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INFLUENCE OF SUGARCANE BAGASSE AND LDPE WASTE PLASTIC BY PARTIAL REPLACEMENT TO THE BLACK COTTON SOIL AT SUBGRADE

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Abstract

Soil stabilization is the process which involves enhancing the physical and Geotechnical properties of the soil in order to improve its strength, durability etc. by blending or mixing with different materials or additives. In the present situation as the industrialization and urbanization is taking place has generated many wastes. This leads to depleting landfill space, soil contamination and many other hazardous effects, hence in this study utilization of waste (i.e., bagasse and LDPE) for improving the soil pro perties is made. In this study behavior of black cotton soil is studied by using bagasse and Plastic as stabilizing agent. Under this study laboratory experiments are carried out for different percentages (7%, 9% and 11%) of bagasse and (1%, 2% and 3%) of Plastic. After that Both materials are mixed together with proportion of (7% BA+1% Plastic, 9% BA+2% Plastic, 11% BA+ 3% Plastic) with Black Cotton Soil. By performing the series of tests on Black Cotton Soil with using this stabilizing agent. Results of the CBR tests demonstrated that the inclusion of plastic and bagasse in Black Cotton Soil improves the strength of the soil especially with 7% Bagasse + 1% Plastic. Furthermore, the plasticity index decreased from 33.24 to 22.01%. The maximum dry density of the specimen increased from 1.32 to 1.92 g/cc. But with further addition of material the maximum dry density slightly decreased with increased in optimum moisture content. By using Bagasse and Plastic the Unconfined compressive strength of soil also improved. The outcomes of these tests demonstrate that stabilization of expansive soils using bagasse and plastic can improve the strength.

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Keywords: Sugarcane Bagasse, LDPE, California Bearing Ratio, Unconfined Compressive strength.

1. INTRODUCTION

The importance of transportation engineering in the development of a country is multidimensional. Transportation is vital for the economic development of any country, any region, since every product produced such as food, clothing industrial products or medicine needs transport at all stages starting from production to distribution. Everywhere land is being occupied for various structures from ordinary house to skys c r a p e r s , bridges to airports and from rural roads to expressways. Almost all the civil engineering structures are located on various soil types. The unconsolidated material obtained from the disintegration of rocks by various weathering agencies like water, air etc. is called Soil. Weathering and decomposition from chemical changes that arises when water, oxygen and carbon dioxide moderately combine with minerals within the rock formation, thus it is breaking down to sand, silt and clay. Transportation of soil materials by wind, water and ice configure different soil formations. Temperature, rainfall, and drainage play important roles in the formation of soils as in the different climatic areas.
India h a s been split into five major soil categories: -1. Alluvial Deposit, 2. Black cotton Soil, 3. Laterite Soil, 4. Desert Soil, 5. Marine Deposits

Encountering land having soft soil for construction of structure leads to an attention towards adopting ground improvement techniques such as soil stabilization. Stabilization is accomplished by increasing the shear strength and the overall bearing capacity of a soil. Stabilized soils provide a strong working platform, the foundation for all other parts of projects. After stabilization techniques, weak soils can be transformed by the formation of permanent pozzolanic reactions. Meaning that soils are not liable to leaching and have drastically reduced permeability resulting in reduced shrink/swell potential. In addition, soils that have been stabilized have also undergone some modification. In other words, the soil has physically changed making compaction easier and reducing plasticity. Easier compaction makes achieving maximum dry density easier.

Plasticity index is an important geotechnical measure that involves the critical water contents of soils. Any time plasticity in soils is reduced, the soils are more friable and workable.

Figure.1 Soil Stabilization

1.1 Material Used

Here we are using bagasse and plastic (Low Density Polyethylene) for stabilization of soil. This material is usually dumped outside which are harmful to environment. So we are utilizing it for improving the properties of black cotton soil.

1. Black Cotton Soil

Black cotton soil is available in many regions in India. Many problems arise while constructing a structure on expansive soil. This soil soaks so much water therefore it has high swelling and shrinkage quality which makes it difficult to build a structure on it. The swelling and shrinkage property of expansive soil may damage a structure. Therefore, there is prerequisite to enhance the properties of this soil by ground improvement technique. So Soil stabilization is one of the technique by which the properties of soil can be improved.

