STABLIZATION OF SUBGRADE BY USING SUITABLE STABLIZER AND ITS COST ANALYSIS

Submitted in partial fulfillment of the requirements of the degree of

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CIVIL ENGINEERING

by

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DECLARATION

I, **Vikash Kumar Singh** (11208221), hereby declare that this submission is my own work and that to the best of my insight and conviction, it contains no material beforehand distributed or composed by other individual or office. No material which has been acknowledged for reward of some other degree or certificate of the college or other organization of higher learning with the exception of where due affirmations have been made in the content. It was arranged and displayed under the direction and supervision of **Mr. Akash Verma**(Assistant Professor).

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CERTIFICATE

This is to certify that **Vikash Kumar Singh** under Registration No. 11208221 has prepared the dissertation-2 report titled "STABLIZATION **OF SUBGRADE BY USING SUITABLE STABLIZER AND ITS COST ANALYSIS**" under my direction. This is a bonafide work of the above competitor and has been submitted to me in fractional satisfaction of the prerequisite for the honor of Masters of Technology in Civil Engineering.

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Signature of student

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ABSTRACT

In India construction is one of the most important area for the economic growth of country is transportation. ROADWAYS are convenient mode of transportation is majorly used. In the present scenario there is a rapid increase in the usage of vehicles in both public sector and private sector due to this there is an increase in stress on the soil sub grade. Several types of loads are subjected on the pavement surface which is transferred to the lower layers in the form of layer to layer transmission.

This leads to the failure of pavement in where the soil is weak. So, there is an immediate requirement to improve the strength of the soil to resist the stresses produced due to the vehicle movement. Soil with less stability creates numerous problems so this can be solved by the stabilizing the soil by using the admixtures as result there are more advantages. The improvement of the soil sub grade is important to increase the life time of the pavement and to reduce the maintenance of the pavement.

The wastes like bagasse ash and wooden ash are used for the improving the strength of soil sub grade. By treating the soil with these additives, the sub grade can attain the more strength which is already proved. The soil is treated with the additives in different mix proportions like 3%, 6%, 9%, and 12%. Comparing and analyzing the characteristics of the soil by performing the tests in the laboratory. Then suggesting the more appropriate additive and the mix proportion to the local soil that strength of soil sub grade can be improve and reduction in project costs in the district Kapurthala.

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CHAPTER-1

INTRODUCTION

1.1 GENERAL

Soil sub grade is the most important layer in the pavements because the sub grade acts as the foundation to any type of pavement. The sub grade should have sufficient support when most unfavorable situation arises i.e. bad climatic conditions and in heavy loading situations. The will be a form of waves, rutting, and corrugations are failures due to the less strength in soil sub grade. And in some situation, there will be breakages on the edges of the pavement majorly it can be identified in the in flexible type pavements.

The properties like Stability, Incompressibility, good drainage, ease of compaction are more ethical properties of the soil sub grade. The sub grade should be ethical enough to bear the pressure that impart to bottom of the pavement from top. In the sub grade the cover of 50cm soil grains are densely packed with the optimum moisture content to accomplish certain density. When the required strength is not meet we go for the improvement of strength in soil sub grade.

In present scenario land scarcity and cost of land is highly rising. The population growth has led people to move from village to urban regions means the number of trips generation is increased thus construction of flexible and cement concrete pavements are increasing for efficient transportation. As there is a huge growth in cities in India there is increasing demand in all-weather pavement. Concrete pavement structures have long life and it carries a lot loads. There is very less requirement of carrying out maintenance in these structures. The developing countries like INDIA the flexible pavements are very important for connecting major cities and capitals because it less cost compared to the cc pavements. The loads in the flexible pavements are transfer by layer to layer transmission where the strength of sub grade is most important parameter. Now a days importance is given to the improving techniques for the improving the strength of soils which are urgent proximity for the construction work where the soils are not meeting the required specification. To attain the specified requirement the soil is treated for improving the soil strength with cementing and chemical materials. In present state many researchers have focused on the cost reduction of the projects by choosing the locally availability materials that can helpful to the project. Bagasse ash and wooden ash are the most locally available materials and the cheapest materials. Bagasse ash is produced from the bagasse which is a byproduct in the sugar cane industry and alcohol industry. Wooden ash is produced from the thermal power plants and small scale industries where the wood is main source of the fire. The analysis is done by the input data that is obtained from the tests conducted in the laboratory of the soil that has mixed with the additives in different proportions. The laboratory tests that to be performed to classify the soil by the sieve analysis and other tests to know the strength properties.

1.2 SOIL STABILIZATION

The strength of the soil sub grade can be attained by stabilizing the soil which known as soil stabilization. This process can be performed by using the various admixtures and the control compaction. Majorly soil stabilization deals with the physical and physicochemical and chemical methods to ensure the soil stabilized layers serves as intended in the components there are some basic principles of the soil stabilization

- Analyzing the properties of the soil and identifying the deficiency in the soil.
- Giving suitable or appropriate material that as supplement to the soil
- Designing mix proportion of the soil that intended to stability and durability
- Facilitating the suitable construction procedure to stabilization

It may result any one are more following changes:

- Rise in the strength characteristics of soil
- Adjustments in some undesirable properties of the soil
- Change in the chemical properties of the soil

1.3 SOIL STABILIZATION TECHNIQUIES

Based on the obtained results one of the technique is choose from group of the below stated technique

- Proportioning and mixing different materials
- Using cementing agent
- Using modifying agent

- Using water-proofing agent
- Using water-repelling agent
- Using water-retaining agent
- By heat treatment
- By chemical stabilization

1.4 OBJECTIVES OF THE STUDY

The thesis describes the comparative study of improvement of soil sub grade by using additives like bagasse ash and wooden ash. The main parameters that are considered for comparative study are sub grade performance when mixed with wooden ash and bagasse ash.

The objectives of the present study are listed below:

- To reduce the disposing problem of the waste produced from the industries.
- To study the changes in the soil properties when it is treated with different materials.
- To study the various characteristics of the soil when it is treated with the bagasse ash and wooden ash in different percentages like 3%,6%,9%,12%
- To use the present waste that produced form the industries.
- To suggest the best material for the sub grade strength improvement from bagasse ash and wooden ash.

1.5 NEED FOR STUDY

To economize project: By improving the sub grade strength of soil we can shun the excavation and dumping, which results the contractor to get benefit economically.

Saving by design: Suggesting the most suitable material to stabilize and its percentage to be adding in the weak soil. By this the strength of the sub grade increase and there is decrease in the thickness of the pavement through the decrease in the consequent layer thickness. By this the project cost, time and material is reduced.

Saving the waste: By using the material which is the waste product in the nature. The percentage of the waste can be reduced and solving the problem of dumping the waste.

1.6 SCOPE OF THE STUDY

For the soil sample, selected is tested in the laboratory in order to determine the engineering properties.

The laboratory tests like atterberg limits and particle size distribution and moisture content will assessing the characteristics of the soil. Other lab tests such as CBR are determined the thickness of pavement. To minimize the agricultural wastes that are produced and to state the comparative properties of the soil when it is mixed with the bagasse ash and wooden ash.

CHAPTER-2

LITERATURE REVIEW

2.1 PAST STUDIES

Many of researches attempted to improve subgrade strength of soil by using the additives having cohesive materials and agriculture waste as a combination, here below we discuss some of the works done for the improvement of the strength of soil subgrade based on use of bagasse ash and wooden ash.

Ken C.Onyelowe studied 'cement stabilized akwuete lateritic soil and use of bagasse ash. The soil is collected from the depth of 1.5m from the normal surface of the soli to avoid the top soil. The soil is mixed with additives like cement and bagasse ash in various proportions i.e. proposition of cement is 4% and 6% whereas bagasse ash ranging from 0%, 2%, 4%, 6%, 8%, 10% by the dry soil weight. The tests like OMC, MDD and CBR were performed to the soil in which additives are mixed. The obtain results of the OMC, MDD at 4% with different proposition of bagasse ash has observed that there is a reduction in MDD and increasing MDD at 6% of cement content. The optimum moisture content is directly proportional to the bagasse ash content i.e. if optimum moisture content increases there is an increasing bagasse ash content. There is a great improvement in strength of subgrade soil when the soil is mixed with additives compare to the normal soil it is found by conducting CBR test.

Kiran R et al: had studied 'the analysis of strength characteristics of black soil using bagasse ash and additives as stabilizer'. The researches had chosen the black cotton soil from Devanagari district, Karnataka. The propositions of bagasse ash added are 4%, 8%, 12%, and additives mixed. The laboratory tests are performed for the mixed soil to know the strength parameter like CBR and UCS. The density of the black cotton soil is changed due to with different proposition of bagasse ash. The density values increased from 1.16 KN/m3 to 16.5KN/m3 due to addition of 8% bagasse ash and cement. The CBR values are increased from 2.12 to 5.43 due to addition of 4% bagasse ash and 8% of cement and UCS values got increased from 74.91KN /m2 to 84.92KN/m2 due to addition of 8% of bagasse ash and cement

Moses G, et al: studied influence of 'compactive effects on cement bagasse ash treatment on expensive black cotton `soil' the soil is mixed with different proportion of additives like bagasse ash and cement in following percentages i.e. 0, 2,4,6 and 8 by dry weight of the soil. Tests are done for the treated soil to know the moisture density relationship California baring ratio and unconfined compressive strength tests are carried out in laboratory. The optimum proposition of the bagasse ash and cement to blend the soil is 8% and 4% for the soil which is used as a sub-base material.

