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Stabilization of Alluvial soil with the help of Rice Husk Ash and Cow Dung Ash

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ABSTRACT
This research aims to study the effect of cow dung ash and rice husk ash on the stabilization of alluvial soils.
The term soil stabilization means bearing capacity of soil by the use of controlled compaction; proportioning of the addition of suitable admixtures or stabilizers.
Due to variation in water content , the volume of alluvial soil changes. It usually expands during the rainy season due to the addition or absorption of water, and shrinks during the winter. Therefore, it is very important to replace the weak soil accompanied by the stabilized one.
Although, a number of studies has been accomplished on cement as a soil stabilization material, but most of them were done on expansive soil.
Improvement of alluvial soil by using marble dust causes the release of CO2 gas in the atmosphere, which is not good for the Environment.
Hence, by using RHA and CDA, and thus utilizing these wastes for the improvement of alluvial soil will be a leading alternative, both economically and environment friendly.
KEY WORDS : Construction Materials, Rice Husk Ash, soil, Cow Dung Ash.

INTRODUCTION

- Before doing any construction work at any site, it is important to know about the soil that exists under the ground.
- The study of soil comes under the branch of Civil Engineering known as Geotechnical Engineering. It deals with the study of the type, characteristics and engineering properties related to the soil, which gives us an overview about the behavior of soil.
- India is an agricultural top united states so quite a number crops are cultivated. India by myself produces round a hundred and twenty million tons of rice paddy per year, giving round 24 million tons of rice husk per year, for each a thousand kg of paddy milled, about 220 kg (22%) of husk is produced and when this husk is burnt in the boilers, about fifty-five kg (25%) of RHA is generated.
- About 10–15 kg of cow dung is produced by a cow in a day. Therefore, cow dung can be utilized through burning it at a temperature of 450–500 _C as a subgrade material.
- A rural avenue improvement challenge below Pradhan Mantri Gram SadakYojna (PMGSY) is nonetheless in development in India. The subgrade soil is the basis of the pavement and its residences are vital in sketch of pavement structure. The major characteristic of subgrade is to supply adequate support to the pavement and for this the subgrade should possess precise load bearing capacity, consistency limits, accurate drainage steadiness beneath detrimental local weather and load bearing conditions. Therefore, there is a want to design one of the appropriate strategies of low fee street construction. The development fee can be considerably decreased with the aid of deciding on domestically reachable substances for stabilization of the present soil. This find out about consists of the stabilization of subgrade soil the use of specific domestically available materials such as sugarcane bagasse ash, cow dung ash and rice husk ash.
- In this presentation, we shall discuss about the properties of Alluvial Soil, and focus on improving its bearing capacity (strength) using a method known as Soil Stabilization.

1.1 ALLUVIAL SOIL

- This soils are formed in India mainly due to the deposition of sediments by Indo-Gangetic and Brahmaputra Rivers. Wave activity in coastal areas causes some alluvial soil deposition.
- Alluvial soils are formed when streams and rivers slow their velocity, and thus, deposition of sediments takes place. It is a kind of Transported Soil.
- Clay, silt, sand, gravel, metals, and other earthy components generally formed alluvial soil, which is generally found near a water source i.e. stream, river.
- Alluvial soil contains high nutrients and mineral content. So it is considered best for growth of plants and crops.
- It is found in the plains like Assam, Gujarat, Madhya Pradesh, Punjab, Orissa, Tamil Nadu, Punjab, Haryana, Uttar Pradesh, Bihar, and West Bengal. Thus, these soils cover 40-45% of the entire land area in India.
- The soil is porous because of its loamy in nature. It also occurs in deltas of the Krishna, and the Kaveri, where these are known as coastal alluviam. This type of soil replenished by recurrent floods.

- The largest of the primary types of soil particles is sand, which ranges between 0.05mm and 2mm in diameter. But the silt particles are smaller than the sand particles, ranging between 0.002mm and 0.05mm in dia., and clay particles are smaller than 0.002mm dia.

1.2 SOIL STABILIZATION

- Soil stabilization is a method of improving the stability or bearing capacity of the soil.
- With the use of controlled compaction, and proper proportioning of suitable materials, the properties of the soil are improved.
- These changes in the soil properties are brought about either by the mixing of proper amount of additives or by mechanical blending of different soil types.
- Commonly used admixtures are cement, lime, bitumen, fly ash.

We shall use RHA and CDA as stabilising materials in the Physical Method of Soil Stabilization.

1.3 MATERIALS USED FOR STABILIZING SOIL

1.3.1 RHA-Rice Husk Ash

- RHA is obtained from the burning of rice husk. The husk is a by-product of the rice milling industry.
- By weight, 10% of the rice grain is rice husk.
- On burning the rice husk, about 20-25% by weight becomes RHA.
- Rice husk ash RHA is a pozzolanic material.
- The RHA had 90.2% silica content. This high amount provides good Pozzolanic Action.
- Almost every year, India produces over 120 million tonnes of rice paddy, yielding approximately 24 million tonnes of rice husk.
- For every 1000 kg of paddy grown, around 220 kilogramme(22%) of husk is produced, and when this husk is burned in incinerators, approximately 55 kg(25%) of RHA is generaed.

1.3.1.1 Advantages of RHA

- RHA increases the resistance of soil against chemical attacks and sulphate attack.
- Improves the compressive strength of the soil.
- Reductionin the amount of cement, for making concrete as compared to that of concrete prepared using OPC.
- Reduces the material cost and emission of CO_2 due to less utilization of cement.
- RHA mixed concrete shows better bond strength as compared to OPC cement.
- Reduce shrinkage due to particle packing, making the soil denserand stable.
- Reduces the plasticity of soil.

1.3.1.2 Disadvantages of RHA

- To achieve good quality ash, a suitable incinerator/furnace as well as a grinding process are necessary for burning and grinding the rice husk.
- Transportation problem occurs.
- Improper burnt rise husk ash is not suitable for soil stabilization or for concrete production.

