Study of mix design of Fly ash, Quarry dust, GGBS for Soil Stabilization

Mix design of stabilizers for soil stabilization

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Abstract : Black cotton soil always shows the nature of swelling or shrinking ultimately. It's depends on its moisture content. Because of this kind of characteristics of soil, the structures constructed over this type of soil may leads to problems of cracks development . It is there for necessary to stabilize the soil, Before any construction work carried out on this soil, it need to maximize its engineering properties. waste materials like fly ash from thermal power plant, Quarry dust is a waste from aggregate crushing industries and ground granulated blast-furnace slag from iron industry are in available at various parts of our country. These wastes not only create health problems. There is problem in disposal of these by-products. This project deals with a feasibility study carried out to find the suitability of using waste material i.e. fly ash, quarry dust and ground granulated blast-furnace slag as stabilizing material for improving the engineering properties of black cotton soil. Various tests like , Direct strength test , CBR ,free swell index will performing on the soil samples prepared by using mix proportion of black cotton soil with fly ash, quarry dust and GGBS with different percentages. On the basis of the results obtaining from these tests, it may be concluding that the strength of black cotton soil can be substantially improved by mixing with fly ash, quarry dust and GGBS as stabilizer materials.

Index Terms **- Black Cotton Soil, Soil Stabilization, Fly ash, Quarry dust.**

I. INTRODUCTION

For any land-based structure, the foundation of any structure is always supposed as an important part of structure and a structure can't stand strong without it's foundation. For the strong foundation, the soil has to be stronger, for construction of any structure we must have the proper knowledge about the soil, where we are going to built the structure. For expansive soil we should know the various process of soil stabilization Admixtures that is the various types of stabilizer helps to achieve the required engineering properties. From the beginning of construction work, there are always requirements for improvement of soil properties has come to the light. Ancient civilizations had derived various methods to strengthen the soil. Chinese, Romans and Incas are few of those. Some structures, which they have constructed at that era, still exists.

1.1 Fly ash

Fly ash is a waste material, which is a by-product from the flue gases of a coal fired furnace. These shows close resemblance to the volcanic ashes, these ashes were used as hydraulic cements in ancient time. In general the fly ashes are nano(micro) sized particles which are consist of alumina, silica and iron. These particles are of spherical in shape, which makes them easy to flow and blend, to The fly ash contains both amorphous and crystalline nature of minerals. Its composition varies according to the nature of the coal burned and basically is non-plastic fine silt. In present days, the total utilization of Fly ash is difficult. Fly has a potential material for waste liners. fly ash can also be used as a barrier material if combined with lime and bentonite.

1.2 Quarry dust

Quarry dust is a waste material in powder form from aggregate crushing industries. The quantities of these waste material exists in very large quantity. It has hazardous effect on environment as well as public health.

1.3 GGBS

Ground granulated blast-furnace slag, i.e. GGBS also called slag cement, is made from iron blast-furnace slag. it is nonmetallic hydraulic cement . It consists of silicates and alumino silicates of calcium developed in a molten condition simultaneously with iron in a blast furnace. The molten slag at a temperature of about 1500°C (2730°F) is rapidly chilled by rapidlydeeping in water to form a glassy material, glassy sand like granulated material. The granulated material, it has size less than 45 microns, has a surface area fineness of about 400 to 600 m2/kg

II. LITERATURE REVIEW

Sridevi G. and Sreerama Rao A. (2014) studied that the GGBS-stabilized expansive soil, tests are taken on soil with and without lime, as a cushioning material is effective in reducing the heave of the underlying soil bed apart from improving the soaked CBR test and increases the unconfined compressive strength of the soil, system with GGBS mix .

Dr. Robert M. Brooks (2009) studied effect of fly ash and rice husk ash (RHA) in stabilization expansive soil. The test result showed stress strain behavior of unconfined compressive strength showed that failure stress and strains increased by 106% and 50% respectively when the fly ash content was increased from 0 to 25%. When content of rice husk ash was increased from 0 to 12%, results shown change in unconfined compressive stress. There were an increment in Unconfined Compressive Stress by 97% while CBR improved by 47%. Therefore, 12% content of rice husk ash and 25% content of fly ash are recommended for improving engineering properties of the expansive sub-grade soil. About 15% content of fly ash is recommended for mixing into RHA to form a swell reduction layer because of it's good performance in the laboratory tests. [2]

