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# Stabilization of Red soil and Black Cotton soil using Iron Slag and Fly Ash

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***Abstract*: : *The infrastructure is increasing day by day which leads to construction in the space where soil is not much of good strength and the Safe Bearing Capacity of soil is very low. In such areas soil stabilization can prove to be good alternative for improvement in its properties. The stabilization has been found to be effective in improvement of strength and compressibility. If soil is used for any construction purpose like pavement construction or embankments then such constructions may prove to be cost effective. Mixer like what is used in concrete making can be employed to mix the soil with different admixtures (Iron slag and fly ash) and then placing a mix soil for making road and embankment. If such constructions are done without stabilization then it will lead to decrease in strength and also increase in construction cost. The structures built upon such soil may also lead to failure. Initially cement and lime have been used to stabilize the soil but now we need to find other alternatives as there is lot of $CO_2$ emission in the production of cement which is not safe for our environment. The alternatives to be used should not harm to the environment. In the present study we have used fly ash and iron slag in different proportion for red soil which obtained by the weathering of basalt (It is termed as red bole in Geological terms). The percentage of iron slag is used as 2%,4%,6%,8% and 15%by weight of soil and fly ash is used in 10%, 15%, 20% and 25%by weight of soil. After procuring the soil the Standard Proctor Tests were conducted to determine the Optimum Moisture Content and Maximum Dry Density. Red bole soil and black cotton soil are stabilized using iron slag and fly ash and then the results of various tests have been compared. Consistency Limits, Specific Gravity, Free Swell Index, Standard Proctor, Permeability, Direct Shear, Unconfined Compression Strength and Swelling Pressure tests were performed on each soil (i.e. red bole and black cotton). The tests were performed using the standard codes and the methodology as per various IS codes.*

***Keywords:* Black cotton soil, Fly ash, Iron slag, Red bole, Stabilization.**

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## I. INTRODUCTION

In this modern time lack of resources are observed because of population growth, which leads to the expansion of city or town even on the areas where soil quality is not suitable to be used for construction.

Thus improvement of soil properties is the need of the today's technocrats. The method of improvement of soil is term as 'Stabilization' as per the aspect of civil engineering. In other words soil stabilization refers to the physical, chemical, biological or combined method of changing a natural soil to meet the engineering purpose.

Mostly stabilization is used in construction of road or pavements so as to increase the stability of soil and thereby decrease in construction cost.

Mechanical stabilization refers to stabilizing the soil by changing the composition of soil by addition or removal of certain constituents. There can be change in the properties of soil by addition or removal of a constituent and then compacting through desired method.

Expansive soil i.e. black cotton soil is a biggest problem in field of Geotechnical Engineering due to its nature of swelling and shrinking. Such nature is due to presence of montmonolite minerals in it. These soils swell in presence of water, shrink when dry and expand when exposed to frost. These swelling soils consolidate under loading which results in differential settlement of the structure, so stabilization is needed to decrease its swelling and shrinking property.

Red bole is formed due to weathering of igneous basaltic rocks bole as to whether it is a product of weathering showing a gradational contact with variation in the major elements from basalt to bole or it can be a separate entity formed by normal processes of deposition unrelated to the basalt giving rise to a sharp break in the contents of major elements at the contacts. The bole beds in Deccan Traps are so prominent that they indeed form excellent marker horizons aiding 'and guiding the systematic geologist in his task of establishing the flow stratigraphy and thereby to locate the sources of the flows and sets of flows from different sources.

Many materials like cement; lime etc are used to stabilize the soil. As lime and Cement produce lot of CO2 during its production and lime also results in swelling on increase in moisture. Reuse of waste material generated from domestic and industries is the main focus of society and Engineers these days. Stabilization through waste material is economical as well as easily accessible. This will reduce the material which is disposed to land fill which will decrease the amount of pollution generated through this waste if gone to landfill.

Fly is the waste generated through burning of coal. Iron slag is the waste iron particle generated in the iron mills.

## II. OBJECTIVES TO STUDY

- The main objective of the present study is to compare between different properties of problematic soils by adding iron slag and fly ash.
- To compare the results of Black cotton and red soil.
- To find the variation in strength of soil by adding iron slag and fly ash.
- To ascertain percentage of iron slag and fly ash so as to get the maximum desired result.

