Subgrade Soil Stabilization Using Ground Granulated Blast Furnace Slag, Fly Ash & Silica Fume

[1]Mahabubi Sheikh, [2]Jyoti Shukla, [3]Kousick R V, [4]Janhavi Meshram, [5]Alkesh Bhalerao.

Department of Civil Engineering.
New Horizon Institute of Technology and Management, Thane, Maharashtra

---***---

ABSTRACT: Subgrade soil is an important part of the road pavement structure because it supports the pavement layers such as the subbase, base, and wearing courses from beneath. The properties of subgrade soil are critical for the design of a pavement structure. Any weakness in the subgrade soil affects all of the overlying layers of pavement, especially flexible pavement. The subgrade should be stable enough under adverse weather conditions to support the pavement. Poor subgrade conditions cause waves, corrugations, rutting, and shoving in blacktop pavements. Stabilization is a broad term for the various methods of modifying the properties of a soil to improve its engineering performance and use in a variety of engineering works. The varying percentage of Fly ash, Silica fume and GGBS were with mixed with soil sample to conduct the soil test

Keywords – Soil stabilization; Murrum soil; Fly ash; GGBS; Silica fume; California bearing ratio; Unconfined compression strength test; Standard proctor test.

I. INTRODUCTION

The soil is weak and unstable enough to support heavy loads. The study's goal is to use waste material for soil stabilisation. For this project, we chose to use waste industrial materials that are commonly available as waste in every nook and cranny of not only our country, but the entire world. To improve the strength of sub-grade soils, soil reinforcement techniques can be a significant secondary market for waste industrial materials such as GGBFS, Fly Ash, and SilicaFume. This technique has been found to be an effective and dependable method for increasing the strength of sub-grade soils. When compared to an untreated and weaker subgrade, a treated or stronger subgrade soil requires a relatively thinner section of a flexible pavement, resulting in a significant cost advantage. Geotextiles and other polymeric reinforcements, such as geogrids, have become increasingly popular in geotechnical engineering over the years. However, in some cases, particularly for low cost. The experimental work was used to study the stabilisation of murrum soil using industrial waste. These works are evaluated in light of the methodology, principal, and various aspects of the situation. Based on the literature review, a gap in research work is identified in order to conduct additional research.

II. LITERATURE REVIEW

Nanda et al. (2016) studied experimental investigations that are made to evaluate the unconfined strength including compaction characteristics of Lithomarge soil (shedi soil) stabilized with ground Granulated Blast furnace Slag (GGBS) and lime. It was found that the inclusion of lime can significantly enhance the UCS values of stabilized shed soil.

Abhijit et al. (2015) have conducted an experimental study to find the effect of ground granulated blast furnace slag (GGBS) and Sisal fibres on the mechanical properties of black cotton soil. In the initial, the basic properties of black cotton soil and sisal fibre were found out. The next phase focuses on the unconfined compressive strength and CBR values of the mixture of black cotton soil and the optimum dosage of GGBS randomly reinforced with varying percentages of sisal fibres. The results indicated that with the addition of GGBS to black cotton soil the maximum dry density increased, and optimum moisture content decreased. The unconfined compressive strength and CBR values increased the addition of sisal fibres to a mixture of black cotton soil and optimum dosage of GGBS. The highest result was obtained for a mixture of black cotton soil and optimum dosage of GGBS with 0.75% of sisal fibers

Dayalan et al. (2016) has conducted experiments with different amounts of fly ash and GGBS. The performance of stabilized soil is evaluated using physical and strength performance tests like specific gravity, Atterberg limits, standard proctor test, and CBR test at optimum moisture content. From the results, it was found that the optimum value of fly ash is 15% and GGBS is 20% for stabilization of given soil based on CBR value determined.

