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EFFECT OF SAW DUST ASH AND LIME ON EXPANSIVE SOIL (BLACK COTTON SOIL)

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Abstract - Soil is very important natural material used to support the foundation and transfer the load. In construction point of view soil should be strong and capable for bearing the load without its failure. We all know that the soil nature is an isotropic i.e. the properties of soil are not same at each location therefore to improve the properties of soil we add saw dust ash and lime to the soil. Stabilization is one of the solutions. This expansive soil possesses peculiar properties such as swelling and shrinkage. In monsoon, these soils absorb water and swell, whereas in summer they shrink due to evaporation of water. Due to such behavior of soil it is inappropriate to rely on the strength characteristics, different stabilizing materials are used in varying percentages, so that they can match the specifications of the construction industry. This study is an attempt to analyze the effect of SDA and Lime on Expansive soils, for improvement in compressive strength and swelling-shrinkage characteristics and increase its suitability for effective use in construction. The proportion for addition of SDA and Lime was taken as 1%,2%,3%,4% and 5%.

Key Words: Expansive soil, stabilization, Compressive Strength, SDA, Lime.

1. INTRODUCTION

Due to land limitations and increase in population, peoples are utilizing every land available for construction. According to world population prospects, India will surpass china and to become most populous country in the world by 2022. The behavior of soil at any location is not same due to anisotropic nature. Sometimes poor soil is encountered during construction. When a project is to be carried out in difficult foundation condition, the possible alternate solutions are, avoid the particular sites, design the plan structure accordingly, use pile foundation which transmits the total load to hard strata, removed and replaced the foundation soil and attempt to modify the existing ground, except modification of existing ground than all alternative solutions are not so economical and therefore modification of existing soil i.e. Soil stabilization is one of the cheaper solution. Soil stabilization is a process of improving the engineering properties of soil. It is extremely cost-effective method of converting poor quality soil into hard impermeable medium..

2. LITRATURE REVIEW

There are various literatures available on the stabilization of the soil. Considering the utilization of waste stabilize materials such as copper slag, steel slag, waste paper sludge, red mud, brick dust, ceramic dust, lime, brick kiln dust etc.

Karthik.S(2014) have used Fly Ash derived from combustion of sub-bituminous coal at electric power plants in stabilization of soft fine-grained red soils. California bearing ratio (CBR) and other strength property tests were conducted on soil. The soil is in range of plasticity, with plasticity indices ranging between 25 and 30. Tests were conducted on soils and soil–Fly Ash mixtures prepared at optimum water content of 9% .Addition of Fly Ash resulted in appreciable increases in the CBR of the soil. For water contents 9% wet of optimum, CBRs of the soils are found in varying percentage such that 3, 5, 6 and 9. They found optimum CBR value of the soil is 6%[1].

Wajid Ali Butt(2014) have used fibers of different length and equivalent diameter with an aspect ratio ranged from 295 to 500. The test result reveals that the strength significantly improves with the inclusion of HHF and also prevents the sample from cracking. Moreover an environmental concern is also included by utilization of waste human hair fiber materials and they can be made useful for improving the soil characteristics and to solve the problems related to the disposal of waste human hair fibers material[2].

Geethu Saji (2016) has studied the effect of Egg Shell Powder (ESP) and Quarry Dust (QD) on the properties of clayey soil. Eggshell primarily contains calcium, magnesium carbonate and protein and the quantity of lime in eggshell is almost the same as in limestone on ton for ton basis. When quarry dust is added with expansive soil it is expected that it will make it more porous, less durable, reduce cohesion etc. The main objective of this paper is to determine the improvement in engineering properties of clayey soil under varying percentage of ESP and QD. An improvement in the strength properties of soil by addition of ESP and QD will help to find an application for waste materials to improve the properties of clayey soil and can be used as a better stabilizing agent[3].

