ISSN XXXX XXXX © 2018 IJESC

Research Article Volume 8 Issue No.6

Shear Strength Characteristics of Jarofix Treated Cochin Marine Clay

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Abstract:
This paper presents the result of a series of experimental investigation carried out to study the shear strength characteristics of Jarofix treated Cochin marine clay. In this study the cochin marine clay is treated with 0.5 %,1 %,1.5 %,2 %, 2.5% and 3% of Jarofix. Jarofix is a waste material produced during the extraction of zinc ore. In order to investigate the strength properties, unconsolidated-undrained test were performed under confining pressures of 50 kPa, 100 kPa and 150 kPa. Modified failure envelope was plotted for various percentage of Jarofix treated soil. Variation of cohesion, angle of internal friction and young's modulus were also plotted for different percentage of Jarofix. Effect of curing period of 3 and 7 days on the shear strength characteristics of the jarofix treated soil was also studied. From the test results, adding of Jarofix to the cochin marine clay results in improvement of the shear strength properties. Providing curing to the jarofix treated clayey soil has higher improvement in shear strength charateristics than the without cured jarofix treated clayey soil.

Keywords: Angle of internal friction, Cochin marine clay, Triaxial compression test, Unconsolidated – Undrained strength, Young's modulus.

1. INTRODUCTION

Clay soils exhibit generally undesirable engineering properties. They tend to have low shear strength which reduces further upon wetting or other physical disturbances. They can be plastic and compressible; expand when wetted and shrink when dried. Some types expand and shrink greatly upon wetting and drying, thereby, exhibiting some very undesirable features. Cohesive soils can creep over time under constant load, especially when the shear stress is approaching its shear strength, making them prone to sliding. They develop large lateral pressures and tend to have low resilient modulus values. For these reasons, clays are generally poor materials for foundations. Their properties may need to be improved upon in some cases by soil stabilization. Stabilisation is the process of blending and mixing materials with a soil to improve the properties of the soil. The process may include the blending of soils to achieve a desired gradation or the mixing of commercially available additives that may alter the gradation and improve the engineering properties of soil, thus making it more stable. This study seeks to determine the shear strength characteristics of clayey soil treated with Jarofix through Triaxial compression tests. The disposal of wastes produced from different industries has become a great problem. These materials pose a threat to the environment because they can result in pollution in the nearby locality since they are majorly non-biodegradable.

2. LITERATURE REVIEW

Santhosh et al. (2016) have studied the effect of Jarofix on geotechnical properties of red earth. This investigation includes the study on the variation of properties of the soil such as Atterberg's limits, compaction characteristics, compressive strength and CBR values when the Jarofix is mixed with the soil. The major findings of the present study is that, even though there is a reduction in strength characteristics of the soil with the addition of Jarofix, the properties are improving with age. A K Sinha et al. (2015); have studied the geotechnical properties of jarofix along with chemically stabilized unconfined compressive strength (UCS). Deformation behaviour of stabilized jarofix is also presented. It is observed that stabilized jarofix waste material has improved UCS value. However, it is recommended that stabilized jarofix may not be economically viable for the construction of pavement layers. Izabel K J et al. (2014) have studied 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 analysed for their variation in index and engineering properties.

3. EXPERIMENTAL WORK

3.1 Materials

In this project jarofix is used for the stabilization of clay. The properties of the soil and the Jarofix are described below.

3.1.1 Marine Clay

The soil sample was collected from Kadavanthra, Ernakulam, Kerala, India. Fig 1 shows the collected soil sample.

