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Investigation on Percentage Addition of Sand, Red murrum and Steel slag for Strengthening the Subgrade Soil

Miss. Sangita Z Palve[1], Dr. V. K. Sharma[2]

PG Student, Geotechnical Engineering , Department of Civil Engineering,

Matoshri College of Engineering and Research Centre , Nashik, Maharashtra[1]

Professor, Department of Civil Engineering,

Matoshri College of Engineering and Research Centre, Nashik, Maharashtra[2]

Abstract: In this study, laboratory investigations have been carried out on a number of soil samples procured from different roadwork sites. Preliminary properties of soil can be evaluated, such as specific gravity, liquid limit, plastic limit, shrinkage limit, free swell index, and heavy compaction test i.e MDD and optimum moisture content, CBR tests, UCS tests. CBR tests have been conducted for same samples under various conditions of soaked and unsoaked condition with due emphasis on moisture content parameters in the soil sample. In this study for the purpose of comparison three different types of soils stabilizers have been considered to study the variation percentage of red murrum, sand and steel slag. To study behaviour of percentage addition of sand, red murrum and steel slag in sub grade soil. The CBR value of the sub grade soil is being used widely since a long time in design of pavement structure and is critical in deciding the overall thickness of the pavement. Additionally, for good drainage, a typical specification for the pavement foundation design requires the value of permeability coefficient of the sub grade material to be specified. Thus, UCS and CBR constitute two important parameters in the design and assessment of long-term performance of the pavement. In this project only strength aspects of pavement sub grade have been considered.

Keywords: Index properties, free well, heavy compaction, CBR, UCS, Strength, sub grade soil.

1.INTRODUCTION

All civil engineering works such as the construction of highway, building structure, dam and other structure have a strong relationship with soil. All those structures need a strong layer of soil to make sure the structure are strong and stable. The weakness and failure of soil may capable make the structure which builds above of it become weak and collapse or fail. Therefore, the proper analysis of soil is necessary to ensure that these structures remain safe and free endue settling and collapse. Soil conditions vary from one location to another location. Hence it is difficult to predict the behaviour of soil. As a result, soil conditions at every site must be thoroughly investigated for proper design.

Most of the Indian highways system consists of flexible pavement. There are different methods of design of flexible pavement. The California Bearing Ratio (CBR) test and Unconfined Compression Test is an empirical method of design of flexible pavement. Sub grade soil bearing capacity plays very important role for the design of highway structure. It determines the thickness of the pavement. In other words, sub grade that has lower CBR value will have thicker pavement compared with the sub grade that has higher CBR value. CBR values can be measured directly in the laboratory test in accordance with IS 2720 part -XVI on soil sample obtained from the site. However, to conduct a CBR test, representative soil sample has to be collected from the location selected, from which a remoulded specimen has to be prepared at predetermined Optimum moisture content and maximum dry density with standard proctor compaction, for the test to be conducted. To obtain soaked and unsoaked CBR value of a soil sample, it takes about a week, making CBR test expensive, time consuming and laborious.

2. RESEARCH REVIEW

Andrew Hin Cheong Chan et.al [1990]

The paper outlines the theory of generalized plasticity in which yield and plastic potential surfaces need not be explicitly defined, and shows how a very effective general model describing the behaviour of sands and of clays under monotonic or transient loading can be developed.

Yucel Guney et.al [2006]

The high cost of landfilling and the potential uses of waste foundry sands have prompted research into their beneficial

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reuse. Roadways have a high potential for large volume usage of the foundry sands. A laboratory testing program was conducted on soil-foundry sand mixtures amended with cement and lime to assess their applicability as highway subbase materials. The mixtures were compacted in the laboratory at a variety of moisture contents and compactive efforts and subjected to unconfined compression, California bearing ratio, and hydraulic conductivity tests. The results of the study show that the strength of a mixture is highly dependent on the curing period, compactive energy, lime or cement presence, and water content at compaction.

M. Olatunji et.al [2009]
In this research the relations hip between depth of cut, increase in weight of disc plough as well as the draught has been investigated using dimensional analysis on a sandy loam soil. The experiment was conducted on a site with three different moisture contents level at five different speed (0.83, 1.39, 1.94, 2.5 and 2.78). It was observed that the depth of penetration increase with an increase in draught and increase in soil moisture content.

