x 50 mm. Three principal stresses are applied to the soil sample, out of which two are applied water pressure inside the confining cell and are equal. The third principal stress is applied by a loading ram through the top of the cell and is different to the other two principal stresses. The soil sample is placed inside a rubber sheath which is sealed to a top cap and bottom pedestal by rubber rings. For tests with pore pressure measurement, porous discs are placed at the bottom, and sometimes at the top of the specimen. Filter paper drains may be provided around the outside of the specimen in order to speed up the consolidation process. Pore pressure generated inside the specimen during testing can be measured by means of pressure transducers. This method determines the unconsolidated, undrained, compressive strength of cylindrical specimens of cohesive soils in an undisturbed condition, using a strain controlled application of the axial compression-test load where the specimen is subjected to a confining fluid pressure in a triaxial chamber .The confining pressure applied was 40KPa.The elastic moduli value calculated for different percentages of terrasil with soil and for different percentages of CKD with soil. The increasing trend showed for both the additives .The value increased from 10.13 to 26.1 MPa for terrasil content varying from 0.8% to 1.6%.The elastic modulus value increased from 8.8% to 16.98%.The stress strain graph for various percentages of terrasil with soil and for various percentages of CKD with soil are shown in figure 3 and figure 4 respectively.

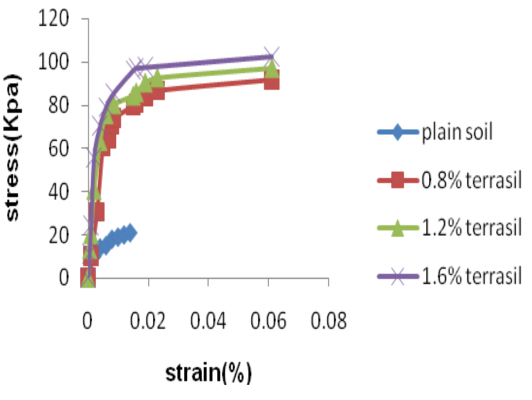

Figure 3: Stress strain curve for plain soil and soil with Terrasil

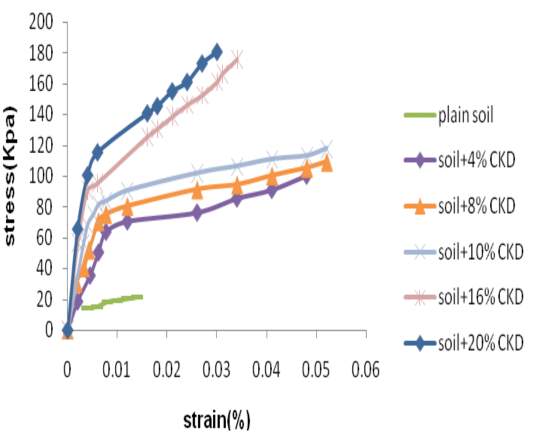

Figure 4: Stress strain curve for plain soil and soil with CKD

E. Permeability test

The permeability test was conducted using variable head permeability test. The entire system, including the porous stones and tubing, must be saturated prior to the test. This can be done by forcing water through the system and allowing the apparatus to stand full of water for a while just before inserting the specimen. The time in seconds for head of water to fall to the level of the overflow pipe is noted.The coefficient of permeability values are shown in Table 5 and Table 6.

TABLE 5: PERMEABILITY TEST RESULTS FOR PLAIN SOIL AND SOIL WITH TERRASIL

Terrasil dosage(%)	Coefficient of permeability(cm/sec)
0	7.39×10^{-7}
0.4	1.09×10^{-8}
0.8	7.5×10^{-9}
1.2	7.5×10^{-9}
1.6	7.5×10^{-9}

TABLE 6: PERMEABILITY TEST RESULTS FOR PLAIN SOIL AND SOIL WITH CKD

Terrasil dosage(%)	Coefficient of permeability(cm/sec)
0	7.39×10^{-7}
0.4	1.09×10^{-8}
0.8	7.5×10^{-9}
1.2	7.5×10^{-9}
1.6	7.5×10^{-9}

V. DISCUSSIONS

Based on the laboratory results it was found that siloxane bonds in terrasil make the soil impervious. CBR value of plain soil was 0.8 and after stabilisation of soil with terrrasil the CBR value improved to 29%.The elastic modulus value increased from 1.7 to 26.1 MPa. The increase in stiffness with the increase in cement kiln dust due to the reaction of the stabilizer with the clay material and the pozzolanic products bind together the clay particles. The CBR value for soil treated with cement kiln dust the value increased to 16%.The elastic modulus value of treated sample got improved to about 17.2MPa.The coefficient of permeability showed a slight reduction for the different percentages of cement kiln dust.

VI. CONCLUSIONS

The behavior of soil varies largely with introduction of stabilizer. It is observed that increment in dosages resulted in decrement of consistency limits. So it is clear that the chemical makes the soil stiff. It is noted that CBR value increases with increase in dosage of stabilizer and an optimum value is obtained. Cement kiln dust being a waste product is economical and the CBR value also showed a considerable increase. The water proofing property of soil had a significant effect of adding Terrasil compared to cement kiln dust. The elastic modulus value for soil with additives showed a considerable increase compared to unstabilized soil.

REFERENCES

[1] Amin Esmaeil Ramaji., (2012) "A Review on the Soil Stabilization Using Low-Cost Methods" Journal of Applied Sciences Research, 8(4)

[2] Arpita V Patel.,(2011) "Study of Geotechnical properties of black cotton soil contaminated by castor oil and stabilization of contaminated soil by sawdust" National Conference on Recent Trends in Engineering & Technology

[3] Eric.,(2012) "cementitious materials like cement and flyash for soil stabilization"construction and building materials journal

[4] Gerald Miller,A.,U, Shahriar Azadb.,(2000) "Influence of soil type on stabilization with cement kiln dust" construction and building materials journal pp 89-97

[5] Jayalekshmi et al.,(2012) "study of polymer based chemical Renolith with lime as soil stabilizer" International Journal of Engineering Research & Technology

[6] Lekha, B. M., Goutham,S., Ravi Shankar, A. U.,(2013)., "Laboratory investigation of soil stabilized with nano chemical" Proceedings of Indian Geotechnical Conference

[7] Madhavi Vedula., Pawan Nath G.,(2012) "A critical review of innovative rural road construction Techniques and their impacts" NRRDA, New Delhi

[8] Mukesh A., Patel H.S(2013)" Laboratory Assessment to Correlate Strength Parameter from Physical properties of Subgrade'' *Nirma University International Conference on Engineering* PP 200-209

[9] Madurwar K.V., Dahal P.P (2013) "Comparative Study of Black Cotton Soil Stabilization with RBI Grade 81 and Sodium Silicate*" International Journal of Innovative Research in Science, Engineering and Technology Vol. 2*

[10] *Mamta1., Mallikarjun.Honna.,(2014)"* Using rbi grade 81 a comparative study of black cotton soil and lateritic soil" *International Journal of Research in Engineering and Technology Volume.3*

[11] Patil B.M.,Patil K. M(2013) "Effect of fly ash and rbi grade 81 on swelling Characteristics of clayey soil" *International Journal of Advanced Technology in Civil Engineering Volume-2*

[12] Rafael et al.,(2012)"The use of sugarcane bagasse ash and lime to improve the durability and mechanical properties of compacted soil blocks*" construction and building materials journal*

[13] Rodney Wotherspoon" Stabilization of marginal soils using geofibers and nontraditional additives"thesis report.