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An Experimental Study on Paper Mill Lime Sludge as Stabilizing Agent

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ABSTRACT: The present paper deals with the properties of black cotton soil & red soil mixed with lime sludge in varying proportions. The properties of sample S1 and sample S2 are individually determined. The properties like OMC, MDD and CBR are evaluated in different percentages of lime sludge varying from 5% to 20% with an interval of 5%, added to its dry weight of soil. It is found that mixing lime sludge in varying proportions increases the Bearing Capacity of the soil.

KEYWORDS: Lime sludge, Sub-Base, Compaction Test, and California Bearing Ratio.

I. INTRODUCTION

Soil stabilization helps increase the strength of the existing soil to improve its capacity for load bearing. Dust control and soil water proofing are two other reasons why soil stabilization is done. With dust control, the dust that is generated by the consistent use of equipments and machinery can be eliminated, especially in dry and arid weather. The third purpose of soil stabilization, soil water proofing, preserves the natural strength of a soil by obstructing the entry of surface water.

Lime sludge is generated from paper, acetylene, sugar, fertilizer, sodium chromate, soda ash industries, and water softening plants. Approximately 4.5 million tons of sludge in total is generated annually from these industries. The study has revealed that sludge from paper industry can be utilized up to 74 % (dry basis) as a component of raw mix for the manufacture of cement clinker. In addition to it around 30 % (dry basis) lime sludge can also be utilized for the manufacture of masonry cement. Due to the presence of higher quantities of deleterious constituents in carbide sludge, it can be used up to 30 % whereas level of utilization for other sludge could reach to only 10 % in the manufacture of cement clinker.

II. RELATED WORK

Raghu et al. (1987) attempted these tests on the sludge they studied but were not able to report any values: in the liquid limit test, they could not find a moisture content that closed the gap in over 15 blows; in the plastic limit test, they were not able to roll out 1/8-inch diameter beads (for plastic limit). It is possible that small changes in moisture content resulted in large changes in the plasticity of the material, and that this was the reason why the properties could not be determined.

Wang et al. (1991) and **Maher et al. (1993)** had high values for the liquid limit, plastic limit, and plasticity index. Limits such as these are common in expansive soils were able to produce characteristic moisture-density curves. Possible reasons for this success could be their using lime sludge with a higher specific gravity.

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Cokca, (1999) in recent years, researchers from many fields have attempted to solve the problems posed by industrial wastes. Recent projects illustrated that successful waste utilization could result in considerable saving in construction costs.

Osinubi and Thomas (2007) had studied the influence of three compactive efforts (British standard light, British standard heavy and West African standard) on strength properties of lime sludge treated black cotton soil. **Osinubi et al. (2009)** had also studied the effect of lime sludge on different engineering properties lime stabilized expansive soil.

III. MATERIALS AND METHODOLOGY

A. MATERIALS

- Black cotton soil
- Red soil
- Lime sludge

In the current work, as stated above the samples is collected from Proddatur, KSRM College at Kadapa and where as the lime sludge is obtained from a Prompt pulp and fibers private limited industry of Hyderabad. The samples are treated with different proportions of lime sludge and the tests were conducted. From the initial experimental test analysis the soil is classified as clays with high compressibility and silty sand.

Table3.1: Properties of Soil

S.no	Description	Results		
		Sample S1	Sample S2	
1	Specific Gravity	2.40	2.60	
2	Grain Size Analysis	Gravel	2.0 %	0.0 %
		Sand	15.1 %	96.3 %
		Silt	24.9 %	2.8 %
		Clay	58.0 %	0.9 %
3	Consistency Limits	Liquid Limit (w_L)	58.0 %	23.0 %
		Plastic Limit (w_p)	18.8 %	Non plastic
		Plasticity Index (I_p)	39.2 %	23.0 %
4	IS Classification	CH	SM	
5	Proctor Compaction	Optimum Moisture Content	20.7 %	14.3 %
		Max. Dry Density	1.51 g/cc	1.87 g/cc
6	California Bearing Ratio	Un-Soaked	4.4	5.21
		Soaked	2.3	3.12