1.3.1.3 Chemical Composition of RHA

Table no.1 - Chemical Composition of RHA

S . N O	COMPONENT	SYMBOL	%
1	SILICA	SiO_2	90.2
2	ALIMINA	Al_2O_3	2.74
3	FERRIC OXIDE	Fe_2O_3	0.30
4	TITANIUM DIOXIDE	TiO_2	0.10
5	CALCIUM OXIDE	CaO	1.89
6	MAGNESIUM OXIDE	MgO	0.32
7	SODIUM OXIDE	Na_2O	0.28
8	POTASSIUM OXIDE	K_2O	0.12
9	LOSS OF IGNITION	LOI	5.37

Figure 1 – Rice Husk

Figure 2 – Burning of Rice husk

Figure 3 – Rice Husk Ash

1.3.2 CDA-Cow Dung Ash

- About 10–15 kg of cow dung is produced by a cow in a day.
- Therefore, cow dung can be utilized by burning it at a temperature of 450–500 C in the form of cow dung ash.
- CDA can be used as a good subgrade material in pavements, and cab be utilized for soil stabilization up to a certain level.
- CDA is obtained by drying and burning of dried cow dung pats and has large content of Nitrogen, Calcium and phosphorous. It has low thermal conductivity and requires a maximum of 400 degree centigrade of heat energy.

1.3.2.1 Advantages of CDA

- Easy availability
- Eco-friendly.
- Economical.
- Cause no harm to soil.

1.3.2.2 Disadvantages of CDA

- On increasing the concentration of CDA, it leads to increase in water content.
- Collection and processing is a tedious process.

Figure 4 – Cow Dung PatsFigure 5-Burning of cow dungFigure 6 –Ash of cow dung

1.3.2.3 Chemical Composition of CDA

Table 2 - Chemical Composition of CDA

S . N O	COMPONENT	SYMBOL	%
1	SILICA	SiO_2	65.76
2	ALIMINA	Al_2O_3	4.45
3	FERRIC OXIDE	Fe_2O_3	3.16
4	TITANIUM DIOXIDE	TiO_2	0.37
5	CALCIUM OXIDE	CaO	12.98
6	MAGNESIUM OXIDE	MgO	2.01
7	SODIUM OXIDE	Na_2O	0.51
8	SULPHUR TRIOXIDE	SO_3	0.94
9	LOSS OF IGNITION	LOI	9.82

LOCATION OF STUDY AREA

Meerut is the largest city in NCR after Delhi. Meerut lies between the plains of the Ganges and those of the Yamuna. **Meerut** is a city in the Indian state of Uttar Pradesh. The city lies 70 km (43 miles) northeast of the national capital New Delhi, and 453 km northeast of the state capital Lucknow.

Meerut has a monsoon influenced humid subtropical climate. Summers last from early April to late June, with temperatures reaching 49°C (120°F). In June, monsoon arrives and continues till the middle of September.

Again in October, temperature rises and the city then has a mild. From late October to the middle of march, the lowest temperature ever recorded is-0.4°C (31.3°F). Rainfall is about 845 millimeters (33 in) per annum, that is suitable for growing crops. Generally most of the rainfall is received during the monsoon. The humidity varies from 30 to 100%.

2.1 Sample Collection

Soil samples for determinations of geotechnical properties were collected from the contamination area. The sample was oven dried in laboratory at 105°C before conducting experiment. And important material used is CDA and RHA. To the determination of geochemical properties, soil sample were collected from same area.

2.2 Methodology

2.2.1 Geotechnical properties assessment

1. Water content by oven drying method as per IS: 2727 (part-2)-1973
2. Specific gravity by density bottle as per IS: 2720 (part-3, sec-1)-1980
3. Grain (particle) size analysis by sieving as per IS: 2720 (part-4)-1985
4. Liquid limit and Plastic limit of soil as per IS: 2720 (part-5)-1985
5. Proctor test (OMC & MDD) by using light compaction as per IS: 2720 (part-7)-1980
6. California bearing ratio test as per IS: 2720 (part-16)-1979

2.3 Laboratory performance

The experimental work consist of the following steps

1. Grain (particle) size analysis by sieving
2. Water content by oven drying method
3. Specific gravity by density bottle
4. Determination of soil index properties (Atterberg's limit)

a. Liquid limit
b. Plastic limit

5. Determination of the maximum dry density and the corresponding optimum moisture content by proctor compaction test
6. Calculation of CBR strength

a. To mould the soil sample into standard moulds keeping its moisture content and proctor density respectively.
b. Determination of California Bearing Ratio (CBR) strength of the respective soil samples in moulds using the California Bearing Ratioinstrument.

2.3.1 Particle Size Distribution:

When soil is passed through 75 micron sieve, if more than 50% passes through this sieve, it is known as fine grained soil; and if more than 50% soil retains on this sieve, it is known as course grained soil. Coarse grained soils may have rounded to angular bulky, hard, rock particles with the following sizes:

1. Boulder- more than 300 mm dia.
2. Cobble- smaller than 300 mm and larger than 80 mm dia.
3. Gravel has smaller than 80mm and larger than 4.75mm.
4. Coarse gravel- 20 mm to 4.75 mm
5. Sand has Smaller than 4.75 mm and larger than 0.075 mm

- Course: 4.75 mm to 2.0 mm
- Medium: 2.0 mm to 425 micron
- Fine: 425 micron to 75 micron

6. Clay- smaller than 75 micron
7. Silt-smaller than 2 micron

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Figure 9 – Sieves and Mechanical Vibrator

3.4.1 THE WATER CONTENT OF SOIL BY OVEN DRYING METHOD

It is defined as the ratio of the mass/weight of water to the mass/weight of soil solids,

$$w = \frac{W_w}{W_s}$$

Where,
w = water content
Ww = Weight of water
Ws = Weight of soil solids (mass of oven dry soil).