Figure.2 Black Cotton Soil

Black Cotton soils are highly clayey soils, Grayish to blackish in color found in several states in India. The black cotton soils have been formed from basalt or trap and contain the clay mineral montmorillonite, which is responsible for the excessive swelling and shrinkage characteristics of soil. Expansive soils cause several problems for civil engineering infrastructure. Various methods are applied to improve the characteristics of expansive soils. Soil stabilization is one of the construction techniques because it improves the engineering properties of soil such as the strength and volume stability. When the soil strength properties cannot be improved by mechanical stabilization, the chemical admixture technique is used to achieve the desired strength. Chemical stabilization is the most popular method utilized to enhance the physical and mechanical properties of problematic soils consisting of soft soil and expansive soil.

2. Bagasse

Bagasse is fibrous waste which is obtained by extraction of sugarcane juice. Nearly 80 million metric tons (MMT) of bagasse produces in India. The dumping of bagasse is major problem. This bagasse is either used for some recycling work or dumped into the water body which causes pollution. The Indian sugar industry's growth and residual lignocellulose sugarcane bagasse (RSB) generation rate are complementary to each other. It is estimated that over 75–90 million tons of wet RSB are produced annually from 600 operational sugar mills in India. Therefore, the efficient utilization of residual bagasse needs immediate attention from sugar industries and the scientific community worldwide. It can ruin the environment so there is need to utilize it properly.

Figure.3 Bagasse

3. Low Density Polyethylene (LDPE)

The production of plastic in India is increasing day by day. Recycling of a plastics is an alternative for plastic waste management. LDPE can be used mostly in packaging industry. Milk pouches are generally made up of LDPE. Most of the garbage that generates in household is due dairy product packages like milk pouches, yogurt pouches, buttermilk pouches. Also there are around 40 to 50 milk pouches generated in every tea stall. This plastic can be recycled but if it does not reach the recycling unit then it can create problems. Also use of plastic products has been significantly increased, which may lead to many environmental issues. So here plastic is also used for stabilization process. The use of plastic material can be considered as an eco- friendly method for soil stabilization.

Figure.4 Crushed Low Density Polyethylene

2. LITERATURE REVIEW

Rajshekhar G Rathod et.al (2017) experiment on improving subgrade property of two natural residual soil and mixed with different proportions of liquid chemicals. There are many soil stabilization techniques which can be used to improve properties of soil. In this study, the

following tests are carried out to find out properties of soil blended with chemical. All these tests are conducted to evaluate the effectiveness and performances of chemical as soil stabilizing agent. Firstly, the geotechnical properties of untreated soils are determined. Black cotton soil and red soil are used in the work and Terrassa is used for stabilization. By comparing the conventional and chemically stabilized soil it is observed that the MDD value got increased from 1.17gm/cm^3 to 1.91gm/cm^3 for red soil by adding chemical and OMC value decreased. The CBR value increased from 8.37% to 16.1% for 2.5mm penetration and from 9.47% to 21.6% for 5mm penetration of red soil. The CBR value increased from 8.69% to 10.84% for 2.5mm penetration and from 7.78% to 20.17% for 5mm penetration of Black Cotton soil. From all the observation it is concluded that Chemical stabilization had more CBR value than conventional method of soil stabilization.

Rajshekhar G Rathod et.al (2018) Performed the tests on black cotton soil with addition of crushed sand. The crushed sand is used with varying percentage. The results of blended soil with different percentage are calculated. The crushed sand is used with percentage of 5%, 10% and 15% in soil. Sieve Analysis, Atterberg's limits, Specific gravity, Compaction test and Unconfined compression test at different proportions of crushed sand has been carried out. And according to the result obtained it is concluded that Soil permeability and resistance has been improved by blending the Crushed sand with black cotton soil with different proportions. And also, the blended sample can be used as subgrade for pavement.