From table 3.1 shows that physical properties of the soil. In these specific gravity, grain size analysis, consistency limits, IS classification of soils, proctor compaction and California bearing ratio values where determined for two different samples S1 and S2. The unsoaked and soaked CBR experiments are conducted for the samples treated with various percentages of lime sludge. The CBR values of untreated sample S1 and sample S2 the samples treated with

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lime sludge percentages. The particle size analysis of samples and lime sludge was performed to determine the gravel, sands, silts and clay contents. The percentages of various sizes of particles in all the samples and lime sludge were obtained by wet sieve analysis.

Determination of Consistency limit

The consistency is largely related with the amount of water content of soil and mostly used for fine grained soils. Liquid limit (w_L) was determined by using cone penetrometer for red soil and plastic limit (w_p) was obtained by thread rolling method. Shrinkage limit was not determined here. Soils are found to be silts and clay of high compressibility and silty sand (CH and SM).

Determination of Compaction Property and CBR value

Compaction properties are determined by standard Proctor test. The test was performed in a cylindrical mould of 1000 ml capacity using a rammer of weight 2.6 kg with 310 mm height of free fall. Soaked CBR values of soil sample were determined.

Determination of properties of soil lime sludge mixture.

In order to investigate the effects of lime sludge on the properties of soils mentioned above, the collected samples (S1 and S2) were treated with the percentage of 0, 5, 10, 15, 20% lime sludge based on the dry weight and then standard samples were prepared for physical testing. Due to the high water content of lime sludge, initially it was dried to environment temperature and subsequently screened before being mixed with the soil samples. All the tests as stated above (except particle size analysis) were performed on the mixture of soil and lime sludge.

IV. EXPERIMENTAL RESULTS

A. COMPACTION PROPERTIES

Clean, dry and slightly grease the mould and the base plate for light compaction. Add water to the soil specimen to bring the moisture content to about 4-5 percent in sandy soil and 8-10 percent in clayey soils. Mix the water with soil thoroughly. Keep this soil water mix in an airtight container for 5 to 30 minutes for sandy soils and 18 to 20 hours for clayey soils. For light compaction compact one part of the wet in three equal layers using the rammer of mass 2.6kg and free fall 310mm with 25 evenly distributed blows in each layer for 100mm diameter mould before putting the second layer of the soil, the top surface of the first compacted layer should be scratched with the help of a sharp edged tool the second and third layers are similarly compacted. Rotate the collar to break the bond between it and soil and then remove collar. Trim off the soil to make it flush with the top of the mould by means of a straight edged tool or knife. Clean all the loose soil from the outside and base of the mould. Weigh the mould with base plate and compacted soil. Now eject the soil out of the mould, take a representative sample from centre of the compacted specimen and keep it in an oven for its water content determination. Plot the curve with moisture in percentage as abscissa and dry density as ordinate. This gives the maximum dry density and optimum moisture content.

Table 4.1: Standard Proctor Test Results

Samples	Lime sludge content (%)	OMC (%)	MDD (g/cm^3)
S1	5	18.07	1.61
	10	17.31	1.66
	15	15.49	1.75
	20	13.04	1.82
S2	5	12.90	1.89
	10	11.11	1.92
	15	10.77	1.93
	20	9.09	1.96

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From table 4.1 with increasing percentages of lime sludge the optimum moisture content and maximum dry density is increased i.e., for sample S1 at 5% of lime sludge the optimum moisture content and maximum dry density is 17.07% and 1.67 g/cc, similarly 10% of lime sludge the optimum moisture content is 17.31% and maximum dry density is 1.66 g/cc, 15% of lime sludge the optimum moisture content is 15.49% and maximum dry density is 1.75, 15% of lime sludge the optimum moisture content is 15.49% and maximum dry density is 1.82.