Figure 10 – Container

Figure 11 – Oven

3.4.3 THESPECIFIC GRAVITY OF SOIL BY DENSITY BOTTLE METHOD:

It is defined as the ratio of mass (wt) of a given volume of solid to the mass of equivalent volume of water.

Density bottle method can be used to determine specific gravity of all type of soil.

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Table 3 - Standard values for Specific Gravity of different types of soils

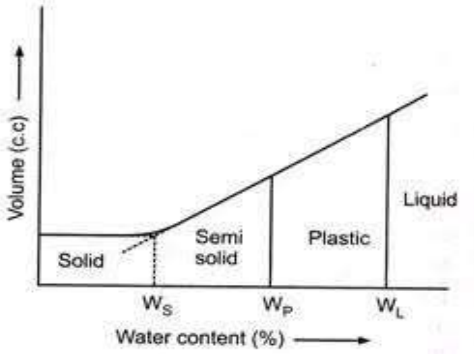
Sr.no.	Soil Type	Specific Gravity
1	Gravel	2.65 – 2.68
2	Sand	2.65 – 2.68
3	Silty Sand	2.66 – 2.70
4	Silt	2.66 – 2.70
5	Inorganic Clay	2.68 – 2.80
6	Organic Soil	Vairable, may fall below 2.0

Figure 12- Density Bottle

3.4.4 Determination of Atterberg Limit:

Atterberg Limits or Consistency Limits are basic measure of the nature of a soil. It depends upon the water content in the soil, it might appear in four states: solid, semi-solid, plastic and liquid. In every state, behavior and consistency of the soil is different and so are its engineering properties. So, the boundary between each state can be defined based on a change in the soil's behavior.

Figure 13 – Atterberg Limits Chart



3.4.4.1 Liquid limit (LL): It is the moisture content at which the groove, formed by a standard tool into the sample of soil taken in the standard cup, closes for 10 mm on being given 25 blows in a standard manner. At this limit the soil possess low shear strength.

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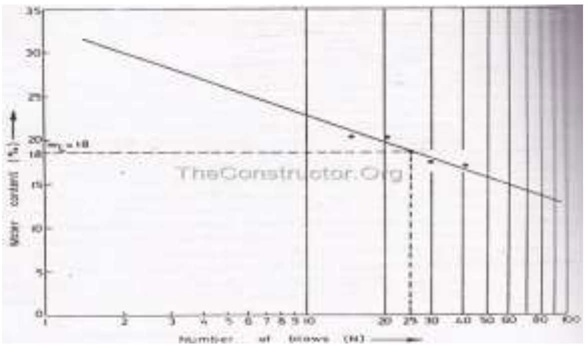
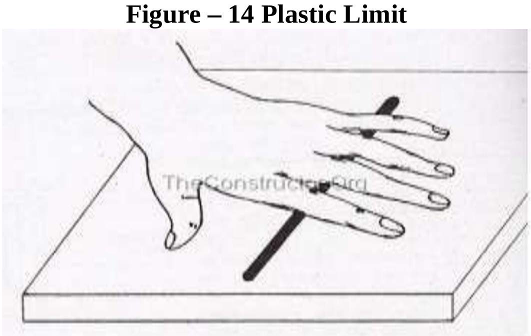
Graph 1 - Flow Curve on Semi-logGraph



3.4.4.2 **Plastic limit (PL):**Plastic limit is the water content below which the soil stops behaving as a plastic material. It starts to crumble when rolled into a thread of soil of 3 mm dia. At this water content, the soil loses its plasticity and passes to semi solid state.

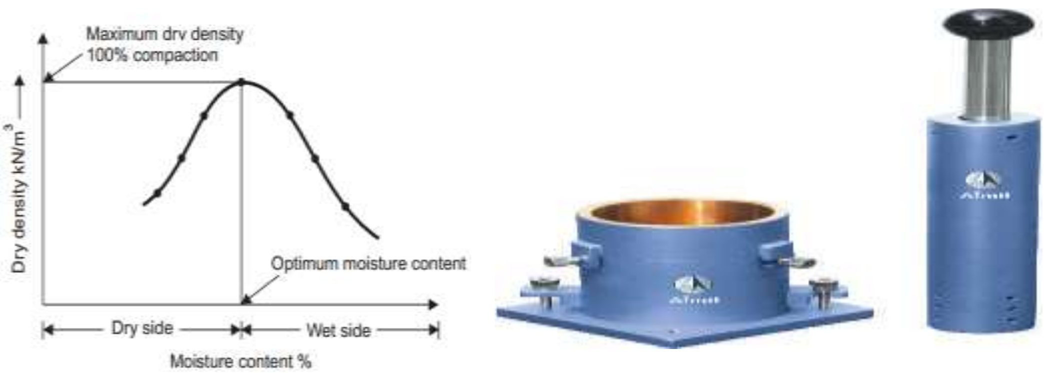
Figure – 14 Plastic Limit



3.4.5 PROCTOR COMPACTION TEST:

Compaction of a soil is a mechanical process by which the soil particles are constrained to be packed more closely together by reducing the air voids. Soil compaction cause decrease in air voids and consequently an increase in dry density. It might result in increase in shearing strength. The possibility of future settlement of compressibility decreases and also the tendency for subsequent changes in moisture content decreases. Degree of compaction is usually measured quantitatively by dry density.

Figure – 15 Standard Compaction Curve



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3.4.6 **CALIFORNIA BEARING RATIO (CBR) TEST:**

It is a penetration test developed by California State Highway Department (U.S.A).

"It is the ratio of force per unit area required to penetrate a soil mass with standard circular piston at the rate of 1.25 mm/min. to that required for the corresponding penetration of a standard material."