Dr.A.I. Dhatrak et.al. (2015) After reviewing performance of plastic waste mixed soil as a geotechnical material. It was observed that for construction of flexible pavement to improve the sub grade soil of pavement using waste plastic bottles chips is an alternative method. In his paper a series of experiments are done on soil mixed with different percentage of plastic (0.5%, 1%, 1.5%, 2%, 2.5%) to calculate CBR. On the basis of experiments that he concluded using plastic waste strips will improve the soil strength and can be used as subgrade.

Pandey et al. (2014) The investigation showed that generally the engineering properties which improved with addition of GGBS. The addition of GGBS resulted in a dramatic improvement within the test ranges covered in the programme. The maximum dry density increased and the optimum moisture content decreased with the increasing GGBS content and at 25% we got the maximum value of dry density.

Sharma et al. (2016) Addition of Fly ash and GGBS based binder was found to decrease liquid limit and plasticity index of the soil. The increase in shrinkage limit shows resistance to volume change. Fly ash and GGBS mixture at mixing 70.30 provides a better opportunity for utilization in various Geotechnical and Geo-environmental application.

Rajkumar Nagle et.al. (2014)] It performed CBR studied for improving engineering performance of sub grade soil. They mixed polyethylene, bottles, food packaging and shopping bags etc., as reinforcement within black cotton soil, yellow soil and sandy soil. Their study showed that MDD and CBR value increases with increase in plastic waste. Load bearing capacity and settlement characteristics of selected soil material are also improved.

Manjunath.et al. (2012) carried out research on the influence of GGBS and lime on the unconfined compressive strength properties of black cotton soil. Lime and GGBS were added in various combination with curing of 0, 7 & 28 days. The results showed that soil stabilised with GGBS and lime gave strength higher than that with lime only. The optimum mixture identified that with 30% GGBS and 4% lime, the strength was 18 times more than the black.

III. PROPOSED WORK

The material used for experimental study was murrum soil. The various laboratory tests were performed on murrum soil with relevant IS codes. Laboratory test were performed on murrum soil are Water content in murrum soil, Specific Gravity, Liquid limit and Plastic Limit of murrum soil. The various tests conducted to obtain Engineering Geotechnical properties of murrum soil.

1. Specific Gravity
2. Liquid Limit
3. Plastic Limit
4. Standard proctor test
5. Unconfined compression test.
6. California Bearing Ratio test.

Following are the results obtained from the various tests conducted on the murrum soil: -

Sr. No	Laboratory Test	Result
1	Specific Gravity	2.66
2	Liquid Limit	36.57%
3	Plastic Limit	30.227%
4	Plastic Index	6.35%
6	CBR	4.18%
7	Maximum Dry Density	1.15 g/cm^2
8	Optimum Moisture Content	23.05%
9	Compressive strength	327.76kPa

IV. TESTS PERFORMED

1 ATTERBERG LIMITS

1.1 Liquid Limit

The liquid limit of a soil water content at which the soil behaves practically like liquid, but it has small shear strength. It flows to close the groove in just 25 blows in Casagrande's liquid limit device. Take about 120g of air died soil sample passing 425 µ IS Sieve. Mix the sample thoroughly with distilled water in an evaporating dish or a glass plate to form a uniform paste. Place the specimen in an air tight container for the water content determination. Determine the water content. Draw the flow curve between water content and number of blows, and determine the liquid limit corresponding to 25 blows.

Observation	Trial 1	Trial 2	Trial 3
Weight of Container (W1)	18.20	15.92	18.64
Weight of Container + Wet soil (W2)	32.93	31.78	32.03
Weight of Container + oven dry soil(W3)	29.11	27.81	28.34
Moisture Content	35.01	33.38	38.04

Average of moisture content=36.5

1.2 Plastic Limit

The plastic limit of the soil is the water content of the soil below which it ceases to plastic. It brings to crumble when rolled into threads of 3mm diameter. Take about 20gm of air dried soil thoroughly, mixed sample of the soil passing 425 µ sieve. Mix the soil with distilled water in an evaporating dish on a glass plate to make it enough shape into a small ball. Collect the pieces of the crumbled soil thread in a moisture content container. Repeat the procedure at least twice more with fresh sample of plastic soil.

