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Feasibility Study on Jarofix Columns in Clay Soil

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Abstract: Construction works on soft clay foundations are often very challenging and very complex task since they are since they are generally characterized by its low strength properties. Still clayey soils are widely used for construction purposes due to economic reasons. This study examines the geotechnical improvement of clay soils using the jarofix column technique on a laboratory-scale model. Industrial effluent Jarofix provided as deep columns in clay soil for improving its properties. Remolded compacted clay soil blocks were carefully prepared in circular steel test tanks with jarofix piles installed in them. The treated soil block properties were then investigated as a function of radial column distances and curing periods. Curing period is taken as 7, 14, 28, and 56 days and radial distance is taken as 1D,2D and 3D of jarofix column. There will be significant changes in the unconfined compressive strength of the treated soils due to the clay–jarofix reactions.

Keywords: Jarofix columns, Radial distance, unconfined compressive strength

1. INTRODUCTION

Soil stabilization is one of the most applied solutions for many dissimilar base problems such as expansive soils and low foundation bearing capacity. Construction works on soft clay foundations are often very challenging and very complex task since they are since they are generally characterized by its low strength properties. Soil Stabilization is the process by which the engineering properties of soil layers can be improved or treated by addition of other soil types, mineral materials or by mixing the appropriate chemical additive into the pulverized soil and then carry out compaction. Deep stabilization is an effective method used in various applications in soft soil, primarily to reduce subsidence and improve soil stability. This method is economic and reliable and it is often used to reinforce soil on road and railway embankments, slopes, pits and pipeline installations. The durability of the columns increases over time after installation, which further improves the interaction between the pillars and the surrounding soil. In this study clay soil is stabilising using deep stabilization with jarofix industrial effluent, as it is economical than shallow stabilization. Jarosite is the effluent from zinc industry produced after the extraction of zinc ore. Jarosite is a hazardous unstable effluent, it is stabilized with the addition of 2% lime and 10% cement. This stabilized form of Jarosite is known as Jarofix**.**

2. MATERIALS USED

2.1 Soil

For the purpose of deep stabilization, clayey soil (CH) was obtained. The soil was collected from Gudallur, Tamilnadu. Uniform layers of clay were obtained after a depth of 1.5 metres. The collected soil was dark brown in color. Fig. 1 given below shows the collected soil sample.

Figure 1: Soil sample collected

Properties of collected soil sample has shown in table 1

Table. 1. Geotechnical properties of soil

PROPERTIES	VALUE
Initial water content (%)	47
Specific gravity	2.66
Percentage of clay (%)	48
Percentage of silt (%)	34
Percentage of sand (%)	18
Free swell (%)	37
Liquid Limit (%)	84
Plastic Limit (%)	43
Shrinkage Limit (%)	23
Plasticity Index (%)	41
Maximum dry density (kN/m^3)	16.1
Optimum moisture content (%)	24
IS classification	CH
Unconfined Compressive strength (kN/m^2)	68

2.2 Jarofix

Jarosite is a waste material produced during extraction of zinc ore concentrate by hydrometallurgy operation. When it is mixed with 2% lime and 10% cement, the resulting stable material is called Jarofix. In this study clay soil is stabilised with deep columns of jarofix. Fig.2 given below shows the jarofix collected from BinanipuramZinc.Ltd at Ernakulam.

Figure 2: Jarofix

Properties of jarofix has shown in table 2.

Table. 2. Geotechnical properties of soil

PROPERTIES	VALUES
Specific gravity	2
Percentage of fine particles (%)	97.9
Percentage of sand (%)	1.7
Percentage of gravel(%)	0.4
Liquid Limit (%)	64
Plastic Limit (%)	46
Shrinkage Limit (%)	28
Maximum dry density (kN/m3)	13.8
Optimum moisture content (%)	47
UCC (kN/m2) 236	236

2.3 GI Tanks

For the purpose of deep stabilization clayey soil is embedded with 5 jarofix columns. This setup is carried out in GI tank. Four GI circular tanks are used in this study. Dimension of tank is 40cm in diameter and 40cm in height.

3. SAMPLE PREPARATION

3.1 Sample filling

The natural clay soil was oven-dried at 50° C, then mechanically ground into a pulverized form. The pulverized dry soil sample was mixed with water in an appropriate quantity using the initially determined in situ moisture content. The prepared wet soil was packed in an airtight polythene bag where it remained for 24h, which allowed intimate curing of the soil water admixture and prevented water loss. The desired amount of wet soil needed to be compacted in the test tank was predetermined from the in situ bulk density and water content values to simulate the natural field conditions. The soil was compacted in a circular test tank that was 40cm in both diameter and height. The test tank was partitioned into four equal layers of 9cm each by height. The compaction of the wet soil was performed in four successive layers. The moist soil mass of known weight was placed in the test tank for each layer and compacted using a modified rammer until the required volume and bulk density were achieved. This was subsequently done for the other three layers to achieve the same bulk density up to the 36cm mark in the test tank. In the test tank, 4cm in height was left above the soil block for the moveable steel plate cover to fit into the tank for proper moisture control.

