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Effect Of Calcium Salts On The Compaction Behavior Of Non Expansive Soil In The Presence Of Bagasse Ash And Lime

Ramesh H.N [1], Madhavi Gopal Rao Kulkarni [2]
[1](Department of Civil Engineering, UVCE / Bangalore University, Bangalore, India)
[2](Department of Civil Engineering, UVCE / Bangalore University, Bangalore, India)
*Corresponding Author: Ramesh H.N

ABSTRACT: *Red earth soils are non expansive soils and compaction behaviour of non expansive soil, treated with various percentage of bagasse ash are studied and presented in this paper. Compaction tests were conducted and with the addition of bagasse ash to non expansive soil, the maximum dry unit weight decreased and optimum moisture content increased due to the flocculation of soil particles. Due to low lime content in bagasse ash, lime is added to soil and bagasse as mixture and the results showed the decrease in maximum dry unit weight and increase in optimum moisture content due to enhanced flocculation and cementation of particles. Further studies were made with the addition of Calcium salts to soil, bagasse ash and lime mixture and it was found that there is an increase in maximum dry unit weight with an increase in optimum moisture content and is due to the reduction in resistance offered by the cluster to the densification of soil particles.*

KEYWORDS *- non expansive soil, bagasse ash, lime, compaction behaviour, flocculation, Calcium Sulphate , Calcium Chloride*

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I. INTRODUCTION

Non expansive soils are also called as red earth soils and red colour is imparted to soil due to the presence of iron oxides. Kaolinite is the chief mineral constituent in these soils. Compaction is one of the simplest and the oldest methods to stabilize the weak soils. Compaction of soil brings about many advantages such as increased shear strength, decreased compressibility and decreased permeability with the reduction in voids ratio of the soil. Changes in compaction behavior brought about by the addition of stabilizing agents such as fly ash, rice husk ash, bagasse ash, to name a few are used alone or combined with other additives such as lime, fibers were studied by various researchers. [1], [2], [3] and [4]. In the present work, non expansive soil is used and its compaction behavior of is studied with the addition of bagasse ash. Bagasse ash is an agro industrial waste from sugar industry. Bagasse ash is dumped near the sugar industries and when left in open, a disease known as Bagossis spreads and is very harmful disease which affects lungs. Sugar industries are facing disposal problem without affecting the surrounding environment. To solve the disposal problems faced by sugar industries, bagasse ash can be effectively used to improve the engineering properties of problematic soil. Bagasse ash is a pozzolanic material and is rich in amorphous silica content and very less percentage of lime. To improve the compaction characteristics further, addition of lime becomes necessary. It has been reported by researcher [5] that Maximum dry density decreased and optimum moisture content increased with the addition of Lime. Calcium salts such as Calcium Sulphate and Calcium Chloride are added to lime treated soil-bagasse ash mixture to study the compaction behaviour. However, many researchers reported the detrimental effect of Calcium Sulphate addition, due to the formation of ettringite needles within the clay matrix and with the addition of Calcium salts, maximum dry density and optimum moisture content increases due to the enhanced cluster formation which resists the compactive effort [6]

II. MATERIALS

Following materials are used for the present investigation.

2.1 Materials

The materials used in the study are non expansive soil, bagasse ash, lime, Calcium Sulphate and Calcium Chloride

2.1.1 Non Expansive Soil

Non expansive soil also called as red earth soil (RES) was procured from Bangalore University, Jnanabharathi campus, Bangalore, India. The soil was collected at a depth of 1.5 meter below the natural ground surface. The soil was oven dried, pulverized in a ball mill and sieved through 425 micron BIS sieve before being used in the present investigation. Red earth soil is classified as clays of medium plasticity (CI) as per BIS Soil Classification system.

2.1.2 Bagasse ash

Bagasse ash (BA) is collected from Koppa sugar industry, Mandya district, Karnataka, India. The organic content of bagasse ash is removed by burning in a furnace.

2.1.3. Lime

Laboratory reagent hydrated lime, supplied by Vasa Scientific Company; Bangalore is used for experimental purpose.

2.1.4. Calcium Sulphate (Gypsum)

Chemically pure Calcium Sulphate, supplied by Vasa Scientific Company, Bangalore has been used for laboratory purpose.

2.1.5. Calcium Chloride

Chemically pure Calcium Chloride supplied by Vasa Scientific Company, Bangalore has been used for laboratory purpose.