### A. Material Used

Experimental work has been conducted on the following materials:-

A. **Black Cotton Soil**: The black soil was obtained from the field near SGSITS Campus, Indore (M.P).

B. **Red Bole soil:** Red bole soil is obtained by us from the Dhamnoad (M.P).

C. **Fly Ash:** Fly ash is a residue obtained by burning of coal which has a binding property and easily available in industrial areas where coal is burnt in high quantity daily. We obtained fly ash from Mudra Steels Pvt. Ltd. Indore.

D. **Iron Slag:** Iron slag is a waste material obtained in making of steel reinforcement. It contains about 70% iron and 30 % other materials. We obtained iron slag from Mudra steel Pvt. Ltd. Indore. Different tests have been performed on the red and black soil and its results have been tabulated in various tables.

## III. METHODOLOGY

The methodology adopted for the research work can be summarized in the following steps.

(1) Sample Collection: The materials used for the experimental study have been collected from the various sources as described above.

(2) Laboratory Testing: On the collected soils i.e Red bole and black cotton soil the Standard Proctor Tests were conducted to find the OMC (Optimum moisture content) and MDD (Maximum dry density). The other tests like Free Swell Index, Swelling Pressure, and Direct Shear etc. were conducted.

(3) Mixing of Admixtures: Fly ash is mixed with both red bole and black cotton soil in different proportions viz. 10%, 15%, 20% and 25% by weight of the soil and all the tests were performed. Iron Slag is mixed with both red bole and black cotton soil in different proportions viz. 2%, 4%, 6%, 8% and 15% by weight of soil and the same tests were performed.

(4) Finding the optimum percentage of Admixtures: To find the optimum dose of Iron Slag and Fly Ash a number of trial mixes were used and finally they were mixed in the soil in the optimum percentage (20% Fly Ash and 8% Iron Slag) and then same tests were performed.

(5) Compilation of Test Results: The results of various laboratory tests conducted on each soil with different admixtures have been compiled. Results of red bole and black soils are compared.

## IV. EXPERIMENTS PERFORMED

In laboratory following experiments has been performed:-

A. **Standard Proctor Tests**: Standard Proctor Tests were performed in accordance with IS 2720 (Part VII) using a 1000 $cm^3$ mould by filling the soil in 3 layers and giving 25 blows to each layer to determine the Maximum Dry Density (MDD) and Optimum Moisture content (OMC).

B. **Permeability Tests:** Using Falling head method; a 1000 $cm^3$ mould was used to measure the fall of head in different time intervals using standard tube to allow water to permeate in soils. IS 2720 (Part XVII ) was followed to conduct these tests

C. **Direct Shear Tests:** This test tells about the value of cohesion(c) and angle of shearing resistance ($\phi$) so as to know its shear strength. IS 2720 (Part XIII) was followed to perform these tests.

D. **Free Swelling Index Tests:** Free swell index is the increase in volume of soil on submergence in water. Two glass tubes having kerosene and water respectively were filled with measured amount of soil in each tube and then add the soils in both tubes to swell in both tubes. These tests have been conducted as per the procedure described in IS 2720 (Part XL).

E. **Swelling Pressure Tests:** Swelling pressure test was performed on constant volume apparatus which has a volume of 56.54cm3 and this test tells about the pressure which it exerts on walls if not allowed to swell. These tests have been conducted as per the procedure described in IS 2720 (Part XLI).

F. **Consistency Limits Tests:** Liquid, Plastic and Shrinkage limit (all taken together is called Consistency or Atterberg's Limits) tests were performed so as to know at what percentage of water the soil changes its characteristics. These tests have been conducted as per the procedure described in IS 2720 (Part V).

G. **Specific Gravity Tests:** Specific gravity test was performed in Borosil specific gravity bottle as the soil was not sandy. Borosil Specific gravity bottle of 50 ml and 100 ml were used to find the specific gravity. These tests have been conducted as per the procedure described in IS 2720 (Part III).

H. **Unconfined Compressive Strength:** A cylindrical specimen with height to diameter ratio to was tested in loading cell at a rate of strain of 1.25 mm/min and the load at which specimen fail was noted. By plotting a curve between UCS value was determine. These tests have been conducted as per the procedure described in IS 2720 (Part X).