3.1.2 Jarofix

The Jarofix was collected from Binani Zinc.Ltd at Binanipuram, Aluva, Ernakulam as shown in fig 2

Figure.1. Marine Clay

Figure.2. Jarofix

Table.1. Geotechnical Properties Of Soil

Properties	Values
Natural moisture content(%)	33
Specific gravity	2.64
Liquid limit(%)	61
Plastic limit (%)	28
Shrinkage limit(%)	17
Plasticity index (%)	33
IS classification	CH
Maximum dry density(kN/m^3)	14
Optimum moisture content (%)	29
Swell index(%)	32
Percentage gravel (%)	0.2
Percentage sand (%)	10.6
Percentage silt (%)	15.18
Percentage clay (%)	74.02
Undrained cohesion(kN/m^2)	19
Angle of internal friction(º)	15

Table.2. Geotechnical properties of Jarofix

Properties	**Values**
Specific gravity	2.16
Liquid limit (%)	66
Plastic limit (%)	48
Shrinkage limit (%)	27
Plasticity index (%)	18
Percentage of clay sized particle (%)	6
Percentage of silt sized particle (%)	94
Maximum dry density(kN/m3)	13.7
Optimum moisture content (%)	41
Undrained cohesion(kN/m2)	69
Angle of internal friction(º)	28

4. EXPERIMENTAL STUDY

The soil properties of the particular soil selected for this study were determined in the laboratory according to the relevant I.S. code (IS 2720). Triaxial compression test were carried out on the prepared samples. Jarofix is added to the soil at 0.5%, 1%, 1.5%, 2%, 2.5% and 3% and the shear strength characteristics are evaluated. Effect of curing on the shear strength charateristics was also evaluated by providing curing period of 3 and 7 days. Shear strength characteristics of the cured specimens were also evaluated.

5. RESULTS AND DISCUSSIONS

Triaxial compression test was carried out on Jarofix treated soil as discussed below.

5.1 Triaxial Compression Test

The Triaxial compression test was carried out as per IS 2720 (Part XI) - 1993 on cylindrical specimens of size 37 mm diameter and 70 mm height. Specimens were prepared at different percentages of Jarofix viz. 0.5%, 1%, 1.5%, 2%, 2.5% and 3%.Triaxial compression test was carried out to determine the shear strength. Deviatoric stress was applied upto 3.56% axial strain level.

5.1.1 Variation in deviatoric stress

Table.3. Variation In Deviatoric Stress- Without Curing

Without Curing			
Variation in Jarofix content(%)	Confining pressure(kPa)		
	50	100	150
	Deviatoric stress at 3.57 % strain, (kPa)		
0	82	119	158
0.5	140	211	401
1	296	364	422
1.5	454	501	594
2	470	515	618
2.5	359	396	465
3	219	277	319

Table.4. Variation In Deviatoric Stress- Three Days Curing

Three days curing			
Variation in Jarofix content(%)	Confining pressure(kPa)		
	50	100	150
	Deviatoric stress at 3.57 % strain, (kPa)		
0	82	119	158
0.5	494	583	636
1	607	686	726
1.5	662	791	897
2	710	831	937
2.5	670	723	792
3	567	673	713

Table.5. Variation In Deviatoric Stress- Seven Days Curing

Seven days curing			
Variation in Jarofix content(%)	Confining pressure(kPa)		
	50	100	150
	Deviatoric stress at 3.57 % strain, (kPa)		
0	82	119	158
0.5	607	649	755
1	660	734	776
1.5	697	841	905
2	742	845	969
2.5	699	787	831
3	673	702	787

Test results shows that, the deviatoric stress at failure increases as the percentage of jarofix content increases. Maximum increase occur at the 2% of jarofix addition. More than 2% of jarofix to the soil results in the decrease of stress at failure.Curing of the test specimen has significant effect on the deviatoric stress. There was sudden increase of deviatoric stress upto 3 days and from 3 to 7 days only slight increase of stress occurred.

5.1.2 Variation in undrained cohesion and angle of internal friction due to Jarofix addition

Undrained cohesion and angle of internal friction is calculated by drawing modified failure envelope.