Kanchan Lata Singh et al: the researcher has studied ‘stabilization of soil using bagasse ash’ he had chosen the different percentages of bagasse ash to treat the soil are 0%, 3%, 6%, 9%, 12%, 21%, 30%. Increasing the bagasse ash indirectly proportional to MDD of mix i.e. if percentage of bagasse ash is increased there is a decreasing in MDD. The California baring ratio of the soil is increased up to the optimum percentage of the bagasse ash mix for clayey soils.

Vishal V. et al: The researcher had presented as study on ‘expensive soil stabilization using bagasse ash’ they had chosen the different percentages of bagasse ash to treat the soil are 3%, 6%, 9%, 12%. For the treated soil the MDD OMC are Increasing the bagasse ash indirectly proportional to MDD of mix i.e. if percentage of bagasse ash is increased there is a decreasing in MDD. The California baring ratio of the soil is increased up to 6% for the optimum percentage of the bagasse ash mix for clayey soils and MDD decreases further. The compressive strength of soil increases with 5% replacement of a SCBA, for further replacement the value decreases.

SS.Quadri et al.: They had conducted research on soil stabilization of black cotton soil with respective permeability aspects for the use in engineered landfills. They have chosen the additives like sodium bentonite and lime for improvement of black cotton soil. For the black cotton soil they had performed some laboratory test to check the permeability of the soil. Finally the conclusion that the soil can be used as landfills covers when the soil is treated with bentonite and lime.

M. Chiiaranjan, et al: The team of researchers conducted research on ‘agriculture waste as soil stabilizer’. The following are the agriculture waste i.e. rice husk groundnut shell, bagasse ash which are used in the project for stabilization of soil to hence the properties. The treatment is given to the soil with the agriculture waste in different percentage i.e. 0%, 3%, 9%, 12%, and 15% respectively. The sub grade strength is known by performing the CBR test to the soil. The CBR valve is improved by the increasing the percentages of the agricultural wastes to 9%.

K.J. Osinubi et al: They had studied Effect of the bagasse ash on lime treated of the black cotton soil. The soil classification test if performed to classify the soil and mentioned the soil comes under the CH respectively. The OMC and MDD are inversely proportional to each other i.e. OMC of the soil increases with the decrease in the MDD of the soil The CBR valve for the soil sub grade is appreciable for the soil that is treated with the additives.

Alavez-Ramirez et al: The researches had conducted research on the 'Improvement of the mechanical properties of the soil by using the Bagasse ash and Lime'. They had treated the soil with the additives like Lime and Bagasse ash with 10% in the dry weight of the soil. They had performed the tests on the treated soil and finally concluded that the mechanical properties and the durability of the soil compacted soil blocks are improved.

Y.I Murthy: He had presented on 'stabilization of the Expensive soil using mill waste'. In this research, the researcher has observed that the physical and mechanical properties of the soil are changed when it is treated with mill waste. He had conducted the experiments to the treated soil to find the bearing capacity, permeability and plasticity of the soil. He finally concluded that there is an increase in the bearing capacity of the soil to certain limit and the permeability of the soil increases with the decreasing in the plasticity of the soil by increasing the mill waste.

CHAPTER-3

METHODOLOGY AND EXPERIMENTAL SETUP

3.1 RESEARCH METHODOLOGY

In the literature review or past studies, we will collect some data about the project that we are going to do experiments and their suggestions. Generally, the data is two types' primary data and secondary data, the primary means related to experience that have been experienced in the site or job and the secondary data is related to the collection of data through internet, journals, newspapers, publications and so on.

After all this our methodology of experimentation starts by collecting the data and doing the experimentation. In the experimentation, we will study about the different tests to be conducted on the soil to know how capacity it can bear, soil strength, soil nature. This nature of soil is important for mixing the admixtures, depending upon the nature only we will decide which type of admixtures should be mixed for clay, silt, fine graded, and coarse graded soil. In the experimenting, we will take different percentages of admixtures in the soil and test the sample the exact percentage to be mixed in the soil is defined by the analysis part graphs. Depending on this analysis part only we will do the experimentation.

In the experimentation, the following tests are conducted a). Light compaction test, & Heavy compaction b). CBR test, c). Sieve analysis d). LL and PLThe soil classification can be done with the help of unified soil classification. After the soil classification, the LL and PL are calculated and the observation is done how the LL and PL are changing with change in percentage of admixture usage.

In the light compaction or heavy compaction, the main aim intention is to find the OMC and MDD. The OMC obtained in the standard proctor test or modified proctor test is used in the preparation of CBR mold. For each percentage of change in admixture the OMC should be calculated generally after the experimentation we will go to analysis the result. The analysis can be done in the form of graph, from this graph we will find all the values and how much amount of admixtures to be used in the soil, if taken percentage of admixture is not showing good result then again we go back to the experimentation part and change the percentage and again we test and analysis. Like this the procedure goes on finding.

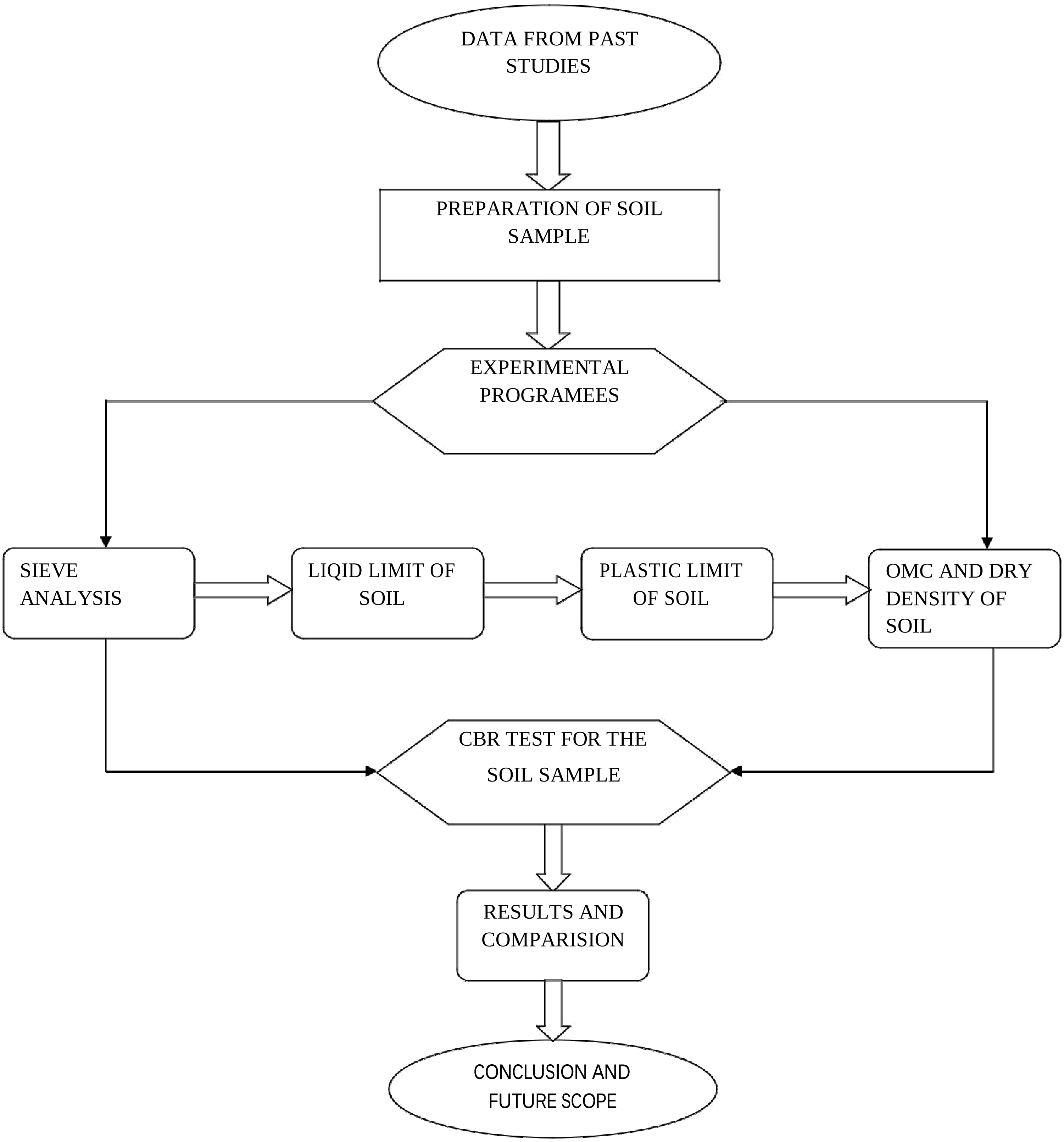


Fig no: 3.1 flow chart of the study

3.2 MATERIALS

Materials that are chosen as the additives are bagasse ash and wooden ash and the existence of these materials and the properties of these substances are discussed below:

3.2.1 BAGASSE ASH

Bagasse is the pulpy residue and fibrous material i.e. is left out after production of the juice from sugar cane in sugar cane industry. This bagasse currently used as bio fuel and manufacturing of pulp and paper products and building materials in present scenario for every 10 tonnes of sugar cane crushes 3 tons of bagasse is produced as waste from the sugar cane industries

- Composition: the composition of bagasse is
- Cellulose :45-55%
- Hemi cellulose :20-25%
- Lignin :18-24%
- Ash: 1-4%

Property: the bagasse ash acts as a cementing material due to presence of amorphous silica, so that there is a good bonding between the soil grains in the week soils

Chemical composition: the chemical composition of the bagasse ash is is tabulated below which is tested in POLLUCOL LABORATORIES PVT.LMT

Table3.1 Composition of bagasse ash

ELEMENTS	**CHEMICAL FORMULE**	**PERCENTAGE %**
SILICA	SiO_2	68.42
ALUMINIUM OXIDE	Al_2O_3	5.812
FERRIC OXIDE	$Fe_2 O_3$	0.218
PHORSPEROUS OXIDE	P_2O_5	1.28
MEGNISIUM OXIDE	Mg O	0.572
SULPIDE OXIDE	SO_3	4.33
CALCIUM OXIDE	CaO	2.56
LOSS OF IGNITION	-	16.808

Table3.2 Composition of heavy metals in bagasse ash

HEAVY METAL	SYMBOL	EPA	BAGASSE ASH
BARIUM	Ba	100	0.148
ARSENIC	As	5	0.00445
CADMIUM	Cd	1	0.00185
CHROMIUM	Cr	5	0.0326
LEAD	Pb	5	Nd
MERCURY	Hg	0.2	Nd
SELENIUM	Se	1	Nd

Note: the meaning of bdl-below detection limit and for nd=non-detect

3.2.2 WODDEN ASH

The residue that has been left out after burning of the wood is called wooden ash approximately 6%-10% mass of brunt wood result as ash. The quantity of the ash that is obtained will be majorly dependent o the combustion temperature and type of the wood selected.

