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Stabilization of Soil by Foundry Sand with Fly-Ash

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ABSTRACT: The complete analysis of the improvement of soil properties and its stabilization using Fly-Ash and Foundry sand. Soil is the basic foundation for any civil engineering structures. It is required to bear the loads without failure. In some places, soil may be weak which cannot resist the oncoming loads. In such cases, soil stabilization is needed. Numerous methods are available in the literature for soil stabilization. In this study 'Fly-Ash and Foundry sand' is mixed with soil to investigate the relative strength gain in terms of bearing capacity and compaction. The effect 'Fly-Ash and Foundry sand' on the geotechnical characteristics was investigated by conducting 'standard proctor compaction tests', 'CBR test'. The tests were performed as per Indian Standard specifications.

KEYWORDS: Stabilization, Permeability, Sustain, Pavement, foundry sand, Fly-Ash.

I. INTRODUCTION

Soil stabilization is a technique aimed at increasing or maintaining the stability of soil mass and chemical alteration of soils to enhance their engineering properties. Stabilization can be used to treat a wide range of sub-grade materials from expansive clays to granular materials. This allows for the establishment of design criteria as well as the determination of the proper chemical additive and admixture rate to be used in order to achieve the desired engineering properties. Benefits of the stabilization process can include higher resistance values, reduction in plasticity, lower permeability, reduction of pavement thickness, elimination of excavation material hauling or handling. Stabilization of expansive soils with admixtures controls the potential of soils for a change in volume, and improves the strength of soils. In the field of geotechnical engineering, it has long been known that swelling of expansive soils caused by moisture change result in significant distresses and hence in severe damage to overlying structures. Expansive soils are known as shrink swell or swelling soils. Different clays have different susceptibility to swelling. Such soils expand when they are wetted and shrink when dried. This movement exerts pressure to crack sidewalks, basement floors, pipelines and foundations. In developing country like India, due to industrial development there is an increase in a demand for energy which has resulted in construction of considerable coal-burning power plants. This development brought with the problem of safe disposal or beneficial utilization of large quantities of by-product like fly ash every year and there is a signal requirement to be carried out toward management of fly ash disposal and utilization.

Foundry sand is high-quality uniform silica sand that is used to make molds and cores for ferrous and nonferrous metal castings. The metal casting industry annually uses an estimated 100 million tons of foundry sand for production. Over time, foundry sands physically degrade until they are no longer suitable for molds. Consequently, 9 to 10 million tons of sand is discarded each year. However, the discarded foundry sands have remarkably consistent composition and are typically considered higher

II. LITERATURE REVIEWS

S.Bhuvaneshwari and S.R. Gandhi [2013] Studied the effect of engineering properties of expansive soil through an experimental programme. Infrastructure projects such as highways, railways, water reservoirs, reclamation etc.

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requires earth material in very large quantity. In urban areas, borrow earth is not easily available which has to be hauled from a long distance. Quite often, large areas are covered with highly plastic and expansive soil, which is not suitable for such purpose. Extensive laboratory / field trials have been carried out by various researchers and have shown promising results for application of such expansive soil after stabilization with additives such as sand, silt, lime, Fly Ash, etc. As Fly Ash is freely available, for projects in the vicinity of a Thermal Power Plant, it can be used for stabilization of expansive soils for various uses. The present paper describes a study carried out to check the improvements in the properties of expansive soil with Fly Ash in varying percentages. Both laboratory trials and field tests have been carried out and results are reported in this paper. One of the major difficulties in field application is thorough mixing of the two materials (expansive soil and Fly Ash) in required proportion to form a homogeneous mass. The paper describes a method adopted for placing these materials in layers of required thickness and operating a “Disc Harrow”. A trial embankment of 30m length by 6m width by 0.6m high was successfully constructed and the in-situ tests carried out proved its suitability for construction of embankment, ash dykes, filling low-lying areas, etc.

Bhimani (2013) stated that up to 30% we can use foundry sand for economical and sustainable development of concrete. By using foundry sand, we can save the metal industry disposal costs and produce a ‘greener’ concrete for construction.

Sahu and Gayathri (2012) formulated a composite named “FALS” which was made by judiciously blending fly ash with foundry sand in proper proportion. The foundry sand used in the study is a waste generated from water treatment plants. Lime sludge was added from 5 to The use of stabilized fly ash as a green material in pavement substructure: 50% and the commercially available gypsum was added in 1 and 2% to all the proportions. The effect of adding foundry sand and gypsum to the fly ash on unconfined compressive strength (UCS) was studied. The strength of fly ash continuously increased with the amount of lime sludge added. The chemical analysis of lime sludge also shows that it is rich in calcium oxide and hence can stabilize the fly ash just like commercial lime. They concluded that the beneficial utilization of FALS in geotechnical application presents an opportunity to achieve sustainable utilization of natural and/or conventional resources.