In most cases, CBR decreases as the penetration increases. Generally, the ratio at 2.5 mm penetration is used as the CBR value. In some case, the ratio at 5mm may be greater than that at 2.5mm. If this occurs, the ratio at 5mm should be used.

Figure 16 – CBR Test

RESULTS & DISCUSSION

4.1 Experimental work on soil and discussion

The experiment conducted on all the soil and CDA and RHA samples are index properties, engineering properties and analysis. The results are summarizes below and graphs has been plotted showing variation of different property of soil and CDA and RHA sample.

4.2 Particle size Distribution:

First 'A' sample of 1000gm of soil was passed through 75 micron sieve, to classify it a fine or course grained soil.

- Total soil retained on 75 micron sieve = 624gm % retained = 62.4 %
- Total soil passed through 75 micron sieve= 376gm, %passed= 37%

Since more than 50% soil is retained from sieve, soil can be classified as course grained soil.

Now soil classification is done.
Total weight of coarse grained soil= 624gm
Now, the soil is passed through 4.75mm sieve

- Total soil retained on 4.75mm sieve =47gm is 7.53%
- Total soil passed through 4.75mm sieve= 577gm, is 92.47%

Since more than 50% soil passes through 4.75 mm sieve, the soil is sandy.

Table 5 - Sieve Analysis

IS Sieve no	Wt retained	%wt retained	Cumulative % retained	% passing= 100-cumulative %
10mm	0	0	0	100
4.75mm	31	3.1	3.1	96.9
2.36mm	47	4.7	7.8	92.2
1.18mm	69	6.9	14.7	85.3
600µ	117	11.7	26.4	73.6
300 µ	139	13.4	39.8	60.2
150 µ	125	12.5	53.3	47.7
75 µ	101	10.1	62.4	37.6
Pan	376	37.6	100	0

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4.3 Water content:

Soil mass is passed through 425µ sieve minimum wt of soil specimen taken for testing= 25gm

W1= wt of dry container with lid =25.5gm

W2= wt of dry container with lid + moist soil =56.3gm

W3= wt of container with lid + dry soil =50.4gm

$$w = \frac{(W_2 - W_3)}{(W_3 - W_1)} \times 100\ \%$$

W = 23.4%

4.4 Specific Gravity:

W1= wt of dry density bottle = 16.94gm

W2=wt of density bottle + dry soil= 36.92

W3= wt of density bottle + moist soil= 88.18

W4=wt of density bottle+ water = 75.62

Now, $\mathbf{G_s} = \frac{(w2-w1)}{(w2-w1)-(w3-w4)}$

So, Gs= 2.69

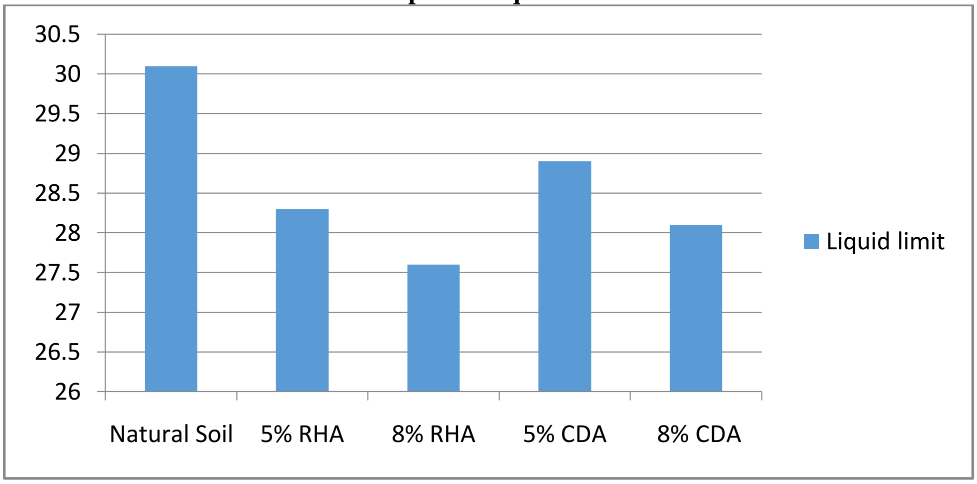
4.5 AtterbergLimits :

4.5.1 Liquid limit:

Table 6 - Liquid limit

Sr. No	Observation and calculation	Determinations				
		Natural soil	RHA		CDA	
			5%	8%	5%	8%
	Observations					
1	No. of blows	25	25	25	25	25
2	Wt of empty container(W1)gm	25.5	25.5	25.5	25.5	25.5
3	Wt of empty container + moist soil (W2) gm	60	59.2	58.5	59	58.2
4	Wt of empty container + dry soil (W3) gm	52	51	50.1	51.5	51.2
	Calculations					
5	Mass of water = W_2-W_3	8	8.2	8.4	7.5	7
6	Mass of dry soil = W_3-W_1	26.5	25.5	24.6	26	25.7
7	Water Content $w = \frac{(W_2 - W_3)}{(W_3 - W_1)} \times 100\ \%$	30.1	28.3	27.6	28.9	28.1

Graph 2 - Liquid limit



4.5.2 Plastic Limit:

Table 7 - Plastic Limit

Sr. No	Observation and calculation	Determinations				
		Natural soil	RHA		CDA	
			5%	8%	5%	8%
	Observations					
1	Wt of empty container(W1)gm	25.5	25.5	25.5	25.5	25.5
2	Wt of empty container + moist soil (W2) gm	33.5	32.9	32.6	32.8	32.4
3	Wt of empty container + dry soil (W3) gm	31.05	31.5	31.22	31.4	31.15
	Calculations					
4	Mass of water = W2-W3	2.45	1.4	1.38	1.4	1.25
5	Mass of dry soil = W3-W1	5.55	6	5.72	5.9	5.65
6	Water Content (w%) = $w = \frac{(W_2 - W_3)}{(W_3 - W_1)} \times 100\ \%$	22.5	23.3	24.1	22.9	23.6