## V. TABLES AND GRAPHS

**Table – 1 Test Results for Red Bole with Iron Slag**

| Name of Test | | Iron Slag Percentage | | | | | |
|---|---|---|---|---|---|---|---|
| | | 0 | 2 | 4 | 6 | 8 | 15 |
| Proctor Compaction | OMC (%) | 10.4 | 11.3 | 10.3 | 12.2 | 12.8 | 10.6 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | MDD (g/cm$^3$) | 1.38 | 1.42 | 1.47 | 1.5 | 1.53 | 1.61 |
| Direct Shear Test | c (kPa) | 48 | 20 | 20 | 14 | 6 | 5 |
| | $\phi^o$ | 11 | 14 | 15 | 16 | 18 | 20 |
| Atterberg's Limits (%) | LL | 59 | 57 | 52 | 43 | 39 | 38 |
| | PL | 49 | 47 | 42 | 34 | 34 | 35 |
| | SL | 17 | 20 | 25 | 27 | 29 | 33 |
| Specific Gravity | | 2.35 | 2.38 | 2.4 | 2.45 | 2.46 | 2.52 |
| Free Swell Index (%) | | 30.2 | 29.5 | 26.67 | 20.41 | 15.21 | 10.3 |
| Permeability (cm/sec) (X $10^{-5}$) | | 2.887 | 7.454 | 8.327 | 9.515 | 10.46 | 4.2 |
| Swelling Pressure (kPa) | | 15.21 | 0.827 | 0.65 | 0.427 | 0.413 | 0 |

| Name of Test | | | | | | |
|---|---|---|---|---|---|---|
| | | 0 | 10 | 15 | 20 | 25 |
| Proctor Compaction | OMC | 10.4 | 6 | 8.6 | 6.8 | 11 |
| | MDD | 1.38 | 1.4 | 1.44 | 1.47 | 1.52 |
| Direct Shear Test | c (kPa) | 48 | 17 | 16 | 20 | 18 |
| | $\phi^o$ | 11 | 16 | 17 | 15 | 19 |
| Atterberg's Limits | LL | 59 | 40 | 47 | 49 | 43 |
| | PL | 49 | 35 | 28 | 25 | 30 |
| | SL | 17 | 21 | 24 | 25 | 29 |
| Specific Gravity | | 2.35 | 2.3 | 2.25 | 2.2 | 2.17 |
| Free Swell Index (%) | | 30.2 | 14.3 | 13.6 | 12.1 | 10.28 |
| Permeability (cm/sec) (X $10^{-5}$) | | 2.887 | 3.75 | 1.65 | 1.02 | 0.75 |
| Swelling Pressure (kPa) | | 15.21 | 4.96 | 2.89 | 0.41 | 0.4 |

**Table – 2 Test Results for Red Bole with Fly Ash**

| Name of Test | | Iron Slag Percentage | | | | | |
|---|---|---|---|---|---|---|---|
| | | 0 | 2 | 4 | 6 | 8 | 15 |
| Proctor Compaction | OMC (%) | 16.3 | 13.3 | 12.1 | 10.5 | 9.8 | 10.6 |
| | MDD (g/cm$^3$) | 1.5 | 1.53 | 1.54 | 1.58 | 1.62 | 1.69 |
| Unconfined compressive strength | | 114 | 119 | 120 | 123 | 124 | 125 |
| Atterberg's Limits (%) | LL | 45 | 42 | 40 | 37 | 34 | 31 |
| | PL | 33 | 29 | 25 | 22 | 19 | 17 |
| | SL | 10 | 18 | 20 | 21 | 23 | 29 |
| Specific Gravity | | 2.4 | 2.45 | 2.48 | 2.51 | 2.55 | 2.59 |
| Swelling Pressure (kPa) | | 20.21 | 16.68 | 13.13 | 10.42 | 8.72 | 3.62 |

**Table – 3 Test Results for Black Cotton with Iron Slag**

| Name of Test | | | | | | |
|---|---|---|---|---|---|---|
| | | 0 | 10 | 15 | 20 | 25 |
| Proctor Compaction | OMC | 16.3 | 12.7 | 11.4 | 9.6 | 9.4 |
| | MDD | 1.50 | 1.52 | 1.54 | 1.58 | 1.60 |
| Unconfined compressive strength | | 114 | 115 | 122 | 124 | 125 |
| Atterberg's Limits | LL | 45 | 40 | 37 | 33 | 30 |
| | PL | 33 | 27 | 24 | 21 | 19 |
| | SL | 10 | 13 | 17 | 20 | 23 |
| Specific Gravity | | 2.40 | 2.38 | 2.32 | 2.30 | 2.26 |
| Swelling Pressure (kPa) | | 20.21 | 18.30 | 16.52 | 13.20 | 9.43 |

