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Stabilization of Marine Clay Using Jerofix

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Abstract: ***Soil is a fundamental engineering material. The quality of soil used in construction affects the overall stability of a structure. Cohesion, angle of internal friction, capillarity, permeability, elasticity and compressibility are the properties of soil taken into account while considering it as a construction material. Many stabilizers are available for improving the performance of soil as a construction material but the invention of new materials lead to the depletion of resources. This necessitates the need of a cost effective and reusable stabilizing agent. Industrial effluents pose a threat to the environment due to lack of efficient disposal methods. This paper focuses on the utilization of Jerofix for the stabilization of marine clay. Jerofix was added to marine clay at 10%, 20%, 30%, 40% and 50% to marine clay; the samples are analyzed for their variation in index and engineering properties.***

Keywords: Environmental geotechniques, effluent, stabilizer, engineering properties, Jerofix

1. Introduction

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. Soil stabilization can be very effective in treating clayey soils for improving its strength properties [8]. 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. Soil stabilization is aimed at improving the strength properties of weak soil. Two general methods of stabilization are mechanical and additive. In mechanical stabilization, soils of different gradations are mixed together to obtain the desired property in the soil. In additive method of stabilization, manufactured products are added to soil in proper quantities to enhance the quality of soil. Contaminations of soil in the vicinity of industrial sites have been reported at many places due the improper disposal of industrial effluents. This alters the index and Engineering properties of the surface and subsurface layers of the ground. Research shows that the addition of certain industrial effluents resulted in the enhanced properties of soil. Change in the Index and Engineering properties of the ground in the vicinity of the industrial plants have been reported.

A study conducted in Kerala points to a situation where acid and base seepage caused destructive cracking and foundation failure [9]. As a preliminary work to soil stabilization ground monitoring should be done. Industrialization is the new phase of development for third world countries. But at the same time the solid and liquid waste produced causes great concern regarding effective disposal of effluents. If these effluents prove to be effective stabilizers, this can bring revolutionary changes in industrial waste disposal in an ecological point of view and stabilization can be done much more economically [3]. Jerosite 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. One of the most important problems third world countries face is the large amounts of wastes and industrial effluents being dumped without any utilization or application. The application of these dumped effluents in soil stabilization not only puts forward an effective method of waste disposal but also helps to identify low cost potential stabilizers.

In this work, Jerofix is added to marine clay at 10%, 20%, 30%, 40% and 50% and the strength characteristics are evaluated. Laboratory tests conducted are Atterberg's limits, standard proctor test, unconfined compressive strength test and California bearing ratio test.

2. Materials

2.1 Marine clay

Marine clay sample was collected from a dredging site, where dredging was carried out at a depth of 5-6 m below the sea water level near Palluruthy, Ernakulam. The collected samples were black in colour and undesirable odour was noted. The presence of sea shells indicated the presence of organic content. The hydrometer analysis conducted on marine clay shows 50% of clay content and 48.95% of silt content. The geotechnical properties of marine clay are shown in table 1.

Table 1: Geotechnical properties of marine clay

Property	*Value*
Specific gravity	2.72
Liquid limit(%)	70.5
Plastic limit(%)	33
Optimum moisture content(%)	34
Unconfined compression strength(kPa)	66
California Bearing ratio value	3.85

2.2 Jerofix

Jerofix collected from zinc industry is a waste material produced during extraction of zinc ore concentrate by hydrometallurgy operations. Zinc ore concentrate contains about 50 % zinc. This concentration is roasted at 900°C and subjected to leaching where jarosite is formed as a waste material. At present, the annual production of Jarosite is about 4 lacs metric tons while its accumulation is nil because it is converted into new material called Jarofix by addition of 2 % lime and 10 % cement. This new material is transported to the Jarofix disposal area with the help of pay loader and dumper. The chemical composition of Jerofix is shown in Table 2.

Table 2: Chemical composition of Jerofix

Parameters	*% Composition*
Zn	2.38
Fe	15.9
Pb	3.2
Cd	0.0233
Cu	0.3419
Na	1.2471
Mg	0.2501
Mn	0.0715
Ca	8.6895
Al	1.0774
Ag	0.014
SiO_2	11.29

The analysis is done on dry basis and rest of the weight is made up by a complex of sulphate and hydroxyl ions.

3. Results and Discussion

The tests conducted are Atterbergs limits, Standard proctor test, unconfined compression test, California bearing ratio test.

3.1 Atterberg's limit

Atterberg limits reveal the basic information about the strength and settlement properties of soil. The test was done for all mix proportions considered according to ASTM D4318 (ASTM, 2003).

Table 3: Atterberg's limit

Jerofix content (%)	*Liquid limit*	*Plastic limit*
0%	70.5%	33.86
10%	53%	27.29
20%	49.39%	26.11
30%	49.23%	24.99
40%	49.19%	22.23
50%	48.15%	21.82

The result of Atterberg limit test is shown in table 1. With increasing percentage of Jerofix added, both the liquid limit and plastic limit is found to decrease. The reduction in Atterberg limits can be attributed to the ion exchange reaction where single valence ions get replaced by divalence ions of calcium which results in the decreased water absorption property of soil particles.

