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Experimental Investigation of Rigid Inclusions in Black Cotton Soil

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Abstract: **This paper discusses the result of study conducted on rigid inclusions in black cotton soil. Black cotton soils are problematic soils. These soil swells on addition of water and shrinks on loss of moisture. Due to this buildings constructed in black cotton soil cause structural distress by differential settlement. Therefore rigid inclusions are adopted for improvement of these soils. Rigid inclusion is a ground improvement technique utilized in black cotton soil to improve the bearing capacity of the soil. It reduces the largest settlement by transferring the vertical load of the upper structure to the underlying load bearing stratum in which the piles are installed. A comparison between the virgin clay and rigid inclusion were also studied, in order to find the increment of load carrying capacity. The main objective of this paper is to investigate the characteristics, testing of rigid inclusion piles with one, two three number of piles and benefits in using black cotton soil. The experimental investigation of piles indicated that the required performance of the rigid inclusions is achievable.**

Keywords: **Rigid inclusions, bearing capacity, Settlement, Black cotton soil, Structural distress.**

I. INTRODUCTION

Black cotton soil is one of the major soil deposits of India. These soils are problematic for civil engineers, because of their unconventional behaviour. They exhibit high volume changes with respect to variation of seasonal moisture content. Black cotton soils consists of kaolinite and montmorillonite. High percentage of montmorillonite renders high degree of expansiveness. So building to be founded on this soil may suffer severe damage with the change of atmospheric conditions. Bearing capacity of black cotton soil can be improved by using rigid inclusion piles. Rigid inclusion is one of the ground improvement technique adopted for soft soils. These technique has been utilized to increase the load carrying capacity of poor soils and it reduce the settlement of substructure and superstructure constructed on them. This technique is most often used when substrata have poor mechanical properties. Rigid inclusions can achieve massive soil improvement. This soil improvement method can be applied in all construction sectors residential, industrial and commercial buildings, embankments for highways and rail, harbour structures. The selection of the sizes and types of rigid inclusions to use on a project depends on the magnitude of loads being supported and the subsurface conditions.

II. EXPERIMENTAL PROGRAM

All the experiments were carried out on a 26 mm diameter rigid inclusion pile surrounded by soft clay. The cylindrical tank of diameter 280 mm and height 310 mm was used. According to the stress isobar, the length of the pile is fixed about 200 mm. so that the stress isobar equally distributes the vertical pressure to the soil in the cylindrical tank. The spacing between the two piles is 2D.The testing of piles was studied with one, two, three number of rigid inclusion piles. And also the negative skin friction between the pile and the surrounding soil is controlled. The efficiency of using these piles in black cotton soil increase the load carrying capacity and decreases the settlement.

III. TEST SETUP

The rigid inclusion piles were tested with the help of a loading frame setup. The setup consists of a proving ring and dial gauge. Two different proving ring were used, 2.5 KN for virgin clay and 30 KN for rigid inclusion. The load is applied through a proving ring with the help of a mechanically operated load frame. The load is tested on the soil with the loading plate of 60 mm diameter based on the specification given in IS code book. The load is applied and observed up to a total settlement of 5 mm.

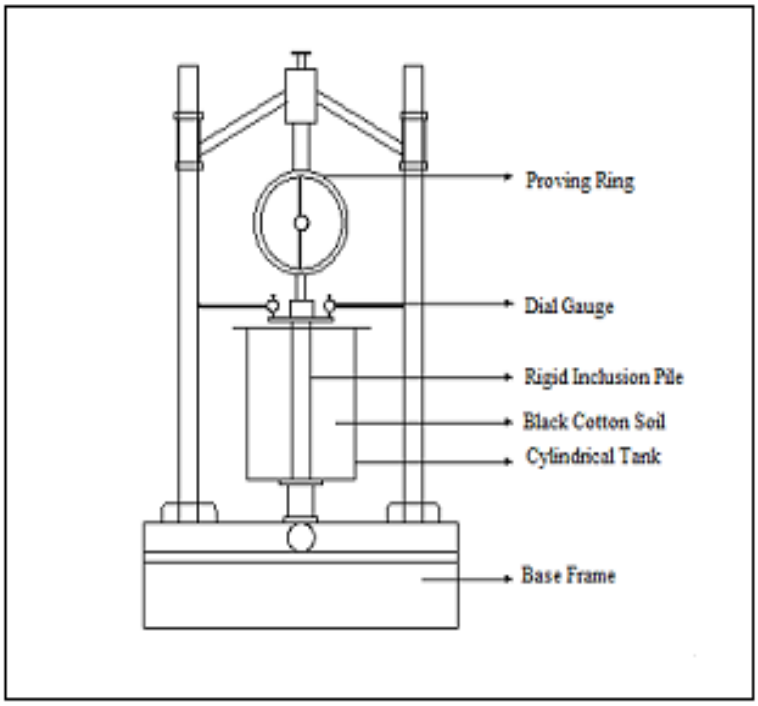

Fig 1 Typical test arrangement for studying load settlement behavior of single rigid inclusion-schematic

