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EXPERIMENTAL INVESTIGATION OF DISPLACEMENT COLUMNS WITH GRANULAR MATTRESS IN BLACK COTTON SOIL

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ABSTRACT

Black cotton soil is one of the weak clayey soil and Stabilisation by mechanical method is more effective to that of other stabilisation methods for weak soil properties. The methods which could be adopted are pile foundations, Vibro compaction, Grouting, Stone columns, Displacement columns etc..,. Stone columns is widely adopted method for soft weak clayey soils. Among these important techniques Displacement columns is ideally suited for soft soils overlying stiff bearing strata and for contaminated sites where handling excavated sites is environmentally unacceptable. Displacement columns consist of cement treated aggregate, grouted aggregate or concrete columns that are often used to transfer the stress from foundation or emblent loads from soft soil down to rock layers. When a soft stratum is under laid by a hard stratum, the use of rammed aggregate pier elements cannot control settlement. Displacement columns are effective for following means such as Isolating stress from heavily isolated footings, supporting heavily loaded mats and slabs, spanning organic and peat layers and providing foundation support adjacent to below grade structures. For this research soil is taken two metres below the ground level where the consolidation leads to secondary settlement. The characteristics of soil are determined and load carrying capacity and bearing pressure when piled with Displacement columns with granular mattress. Columns are piled according to the stress isobar distribution in the soil for the maximum loading.

Key words: Clayey soil, Displacement columns, Load transfer, Stress Isobar, Consolidation settlement, Granular mattress.

1. INTRODUCTION:

In India, one tenth of part of the total land area is concealed with black cotton Soil. Black soils, locally called as “Black cotton soils” and internationally known as “Tropical Black Earths” or “Tropical Chernozems” have been developed by the weathering of the Deccan Lava in the major parts of Maharashtra, Madhya Pradesh, Gujarat, Andhra Pradesh, Rajasthan, Tamil Nadu, Uttar Pradesh. It
is described that this soil is essentially a mature soil which has been produced by relief and climate rather than by a particular type of rock. The most important property of Black Cotton Soil is highly Expansive in nature and, it Swells when moistured and gets hardened when dried out. Due to its swelling nature, when the soil is loaded by the structure constructed on it, the Uplift Pressure from the soil makes the Footing get Stressed and finally the Structure lead to failure. These property results Cracks without any warning. These cracks may sometimes extent to severe limit 125cm wide and 300cm deep. So, the building to be founded on this soil may damage with change in atmospheric conditions. This implies that Black soils are not suitable for Constructions.

1.2 DISPLACEMENT COLUMNS:

Displacement columns is a ground improvement technique that transfers loads from the weak strata to a firm underlying stratum using high modulus, controlled stiffness columns. They consist of aggregate mixed with cement or grout, or elements made of plain concrete. The elements are stiff enough to transfer the stress from a slab, footing or embankment load through soft soil layers down to a firm soil or weathered rock layer. The selection of the sizes and types of displacement columns to use on a project depends on the magnitude of loads being supported and the subsurface conditions. The installation of displacement columns can be bottom feed or top feed. The load is carried by the soil with the help of increase in skin resistance and the load is transmitted into the soil formation via shaft friction and base resistance. In addition to it, when a granular layer is placed at the top of the network of piles, it reduces vertical load on the supporting soil and vertical settlement of the upper structure. The importance of

granular layer thickness is to increase load transfer intensity and to reduce vertical settlement.

2. LABORATORY INVESTIGATIONS:

2.1 TESTING OF SOIL AND AGGREGATE PROPERTIES:

The properties if soil and aggregate are tabulated below in table and table.2 respectively.

TABLE.1 Properties of soil

S.NO	PROPERTIES	RESULTS
1.	pH of the soil	8.9(alkaline)
2.	Liquid limit	57.6%
3.	Plastic limit	31.58%
4.	Shrinkage limit	20.92%
5.	Differential free swell	40.5%
6.	Optimum moisture content Maximum dry density	16.3% 1.68g/cc
7.	Unconfined compression strength	33.8 KN/sq.m
8.	Vane shear strength	0.3 kg / cm^2

TABLE.2: Properties of aggregate

S.NO	PROPERTIES	VALUES
1.	Specific gravity	2.82
2.	Impact test	30%
3.	Crushing test	24%
4.	Abrasion test	26.2%

3. EXPERIMENTAL INVESTIGATION:

3.1 SPECIFICATION OF DISPLACEMENT COLUMNS WITH GRANULAR MATTRESS:

The displacement column pile is made of plain cement concrete of ratio 1:4:8 and of density 2.025 g/cc. The size of displacement column used is of 26 mm diameter and installed to a height of 200 mm from top to maintain the stress isobar produced due to application load on the soil. The coarse aggregate used in concrete is passing through 12 mm sieve and retained on 10 mm sieve with specific gravity of 2.7.The cement used is Ordinary Portland Cement of grade 43 with specific gravity of 3.15.The fine aggregate used is of specific gravity 2.65. The water-cement ratio adopted is 0.55. Above the inclusions, for a diameter of 60 mm and thickness 6 mm a layer of granular mattress made of fine aggregate is filled with density of 1.77 g/cc.

