AN EXPERIMENTAL ANALYSIS ON STABILIZATION OF EXPANSIVE SOIL WITH STEEL SLAG AND FLY ASH

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ABSTRACT
This paper deals about the stabilization of expansive soil on experimental basis. The stabilization of expansive soil is required because their volume can be change due to the variation in moisture content on it, which leads to either shrink or swell while the soil is in dry or wet condition respectively. The stabilization of expansive soil is assessed by the presence of different percentage of steel slag and fly ash on the expensive soil and the performance of modified expansive soil is evaluated using index properties test, permeability test, compaction test and unconfined compressive strength test. Based on this performance tests, optimum amount of steel slag and fly ash on expensive soil is also determined.

KEYWORDS: *Expensive Soil, Moisture Content, Stabilization, Steel Slag & FlyAsh.*

I. INTRODUCTION

The expansive nature of the clay is less near the ground surface where the profile is subjected to seasonal and environment changes. The more water they absorb the more their volume increases. Expansive soils also shrink when they dry out. Fissures in the soil can also develop. These fissures help water to penetrate to deeper layers when water is present. This produces a cycle of shrinkage and swelling that causes the soil to undergo great amount of volume changes [1]. Actually the soil which unstable for taking the load, fails due to shear, crushing or shows excessive settlement can be taken as "unstable". The main objective is to increase the strength or stability of soil and to reduce the construction cost by making best use of the locally available materials. Stabilization of expansive soil has been done by addition of different types of industrial wastes like, phosphogypsum (Mishra and Mathur, 2004), copper slag(Havanagi et al., 2006), cement kiln dust (Peethamparan and Olek, 2008), rice husk ash and marble dust(Sabat and Nanda, 2011), bagasse ash and lime sludge(Sabat, 2012), ceramic dust(Sabat, 2012), brick dust and lime(AbdmEL-Aziz and Abo –Hoshma, 2013), steel mill dust (Meshida et al., 2013), ground polyvinyl waste(Oyekan et al. 2013) and silica fume(Negi et al. 2013) etc [2]. In this paper, the expansive soil is embedded with different proportion of steel slag and fly ash. Various tests are carried out on the modified expansive soil to find the index properties, permeability, maximum dry density and shear strength parameter of soil.

II. LITERATURE REVIEW

Gyanen Takhelmayum et.al. evaluated that the compaction and unconfined compressive strength of stabilized black cotton soil using fine and coarse ground granulated blast furnace slag (GGBS). A series of compaction test were carried out using mini compaction mould for different combination of soil along with fine and coarse ground granulated blast furnace slag (GGBS) mixtures [3].
LaxmikantYadu and Dr.R.K.Tripathi investigated the potential of using industrial wastes materials in the field of geotechnical engineering. They preferred four types of admixture to stabilize the soil GBS and Fly ash. They mix the admixture in different combination. They assumed some percentage of admixtures to mix the soft soil. In GBS they assumed 3%, 6%, 9% and 12%. In Fly ash they assumed

3%, 6%, 9% and 12%. They added to soil and they take a test on compaction test and CBR. The optimum amount of GBS with Fly ash was determine as 3% Fly ash + 6% GBS [4].

Vinay Agarwal and Mohit Guptha said that addition of marble dust decreases liquid limit, plasticity index and shrinkage index, increase plastic limit and shrinkage limit [5].

Dr.A.S.Wayal et.al. presents experimental results on the use of bentonite and lime in stabilizing dune sands. The results showed substantial improvements in unconfined compression strength with addition of 15% bentonite and 3% lime [6].

Oormila.T.R and T.V.Preethi evaluated that the different percentages of flyash (5, 10%, 15% and 20%) and GGBS (15%, 20%, 25%) was added to find the variation in its original strength. Based on these results CBR test was performed with the optimum flyash, optimum GGBS and combination of optimum flyash with varying GGBS percentages (15%, 20%, and 25%). From these results, it was found that optimum GGBS (20%) gives the maximum increment in the CBR value compared with all the other combinations [7].

Er. Pratibha Panwar and Dr. Ameta N.K. attempted to stabilize this soil with the aid of lime and bentonite. Standard Proctor test, unconfined compressive strength, in addition to some preliminary tests was conducted for assessing the suitability of limebentonite mix with dune sand. The development of the strength in dune sand stabilized with bentonite and lime depends on the mix composition curing environment and curing time, of these curing environment appears to have the greatest influence on the strength development [8].

Emilliani Anak Geliga and Dygku Salma Awg Ismail discribed the different proportion of fly ash and soil sample understanding of the properties of fly ash is gained from the study and the test indicates an improved strength and better properties of soft soil when stabilized [9].