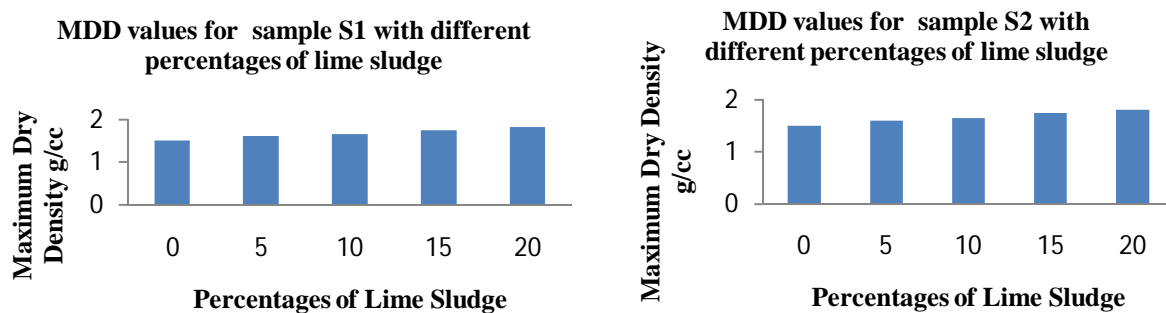


Figure 4.1: MDD values for soil sample 1 and 2 with different percentages of lime sludge

From figure 4.1 the maximum dry density values for sample S1 and S2 with different percentages of lime sludge. With increasing percentages of lime sludge the maximum dry density is increased for two different samples S1 and S2.

B. CALIFORNIA BEARING RATIO (CBR)

The test material should pass 20mm sieve and retained on 4.75mm sieve. If coarser materials retained on 20mm sieve, it should discard and an equal amount of material should be replaced. However the test can be performed on almost all types of soils, ranging from clay to gravel. Compact the wet soil in the mould using the light compaction the soil in three equal layers by giving 56 blows to each layer 2.6kg rammer. The mould containing the test specimen is placed on the lower plate of the testing machine with the base in position and the top surface exposed. Surcharge masses, sufficient to produce an intensity of loading equal to the weight of the base material and pavement is placed on the specimen to prevent upheaval of soil in to the hole of the surcharge weights, a 2.5kg annular mass is placed on the soil surface prior to seating the penetration plunger after the which the remainder of surcharge weights shall be placed. The plunger shall be kept under a load of about 4kg so that full contact is ensured between the surface of the specimen and plunger. The stress and strain dial gauges are set to initial zero reading. The initial load applied to the plunger is termed as zero loads while determining the load penetration relation. Load is applied to the penetration of 0.0, 0.25, 1.0, 1.5, 2.0, 2.5, 4.0, 5.0, 7.5, 10.0 and 15.5mm. The maximum load and penetration is recorded for a penetration of less than 12.5mm.

Table 4.2: CBR Un-Soaked and Soaked Values for Soil Sample S1 and Soil Sample S2

Percentage of lime sludge	Soil 1		Soil 2	
	Un-Soaked	Soaked	Un-Soaked	Soaked
0	4.44	2.31	5.21	3.12
5	4.57	3.12	5.76	3.05
10	4.70	3.80	5.98	4.10
15	6.70	5.08	6.96	5.55
20	7.51	5.89	7.85	6.83

From table.4.2 shows that California bearing ratio value results for two different soil samples (S1, S2) with respect to different percentages of lime sludge (5%, 10%, 15%, and 20%) and it is evident that CBR value increases with

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addition of lime sludge in all types of soil. For unsoaked and soaked soil sample S1, with increase in percentage of lime sludge the CBR value is increase, maximum is obtain at 20% of lime sludge, value is 7.51 and 5.89. For unsoaked and soaked soil sample S2 ,with increase in percentage of lime sludge the CBR value is increase, maximum is obtain at 20% of lime sludge, value is 7.85 and 6.83.