Prdeep Muley et.al [2010]
Murrum is widely used material for the construction of pavement shoulders. Sometimes the available murrum may not satisfy the requirement of CBR and hence need to be modified. The locally available granular material like sand and/ or the crusher dust may be mixed to the soil to obtain the desired characteristics. The paper discusses results of the experimental study in which the quality of local murrum has been improved by adding stone dust. The index properties, compaction characteristics and California Bearing Ratio (CBR) parameters for the murrum blended with varying percentages of the stone dust has been presented and it is shown that the utility of the soil as a road material has been increased greatly by simple mixing of the granular material**.**

N.P. Daphalapurkar et.al [2010]
Determination of the mechanical properties of individual sand grains by conventional material testing methods at the macroscale is somewhat difficult due to the sizes of the individual sand particles (a few μm to mm). In this paper, we used the nanoindentation technique with a Berkovich tip to measure the Young’s modulus, hardness, and fracture toughness. An inverse problem solving approach was adopted to determine the stress-strain relationship of sand at the granular level using the finite element method. A cube-corner indenter tip was used to generate radial cracks, the lengths of which were used to determine the fracture toughness.

K.V. Manjunath et.al [2012]
Soil Stabilization may be defined as alteration or modification of one or more soil properties to improve the engineering characteristics and performance of a soil. Black cotton soil is known for its high swell potential and low shear strength. Stabilization of such soil using cement or lime is well established. But very few have researchers have tried the blast furnace slag (an industrial waste) for this purpose. In this study, experimental investigations are done to know the effect of Ground Granulated Blast Furnace Slag (GGBS) on black cotton soil with small percentages of lime. It is found to be very useful for the purpose and also it is beneficial to the environment by putting an industrial waste to good use as well as reducing the carbon foot print by not using cement.

3. EXPERIMENTAL INVESTIGATIONS

3.1 Black cotton soil
Natural black cotton soil was obtained from Sangamner, Ahamednagar distict in Maharashtra state. The soil was excavated from a depth of 1m from the natural ground level. The soil is black in color. The obtained soil was air dried, pulverized manually and passing through 4.75 mm IS sieve was used .The soil has a property of high volume change and develops cracks in summer. This soil predominantly consists of montmorillonites the principal clay mineral.

3.2 Sand
Sand for the present investigation was collected from the Mhalungi River located in Chas Nashik distict. The reason for choice of these types of sand was mainly for their easy availability in many parts of the country for possible use in practice.

3.3 Red murrum
Red murrum for the present investigation was collected from the Malwadi located in Nashik distict. However the quality of Murrum varies with the locations of the quarry.Murrum is generally a residual soil decomposed from Laterite rock is red to reddish brown in color. It is widely used material in different civil engineering construction works in highways and railways.

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3.4 Steel slag

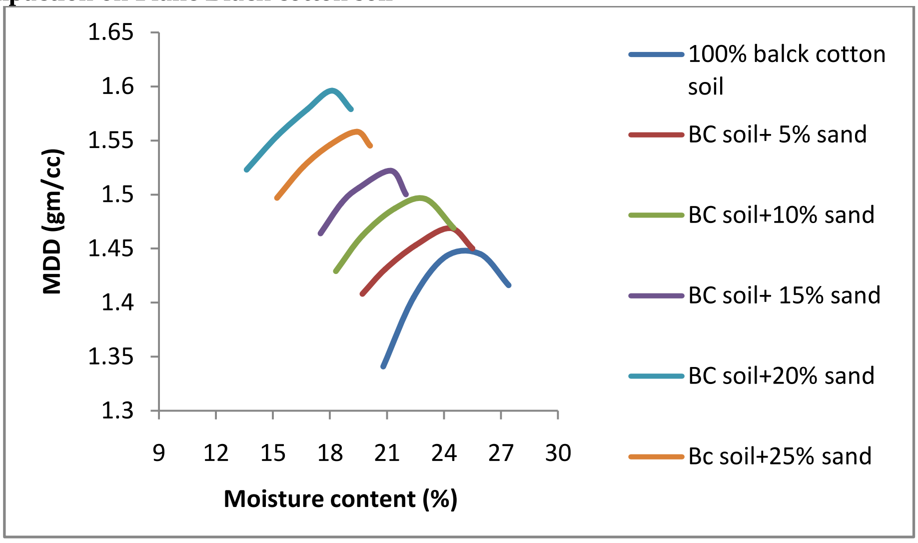
Steel slag for the present investigation was collected from the Bhagvati steel industry pvt. Ltd. Malegaon MIDC located in Nashik distict. The reason for choice of thease types of steel slag was waste material and easily available in many parts of country for possible use and it gives the better strength to the expensive soil.