Pallavi (2016) had studied the effect of fly ash and Nylon fibres on certain properties of soil such as Liquid Limit, Plastic Limit, Plasticity Index, Dry density, OMC, CBR (Soaked) of clayey soil. Study the effect of varying percentage of fly ash (10%, 20%, 30%,40%) and varying percentage of Nylon Fibre (0.25, 0.50, 0.75, 1, 1.25, 1.50) at varying aspect ratios (20,40,60,80) on properties of Black

Cotton Soil and then study the combined effect of varying percentage of optimum quantity of fly ash and optimum quantity of Nylon fibre at various aspect ratio on properties of Black Cotton Soil. Results from various test determine optimum percentage quantity of fly ash and optimum value of fibre aspect ratio and fibre content and also determine the effect of optimum nylon fibre and fly ash on varying depth of sub grade in soil with appropriate proportion improved strength[4]

Richa Bhadouria (2017) have conducted various studies to analyze the effect of rice husk ash on optimum moisture content, maximum dry density, and California bearing ratio of soil. Results shows increase in optimum moisture content but decrease in maximum dry density, Along with increase in California bearing ratio, from the observations it can be seen that 10% of rice husk ash and 6% of cement results in maximum improvement in desired soil properties. Due to its low cost and effectiveness in increasing the California bearing ratio of soil this method of soil stabilization is strongly recommended[5].

3. SYSTEM DEVELOPMENT

In general various test such as consistency limit, compaction characteristics and strength characteristics of black cotton soil was studied in the proposed work with the different percentage of stabilizing material i.e. saw dust ash and lime. The main objective of proposed work is to be carried out laboratory investigation on stabilized soil.

3.1 Theme of Present Work

The following tests were carried out on various soil samples with treated and untreated soil.

1. Atterberg's Limits Test i. Liquid Limit ii. Plastic Limit
2. Standard Proctor Test
3. Unconfined compression Test
4. C.B.R Test

1. Atterberg's Limits Test

The Atterberg'slimits are a basic measure of the nature of a fine-grained soil. Depending on the water content of the soil, it may appear in four states: solid, semi-solid, plastic and liquid. In each state, the consistency and behavior of a soil is different and thus so are its engineering properties. Thus the boundary between each state can be defined based on the change in the soil behavior. The Atterberg's limits can be used to distinguish between silt and clay. These limits were created by Albert Atterberg, and later refined by Author Casangrande.

- Liquid limit

It is defined as the maximum water content at which the soil is in liquid state and has a small shearing strength against flowing. With references to a standard mechanical device by Casangrande, it is defined as the minimum water content at which a groove of standard dimensions cut in soil pat flows together for a distance of 10-12 mm at the bottom under an impact of 25 blows[6].

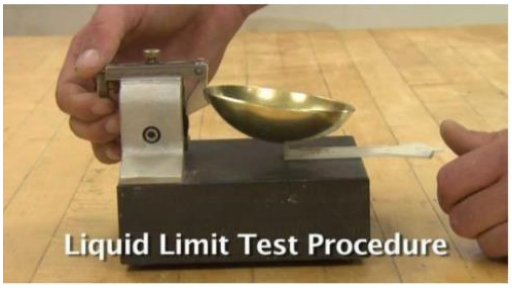


Figure: Liquid Limit Test Procedure

- Plastic limit

It is defined as the water content of soil which is in between plastic and semisolid state of consistency of soil. It is defined as that water content of soil when rolled into a thread of 3 mm diameter just begins to crumble and the difference between liquid limit and plastic limit is called plasticity index of the soil.

Figure: Plastic Limit Procedure

2. Standard Proctor Test

This is conducted for determination of maximum dry density (MDD) and optimum moisture content (OMC). Compaction achieved for given effect is maximum at water content known as optimum content and the corresponding density is called maximum dry density. The process of compaction increases the density of soil which ultimately makes it strong, durable and impervious[7].

Figure: Standard proctor test

4. UNCONFINED COMPRESSION TEST (IS 2720 PART 10- 1973)

The unconfined compression test is a special case of triaxial compression test in which σ2 = σ3 = 0. The cell pressure in the triaxial cell is also called the confining pressure. Due to the absence of such a confining pressure, the uniaxial test is called the unconfined compression test. The cylindrical specimen of soil is subjected to measure principal stress σ1 till the specimen fails due to shearing along a critical plane of failure.

