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Study on Observed Values of Soaked CBR of Copper Slag Cushion Laid Over Lime Stabilized Marine Clay

G. J Asmine Vincent [#1], Sumanjali Parimi[#2], Vijaya L[#3]
[#]Civil Engineering Department ,
Raghu Engineering College JNTUK), Andhra Pradesh,India

Abstract: **The improvement of road construction is subjected to changes with changing vehicular pattern, construction materials and sub grade conditions. Majority of the pavement failures could be arise due to the presence of poor sub grade conditions and expansive sub grade is one such problematic situation. Marine clays are expansive soils and they exhibit unusual physical properties like high Liquid limit, low bearing capacity , higher settlement and high seepage loss but being predominantly distributed all over the world. Stabilization of Marine clay is a method employed for modifying the properties of a clay to improve its engineering performance. Now a day's various waste materials are available for the improvement of strength and characteristics of soil. In this study, in order to improve the properties of Lime stabilized Marine clay the Industrial waste that is Copper slag is added and laid as cushion. Due to this it reduced the consistency values , improves the Shear Strength Parameters and increased the soaked CBR values. There are several tests to be carried out, they are Atterberg limits (liquid limit and plastic limit),Heavy Compaction , specific gravity , Differential Free Swell, wet sieve analysis ,Direct Shear test, Soaked California Bearing Ratio . These tests will be conducted based on the varying percentages 2%, 4% and 6% by weight of lime and copper slag with the Marine Clay.**

Key Words: Marine Clay, Copper Slag, Lime, OMC, MDD, Direct Shear, Soaked CBR, Cushion

I. INTRODUCTION

Civil Engineering structures require bulk quantities of natural soils to suit as construction and foundation material and to meet certain specifications such as stones, sands, gravel soils etc. Some materials are durable and some of them have been continuously deforming when contacted with water. These result in development of failures with respect to loss of strength and finally subjected to abnormal settlements which threat the life of the structure as a whole .A number of researchers have made their contributions for the utilization of above said materials in various geotechnical applications. The soil found in the ocean bed is classified as Marine soil. It can be even located onshore as well .The properties of marine clay depends significantly on its initial conditions. All over the world problem of marine clay have appeared as cracking and break up of pavements. Marine or soft clay exists these region are weak in nature. For any construction works soil surrounding it plays an important role. Most of the soils especially in marine areas are not at all suitable for any construction works . Improvements in soil properties make it suitable for various purposes especially for road pavements. Marine Clay tend to swell and become soft when wetted and may shrink and become stiff when dried. Stabilized soils can be successfully used for construction of roads. In this study , for the stabilization of marine clay we are using Copper Slag for the improvement of properties and make it suitable as a sub – grade material in the pavement and some soil tests are to be done are discussed below. Copper Slag is an industrial waste is also used for soil stabilization along with lime in this study. Copper Slag is a waste product comes out from smelting process. Lime has been found to be the most effective and economical of all additives .Addition of lime to expansive soils reduces swell potential and increases workability and strength. Various studies were carried out by researchers on utilization of Copper slag and Lime for the expansive soil.

II.MATERIALS AND METHODOLOGY

i.MATERIALS USED

A. Marine Clay (MC):

The Marine clay used in this study is locally available and collected from HPCL Visakhapatnam up to a depth of 3m below the ground as shown in the below figure. The soil was air dried before the commencement of experiments .As per I.S classification (IS) the Marine Clay is classified as CH. The Physical Properties of Marine Clay is tested in the Laboratory studies are listed below.

figure1: Marine Clay

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The following properties are observed from visual classification in dry condition.
Color : Black Color
Odour : Decaying vegetation
Texture : Fine grained
Dry strength : Medium
Plasticity : Highly plastic

Table 1: Physical properties of Marine Clay

Properties	Values
Is Classification	CH
Specific Gravity	1.83
Liquid Limit	64
Plastic Limit	35.56
Plasticity Index	28.44
Toughness Index	2.32
Flow Index	11.9
Differential Free Swell	62.9
Maximum Dry Density	1.74
Optimum Moisture Content	16.4
Cohesion	0.3
Angle Of Internal Friction	17
Soaked CBR	1.57

B. Copper Slag (CS)

Copper slag is an Industrial by-product obtained in the production of copper extraction by smelting .The impurities which float on the metal are removed is known as copper slag, which is obtained in a molten state. Addition of copper slag as fine aggregate in various bituminous mixes improves good interlocking and eventually improved the volumetric properties. The production of copper slag is 120-130 lakh ton per annum and copper producing units in India leave thousands of tons of copper slag as waste every day, granulated copper slag is more porous and, therefore has particle size equal to that of coarse sand . Various studies were carried out by researchers on utilization of copper slag in expansive soil results for good soil stabilizations also copper slag has high angularity and friction angle (up to 520) of aggregates contribute to the stability and load bearing capacity. Also copper slag aggregates tend to be free draining and are not frost susceptible. Copper slag can be recommended for sub-base, Sub-grade, bitumen mixes.