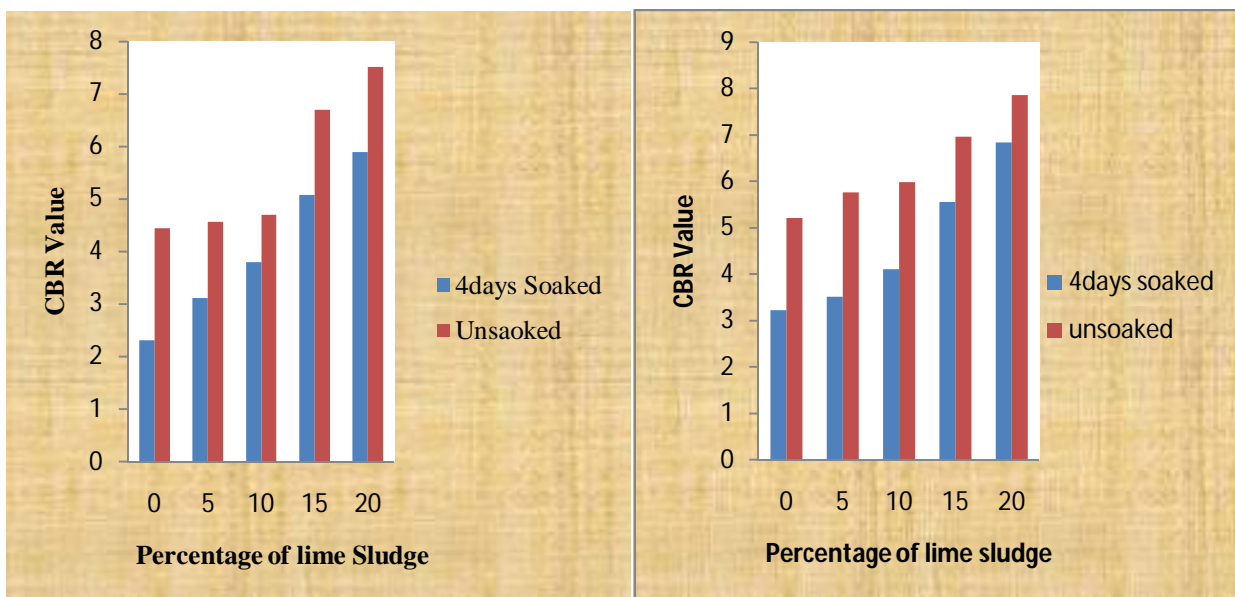


Figure 4.2: CBR Un-Soaked and Soaked Graph for Soil Sample S1 and Soil Sample S2

From Figure 4.2, unsoaked and soaked tests were done for two samples to determine the CBR value, soaking is done for 4 days. It is evident that CBR value increases with addition of lime sludge in all types of soil. For un-soaked and soaked soil sample S₁, with increase in percentage of lime sludge the CBR value is increase, maximum is obtain at 20% of lime sludge, value is 7.51 and 5.89. For un-soaked and soaked soil sample S₂ ,with increase in percentage of lime mud the CBR value is increase, maximum is obtain at 20% of lime sludge, value is 7.85 and 6.83.

V. CONCLUSION

The following are the conclusion for compaction, CBR tests for sample S1 and S2

For sample S1

When compare to the untreated soil (dry density 1.51), soil treated with 20% of lime sludge attained a dry density of 1.82 .The percentage increase in dry density is 20.52%.

For unsoaked and soaked soil sample S1, with increase in percentage of lime sludge the CBR value is increased, maximum value is obtain at 20% of lime sludge, value is 7.51 and 5.89. Percentage increased when compare to untreated soil is 69.2% and 155%.

For sample S2

When compare to the untreated soil (dry density 1.87), soil treated with 20% of lime sludge attained a dry density of 1.96 .The percentage increase in dry density is 4.81%.

For unsoaked and soaked sample S2, with increase in percentage of lime sludge the CBR value is increased, maximum value is obtain at 20% of lime sludge, value is 7.85 and 6.83. Percentage increased when compare to untreated soil is 50.67% and 119%.

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