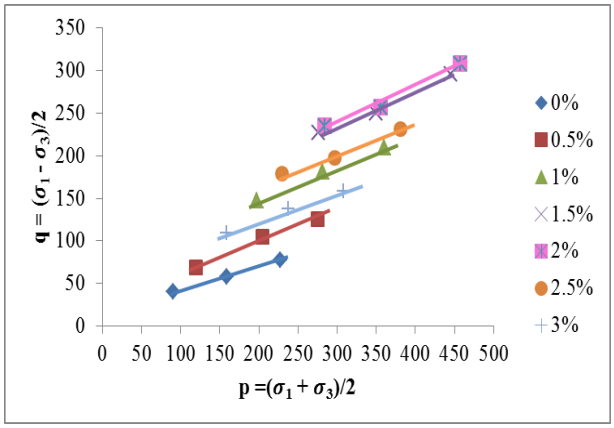


Figure.3. Modified failure envelope(without curing)

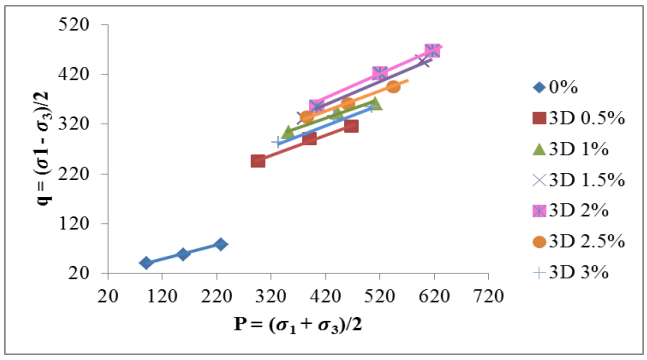
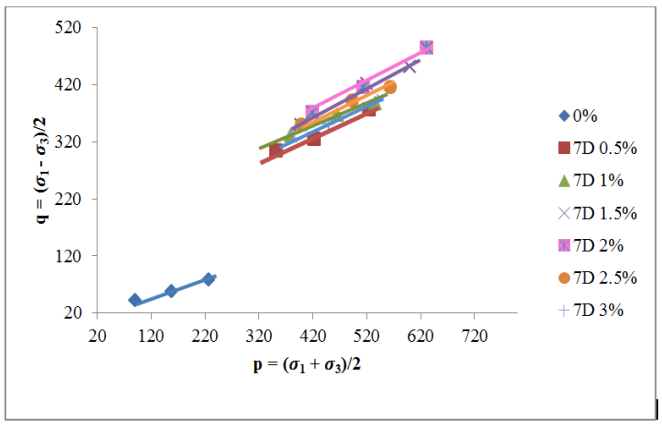


Figure.4. Modified failure envelope (3 days curing)

Modified failure envelope indicates that the soil is in stable condition below the failure envelope. Stress conditions above the failure envelope indicates that the structure is failed From the test results, adding jarofix content to the soil increases the stability of structure. from figure 4 and 5 ,shows that curing has greater influence on the stability of structure.



Figur.5. Modified failure envelope(7 days curing)

Table.6. Variation In Undrained Cohesion And Angle Of Internal Friction(Without Curing)

Without curing		
Variation in Jarofix content(%)	Undrained cohesion(kPa)	Angle of internal friction(°)
0	19	15
0.5	22	24
1	76	24
1.5	131	24
2	132	25
2.5	87	24
3	64	20

Table.7. Variation In Undrained Cohesion And Angle Of Internal Friction(3 Days Curing)

Three days curing		
Variation in Jarofix content(%)	Undrained cohesion (kPa)	Angle of internal friction(°)
0	19	15
0.5	123	27
1	170	27
1.5	182	28
2	205	29
2.5	157	27
3	156	27

Table.8. Variation In Undrained Cohesion And Angle Of Internal Friction(7 Days Curing)

Seven days curing		
Variation in Jarofix content(%)	Undrained cohesion(kPa)	Angle of internal friction(°)
0	19	15
0.5	157	27
1	180	27
1.5	204	28
2	215	28
2.5	181	28
3	158	28