Figure: UNCONFINED COMPRESSION TEST

5. C.B.R Test

The laboratory CBR apparatus consists of a mould 150 mm diameter with a base plate and a collar, a loading frame and dial gauges for measuring the penetration values and the expansion on soaking. The specimen in the mould is soaked in water for four days and the swelling and water absorption values are noted. The surcharge weight is placed on the top of the specimen in the mould and the assembly is placed under the plunger of the loading frame. Load is applied on the sample by a standard plunger with dia of 50 mm at the rate of 1.25 mm/min. A load penetration curve is drawn. The load values on standard crushed stones are 1370 kg and 2055 kg at 2.5 mm and 5.0 mm penetrations respectively. CBR value is expressed as a percentage of the actual load causing the penetrations of 2.5 mm or 5.0 mm to the standard loads mentioned above. The CBR can therefore be mathematically expressed as below:

$$CBR = \frac{p}{p_s} \cdot 100$$

CBR = CBR [%]
p = measured pressure for site soils [N/mm^2]
ps = pressure to achieve equal penetration on standard soil [N/mm^2]

Figure: C.B.R Machine

6. PERFORMANCE ANALYSIS

The engineering properties of black cotton soil mixed with various percentage of Saw Dust Ash and Lime were obtained by performing various laboratory tests as per relevant IS codes. The tests such as standard proctor test, CBR, UCS, specific gravity test were conducted. The change in the properties of soil due to inclusion of SDA and Lime is suitably presented and discussed.

6.1 PROPERTIES OF SOIL WITHOUT ADDITION OF LIME AND SDA

6.1.1 SPECIFIC GRAVITY

The specific gravity of soil is determined by the pycnometer method. The formula as mentioned below was used. It is also affected by temperature, so it is generally done at standard temperature pf 250 degree Celsius.

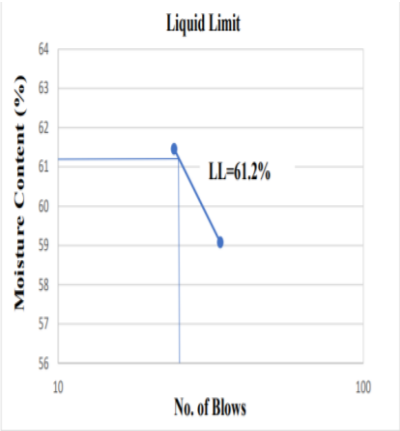
$$\text{Specific gravity of soil} = \frac{\text{Density of substance}}{\text{Density of water}}$$

The specific gravity of Black Cotton Soil at 0% SDA and Lime addition was determined as 1.97.

6.1.2 ATTERBERG'S LIMIT:

Atterberg's limits consist of liquid limit, plastic limit, and shrinkage limit. Among these liquid limit and plastic limit were found out for the soil. The liquid limit test was performed by Casangrande's apparatus. Plastic limit was found out by rolling the soil mould in 3mm diameter threads.

- Liquid Limit

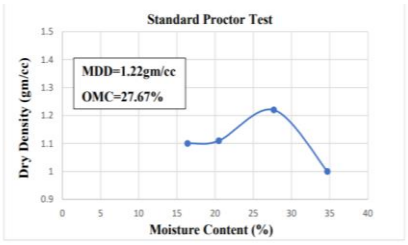


Graph: Liquid Limit curve for BC Soil

The liquid limit for soil with 0% SDA and lime addition was found to be 61.2%.

6.1.3 Standard Proctor Test

Standard Proctor Test gives a compaction curve. A compaction curve is plotted between the water content as abscissa and corresponding dry density as ordinate as shows in figure. The water content corresponding to the maximum dry density is the optimum water content (OMC). Maximum dry density gives the maximum mass of soil at the given volume at minimum water content which fill all voids.

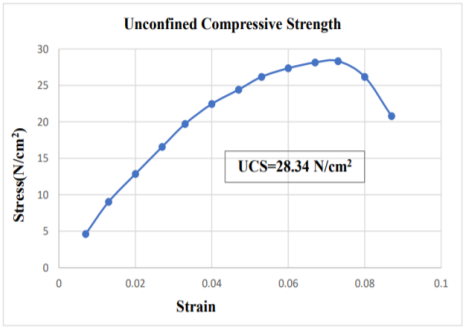


Graph: : Standard Proctor Test curve for BC Soil

The maximum dry density of soil was 1.22 gm/cc with optimum moisture content of 27.67%.

6.1.4 Unconfined Compression Strength test

The following test was performed to find the compression strength of BC soil.