3.2 EXPERIMENTAL SETUP:

The testing of soil is done with the help of a loading frame setup. The setup consists of proving ring and dial gauge. In this experiment, proving ring of 30 KN is used. The load is applied through a proving ring, with the help of a mechanically operated load frame. The dial gauge readings are calibrated. The load is applied on the soil with the help of a loading plate of 60 mm diameter based on the specification given in IS codebook. The setup of loading frame is shown in the figure.1.

FIG.1: Experimental setup

3.3 MODEL TANK:

The mould used for testing is of diameter 28 cm, height of 31 cm and thickness 1 cm. The volume of the mould is about 19088.3 cm^3.The model tank is shown in figure.2.

Fig.2: Model tank

4. TESTING OF BLACK COTTON SOIL WITH DISPLACEMENT COLUMNS WITH GRANULAR MATTRESS:

In this the soil is filled and compacted using above procedure. Then displacement columns of one, two, three number of diameter and length as mentioned are installed. Above the columns the layer of granular mattress is placed. Then the soil is tested using the loading frame setup. The load is applied and observed up to a total settlement of 5 mm. The load settlement curve observed for one, two, three number of displacement columns with granular mattress is shown in fig.3, fig.4, fig.5 respectively.

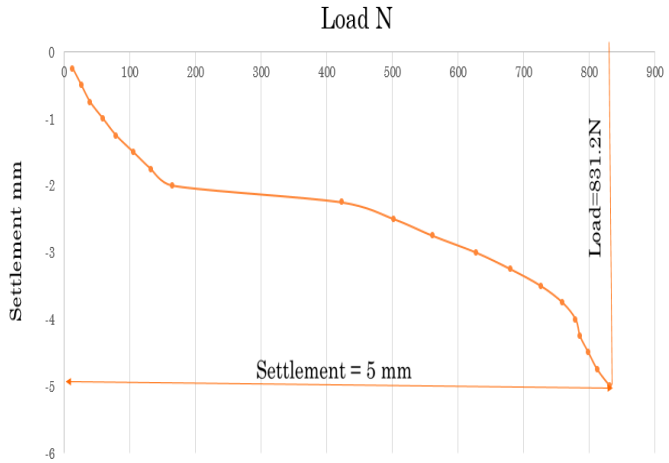

Fig.3. Load settlement curve for one displacement column with granular mattress

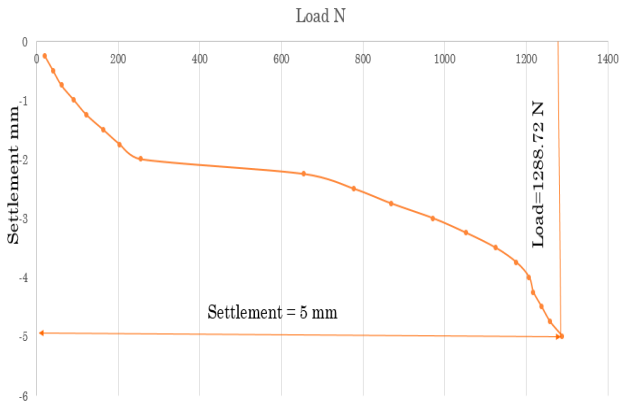

Fig.4: Load settlement curve for two displacement columns with granular mattress

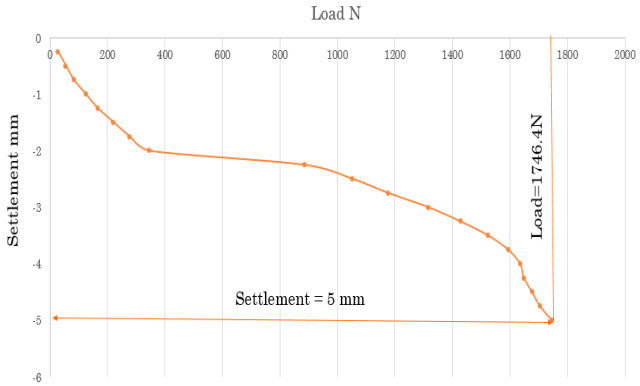

Fig.N. Load settlement curve for three displacement columns with granular mattress

5. CONCLUSION:

Hence black cotton soil is not suitable for construction purposes, displacement columns are adopted for improving the bearing pressure and load carrying

capacity of the soil to make it adaptable for construction. Thus it is observed, increase in one number of column nearly increases 13-15% of load carrying of capacity of the soil. The displacement columns are considered to be adaptable, effective and efficient for almost all problematic soils and it is proved in this research in black cotton soil. The use of granular mattress decreases the vertical settlement and the frictional force makes the column to withstand the maximum load without any failure. From this experimental investigation, displacement columns are vibration free and economical and corrosion resistance, durable for a longer span.

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