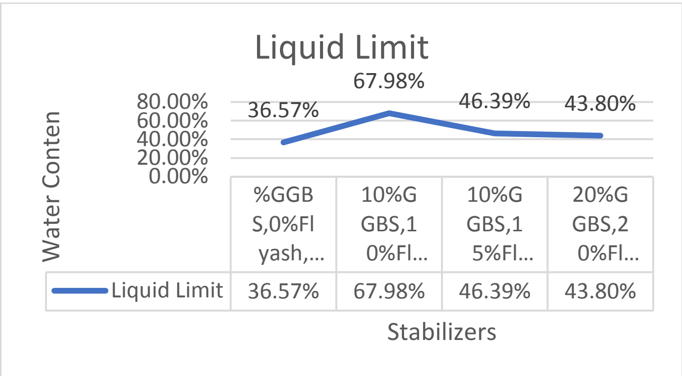
Observation	Trial 1	Trial 2	Trial 3
Weight of Container (W1)	19.74	19.67	18.02
Weight of Container + Wet soil (W2)	25.42	23.72	22.22
Weight of Container + oven dry soil(W3)	24.26	22.65	21.35
Moisture Content	25.66	35.90	29.12

Average Plastic Limit = 30.22%

Plasticity index sample on replacement of Fly ash and GGBS

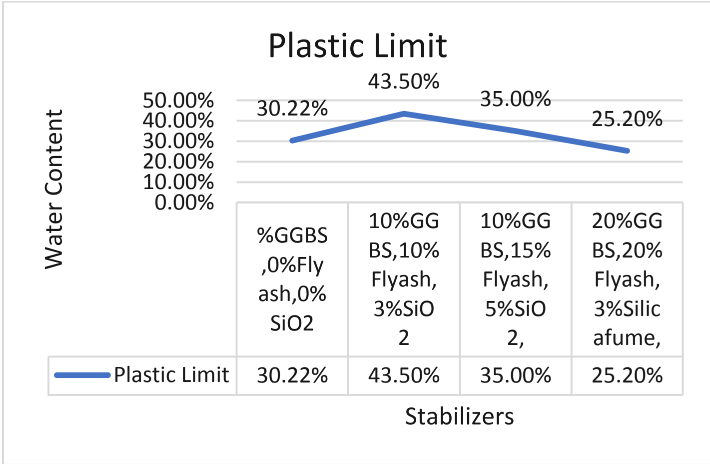
% GGBS, FlyAsh and Silica Fume	Liquid Limit	Plastic Limit	Plasticity Index
0%GGBS,0%FS& 0 % of SF	36.57%	30.22%	6.35
10%GGBS,10%FS& 3 % of SF	67.98%	43.50%	24.48
10%GGBS,15%FS& 5% of SF	46.39%	35%	11.39
20%GGBS,0%FS &3% of SF	43.80%	36.34%	7.46%