Chemical composition: The Chemical composition of the wooden ash is tabulated below

Table3.3 Composition of wooden ash

ELEMENTS	CHEMICAL FORMULE	PERCENTAGE %
SILICA	SiO_2	31.8
ALUMINIUM OXIDE	Al_2O_3	28
FERRIC OXIDE	$Fe_2 O_3$	2.34
PHORSPEROUS OXIDE	Na_2O	6.5
MEGNISIUM OXIDE	$Mg O$	9.32
SULPIDE OXIDE	$K_2 O$	10.38
CALCIUM OXIDE	CaO	10.53

Table3.4 Composition of heavy metal in wooden ash

HEAVY METAL	SYMBOL	EPA	WOODEN ASH
BARIUM	Ba	100	0.4608
ARSENIC	As	5	bdl
CADMIUM	Cd	1	nd
CHROMIUM	Cr	5	0.0328
LEAD	Pb	5	0.00116
MERCURY	Hg	0.2	nd
SELENIUM	Se	1	nd

Note: the meaning of bdl-below detection limit and for nd=non-detect

3.2.3 PROPERTIES OF WOODEN ASH AND BAGASSE ASH

Different properties of the bagasse ash and wooden ash are as follows

Table3.5 Properties of bagasse and wooden ashes

Material	Particle Size (MM)	Bulk Density (Kg/m^3)	Co-Efficient Of Uniformity	Co-Efficient Of Uniformity	Specific Gravity
BAGASSE ASH	0.230	410-590	10.40	1.68	2.41
WOODEN ASH	0.023	663-977	3.15	1.25	2.34

3.3 EXPERIMENTS

Following are different type of experiments conducted in this project:

1. Sieve analysis.
2. Liquid limit.
3. Plastic limit.
4. Standard proctor test (SPT).
5. California bearing ration (CBR).

3.4 SIEVE ANALYSIS

Take the is sieves and place them in increasing order from bottom to top i.e.0.75, 0.009, 0.212, 0.425, 1, 2, and4.75.the point to be remember while performing the test is that the percentage loss should not be exceeding 2%. After that the soil that has to be tested should bring from the site to the lab for experimentation. Take soil of 1kg place it on the top pan and start the process of sieving for 15-18 minutes. Note the values of the soil that is passing from the each sieve and the soil that has retained on the each sieve. From the noted valves calculate the percentage of passing and percentage of retained on each sieve.

Fig.3.2 Sieves

After calculating the percentages of total loss will be obtained. For this the percentage of loss is 0.8 the valve less than the 2.so we can continue to the further process that is soil classification.

- First look the .075 in which passing is less than 50% so it is coarse grain soil.
- Percentage of passing through the sieve size 4.75 mm is greater than 50% so it is sand.
- In third step looks the sieve size .075mm in which fines is greater < 5% so it is having
- Calculate the C_u and C_c values from the below log graph.
- Log is used because sizes of particles are accurately denoted.
- From the graph D_{10}=0.1, D_{30}=0.16, D_{60}=0.33 are known.

$C_u = D_{60}/D_{10}$

$=0.33/0.1 \quad = 3.3$ mm

$C_c = (D_{30})^2/(D_{10}*D_{60})$

= 0.78 mm

- This satisfied the both the conditions of poorly graded sand
    - $C_u<6$ and/or $1>C_c>3$

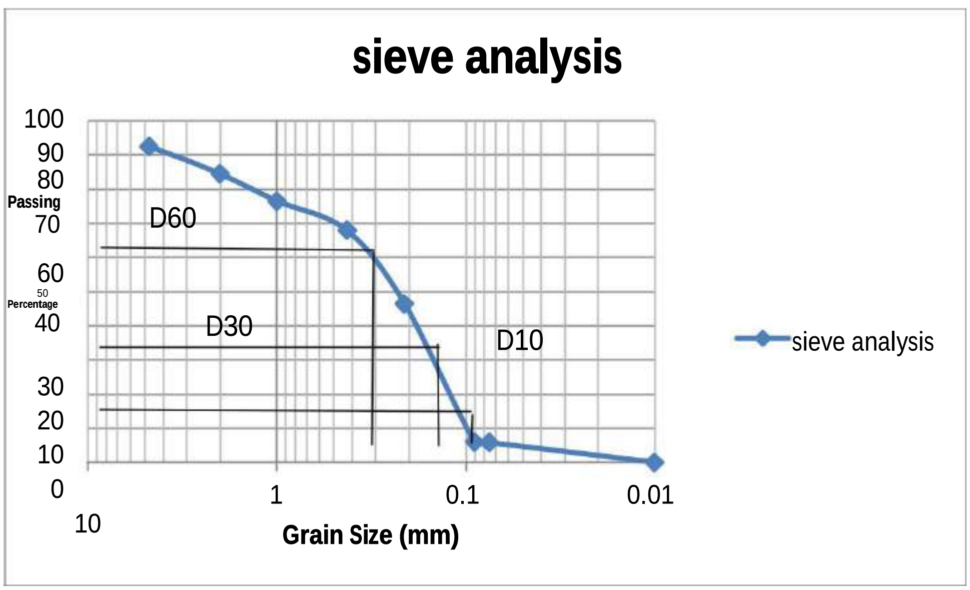


Fig.3.3 semi log graph to effective size values

Finally, is has concluded that the soil is poorly graded sand.

3.5 LIQUID LIMIT

First check the device to ensure that it was clean and working order. A soil sample of is prepared by sieving the soil in 0.425mm sieve take 120gm of it in dish. Add some distilled water tom the sample and mix it thoroughly to from a uniform paste with the help of spatula. Then soil become clay and left it for 20min to ensure uniform master distribution. Now place a portion of paste in the cup of liquid limit device and squeeze down and spread the paste in the cup with spatula. Trim the soil at the top so that the maximum depth of soil in the cup is 1cm.Now use the Casagrande's tool to groove the soil if it is clay and if it is sandy use ASTM type grooving tool. Now lift and drop the cup by rotating handle at the rate of two revolutions per second ill the two halves of the soil cake come in contact by flowing not by sliding with the bottom of the group along the distance about 12mm.count the number of blows required for the process and note in table. Ensure that the number of blows should be 15to 34. From the float portion take a representative of the soil using spatula in sample container of known weight. Ensure that spatula cuts the soil across the right angle to the group. Repent the experiment with different water contents that is dryer to water conditions of the soil and record the various observations.

After taking various samples place these samples in the oven for drying tov24hours. After on day weight the samples and note the values in the table. Then calculate the moisture content of the soil in particular number of blows. Plot the graph between moisture content and number of blows on a semi log graph. The moisture content corresponding to the 25 blows from the flow curve is the liquid limit of the soil.

Calculation:

$$\text{Water content} = [(W_1 - W_2 / W_2 - W_0) * 100\%].$$

W_0 = Weight of container.

W_1 = Weight of container+ wet soil.

W_2 = Weight of container+ oven dry soil.

$$W_1 - W_2 = \text{Weight of water.}$$

$W_2 - W_0$ = Weight of oven- dry soil.

Result: The obtained liquid limit of the normal soil is 24 %

3.6 PLASTIC LIMIT

Plastic limit is the water content at which the soil just begins to crumble when rolled into a thread approximately 3mm in diameter. The 50gm soil sample is taken which is sieved in 0.425mm sieve. Now add distill water to the soil sample mix it thoroughly so that the soil mass is plastic enough to be easily molded. Now prepare a ball from the soil mass of 8 gm and place it on the glass plate and roll it with the figures so that a thread of uniform diameter is formed. The rate of rolling should be 80to90 stalks per minute and continue the rolling until thread reaches to 3mm by taking the reference of the metallic rod. Then collect crumble pieces of soil thread in a container and weight them and determine the moisture content. Repeat the process two more times and record the values.

After this take, the sample and put in the oven and calculate the moisture content

Fig: 3.4 rolled soil sample

3.7 STANDARD PROCTOR TEST (SPT)

Compaction is a process by which soil particles are artificially rearranged and packed together in to closer state of contact by mechanical means in order to decrease the void ratio and increase the dry density of the soil. The compaction process can be accomplished by tamping, rolling and vibrating depending upon the type of soil.in this process we can find out the dry density and optimum water content of soil using light compaction as per IS:2720 part 7.