3.5 Experimental investigation and testing program

Initially experiments were conducted to find out different properties of soil as specific gravity , free swell index, liquid limit, plastic limit, shrinkage limit etc. Later on heavy compaction tests were conducted to find out the optimum moisture content and corresponding maximum dry density. Then CBR tests were made at different moisture contents including OMC and analysis made to investigation the variation of CBR with respect to different days of soaking i.e. from unsoaked (day 0) to soaked (day 4). The variations also made with regards to moisture content at different layers along with different positions (east, west, north, south, center position) and also the variation of moisture content with respect to different days of soaking were observed. The investigation was aimed at studying the effect of compaction delay on relationship between moisture and density of a black cotton soil mixed with different proportions of sand, red murrum and steel slag. Also the Unconfined compression test for sand, red murrum and steel slag with different percentage are conducted.

4. RESULT AND DISCUSSION

4.1 Effect of compaction on Plane Black cotton soil



Graph 4.1 Comparative graph of Relationship between MDD and moisture content for Black cotton soil after addition of 5% to 25% sand.

Graph 4.1 shows the relationship between dry density and moisture content for black cotton soil in its natural state. The results obtained from the graph shows that MDD = 1.445gm/cc and OMC =25.93%

After the addition of 5% to25% sand the results obtained from the graph shows that MDD =1.469gm/cc and OMC = 24.3%. After the addition of 10% sand the results obtained from the graph shows that MDD =1.496gm/cc and OMC = 23%. After the addition of 15% sand the results obtained from the graph shows that MDD =1.522gm/cc and OMC = 21.2%. After the addition of 20% sand the results obtained from the graph shows that MDD =1.596gm/cc and OMC = 18.1%. After the addition of 25% sand the results obtained from the graph shows that MDD =1.558gm/cc and OMC = 19.4%.

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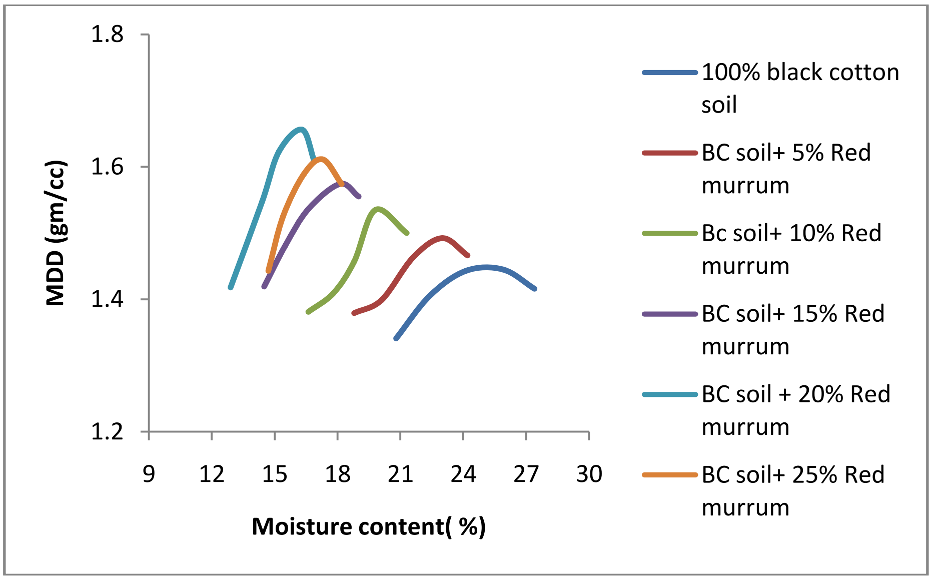
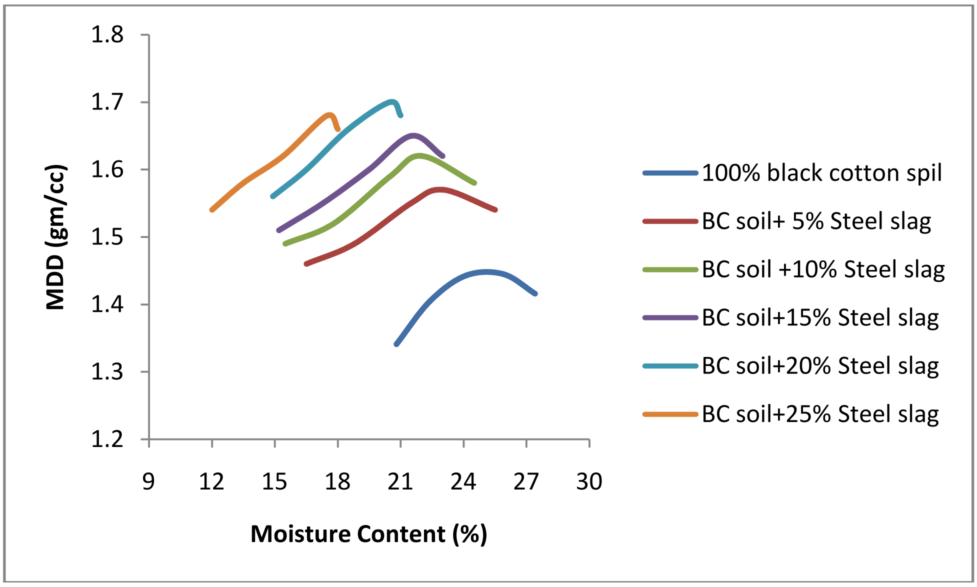


