International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 08 | Aug 2021 www.irjet.net p-ISSN: 2395-0072

STABILIZATION OF BLACK COTTON SOIL USING MINE TAILING AND LIME

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Abstract - *The foundation on black cotton soil always have a difficulties, cracks will appear without any warning. The black cotton soil having swelling and shrinkage nature due to present of mineral montmorollite. Due to this nature there will be serious damage to the structure. This problem can be solved by stabilizing the soil. The stabilizing agent used are the mine tailing (which is the waste material obtained during mining) and lime. These black cotton soils are majorly found in Madhya Pradesh, Maharashtra and Karnataka.*

In this project the different combination of mine tailing (i,e 10%,20%,30%,40%,50%)and 4% lime are used to increase the compressive strength of black cotton soil. The experiment conducted in this project liquid limit, plastic limit, MDD, OMC, specific gravity, UCS test. The aim of the project is to overall increasing the engineering properties of the black cotton soil.

Key Words: Lime, OMC, MDD, Properties, Black cotton soil.

1. INTRODUCTION

Soil stabilization is the improvement of the soil strength by compact compaction with various percentages of mine tailing and lime. The combination varies at different percentage at different location based on the location. The stabilizing agent like mine tailing will increase the compressive strength of the soil which is having weak compressive strength. The various combinations of mine tailing and lime are used to find the MDD and OMC based on OMC the optimum moisture content of soil will be find out. Where lime acts as a binding material where it binds the black cotton soil and mine tailing. By using lime as a binding material the overall compressive strength of soil will increases.

This stabilization can be applied in road construction, Building construction and earth filling. Since mine tailing is the waste material obtained during mining and can be used for stabilization process. Therefore it is environmental friendly process.

2. MATERIALS USED

BLACK COTTON SOIL

Fig -1: Black Cotton Soil

Black cotton soil is a sedimentary type of soil that is formed by wear and tear of the specific rock. The moderate climate condition and volcanic erupted igneous or basalt rock as a parent rock is required for the formation of black soil. And then weathering or breaking of the igneous rock and cooling and solidification of the lava causes black soil formation. It is also known as lava soil since it is formed from lava soil. Black cotton soil is a heavy clay soil, varying from clay to loam. It is generally light to dark grey in color. Cotton is grown in this type of soil. Black cotton soil occupies about 3% of world land area. The soil prevails generally in central and southern parts of India. One of the most important characteristics of this type of soil is that it shrinks and becomes hard like stone when it is dry and has very high bearing capacity. Large cracks are formed in the bulk of soil. The whole area splits up and cracks up to 150mm wide are formed up to depth of 3.0 to 3.5m. But when the soil is moist it expands, becomes very soft and there is loss of bearing capacity. Black cotton soil is mainly divided into three types based on its thickness and they are, shallow black soil(thickness less than 30cm), medium black soil(thickness ranges from 30cm to 100cm), deep black soil(thickness is more than 1m and is found in low lands).

In tropical countries like India because of wide variation in temperature and because of distinct dry and wet seasons, leading to wide variations in moisture content of soil. The main problems that are faced while working with black cotton soil are high compressibility, swelling, shrinkage. Basic engineering properties that are analyzed for

the soil are permeability, plasticity, compaction, compressibility, shear strength.

LIME

Fig -2: Lime

Lime is utilized as an effective way to modify soils improving both workability any load bearing characteristics while increasing stability any impermeability. The workability is improved because flocculation makes the clay more friable this assists combination for effective mixing any compaction lime increases the optimum water content for compaction, which is an advantage when dealing with wet soil. The compaction curve for lime treated clay is generally flatter, which makes moisture control less critical and reduces the variability of the density produced. In first few hours after mixing, lime additives cause a steady increase in strength, but at a slower rate than cement.

The need for compaction immediately after mixing is therefore less critical for lime than cement. Lime increases the strength of clayey soil. Related to strength is improved durability under traffic or resistance to the action of water, wind, and freeze-thaw cycles. The shrinkage and swell characteristics of soil are reduced markedly. The lime stabilized layer forms a water resistant barrier by impeding penetration of gravity water from above and capillary moisture from below.

MINE TAILING

Fig -3: Mine Tailing

Mine tailings are the byproducts left over after the separation process (separation of valuable fraction from the uneconomic fraction) of an ore. But tailings are distinct from overburden, which is the waste rock or material that overlies an ore or mineral body and is displaced during mining without being processed. Thus extraction of minerals from ore can be done in two ways: first is placer mining which uses water and gravity to concentrate the valuable minerals and second is hard rock mining, which pulverizes the rock containing the ore into fine particles to facilitate extraction of the target elements. Because of this combination, tailings consist of slurry of fine particles, ranging from the size of a grain of sand to a few micrometers.