Variation of Liquid Limit with % of GGBS, Fly Ash and Silica Fume



Graph 1: liquid limit result with varying with %of Fly ash, GGBS and Silica Fume

Variation of Plastic Limit with % of GGBS, Fly Ash and Silica Fume



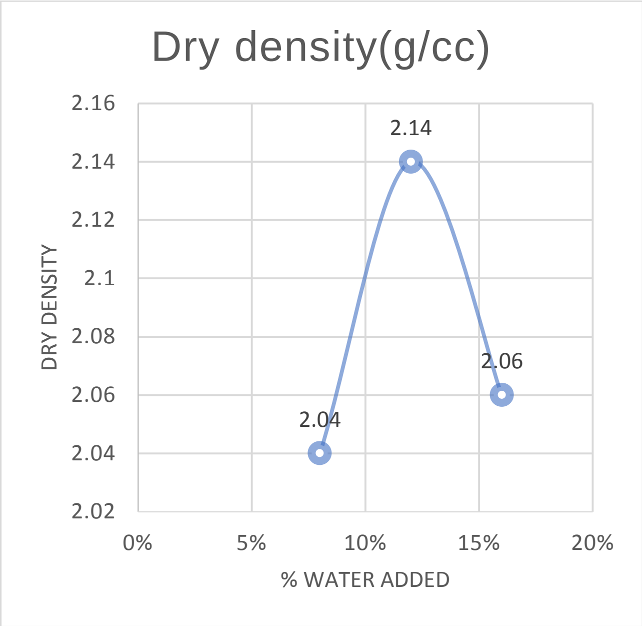
Graph 2: Plastic limit result varying with %of Fly ash,GGBS and Silica Fume

2. STANDARD PROCTOR TEST

Compaction is the process of dandification of soil by reducing air voids. The degree of compaction of a given soil is measured in terms of its dry density. The dry density is maximum at optimum water content.2.5 kg of dry soil passing through 4.75 mm IS sieve was taken. The 8% of water is added to the soil and it was mixed thoroughly to ensure the uniform distribution of moisture and attach the collar to the mould. One part of soil is placed in the mould and it was compacted with 25 blows by using 2.5 kg rammer. The second layer should also be compacted by 25 blows.

Dry density of sample replaces with 15 % Fly ash & 10% GGBS and 5% Silica Fume

%of H2O Added	8%	12%	16%
Weight of empty mould	4810	4810	4810
Weight of mould +compacted soil	6753	6863	6999
Weigh of compacted Soil (gm)	1943	2053	2198
Wet unit weight (gm/cc)	1.943	2.053	2.198
Dry unit weight (gm/cc)	2.04	2.14	2.06



Graph 3: OMC AND MDD for 15% of Fly ash, 10%GGBS & 5% Silica Fume

Report: The maximum dry density is 1.878 and OMC is 12 % for soil mixed with 15% of Fly ash & 10% GGBS

3. CALIFORNIA BEARINGRATIO TEST

The California Bearing Ratio is conducted for evaluating the suitability of the sub grade and material used in sub base used and base of a flexible pavement. Take about 4.5 to 5.5 kg material. Mix it thoroughly with required quantity of water. Fix the extension collar of the top mould also fix the base plate of the bottom. The soil is to be compacted into 3 equal layer; each layer is given 56 blows by 2.6kg rammer with drop of 310mm.Remove the extension collar. Trim even the excess compacted soil carefully with a straight edge with top of mould. Place a filter disc on the base plate. Invert the mould with compacted soil. Clamp the base plate Applied load on the plunger. Record the load corresponding the penetration of 0.0,0.5, 1.0, 1.5,2.0,2.5,3.0,4.0,5.0,7.5, 10.0 and 12.5mm.