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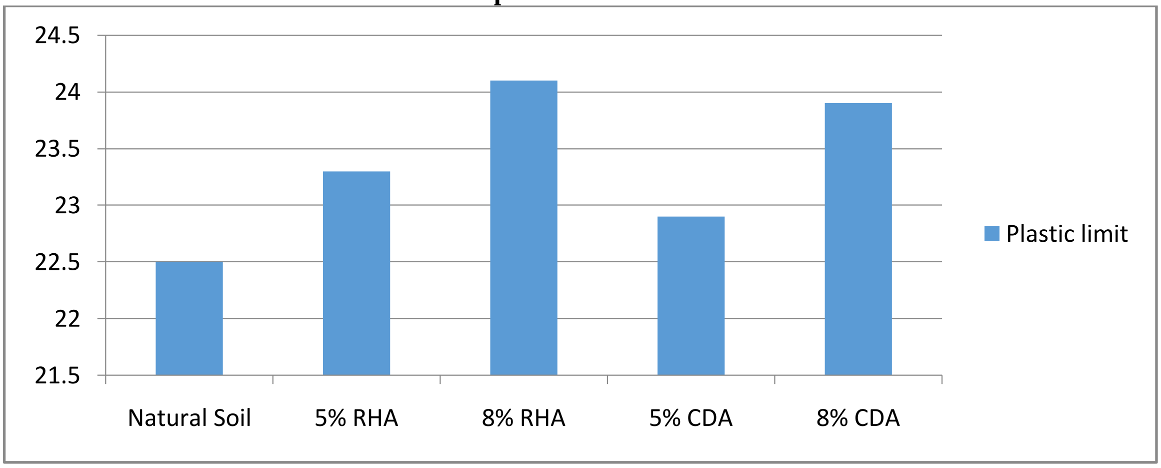
Graph 3 - Plastic Limit

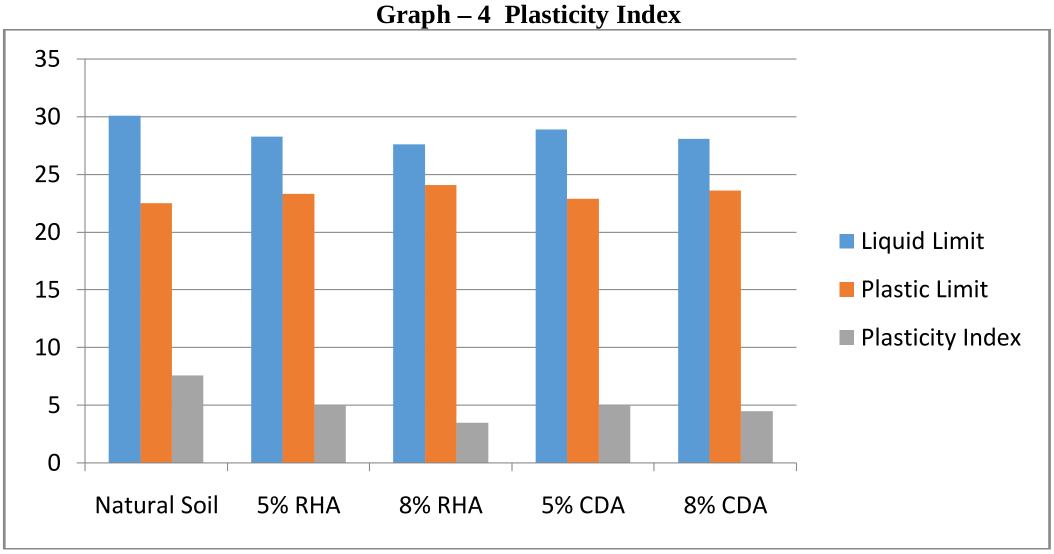


Using liquid limit (WL) and Plastic limit (Wp), we can calculate
Plasticity index, $I_p = W_l - W_p$

Table 8 – Plasticity Index

Determination	Natural soil	RHA		CDA	
		5%	8%	5%	8%
W_l	30.1	28.3	27.6	28.9	28.1
W_p	22.5	23.3	24.1	22.9	23.6
$I_p = W_l - W_p$	7.6	5	3.5	4	4.5

Graph – 4 Plasticity Index



4.6 Proctor Compaction Test

Table 9.1 – For natural soil

Sr. No	Observation & Calculation	Natural soil		
		Water content		
		5%	11%	15%
	Observation			
1	Mass of empty mould + base	5540	5540	5540

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	plate = M1 (g)			
2	Mass of empty mould + compacted soil = M2 (g)	7506	7641	7625
	Calculation			
3	Mass of compacted soil M = M2 – M1	1996	2085	1924
4	Bulk density (in g/cc) $\ell = \frac{M}{V}$	1.966	2.085	1.924
5	Dry density (in g/cc) $\ell d = \frac{\ell}{1+w}$	1.872	1.895	1.350
6	Void ratioe $= \frac{G\ell w}{\ell d} - 1$	0.436	0.419	0.99
7	Saturation (in %) $S = \frac{Gw}{e}$	30.63	70.62	40.75

