Global Journal of Researches in Engineering: E
Civil And Structural Engineering
Volume 16 Issue 2 Version 1.0 Year 2016
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Geo-Technical Investigation on Black Cotton Soils

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Abstract- Black cotton soils are predominantly available in India. Though black cotton soil plays a vital role in agriculture but it is posing many difficulties in civil engineering aspect. All the black cotton soils are not expansive soils and all the expansive soils are not black in color. These soils passed high strength in summer and decreased rapidly in winter. The soil has a swelling property due to the presence of montmorillonite mineral. Though various constructions techniques are utilized, the cracking (Minor Cracking) is seen in the buildings. For the site investigations, the behavior of soil is important. This paper gives information regarding bearing capacity and suitable foundations for different types of constructions in black cotton soils.

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GJRE-E Classification : *FOR Code: 090501*

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Geo-Technical Investigation on Black Cotton Soils

B. Vinod [α], Prithanjali Shende [σ] & Md. Hyder Baba [ρ]

Abstract- **Black cotton soils are predominantly available in India. Though black cotton soil plays a vital role in agriculture but it is posing many difficulties in civil engineering aspect. All the black cotton soils are not expansive soils and all the expansive soils are not black in color. These soils passed high strength in summer and decreased rapidly in winter. The soil has a swelling property due to the presence of montmorillonite mineral. Though various constructions techniques are utilized, the cracking (Minor Cracking) is seen in the buildings. For the site investigations, the behavior of soil is important. This paper gives information regarding bearing capacity and suitable foundations for different types of constructions in black cotton soils.**

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I. Introduction

In India, expansive soils are called as Black Cotton soil. The name "Black Cotton" as an agricultural origin. Most of these soils are black in color and are good for growing Cotton. All the black soils are not expansive soils and all the expansive soils are not black in color. These soils passed high strength in summer and decreased rapidly in winter. The soil has a swelling property due to the presence of montmorillonite mineral[1]. High percentage of montomorillonite renders high degree of expansiveness. These property results cracks in soil without any warning. These cracks have sometimes extent severe limit like ½" to 12" deep. Use of this type of land may suffer severe damage to the construction with the change in atmospheric conditions[2][8]. In Indiaexpansive soils cover about 20% of the total land area (Ranjan and Rao 2005, Shelke and Murthy 2010).These soils increase in volume on absorbing water during rainy seasons and decrease in volume when the water evaporates from them (Chen, 1988)[3]. Black cotton soils cover an extensive area of 300,000 km^2. The engineering properties of such soils are as follows:

- High compressibility
- Low bearing capacity
- Low shearing strength

It is a well known fact that water is the worst enemy of all structures, particularly in expansive soil areas. Water penetrates into the foundation from three sides viz. top surface, and from bottom layers due to capillary action. Therefore, specifications in expansive soil areas must take these factors into consideration. The surfacing must be impervious, sides paved and soil beneath well treated to check capillary rise of water [4].

The soilis very hard when dry, but loses its strength completely when in wet condition [5]. The wetting and drying process causes vertical movement in the soil mass which leads to failure of a pavement, in the form of settlement, heavy depression, cracking and unevenness [6].

As this black cotton soils are very important for construction many tests are performed for it's strength and bearing capacity and different methods are proposed for good construction. A sample data of black cotton soils which is available in RGUKT-Basar of Adilabad district of Telangana state has taken and examined to know the suitable foundation and its bearing capacities.

a) Objective

The primary objective of this geotechnical investigation is to examine the soil present in the top 5m zone, to determine the allowable bearing capacity of soil present in this zone and to examine the feasibility of providing shallow foundations for the upcoming structures.

II. Methodology

The trial pit method of investigation was referred as the zone of study is limited to 5m below the EGL. The salient features of the investigation program are presented below.

a) The Geo-technical Investigation Program

The location of trial pits was fixed in consultation with the DEE, RGUKT-Basar. Care was taken to see that, the location is within the area where the structure is proposed and at the same time, it do not coincide with the exact foundation location. After the excavation by mechanical excavator, the ground was further excavated manually for at least for another 30cm to avoid the influence of the excavator. Excavation of the pit up to 2m below EGL and collection of UDS-1 at this level. The thin walled tube samples were used to collect the UDS. All necessary precautions were taken to ensure quality UDS. A minimum of three cores were collected to ensure representativeness of the ground. In addition, a

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100mm diameter core was also collected, for extruding specimen for consolidation and swell pressure tests.