Graph 4.2 Comparative graph of Relationship between MDD and moisture content for Black cotton soil after addition of 5% to 25% red murrum.

Graph 4.2 shows the relationship between dry density and moisture content for black cotton soil after the addition of 5% to 25% red murrum. The results obtained from the graph shows that MDD =1.492gm/cc and OMC = 23%. After the addition of 10% red murrum the results obtained from the graph shows that MDD =1.535gm/cc and OMC = 19.8%. After the addition of 15% red murrum the results obtained from the graph shows that MDD =1.574gm/cc and OMC = 18.1%. After the addition of 20% red murrum the results obtained from the graph shows that MDD =1.656gm/cc and OMC = 16.3%. After the addition of 25% red murrum the results obtained from the graph shows that MDD =1.611gm/cc and OMC = 17.3%



Graph 4.3 Comparative graph of Relationship between MDD and moisture content for Black cotton soil after addition of 5% to 25% steel slag.

Graph 4.3 shows the relationship between dry density and moisture content for black cotton soil after the addition of 5% to 25% steel slag. The results obtained from the graph shows that MDD =1.57gm/cc and OMC = 23%. After the addition of 10% steel slag the results obtained from the graph shows that MDD =1.62gm/cc and OMC = 22%. After the addition of 15% steel slag the results obtained from the graph shows that MDD =1.65gm/cc and OMC = 21.5%. After the addition of 20% steel slag the results obtained from the graph shows that MDD =1.7gm/cc and OMC = 20.5%. After the addition of 25% steel slag the results obtained from the graph shows that MDD =1.68gm/cc and OMC = 17.5%

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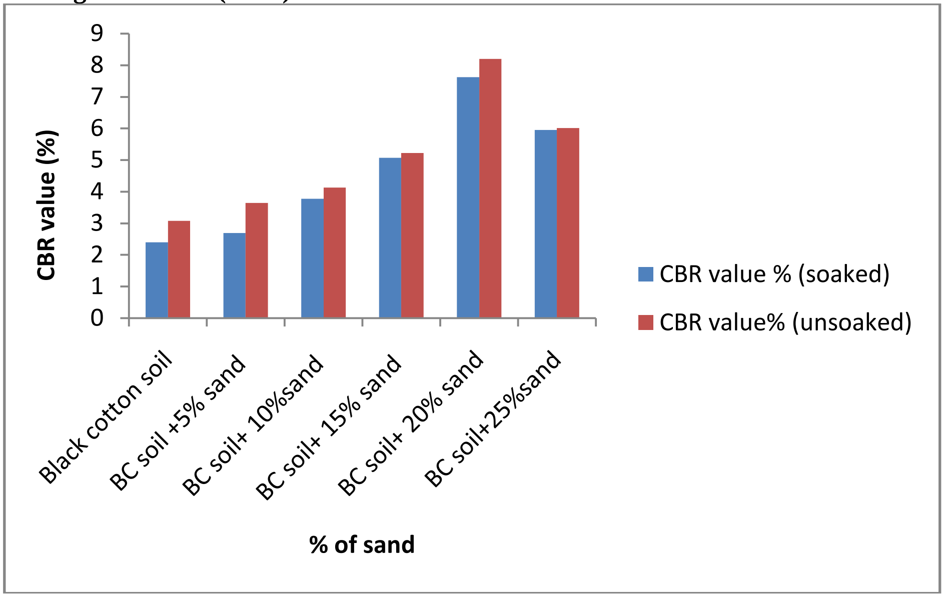
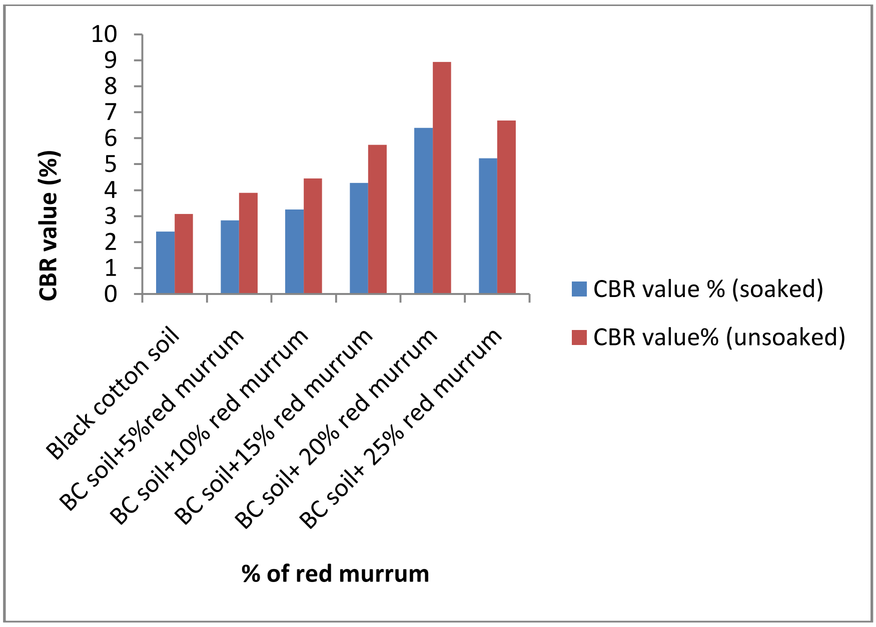
4.2 California Bearing Ratio Test (CBR)



