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COMPARATIVE STUDY ON STABILIZATION OF BLACK COTTON SOIL TREATED WITH POND ASH AND SODIUM LIGNOSULPHONATE

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Abstract

The objective of this work is to use industrial wastes in place of natural soil in the construction of road and highway after increasing its strength, stability and durability by the method of stabilization. The admixture such as pond ash and chemical agent sodium lignosulphonate are used for stabilization. The present study is to investigate the properties such as maximum dry density, optimum moisture content and consistency limits of black cotton soil stabilized with admixture and chemical by varying percentages. There was decrement in the values of Liquid limit and plasticity index upon the addition of pond ash and sodium lignosulphonate. UCS values of parent soil was found to be 24kPa but when pond ash was added it was found to be 120kPa at 24% whereas for sodium lignosulphonate was 235kPa at 12% dosage for 14 days curing. Parametric study was done on combination of pond ash and sodium lignosulphonate. Optimum24% pond ash was mixed with sodium lignosulphonate in the range 3% to 12%.The combinations of these two improved engineering properties as compared to parent soil. It was found that pond ash mixed with sodium lignosulphonate-stabilized black cotton soil showed improvement in strength 355kPa after 14 days curing.

Keywords: - *Black Cotton Soil, Pond Ash, Sodium Lignosulphonate.*

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1. INTRODUCTION

Black cotton soil causes many problems to road constructed on it. About 20% of the soil found in India is expansive in nature. Roads on black cotton soils are known for bad condition. In rainy season black cotton soil absorbs water heavily which results into swelling and softening of soil. In addition to this it also loses its strength and becomes easily compressible.[1] Black cotton soil has tendency to heave during wet condition. In summer season due to reduction in water content it shrinks and produces cracks.

Stabilization is the process of improving the engineering properties of soil and making it more stable. [2]There are many types of soils which possess low strength that causes problems for geotechnical constructions. The reason for low strength of soil is associated with the increased water content, expansiveness (swelling behavior), low density and disturbance to the in-situ condition.Chemical stabilization involves mixing chemical additives (binding agents) with natural soils to remove moisture and improve strength properties of the soil (sub-grade).[2]

An attempt has been made to study the behaviour of treated black cotton soil and to improve the properties with the aid of locally available admixture pond ash and a chemical sodium lignosulphonate which is derived from lignin. The geotechnical properties of the soil play an important role in influencing its behaviour and the aim of the work is to expose the effects of admixture and a chemical.

2. STUDY AREA AND DATA EXTRACTION

2.1 Description of Study Region

The soil was brought from Navalgund which is located in Dharwad city. The soil samples were procured at a depth of 2m to carry out laboratory tests in order to evaluate various properties of soil. The Soil used in this study is a blackish gray inorganic clayey soil of high plasticity which belongs to CH group. The soil was dry and was sufficiently hard.

In the present study, an attempt is made to examine strength behaviour of black cotton soil, which is quite problematic, abundantly available in Karnataka State, India. Black cotton soil is characterized by its poor strength in compression and shear. Roads constructed on this type of soil sub-grade become problematic during monsoon and exhibit spongy nature and poses difficulties for design, construction, and maintenance of most of the roads. The experimental work under taken investigates to study the influence of combination (pond ash and sodium Lignosulphonate) on index and engineering properties of black cotton soil.

The fundamental purposes behind picking these materials are

1) They are practical as they are the waste items
2) They don't have critical use in any gainful work
3) They have transfer issue
4) They are locally accessible.

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2.2 Discription of Stabilizers Used

Pond ash has been collected from the Thermal Power Plant ShaktinagarRaichur, India. This is generally grey in colour and pozzoloanic in nature. The most common chemical compositions of pond ash are SiO_2, Al_2O_3, MgO, CaO, Fe_2O_3, organic carbons and others. The pond ash was collected from near the slurry disposal point which is coarser in nature.

Lignosulphonates are natural polymers derived from lignin that stabilises soil by physically binding the soils particles together with minor chemical effects. Individual soil particles can become coated in a thin adhesive-like film that acts to cement the particles together. Lignosulphonates are ionic and therefore there is potential for cation exchange that can alter the molecular structure of the soil. This has the potential to reduce the surface charge that can lead to flocculation, close packing and hydrophobic characteristics.