Kiran B Biradar described the properties of clayey soil with the addition of Fly ash and Steel slag. Fly ash and Steel slag are blended with unmodified soil in varying percentages to obtain the optimum percentage of admixture required for the soil stabilization. In this comparative study laboratory tests such as Atterberg's limit, Compaction test and CBR test were carried out for both modified and unmodified clayey soil [10].

Laxmikant Yadu and R.K. Tripathi was evaluated the performance of GBS with fly ash modified soils using compaction and California bearing ratio (CBR) test. Based on these performance tests, optimum amount of GBS with fly ash was determined as 3% fly ash + 6% GBS. Reasonable improvement has been observed for unsoaked and soaked CBR value of soils with this optimum amount [11].

Karthik. S, et.al., were conducted test on soils and soil–Fly Ash mixtures prepared at optimum water content of 9% .Addition of Fly Ash resulted in appreciable increases in the CBR of the soil. For water contents 9% wet of optimum, CBRs of the soils are found in varying percentage such that 3,5,6and 9.We will found optimum CBR value of the soil is 6%.Increment of CBR value is used to reduce the thickness of the pavement. And increasing the bearing capacity of soil [12].

III. PROBLEM DEFINITION

The previous literature studies focused on the use of industrial wastes materials in the stabilization of expansive soil to reduce the swelling and shrinkage and to improve the strength of the soil. Here, the work was carried out to find the percentage of steel slag and fly ash in the expansive soil through the performance test on it.

IV. EXPERIMENTAL INVESTIGATION

4.1. Index Properties of soil

The following table illustrates the index properties of the expansive soil.

Table 1. Index properties of the expansive soil.

SOIL PROPERTIES	DESCRIPTION
Field moisture content	16.5%
Liquid limit	53%
Plastic limit	29.17%
Shrinkage limit	13.28%
Plasticity index	23.83%
Free swelling index	76%
Specific gravity	2.34
Indian standard soil classification	CH-MI
Bulk Unit weight	16.7kN/m^3

4.2. Standard Proctor Compaction Test

Take about 3kg of air dried soil. Sieve the soil thorough 4.75mm sieve. Take the soil that passes through the sieve for testing. Then add water to it to bring its moisture content to about 8% of fine grained soil. Clean the mould and base plate and apply the grease. Compacted the wet soil in three equal layers by the rammer with 25 evenly distributed blows in each layer. Remove the collar and trim off the soil flush with the top of the mould in removing the collar rotate it to break the bond between it and the soil before lifting it off the mould. Remove the soil from the mould and weight the mould with soil and base plate. Repeat the above procedure with 12% and 16% of water to the test sample. From the experiment, the maximum dry density is 17.5 kN/m^3 and Optimum moisture content is 10% .

4.3. Permeability Test

Compact the soil sample into the mould at a given dry density and moisture content by a suitable device. Place the specimen centrally over the bottom porous disc and filter paper. Place a filter paper, porous stone and washer on top of the soil sample and fix the top collar. Connect the stand pipe to the inlet of the top plate. Fill the stand pipe with water. Connect the reservoir with water to the outlet at the bottom of the mould and allow the water to flow thorough and ensure complete saturation of the sample. Open the air value at the top and allow the water to flow out so that the air in the cylinder is removed. Fix the height h1 and h2 on the pipe from the top of the water level in the reservoir. When all the air has escaped. Close the air value and allow the water from the pipe to flow thorough the soil and establish a steady flow. Record the time required for the water head to fall from h1 to h2. Change the height h1 and h2 and record the time required for the fall of head. From the conducted experiment, the Permeability of soil is 1.46×10^{-3} m/sec.

4.4. Unconfined Compression Test

The sample is provide using hard ward miniature apparatus and is removed from the sampling tube in the UN disrupted manner. The sample ends are trimmed carefully and is preferably 2 to 2.5 times high as its lateral dimensions. The sample is weight and its testing machine with its vertical axis as near the center of the loading plates as possible. The meaning dials are adjusted to zero and the proving ring details are noted. The motor is started and load is applied at a strain rate of 0.05. The load and strain dial gauge readings are recorded simultaneously at frequent intervals to define the stress strain relationship. The test is continued till cracks and well defined failure plane has been developed. Then the specimen is removed. From the conducted experiment, the unconfined compression strength of a soil is 27.15 kN/m^2.

4.5. Preparations of Samples

Using Steel Slag and Fly Ash for stabilization of expansive soil. Assumed admixtures at some percentages of Steel Slag and Fly Ash are added with soil. Steel Slag is assumed 4, 8 and 12% and Fly Ash 3, 6 and 9%. The mixtures were 100% like soil: Steel Slag: Fly Ash (93: 4: 3) etc. All tests should be conducted from this combination. The samples were tested according to the procedures given in relevant IS codes. To prepare the sample as per bulk density of the site and tested the samples weather the reasonable strength is to be occur to change the sample proportions.