III. EXPERIMENTAL RESULTS

SPECIFIC GRAVITY OF SOIL

The Pycnometer is used for determination of the specific gravity of soil particles of both fine grained and coarse grained soils. The specific gravity of soil is determined using the relation:

$$G = \frac{M_2 - M_1}{(M_2 - M_1) - (M_3 - M_4)}$$

Where M_1 =mass of empty Pycnometer,

M_2 = mass of the Pycnometer with dry soil

M_3 = mass of the Pycnometer and soil and water,

M_4 = mass of Pycnometer filled with water only.

G= Specific gravity of soils.

| No. | DETERMINATION NO | NOTATION | 1 | 2 |
|-----|-------------------------|---|-------|-------|
| 01 | Pycnometer no | | 01 | 22 |
| 02 | Mass of pycnometer | M1 kg | 0.643 | 0.645 |
| 03 | Mass of pyc.+soil | M2 kg | 0.844 | 0.844 |
| 04 | Mass of pyc.+soil+water | M3 kg | 1.781 | 1.789 |
| 05 | Mass of pyc+water | M4 kg | 1.657 | 1.668 |
| 06 | Specific gravity | $G = \frac{M_2 - M_1}{(M_2 - M_1) - (M_3 - M_4)}$ | 2.610 | 2.531 |

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$$\text{AVERAGE SPECIFIC GRAVITY} = \frac{(2.610)+(2.531)}{2}$$

$$= 2.57$$

SPECIFIC GRAVITY OF FLY-ASH

| No. | DETERMINATION NO | NOTATION | 1 | 2 |
|-----|------------------------------|-------------------------------------|-------|-------|
| 01 | Pycnometer no | | 01 | 22 |
| 02 | Mass of pycnometer | M1 kg | 0.644 | 0.644 |
| 03 | Mass of pyc.+fly-ash | M2 kg | 0.844 | 0.844 |
| 04 | Mass of pyc.+ fly-ash +water | M3 kg | 1.770 | 1.769 |
| 05 | Mass of pyc+water | M4 kg | 1.661 | 1.663 |
| 06 | Specific gravity | $G = \frac{M2-M1}{(M2=M1)-(M3-M4)}$ | 2.19 | 2.12 |

$$\text{AVERAGE SPECIFIC GRAVITY OF FLY-ASH} = \frac{(2.19)+(2.12)}{2}$$

$$= 2.15$$

SPECIFIC GRAVITY OF FOUNDRY SAND

| No. | DETERMINATION NO | NOTATION | 1 | 2 |
|-----|------------------------------|-------------------------------------|-------|-------|
| 01 | Pycnometer no | | 01 | 22 |
| 02 | Mass of pycnometer | M1 kg | 0.646 | 0.646 |
| 03 | Mass of pyc.+ foundry sand | M2 kg | 0.846 | 0.845 |
| 04 | Mass of pyc.+ fly-ash +water | M3 kg | 1.770 | 1.769 |
| 05 | Mass of pyc+water | M4 kg | 1.661 | 1.663 |
| 06 | Specific gravity | $G = \frac{M2-M1}{(M2=M1)-(M3-M4)}$ | 2.29 | 2.42 |

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$$\text{AVERAGE SPECIFIC GRAVITY OF FOUNDRY SAND} = \frac{(2.29)+(2.42)}{2}$$

$$= 2.355$$

STANDARD PROCTOR TEST OF SOIL SAMPLE WITH 1% FLY-ASH AND 0.25% FOUNDRY SAND:

The test consists in compacting soil at various water contents in the mould, in three equal layers, each layer being given 25 blows of the 2.5 kg rammer dropped from a height of 30.5cm. The dry density obtained in each test is determined by knowing the mass of the compacted soil and its water content. The compactive energy used for this test is 6065 kg cm per 100 ml of soil.

We get 3kg of oven dried soil passing through 4.75 mm sieve is then taken and thoroughly mixed with water. The quantity of water to be added initially depends upon the probable optimum water content for the soil. The initial water content is taken about 4% for the used samples of fly ash. The empty mould attached with the base plate is weighted without collar. The collar is then attached to the mould. The mixed and matured soil is placed into eh mould and compacted by giving 25 blows of the rammer uniformly distributed over the surface, such that the compacted height of the soil is about 1/3 the height of the mould. The second and the third layers are similarly compacted, each layer being given 25 blows. The last layer should not project more than into the collar. The collar is removed and the top layer is trimmed off to make t level with the top of mould.