**Table – 4 Test Results for Black Cotton with Fly Ash**

| Name of Test | | Red Bole Mixed with 20% Fly Ash & 8% Iron slag | Black Cotton Mixed with 20% Fly Ash & 8% Iron slag |
|---|---|---|---|
| Proctor Compaction | OMC (%) | 19.1 | 13.2 |
| | MDD (g/cm$^3$) | 1.64 | 1.66 |
| Direct Shear Test | c (kPa) | 0 | - |
| | $\phi^o$ | 24 | - |
| Unconfined compressive strength | | - | 130 |
| Atterberg's Limits (%) | LL | 42 | 40 |
| | PL | 26 | 19 |
| | SL | 24 | 24 |
| Specific Gravity | | 2.36 | 2.54 |
| Free Swell Index (%) | | 10.5 | - |
| Permeability (cm/sec) | | Impermeable | - |
| Swelling Pressure (kPa) | | 0 | 0.41 |

**Table – 5 Test Results for both soils mixed with Iron Slag & Fly Ash**

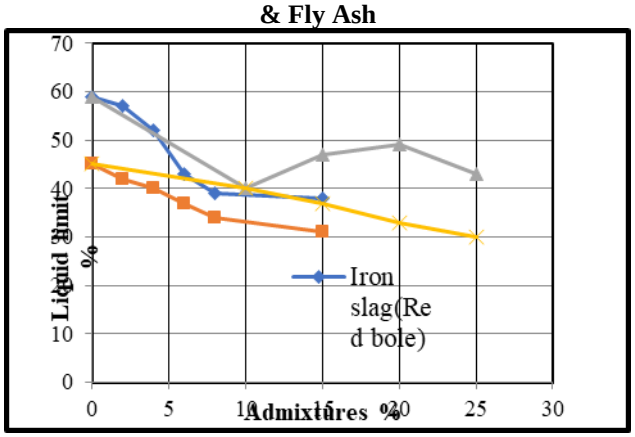


**Fig.1 Variation of Liquid Limit with variation of admixture percentage**

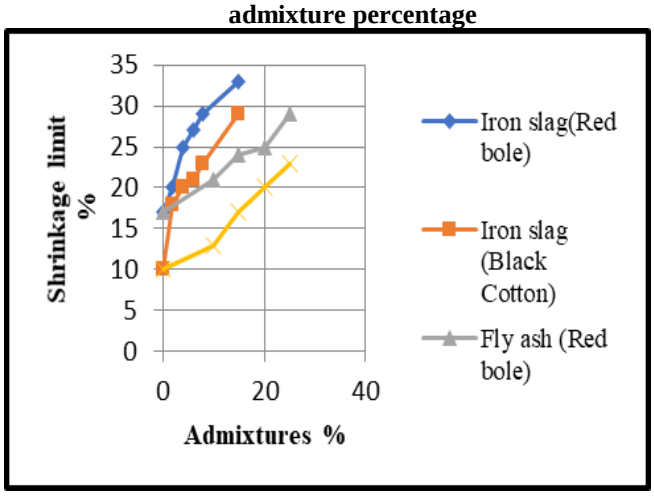


**Fig.2 Variation of Shrinkage Limit with variation of admixture percentage**

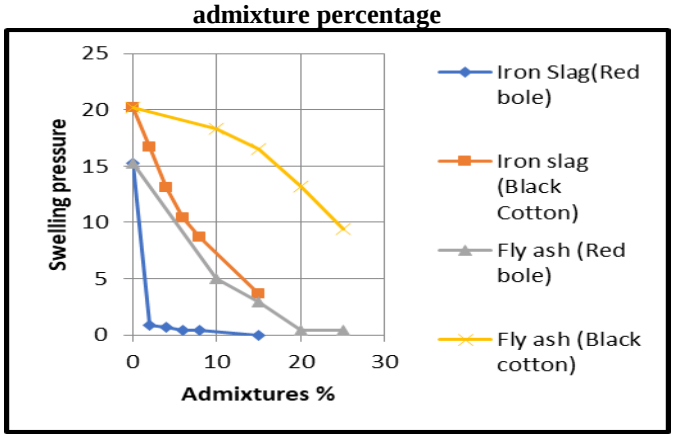


**Fig.3 Variation of Swelling Pressure with variation of admixture percentage**

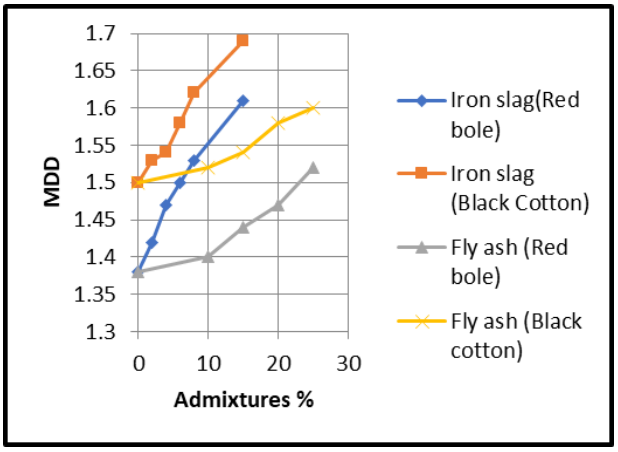


**Fig.4 Variation of Maximum Dry Density with variation of admixture percentage**

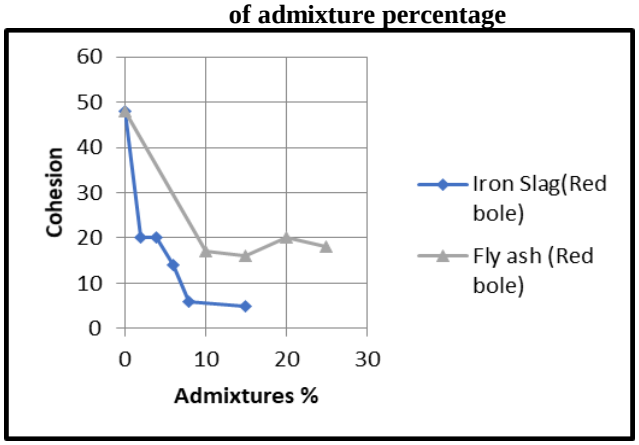


**Fig.5 Variation of Cohesion with variation of admixture percentage**

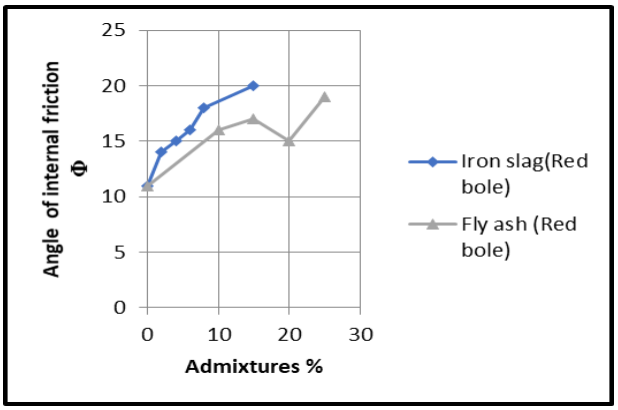


**Fig.6 Variation of Angle of Internal Friction with variation of admixture percentage**

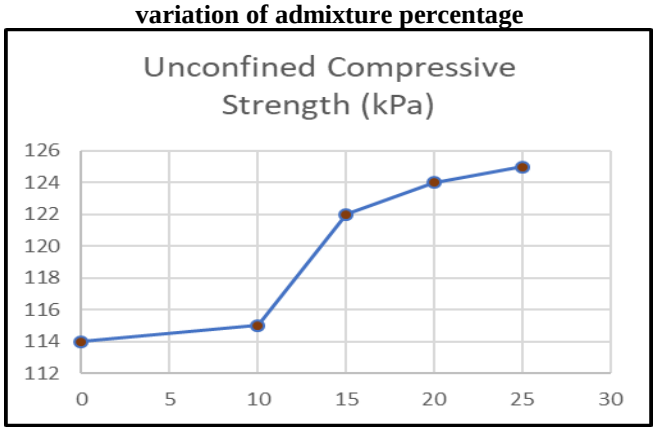


**Fig.7 Variation of Unconfined Compressive Strength with variation of Fly ash percentage**

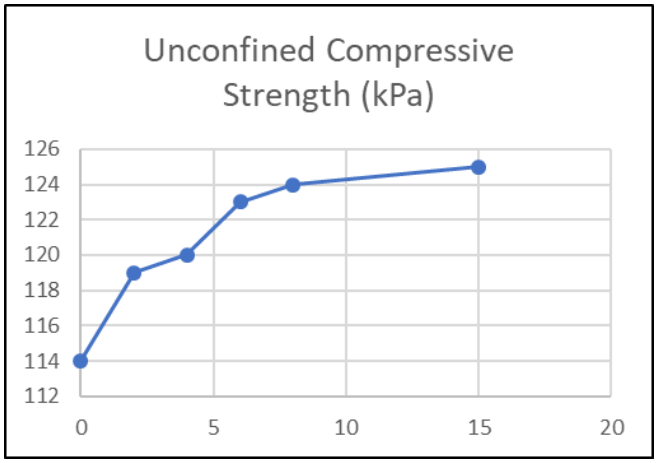


**Fig.8 Variation of Unconfined Compressive Strength with variation of iron slag percentage**

## VI. RESULTS AND DISCUSSIONS

(A) Red Bole