Graph 5.1 - For natural soil

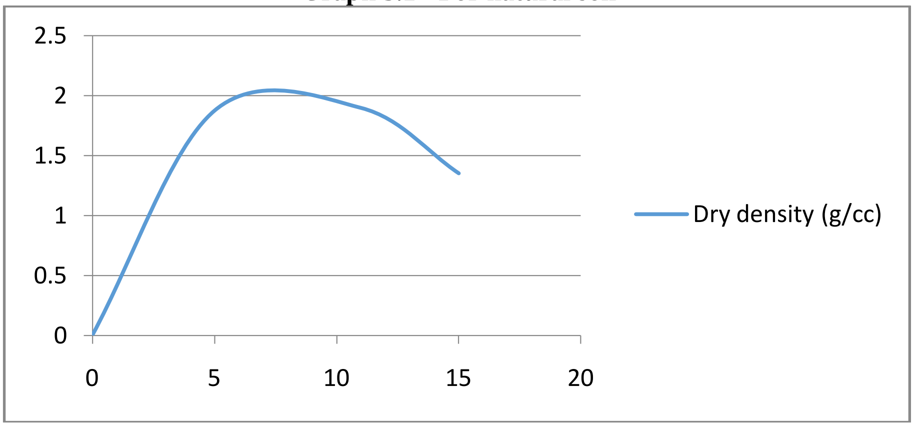

Table 9.2 – For 5% RHA

Sr. No	Observation & Calculation	5% RHA		
		Water content		
		5%	11%	15%
	Observation			
1	Mass of empty mould + base plate = M1 (g)	5540	5540	5540
2	Mass of empty mould + compacted soil = M2 (g)	7489	7603	7541
	Calculation			
3	Mass of compacted soil M = M2 – M1	1949	2063	2001
4	Bulk density (in g/cc) $\ell = \frac{M}{V}$	1.949	2.063	2.001
5	Dry density (in g/cc) $\ell d = \frac{\ell}{1+w}$	1.846	1.869	1.74
6	Void ratioe $= \frac{G\ell w}{\ell d} - 1$	0.449	0.437	0.535
7	Saturation (in %) $S = \frac{Gw}{e}$	29.95	66.19	74.03

Graph 5.2 - For 5% RHA

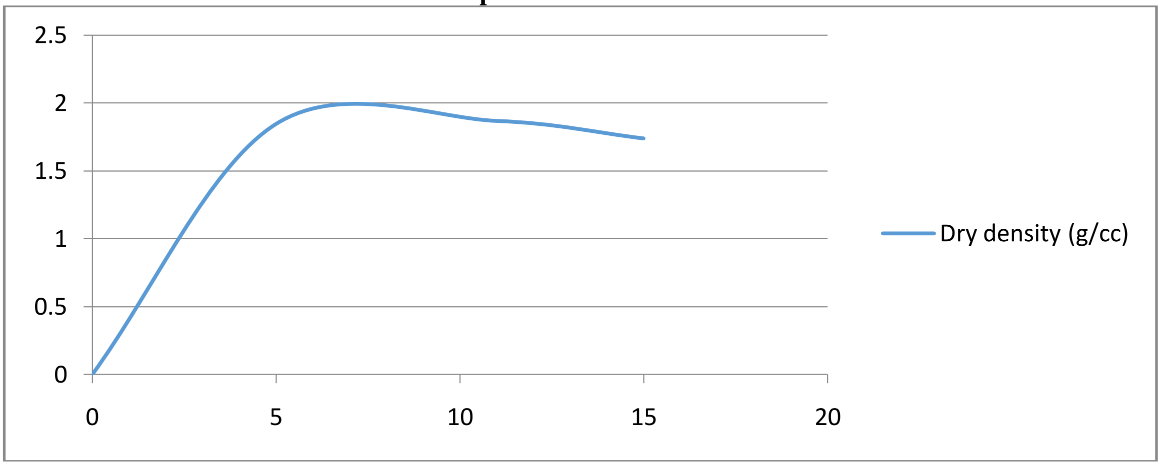

Table 9.3 – For 8% RHA

Sr. No	Observation & Calculation	8% RHA Water content 5%	11%	15%
	Observation			
1	Mass of empty mould + base plate = M1 (g)	5540	5540	5540
2	Mass of empty mould + compacted soil = M2 (g)	7437	7563	7509
	Calculation			
3	Mass of compacted soil M = M2 – M1	1933	2023	1969
4	Bulk density (in g/cc) $\ell = \frac{M}{V}$	1.933	2.023	1.969
5	Dry density (in g/cc) $\ell d = \frac{\ell}{1+w}$	1.822	1.840	1.712
6	Void ratioe $= \frac{G\ell w}{\ell d} - 1$	0.464	0.476	0.571
7	Saturation (in %) $S = \frac{Gw}{e}$	29.17	62.16	70.66