- The Excavation was taken to a level of 4.50 m to 4.80 m below EGL and UDS-2 was collected.
- Laboratory tests on UDS and DS as per relevant provisions of IS:2720.
- Interpretation and analysis of the laboratory data to arrive at the allowable bearing capacity at various levels.
- Preparation of report together with necessary recommendations.

b) Site Condition

The site selected for the test is mainly of Black cotton soil. The soil on the surface was indicating shrinkage cracks of around 40mm width. The light weight structures with load bearing type of walls having foundations laid at shallow depth on the in-situ soil have developed cracks, indicating the typical features of expansive clays such as Black cotton soils. So a shallow foundation is usually provided when the soil at a shallow depth has adequate capacity to support the load of the structure. However, in situation where the soil at shallow depth is poor, in order to transmit the load safely, the depth of foundation has to be increased till a suitable soil stratum is met. In view of increased depth, such foundations are called deep foundations. Piles, piers and wells are examples of deep foundations [7].

Figure 1 : Cracks, Swelling in Black cotton soil

III. Results and Discussion

All necessary laboratory tests are proposed to determine in the index and engineering properties as per IS: 2720. The test results are summarized in Table-1.

Table 1 : Test Results

Sample code	Uds -1	Uds– 2
Depth of collection (m)	2.00	4.80
Specific Gravity of solids (G)	2.64	2.66
Natural density ,g/cc	1.96	2.06
Natural moisture content (%)	28.17	28.31
Dry density (g/cc)	1.53	1.61
Natural void ratio	0.73	0.65
Water content at saturation (%)	27.65	24.43
Grain size distribution		
Gravel size (%)	0.00	5.60
Coarse sand size (%)	3.60	2.50
Medium sand size (%)	4.40	1.80
Fine sand size (%)	3.20	2.96
Slit size (%)	4.20	7.10
Clay size (%)	84.60	80.10
Consistency limits		
Liquid limit (%)	74.80	69.40
Plastic limit (%)	30.30	32.30
Plastic index	44.50	37.10
Differential free swell index (%)	72.70	45.70

a) Swell Pressure test

The swell pressure test is performed as per IS:2720, Part-41, Section-2, on the specimen extruded from UDS and the average swell pressure observed was 214kN/sqm for the BC Soil layer present from GL to a depth of 0.60m to 2.40m at its in-situ density and moisture content as on 18.11.2013. Keeping in view of the seasonal moisture variations, similar test was performed at the in-situ density with moisture content at shrinkage limit. The swell pressure was observed to be 286kN/sqm.

b) Hydrometer Test

The particle size distribution was determined using hydrometer method as per IS:2720, Part-4. Double jar system was used to eliminate correction for temperature.

c) Computation of Net Allowable Bearing Capacities

Based on the laboratory test results, the feasibility of providing shallow foundations has been examined by computing the net allowable bearing capacities for a

- 2m wide square footing and
- 8m wide raft foundation.

The calculations are provided. The outcomes of the calculation are summarized in Table 2.

IV. Conclusion

Based on investigations made on Black cotton soil, different conditions are examined and the strength of the soil is found by consolidation method, swell pressure method, Hydrometer analysis, consistency index tests. Moreover the bearing capacity and suitable foundations for different constructions was known appropriately. In view of the above, based on the observation of the ground during field visit and based on the analysis of the laboratory test results, the end bearing type of cast-in-situ pile foundations are found to be more appropriate, In view of the expansive nature of the top soil necessary precautions may be taken in all those lightly loaded structural components that need to be rested on the in-situ expansive clay

Table 2 : Bearing capacities

TP location	2m wide square footing		8m wide raft foundation	
	Net Safe Bearing Capacity (kPa)	Net Bearing Capacity for an Allowable Settlement of 50mm	Net Safe Bearing Capacity (kPa)	Net Bearing Capacity for an Allowable Settlement of 100mm
TP-1	50.6	28	109.8	21
TP-3	90.7	27	119.4	20

V. Acknowledgements

This work was partially supported by Brunda and Siri constructions present in RGUKT-Basar, who provided insight and expertise that greatly assisted this paper.

We would also like to show our gratitude to Mr. Ranadheer Sagi, HOD, Dept. of Civil Engineering for sharing his pearls of wisdom with us during the course of this paper.

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