The equipment required for the test is compaction mould, collar, detachable plate, weighing machine, water, oven and metal rammer of 2.6kg and find the volume of the mould. take the soil sample about 2.5 kg and the water content of 4% in the soil if it is sandy soil and about 8%if it is clayey. Clean the mould and apply grease or oil to avoid the sticky ness of soil to the mould. Take the weight of the mould without attaching the collar to it. Place the soil in the mould in to three layers and compact each layer by the rammer about 25 blows having a free fall from 36cm height. Now remove the collar and trim of the excess soil projecting the mould using the straight edge. Take the weight of the mould with the compacted soil and record the values. Remove soil from the mould using the tool and take the soil sample from the middle portion of the soil in to container for the water quantity determination.

Dry density of the soil can be determined by using the formula is shown below

$$\gamma_d = \gamma_b / (1 + w)$$

γ_d = *Dry density*

γ_b = *Bulk density*

w = *water content*

Fig.3.5Formula of dry density

3.7.1 MDD AND OMC OF STANDRAD PROCTOR TEST:

The OMC and the MDD of the for the normal soil and to the soil with admixtures has been calculated from the results that are plotted in the graphs for dry density and moisture content which have been shown in analysis part

Table 3.6 OMC and MDD valves of soil with the admixture wooden ash by various percentages

Wooden ash	OMC	MDD
0	16.4	1.86
2	14.3	1.76
4	17.3	1.74
6	19.2	1.66
8	19.0	1.64
10	16.8	1.68

Table 3.7 OMC and MDD valves of soil with the admixture baggase ash by various percentages

Baggase ash	OMC	MDD
0	16.4	1.86
2	16.3	1.82
4	17.58	1.88
6	17.34	1.85
8	17.77	1.81
10	18.05	1.58
12	21.0	1.37

3.8 CALIFORNIA BARING RATIO

The highway department of California State has developed the CBR method to find the strength of soil sub grade of the pavement. The bearing valve of soil can be obtained by the CBR test. The CBR can be performed in the site and in the lab too with the help of plunger on the both remolded samples and original samples. The loading is 1.25mm/minute and the plunger having a diameter of 50mm. the loads required to penetrate 2.5 mm and 5mm are recorded.CBR is expressed with respective to the standard load in percentages. Standard load at 2.5, 5, 7.5, 10 and 12.5mm. CBR valve is defines as the ratio of load per unit area required to penetrate the soil mass by its standard plunger at the specified rate to that corresponding required for penetration of standard material.

3.8.1 OPERATION OF CBR

To perform the test the apparatus as per IS:2720 comprises of mold with internal diameter150mm and height of 175mm with the detachable collar and detachable base plate having perforations at the bottom. A spacer disc of 148mm diameter and a height of 47.7mm.the surcharge weights having central hole of 2.5kg and a plunger with 15mmdia and 100mm height.

A loading machine of 5000kg and capable of travelling vertically of 1.25mm per minute. The test consists of two parts there are

- Preparing test specimen.
- Penetration test.

Fig No 3.5 CBR test mould

Penetration test specimen: the specimen can be prepared by dynamic compaction and static compaction. In static compaction the load applied gradually and in dynamic compaction the load is applied by hammering. The dynamic compaction can be prepared by the light compaction or heavy compaction. In light compaction the specimen prepared in three layers the hammer used is 2.6kg with a free fall of 30cm with 56blows to each layer. Various in the heavy compaction the specimen prepared in five layers the hammer used is 4.89kg with a free fall of 45cm with 75blows to each layer. Let us see the hoe dynamically compacted specimen is prepared to assemble the mold space the spacer disc with threaded hole side at the bottom of base plate and filter paper top on it and apply lubricating liquid at inner side of the mold to prevent the sticking of the soil also fix the color and tight the clamps. Now take the 5kg of soil passing from the20mm sieve and mix with the predetermined quantity of the water such that the water content of the soil is equal to OMC or equal to the field moisture content.

Mix the water and soil thoroughly so has to prepare the uniform consistency. Transfer the soil in to the mold and fill such that after compaction the layer is about 1/3 rd or1/5th of the total thickness case may be now compact soil with suitable number of blows as stated above. After compaction of the soil scratch on the top surface of the layer and add more soil and compact in similar manner for second layer. Repeat the same process for top layer also and remove the color and trim the top of the surface also remove the base plate and filter paper. Remove the spacer disc and place the filter paper at the bottom place the mold such that the compacted surface at the bottom. Place the assembly on the pedestal of the loading machine to fix the plunger and bring the plunger in contact with the soil sample and apply seating load of 4kg this is to establish the good contact between soil and plunger.

Now add other 2.5kg slotted weight at the top and set dial readings zero allow the plunger to penetrate at rate of 1.25mm per minute. Note down the readings on proving ring corresponding to a penetration of 0.5, 1.0, 1.5, 1.5, 2.0, 4.0, 5.0 7.5, 10.0, and12.5. Sometimes the CBR curve may exhibit a concavity in the beginning in which case the correction is to be applied. From the curve determine the load corresponding to 2.5mm and 5.0mm penetration and compute CBR valve based of below formula

$$\text{CBR, \%} = \frac{\text{(Load or pressure sustained by specimen at2.5 or 5.0mm penetration)*100}}{\text{(Load or pressure sustained by standard aggregates at the corresponding Penetration values)}}$$

3.8.2 CALCULATION OF CALIFORNIA BEARING RATIO

$$\text{CBR (\%)} = \frac{(Pr*C_f)}{Ps} *100$$

Pr= Corrected Unit test load in kg

Ps= Total standard load for the same depth of penetration.

C_f = Proving ring correction factor.

As the CBR test is conducted for unoaked soil sample the load at the 2.5 mm penetration of the soil is 80.5kg.as we know the standard load at 2.5mm penetration that is 1370kg.the correction factor for the proving ring is 1.17. Therefore, the CBR obtained for the bagasse ash is proved from the below calculation.

$$\text{CBR (\%)} = \frac{(80.5*1.17)}{1370} *100$$

$$\text{CBR (\%)} = \frac{94.185}{1370} *100$$

$$\text{CBR (\%)} = \frac{9418.5}{1370}$$

Therefore, the CBR for the bagasse ash is 6.89% when the soil is mixed with 10% of SCBA in the un-soaked condition of the soil sample.

3.8.3 CBR VALVES OF STANDARD PROCTOR TEST

The CBR valves for the soil samples is calculated as mention in the previous section and tabulated below

Table 3.8 CBR valves for soaked and un soaked samples of soil + wooden ash

Bagasse ash	**Un-soaked**	**Soaked**
0	1.75	1.17
2	2.61	2.09
4	3.04	2.86
6	3.56	3.23
8	4.09	3.82
10	3.69	3.53

Table 3.9 CBR valves for soaked and un soaked samples of soil + bagasse ash

Bagasse ash	**Un-soaked**	**Soaked**
0	1.75	1.17
2	2.05	1.56
4	3.56	3.03
6	4.96	3.98
8	5.42	4.96
10	6.89	6.24
12	6.23	5.62

3.9 Design of Flexible Pavement as Per IRC 37-2012

The average rain fall in the selected site is625mm which is more than 500mm so the considering C.B.R. values should be for the soil ~~in the soaked condition.~~

A=Number of Commercial Vehicles per day

D=Lane Distribution Factor

F= Vehicle Damage Factor

r=Growth Rate

n=Design life

The traffic in the completion can be estimated using formula

$$A=P(1+r)^{x}$$

Table 3.10 Thickness of the pavements as per IRC37-2012

Type of soil	CBR(%)	Thickness of pavement	BC/SDBC	DBM	GBS	GSB
Normal soil	1.17	660	20PC		225	435
Soil wooden ash	6.23	560	20PC	50	225	265
Soil bagasse Ash	3.82	425mm	20PC	50	225	175

CHAPTER-4

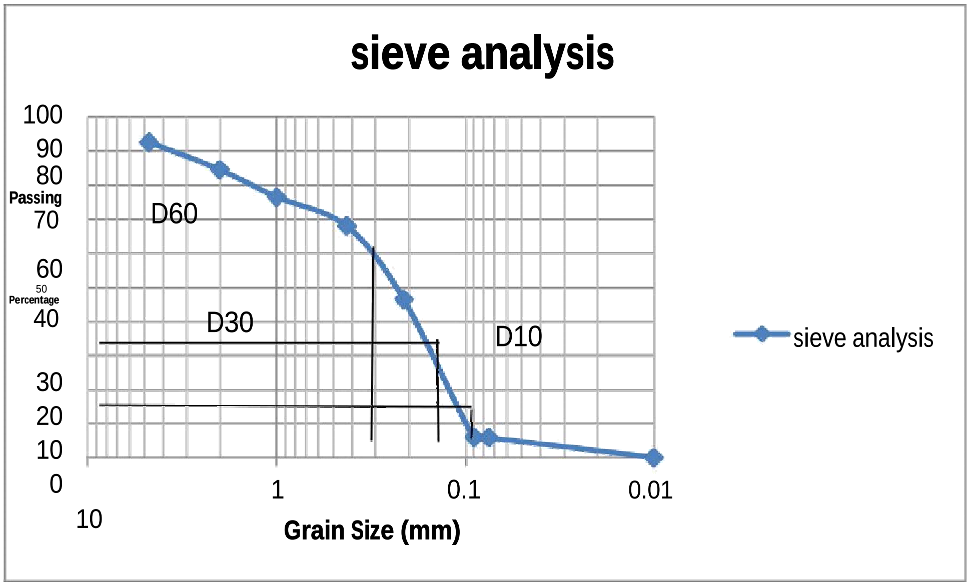
RESULTS AND DISCUSSION

4.1 OBTAINED RESULTS

- By performing the sieve analysis, it is known that he soils sample taken is poorly graded sand.
- By performing the liquid limit analysis, it is known that he soils sample contains 24% of the moisture content.
- By performing the plastic limit analysis, it is known that the plastic for the sandy soils are not able to prove because the sample breaks when it is rolled.so the soil ha non-plastic properties.
- Result of sieve analysis

Table 4.1 Sieve Analysis

Sieve sizes (mm)	**Mass retained in each sieve(grams)**	**% Retained**	**% passing**
4.75	77	7.854985	92.14502
2	82	8.056395	84.08862
1	81	8.257805	75.83082
0.425	84	8.459215	67.3716
0.212	214	21.55086	45.82075
0.09	405	40.7855	5.035247
0.075	1	0.100705	4.934542
0.01	49	4.934542	0
	993		



Finally, is has concluded that the soil is poorly graded sand.