Kiran R. G et.al (2013) studied behavior of black cotton soil by using bagasse ash and additives as stabilizing agent. With additives mix proportion, bagasse ash is blended with percentage of 4%, 8% and 12%. The bagasse ash waste is effectively used for pavement construction. The additives proportion used with bagasse ash were 4%, 8%, 12% cement and 2%, 4%, 6% lime. With addition of bagasse ash in black cotton soil, the density has no notable changes, but when 8% bagasse ash has been used CBR and UCS value have been increased. Then the blended bagasse ash with different percentage of lime for black cotton soil gave considerable change in CBR and UCS values. But when higher amount of lime is added the density values got decreased. From 2.12% to 4.57% improvement has been seen for addition of 4% bagasse ash with 4% lime.

Leonardo Behak et.al (2015) used agricultural waste Rice Husk Ash (RHA) to stabilize the Soil. RHA has lack of cementitious properties therefore soil is treated with RHA and cement. And it was observed that UCS value got increased with RHA and Cement blend. But when above 6% RHA used with soil the UCS value started decreasing. The tests included the standard compaction test, unconfined compressive strength (UCS) test, California Bearing Ratio (CBR) test, and resilient modulus (Mr) tests. In all these tests, the fiber content was added in two lengths, which were 1.0 cm and 2.0 cm. Laboratory test results revealed that the plastic pieces decrease maximum dry density (MDD) and optimum moisture content (OMC) of the stabilized soils, which are required for the construction of embankments of lightweight materials.

S. Peddaiah et.al (2018) With rapid advancements in technology globally, the use of plastics such as polyethylene bags, bottles etc. is also increasing. The disposal of thrown away wastes pose a serious challenge since most of the plastic wastes are non-biodegradable and unfit for incineration as they emit harmful gases. Soil stabilization improves the engineering properties of weak soils by controlled compaction or adding stabilizers like cement, lime etc. but these additives also have become expensive in recent years. This paper presents a detailed study on the behavior and use of waste plastic in soil improvement. Experimental investigation on

reinforced plastic soil results showed that, plastic can be used as an effective stabilizer to encounter waste disposal problem as well as an economical solution for stabilizing weak soils. Plastic reinforced soil behaves like a fiber reinforced soil. This study involves the investigation of the effect of plastic bottle strips on silty sand for which a series of compaction, direct shear and California bearing ratio (CBR) tests have been performed with varying percentages of plastic strips and also with different aspect ratios in terms of size. The results reflect that there is significant increment in maximum dry unit weight, Shear Strength Parameters and CBR value with plastic reinforcement in soil. The quantum of improvement in the soil properties depends on type of soil, plastic content and size of strip. It is observed from the study that, improvement in engineering properties of silty sand is achieved at 0.4% plastic content with strip size of (15 mm 9
15 mm). Keywords Plastic bottle strips Waste disposal methods Soil Stabilization Compaction Test Direct shear test CBR test.

3. METHODOLOGY

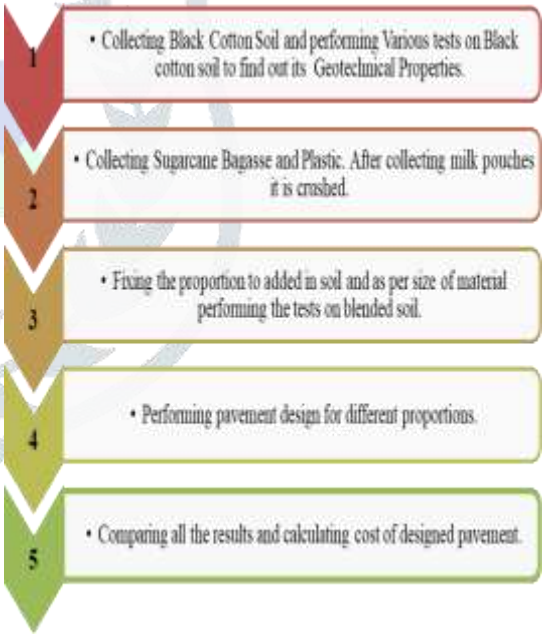


Figure.5 flowchart

3.1 Tests performed on soil:

1. Sieve Analysis
2. Specific gravity test by a pycnometer
3. Atterberg's limit
   a. Liquid Limit
   b. Plastic Limit
4. Shrinkage limitModified Proctor Test
5. Unconfined compression test
6. California Bearing Ratio Test