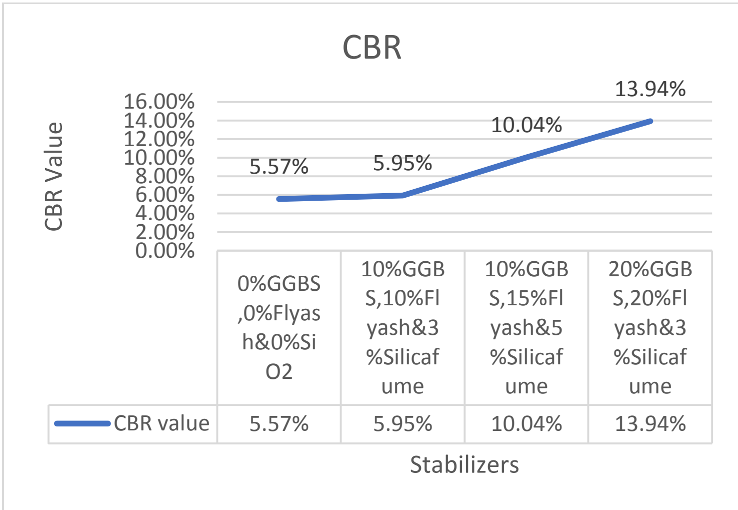
CBR Apparatus

CBR value for replacement of 20% of Fly ash and 20% of GGBS and 3 % Silica Fume

CBR value @ 2.5mm penetration =9.5 %

CBR value @ 5mm penetration = 13.94%

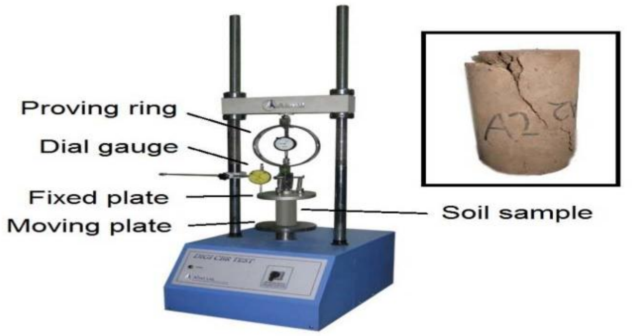
Dial gauge reading in (div)	Proving ring readings in (div)	Load in kg
0	21	12
0.5	48	27
1	86	48
1.50	115	64
2.00	135	75
2.50	160	89
3.00	189	105
4.00	237	132
5.00	279	155
7.50	336	187
10.00	426	237
12.50	603	335



Graph 4: Variation of CBR value at different % of Fly ash, GGBS& Silica Fume

4. UNCONFINED COMPRESSIVE STRENGTH TEST

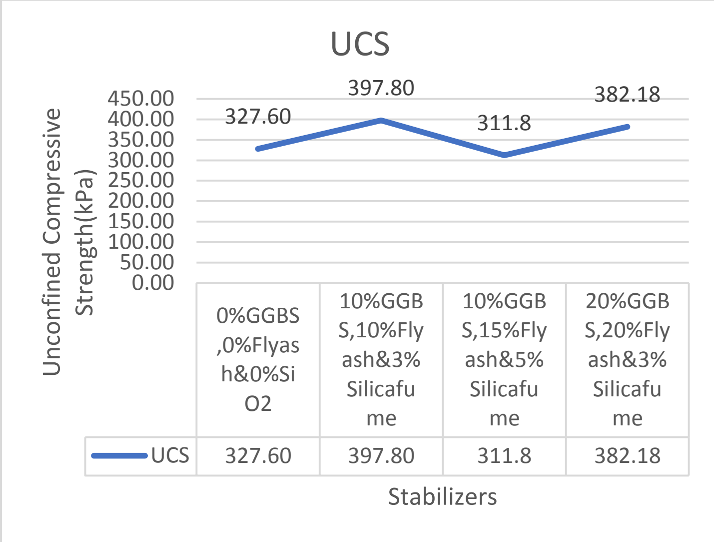
The shearing strength is commonly investigated by means of compression tests in which an axial load is applied to the specimen and increased until failure occurs. The unconfined compressive strength is the load per unit area at which and unconfined cylindrical specimen of soil will fail in a simple compression test. If the unit axial compression force per unit area has not reached a maximum value up to 20 percent axial strain, unconfined compressive strength shall be considered the value obtained at 20 percent axial strength. This test was conducted as per IS 2720 (Part10): 1973.



UCS Apparatus

UCS Value for Murrum Soil with 10% of GGBS ,10% of Fly Ash And 3 % of Silica Fume

Dial gauge Reading	Axial deformation (mm)	Axial Strain, E	Area (mm^2), A= A_0/(1-E)	Proving ring dial reading	Axial force (kg)	Compressive Stress (KPa)
0	0	0	1134.1	0	0	0
50	0.5	0.7	1141.6	7	1.7	14.6
100	1	1.3	1149.2	13	3.2	27.0
150	1.5	2	1156.9	19	4.6	39.1
200	2	2.6	1164.8	28	6.8	57.3
250	2.5	3.3	1172.7	43	10.4	87.4
300	3	3.9	1180.7	64	15.5	129.2
350	3.5	4.6	1188.9	89	21.6	178.4
400	4	5.3	1197.1	113	27.4	224.9
450	4.5	5.9	1200.1	137	33.3	270.8
500	5	6.6	1204.0	154	37.4	302.8
550	5.5	7.2	1209.6	160	45	397.8
600	6	7.9	1231.3	140	34.0	270.9