After performing sufficient number of tests on red bole, results were compared by plotting curves. Table – 1 shows the variation of test results when different percentage of Iron Slag was used while Table – 2 shows the variation of test results when different percentage of Fly ash was added.

On adding iron slag to red bole soil, there is an increase in MDD. The Maximum Dry Density of red bole alone was 1.38 g/cm$^3$ which increase to 1.53 g/cm$^3$ when 8% of Iron Slag is added. Shear parameter cohesion (c) was found to be decreasing with increase in Iron Slag. It is varied from 48kPa (red bole alone) to 5 kPa (15% Iron Slag)whereas there is increase in angle of internal friction from 11$^o$(red bole alone) to 20$^o$ (15% Iron Slag). The addition of Iron Slag makes the soil almost four times permeable. The parameters showing the expansive character Free Swell Index and Swelling Pressure were found to be continuously decreasing with addition of Iron Slag. The Swelling Pressure is reduced to zero for 15% Iron slag as compared to 15.21 kPa for red bole alone. Liquid Limit decreases continuously from 59% (for red bole alone) to 39% (adding Iron Slag as 8%) while Shrinkage Limit is found to be increasing continuously from 17% (for red bole alone) to 33% (adding 15% Iron Slag).

Similar results were obtained for addition of Fly ash except for Permeability. The addition of Fly ash makes the soil less permeable. It can be concluded that the use of Iron Slag is more beneficial as compared to fly ash.

It was not possible to conduct the Unconfined Compression Strength for red bole soil as sample was crumbling.

**(B) Black Cotton Soil**

After performing sufficient number of tests on expansive black cotton soil the results were compared by plotting curves. Table – 3 shows the variation of test results when different percentage of Iron Slag was used while Table – 4 shows the variation of test results when different percentage of Fly ash was added.