Graph 5.3 - For 8% RHA

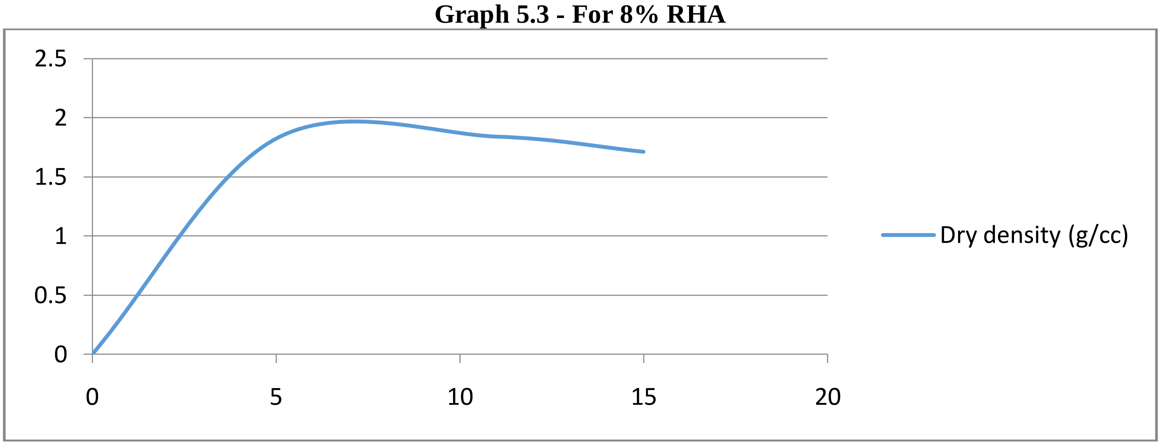

Table 9.4 – For 5% CDA

Sr. No	Observation & Calculation	5% CDA Water content 5%	11%	15%
	Observation			
1	Mass of empty mould + base plate = M1 (g)	5540	5540	5540
2	Mass of empty mould + compacted soil = M2 (g)	7497	7561	7523
	Calculation			
3	Mass of compacted soil M = M2 – M1	1957	2031	1983
4	Bulk density (in g/cc) $\ell = \frac{M}{V}$	1.957	2.031	1.983
5	Dry density (in g/cc) $\ell d = \frac{\ell}{1+w}$	1.829	1.863	1.724
6	Void ratioe $= \frac{G\ell w}{\ell d} - 1$	0.443	0.470	0.561
7	Saturation (in %) $S = \frac{Gw}{e}$	30.36	62.95	72.05

Graph 5.4 - For 5% CDA

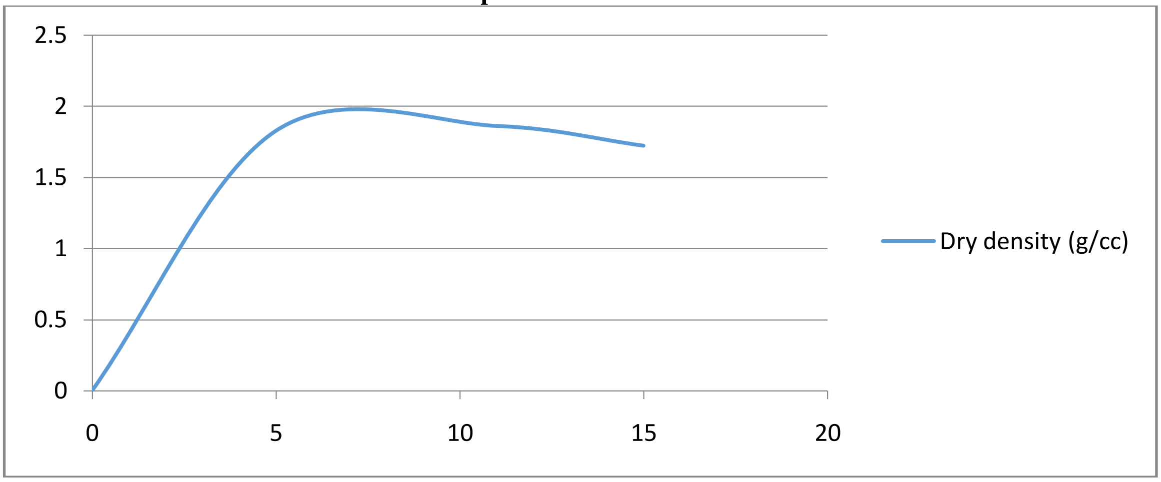

Table 9.5 – For 8% CDA

Sr. No	Observation & Calculation	8% CDA Water content 5%	11%	15%
	Observation			
1	Mass of empty mould + Base plate = M1 (g)	5540	5540	5540
2	Mass of empty mould + Compacted soil = M2 (g)	7482	7548	7507
	Calculation			
3	Mass of Compacted soil M = M2 – M1	1942	2008	1963
4	Bulk density (in g/cc) $\ell = \frac{M}{V}$	1.942	2.008	1.963
5	Dry density (in g/cc)	1.809	1.849	1.706

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	$\ell d = \frac{\ell}{1+w}$			
6	Void ratioe $= \frac{G\ell w}{\ell d} - 1$	0.454	0.487	0.576
7	Saturation (in %) $S = \frac{Gw}{e}$	29.62	60.75	70.05