- Results for the liquid limit

Table 4.2 Liquid Limit for Normal soil

Wet weight of soil(w1)	**Dry weight of soil(w2)**	**Wet weight of soil-dry weight of soil(w1-w2)**	**weight of water/dry weight of soil**	**Moisture content(%)**	**Blows count**
26	22	4	0.18	18.18	36
96	78	18	0.23	23.07	29
30	24	6	0.25	25	19

Liquid limit of normal soil

4.2 STANDARD PROCTOR TEST

Dry density and OMC of the normal soil is represented below for different water proportions

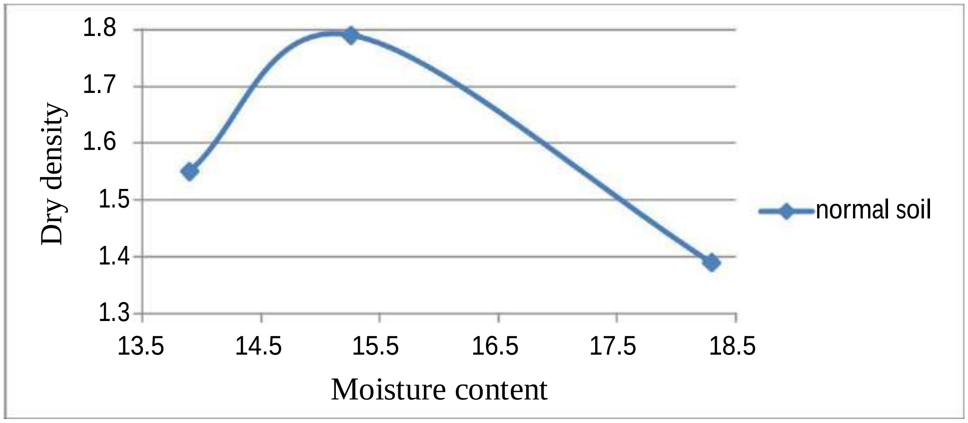


Fig 4.1 Dry density vs moisture content for the normal soil

The graph is plotted between moisture content on X-axis and dry density on y-axis as shown in figure 4.1. for the normal soil and the maximum optimum moisture content is 15.25 at dry density of 1.8 g/cm3

4.2.1 SUGAR CANE BAGASSE ASH

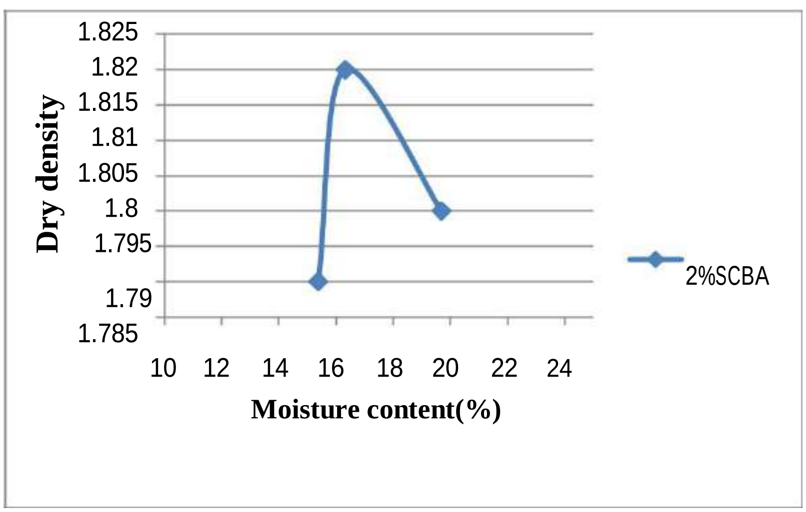


Fig 4.2 Dry density vs moisture content of 2% of bagasse ash and soil

The graph is plotted between moisture content on X-axis and dry density on y-axis as shown in figure 4.2. the soil is mixed with 2% of SCBA the maximum optimum moisture content is 16.3 at dry density of 1.86 g/cm3

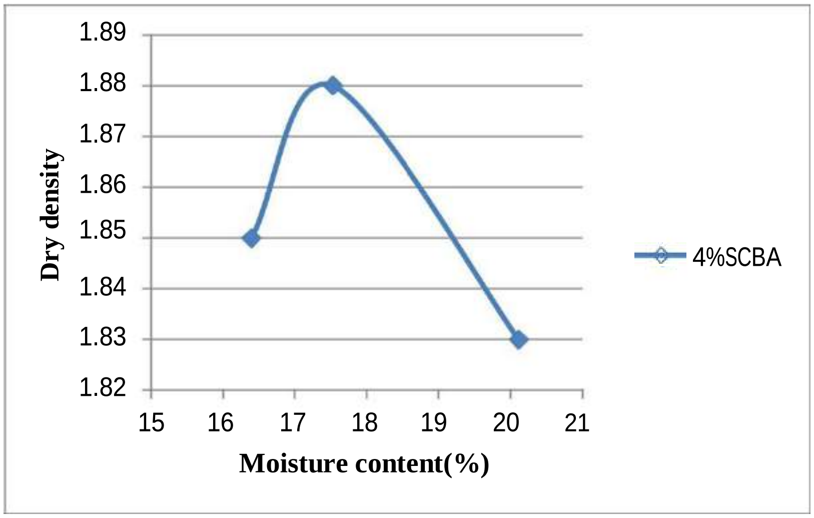


Fig 4.3 Dry density vs moisture content of 4% of bagasse ash and soil

The graph is plotted between moisture content on X-axis and dry density on y-axis as shown in figure 4.3. the soil is mixed with 4% of SCBA the maximum optimum moisture content is 17.58 at dry density of 1.88 g/cm3

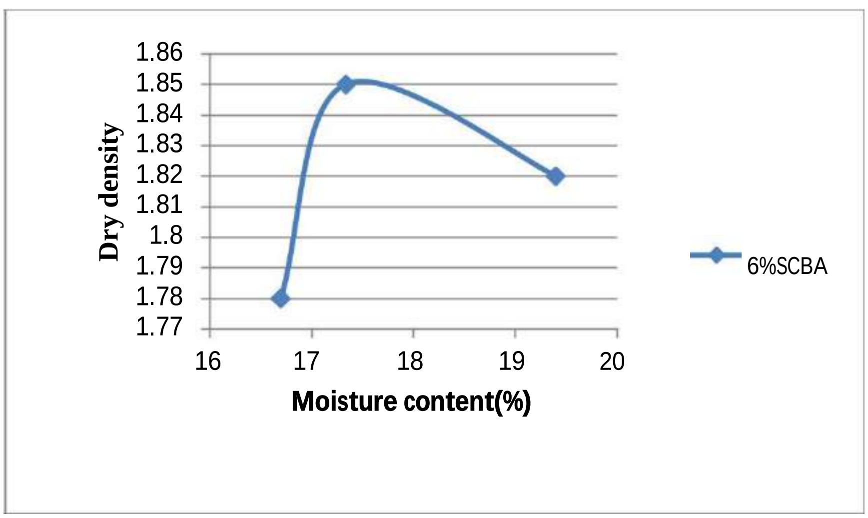


Fig 4.4 Dry density vs moisture content of 6% of bagasse ash and soil

The graph is plotted between moisture content on X-axis and dry density on y-axis as shown in figure 4.4. the soil is mixed with 6% of SCBA the maximum optimum moisture content is 17.34 at dry density of 1.85 g/cm3

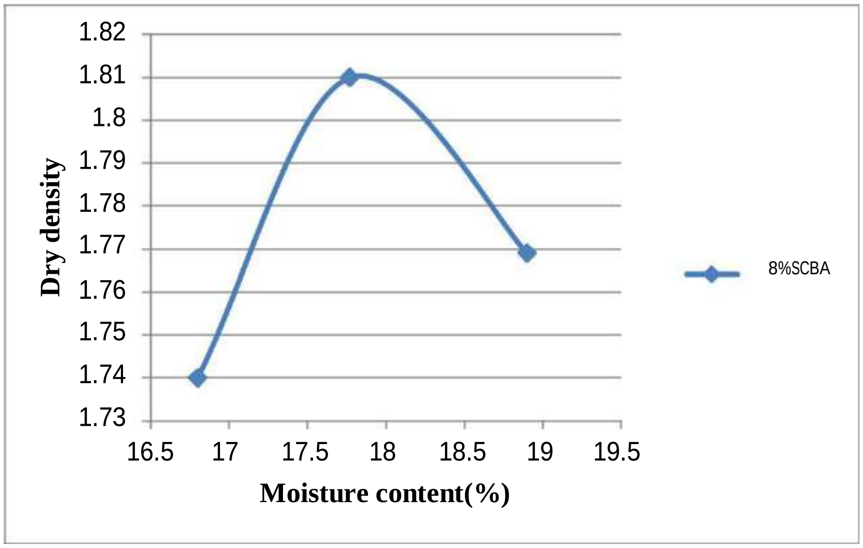


Fig 4.5 Dry density vs moisture content of 8% of bagasse ash and soil

The graph is plotted between moisture content on X-axis and dry density on y-axis as shown in figure 4.5. the soil is mixed with 8% of SCBA the maximum optimum moisture content is 1.77 at dry density of 1.81 g/cm3