Fig2: COPPER SLAG

Table 2: Physical Properties of Copper Slag

Physical Properties	Copper slag
Particle shape	Irregular
Appearance	Black &glassy
Type	Air cooled
Moisture content	0.1%

Table 3: Chemical Properties of Copper Slag

Properties	Value
Iron oxide (fe_2o_3)	42-48
Silica (sio_2)	26-30
Aluminum oxide (Al_2o_3)	1.0-3.0
Calcium oxide (Cao)	1.0-2.0
Manganese oxide (Mgo)	8-1.5

C.LIME

Lime stabilization is done by adding lime to a soil. It is useful for stabilization of clayey soils. When lime reacts with soil there is an exchange of cat ions in the absorbed water layer and decrease in plasticity of soil occurs .It is produced by burning of lime stones in kilns. Lime is routinely used as a soil modification agent to improve the performance of sub grade soils with the primary goal of reducing volume change. Effective mixing of lime and soil is critical to ensuring that the expected improvements occur throughout the soil mass. Lime also decreases the apparent amount of fines in a soil by causing flocculation and agglomeration of the clay particles (Little 1995). This results in an increase in the percentage of sand and silt size particles as measured by standard grain size distribution methods (Basma and Tuncer 1991.Lime also tends to reduce the swell potential of fine grained soils (Kennedy et al 1987). Moisture content plays an important role in the swell potential of a lime treated Clay.

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Fig3: LIME

PROPERTIES OF QUICKLIME

- Lime is a white amorphous solid.
- It has a high melting point of 2600° C.
- It is highly stable and even fusion cannot decompose it.

CHEMICAL PROPERTIES:

- On hydration, quick lime forms slaked lime or lime water. When water is added to lime it becomes hot and cracks to form a white powder. This is called slaking of lime.

  $CaO + H_2O \rightarrow Ca(OH)_2$

  Slaked lime
- Calcium oxide is a basic oxide. It can react with acids to give calcium salts.

  $CaO + H_2SO_4 \rightarrow CaSO_4$

  Sulphuric acid calcium sulphate
- With acidic oxides like silicon dioxide and phosphorus pent oxide, it forms silicates and phosphates. This property makes lime useful as a flux in metallurgy to remove impurities.

  $CaO + SiO_2O \rightarrow CaSiO_3$

  Calcium silicate

  $3CaO + P_2O_5 \rightarrow Ca_2(PO_4)_2$

  Calcium phosphate

ii.METHODLOGY

Copper Slag and Lime are added separately in the Marine Clay of varying percentages of 2%, 4% and 6%.

There are several tests to be carried out, they are Atterberg limits (liquid limit and plastic limit),Heavy Compaction , specific gravity ,Differential Free Swell, wet sieve analysis ,Direct Shear test, Soaked California Bearing Ratio as per I.S Standard Codes of Practice.

III.RESULTS AND DISCUSSION

In this study copper sag and lime are added separately in the marine clay of varying percentages of 2%,4%a and 6%.Atterberg Limits, Differential Free Swell, Specific Gravity, Heavy Compaction ,Direct Shear and Soaked California Bearing Ratio tests are have been conducted as per IS codal provision. Different test results of Copper Slag and Lime mixed with Marine Clay are tabulated below table 5 and 6 respectively.

Table 5: Test results of CS mixed with MC

TESTS	MC	98%MC+2%CS	96%MC+4%CS	94%MC+6%CS
specific gravity	1.83	1.94	2.01	2.08
DFS	62.9	47	40	36
Liquid Limit	64	61.9	60.9	59.8
Plastic Limit	35.56	33.53	32.7	31.74
Plasticity Index	28.44	28.38	28.2	28.06
Toughness Index	2.32	2.27	2.15	1.76
Flow Index	11.9	12.49	13.06	15.9
OMC (%)	16.4	21.4	24.2	17.5
MDD(Gm/Cc)	1.74	1.64	1.62	1.71
Cohesion	0.3	0.16	0.18	0.19
Angle of Internal Friction	17	30	27	24
Soaked CBR at 2.5mm	1.57	-	7.88	-
Soaked CBR at 5mm	1.31	-	6.04	-