Table -1: Chemical Properties Of Pond Ash

Sr. No	Major element	Percentage
1	SiO_2	91.33
2	Al_2O_3	0.117
3	Fe_2O_3	0.103
4	Cao	2.33
5	Loss on ignition	1.40

Table -2: Chemical Properties of Sodium Lignosulphonate

Parameters	Percentage
Molecular formula	$C_{20}H_{24}Na_2O_{10}S_2$
Molecular weight	534.51
Description	Mealy powder
pH of 3% soln	6
Reducing sugar on dry (%)	6.5
Sulphur (%)	4
Sodium (%)	10
Ash on dry (%)	7.5

3. RESULTS AND DISCUSSION

Soil has been tried with the admixture at various extent to locate the index properties like Liquid Limit, Plastic Limit and swelling properties like Free swell index. Unconfined compression test was done to check the strength of soil.

The experimental work under taken investigates,

1) To stabilize the locally available black cotton soil by varying the percentage of pond ash,sodiumlignosulphonate .
2) To arrive at optimum content of pond ash.
3) To study the influence of combination (pond ash and sodium Lignosulphonate) on index and engineering properties of black cotton soil.

3.1 Test Results of Parent Soil

S.No	Parameters	Values
1	Specific Gravity	2.4
2	Grain Size Distribution Gravel Silt clay	 0 32 68
3	Liquid Limit (%)	86.10
4	Plastic Limit (%)	40.10
5	Plasticity Index (%)	46
6	Free Swell Index	52
7	IS Classification of Soil	CH
8	Maximum Dry Density(g/cc) Optimum Moisture Content(%)	1.22 34
9	Unconfined Compressive Strength(kPa)	24

3.2 Consistency Limits of Soil Treated With Pond Ash

To determine the effect of pond ash on consistency limits of Black cotton soil, liquid limit and plastic limit tests were conducted. The pond ash is incorporated into the soil at 6%, 12%, 18%, 24% and 30%.

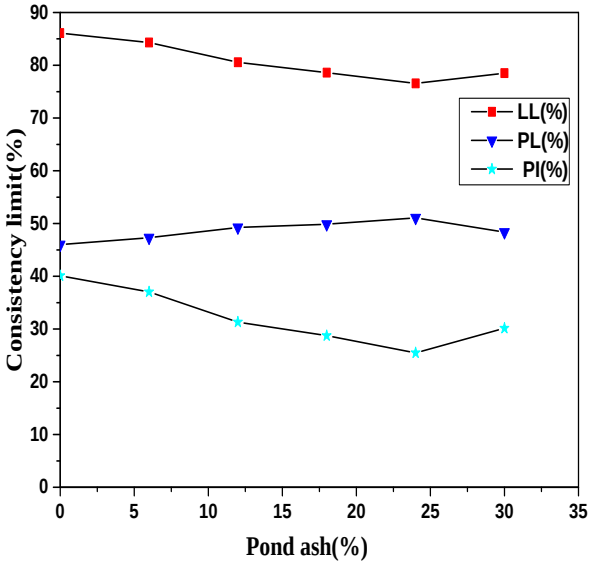

Chart -1: Consistency Limits of soil + pond ash

From the above figure it is clearly observed that the treated soil has followed a trend of continuous reduction in the liquid limit with increase in percentages of pond ash. After addition of Pond ash up to 24 % liquid limit value goes on decreasing, after that with further addition of Pond ash the value of liquid limit decreasing due to change in gradation of soil particles.

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3.3 Compaction Characteristics of Soil Treated with Pond Ash

The compaction characteristics of the Black cotton soil were determined by Standard Proctor Compaction test i.e. with the aid of light compaction. The compaction test was carried out to determine the maximum dry density and optimum moisture content of the untreated and treated Black cotton soil for different percentages of pond ash and the compaction tests results are shown below