Graph 5.5 - For 8% CDA

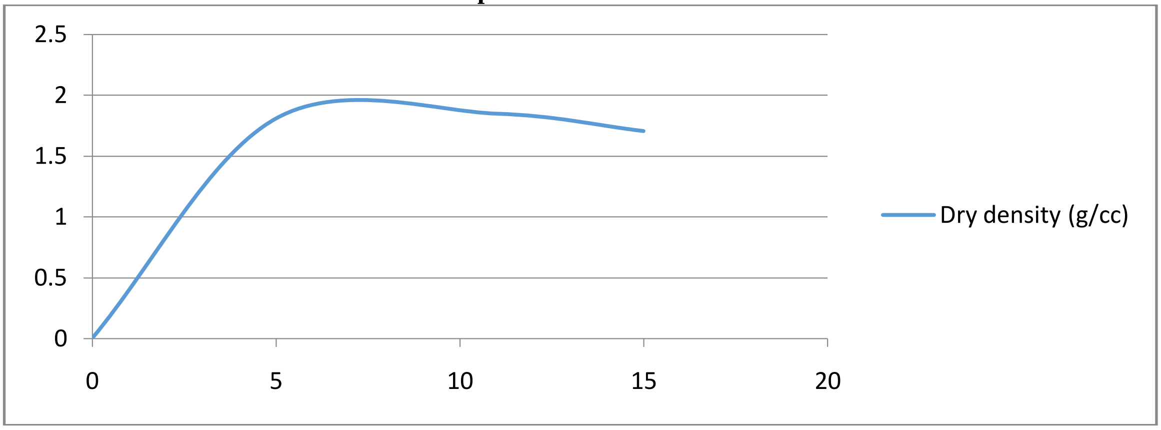


Table 9.6 - Values of MDD and OMC

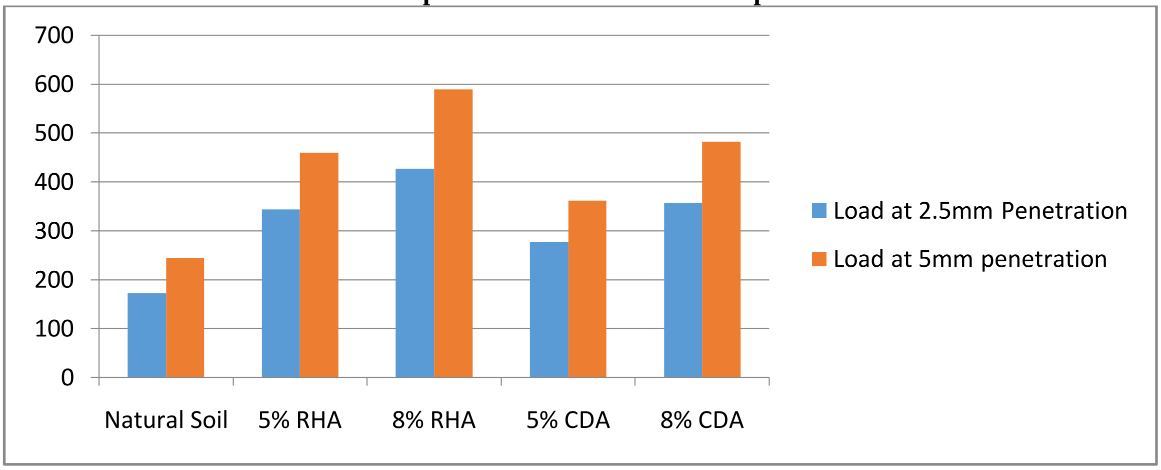
	OMC (%)	MDD (g/cc)
Natural soil	7	2.105
RHA		
5%	7.67	1.995
8%	8.2	1.882
CDA		
5%	7.23	1.978
8%	7.39	1.931

4.7 CBR Test:

Table 10 - Load-Penetration Values (CBR Test)

Sr. No	Load (kg) at penetration of	Natural Soil	RHA		CDA	
			5%	8%	5%	8%
1.	2.5mm	172.62	343.87	427.44	276.74	357.57
2.	5mm	244.55	460.32	589.78	361.7	482.73

Graph 6 – Load-Penetration Graph



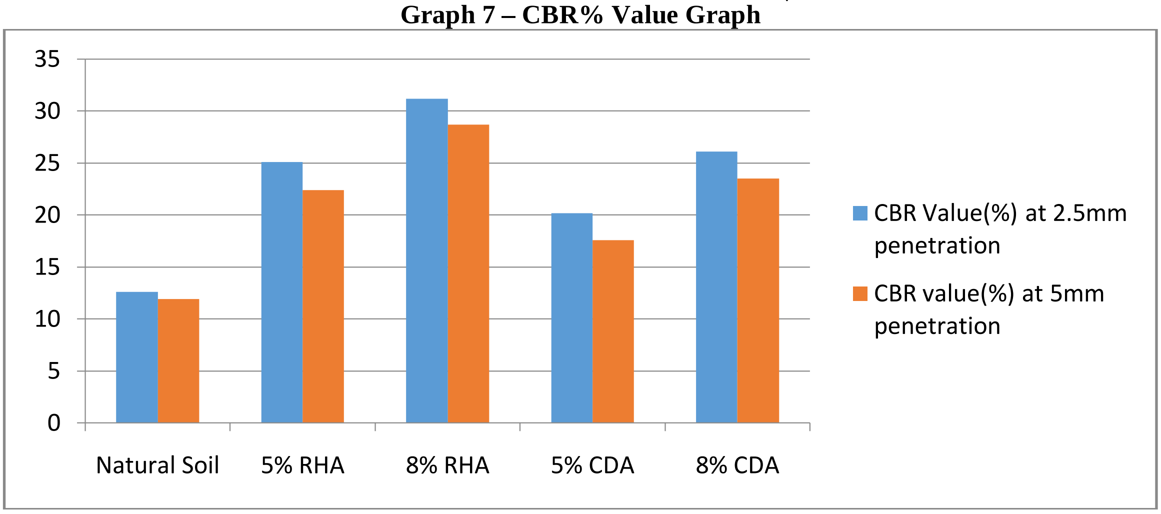
Now, CBR % is calculated at 2.5mm and 5mm
Standard load at penetration of 2.5mm =1370kg
Standard load at penetration of 5mm = 2055kg

$$CBR\% = \frac{\text{Corrected load value}}{\text{Standard load}} x100$$

Table 11 – CBR% Values

Sr. No	CBR value (%)	Natural soil	RHA		CDA	
			5%	8%	5%	8%
1	At penetration of 2.5mm	12.6	25.1	31.2	20.2	26.1
2	At penetration of 5mm	11.9	22.4	28.7	17.6	23.5

Graph 7 – CBR% Value Graph



CONCLUSIONS

1. More water content is required to stabilize the soil, for CDA than RHA, which is a disadvantage of CDA.
2. On increase in quantity of stabilizing material:

- Liquid limit decreases - as the stabilizing material is mixed with soil and bearing capacity of soil increases, due to which the flow property of soil decreases, and its shear strength increases.
- Plastic limit increases - due to better mixing of soil, filling of voids by the stabilizing material and strength of soil increases, due to which it tends to become a little harder. Soil can be molded effectively. More plasticity means, that soil can hold and absorb more amount of water.
- Hence, the Plasticity Index decreases because

$I_p = W_l - W_p$

3. On increase in quantity of stabilizing material:

- OMC increases – due to the decrease in quantity of free silt, clay fraction and coarser mix, which require more water to mix.
- MDD decreases – due to addition of stabilizing material, which has a lower value of Specific Gravity, than soil, the overall Dry Density of the mix reduces.

4. CBR Test –

- On increase in quantity of stabilizing material, CBR value increases upto a certain limit, because the stabilizing material gets mixed properly upto an optimum quantity.
- On further addition of stabilizing material, CBR value decreases, as the stabilizing material mixes upto a certain proportion, and afterwards, it doesn't mix properly and remains unused in the mix.

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