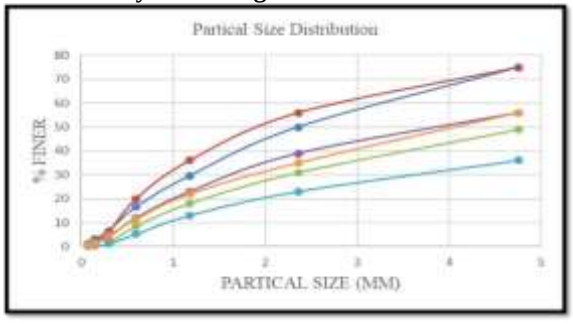
4. RESULTS AND DISCUSSION

4.1 Properties of black cotton soil

Table No.-1 Properties of Black cotton soil

Properties	Black Cotton Soil
Color	Grayish Black
Specific Gravity	2.43
Free Swell Index (%)	63.33
GRAIN SIZE DISTRIBUTION	
Gravel (%)	0.69
Sand (%)	6.39
Silt / Clay (%)	92.92
IS Classification	CH
ATTERBERG'S LIMIT	
Liquid Limit (%)	67.70
Plastic Limit (%)	33.24
Plasticity Index (%)	31.69
Shrinkage Limit (%)	24.51
COMPACTION CHARACTRISTIC	
Maximum Density (g/cc)	1.32
Optimum Moisture Content (%)	25.84
Unconfined Compressive Strength (Kg/cm^2)	0.550
CALIFORNIA BEARING RATIO (SOAKED)	
2.5mm penetration (%)	2.63
5mm penetration (%)	2.4

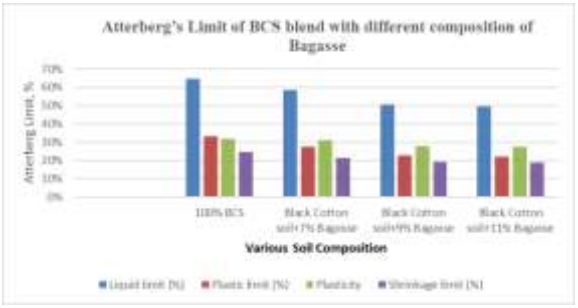
4.2 Sieve analysis of Virgin Black cotton soil



Graph.1 Particle Size Distribution Curve

4.3 Tests on Bagasse Blended Black CottonSoil

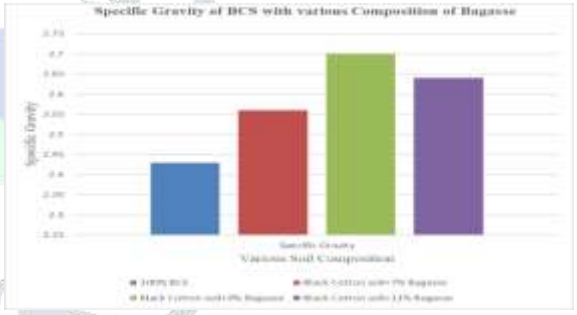
1. Atterberg's Limit Test result for different Composition of Bagasse



Graph 2. Atterberg's Limit of BCS blend with different Composition of Bagasse

As shown in graph, the liquid limit of the soil alone was found to be 64.70%, Plastic limit is 33.24%, Plasticity Index is 31.69% and Shrinkage limit is 24.51%. It can clearly see that that the Liquid Limit, Plastic limit, Plasticity Index and Shrinkage limit of black cotton soil goes on decreasing with increasing the percentage of Bagasse.