Mine tailings are usually produced from the mill in slurry form, which is a mixture of fine mineral particles and water. Tailings that are stored in water by tailings dam in ponds, can be dangerous sources of toxic chemicals, such as heavy metals, sulphides and radioactive content. These ponds are also vulnerable to major water sources like beaches, lakes, ponds which cause environmental disasters. It also leads to groundwater leakage, toxic emissions, or bird death, tailing piles and ponds often are under regulatory scrutiny. There are a wide range of methods for recovering economic value containing or otherwise mining can be used for constructions and reduce the impact on nature.

3. SCOPE OF THE STUDY

Black cotton soil swells when it comes in contact with the water and shrinks on drying. This type of soil is characterized by inherent swelling and shrinkage characteristics due to the presence of montmorillonite clay minerals present in the soils. Because of volume change behaviour, the structure construction in such soil will undergoes differential settlement, cracking in structures. In this investigation, mine tailings and lime are used to improve the geotechnical property of Black Cotton soil.

The scope of the study is mentioned as follows:

- To study the Index properties of black cotton soil with and without additives at various percentages.
- To improve the engineering properties of black cotton soil by different additives with various percentages for different curing periods.
- To study the compaction characteristics of black cotton soil with the addition of lime in presence of mine tailing.
- To study the strength behavior of black cotton soil with and without additives for various curing periods.

4. PROPERTIES

BLACK COTTON SOIL

The soil used was locally available expansion soil which was collected from kadur, Karnataka. The properties of the soil determined by various experiments have been enumerated below:

Table -1: BASIC PROPERTIES OF BLACK COTTON SOIL.

SL.NO	PARTICULARS	BLACK COTTON SOIL
1.	Colour	Black
2.	Specific Gravity	2.58
3.	Gravel(%)	10.25
4.	Sand(%)	5.3
5.	Silt(%)	5.0
6.	Clay(%)	79.45
7.	Liquid Limit(%)	51.5
8.	Plastic Limit(%)	37.2
9.	Plasticity Index(%)	14.3
10.	IS Classification	CH
11.	Maximum Dry Density (MDD) In (g/Cc)	1.56
12.	Optimum Moisture Content (OMC) In (%)	23.07

Table -2: CHEMICAL PROPERTIES OF BCS

SL NO.	PARTICULARS	BLACK COTTON SOIL
1.	Ph	7.33
2.	Electrical Conductivity (Ds/M)	0.22
3.	Organic Carbon (%)	0.25
4.	Available Nitrogen (Kg/Ha)	201
5.	Available Phosphorus (Kg/Ha)	26
6.	Available Potassium (Kg/Ha)	457
7.	Zinc (Zn) In (Ppm)	0.30
8.	Copper (Cu) In (Ppm)	0.49
9.	Iron (Fe) In (Ppm)	0.14
10.	Manganese (Mn) In ppm	1.47

MINE TAILING:

The byproduct of mine is obtained from kolar gold field which is obtained during extraction of gold. The properties of the mine tailing determined by various experiments have been enumerated below:

Table -3: BASIC PROPERTIES OF MINE TAILING.

SL NO.	PARTICULARS	MINE TAILING
1.	Colour	Dark Grey
2.	Specific Gravity	2.77
3.	Gravel	2.95
4.	Sand	97.05
5.	Silt	3
6.	Clay	17.6
7.	Maximum Dry Density (MDD) In (G/Cc)	1.52
8.	Optimum Moisture Content (OMC) In (%)	20

Table -4: CHEMICAL PROPERTIES OF MINE TAILING

SL NO.	PARTICULARS	MINE TAILING
1.	Ph	5.33
2.	Electrical Conductivity (Ds/M)	2.4
3.	Organic Carbon (%)	0.31
4.	Available Nitrogen (Kg/Ha)	247
5.	Available Phosphorus (Kg/Ha)	51
6.	Available Potassium (Kg/Ha)	87
7.	Zinc (Zn) In (Ppm)	0.24
8.	Copper (Cu) In (Ppm)	3.89
9.	Iron (Fe) In (Ppm)	0.59
10.	Manganese (Mn) Ppm	0.18

5. TEST CONDUCTED

1. Specific gravity
   As per IS: 2720 (part-3/sec-1)-1980
2. Grain size analysis
   As per IS: 2720 (part-4)-1985
3. Atterberg's limits
   - Liquid limit
     As per IS: 2720 (part-5)-1985
   - Plastic limit
     As per IS: 2720 (part-5)-1985
   - Shrinkage limit
     As per IS: 2720 (part-6)-1972
5. Mini Compaction test
6. Unconfined compression strength test
   As per IS: 2720 (part-10)-1973

Table -5: BASIC PROPERTIES OF MINE TAILING.