3.2 Specific gravity

The Specific gravity of clay was found out from the standard Pycnometer test. Specific gravity denotes the number of times the soil particles are heavier than equal volume of water. The specific gravity of the soil sample was found out to be 2.72, which conforms to the clay and silty clay category.

3.3 Standard proctor test

The optimum moisture content and maximum dry density have an important role in changing the strength properties of clay. Also the optimum moisture content have an important role to carry out other tests like unconfined compression, cbr etc. The result obtained for optimum moisture content and maximum dry density for 0%, 10%, 20%, 30%, 40% and 50% are shown in figure 1. The optimum moisture content and maximum dry density of uncontaminated marine clay was found to be 34% and 1.33g/cc respectively. With the increasing Jerofix content, optimum moisture content is found to decrease and maximum dry density is found to increase.

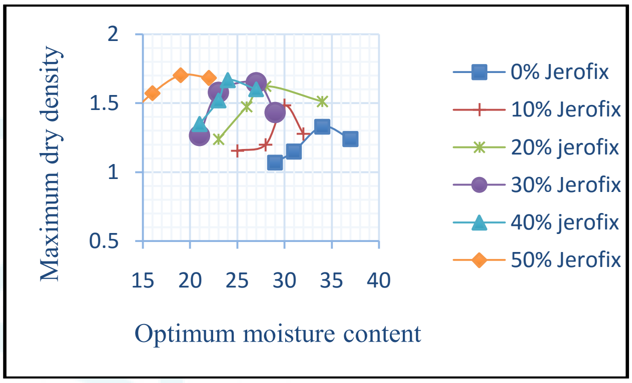

Figure 1: Maximum dry density Vs Optimum moisture content

3.4 Unconfined compression test

The compressive strength of clay sample mixes was found out by conducting the unconfined compressive strength test. Prior to the experiment marine clay fairly air dried and mixed with different percentages of Jerofix to get a uniform mixture. The load at which the sample fails was noted. The result obtained is presented in figure 2.

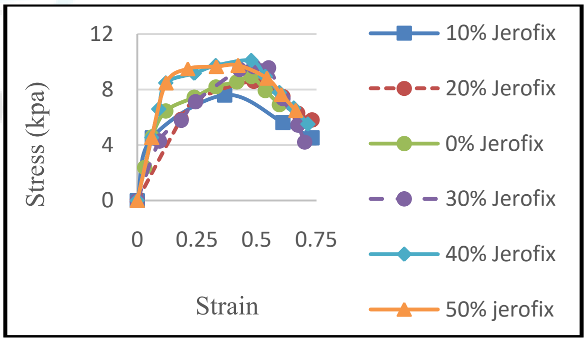

Figure 2: Stress- Strain graph

The unconfined compressive strength of marine clay was found out to be 66.5 kPa. When Jerofix was added to marine clay, an initial decrease in unconfined compression strength was noted but from 30% addition onwards strength increases and maximum value for unconfined compression strength was obtained at 40% Jerofix addition. At 50% addition of Jerofix, the unconfined compressive strength decreases and this is shows the brittle nature of marine clay at higher percent additions of Jerofix.

3.5 California Bearing Ratio Test

The California bearing ratio (CBR) test is one of the most commonly used methods for the evaluation of sub grade strength of roads and pavement stone. The results obtained from the test are compared with the empirical curves to calculate pavement and component layer thickness. The results obtained are shown in figure 3. The CBR value seems to increase with the addition of marine clay.CBR value of uncontaminated marine clay was found to be 3.85 and the optimum of 6.05.

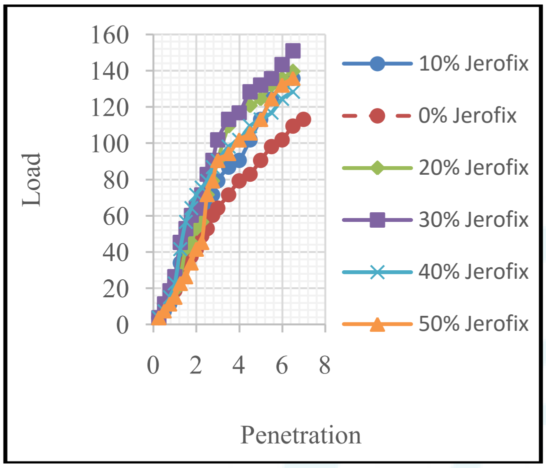

Figure 3: Load Vs penetration

4. Conclusion

It can be concluded that addition of Jerofix has improved the following soil properties considerably:

- Liquid limit and plastic limit decreased on addition of Jerofix when compared with marine clay.
- Maximum dry density increased whereas the OMC showed a decreasing trend with the addition of Jerofix.
- Unconfined compression strength increased with addition of Jerofix and a maximum value of 106kPa was obtained with the addition of 40% of Jerofix.
- CBR value of uncontaminated marine clay which was 3.85 increased to 6.04 with the addition of 30% of Jerofix. Thus it is suitable for construction of road embankment.

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