Effect of PolyCom admixture on Geotechnical Properties of Black Cotton Soil

D.V. Siva Sankara Reddy, M. Chittaranajan, K. Ramu

Abstract: ***Over the past few years to stabilize the clayey soil which has been generally adopting these days in developing paved and unpaved roads, cement based products such as soil cement, and different kind of materials like lime are used. These additives being used in soil improves the strength, durability and workability of soil and generally it leads to a thickness reduction of the pavement layers. Regrettably, boundless amount of conventional additives are required to strengthen the soil used in pavements which leads to relatively long curing time. The compaction action should be completed within the stipulated time period, because which significantly affects the construction costs. The other disadvantages associated with cement stabilized layers can be the shrinkage cracks developed which reflect rapidly through asphaltic surfaces and cause greater deterioration. Therefore the development of polymeric based additives has been of particularly interest as they demonstrate many added advantages; such as their ability to reduce permeability, increase durability, allow non time depending during the mixing stage and provide increased flexibility.***

In this project PolyCom is being used as additive from the list of various Polymer Stabilization Materials. The advantage being selecting PolyCom as it does not create a chemical reaction and is not a rigid setting agent. Black cotton soil was taken in the analysis and it is added with PolyCom to find out the changes in the properties and from the inference of results it was observed that PolyCom addition enhances the Geotechnical properties of soil when compared to the black cotton soil used alone as a stabilized material.

Keywords: Black Cotton Soil; PolyCom; Permeability; Durability; Flexibility

I. INTRODUCTION

Soil improvement is to be one of the main concerns in the construction activities due to rapid growth of population, urbanization and industrialization. The term soil improvement is being used in the ground improvement techniques which improve the index properties and other engineering properties of weak soils. Where the soils are unsuitable for construction activities that soil can be effectively improved by the process of soil stabilization and also enhance the broad range of sub-grade soil properties altering from clay to granular materials. In soil stabilization process, revamp the durability, strength and other qualities of soil by modifying its physical properties and it improves the load bearing capacity, shear strength capacity of soil and also it controls the swell-shrink potential of expansive soil subgrade. This process is practiced by using a vast variety of admixtures i.e. metakaolin, Portland cement, lime, stone dust, fly ash and by products of different materials are cement-kiln dust and lime-kiln dust. Soil intensification by using stabilization is more resistant to damaged by frost or inclement and water conditions.

Subgrade soil provides base for the whole pavement structure. Weak expansive soil subgrade is contact with water has high tendency to swell and shrink. This behaviour is commonly exhibit from clayey soil by the presence of rich of Montmorillonite mineral. These weak soils can be intensifying through the insertion of cementitious additives and chemical admixtures. Many construction purposes, like airport and highway construction to alter the sub base and subgrade properties. Black cotton soils/Weak sub grade soils can be stabilized or usually improved by the inclusion of a small percentages of lime and cement. This study investigates the changes in the strength of the Black cotton soil by using PolyCom as admixture.

1.1 Black Cotton Soil

Black Cotton soils are those soils, which have tendency to increase in volume when water is available and decrease in volume when water is removed. These volumetric changes are due to the rich existence of Montmorillonite clay mineral in expansive soils. These volume changes of expansive soils provoke severe damage to structures resting on it. In India Black Cotton soils are also known as expansive soils. Expansive soils are common in Africa, Australia, India, South Africa, U.S., Israel, Indonesia, Burma and other countries in Europe. In India expansive soils common in Western Madhya Pradesh, part of Rajasthan, Uttar Pradesh, Andhra Pradesh, Karnataka.20% of the total area covered with expansive soils in India. In India Black cotton soils is also called as Expansive soils due to their color and property of growing cotton.

The BC Soils in India have Liquid Limit of 50-100%, Plasticity index of 20-65%, Shrinkage Limit of 9-14% ,<2 micron 40-75%. These soils are exceptionally stiff in dry condition and possess high shear strength. When ingress of water it gets reduced significantly. In summer season, it is very common to see shrinkage cracks with hexagonal column structures with vertical cracks as wide as even 10cm extending up to a depth of 3m or more.

II. EXPERIMENTAL STUDY

2.1 Material Used

Black cotton Soil: The soil taken for this investigation is obtained from Karapa village near Kakinada, East Godavari (District). The oven dried and crumbled material passed through I.S.4.75 mm sieve is used for the study. The index and engineering properties of

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the virgin soil are given in Table 1. As per Indian standard classification (IS 1498:1970) the soil is classified as highly compressible Clay (CH). The Differential Free Swell Index (DFSI) of soil is about 98% and it is highly expansive in nature.