Table 6: Test results of LIME mixed with MC

TESTS	MC	98%MC+2%LIME	96%MC+4%LIME	94%MC+6%LIME
specific gravity	1.83	2.03	2.07	2.1
DFS	62.9	50	43	40
Liquid Limit	64	50.2	46	43.5
Plastic Limit	35.56	34.4	33.2	31.4
Plasticity Index	28.44	15.8	12.8	10.9
Toughness Index	2.32	1.02	0.6	0.5
Flow Index	11.9	13.49	17.05	21.59

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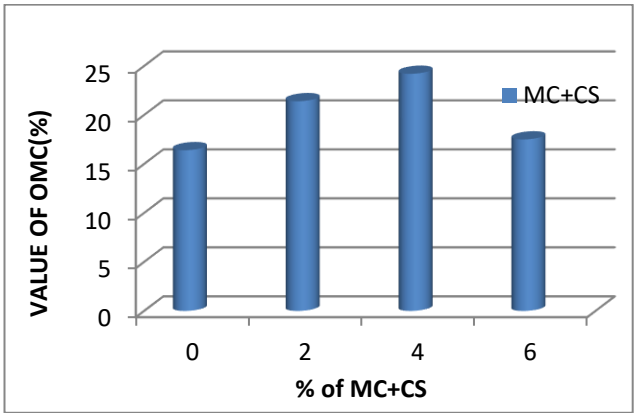
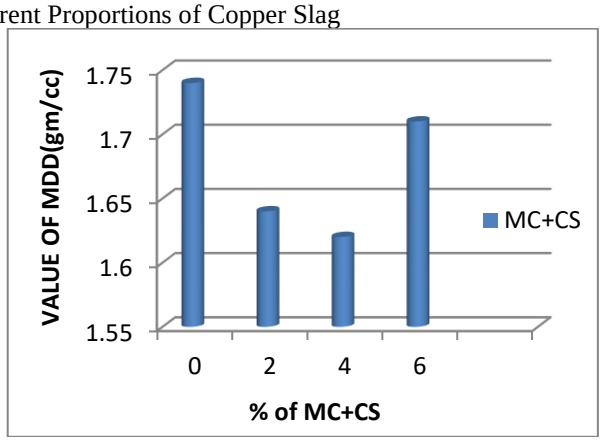
OMC (%)	16.4	19.6	23.17	21.98
MDD(Gm/Cc)	1.74	1.63	1.58	1.61
Cohesion	0.3	0.26	0.24	0.21
Angle of Internal Friction	17	29	25	21
Soaked CBR at 2.5mm	1.57	-	10.64	-
Soaked CBR at 5mm	1.31	-	9.19	-

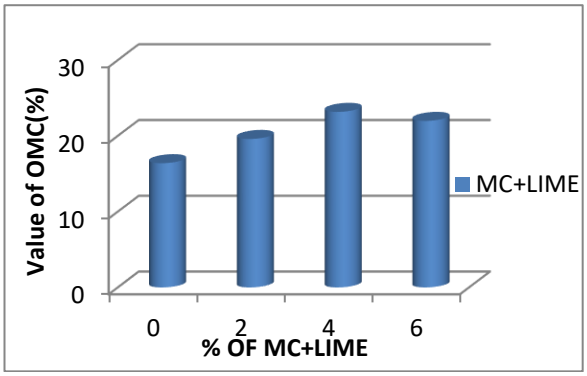
Further, the variations of liquid limit ,Plastic Limit, Optimum Moisture Content, Maximum Dry Density, Cohesion, Angle Of Internal Friction And Soaked CBR values with Cushion ,With Percentages Of CS and LIME are shown below figures.

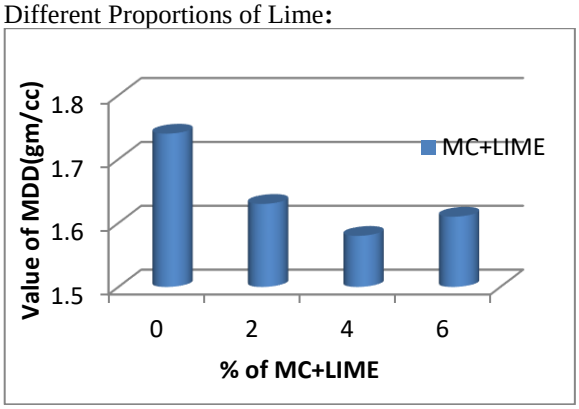
OMC and MDD for Different Proportions of Copper Slag