The weight of the mould, base plate and the compacted soil is taken. A representative sample is taken from three different layers of the mould, one from the top layer, other from the middle section and the third from the bottom section of the mould, and kept for water content determination. The bulk density and the corresponding dry density for the compacted soil are calculated from the following table and graph.

| Trial Number | NOTATIO N | I | II | III | IV | V | VI | VII | VIII |
|---|------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Weight of Soil | | 2.5kg | 2.5kg | 2.5kg | 2.5kg | 2.5kg | 2.5kg | 2.5kg | 2.5kg |
| Weight of mould (without collar) | | 3.675k g | 3.675k g | 3.675k g | 3.675k g | 3.675k g | 3.675k g | 3.675k g | 3.675k g |
| Container Number | | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Weight Of Container | W0 (grams) | 21.24 | 21.8 | 20.55 | 21.68 | 21.52 | 21.72 | 21.29 | 21.07 |
| Weight Of Container + Wet Soil | W1 (grams) | 25.27 | 24.2 | 23.84 | 24.99 | 24.82 | 25.72 | 24.44 | 29.91 |
| Weight Of Container + Oven-dry Soil | W2 (grams) | 24.72 | 23.79 | 23.39 | 24.49 | 24.3 | 25 | 23.85 | 28.03 |
| Weight Of Water | W1-W2 (grams) | 0.55 | 0.41 | 0.45 | 0.5 | 0.52 | 0.72 | 0.59 | 1.88 |
| Weight Of Oven-dry soil | W2-W0 (grams) | 3.48 | 1.99 | 2.84 | 2.81 | 2.78 | 3.28 | 2.56 | 6.96 |
| Density | | 1.707 | 1.754 | 1.862 | 1.929 | 1.979 | 1.993 | 1.988 | 1.958 |

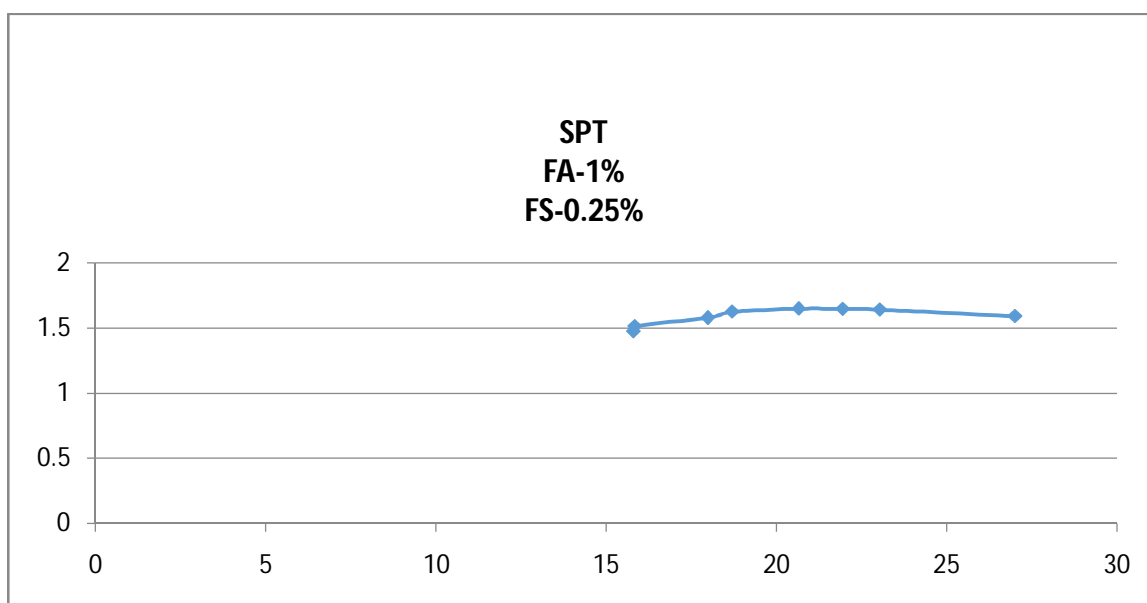
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| | | | | | | | | | |
|-------------------|------------|-------|-------|-------|-------|-------|-------|-------|-------|
| Water Content (%) | W | 15.8 | 15.84 | 17.99 | 18.7 | 20.66 | 21.95 | 23.04 | 27.01 |
| DRY DENSITY | M/V 1+w | 1.474 | 1.514 | 1.579 | 1.625 | 1.649 | 1.647 | 1.642 | 1.591 |



The maximum dry density of soil is 1.665 at 20 % of water content.