Table 1: Geotechnical Properties of Untreated Soil

SI. No	Property	Values
1	Grain size distribution	
	(a) Gravel (%)	1.4
	(b) Sand (%)	15
	(c) Silt & Clay (%)	83.6
2	Atterberg Limits	
	(a) Liquid Limit (%)	73
	(b) Plastic Limit (%)	28.2
	(c) Plasticity Index (%)	44.8
3	Differential Free Swell Index (%)	98
4	Specific Gravity	2.69
5	Shrinkage limit (%)	13.33
6	Compaction Characteristics (Standard)	
	Optimum Moisture Content (%)	26.1
	Maximum Dry Unit Weight (kN/m^3)	14.2
7	Compaction Characteristics (Modified)	
	Optimum Moisture Content (%)	24.8
	Maximum Dry Unit Weight (kN/m^3)	14.6
8	California Bearing Ratio Value (Unsoaked)	
	CBR @ 2.5mm Penetration	4.033
	CBR @ 5.0mm Penetration	3.88
9	California Bearing Ratio Value (Soaked)	
	CBR @ 2.5mm Penetration	2.24
	CBR @ 5.0mm Penetration	2.09
10	UC Compressive Strength (kN/m^2)	196.13
11	Direct shear parameters	
	Cohesion (kg/cm2)	0.08
	Angle of internal friction(degrees)	21.8

PolyCom: PolyCom Stabilizing agent is manufactured at Australia, used to strengthen the any material commonly found in road construction and earthworks projects. PolyCom is used for the construction and maintenance of paved and unpaved roads, heavy vehicles parked areas, sites for digging of minerals, trail roads, approach roads, shoulders, airstrips and other pavements where material rrequires development. PolyCom delivers a stronger and hard pavement, improving the flexibility and workability of the materials to create a tighter, water-resistant surface.

Polymers are huge molecules which consist of long hydrocarbon chains. Various polymer solutions are used for soil improvement, including cationic, anionic, and non-ionic polymers. Maximum number of chemical admixtures reacts with dry soil or moisture soil in two approaches: 1. specified chemical reactions takes place between soil particles and solution, 2. the stabilizing agent provides physical stabilization through the binding property presence in the material. Polymers fall into the second category. The following Table.2 shown Physical and Chemical properties of PolyCom admixture.

Table 2: Physical and Chemical properties of PolyCom

Properties	Description
Form	Powder
Color	Blue/green
Decomposition Temperature	Not available
Boiling Point	Not available
Specific Gravity	0.8
Vapor Pressure	Not applicable
Evaporation Rate	Not available
Viscosity	Not available
Flash Point	Not applicable
Auto-Ignition Temperature	Not applicable
Explosion Limit - Lower	Not applicable
Appearance	Blue/green powder
Odor	Slight
Melting Point	Not available
Solubility in Water	Miscible
P^H	6.9 at 25°C (5000 : 1)
Vapor Density (Air=1)	Not applicable
Odor Threshold	Not available
Partition Coefficient: n-octane/water	Not available
Flammability	Non-combustible
Explosion Limit – Upper	Not applicable

2.2 Application of PolyCom

As detailed by the manufacturer, PolyCom is applied at a rate of 2kg per 500m^2 at specified depth of 100mm. This corresponds to a rate of 2kg of PolyCom per 50m^3 with the constraint that each layer must be 100m^2. There are fundamentally two methods by which contractors can apply PolyCom to a specified area of soil. These can be referred to as both the "Dry Application Method" and the "Wet Application Method". The following information regarding the two methods of applying PolyCom was obtained by the website of the manufacturer of PolyCom.

Figure 2.1 PolyCom Admixture

III. COMPARISON OF RESULTS

Table 3: Comparison of Black Cotton Soil Results without and with PolyCom Addition