Ashish Kumar Pathak et.al (2014) studied effect soil stabilization using ground granulated blast furnace slag on soil properties. GGBS are added from0% to 25% by dry weight of soil, check the all soil property at 0 % (no GGBS) and then compare after addition of GGBS from 5% to 25%. The various researches has showed that, the soil has improved because of addition of GGBS . The addition of GGBS resulted in a considered improvement within the test ranges covered in the programs.Theoptimum moisture content decreased with increasing GGBS content and The maximum dry density increased at 25% got the maximum value of dry density. Tri-axial test result indicated that with the increases of GGBS percentage cohesion (C) decreasewhile angle of internal friction (Ø)increases considerably, thus making the soil less cohesive and more resistant. [3]

MATERIAL: THE SOIL SAMPLE USED IN THE STUDY WAS TAKEN FROM CHUTTUGUNTA, GUNTUR DIST., IN ANDHRA PRADESH. WHILE COLLECTING THE SOIL, THE PRECAUTION IS TAKEN THAT IT DID NOT CONTAIN ANY KIND OF ORGANIC MATTER. THE GROUND GRANULATED BLAST FURNACE SLAG WAS TAKEN FROM THE INDUSTRY

III. SCOPE OF STUDY

Multiple mix proportion of these chemical stabilizing agents, vigorous laboratory experimentation can be performed in order to formulate guidelines for mix design of chemical agents for soil stabilization.
Soil stabilization is very important for industry practices, especially for construction jobs for example road construction, building construction.
It is used for optimize the soil's physical properties like sheer strength, to prevent shrinking & swelling due to moisture & other environmental stimulus

IV. OBJECTIVES

i. To optimize the mix proportion of Fly ash, GGBS & Quarry dust for soil stabilization.
ii. To study new binder alternatives based on industrial byproducts for use in stabilization
iii. To help for minimize the disposal problem of industrial waste such as Fly ash, GGBS etc
iv. The objectives of this study is to investigate the effect of GGBS on plasticity and swell potential of expansive soil (black cotton soil) and provide a comprehensive stabilization of soils.

I. RESEARCH METHODOLOGY

i. Collection of sample from site
ii. Laboratory experiment on sample soil
iii. Collection of experimental data of pure sample (without any admixture)
iv. Taking various proportion of GGBS and stabilize the sample.
v. Tests on stabilized soil having various mix proportion of stabilizer.
vi. Shear strength test, standard proctor test etc, free swell index test.
vii. Compare test results select the appropriate mix proportion.
viii. Selection of mix proportion of soil and GGBS giving higher stability
ix. Conclusion

3.1 Data and Sources of Data

Sr. No	Mix proportion	Designation	Percentage of stabilizer in mix proportion		
			GGBS	Flyash	Quarry dust
1	Soil	MP0	0 %	0 %	0 %
2	Soil + GGBS (3%) – FA (3%) – QD (3%)	MP1	3 %	3 %	3%
3	Soil + GGBS (5%) – FA (5%) – QD (5%)	MP2	5%	5 %	5 %
4	Soil + GGBS (2%) – FA (6%) – QD (4%)	MP3	2 %	6 %	4 %
5	Soil + GGBS (2%) – FA (4%) – QD (6%)	MP4	2 %	4 %	6 %
6	Soil + GGBS (2%) – FA (12%) – QD (6%)	MP5	2 %	12 %	6 %

7	Soil + GGBS (2%) – FA (6%) – QD (12%)	MP6	2 %	6 %	12 %

On the prepared mix proportions following test are conducted.

- Standard Proctor Test
- Direct Shear Test
- Free Swell Index Test
- Analyze the result obtaining from these tests with basic properties of black cotton soil. After analyzing the result choose appropriate mix proportion for soil stabilization

3.2 Materials

In the present investigation, expansive black cotton soil was procured from a site having Wakdewadi, Pune, Maharashtra. The black cotton soil was collected by method of disturbed sampling after removing the top soil at 500 mm depth and transported in sacks to the laboratory. Some amount of the sample was sealed in polythene bag for determining its natural moisture content. The soil was air dried, pulverized and sieved with 4.75 mm as required for laboratory test. Following are the properties of black cotton soil

3.3 Test performed

3.3.1 Specific gravity

Specific gravity test confirming to **IS 2720: Part 3 / Sec 1: 1980**. The specific gravity of soil is the ratio between the weight of the soil and weight of equal volume of water. With the help of a volumetric flask it is measured in a very simple experimental setup where the volume of the soil is found out and its weight is divided by the weight of equal volume of water.