4.4 comparative graph between Black cotton soil in soaked and unsoaked condition after the addition of 5% to 25% Sand.

The results of California bearing ratio (CBR) tests on black cotton soil treated with sand are shown in graph. It is observed that soaked and unsoaked CBR value of black cotton soil increased with addition of different percentage of sand. The value of soaked and unsoaked CBR of black cotton soil increases from 2.4 % to 5.95% at 2.5 mm penetration similarly the CBR value for unsoked at 2.5mm penetration increases from 3.08% to 6.01% respectively. But we have to take greater value for design consideration. 2.5 mm penetration value are greater than 5mm penetration. The CBR value is maximum at 20% addition of sand are 7.62% for soak condition and 8.2 % for unsoaked condition, hence the unsoaked CBR value is always greater than soaked CBR value and hence the 20%is the optimum range of sand.



4.5 comparative graph between Black cotton soil in soaked and unsoaked condition after the addition of 5% to 25% red murrum.

The results of California bearing ratio (CBR) tests on black cotton soil treated with red murrum are shown in graph. It is observed that soaked and unsoked CBR value of black cotton soil increased with addition of different percentage of red murrum. The value of soaked CBR of black cotton soil increases from 2.4 % to 5.23% at 2.5 mm penetration similarly the CBR value for unsoaked condition at 2.5mm penetration increases from 3.08% to 6.68 % respectively. But we have to take greater value for design consideration. 2.5 mm penetration value are greater than 5mm penetration. The CBR value is maximum at 20% addition of red murrum are 6.4% for 2.5 mm penetration for soked condition and 8.94% for unsoked condition 2.5 mm penetration, hence the unsoaked CBR value is always greater than soaked CBR value and hence the 20%is the optimum range of red murrum

