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STABILIZATION OF CLAYEY SOIL USING VARIOUS ADDITIVES

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Abstract **-** *Construction of various civil engineering structures on available clayey soil is highly risky on geotechnical grounds due to poor strength properties (swell - wet condition, shrink - dry condition) of the clayey soil. Therefore, there is a need for soil treatment which improves the engineering properties of soil. In practice admixtures like human hair fibres (HHF), plastic fibres, rubber crumbs and many other materials are used. Such materials which are non biodegradable may also cause environmental as well as health issues if not disposed properly. To avoid their improper disposal and also to use them effectively, these materials can be used as admixtures to strengthen the clayey soil. Various test results obtained from CBR tests and UCC tests have proven that the addition of these admixtures effectively overcome the shrink and swell property of clayey soil.*

Key Words*: *Human hair fibres, egg shells, rubber crumbs

1. INTRODUCTION

Our environment is getting modernized every day that created a need for the accumulation of huge population in lesser area, so there is a need for the construction of high rise buildings. But the clayey soil present in most of the urban areas is not capable of withstanding such heavy loads from the super structure and the foundation. To overcome this problem, stabilization of soil has become essential. Various admixtures have been used for this purpose but the selection of admixtures depends on the availability, efficiency, non biodegradable property. Various additives which satisfy the above demands are human hair fibres, egg shells, rubber crumbs, coconut shells, polypropylene fibres, papyrus, fly ash, lime, rice husk, marble dust, glass fibres and geosynthetic materials. Among these materials the research work on three different materials such as human hair fibre, egg shell and rubber crumbs have been discussed.

Stabilization is the alteration of foundation soils to conform to desired characteristics or the improvement of less stable soil in both strength and durability. Many different types of soils are subject to differential expansion and shrinkage, when they undergo changes in moisture content. Many soil also rut and move when subjected to moving wheel loads.

2. MATERIALS USED

2.1. Human Hair Fibre

Human hair is the easy available and valueless solid waste which creates serious environmental issues. Thus these wastes can be potentially used in civil field to attain stabilization of clayey soil.

Figure 1: Human Hair Fibres[1]

2.1.1. Properties of human hair

The objective of this research is to identify a natural fiber to investigate and understand the variation in the strength of the cohesive soil with help of human hair fibers when randomly mixed with the soil samples.

Table 1

Property	Remark
Cross-section	Circular
Diameter	50μm
Length	20-25 mm
Linear density (gm/cc)	1.25–1.40
Elongation	1.5 times its dry weight
Tensile strength	About 400 Mpa
Flexural strength (Mpa)	25–30
Chemical reaction	Depends on Hair surface porosity. About 80 % of human hair is formed by a protein known as keratin Depends on physical process of surface tension.
Friction	It depends on the cuticle geometry and on the physical–chemical status of the hair

The properties of human hair fibers are given in table-1 which is obtained from a research paper[2].

2.1.2. Test procedure

All the basic tests were carried out for the plain soil such as, Sieve analysis (Wet and Dry), Modified Proctor Test, Atterberg test, Specific Gravity Test, Unconfined Compressive Strength and CBR Test. Modified Proctor compaction test has been carried out according to IS: 2720 (Part VII) with which maximum dry density is determined. Although UCC test was carried out for the samples after mixing the HHF at various proportions such as 0%, 0.05%, 0.1%, 0.2%, 0.3%, 0.4%, 0.5%.

2.1.3. Test result

Thus it is evidently proven that addition of HHF at about 0.1% increases the strength of clayey soil to about 1.93%.

From the UCC test, the increase in UCC values due to addition of HHF to clayey soil may be attributed because of improvement in the interfacial adhesion between fibre and the soil particles, which permits more effective transfer of stress along the fiber matrix interface. However, the decrement in the UCC values beyond optimum fiber content may be because of the increase in fiber–fiber interaction. Thus, up to some optimum content of natural fibers when used as a potential reinforcement ingredient offers many advantages such as good strength properties, low cost and high toughness.

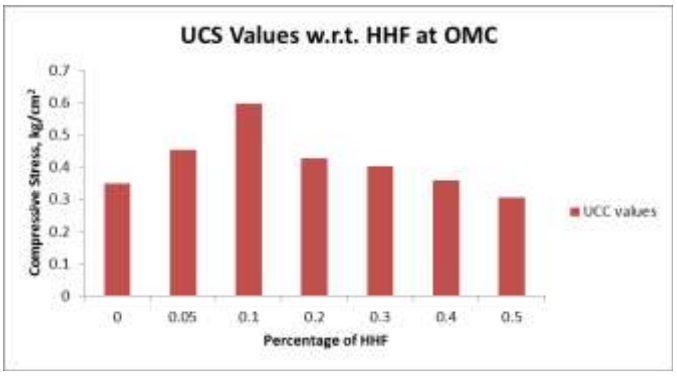


Figure 2: Variation of strength with varying percentage of HHF[1]

For the optimum content of HHF, which is obtained from UCC test and CBR test were carried out for the optimum HHF. This is carried out for both soaked and un-soaked conditions. Then the CBR values are compared with CBR values with 0% HHF. With 0% HHF, the CBR value obtained under soaked condition is 2.89% which is then increased to 4.82% after addition of 0.1% HHF as shown in figure 3.