The grain size distribution curve for non expansive soil and bagasse ash are shown in Fig.1. Physical properties of non expansive soil and bagasse ash are shown in Table1 and chemical composition of bagasse ash is shown in Table 2.

Table 1Physical properties of non expansive soil and Bagasse ash

Property	**Red Earth soil**	**Bagasse ash**
Specific gravity	2.68	1.71
Sand (4.75–0.075 mm) (%)	8	77.2
Silt (0.075–0.002 mm) (%)	52	22.8
Clay (<0.002 mm) (%)	40	--
Liquid limit (%)	39	61
Plastic limit (%)	22	Non plastic
Plasticity index (%)	17	--
Shrinkage limit (%)	15	--
Optimum moisture content (%)	16.4	43
Max. dry unit weight (kN/m^3)	18	10.34
IS soil classification	CI	-

Table 2 Chemical composition of Bagasse ash

Material	**Silica (SiO_2)**	**Alumina (Al_2O_3)**	**Ferric oxide (Fe_2O_3)**	**Calcium oxide (CaO)**	**Magnesium oxide (MgO)**	**Sodium oxide (Na_2O)**	**Potassium oxide (K_2O)**	**Loss on ignition**
Bagasse ash	65.92	11.96	2.86	5.6	4.03	1.79	3.19	16.18

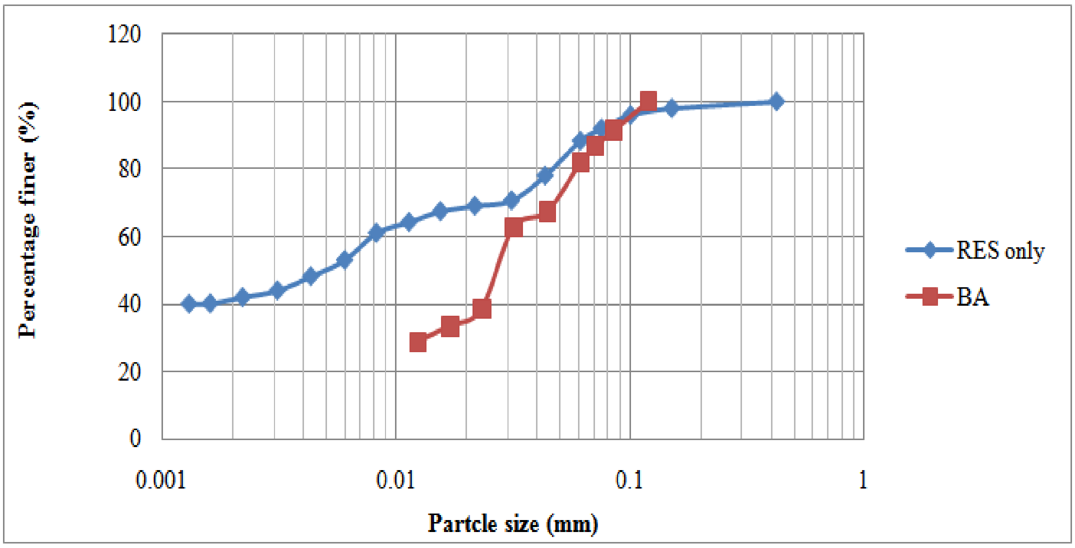

Fig 1 Grain size distribution curve for non expansive soil and bagasse Ash

2.2 Methods

The compaction tests were conducted using mini compaction test apparatus as per the procedure of Sridharan and Shivapullaiah [7]

III. RESULTS AND DISCUSSION

Compaction tests were conducted for the samples without any curing for non expansive soil alone and for the soil treated with 5% to 30% of bagasse ash in an increment of 5%. Further studies were made by adding 1% to 6% lime to the soil-bagasse ash mixture in an increment of 1%. The same tests were conducted with the addition of Calcium salts such as 1% Calcium Sulphate and 1% Calcium Chloride to soil- bagasse ash-lime mixture.

3.1Effect of Bagasse ash on the compaction characteristics of non expansive soil

With the addition of bagasse ash in an increment of 5% to the soil, the Dry unit weight decreased as shown in Table 3 and Fig.2 and this may be due to the low specific gravity value of 1.7 of bagasse ash as compared to that of the soil which is 2.68 and also may be due to flocculation and agglomeration of clay-sized particles due to cat-ion exchange cause increase in volume and decrease in dry density [8]. This may also be due to decrease in strength at particle level and this cause the particle to become closer during compaction and thus decrease in density is observed. This agglomeration cause reduction in water holding capacity and thus increase in optimum moisture content is observed [9] and [10]. It can be observed from Table 3 that, beyond 10% bagasse ash addition, there is marginal change in compaction characteristics and hence 10% bagasse ash is considered as optimum dosage for the present investigation.