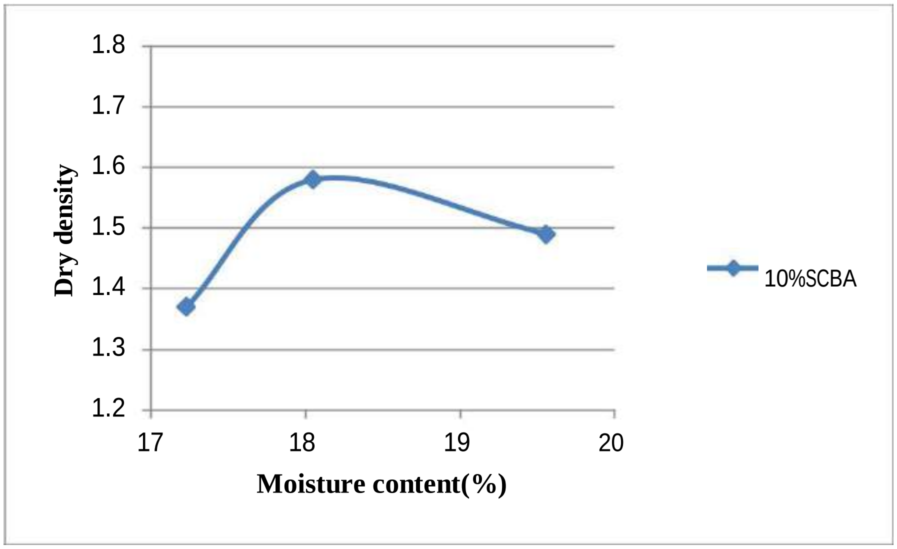


Fig 4.6Dry density vs moisture content for 10% of bagasse ash and soil

The graph is plotted between moisture content on X-axis and dry density on y-axis as shown in figure 4.6. the soil is mixed with10% of SCBA the maximum optimum moisture content is 18.5at dry density of 1.58 g/cm3

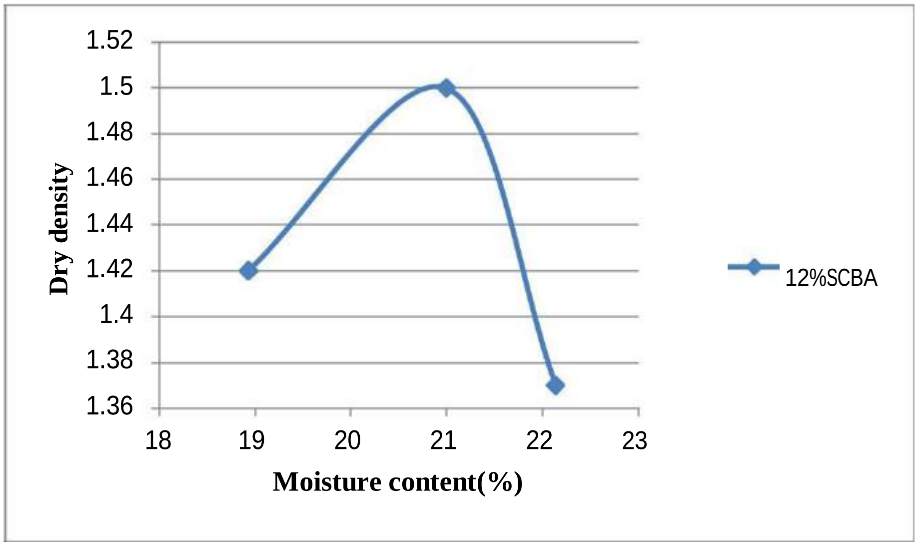


Fig 4.7 Dry density vs moisture content of 12% of bagasse ash and soil

The graph is plotted between moisture content on X-axis and dry density on y-axis as shown in figure 4.7. the soil is mixed with12% of SCBA the maximum optimum moisture content is 21 at dry density of 1.37 g/cm3

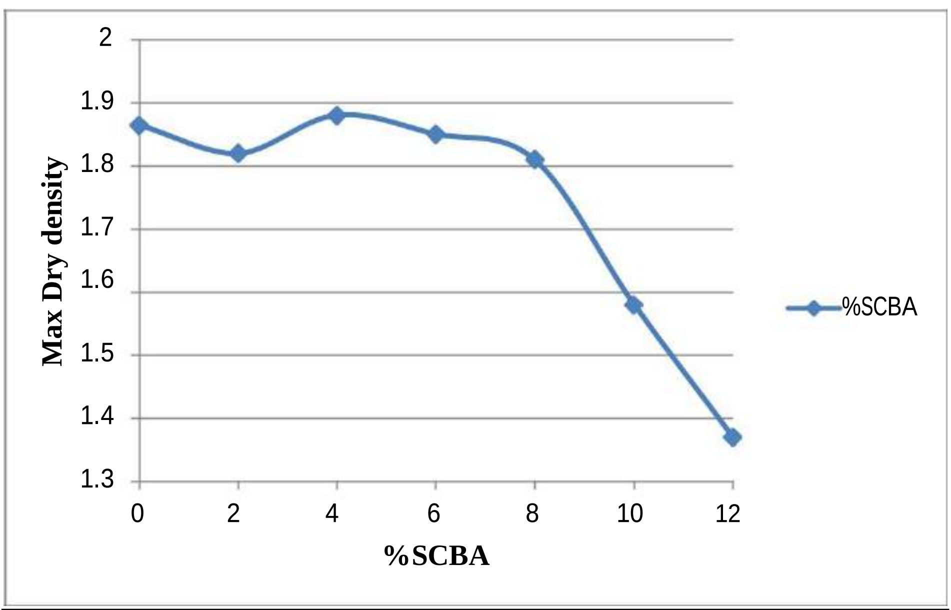


Fig 4.8 Bagasse ash vs Maximum Dry density of the soil

The graph is plotted between % of sugar cane bagasse ash on X-axis and maximum dry density on y-axis as shown in figure 4.8. the maximum dry density of the soil is obtained at 4% of the SCBA.

4.2.2 WOODEN ASH

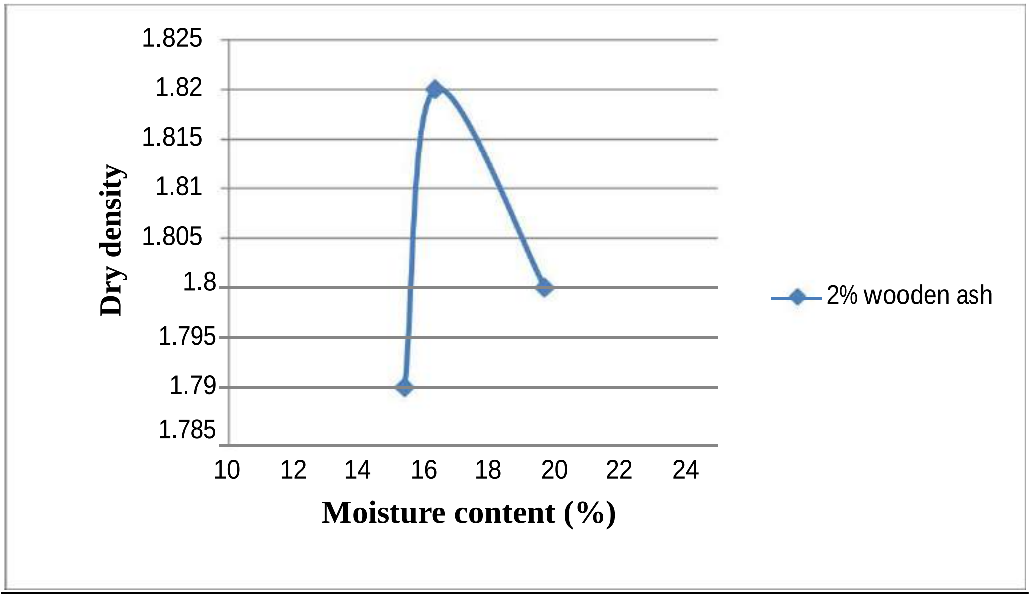


Fig 4.9 Dry density vs moisture content of 2% of Wooden ash and soil

The graph is plotted between moisture content on X-axis and dry density on y-axis as shown in figure 4.9. the soil is mixed with 2% of Wooden Ash the maximum optimum moisture content is 14.3 at dry density of 1.76 g/cm3

