Stabilization of Black Cotton Soil Using Chemical Additive

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Abstract— Due to growth of population and reduction of available land, increasing construction of highway/runway pavement and other civil engineering structure need to carry out on weak and soft soil. Black cotton soils are inorganic clays of medium to high compressibity and form a major soil group in India. They are characterized by high shrinkage and swelling properties. Owing to such high swelling and shrinkage characteristics, the Black cotton soils (BC) soil has been a challenge to the highway engineers. The Black cotton soil is very hard when dry, but loses its strength completely when in wet condition. In this work, BC Soil was tested using two different stabilizing agents - Terrasil & Lime. Investigation includes evaluation of grain size distribution, Atterberg's Limit, Maximum Dry Density, Optimum moisture content, CBR value and UCS value of Black cotton soil Specimens with and without stabilizers for a curing period.

Key words: Soil Stabilization, Terrasil, Lime, California Bearing Ratio, Unconfined Compression test

I. INTRODUCTION

Transport is a vital infrastructure facility for the foundation development in India. Development of a country depends on the connectivity of various places with adequate road network. Roads are very vital for better and economical vehical operation which requires good highway having proper geometric design, pavement and maintenance. The road has be maintained so that safety, comfort and convenience are provided to the traveling people. The movement of men and materials i.e. transport, trade, commerce, service sector which depend on heavy commercial vehicle loads and repetitive applications of it thereby producing heavier stresses on clayey soil ranges are known as bed condition and unpredictable conduct of the clayey contributing to fail of road.

Black cotton soils occurs in climate zones characterized by alternate wet and dry seasons. Black cotton soils experience periodic swelling – shrinkage with variation in water content. Such cyclic swell – shrinkage movements of ground cause considerable damage during rainy season and main causing unsatisfactory drainage of water in the soil. In the case of road less CBR value soil require higher pavement thickness for particular design traffic, resulting in costly pavement composition. To overcome this problem associated with soil in subgrade and to come out with a stabilization method.

Soil stabilization is a process of improving the engineering properties of the soil by adding natural manufactured additives or binders are used. There are several method that have been used to minimize or eliminate the harmful effect of clayey soils on structures. The method include soil replacement, soil cushion method, cohesive non swelling layer, mechanical stabilization, chemical stabilization, stabilization using reinforcement. Chemical additives, such fly ash, cement, lime and other chemical components have used in stabilization of subgrade.

A. Present Work

In the present study, terrasil has been used for stabilization of black cotton soil. Lime also been used as stabilizer to improve the CBR value of clayey soil. The test is carried out ti determine the Atterberg's Limits, compaction test, CBR value of soil with and without stabilizers for a curing period.

B. Objective of study

- Improvement in soil by adding additive [Terrasil and Lime].
- Cost analysis.

II. LITERATURE REVIEW

A. Prof. R.K.Sharma, 2012

In their work on "Subgrade characteristics of locally available Soil Mixed with Fly ash and Randomly Distribution Fibers". This paper presents the results of investigation on behavior of expansive soil modified with fly ash and Recron 3S fiber of 12 mm length. The properties like grain size distribution, moisture-density related and CBR are studied for soil blended with fly ash in range of 20-80%. The mixture of soil with fly ash with 30% fly ash was selected for further modification with fiber content in range of 0.5-1.5%. The properties of moisture-density relation and CBR are evaluated.

B. Azhani Zukri, 2013

"Peaken Soft Clay Treated With Hydrated Lime As A Method of Soil Stabilizer". The main objective of this paper is to determine the optimum lime content (OPC) required for Peken soft soil treatment program and strength. The OLC will be determined using Eades-Grim Ph test Another testing that involved in study are atterberg limit, Unconfined Compressive Strength and proctor Test from the study, the optimum moisture amount to stabilize the clay soil in this particular area and minimum amount of lime to rasie soil ph level to 12 is 4%. The soil strength is reach 116% while the maximum dry density and optimum moisture content for teated soil are 16 kN/m^3 and 13% respectively . All the sample tested reach a significant strength level when enough lime is provided. It can be concluded that, lime stabilization method can be used as a soil treatment program for Peken Clay especially for road construction.

C. Jyoti S. Trivedi, Sandeep Nair, Chakradhar Iyyunni, 2013

"Stabilization of expansive overconsolidated clay using hydraulic binders". This paper is to formulate a model based on genetic Algorithm which can be used to predict variation in the value of CBR of the subgrade soil with the addition of a specific percentage of Fly Ash added (F.A.%). For

anaylsis of soil using fly ash, Evolver 5.7 an add-in software of excel is used. Properties used for analysis are L.L, P.L.,OMC, & CBR. This model will help all types of agencies involved in road construction like NHAI, Infrastructure Developers and Construction Contracting Organization to predetermine the soil stabilization achieved due to fly ash for a particular type of sub grade soil.

D. Manju Suthar and Praveen Aggarwal, 2015

"Clayey Subgrade Stabilization with Lime and Recron Fiber+". In this paper results of a clayey soil modified with lime and recron 3s fiber (6mm & 12mm long separately) is presented. Investigation include evaluation of specific gravity, grain size distribution, atterberg's, maximum dry density, optimum moisture content and CBR value of clayey soil and lime or recron 3s fiber modified clayey soil mixed with lime stabilizer in 2%, 4%, 6% by weight of dry soil. Recron 3s Fiber (6mm & 12mm) are also mixed separately in quantity 0.3%, 0.5%, 1%, 2%, 3% by weight of dry soil. Soaked CBR test results that optimum dose of additive are 4% for lime, 0.5% for 6mm long Recron fiber and 0.3% for 12mm long recron fiber. From the results it is also observed that CBR value of clayey soil can be improved by 63.7% using lime and 10.9% and 11.2% using 6mm & 12mm long fiber respectively.