On adding iron slag to black cotton soil, there is an increase in MDD. The Maximum Dry Density of black cotton soil alone was 1.50 g/cm$^3$ which increase to 1.62 g/cm$^3$ when 8% of Iron Slag is added.

The Unconfined Compression Strength ($q_u$) was found to be increasing with increase in Iron Slag. It is varied from 114kPa (black cotton soil alone) to 125 kPa (15% Iron Slag). The addition of Iron Slag makes the soil more permeable. The parameters showing the expansive character Free Swell Index and Swelling Pressure were found to be continuously decreasing with addition of Iron Slag. The Swelling Pressure is reduced to 3.62 kPa for 15% Iron slag as compared to 20.21 kPa for black cotton soil alone. Liquid Limit decreases continuously from 45% (for black cotton soil alone) to 31% (adding Iron Slag as 15%) while Shrinkage Limit is found to be increasing continuously from 10% (for red bole alone) to 29% (adding 15% Iron Slag).

Similar results were obtained for addition of Fly ash except for Permeability. The addition of Fly ash makes the soil less permeable. It can be concluded that the use of Iron Slag is more beneficial as compared to fly ash.

Unconfined Compression Strength was conducted instead of Direct Shear Test as it is more reliable in case of black cotton soil.

A sample of red bole with 8% Iron Slag and 20% Fly ash was prepared and the same tests were conducted. The combination of admixtures (i.e. Iron Slag & Fly ash) makes the soil impermeable.

A sample of black cotton with 8% Iron Slag and 20% Fly ash was prepared and the same tests were conducted.

The Results of mixture of additives with both types of soils are shown in Table – 5.