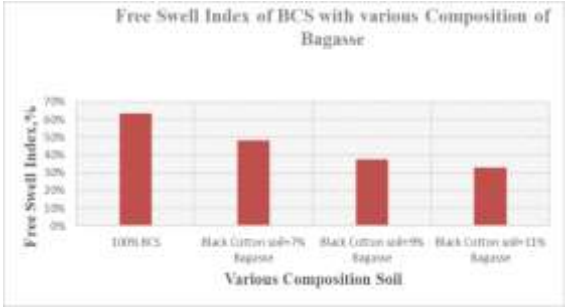
2. Specific Gravity test for Bagasse BlendedSoil



Graph 3. Specific Gravity of BCS with various Composition of Bagasse

The specific gravity of Black cotton soil is found out to be 2.43 but with increasing percentage of bagasse it goes on increasing. The maximum specific gravity is obtained when 9% Bagasse is added to the Black Cotton Soil.

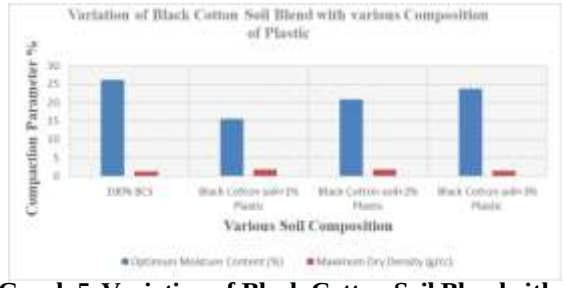
3. Free Swell Index



Graph 4. Free Swell Index of BCS with Various Composition of Bagasse

The free swell index of Black Cotton Soil is 63.33%. but when 7%, 9% and 11% Bagasse is added in Black Cotton Soil the free swell Index goes on decreasing with increasing the percentage of material.

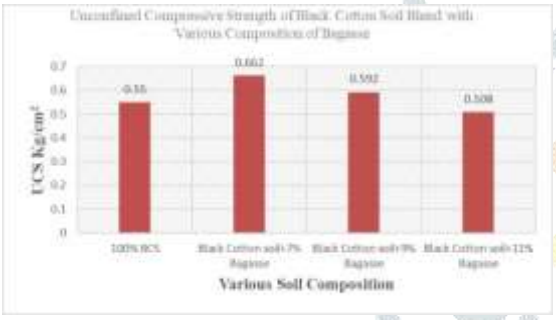
4. Modified Proctor Test



Graph 5. Variation of Black Cotton Soil Blendwith Various Composition of Bagasse

The optimum moisture content (OMC) and maximum dry density (MDD) of soil alone was found to be 25.84% and 1.32 g/cc respectively. The MDD of the soil with addition of 7%, 9% and 11% of Bagasse by weight of soil is found to be.
1.74 g/cc, 1.64 g/cc and 1.19 g/cc respectively and the corresponding OMC is found to be 20.33%, 22.71% and 31.31% respectively. The best result obtained when 7% Bagasse is blended with Black Cotton Soil.

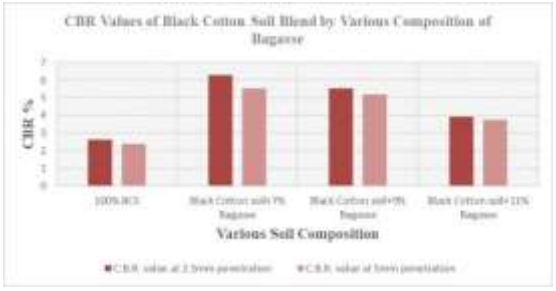
5. Unconfined Compressive Strength Test (UCS)



Graph 6. Unconfined Compressive Strength ofBlack Cotton Soil Blend with Various Composition of Bagasse

It has been observed that the unconfined compressive strength of Black Cotton soil is 0.550 kg/cm^2, when bagasse is added with different proportions the unconfined compressive strength of black cotton soil increases. The better results are obtained at 7% Bagasse added with BCS.