IV. PROPERTIES OF BLACK COTTON SOIL

The materials used for this study are black cotton soil. The black cotton soil is taken from Gomangalamputhur (Latitude N 10º37'12.2905" and Longitude E 77 º9'4.3571") in Udumelphat region, Tirupur district, Tamilnadu, India. The properties of black cotton soil are as follows,

Table 1 Properties of black cotton soil

S.NO	EXPERIMENT	VALUE
1	Liquid limit	57.6%
2	Plastic limit	31.58%
3	Shrinkage limit	16.45%
4	Free swell	40.5%
5	Standard Proctor compaction test • OMC • Max Dry Density	 16.3% 1.68 g/cc
6	Unconfined compression test • q_u • C_u	 33.8 kN/m^2 16.9 kN/m^2
7	Classification	CH

V. PREPARATION OF SOFT CLAY BED

Basically the soil sample is crushed to small size with the help of hammer and the sample is left for drying. About 26 Kg is taken and it is mixed with optimum moisture content (16.3%). After mixing with water, the soil sample is compacted in three layers. The number of blows required for each layer is 386. It is found by using the formula,

E = (P x n x N x h) / (V)

Where, E is compaction energy in kg cm

P is the weight of hammer in kg

n is the number of blows

N is the number of layers

h is the height of drop of hammer

V is the volume of soil to be compacted

The blows should be uniformly distributed over the surface of each layer. The top surface of the first layer should be scratched before placing the second layer. This is proceeded in order to get a bond between the layers. Likewise, second and third layers are compacted. After the completion, cylindrical mould is covered tightly and left for four days as a curing period.

VI. CONSTRUCTION OF RIGID INCLUSION PILES

The construction of rigid inclusion plies can be done in both replacement and displacement method. Designed auger, powered by a hydraulic rotary table was used in field. Here in laboratory, rigid inclusion piles was constructed by replacement method. The top of the soil bed was leveled. The position of the rigid inclusion was marked with respect to the loading frame. A hollow PVC tube with external diameter 26 mm, coated with oil was inserted vertically in the mould. Nextly, the rigid inclusion piles is made of plain cement concrete of ratio 1:4:8and of density 2.025 g/cc is poured into the hole and compacted using tamping rod. The aggregate used in concrete is the one passing through 12 mm sieve and retained on 10 mm sieve with specific gravity of 2.7.The cement used is OPC of grade 43.The fine aggregate used is of specific gravity 2.65. The water-cement ratio adopted is 0.55

VII. TEST PROCEDURE

The soil without any improvement is called virgin clay. For this, proving ring of 2.5 KN is used. The soil is filled and compacted using above procedure and is tested using the loading frame setup. The load settlement behaviour of the one rigid inclusion pile has been studied by applying vertical load with the help of a loading frame. The proving ring of 30 KN is used. The load is applied on the soft soil and the values are noted up to a total settlement of 5 mm. Then the same procedure is repeated for two and three number of rigid inclusion piles. The fig 2 shows the one and two rigid inclusion piles in black cotton soil.

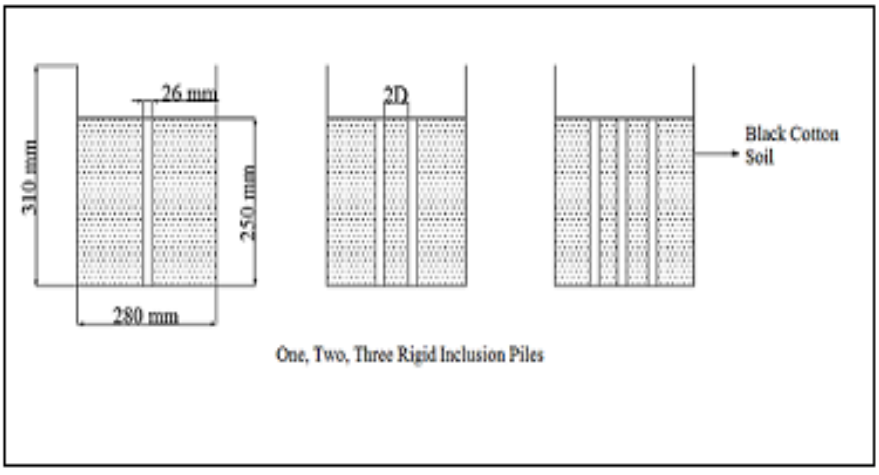

Fig 2 One, Two, Three Rigid Inclusion Piles in cylindrical test tank-schematic

VIII. RESULTS AND DISCUSSIONS

The ultimate load carrying capacity in each case was determined in load settlement curve is shown in fig 3 & N. The bearing capacity of black cotton soil with rigid inclusion piles one, two, three increases accordingly. The settlement resistance of one pile is greater than two piles. Similarly two piles is greater than three piles. These are proved in this experiment.