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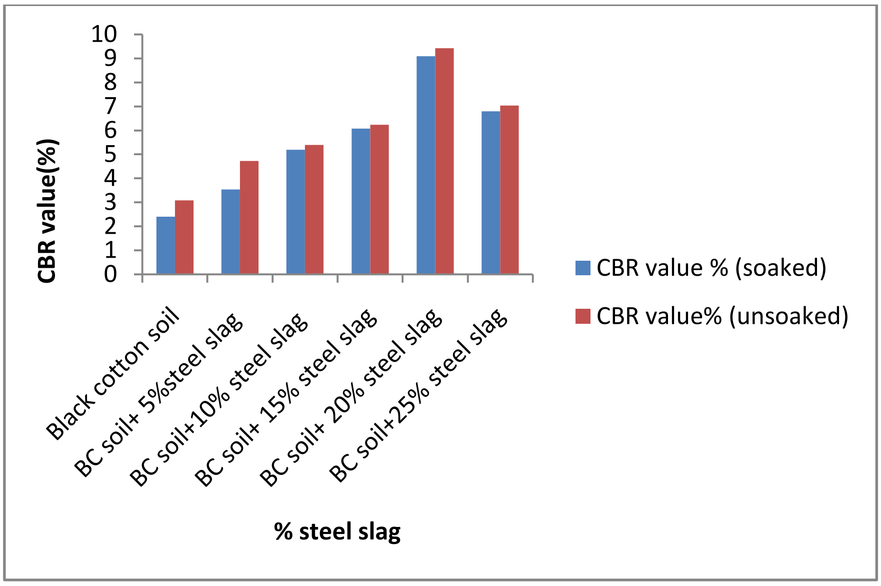
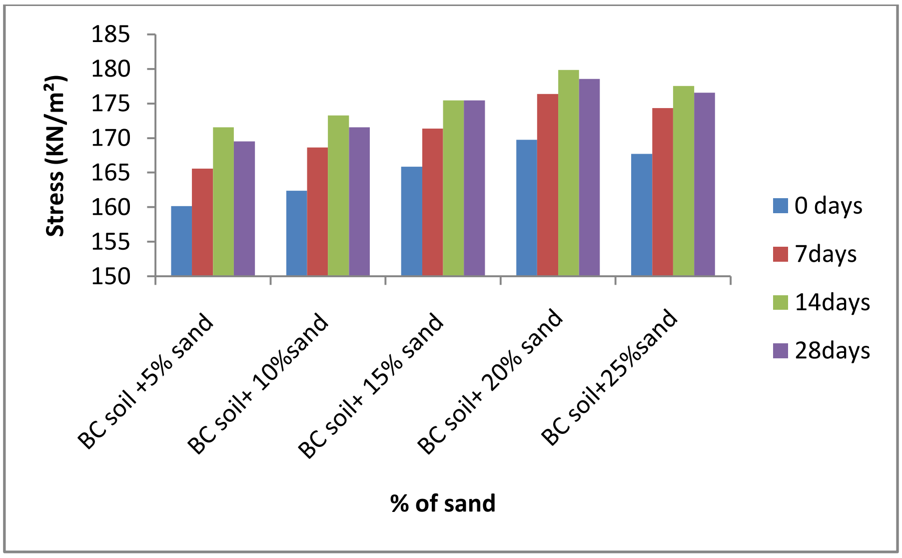


4.6 comparative graph between Black cotton soil in soaked and unsoaked condition after the addition of 5% to 25% Steel slag.

The results of California bearing ratio (CBR) tests on black cotton soil treated with steel slag are shown in graph. It is observed that soaked and unsoked CBR value of black cotton soil increased with addition of different percentage of steel slag. The value of soaked CBR of black cotton soil increases from 2.4 % to 6.8% at 2.5 mm penetration similarly the CBR value for unsoked condition at 2.5mm penetration increases from 3.08% to 7.04% respectively. But we have to take greater value for design consideration. 2.5 mm penetration value are greater than 5mm penetration. The CBR value is maximum at 20% addition of steel slag are 9.09% for 2.5 mm penetration for soaked condition and 9.43% for 2.5 mm penetration for unsoaked condition, hence the unsoaked CBR value is always greater than soaked CBR value and hence the 20%is the optimum range of steel slag.

4.3 Unconfined Compression Strength Test (UCS)

The UCS test is the simplest and quickest test for determining cohesion and shear strength of the cohesive soils. These values are used for checking the short term stability of foundations and slopes, where rate of loading is fast but the drainage is very slow. The change in the shear strength is determined by conducting compression test on black cotton soil with addition of sand, red murrum and steel slag. The results obtained from these tests were plotted and discussed



4.7 comparative graph between Stress and Strain for Black cotton soil after the addition of 5% to 25% Sand for 0, 7, 14, 28 days.

Graph shows the variation of UCS of black cotton soil after the addition of sand in different percentages such as 5%, 10%, 15%, 20% and 25%. UCS test was conducted with 0 days cured, 7 days cured, 14 days cured, 28 days curing effect. From the graph it can be observed that with increase in curing days strength of black cotton soil goes on increasing from 160.154 KN/m^2 to 167.687 KN/m^2 with 0 days . Curing days increases from 7 days, 14 days, 28 days