Table 3 Compaction characteristics of non expansive soil treated with various percentages of bagasse ash

Mixture	MDU (kN/m³)	OMC (%)
Soil alone	16.4	18
BA alone	10.34	43
Soil + 5% BA	15.9	19
Soil + 10% BA	15.4	20
Soil + 15% BA	15	21
Soil + 20% BA	14.4	22
Soil + 25% BA	13.5	23
Soil + 30% BA	13.2	24

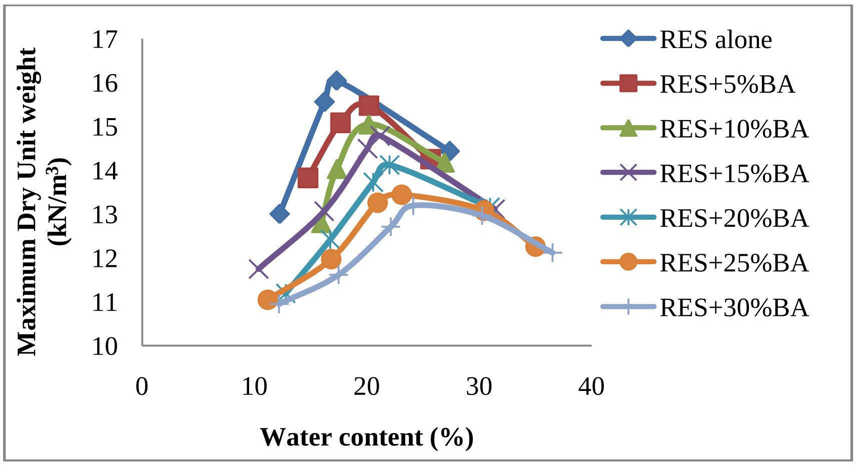

Fig.2 Dry density-water content relationship for non expansive soil with various percentage of bagasse ash

3.2 Effect of Lime on the compaction characteristics of non expansive soil and bagasse ash mixture

Effect of Lime on the compaction characteristics of non expansive soils is shown in Table 4 and Fig.3. With the addition of lime, further reduction in dry density is observed. The gradual reduction in maximum dry unit weight with the increase in lime content reflects flocculated particles resist the compactive effort due to increased friction of flocculated particles. Increasing tendency of optimum moisture content may be the cause of enhancement in water-holding capacity within flocs, which can accommodate water molecules. The increase in optimum moisture content is observed with the addition of lime and this may be due to increase in Hydroxyl ion concentration, liberated by the addition of lime, increases the affinity of the surfaces of clay particles for water. [11]. It is observed from Table 4 that, the change in compaction characteristics is marginal beyond 2% lime addition and therefore 2% lime is considered as optimum in the present investigation.

Table 4 Compaction characteristics of non expansive soil and bagasse ash mixture treated with various percentages of Lime

Mixture	MDU (kN/m^3)	OMC (%)
Soil alone	16.4	18
Soil + 10% BA	15.4	20
Soil + 10% BA + 1%Lime	14.6	21
Soil + 10% BA + 2%Lime	14.5	22
Soil + 10% BA + 3%Lime	14.2	24
Soil + 10% BA + 4%Lime	13.9	25
Soil + 10% BA + 5%Lime	13.8	26
Soil + 10% BA + 6%Lime	13.6	29

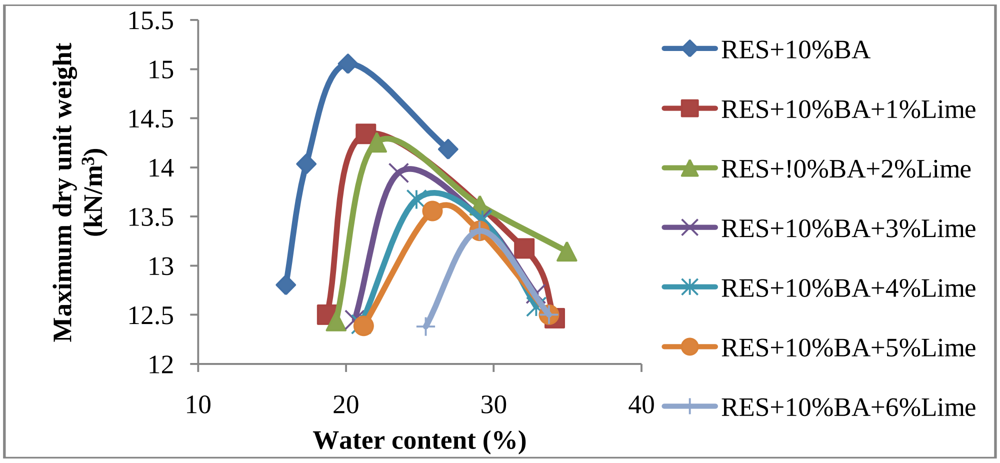

Fig.3 Dry density-water content relationship for non expansive soil and Bagasse ash mixture treated with lime