Table 2. Proportions of admixtures.

SOIL (%)	STEEL SLAG (%)	FLY ASH (%)
93	4	3
89	8	3
85	12	3
90	4	6
86	8	6
82	12	6
87	4	9
83	8	9
79	12	9

V. RESULTS AND DISCUSSIONS

5.1. Index Properties of soil

After adding an admixture with an untreated soil the following readings are obtained. To determine the properties using the combination of 4% steel slag + 6%fly ash. Because the optimum amount of compaction and compression are obtained in that percentage so we choose to determine the index properties of soil. Values of normal soil are Liquid limit is 53%, Plastic limit is 21.17%, Plasticity index is 23.83% and Shrinkage limit is 13.28%.

Table 3. Variations of liquid limit using Admixture in (%)

STEEL SLAG (%) / FLY ASH (%)	4%	8%	12%
3%	50.2	47.64	44.32
6%	42	41.3	42.62
9%	41.8	42.31	43.02

Table 4. Variations of plastic limit using Admixture in (%)

STEEL SLAG (%) / FLY ASH (%)	4%	8%	12%
3%	21.10	19.80	17.60
6%	15.15	14.23	14.92
9%	15.03	16	16.8

Table 5. Variations of plasticity index using Admixture in (%)

STEEL SLAG (%) / FLY ASH (%)	4%	8%	12%
3%	29.1	27.84	26.72
6%	26.85	27.07	27.70
9%	26.77	26.31	26.22

Table 6. Variations of shrinkage limit using steel slag and fly ash in (%)

STEEL SLAG (%) / FLY ASH (%)	4%	8%	12%
3%	9.98	8.92	8.25
6%	7.98	7.23	8.02
9%	8.87	9.32	9.68

5.2. Standard Proctor Compaction Test

The untreated soil sample have the Maximum dry density is 17.5 kN/m^3 for Optimum moisture content 10%. After added an admixture by prepared amount of soil-steel slag-fly ash to determine the MDD and OMC value of treated soil is given below by table

Table 7. Variation of MDD with Admixtures in (%)

STEEL SLAG (%) / FLY ASH (%)	4%	8%	12%
3%	16.8	16.3	15.45
6%	16.1	15.55	14.70
9%	15.3	14.70	14.5

Table 8. Variation of OMC with Admixture in (%)

STEEL SLAG (%) / FLY ASH (%)	4%	8%	12%
3%	15.85	15.70	15.80
6%	15.1	16.4	16.45
9%	19.8	19.85	19.95

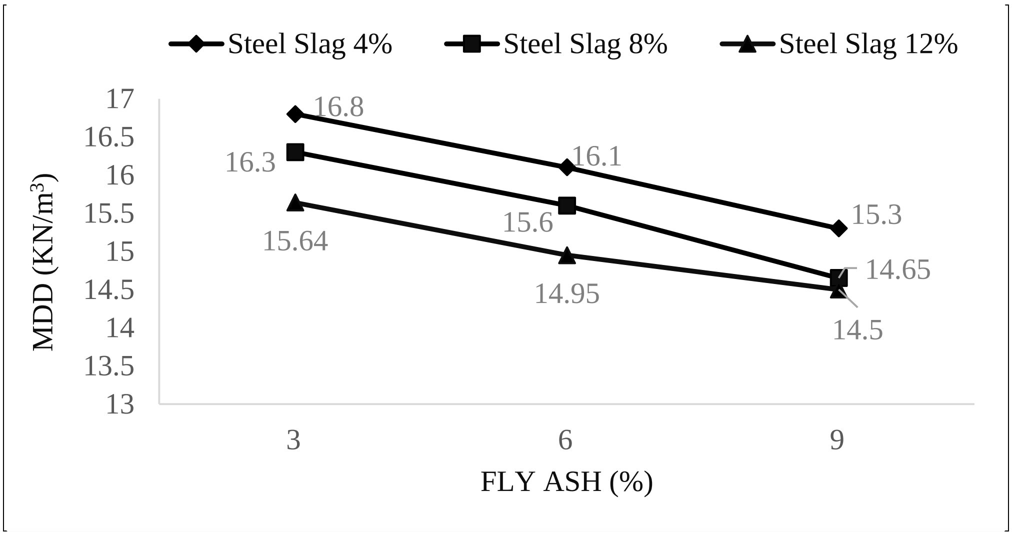

Figure 1. Variation of MDD with Steel Slag and Fly Ash

From the figure 1, maximum dry density (MDD) is decreased with increasing in the percentage of steel slag and fly ash mixture.