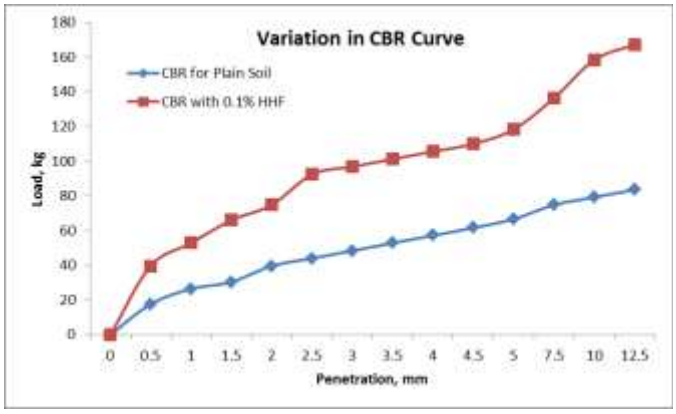
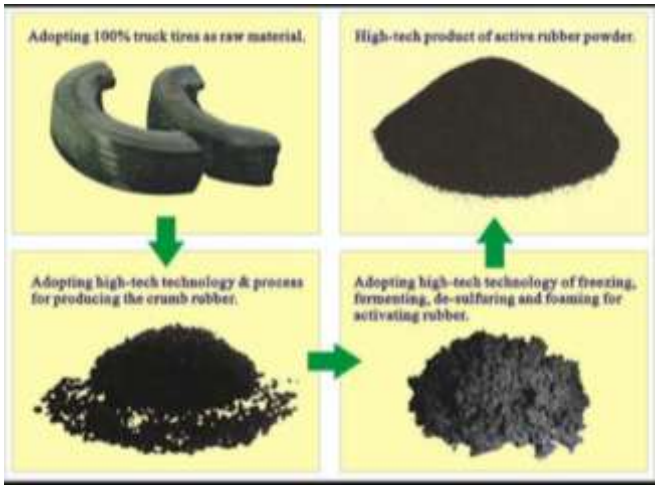


Figure 3: CBR Values with and without reinforcement of HHF[1]

2.2. Rubber crumb

For improving the stability of the soil rubber crumb was choosen as an additive. Crumb rubber is a term usually obtained from recycled rubber or waste tyres. Disposal of tyres by burning creates environmental hazards. Apart from their environmental befits recycling waste tyres are also important. To ensure this these tyres are used in the form of powder or chips. These powder tyres are called as rubber crumbs.



Rubber crumbs are used as additive because of its property to ensure high bearing capacity of the soil.

2.2.1. Properties of rubber crumb

The main properties of rubber crumbs are low density, resilience and high frictional strength. The crumbs are added to the soil in proportion of 5%, 10% and 15% by weight.

The table-2 gives the proportions of the soil used for test which was taken from a research paper.[3]

Table 2: Various proportions of sample used

Various proportions of sample used Sample	Soil (%)	Crumb rubber powder (%)	Lime (%)
A	100	0	0
B	93	5	2
C	86	10	4
D	79	15	6

The above table gives the various percentage proportions by weight.

2.2.2. Test procedure

The effect of rubber crumb as an additive in soil has been proved by conducting various tests such as permeability test, moisture density test, and unconfined compressive test. As clay is weak in addition of crumb the test gives good improvement in the stability of soil.

2.2.3. Test result

The soil proportions S1 and S2 are taken and UCC tests are conducted and the results are combined as shown in table 3 which is taken from a research paper.[4]

Table 3: UCS values of soil and soil-crumb rubber

Soil	UCS Value (kN/m²)				
	Crumb Rubber, %				
	0	5	10	15	20
S1	142	167	206	147	120
S2	100	144	173	180	129

From the above obtained results the following graph is plotted as shown in figure 4 which is taken from a research paper.[4]

Thus from the test results we obtain that 5% to 15% of crumb rubber can be added to the soil.

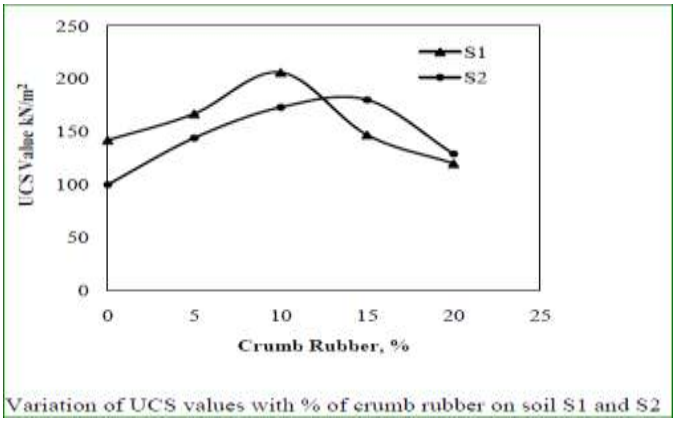


Figure 4: Variation of UCS values with % of crumb rubber on soil S1 and S2

2.3. Egg shell

Eggshell primarily contains magnesium carbonate, protein, calcium and the quantity of lime in eggshell is almost the same as in limestone on ton for ton basis.