E. Mrudul U V, Prof. S. M. Damdariya, Prof. N. B. Parmar, 2016

"Laboratory Investigation of Soil Stabilized using Terrasil". In this paper present that investigation of black cotton soil treated with terrasil and cement. In this study soil with variable dosages were tested for stabilization process and strength of the stabilized soil has been evaluated after curing period. This tests were carried out to determine the consistency limits, CBR value of soil specimens with and without stabilizers for curing period. By this test result maximum dry density of soil decreased with the addition of cement and value of optimum moisture content of cement treated soil increased. By taking values percentage of lime and terrasil i.e. (1% , 2%)lime and (0.02% ,0.04%)terrasil. from this CBR values of soil increased from 2.58 to 29.34 from combination of soil + 1% cement + 0.04% Terrasil in this paper. By CBR value thickness of pavement reduced and cost is reduced.

III. DATA COLLECTION AND ANALYSIS

A. Soil Sample Collection

The soil sample used for this study is collected from location area at the new ring road between Kalavad State Highway and Gondal State Highway, Rajkot, Gujarat at a depth 1.5m soil sample is used.

B. Labortory Experiment

1) Grain Size Anaysis

Sr. no.	**Grain size Distribution**	**Passing value of soil %**
1	Gravel	28.81
2	Sand	47
3	Silt and Clay	24.06

Table 1: Grain Size Distribution

From this grain size analysis soil is sandy.

2) Consistency limit

Sr. no.	**Consistency Limit**	**Value**
1	Liquid Limit	55%
2	Plastic Limit	30%
3	Plasticity Index	25%

Table 2: Consistency Limit

From the obtained valve of liquid limit and plastic limit of soil, soil is classified as "MH" Blackish Silt with highly plasticity.

3) Proctor test Results

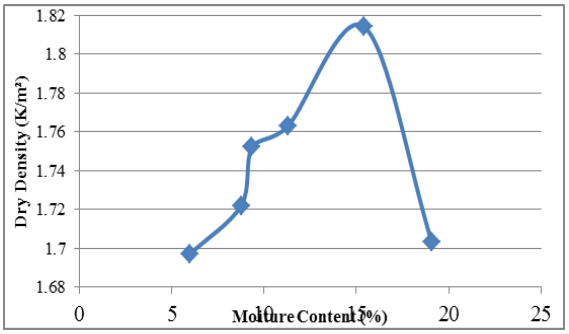

Fig. 1: MDD v/s OMC for Soil

Proctor test of soil in which MDD = 1.82 KN/m^2 and OMC = 12.5 %

4) CBR test Value

In current work, results are shown for soaked and unsoaked CBR only.

Sr. No.	Properties	Soaked(%)	Unsoaked (%)
1	Natural soil	2.46	10.19
2	Soil + 1% Lime	3.75	12.73
3	Soil + 2% Lime	4.24	14.09
4	Soil + 5% Lime	5.60	14.52
5	Soil + 7.5% Lime	5.94	9.85
6	Soil + 10% Lime	2.29	11.97
7	Soil + 15% Lime	2.29	11.29
8	Soil+0.02%Terrasil	6.28	10.70
9	Soil+0.04%Terrasil	8.91	14.43
10	Soil+0.04%Terrasil +1% Lime	8.91	10.91
11	Soil+0.04%Terrasil +2% Lime	11.63	14.43
12	Soil+0.04%Terrasil +5% Lime	22.50	23.43
13	Soil+0.04%Terrasil +7.5% Lime	22.33	25.29
14	Soil+0.04%Terrasil +10% Lime	14.09	26.06
15	Soil+0.04%Terrasil +15% Lime	11.88	11.029

Table 3: Test results of various combination of black soil with lime and terrasil of CBR Value

5) UCS Test

Sr. No.	Properties	Value (kg/cm²)
1	Natural Soil	0.7196
2	Soil + 1% Lime	0.7684
3	Soil + 2% Lime	0.8123
4	Soil + 5% Lime	0.8723
5	Soil + 7.5% Lime	0.8552
6	Soil + 10% Lime	0.4862

7	Soil + 15% Lime	0.3732
8	Soil+0.02%Terrasil	.07850
9	Soil+0.04%Terrasil	0.8664
10	Soil+0.04%Terrasil +1% Lime	0.9530
11	Soil+0.04%Terrasil +2% Lime	1.3261
12	Soil+0.04%Terrasil +5% Lime	1.4175
13	Soil+0.04%Terrasil +7.5% Lime	1.4413
14	Soil+0.04%Terrasil +10% Lime	0.8941
15	Soil+0.04%Terrasil +15% Lime	0.6324

Table 4: Test results of various combination of black soil with lime and terrasil of CBR Value

IV. CONCLUSION

1) CBR value of soil increased from 2.46 to 5.60 on adding proportion of 5% lime and, 2.46 to 5.94 on adding of 7.5% lime, 2.46 to 6.28 adding of 0.02% terrasil and 2.46 to 8.91 on adding of 0.04%. Hence it concluded that 0.04% is better for CBR value.
2) Hence it is concluded that by combination of soil + 5% Lime + 0.04% Terrasil increased the CBR value from 2.48 to 22.50.
3) UCS value of soil increased from 0.7196 kg/cm^2 to 1.4431 kg/cm^2 on adding 7.5 % Lime + 0.04% Terrasil in soil.

V. FUTURE SCOPE OF WORK

1) Cost analysis can be done in future by considering proper MSA load.
2) Further tests can be done by varying proportion of Terrasil and also permeability test can be carried out.

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