3.2 Jarofix column installation

The jarofix column technique uses the pore fluid to aide physicochemical transfer of cat ions from the piles into the surrounding soil. In field applications, a hollow tube is forced into the ground to the desired depth and the binding agent is applied with air pressure into the soil holes, cracks, fissures, and crevices as the tube is being extracted. The technique was simulated in the laboratory with the installation of five columns in the compacted soil block. Each of these columns were 3cm in diameter and 30cm height and were installed in the soil blocks using a hollow Poly Vinyl chloride(PVC) pipe that had openings at both ends. Figure 3 given below shows test set up of jarofix columns in test tank filled with clay.

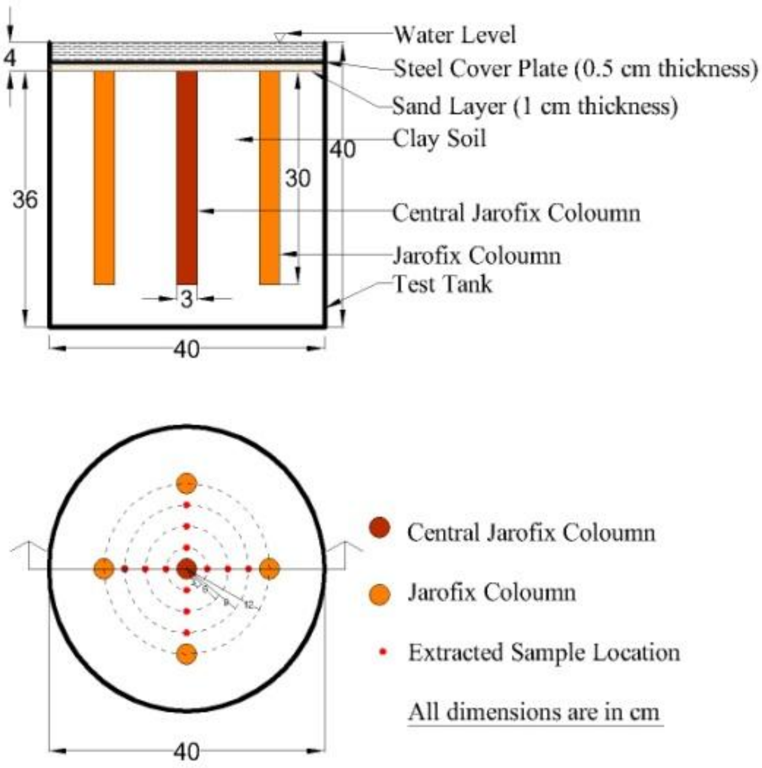

Figure 3: Test setup

The PVC pipe had an internal diameter of 3cm with about 45cm.The PVC pipe length was chosen to aide easy to penetration into the soil block and created the columns without interfering with the properties of the compacted soil block. The advantage of using a PVC pipe was to create smooth holes in the soil block without having to clean the holes a spiral brush prior to filling with jarofix. Then each column was filled with powdered quicklime of uniform mass. The quicklime was applied in three successive uniform layers and layer was lightly compacted to form the jarofix columns.

3.3 Experimental setup

After the jarofix column installation, the setup was covered with a thin perforated fiber cloth and then sandy soil of particle size 2mm was poured on top of the cloth up to the 37cm position (by height) in the test tank as shown in fig. This was to provide a slow absorption rate of water by the jarofix column and to,

1) A void a sudden hydration reaction,
2) Minimize the lateral expansion of the jarofix column,
3) Prevent formation of cracks in the soil blocks.

Figure 4. Experimental setup at laboratory

The fastened moveable steel plate of 0.5cm thickness was positioned in the setup to fit into the tank to maintain the moisture content in the soil block. In the field application of jarofix column are often constructed before the rainy season. During the wet season, the in situ soil and dry jarofix column are supplied with moisture, which allow migration of cations from the jarofix into the soil solution. In the laboratory, dry lime and soil block piles absorbed the water, and then the Ca^{2+} and Mg^{2+} ions were allowed to diffuse into the solution from each pile. The complete laboratory setup was then filled with water up to a point of the 40cm mark. In this study, the water supply was kept constant in the setup to keep the moisture content of the soil block at least 30%.This was to prevent the soil block from drying or cracking. The soil block was left to react chemically with the jarofix columns for different curing periods: 7, 14, 28 and 56 days.

4. LABORATORY STUDIES

4.1 Unconfined Compression Test

Ultimate compressive strength of a material is that value of uniaxial compressive stress reached when the material fails completely. It provides measures of the undrained strength and the stress-strain characteristics of the soil. Unconfined compression test was carried out for 4 curing days 7, 14, 28 and 56 of required radial distances 1D, 2D and 3D. It is found that as the number of day's increases there is increase in the unconfined compressive strength and maximum strength was obtained by the soil at 2d radial distance for every curing days. The test was conducted with reference to IS 2720 Part10-1973. The variation in unconfined compressive strength of high plasticity clay with jarofix columns at 1D, 2D and 3D radial distance for 7, 14, 28 and 56 has shown in figures below.