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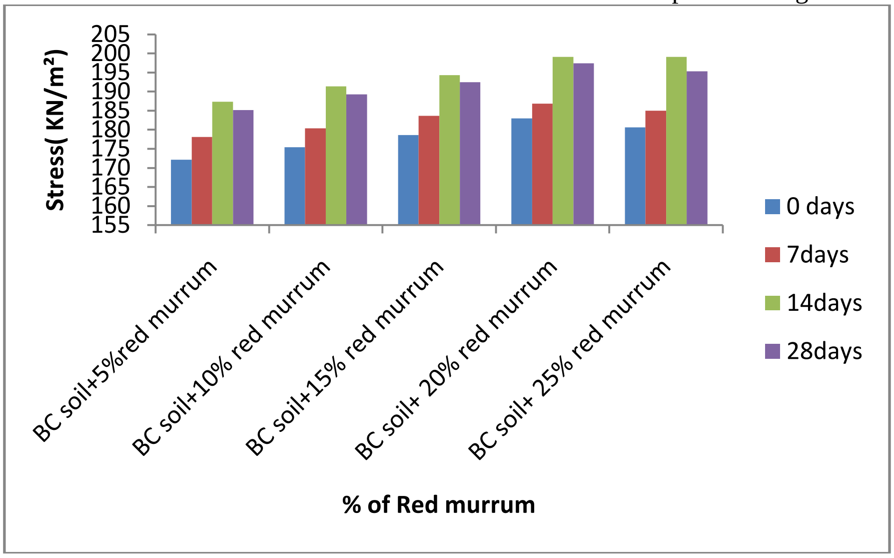
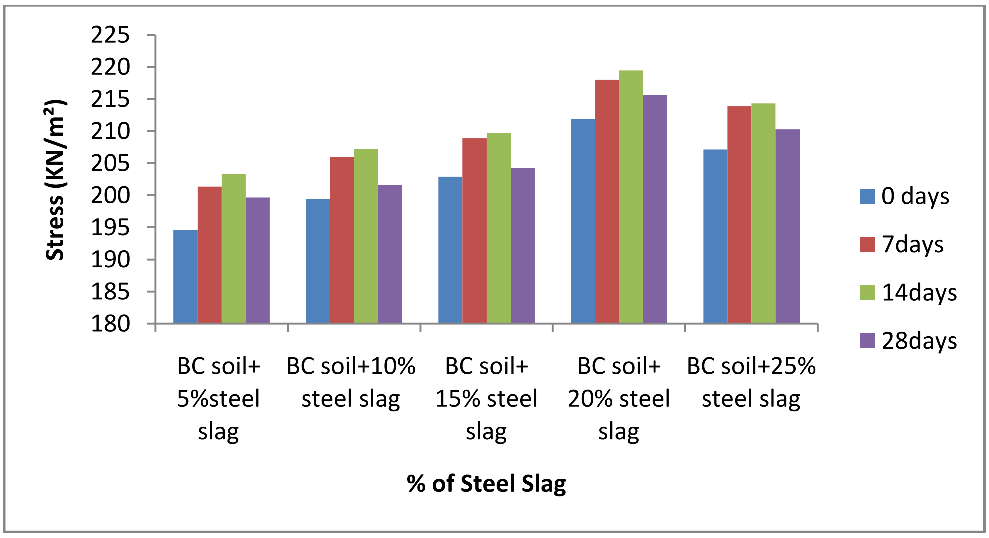
respectively. With increase in strength for 7 days curing from 165.554 KN/m^2 to 174.357 KN/m^2 , similarly for 14 days curing strength increases from 171.554 KN/m ^{2} to 177.545 KN/m^2 also for 28 days curing days strength from 169.524 KN/m^2 to 176.54 KN/m^2 . Graph shows the value of 14 days strength is maximum as compare to 0 days , 7 days , 28 days . Ie the UCS strength of 14 days is the optimum range. Graph also shows the 20% addition of sand the UCS strength is increases from 169.755KN/m^2 to 179.854 KN/m^2 from 0 days to 14 days then UCS strength is decreases from 179.854 KN/m^2 to 178.545KN/m^2. Hence the 20% addition of sand is the optimum range of UCS of soil.



4.8 comparative graph between Stress and Strain for Black cotton soil after the addition of 5% to 25% Red murrum for 0, 7, 14, 28 days.

Graph shows the variation of UCS of black cotton soil after the addition of red murrum in different percentages such as 5%, 10%, 15%, 20% and 25%. UCS test was conducted with 0 days cured, 7 days cured, 14 days cured, 28 days curing effect. From the graph it can be observed that with increase in curing days strength of black cotton soil goes on increasing from 172.154KN/m^2 to 180.654 KN/m ^{2} with 0 days . Curing days increases from 7 days, 14 days, 28 days respectively. With increase in strength for 7 days curing from 178.139 KN/m^2 to 184.997 KN/m^2 , similarly for 14 days curing strength increases from 187.365 KN/m ^{2} to 199.087 KN/m^2 also for 28 days curing days strength from 185.145 KN/m^2 to 195.325 KN/m^2 . Graph shows the value of 14 days strength is maximum as compare to 0 days , 7 days , 28 days . Ie the UCS strength of 14 days is the optimum range. Graph also shows the 20% addition of red murrum the UCS strength is increases from 182.966 KN/m^2 to 199.087 KN/m^2 from 0 days to 14 days then UCS strength is decreases from 199.087KN/m^2 to 197.44KN/m^2. Hence the 20% addition of red murrum is the optimum range of UCS of soil.