2.3.1. Properties of egg shell

The Egg Shells, as per the requirements, was incinerated at 78oC, for 6 hours and was finely powdered to a size finer than 150 μ and was sieved through 75μ, and used as one of the addictives.

Specific Gravity of Egg Shell powder (ESP) used =1.31. Percentages of ESP used: 1,3,5,10,15,20,25,30

2.3.2. Test procedure

It can be inferred from figure 2 that there is increase in OMC with increase ESP. The increase is because of the addition of ESP, that decreases the quantity of free silt, clay fraction and coarser materials with larger surface areas were formed (these processes requires water to take place). This also implies that more water is needed in order to compact the soil-ESP mixture.

The figure 5 shows the variation of OMC with ESP which is taken from a research paper [5]

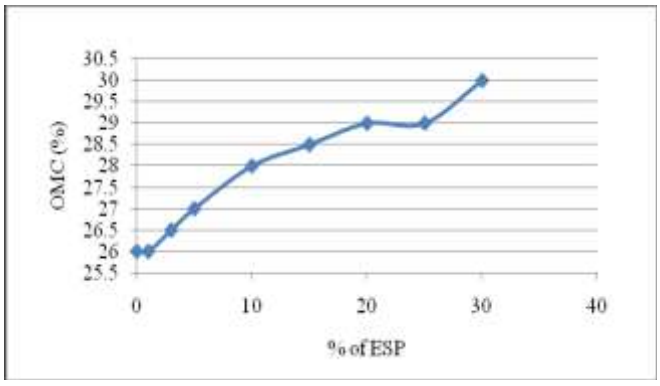


Figure 5: Variation of OMC with ESP

By using Mohr – Coulomb's equation shear strength was calculated. It was found from figure. 6 that with increase in the percentage of ESP the shear strength also gets

increased, later on there is slight decrease at 25% ESP. So the optimum value of shear strength was around 20% with ESP as additive.

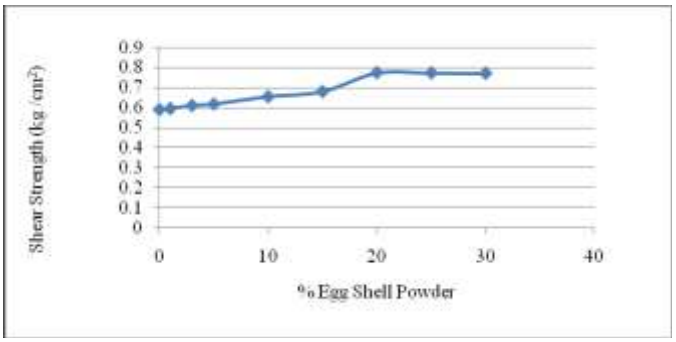


Figure 6: Variation of Shear Strength with Varying % of ESP

The figure 6 shows the variation of shear strength with ESP which was taken from a research paper [5]. From the analysis it is found that 20% of ESP offers considerable improvement in properties of clay soil. Therefore 20% is selected as optimum percentage.

2.3.3. Test result

The normal OMC of soil is 26%. Thus from the above tests results 20% of egg shell powder is taken as an optimum value that should be added to the clayey soil for improved stability in soil.

3. LEATHER POWDER

Leather is one of the most important solid wastes which have to be recycled effectively since burying or burning of these wastes may cause environmental issues. Thus they can be used as stabilizers of clayey soil in civil field.

The various properties which make them as good stabilizers are

- High tensile strength
- Resistance to tear
- High resistance to flexing
- High resistance to puncture
- Good heat insulation
- Resistance to fire
- Resistance to wet and dry abrasion

3.1. Test procedure

The leather wastes obtained from the leather industries are needed to be crushed to powder form. These powders are added to the clayey soil in corresponding proportion such as 1%, 2%,3%,……..,10%. Then various tests such as UCC test, CBR test, proctor compaction test, Atterberg's tests for liquid limit and plastic limit, sedimentation analysis, direct shear test, permeability test are carried for each proportions.

From these tests various results can be attained. By using the values of these results graph can be plotted. By comparing the graphs obtained from the tests on each proportion the optimum percentage of leather powder required to effectively stabilize the clayey soil can be obtained.

4. CONCLUSIONS

The above research paper has dealt with various stabilizing methods and various stabilizing agents at various proportions. Also various tests have been conducted under each category and their results have been discussed. From this discussion it has been found out that addition of

- 0.1% of human hair fibres
- 5% to 15% of rubber crumbs and
- 20% of egg shells

has effectively overcome the shrink and swell properties of clayey soil. In addition to these three materials leather powder is also expected to be an effective agent in the stabilization of clayey soil.

But many researches have not been conducted using leather powders. Hopefully in future many researches will be conducted using leather powder as an efficient stabilizer. Since these powders are easily available. They also cause serious environmental problems if not disposed properly. Thus these materials can be used in civil field for achieving better strength of the clayey soil. This also helps in waste management for protecting our environment.

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