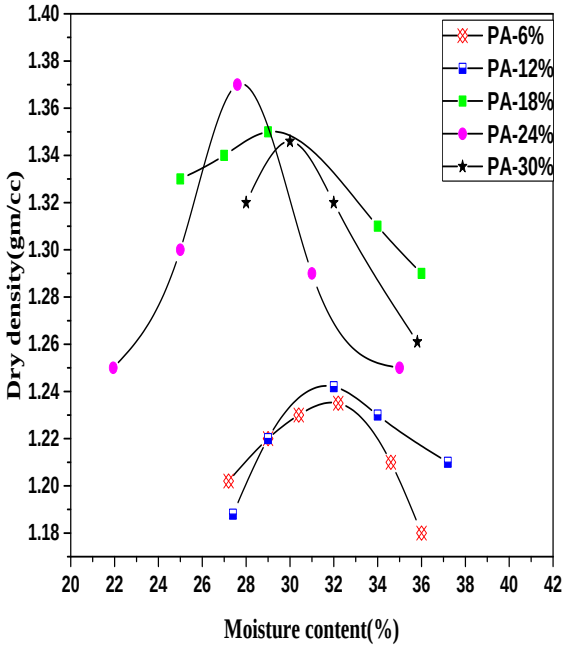

Chart -2: Proctor Compaction of soil + pond ash

The MDD and OMC for untreated soil were 1.22 gm/cc and 34% respectively. Whereas for treated soil are 1.23gm/cc, 1.24gm/cc, 1.35gm/cc, 1.38gm/cc, 1.35gm/cc and 32.0%, 31.5%, 29.5%, 28% and 31.0% respectively. At low percentages of pond ash the MDD did not show much variation but for higher percentages (18%, 24% and 30%), there is a much variation in the dry density. It is because the flocculated soil particles might have collapsed during compaction which has increased its weight. As density depends up on the weight of the soil compacted. Here 24% is considered as the optimum since beyond 24% of pond ash MDD got decreased and OMC increased.

3.4 Unconfined Compressive Strength of Soil Treated with Pond Ash

This test was conducted on treated Black cotton soil under unsoaked condition. The pond ash was mixed to the soil in varying percentages as 6%, 12%, 18% and 24% to the black cotton soil and results have been obtained for various curing periods of 3 days, 7 days and 14 days. . The UCS of untreated black cotton soil was found to be 0.24kg/cm^2 (24 kPa) and the UCS for 6% Pond ash increased with curing days and they are 0.30 kg/cm^2, 0.65kg/cm^2 and 1.05kg/cm^2 at 3days, 7days and 14 days respectively. UCS for 12% Pond ash increased with curing days. UCS's are 0.38 kg/cm^2, 0.70kg/cm^2 and 0.95 kg/cm^2 for 3days, 7days and 14 days respectively. UCS for 18% Pond ash increased with curing days. UCS's are 0.40 kg/cm^2, 0.85 kg/cm^2 and 0.90 kg/cm^2 for 3days, 7days and 14 days respectively. UCS for 24% are 0.50kg/cm^2, 0.90kg/cm^2 and 1.20kg/cm^2 for 3days, 7days and 14 days respectively. The gain in strength in 14days curing samples may be because of long term reaction such as pozzolanic and carbonation.

The maximum UCS for different curing periods such as 3days, 7days and 14 days increased with decrease in strain values. The maximum UCS's are 0.50 kg/cm^2, 0.90kg/cm^2 and 1.20kg/cm^2 at strains 0.05, 0.48 and 0.02 respectively. From the figure it is observed that, the trend followed is that the UCS is increasing with the decrease in the strain values for different curing periods.

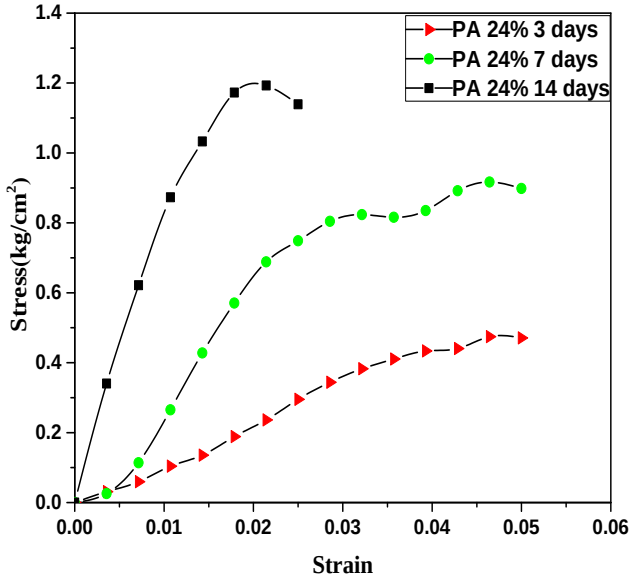

Chart -3: Unconfined strength of soil + pond ash

3.5 Consistency Limits of Soil Treated With Pond Ash

To determine the effects sodium lignosulphonate on consistency limits of Black cotton soil liquid limit and plastic limit tests were conducted. The sodium lignosulphonate is incorporated into the soil as 3%, 6%, 9%, and 12%.