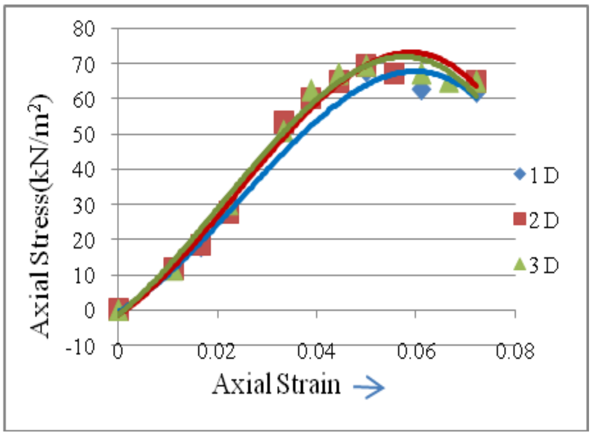

Fig 5. Variation in UCC of 7 days curing

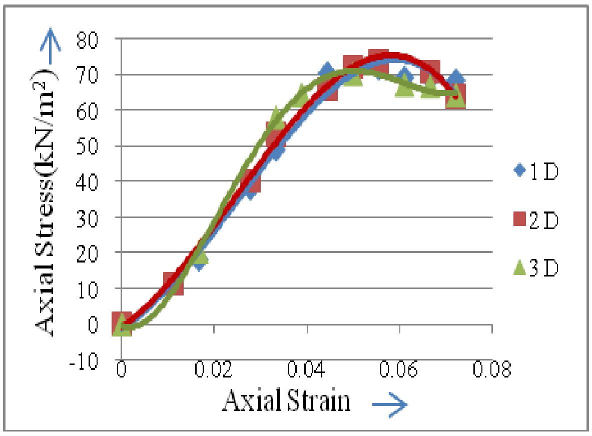

Fig 6. Variation in UCC of 14 days curing

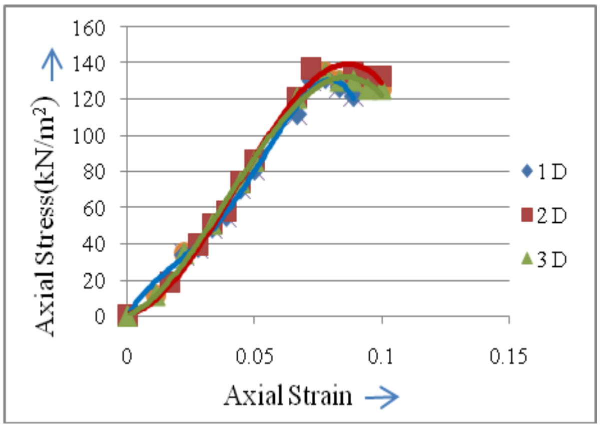

Fig 7. Variation in UCC of 28 days curing

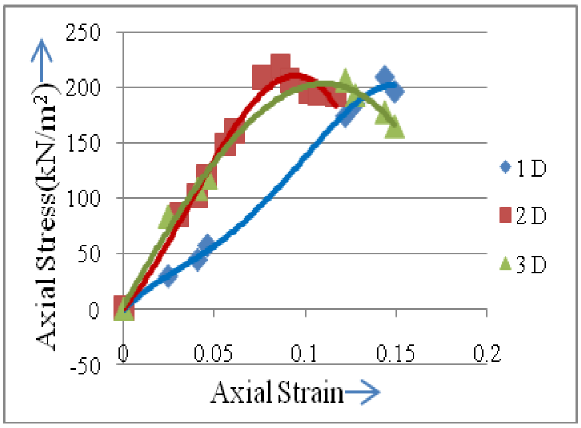

Fig 8. Variation in UCC of 56 days curing

UCC increased to a percentage of 220 than natural clay soil during 56 days curing. UCC shows a rapid increment in its strength during 56 days curing. UCC value get increased due to the formation of cementitious compounds as monovalent ions of soil is get replaced by the divalent ion Ca^{2+} . As thickness of diffuse double layer is get decreased there will be reduction of antiparticle repulsion and there develops cohesion. Flocculation of clay particles also increase UCC value of soil.

5. CONCLUSIONS

1. Basic properties of soil has found out by determing specific gravity, particle size distribution, atterberg's limits, light compaction and UCC.
2. Soil classification is under CH, ie inorganic clay of high plasticity
3. Basic properties of jarofix has determined.
4. Unconfined compressive strength of stabilized soil increases with respect to increase in curing days and highest value obtained at 2D radial distance.
5. UCC increased to a percentage of 220 after 56 during curing.
6. Concentration zone is 2D, that is highest value of UCC obtained at 2D radial distance than 1D and 3D for every curing days.
7. Radial distance 2D has the effect of both 1D and 3D radial distances.

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