3.3 Effect of Calcium Sulphate and Calcium Chloride on the compaction characteristics of non expansive soil, bagasse ash mixture treated with lime.

Effect of Calcium Sulphate and Calcium Chloride on the compaction characteristics of red earth soil and bagasse mixtures treated with lime are shown in Table 5 and Fig.4. With the addition of 1% Calcium Sulphate and 1% Calcium Chloride, increase in dry density is observed. This may be attributed to the enhanced flocculation and cementation of particles and the cluster is formed which counteracts the compactive effort. Increasing tendency of optimum moisture content may be the cause of enhancement in water-holding capacity within flocs, which can accommodate water molecules. [12] and [13]

Table 5 Compaction characteristics of non expansive soil and bagasse ash mixture treated with lime in the presence of Calcium salts

Mixture	MDU (kN/m^3)	OMC (%)
Soil alone	16.4	18
Soil + 10% BA	15.4	20
Soil + 10% BA + 2%Lime	14.5	22
Soil + 10% BA + 2%Lime+1%Calcium Sulphate	14.7	26
Soil + 10% BA + 2%Lime+1%Calcium Chloride	14.8	27

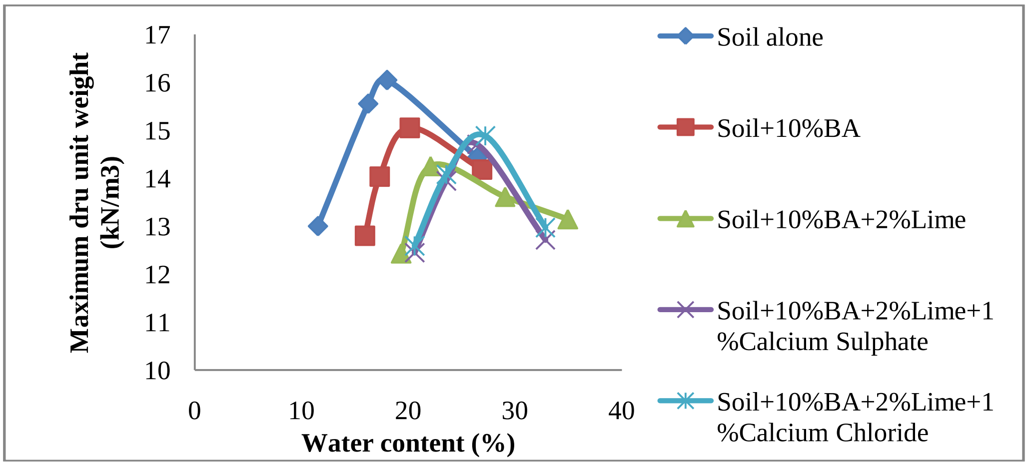

Fig.4 Dry density-water content relationship for non expansive soil and Bagasse ash mixture treated with lime in the presence of Calcium salts

IV. CONCLUSIONS

Following conclusions have been drawn based on the results discussed above

- The maximum dry unit weight decreased with the addition of bagasse ash for non expansive soils due to the low specific gravity value of bagasse ash, flocculation and agglomeration of clay-sized particles and repulsive pressure of soil particles resisted the compactive effort. The optimum moisture content increased due to the increase in fines content with the addition of bagasse ash with larger surface area that required more water to react.
- With the addition of lime, further reduction in dry density is observed for non expansive soil, due to the flocculation and cementation of particles and decrease in thickness of diffuse double layer. Optimum moisture content increased due to increase in hydroxyl ion concentration, increases the affinity of the surfaces of clay particles for water
- With the addition of 1% Calcium Sulphate and 1% Calcium Chloride, increase in dry density is observed and reflects enhanced flocculation and cementation of particles which counteracts the compactive effort. Optimum moisture content increased due to enhancement in water-holding capacity within flocs, which can accommodate water molecules.

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