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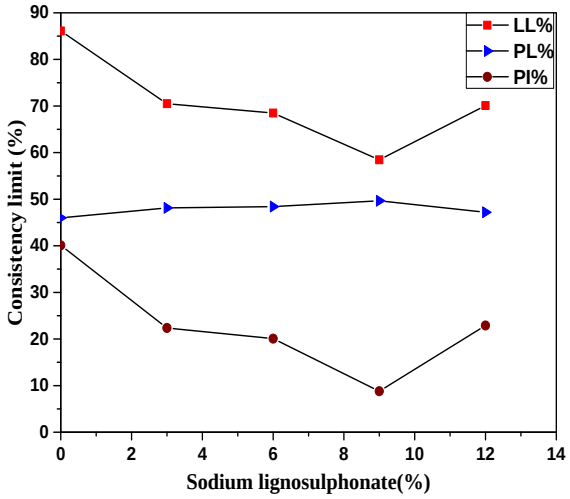

Chart -4: Consistency Limits of soil + Sodium Lignosulphonate

From the above figure it is clearly observed that the treated soil has followed a trend of continuous reduction in the liquid limit with increase in percentages of sodium lignosulphonate. This can be considered to be as a result of the binding soil particles and dispersion of the clay fraction by Lignosulphonate(Which acts a binder to glue the soil particles together).At 9% liquid limit reduced to 58.45% from 86.10%. Here 9% chemical content is more effective in reducing the liquidity.

3.6 Compaction Characteristics Of Soil Treated with Sodium Lignosulphonate

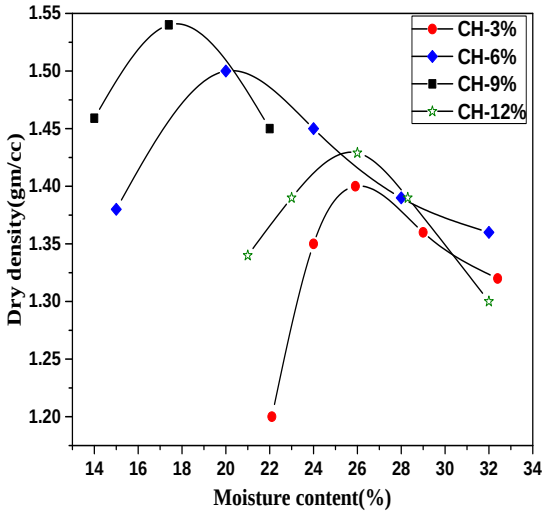

Chart -5: Compaction of soil +Sodium Lignosulphonate

The MDD and OMC for untreated soil were 1.22 gm/cc and 34% respectively. Whereas for treated soil are 1.40gm/cc, 1.50gm/cc, 1.54gm/cc, 1.43gm/cc and 26%, 20%, 18% and 26% respectively. This is because Lignosulphonatebinds the soils particles together with minor chemical effects. Individual soil particles can become coated in a thin adhesive-like film that acts to cement the particles together. It is clearly observed that, addition of small amount of chemical there is a tremendous change in maximum dry densities and optimum moisture contents.

3.7 Unconfined Compressive Strength of Soil Treated with Sodium Lignosulphonate

This test was conducted on treated Black cotton soil under unsoaked condition. The sodium lignosulphonate was mixed to the soil in varying percentages as 3%, 6%, 9% and 12% to the black cotton soil and results have been obtained for various curing periods of 1 day, 7 days and 14 days. Maximum UCS's at 3% dosage for 3days, 7days and 14days are 0.65kg/cm^2, 1.50kg/cm^2 and 1.90kg/cm^2 at strains 0.04, 0.045 and 0.065 respectively. Maximum UCS's at 6% dosage are 0.80kg/cm^2, 1.90kg/cm^2 and 2.10 kg/cm^2 for 3days, 7days and 14 days respectively. Maximum UCS's at 9% doage are 1.50 kg/cm^2, 2.00 kg/cm^2 and 2.18 kg/cm^2 for 3days, 7 days and 14 days respectively. Maximum UCS's at 12% dosage are 1.45 kg/cm^2, 1.75 kg/cm^2 and 2.35 kg/cm^2 for 3days, 7days and 14 days respectively.