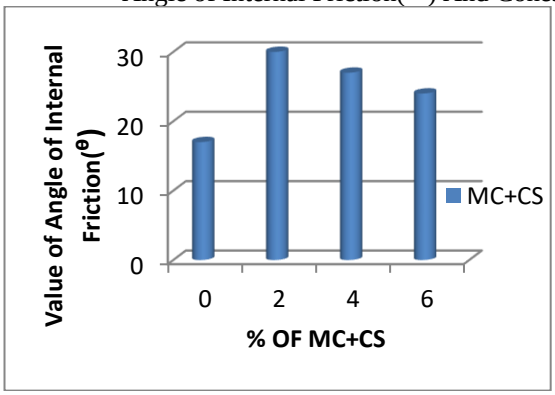


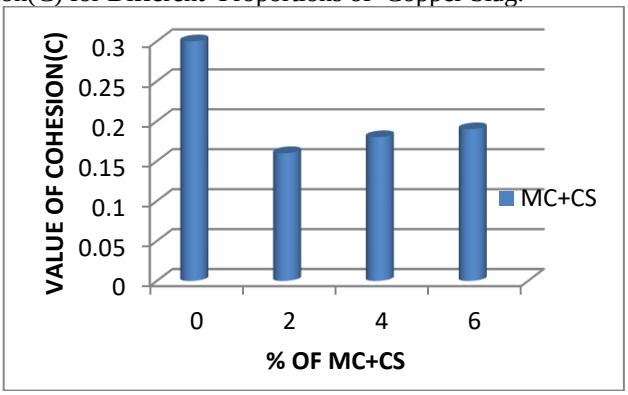
OMC and MDD for Different Proportions of Lime:





Angle of Internal Friction(ϕ) And Cohesion(C) for Different Proportions of Copper Slag:





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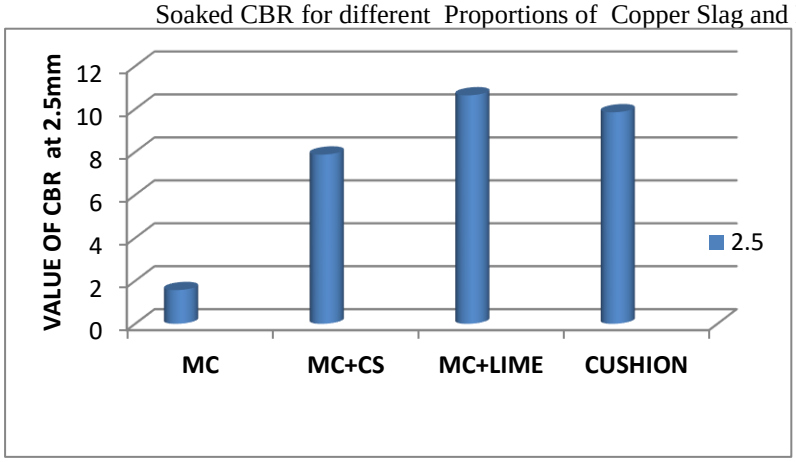
Soaked CBR for different Proportions of Copper Slag and Lime:



IV.CONCLUSION

- Addition of Copper Slag and Lime with 2%,4%and 6% has shown good decrement in DFS and Consistency Indices values, and Increases in specific Gravity value.
- The Optimum Moisture Content is increased 16.64% to 21.4%, 24.6% up to by adding2%, 4% of Copper Slag later goes on decreases 17.5% at 6% of Copper Slag.
- The Maximum Dry Density is decreased 1.74gm/cc to 1.66gm/cc, 1.63gm/cc up to by adding 2%, 4% of Copper Slag later goes on increases 1.71gm/cc at 6% of Copper Slag.
- The Optimum Moisture Content is increased 16.64% to 19.6%, 23.17% up to by adding 2%, 4% of Lime later goes on decreases 21.98% at 6% of Lime.
- The Maximum Dry Density is decreased 1.74gm/cc to 1.63gm/cc,1.58gm/cc up to by adding 2%,4% of Lime later goes on increases 1.61gm/cc at 6% of Lime.
- DFS value is decreased from 62.9% to 47%,40% and 36% by adding 2%, 4% and 6% of Copper Slag. And decreased from 62.9% to 50%,43% and 40% by adding 2%, 4% and 6% of Lime
- Cohesion value is decreased from 0.3 to 0.16, 0.18 and 0.19(kg/cm²) by adding 2%,4% and 6%of Copper Slag. And decreased from 0.3 to 0.26,0.24, and 0.21(kg/cm²) by adding 2%,4% and 6%of Lime..
- Angle of friction value is increased from 17° to 30, 27,and 24° by adding 2%,4% and 6%of Copper slag. is increased from 17° to 29,25,and 21° by ²) by adding 2%,4% and 6%of Lime.
- Soaked CBR value at 2.5mm penetration is increased from 1.576% to 7.88% by adding 4% of Copper Slag. And increased from 1.576% to 10.6% by adding 4% of Lime.
- Soaked CBR value for CUSHION at 2.5mm penetration is increased from 1.576% to 9.85%by adding 4% of copper slag and Lime.

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