CALIFORNIA BEARING RATIO TEST

SOIL SAMPLE WITH 1% FLY ASH & 0.25% FOUNDRY SAND

This is a penetration test developed by the California division of highways as method for evaluating the stability of soil sub Grade and other flexible pavement materials. The CBR test may be conducted in laboratory on a prepared specimen in a mould or in situ in the field. The laboratory CBR apparatus consists of a mould 150 mm diameter with a base plate and a collar, a loading frame with a cylindrical plunger of 50mm diameter and a dial gauge for measuring the expansion on soaking and penetration values.

The load values to cause 2.5mm and 5mm penetration are recorded .These loads are expressed as percentage of standard load values at respective deformation levels to obtain CBR value. For obtain CBR value we used soil sample with 1% FLY ASH and 0.25% foundry sand and the CBR value at 2.5mm and 5mm is given by below table and graph.

| SR.NO | PENETRATION | DIAL READING | LOAD(kg) |
|-------|-------------|--------------|----------|
| 1 | 0.5 | 0.9 | 5 |
| 2 | 1 | 1.3 | 10.3 |
| 3 | 1.5 | 1.9 | 14.9 |
| 4 | 2 | 2.3 | 17.7 |
| 5 | 2.5 | 2.9 | 20.3 |
| 6 | 3 | 3.3 | 22.5 |

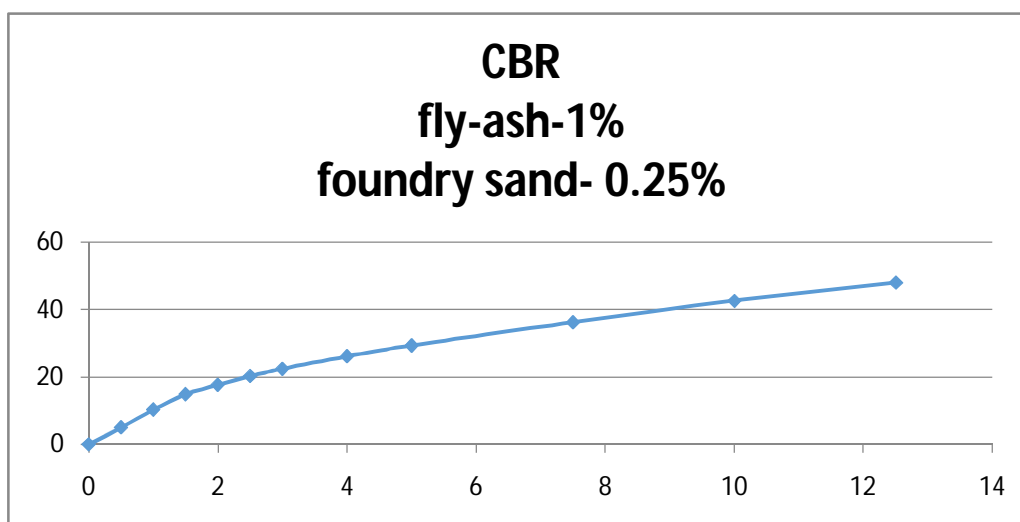
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| | | | |
|----|------|------|------|
| 7 | 4 | 4.4 | 26.2 |
| 8 | 5 | 5.2 | 29.4 |
| 9 | 7.5 | 7.6 | 36.3 |
| 10 | 10 | 10.1 | 42.7 |
| 11 | 12.5 | 12.9 | 48.1 |



1. THE CBR VALUE AT 2.5 MM = 1.503 %

2. THE CBR VALUE AT 5 MM = 1.430%

The CBR Value of soil is = 1.430

IV. CONCLUSION

The stabilized soil can be used as a sub grade, sub base, and base course without aggregate The test result indicates that Fly-Ash and Foundry sand may be used to save natural resources like aggregate and Murom.

- Fly-Ash and Foundry sand can be used as a soil stabilizer to reduce the thickness of sub grade, sub base and base course for road construction as the strength is more if compared with traditional WBM roads.
- In earth roads Fly-Ash and Foundry sand can be used as a soil stabilizer enhanced the Engineering properties of the road and provide smoother surface for vehicle to travel.
- The stabilized soil can be used as a sub grade, sub base, and base course without aggregate The test result indicates that Fly-Ash and Foundry sand may be used to save natural resources like aggregate and Murom.

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2. S.Bhuvaneshwari and S.R. Gandhi (2006) Studied the effect of engineering properties of expansive soil through an experimental programme.
3. Pandian et.al. (2002) Studied the effect of two types of fly ashes Raichur fly ash (Class F) and Neyveli fly ash (Class C) on the CBR characteristics of the black cotton soil. The fly ash content was increased from 0 to 100%.