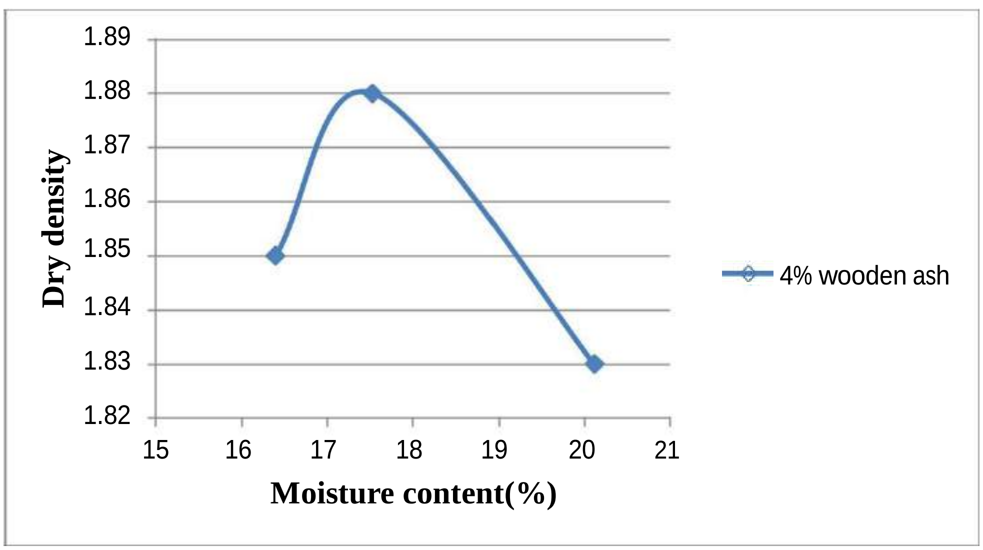


Fig 4.10 Dry density vs moisture content of 4% of Wooden ash and soil

The graph is plotted between moisture content on X-axis and dry density on y-axis as shown in figure 4.10. the soil is mixed with 4% of Wooden Ash the maximum optimum moisture content is 17.3 at dry density of 1.74 g/cm3

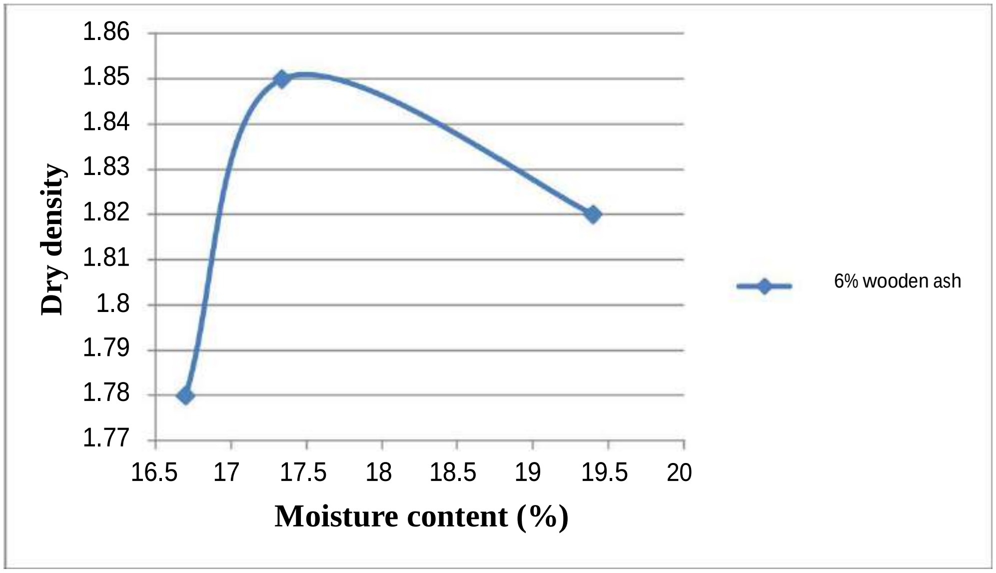


Fig 4.11 Dry density vs moisture content of 6% of Wooden ash and soil

The graph is plotted between moisture content on X-axis and dry density on y-axis as shown in figure 4.11. the soil is mixed with 6% of Wooden Ash the maximum optimum moisture content is 19.2 at dry density of 1.66 g/cm3

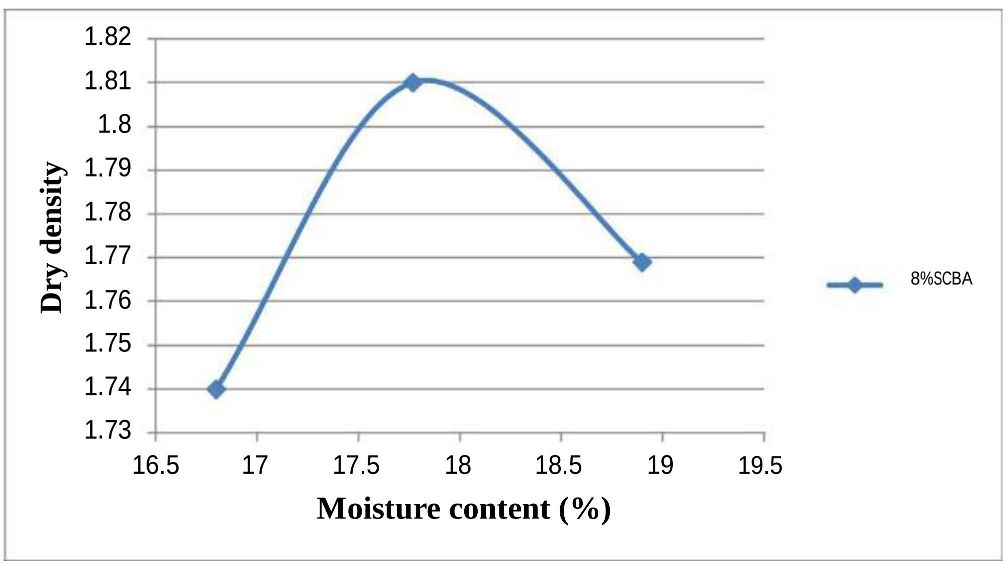


Fig 4.12 Dry density vs moisture content of 8% of Wooden ash and soil

The graph is plotted between moisture content on X-axis and dry density on y-axis as shown in figure 4.12. the soil is mixed with 8% of Wooden Ash the maximum optimum moisture content is 19 at dry density of 1.64 g/cm3.

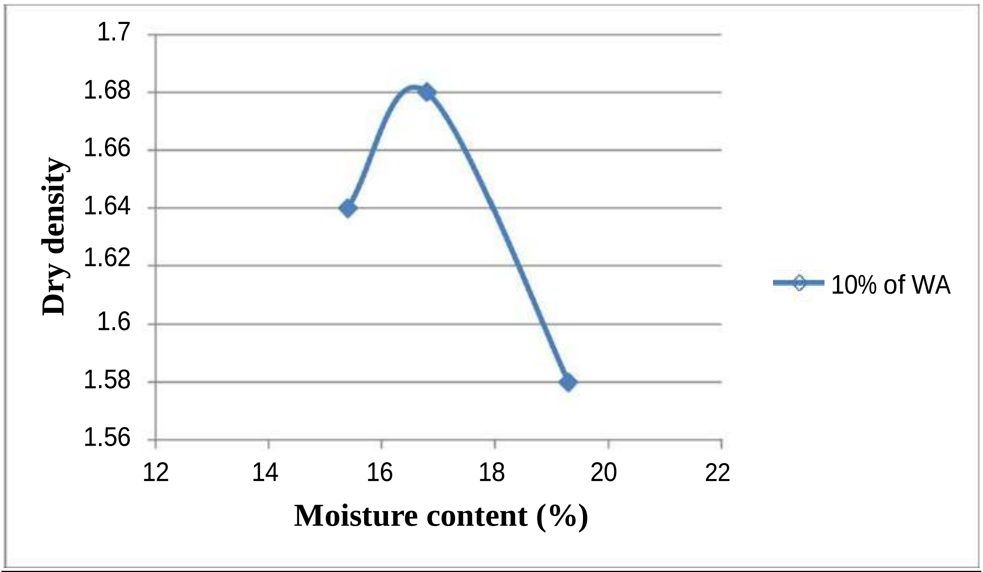


Fig 4.13 Dry density vs moisture content of 10% of Wooden ash and soil

The graph is plotted between moisture content on X-axis and dry density on y-axis as shown in figure 4.13. the soil is mixed with 10% of Wooden Ash the maximum optimum moisture content is 16.8 at dry density of 1.67g/cm3

4.3 CALIFORNIA BEARING RATIO (CBR):

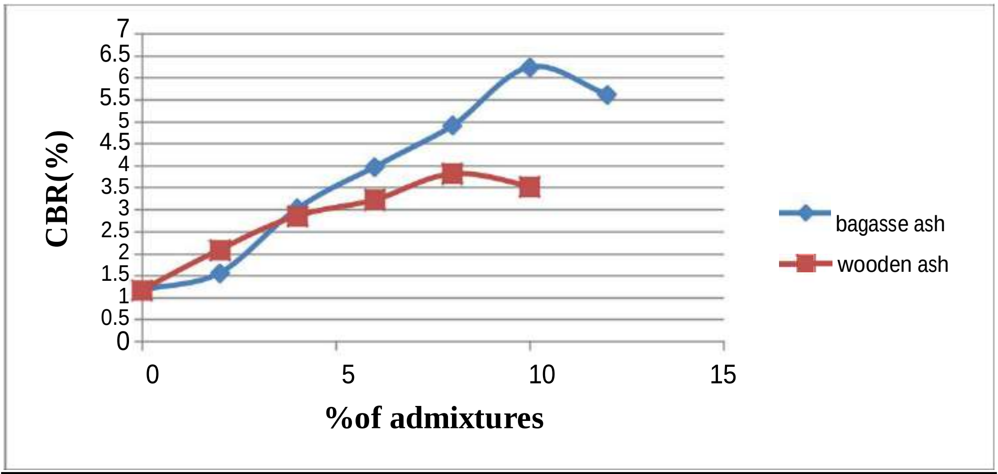


Fig 4.14 CBR for the soaked soil with % of admixtures

The graph is plotted between %of admixtures on X-axis and % of CBR on y-axis as shown in figure 4.14. the soil under the soaked condition with different proportions of Wooden Ash and bagasse ash the maximum CBR is obtained for bagasse ash at10% and for wooden ash the maximum CBR when the soil is mixed with 8%of wooden ash.