SI.No	Properties	Virgin Soil Values	Stabilizing Soil Values		
			0 Days Curing	3 Days Curing	7 Days Curing
1	Atterberg Limits				
	(a) Liquid Limit (%)	73	49	-	-
	(b) Plastic Limit (%)	28.2	24.4	-	-
	(c) Plasticity Index (%)	44.8	24.5	-	-
2	Differential Free Swell Index (%)	98	33.7	-	-
3	Compaction Characteristics (Standard Compaction)				
	Optimum Moisture Content (%)	26.1	25	23.2	20.6
	Maximum Dry Unit Weight (kN/m^3)	14.2	15.1	16.2	17.6
4	Compaction Characteristics (Modified Compaction)				
	Optimum Moisture Content (%)	24.8	23.4	21.6	19.2
	Maximum Dry Unit Weight (kN/m^3)	14.6	16	17.4	18.2
5	California Bearing Ratio Value (Soaked)				
	CBR @ 2.5 mm Penetration	2.24	7.84	14.78	21.51
	CBR @ 5.0 mm Penetration	2.09	7.47	14.34	20.01
6	Unconfined Compressive Strength (kN/m^2)	196.13	348.1	628.61	964.97

The above table.3 represents the comparison of geotechnical properties of black cotton soil before and after PolyCom admixture addition.

IV. GRAPHICAL VARIATION OF RESULTS

This section describes about the Graphical variation of Black Cotton Soil test results prior and after treatment with PolyCom Admixture.

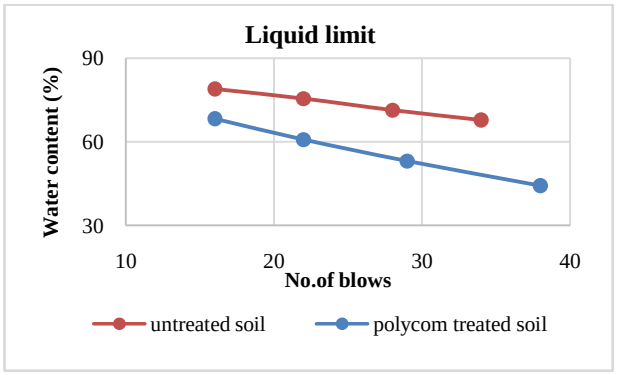

Figure 4.1Variation in the Liquid Limit Results Prior and After Treatment

Graph: 4.1 shows variation in liquid limit of black cotton soil, it shows that maximum reduction in liquid limit was found to be 32.876% from original soil.

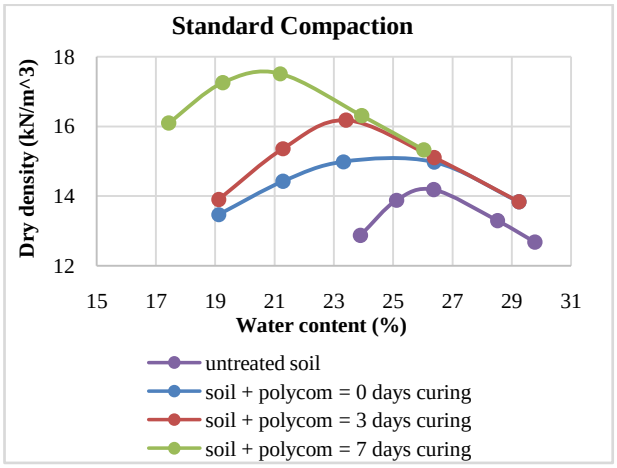

Figure 4.2 Variation in the Standard Compaction Results Prior and After Treatment

Graph: 4.2 shows variation in maximum dry density of black cotton soil, it shows that maximum dry density is observed for 7 days curing period and is about 23.943% more than original soil and maximum reduction in OMC is observed for 7 days curing period about 21.072% less from virgin soil.

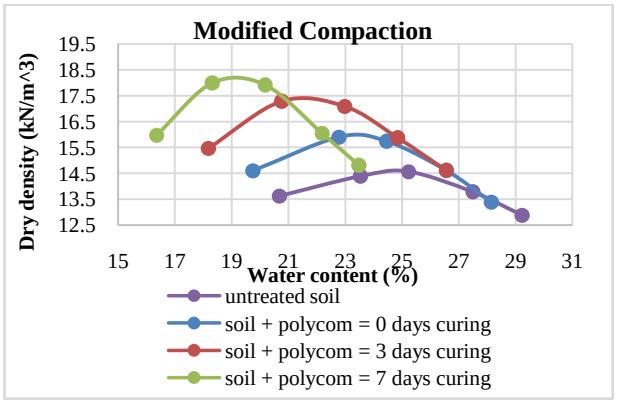

Figure 4.3 Variation in Modified Compaction Results Prior and After Treatment

Graph: 4.3 shows variation in maximum dry density of black cotton soil, it shows that maximum dry density is observed for 7 days curing period and is about 24.657% more than original soil and maximum reduction in OMC is observed for 7 days curing period about 22.880% less from virgin soil.