M_1- Mass of bottle in gms
M_2- Mass of bottle + Dry soil in gms
M_3- Mass of bottle + Soil + Water
M_4- Mass of bottle + Water
Specific gravity is always measured in room temperature and reported to the nearest 0.

Table 3.1: Observations of Specific gravity

Sample number	1	2	3
Mass of bottle in gms (M_1)	631	631	631
Mass of bottle + Dry soil in gms (M_2)	995	1004	998
Mass of bottle + Soil + Water (M_3)	1725	1738	1714
Mass of bottle + Water (M_4)	1521	1520	1525
Specific Gravity	2.275	2.406	2.026
Average Specific Gravity	2.248		

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3.3.2 Standard Proctor Test

This test confirming to **IS 2720: Part 7: 1980**. Proctors test is carried out to determine compaction of soil to understand compaction characteristics of different soils with change in moisture content. Compaction is the process of densification of soil by reducing air voids. The dry density is measured by its degree of compacton. At the optimum moisture content the maximum density is achieved.

This experiment gives a relationship between the dry density of the soil and the moisture content of the soil. The experimental setup consists of (i) cylindrical metal mould (internal diameter- 10.15 cm and internal height-11.7 cm), (ii) detachable base plate, (iii) collar (5 cm effective height), (iv) rammer (2.5 kg). To drive out the air from the voids with the compaction process. It increase the bulk density. The theory used in the experiment is that for any compaction the dry density depends upon the moisture content in the soil. We get the maximum dry density (MDD) when the soil is compacted at high moisture content and almost all the air is driven out, this moisture content is called optimum moisture content (OMC). we can obtain the OMC and MDD. The following equations are used for this experiment:

Table 3.3 observation table of standard proctor test

Title	Container No					
	12	4	5	19	11	3
Mass of container + Weight soil (gm)	28	23	18	18	16	19
Mass of container + Dry soil (gm)	27	22	17	17	15	17
Mass of water (gm)	1	1	1	1	1	2
Mass of container (gm)	10	9	8	9	10	9
Mass of Dry soil (gm)	17	13	9	8	5	8
Water Content (%)	5.88	7.69	11.1	12.5	20	25

Density (gm)

Title	Container no					
	12	4	5	19	11	3
Mass of mould + Compacted soil (gm)	7029	7076	7123	7152	7302	7365
Mass of mould (gm)	5630	5630	5630	5630	5630	5630
Mass of Compacted soil (gm)	1399	1446	1493	1522	1672	1735
Bulk Density (gm/cm^3)	1.48	1.53	1.58	1.61	1.77	1.83
Dry Density(gm/cm^3)	1.39	1.42	1.42	1.43	1.480	1.46
Optimum Moisture Content (%)	20					
Maximum Dry Density (gm/cm^3)	1.48					

3.3.4 Consistency of soil

Soil consistency is vary for various moisture contents to mechanical stresses . It is commonly measured by feeling and molding the soil by hand or by pulling a tillage instrument through it. The description of consistency of soils is generally at three soil moisture levels: wet, moist and dry. Atterberg Limits are basic measure given for the nature of a fine-grained soil. Its depemd on the water content in the soil, it can be seen in four states: solid, semi-solid, plastic and liquid. In each state, consistency of the soil is different, changes from one consistency to another. liquid limit and plastic limit are important Atterberg Limits and so are its engineering properties. Thus, the border between each of state can be defined as follow.

- Shrinkage Limit: Shrinkage limit (SL) can define as water content where any extra loss of moisture will not result in any more volume reduction. ASTM International D4943 have given the standard for testing the shrinkage limit.. Shrinkage limit is used less than the liquid and plastic limits.
- Liquid limit (LL): It can defined as the percentage of water present in the at which a soil changes with decreasing water content from liquid to plastic consistency or with increasing percentage of water in soil from plastic to liquid consistency. It is the percentage of water present in soil at which a soil changes from plastic to liquid behavior. The importance of this liquid limit test is to classification of soils.