## VII. CONCLUSIONS

- When the red bole stabilized with the iron slag there is increase in Maximum Dry Density, Specific Gravity, Shrinkage Limit, Permeability and Angle of Internal Friction while there is decrease in Liquid Limit, Plastic limit, Free Swell Index, Cohesion and Swelling Pressure.
- When the red bole stabilized with the fly ash there is increase in Maximum Dry Density, Shrinkage Limit, and Free Swell Index while there is decrease in Liquid Limit, Plastic Limit, Specific Gravity, Cohesion, Permeability and Swelling Pressure.
- When the Black cotton soil stabilized with the iron slag there is increase in Maximum dry density, Specific gravity, Shrinkage Limit, and Unconfined Compressive Strength whereas Liquid Limit, Plastic limit, and Swelling Pressure decreases. .
- When the Black cotton soil stabilized with the Iron slag there is increase in Maximum Dry Density, Shrinkage Limit and Unconfined Compressive Strength .The decrease in Liquid Limit, Plastic limit, Specific Gravity and Swelling Pressure has been observed..
- It can be concluded that improvement by iron slag is better than fly ash. The treatment of red bole with admixtures is better than black cotton.

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## REFERENCES

1. Alemu Diribsa Gudeta. et.al. (2017), "A Critical Review on Soil Stabilization Using Different Industrial Wastes and Admixtures", IRJET.
2. Vijayakumar. et al. (2019), "Utilization of Waste Materials for the Strengthening of Pavement Subgrade-A", IJITEE.
3. Anil Kumar Sharma. et. al. (2011), "Soil Stabilisation with Waste Materials Based Binder", INDIAN GEOTECHNICAL CONFERENCE.
4. Aparna Roy. et al.(2014), "Soil Stabilization using Rice Husk Ash and Cement", IJCER.
5. Bayshakhi Deb Nath. et.al. (2017), "Study on Strength Behaviour of Organic Soil Stabilization with Fly Ash", HINDAWI.
6. F.Yilmaz. et.al. (2014), "Soil Stabilization with using Waste Materials against Freezing Thawing effect", ICCESEN.
7. Faisal I. Shalabi. et.al. (2017), "Effect of by-product steel slag on the engineering properties of clay soils", JKSU.
8. Jai Prakash. et.al. (2017). "Stabilization of Soil Using Rice Husk Ash", IJIRSET.
9. Jerin Jose. et.al. (2018). "Stabilization of Expansive Soil Using Fly Ash", IRJET.
10. Jyoti S. Trivedi. et.al.(2013), "Optimum Utilization of Fly Ash for Stabilization of Sub-Grade Soil using Genetic Algorithm", ELSEVIER.
11. Karthik.S. et.al. (2014), "Soil Stabilization By Using Fly Ash", IOSR.
12. Leonard Behak. et.al. (2017). "Soil Stabilization with Rice Husk Ash", INTECH.
13. Mandeep Kaur. Et.al. (2018). "Agricultural and Industrial Waste as Soil Stabilizer", IJPA Bioscience.
14. M Rupas Kumar. et.al. (2015), "Soil Stabilization using Iron Powder", IJERGS.
15. Navdeep Singh Sodhi. et.al. (2017). "Soil Strengthening Using Waste Materials", IRJET.
16. Pragyan Mishra. et.al. (2017), "Improvement of Geotechnical Properties of Red soil Using Waste Plastic", IJETT.
17. Rashmi Bade. et.al.(2018), "Expansive Soil Stabilization by using Walnut Shell Power Ash", IJSRT.
18. Rathan. et.al. (2016), "Stabilization of soil using Rice Husk Ash", IJCER.
19. Tejashri A. Kulkarni. et.al. (2017), "Stabilization of Soil by Using Fly Ash & Lime", IFERP.
20. Vishal Dilip Khatate. et.al. (2017). "Stabilization of Black Cotton Soil by Using Iron Dust", IJRAT.
21. V. Siva Sankar. et.al. (2019). "Stabilization of Expansive Soil by Using Agricultural Waste", IJEAT.
22. Yuyi Liu. et.al. (2019). "Utilization of Cementitious Material from Residual Rice Husk Ash and Lime in Stabilization of Expansive Soil", HINDAWI.
23. Zahra asgari. et.al. (2015), "A Study of Using a Variety of wasted materials as additives in soil stabilization", IJSER.

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