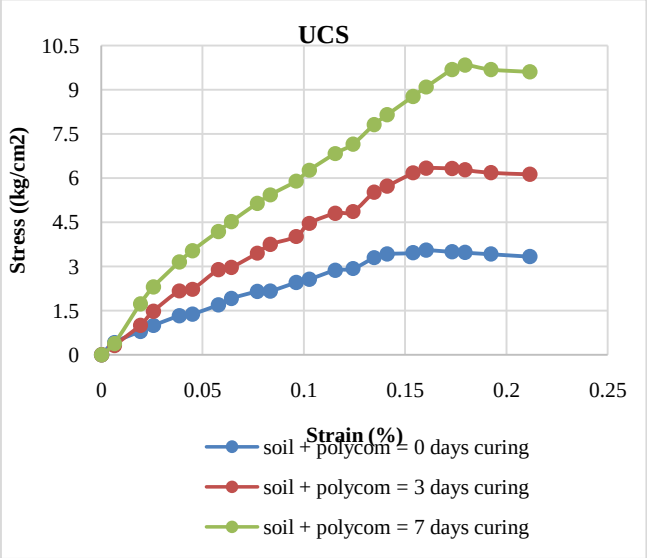

Figure 4.4 Variations in the UCC Test Results Prior and After Treatmen

Graph: 4.4 shows variation in UCC of black cotton soil, it shows that maximum UCC value was found for 7 days curing period and is about 4.919 times more than virgin soil UCC value and the percentage increment is about 391.997%.

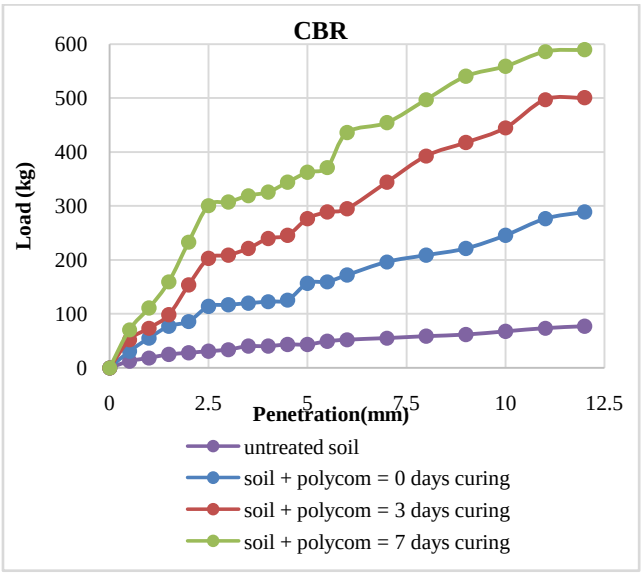

Figure 4.5 Variation in the CBR Results Prior and After Treatment

Graph: 4.5 shows variation in CBR of black cotton soil, it shows that maximum CBR value was found for 7 days curing period and is about 9.60 times more than the virgin soil CBR value and the percentage increment is about 860.267%.

V. CONCLUSIONS

The present study can serve as an effective method to utilize PolyCom as admixture for stabilization of expansive soil. The conclusions are based on the tests carried out on expansive soil in virgin and PolyCom treated condition.

- It has been seen that liquid limit and plastic limit of expansive soil decreases by adding PolyCom and is about 32.876% from virgin soil.
- The differential free swell index of expansive soil is reduced about 64.28% from virgin soil
- For standard compaction, Maximum dry density of PolyCom treated expansive soil is observed to be 17.6 $kN/m^3$for 7days curing period, and increment percentage is 23.843% from original soil. Optimum moisture content was found gradually decreasing by adding PolyCom admixtures and maximum reduction in OMC was found 21.072% for 7 days curing period.
- For modified compaction, Maximum dry density of PolyCom treated expansive soil is observed to be 18.2 $kN/m^3$for 7days curing period, and increment percentage is 24.657% from original soil. Optimum moisture content was found gradually decreasing by adding PolyCom admixtures and maximum reduction in OMC was found 22.880% for 7 days curing period.
- The unconfined compressive strength is maximum for 7 days curing period and is about 4.919 times more than virgin soil UCC value and the percentage increment is about 391.997%.
- Maximum CBR value was found for 7 days curing period and is 9.60 times more than from virgin soil CBR value and the percentage increment is about 860.267%.
- It was found that there is a maximum improvement in strength properties by using PolyCom as admixture for expansive soil. Hence PolyCom is very much useful admixture for construction purposes.

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