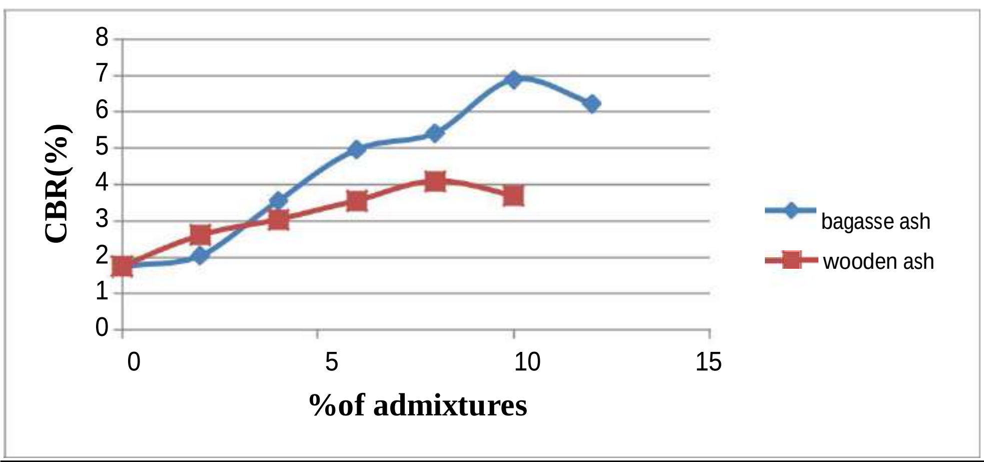


Fig 4.15 CBR for the un-soaked soil with % of admixtures

The graph is plotted between %of admixtures on X-axis and % of CBR on y-axis as shown in figure 4.15. the soil under the Un-soaked condition with different proportions of Wooden Ash and bagasse ash the maximum CBR is obtained for bagasse ash at10% and for wooden ash the maximum CBR when the soil is mixed with 8%of wooden ash.

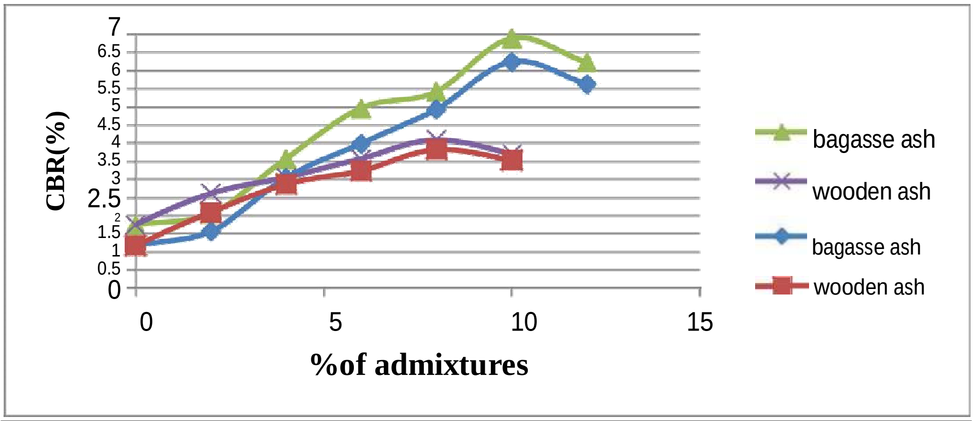


Fig4.16 CBR for the soaked and un-soaked soil with % of admixtures

The graph is plotted between %of admixtures on X-axis and % of CBR on y-axis as shown in figure 4.16. the soil under the soaked and Un-soaked condition of the soil with different proportions of Wooden Ash and bagasse ash the maximum CBR is obtained for bagasse ash at10% of bagasse ash is added and for wooden ash the maximum CBR when the soil is mixed with 8%of wooden ash

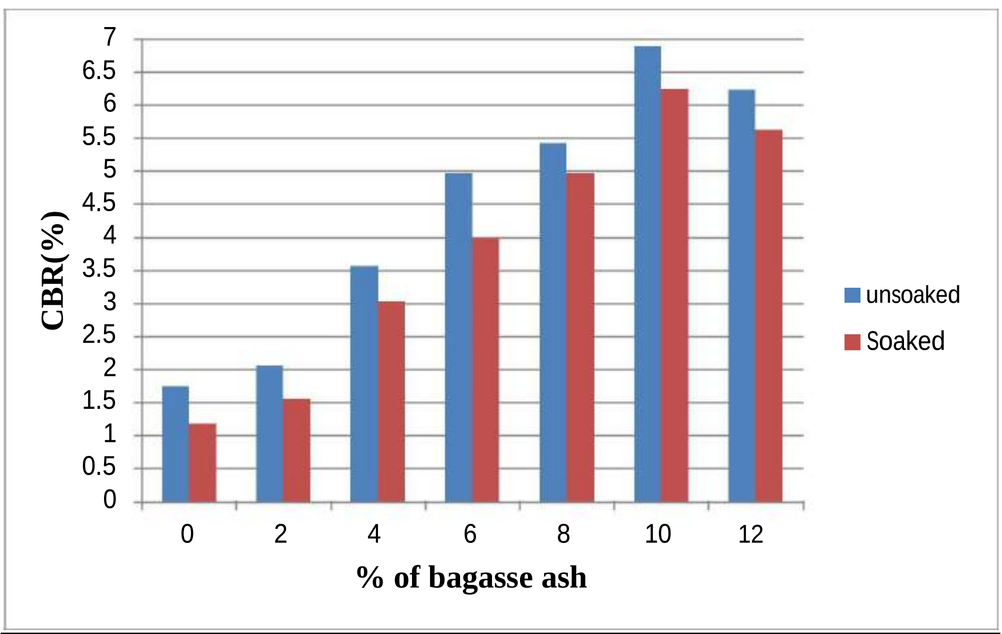


Fig 4.17 CBR for the soaked and un-soaked soil with % of bagasse ash as admixture

The Bar graph is plotted between %of bagasse ash on X-axis and % of CBR on y-axis as shown in figure 4.17. the soil under the Un-soaked condition with different proportions of bagasse ash the maximum CBR is obtained for bagasse ash at10% The blue color represents the un-soaked and the red color represents the soaked.

4.18 CBR for the soaked and un-soaked soil

The Bar graph is plotted between %of wooden ash on X-axis and % of CBR on y-axis as shown in figure 4.17. the soil under the Un-soaked condition with different proportions of wooden ash the maximum CBR is obtained for wooden ash at 8%of wooden ash. The blue color represents the un-soaked and the red color represents the soaked.

4.4 COMPARISION BETWEEN BAGASSE AND WOODEN ASH

WOODEN ASH	BAGASSE ASH
The specific gravity of the bagasse ash is determined as 2.34 gm/cc.	The specific gravity of the bagasse ash is determined as 2.41 gm/cc.
The maximum moisture content of the soil when it is mixed with the wooden ash is 19.2% at the 6%.	The maximum moisture content of the soil when it is mixed with the bagasse ash is 17.77% at the 8%.
The maximum dry density of the soil when it is mixed with the wooden ash is 1.76 at the 2%.	The maximum dry density of the soil when it is mixed with the bagasse is 1.88 at the 4%.
The maximum California bearing ratio of the soil when it is mixed with the wooden ash is 4.09 at the 8% for the un soaked soil.	The maximum California bearing ratio of the soil when it is mixed with the bagasse is 6.89 at the 10% for the unsoaked soil.
The maximum California bearing ratio of the soil when it is mixed with the wooden ash is 3.82 at the 8% for the soaked soil.	The maximum California bearing ratio of the soil when it is mixed with the bagasse is 6.24 at the 10% for the soaked soil.
Based on the California bearing ratio value the thickness of the pavement is 560mm as per IRC37-2012	Based on the California bearing ratio value the thickness of the pavement is 470mm as per IRC37-2012
The thickness of the granular sub base is 265mm as per IRC37-2012	The thickness of the granular sub base is 175mm as per IRC37-2012
The thickness of the granular sub base is 225mm as per IRC37-2012	The thickness of the granular sub base is 225mm as per IRC37-2012

CHAPTER-5

CONCLUSION

For the construction of the roads the poorly graded sand may not attain the required strength for the sub grade of the pavement. the admixtures like bagasse ash and wooden ash has been used to develop improve the strength of the sub grade in this study. By using the bagasse ash the CBR valve has been improved from 1.17 to 1.85 and for wooden ash the CBR valve has been improved to the 4.89%.so that the thickness of the pavement has been reduced 810mm to 470mm and it is benefit to the contractor.

In this process damage to the environment is negligible and the benefits to the environment are more. The problem facing by the most of the sugar industries is deposition of the bagasse powder produced as waste in the industry. This problem can be completely avoided by this use of bagasse ash in the sub grade.

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