6. California Bearing Ratio Test (CBR)

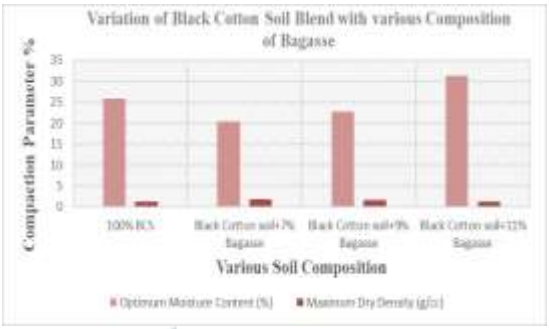


Graph 7. CBR Values of Black Cotton SoilBlend by Various Composition of Bagasse

As shown in above figure, the test has been conducted on the BC soil with different percentages of bagasse by weight of raw BC soil. The best CBR value is added when 7% Bagasse is added in black cotton soil. But with increasing the percentage of bagasse the CBR value goes on decreasing. But with the addition of Bagasse in Black Cotton Soil the CBR value increases.

4.4 Material Analysis for LDPE Plastic BendedBlack Cotton Soil

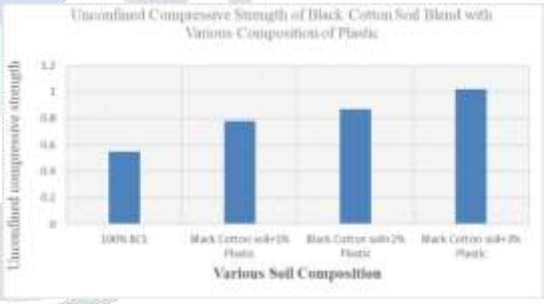
1. Modified Proctor Test



Graph 8. Variation of Black Cotton Soil Blend with Various Composition of Plastic

As shown in above graph, it has been observed that the black cotton soil is having 1.32 gm/cc maximum dry density and 25.84% optimum moisture content. With addition of Plastic maximum dry density is increases and optimum moisture contents are decreased. The best results are obtained when 1% of Plastic is added with Black cotton soil. The maximum dry density is slightly deceased with addition of bagasse.

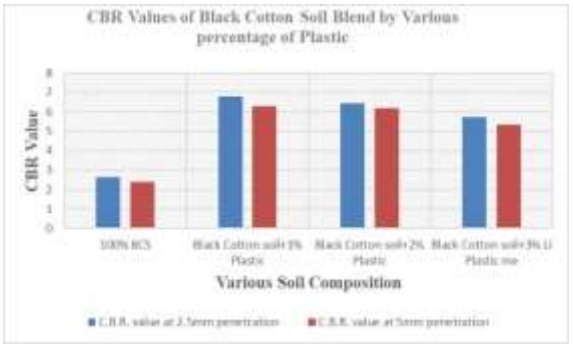
2. Unconfined Compressive Strength Test (UCS)



Graph 9. Unconfined Compressive Strength ofBlack Cotton Soil Blend with Various Composition of Plastic

It has been observed that with increasing the percentage of Plastic in black cotton soil, the unconfined compressive strength increases. The value of unconfined compressive strength for black cotton soil is determined 0.550kg/cm^2 and in addition of plastic it increase by 0.780 kg/cm^2 to 1.02 kg/cm^2 for 1% to 3% plastic in soil.

3. California Bearing Ratio (CBR)

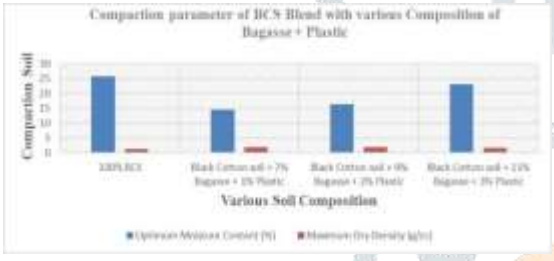


Graph 10.CBR Values of Black Cotton SoilBlend by Various Composition of Plastic

The CBR value of soil alone was found to be 2.63% for 2.5 mm penetration. The CBR value of soil gave better results when 1% Plastic is added to soil but it slightly decreased with further addition of Plastic.