Fig 3 Load settlement curve for virgin clay

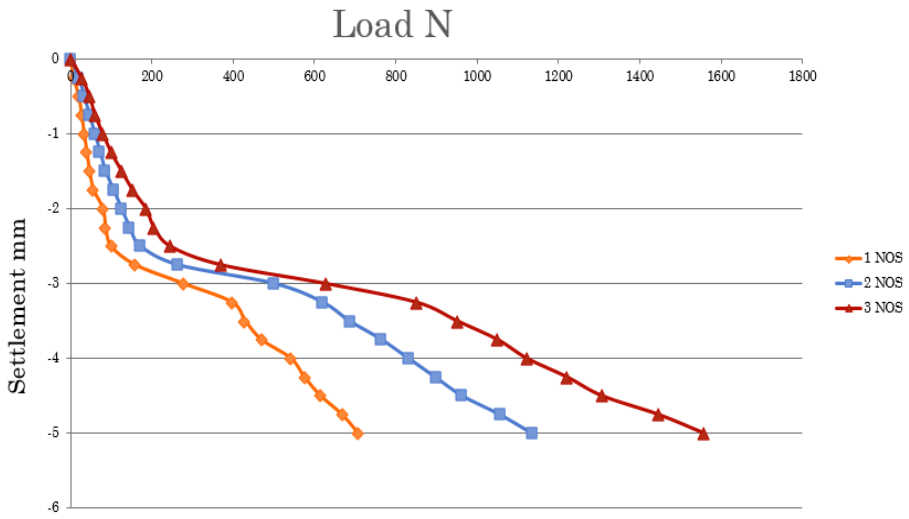

Fig N Load settlement curve for One, Two, Three Rigid inclusion Piles

IX. CONCULSION

The aim of the experiment was to investigate the rigid inclusion piles to strengthen the expansive clay. Load carrying capacity increases with one, two, three number of rigid inclusion piles. The values obtained in these laboratory tests are in good agreement. The major conclusions that can be drawn from the present study are as follows,

- Rigid inclusion piles considerably improves the bearing capacity of expansive clay and it reduce the settlement criteria of the soil
- The load carrying capacity of Rigid inclusion piles increases than virgin clay
- The rigid inclusion piles are considered to be adaptable, effective and efficient for almost all problematic soils and are proved to be in black cotton soil
- It is an economical foundation

REFERENCES

[1] AlexanderKhludnev, Russia, Thin rigid inclusions with delaminations in elastic plates.

[2] A.M. Khludneva, A.A. Novotny, J. Sokoowski A. Zochowski, Russia Shape and topology sensitivity analysis for cracks in elastic bodies on boundaries of rigid inclusions.

[3] Andrei Kotousov, LuizBortolanNeto, AdityaKhanna, Australia, On a rigid inclusion pressed between two elastic half spaces

[4] ASTM and BS – Organic content and Ash content.

[5] BuddhimaIndraratna, Sanjay Nimbalkar, CholachatRujikiatkamjorn, Australia, From theory to practice in track geomechanics – Australian perspective for synthetic inclusions

[6] Cirión A., Paulín J. Soletanche-Bachy-CIMESA, Mexico Racinais J. Menard, France Glandy M. Soletanche-Bachy-Pieux, France, Displacement rigid inclusions Inclusions

[7] Dr.B.C.Punmia, Ashok Kumar Jain (2005), "Soil mechanics and Foundations",laxmi Publications.

[8] D.Misseroni, F. Dal Corso, S. Shahzad, D. Bigoni, Italy, Stress concentration near stiff inclusions: Validation of rigid inclusion model and boundary layers by means of photoelasticity

[9] François Bignonnet, Luc Dormieux, Eric Lemarchand, Universite Paris-Est, France, Strength of a matrix with elliptic criterion reinforced by rigid inclusions with imperfect interfaces.

[10] G.VanLysebetten, A.Vervoort ,J. Maertens , N. Huybrechts, Geotechnical Division, Limelette, Belgium, Discrete element modeling for the study of the effect of soft inclusions on the behavior of soil mix material

[11] Hiroaki Nakamoto, Tadaharu Adachi, Wakako Araki, Japan, In-plane impact behavior of honeycomb structures randomly filled with rigid inclusions.

[12] IS 2720-1974 (Part 1-41) – Properties of soil.

[13] Jorge Castro, Santander, Spain, Numerical modelling of stone columns beneath a rigid footing.

[14] K.R.Arora (2008), "Soil mechanics and Foundation engineering.", Standard publishers and distributors

[15] Luciano G.S. Leite, Wilson S. Venturini, Brazil, Accurate modelling of rigid and soft inclusions in 2D elastic solids by the boundary element method.

[16] Matthieu Blanca, Gérard Rault a, Luc Thorela, Márcio Almeida LUNAM Université, IFSTTAR, Rio de Janeiro, Brazil,Centrifuge investigation of load transfer mechanisms in a granular mattress above a rigid inclusions network.

[17] Oscar Lopez-Pamiesa,n, TahaGoudarzi a, Toshio Nakamura,USA, The nonlinear elastic response of suspensions of rigid inclusions in rubber: I—An exact result for dilute suspensions.

[18] Qiao Wang a,n, Hongyin Yang ba, China,A rigid-inclusion model for fiber-reinforced composites by fast multipole hybrid boundary node method.