Graph 5: Compressive strength varying with %of Fly ash, GGBS and Silica Fume

V. CONCLUSION

The study has been conducted to assess the potential of Fly Ash, GGBFS and Silica Fume for stabilization of Murrum soil and detailed comparison has been presented based on various properties of soil.

- It is observed that with the increase of Fly ash and GGBFS percentage, optimum moisture content goes on decreasing, while maximum dry density goes in increasing.
- The addition of 15% of Fly ash and 10% of GGBFS and 3% of Silica Fume changes the soil group from CH to ML group according to IS1498:1970.
- The shear stress increases with addition of 15% Fly ash and 10% GGBFS and 3% Silica Fume tends to decrease beyond this limit.
- The CBR value increases with increases in amount of Fly ash and GGBS and Silica Fume attained maximum value at 20%,20%,3 % respectively.
- It is concluded that the use of 15%of Fly ash and 10% of GGBS and 5% by weight of soil is recommended for better result.
- It is also concluded that combined use of Fly ash, GGBFS and Silica Fume can be advantageous when compared to using them individually.

REFERENCES

1. Ref. IS: 2720 (Part 2) -1973, for moisture content.

2. Ref. IS: 2720 (Part 7) - 1974, for standard proctor test.

3. Ref. IS: 2720 (Part 16) - 1987 (Re-affirmed 2002), for CBR

4. IS: 2720 -Part 3-1980," Determination of Specific gravity

5. Dayalan. J. Comparative study on Stabilization of soil with fly ash and Ground Granulated Blast Furnace Slag (GGBS). Int. Res. J. Eng. Technol. (Irjet.) 2016, 3, 2198–2204.

6. Ashish Kumar Pathak, Dr.V.Pandey, (2014), "Soil Stabilization Using Ground Granulated Blast Furnace Slag", International Journal of Engineering Research and Application, Vol-4, issue-4, May-2014, pp, 164-171.

7. Anil Kumar Sharma, A.M.ASCE; and P.V.Sivapullaiah (2016), "Fly ash GGBS mixture foe Geotechnical and Geo-Environmental Applications", GSP 272.

8. Kumar, BRP.,Sharma, RS., (2004). "Effect of flyash on engineering properties of expansive soils", J Geotech Geoenivronmental Engineering ASCE 130(7): pp 764-767.

9. Asish Kumar Pathak, Dr.V.Pandey, (2014), "Soil Stabilization Using Ground Granulated Blast Furnace Slag", International Journal of Engineering Research and Applications, Vol4, Issue4, May 2014, pp.164-171.

10. Oormila T.R., Preeti.T.V. (2014), "Effect of Stabilization Using Flyash and GGBS in Soil Characteristics", International Journal of Engineering Trends and Technology (IJETT) – Volume 11 Number 6 - May 2014,pp 284-289.

11. Karthik.S, etal. (2014),,"Soil Stabilization by Using flyash", ISOR Journal Of Mechanical and Civil Engineering, Vol 10, Issue 6, PP 20-26.

12. Laxmikanth yadu and Dr. Tripathi.R.K.,(2013), " Effects of Granulated Blast Furnace Slag in the Engineering Behavior of stabilized soft soil" International Conference in Chemical, Civil and Mechanical Engineering, Procedia Engineering 51(2013) pp125-131.

13. Bhuvaneshwari.S, Robinson.R.G, Gandhi.S.R (2005) "Stabilization of Expansive Soils Using Flyash" Fly Ash India, New Delhi.