4.5 Results of Bagasse and Plastic Both Blended with Black Cotton Soil

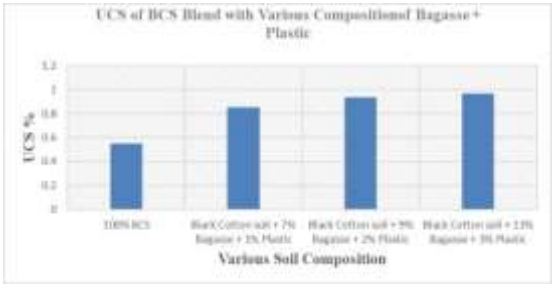
1. Modified Proctor Test



Graph 11. Compaction parameter of BCS Blend with Various Composition of Bagasse + Plastic

As shown in above graph, it has been observed that the black cotton soil is having 1.32 gm/cc maximum dry density and 25.84% optimum moisture content. When Bagasse and Plastic both are added to the Black Cotton Soil the good results are obtained as compared to the individual blend of Bagasse and Plastic. BCS + 7% BA + 1% Plastic gave Maximum Dry Density of 1.92g/cc which is by far the best result of among all the proportions.

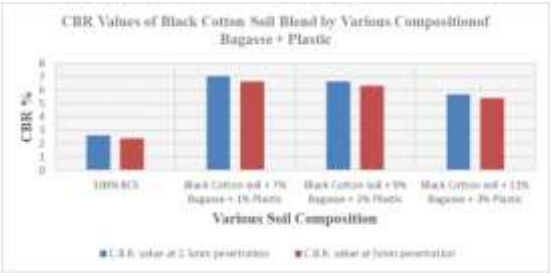
2. Unconfined Compressive Strength (UCS)



Graph 12. UCS of BCS Blend with VariousComposition of Bagasse + Plastic

It has been observed that the Unconfined compressive strength of Black Cotton Soil is 0.550 kg/cm^2 but when both Plastic and Bagasse isadded to Black Cotton Soil with varying percentage the good results are obtained. The Maximum unconfined compressive strength which was obtained is 0.965 kg/cm^2 for BCS + 11% BA + 3% Plastic.

3. California Bearing Ratio (CBR)



Graph 13. CBR Values of Black Cotton SoilBlend by Various Percentage of Bagasse + Plastic

As shown in figure the CBR value of Black Cotton Soil is drastically increased with Bagasse and Plastic is blended with soil. The CBR value is increased by 4.4% for BCS +7% BA + 1% Plastic. The result obtained by both mix blend has more CBR value than the Raw Soil.

5. CONCLUSION

1) The bagasse is added in Black Cotton Soil with varying percentage of 7%, 9% and 11%. And various tests are performed on the Bagasse blended soil. As per the obtained results the Liquid Limit of raw soil was 64.70%, Plastic limit was 33.24% and Shrinkage limit was 24.51%. with increasing percentage of Bagasse from the Liquid Limit, Plastic Limit and Shrinkage Limit goes on decreasing. Also the free swell Index of Black Cotton Soil is decreased by 30.33%.

2) When 7% Bagasse is replaced in Black cotton soil the maximum dry density increased which was 1.74 g/cc and with further addition of Bagasse the maximum dry density slightly decreases. The UCS value also get increased with 7% Bagasse. The CBR Value increased upto 6.30% with addition of Bagasse. So, the optimum Bagasse content considered 7% Bagasse.

3) Further Plastic is replaced in Black Cotton Soil with percentage of 1%, 2% and 3%. The maximum dry density obtained by 1% plastic is 1.86 g/cc which is more than Bagasse blended soil. The unconfined compressive strength of soil increased up to 1.02 kg/cm^2 with addition of Plastic. CBR values showed major changes in comparison with virgin soil. The CBR value increased by 4.17%, 3.8% and 3.11% with addition of 1% Plastic, 2% Plastic and 3% Plastic respectively.

4) The addition of Bagasse and Plastic together in Black Cotton Soil showed positive impact in the properties of Black Cotton Soil. Modified Proctor Test, Unconfined Compression Test and California Bearing Ratio test has been performed on the mix proportions.

5) As per the results obtained the maximum dry density with 7% BA + 1% Plastic is 1.92g/cc and optimum moisture content is 14.58%. It showed that the mix proportion shows good impact on Black cotton soil. The unconfined compression strength also increased. And the maximum CBR value obtained with mix proportion is 7.03%.

6) These materials i.e Bagasse and Plastic helped to enhance the properties of Black Cotton Soil.

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