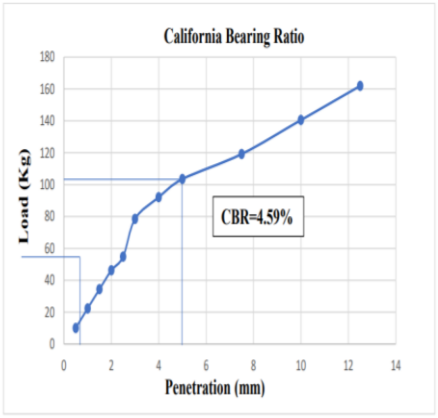


Graph: UCS test curve for BC Soil

The UCS value for soil with 0% SDA and lime addition was found to be 28.34 N/cm2.

6.1.5 California Bearing Ratio Test

CBR test was performed on Black Cotton soil. The CBR graph for Black Cotton soil is shown figure.



Graph: CBR Test curve for BC Soil

$$\text{CBR Value for 2.5mm penetration} = \frac{54.86 \times 100}{1370} = 4.00\%$$

$$\text{CBR Value for 5mm penetration} = \frac{103.49 \times 100}{2055} = 4.59\%$$

The CBR value for soil with 0% SDA and lime addition was found to be 4.59%.

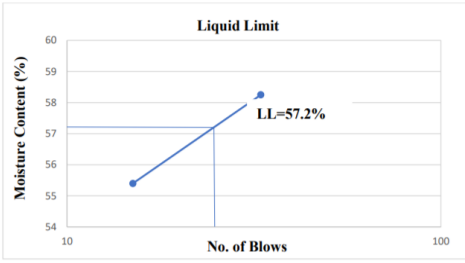
6.2 PROPERTIES OF LIME AND SDA IN ADDITION WITH BLACK COTTON SOIL

After determining various geotechnical properties on Black Cotton soil with 0% SDA and Lime addition, the Black Cotton soil was contaminated with saw dust ash and lime at varying percentage of 1%, 2%, 3%, 4%, 5% by weight of soil. All the geotechnical properties of Black Cotton soil were determined again with SDA and Lime addition.

6.2.1 Liquid Limit

Liquid limit and plastic limit tests were performed with 1%, 2%, 3%, 4% and 5% SDA and Lime addition by weight of soil and observations are as follows,

The results of liquid limit tests with 1%, 2%, 3%, 4% and 5% SDA and Lime addition are shown in table.



Graph: Liquid limit curve for 2% SDA and 2% Lime addition

The liquid limit for soil with 2% SDA and 2% Lime addition was found to be 57.20%

SDA and Lime addition (%)	Liquid Limit (%)
1	61.40
2	57.20
3	66.30
4	69.50
5	70.00

Table: Liquid limit of Black Cotton soil mixed with different percentage of SDA and Lime

6.2.2 Plastic Limit

The results of plastic limit tests with 1%, 2%, 3%, 4% and 5% SDA and Lime addition are shown in table

SDA and Lime addition (%)	Plastic Limit (%)
1	36.99
2	38.25
3	35.45
4	35.07
5	32.65

Table: Plastic limit of Black Cotton soil mixed with different percentage of SDA and Lime

The proctor tests were performed by standard proctor apparatus at 1%, 2%, 3%, 4% and 5% SDA and Lime addition by weight of soil and observations were taken. shows the MDD and OMC for BC soil mixed with 1%, 2%, 3%, 4% and 5% SDA and Lime addition

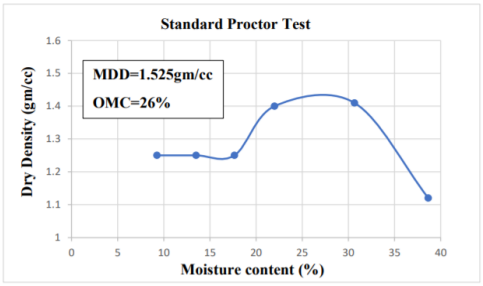


Table: Standard proctor test curve for 2% SDA and 2% Lime addition

From figure the values of MDD and OMC for 2% SDA and 2% Lime addition were 1.525gm/cc and 26% respectively