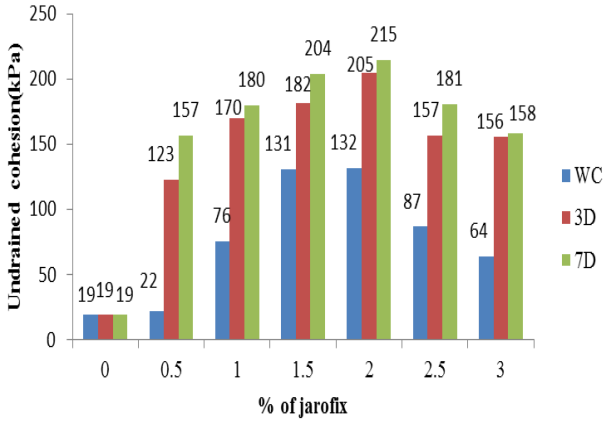


Figure.6. Undrained cohesion v/s % of Jarofix content

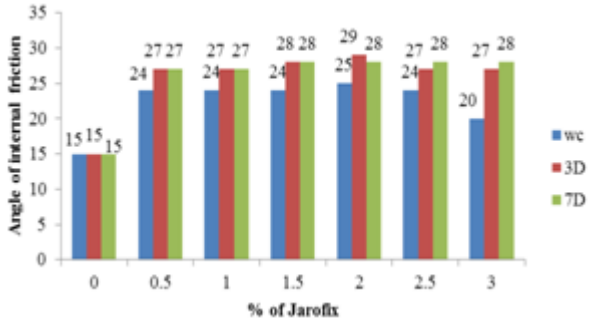


Figure.7 Angle of internal friction v/s % of Jarofix content

As the percentage of jarofix content is increasing the values of undrained cohesion and angle of internal friction is also increasing. The test results shows, maximum increment occurred at 2% of jarofix addition. Undrained cohesion of cured sample is very much higher than the samples without Cured samples.

5.1.3 Variation in young's modulus

Table.9. variation in young's modulus (without curing)

Without curing			
Variation in Jarofix content(%)	Confining pressure(kPa)		
	50	100	150
	Modulus of elasticity(E)		
0	2333	5143	6000
0.5	5000	6250	7143
1	9091	10000	11429
1.5	13333	15000	16666
2	16000	18125	19000
2.5	10000	12500	14000
3	7083	8500	9583

Table.10. variation in young's modulus (3 days curing)

3 days curing			
Variation in Jarofix content(%)	Confining pressure(kPa)		
	50	100	150
	Modulus of elasticity(kPa)		
0	2333	5143	6000
0.5	14545	17500	22000
1	18000	20000	22500
1.5	20000	23333	26666
2	22857	26666	28000
2.5	20000	22000	23333
3	16000	20000	21250

Table.11. variation in young's modulus (7 days curing)

7 days curing period			
Variation in Jarofix content(%)	Confining pressure(kPa)		
	50	100	150
	Modulus of elasticity(kPa)		
0	2333	5143	6000
0.5	18571	20000	22000
1	20000	22500	27500
1.5	25000	25000	30000
2	26000	26666	30000
2.5	20000	20000	25000
3	16666	20000	22500

Modulus of elasticity of the soil is also increases as the percentage of jarofix increase. Curing also has positive effect on the young' modulus.

6. CONCLUSION

Results show that the use of Jarofix as random reinforcing material with clayey soil can result in improved engineering behavior. Deviatoric stress at failure is increases as the percentage of jarofix content increases and the maximum occurs at the 2% of jarofix addition. Undrained cohesion, angle of internal friction and young's modulus is also increases .curing has very positive result on the shear strength characteristics of the soil. Upto 3 days curing provide greater improvement in shear strength characteristics. Beyond 3 days curing provide only small increase in shear strength properties. The strength gain may be due to pozzolonic reaction, cation exchange and strength gaining compounds formed with in the soil Jarofix mixture in presence of water due to the chemical components present in the Jarofix.

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