Sl no.	Procurement of materials.	Black cotton soil, Mine tailing
1.	Determining the physical and chemical properties of the materials used.	a.Sieve analysis. b.Specific gravity. c.Plastic limit. d.Liquid limit. e.Compaction.
2.	Physical test for soil with different percentage of additives.	10%, 20%, 30%, 40%, 50%
3.	Determining the MDD and OMC for various	1. BCS+MT 2. BCS+MT+LIME

	combinations.	
4.	Preparing UCS moulds for different combinations.	Curing period: (0,7,14,28)days.
5.	Finding out compression strength of moulds.	
6.	Comparison of results	Comparing the results obtained during tests on black COTTON soil and black soil with additives.
7.	Results and Conclusion	

To study about the soil stabilization, soil is mixed with mine tailings and lime and their engineering properties were determined. The test procedure adopted has been presented below in detail. The experimental setup and the test procedure have been planned in such a way that it is taken into account all the related aspects.

LIQUID LIMIT AND PLASTIC LIMIT OF BLACK COTTON SOIL:

Table -6 RESULTS OF ATTERBURG LIMITS OF BCS

PARTICULARS	BLACK SOIL
LIQUID LIMIT	51.5
PLASTIC LIMIT	37.2
PLASTICITY INDEX	14.3
IS CLASSIFICATION	CH

LIQUID LIMIT TEST:

Table -7 LIQUID LIMIT OF BCS WITH VARIOUS PERCENTAGES OF MT AND LIME

COMBINATION	LIQUID LIMIT IN %
BCS alone	51.5
MT alone	24.6
BCS+10%MT	74.5
BCS+20%MT	50
BCS+30%MT	29
BCS+40%MT	54
BCS+50%MT	83
BCS+10%MT+4%LIME	76
BCS+20%MT+4%LIME	53
BCS+30%MT+4%LIME	34

COMPACTION TEST:

Table -8 COMPACTION CHARACTERISTIC OF BCS WITH VARIOUS PERCENTAGE OF MT

Combination	MDD in gm/cc	OMC in %
BCS	1.58	23.07
MT	1.52	20
BCS+10%MT	1.63	17.39
BCS+20%MT	1.58	23.25
BCS+30%MT	1.71	12.12
BCS+40%MT	1.73	22
BCS+50%MT	1.89	11.54

The results of the compaction test for the combination of black cotton soil and mine tailing are shown in the above table.

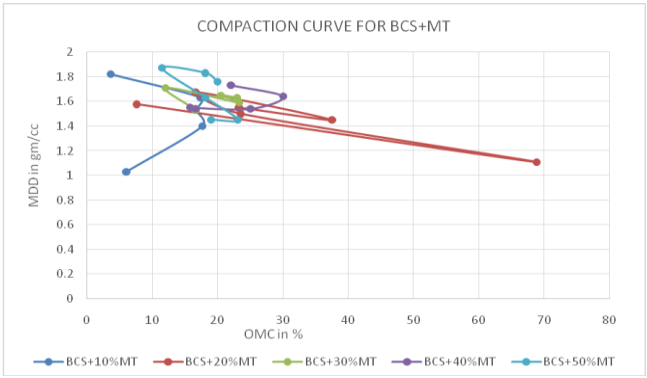

Chart -1: COMPACTION CURVE FOR BCS+MT COMBINATION

Table -9 COMPACTION CHARACTERISTIC OF BCS WITH VARIOUS PERCENTAGE OF MT AND LIME

Combination	MDD in gm/cc	OMC in %
BCS+10%MT+4%LIME	1.65	19.2
BCS+20%MT+4%LIME	1.65	10
BCS+30%MT+4%LIME	1.68	18.75
BCS+40%MT+4%LIME	1.71	15.7
BCS+50%MT+4%LIME	1.62	26.3

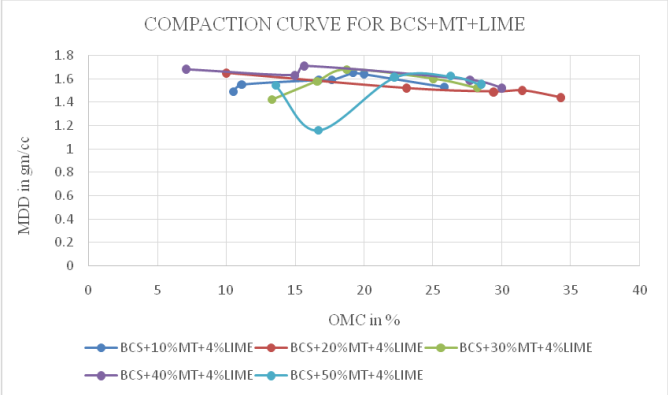

Chart-2: COMPACTION CURVE FOR BCS+MT+LIME COMBINATION

The compaction test was conducted on the various combinations of BCS+MT+Lime. The results obtained are shown in the above graph.