5.3. Permeability Test

The determination the permeability is to find the air voids from the collecting sample. The corresponding value are obtained from the without mixture of admixtures.

Table 9. Variations of permeability with Admixture in (m/sec)

STEEL SLAG (%) / FLY ASH (%)	4%	8%	12%
3%	1.46×10^{-3}	1.43×10^{-3}	1.39×10^{-3}
6%	1.42×10^{-3}	1.40×10^{-3}	1.37×10^{-3}
9%	1.45×10^{-3}	1.43×10^{-3}	1.38×10^{-3}

In this experiment to increase the steel slag is to fill the air voids in the soil – fly ash. To mixture the combinations of steel slag – fly ash the value of coefficient of permeability is to be gradually reduced were increasing the percentage of steel slag.

5.4. Unconfined Compression Test

The unconfined compressive strength of untreated soil is 27.15 kN/m^2. After determination of untreated soil to mix the different combinations of soil-Steel Slag-Fly Ash with an expansive soil to determine the unconfined compression strength.

Table 10. Variation of unconfined compression with Admixture in (kN/sq-m)

STEEL SLAG (%) / FLY ASH (%)	4%	8%	12%
3%	26.6	24.52	19.23
6%	29.12	24.96	18.97
9%	26.34	23.67	19.98

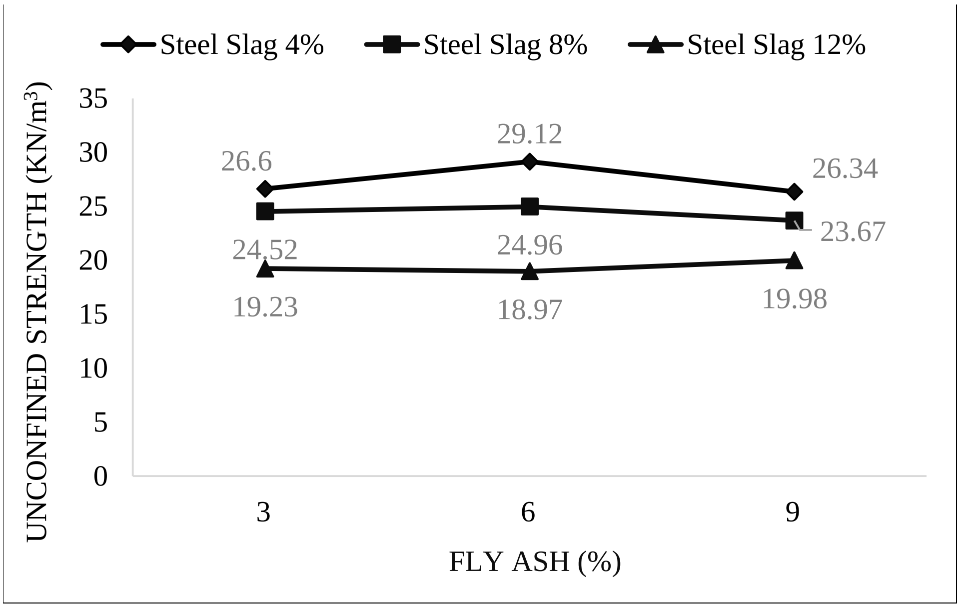

Figure 2. Variations of unconfined strength with steel slag and fly ash

The unconfined compression strength was determined in the laboratory of all trial mixture. Variations of compression strength of the mixtures are shown in figure 2. From this figure, the unconfined strength is increased with the percentage increase of mixtures upto certain limit and decreases further.

VI. CONCLUSIONS

An experimental investigation was carried out to study the improvement in geotechnical properties of an expansive soil stabilized with steel slag and fly ash. The following conclusions are drawn from this study.

- The cohesion goes on decreasing and the angle of internal friction goes on decreasing with the increase in percentage of addition of steel slag – fly ash mixtures.
- The index properties of liquid limit, shrinkage limit, plastic limit and swelling index is decreased adding a steel slag – fly ash.
- To adding the steel slag – fly ash in the permeability is decreased the voids are percent in the soil. The increasing the percentage of steel slag in the mixture is reduces the soil – fly ash air voids. To increasing the steel slag the coefficient of permeability is reduced.
- From figure 2, it is found that the unconfined compressive strength of the expansive soil is higher for the mixture 4 % steel slag + 6 % fly ash and it is concluded as optimum percentage mixture.
- Based on the results, it appears that soft soil can be effectively stabilized with addition of steel slag – fly ash mixtures.

The Scope of future work of this study is to determine the CBR of steel slag and fly ash mixture in both soaked and unsoaked conditions and also to evaluate the temperature effects of steel slag on the soil stabilization process.

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