4.9 comparative graph between Stress and Strain for Black cotton soil after the addition of 5% to 25% Steel slag for 0, 7, 14, 28 days.

Graph shows the variation of UCS of black cotton soil after the addition of steel slag in different percentages such as 5%, 10%, 15%, 20% and 25%. UCS test was conducted with 0 days cured, 7 days cured, 14 days cured, 28 days curing effect. From the graph it can be observed that with increase in curing days strength of black cotton soil goes on increasing from 194.584 KN/m^2 to 207.133 KN/m ^{2} with 0 days . Curing days increases from 7 days, 14 days, 28 days respectively. With increase in strength for 7 days curing from 201.354 KN/m^2 to 213.873 KN/m , similarly for 14 days curing strength increases from 203.354 KN/m ^{2} to 214.326 KN/m^2 also for 28 days curing days strength from 199.64 KN/m^2 to 210.258 KN/m^2 . Graph shows the value of 14 days strength is maximum as compare to 0 days , 7 days , 28 days . Ie the UCS strength of 14 days is the optimum range. Graph also shows the 20% addition of steel slag the UCS strength is increases from 211.915KN/m^2 to 219.446 KN/m^2 from 0 days to 14 days then UCS strength is decreases from 219.446 KN/m^2 to 215.654KN/m^2. Hence the 20% addition of steel slag is the optimum range of UCS of soil.

5. CONCLUSION

On the basis of study and experimental investigations it was observed that the property of black cotton soil effectively improved by use of different percentages of sand, red murrum and steel slag content. In this study varying percentage of sand, red murrum and steel slag 5% ,10%, 15%, 20%, 25% was used to stabilize the black cotton soil.

1. Specific gravity of stabilized soil increased with the increase in percentage of sand up to 5% to 25% is from 2.61 to 2.63. Specific gravity of stabilized soil increased with the increase in percentage of red murrum up to 5% to 25% is from 2.61 to 2.65. Specific gravity of stabilized soil increased with the increase in percentage of steel slag up to 5% to 25% is from 2.61 to 2.74.
2. Liquid limit of black cotton soil decrease with increase in percentage of sand, red murrum and steel slag such as for sand decreased from 65% to 54.4% in percentage 5% to 25%, for red murrum decreased from 65% to 50.41% in percentage 5% to 25%, for steel slag decreased from 65% to 46.78% in percentage 5% to 25%.
3. Plastic limit of black cotton soil decreased with increase in percentage of sand, red murrum and steel slag such as for sand from 25.72% to 23.46%, for red murrum from 25.72% to 19.78%,for steel slag from 25.72% to 17.08%.
4. Shrinkage limit of black cotton soil decreased with increase in percentage of sand, red murrum and steel slag such as for sand from18.64% to 12.79%, for red murrum from 18.64% to 11.43%, for steel slag from 18.645 to 10.42%.
5. Swelling property of black cotton soil decreased with increase the percentage of sand, red murrum, steel slag such as for sand 41% to 28% , for red murrum 41% to 23% and for steel slag 41% to 18%. Sand, red murrum and steel slag control the swelling behavior of black cotton soil.
6. Mixing of soil with varying percentage of sand, red murrum and steel slag the maximum dry density increased with increased percentage of sand, red murrum and steel slag with decrease moisture content. MDD increased for sand from 1.445 gm/cc to1.596 gm/cc then decreased slowly, and moisture content decreased from 25.9% to18.1% then increased slowly. For red murrum MDD increased from 1.445 gm/cc to 1.656gm/cc then slowly decreased, and moisture content decreased from 25.9% to16.3% then increased slowly. For steel slag MDD increased from 1.445 gm/cc to 1. 7gm/cc then slowly decreased, and moisture content decreased from 25.9% to 20.5%.
7. California bearing ratio of black cotton soil increased with the increase in percentage of sand, red murrum and steel slag up to the 20% addition of stabilizer then decreased slowly up to 25% addition of stabilizer.
8. Unconfined compression test increased with increase in percentage of sand, red murrum and steel slag up to the 20% addition of stabilizer then decreased slowly up to 25% addition of stabilizer with varying days of curing such as 0days, 7 days, 14 days, 28 days.

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