- Plastic limit (PL): it is defined as the percentage moisture content at which a soil changes with decreasing water content from the plastic to the semi-solid consistency or with increasing percentage of water from the semi-solid to the plastic consistency. At the end of plastic state plastic limit occur. A fraction percent of increase in moisture above the plastic limit decrease the cohesion of the soil. ASTM standard test method D 431 has defined the plastic limit standards for testing. It changes with the amount of water present in the soil. Such change in soil consistency can be measured in the laboratory. Following procedures used to determine the Atterberg Limits. This limit related to the moisture content at which a soil sample

3.3.5 Determination Of Liquid limit

This test confirming to **IS 2720: Part 5: 1985.** The Casagrande tool used to cuts a groove of size 2mm wide forming at the bottom of the appratus .it is 11 mm wide at the top ,8 mm in height. The number of blows used for the soil samples when the soil come in contact is noted down. Graph is plotted taking number of blows on a logarithmic scale and water content on the ordinate. Liquid limit to match 25 blows from the graph.

4.1RESULTS

4.1.1 Standard Proctor Test

Table3.4.1 shows a result of compaction test performed on black cotton soil, soil treated with addition of mix proportions of GGBS, Fly ash and Quarry dust

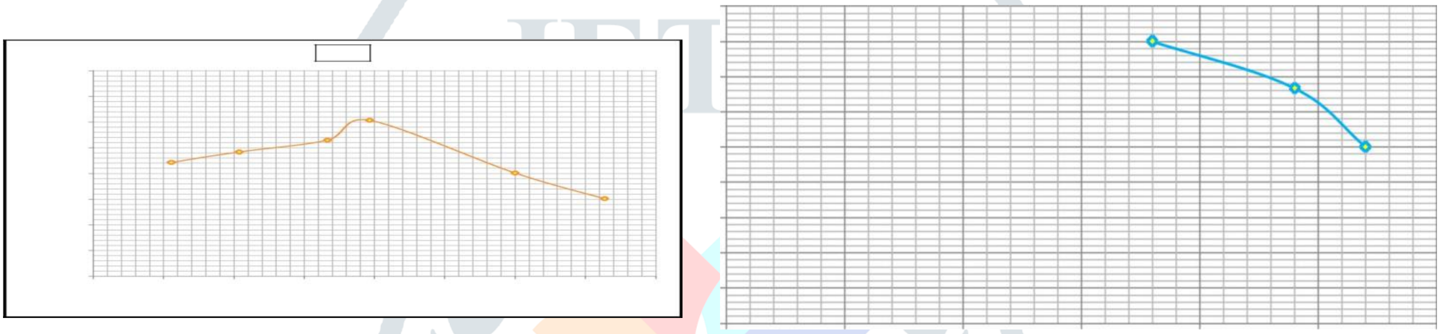

FIGURE 4.1.1: COMPACTION CURVE OF SOIL TREATED WITH MP1

- From the result, it observed that soil treated with mix proportions is increased dry density and decreased optimum moisture content. For Soil treated using mix proportions MP1, MP2, MP3, MP4, MP5 and MP6 MDD increased by 1.35 %, 4.05 %, 4.93 %, 4.26 %, 11.49 % and 6.69% and OMC decreased by 1.75%, 5.45%, 14.15%, 10.1%, 17.2% and 16.9% respectively.
- From compaction curve MP1 and MP2, it is observed that increase equal percentage of all stabilizers in mix proportion increased MDD and decreased OMC value.
- Comparing compaction parameter for MP3, MP4, MP5 and MP6 it is observed that increase in fly ash content affects the MDD and OMC value. Incrementing fly ash content affected the compaction parameters as fly ash is fine material and can easily occupy the void spaces in soil mass.

4.2 CONCLUSION

Based on the obtained results and discussion thereof following conclusions can be made.

- All mix proportion gives result as increases the MDD and decreases OMC as compared to untreated soil.
- Increment of fly ash content in MP3 and MP5 gives increase value in MDD 0.65% and 4.50% as compared to increment of quarry dust content.
- Increase the equal amount of percentage in mix proportion it increase MDD and decreases OMC.
- The mix proportion [Soil + GGBS (2%) – FA (12%) – QD (6%)] having highest percentage of fly ash gives MDD and OMC of treated soil is 1.65 gm/cm^3 and 16.56% respectively.

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