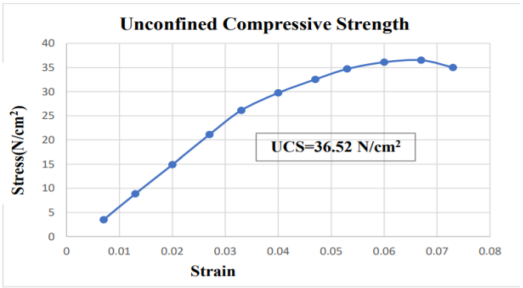
SDA and Lime addition (%)	MDD (gm/cc)	OMC (%)
1	1.335	22.00
2	1.525	26.00
3	1.340	21.00
4	1.265	20.40
5	1.260	20.40

Table: MDD and OMC of BC soil mixed with different percentage of SDA and Lime

6.2.3 Unconfined Compression Strength test

The Unconfined Compression Strength tests were performed by compression testing machine at 1%, 2%, 3%, 4% and 5% SDA and Lime addition by weight of soil and observations were taken.

The results of the UCS tests with varying percentage of SDA and Lime are shown in table.



Graph: UCS curve for 2% SDA and 2% Lime addition

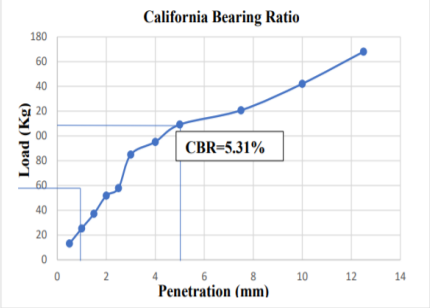
SDA and Lime addition (%)	UCS (N/cm²)
1	28.99
2	36.52
3	35.44
4	34.73
5	19.50

Table: UCS of BC soil mixed with different percentage of SDA and Lime

6.2.4 California Bearing Ratio

The CBR tests were performed at 1%, 2%, 3%, 4% and 5% SDA and Lime addition by weight of soil and observations were taken.

The results of the CBR tests with varying percentage of SDA and Lime are shown in table.



Graph: CBR curve for 2% SDA and 2% Lime addition

SDA and Lime addition (%)	CBR (2.5 mm)	CBR (5 mm)
1	4.93	4.67
2	4.23	5.31
3	4.46	4.87
4	3.59	4.71
5	3.41	4.40

Table: CBR of BC soil mixed with different percentage of SDA and Lime

6.3 Discussion of Results

TESTS	Plain Soil	Soil+1% SDA+1% Lime	Soil+2% SDA+2% Lime	Soil+3% SDA+3% Lime	Soil+4% SDA+4% Lime	Soil+5% SDA+5% Lime
MDD (gm/cc)	1.220	1.335	1.525	1.340	1.265	1.260
OMC (%)	27.67	22.00	26.00	21.00	20.40	20.40
Liquid Limit (%)	61.20	61.40	57.20	66.30	69.50	70.00
Plastic Limit (%)	36.57	36.99	38.25	35.45	35.07	32.65
UCS(KN/m^2)	28.34	28.99	36.52	35.44	34.73	19.50
CBR (%)	4.59	4.93	5.31	4.87	4.71	4.40

Table: Comparison of properties of Black Cotton soil when mixed with varying percentage of SDA and Lime

7. CONCLUSIONS

The experimental investigation was carried out on soil as well as on SDA and Lime contained soil by considering the varying percentage of SDA and Lime. Based on results of present study the following main conclusions are drawn.

1. Liquid Limit (LL) decreases as the SDA and Lime content increases up to 2%. Thereafter the Liquid Limit increases as the SDA and Lime content increases.
2. Plastic Limit (PL) gradually increases up to 2% and then gradually decreases with increase in SDA and Lime content. 3. MDD increases as the SDA and Lime content increases up to 2%. Thereafter MDD decreases with increase in SDA and Lime content.
3. OMC decreases as the SDA and Lime content increases upto 1%. Thereafter it suddenly increases at 2% and decreases thereafter with increase in SDA and Lime content.
4. The Unconfined Compressive Strength increases as the SDA and Lime content increases up to 2% thereafter it decreases gradually with increase in SDA and Lime content.
5. The CBR value increases as the SDA and Lime content increases up to 2% thereafter it decreases slightly with increase in SDA and Lime content

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