SPECIFIC GRAVITY TEST:

Table -10 SPECIFIC GRAVITY

Combination	Specific Gravity
Black cotton soil	2.58
Mine tailing	2.77
BCS+10%MT	2.61
BCS+20%MT	2.68
BCS+30%MT	2.71
BCS+40%MT	2.75
BCS+50%MT	2.76

UNCONFINED COMPRESSION TEST:

Table -11 UNCONFINED COMPRESSION STRENGTH RESULT

Combination	0 Days KPa	7 DAYS KPa	14 DAYS KPa	28 DAYS KPa
BCS+10%MT	216	221	225.2	233.5
BCS+20%MT	249.0	278.4	278.9	281.3
BCS+30%MT	262.3	330.9	197.2	197
BCS+40%MT	112.5	135.4	156.2	262
BCS+50%MT	105.2	122.2	262.5	276.5

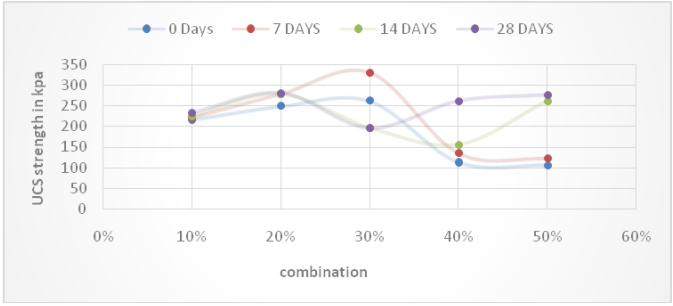

Chart-3: UCS STRENGTH VALUES FOR BCS+MT COMBINATION

Combination	0 Days KPa	7 DAYS KPa	14 DAYS KPa	28 DAYS KPa
BCS+10%MT+ 4%LIME	1098.3	1099	1400.6	1410.5
BCS+20%MT+ 4%LIME	1152.1	1338.0	1420.6	1489.1
BCS+30%MT+ 4%LIME	852.4	966.7	1050.1	1352.4
BCS+40%MT+ 4%LIME	831.3	858.4	879.3	963.7
BCS+50%MT+ 4%LIME	988.2	995	997.5	1052.4

Table -12 UNCONFINED COMPRESSION STRENGTH RESULT

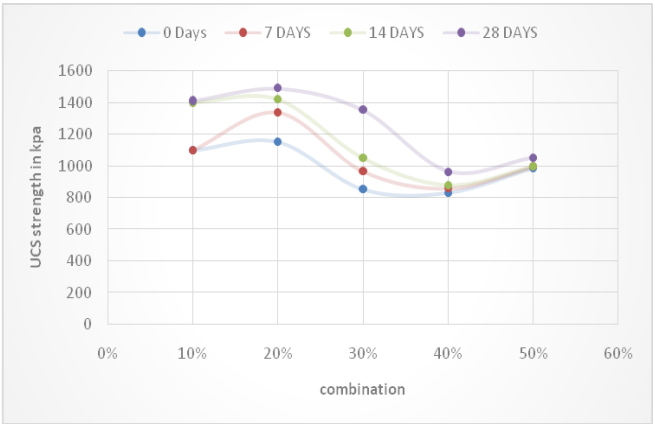

Chart-4: UCS STRENGTH VALUES FOR BCS+MT+LIME COMBINATION

6. CONCLUSIONS

Based on the results obtained from detailed analysis of the results, the conclusion of the Study is as follows:

- Addition of mine tailing to black cotton soil increases its optimum moisture content and dry density. This increases due the presence of mine content.

- The Black cotton soil when replace it by 20% of mine tailing shows the best improvement in its purpose i.e. MDD,OMC etc., therefore soil can be improved by addition of mine tailing
- The addition of lime to black cotton soil leads to slight reduction in the maximum dry
- Unit weight, when compared with the natural soil. This is due to the resistance offered by the flocculated structure of the soil-Lime max against impact.
- Hence mine tailing and lime can be used to stabilize the black cotton soil due to its properties and impact.
- Black cotton soil treated with mine tailing maximum dry density increases up to 20% and then decreases. Mine tailing with lime the maximum dry density and optimum moisture content increases.
- Black cotton soil treated with mine tailing with lime the liquid limit varies i.e. 10 to 40% increases then decreases.
- Black cotton soil with 20% mine tailing shows the high compressive strength i.e.. 281.3KPa.
- Black cotton soil with 20% mine tailing along with 4% lime shows the high compressive strength of 1489.1KPa when compared with compressive strength of black cotton soil of 76.5KPa.

7. REFERENCES

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