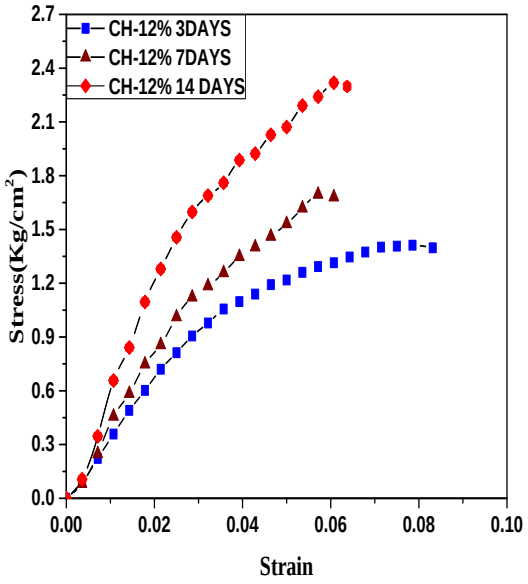

Chart -6: Unconfined strength of soil + Sodium Lignosulphonate

3.8 Test Results of Combination Of Admixtures Treated with Parent Soil

Based on the above results 24% Pond Ash was taken as the optimumdosage and was mixed with sodium lignosulphonate by varying its dosages as 3%,6%,9% to the parent soil.The combination is incorporated into the soil as(24%PA+3%Sodiumlignosulphonate,24%PA+6%Sodiumlignosulphonate, 24%PA+9% Sodium lignosulphonate).

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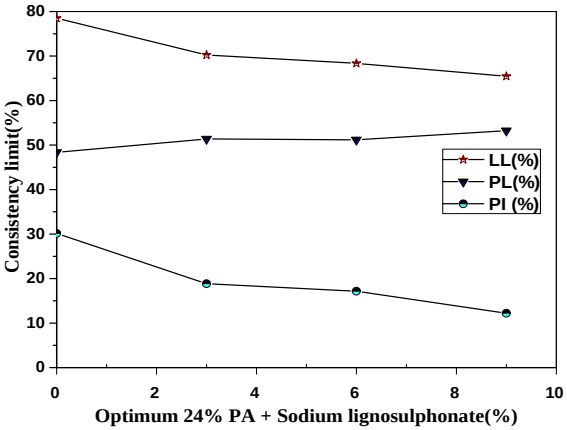

Chart -7: Consistency Limits of soil +PA + Sodium Lignosulphonate

Liquid limit reduced to 65.45% with 24% pond ash and 9% chemical and PI reached to very low value i.e. 12.03%. This is because of the resistance offered by the pond ash against liquidity of the treated soil and addition of chemical made Individual soil particles to become coated in a thin adhesive-like film that acts to cement the particles together. Here 9% chemical content with 24% of pond ash is effective in reducing the liquidity.

3.9 Compaction Characteristics of Soil Treated with Optimum (24%) Pond Ash and Varying Percentages of Sodium Lignosulphonate

The compaction test was carried out to determine the maximum dry density and optimum moisture content of the treated Black cotton soil for combinations of optimum percentage pond ash (24%) ash and varying percentages of sodium lignosulphonate.

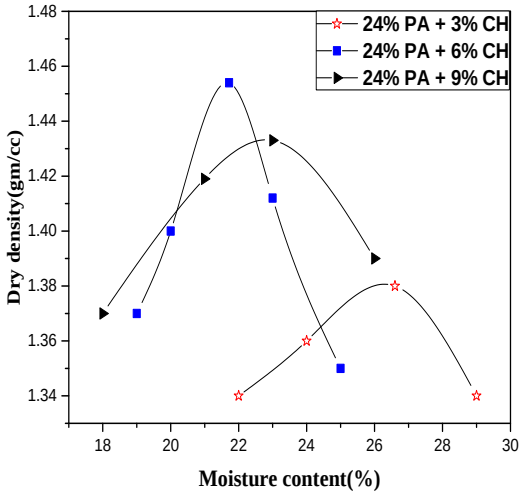

Chart-8: Compaction of soil +PA+SodiumLignosulphonate

The MDD and OMC for untreated soil were 1.22 gm/cc and 34% respectively. Whereas for treated soil with combinations are 1.38gm/cc, 1.45gm/cc, 1.43gm/cc and 26.5%, 21.5%, and 23% respectively. It is because the flocculated soil particles might have collapsed during compaction which has increased its weight and Lignosulphonate binds the soils particles together with minor chemical effects. Here 6% chemical content with 24% of optimum pond ash is more effective in obtaining maximum dry density i.e. 1.45gm/cc and OMC i.e. 21.5%.

3.10 Unconfined Compressive Strength of Soil Treated with Combination of Optimum 24% Pond Ash and Sodium Lignosulphonate

The combination was mixed to the black cotton soil as keeping optimum (24%) of pond ash constant and varying percentages of sodium lignosulphonate as 3%, 6%, 9% and 12% and results have been obtained for various curing periods of 1 day, 7 days and 14 days.

The UCS of untreated black cotton soil was 0.24kg/cm^2 and the UCS for 24% PA+ 3% Sodium lignosulphonate increased with curing days. UCS's are 1.50 kg/cm^2, 2.10kg/cm^2 and 2.20 kg/cm^2 for 3days, 7days and 14 days respectively. UCS for 24%PA+6%CHwere as follows 1.90 kg/cm^2, 2.20 kg/cm^2 and 3.25 kg/cm^2 for 3days, 7days and 14 days respectively. UCS for 24%+ 9% increased with curing days which were as follows 1.50 kg/cm^2, 1.70kg/cm^2 and 3.55kg/cm^2 for 3days, 7days and 14 days respectively.

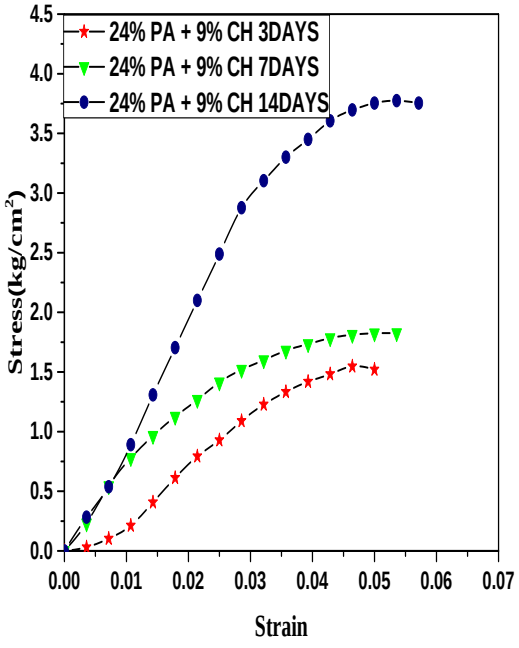

Chart -9: Unconfined strength of soil + PA+SodiumLignosulphonate

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4. CONCLUSION

Following conclusions were drawn from results obtained from experiments carried out.

1. The optimum dosage was found to be 24% for pond ash stabilised with black cotton soil. Whereas for sodium lignosulphonate optimum was found to be 9%.

2. Liquid limit (LL), plasticity index (PI) reduced by 11.14% and 44.61% respectively when pond ash was added to BC soil. Whereas for sodium lignosulphonate and combination, Liquid limit (LL), and plasticity index (PI) reduced by 32.11%, 80.89% and 23.98%, 73.84% respectively.

3. Maximum dry density (MDD) and optimum moisture content (OMC) were 1.54gm/cc and 17.5% respectively when BC soil was treated with sodium lignosulphonate. Chemical alone produced a better results compared to pond ash alone (1.38 gm/cc and 28%) and combination of both (1.45gm/cc and 21.5%).

4. The pond ash treatment shows high peak strength in early age, but it will decrease with the increase of curing time.

5. Unconfined compressive strength value improved by addition of pond ash as well as sodium lignosulphonate but combination (optimum 24% Pond ash+ 9% Sodium lignosulphonate) stabilized BC soil proved to provide more strength which was found to be 355kPa after 14 curing days unlike BC soil was only 24 kPa.

6. For better stabilization results, chemical alone can be used as it provided higher MDD, low OMC, low liquid limit and also compressive strength when compared to pond ash alone.

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