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Stabilization of Black Cotton Soil Using Fly Ash as an Admixture

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ABSTRACT

Around 20% area of our country and also more or less the world, at large, is covered with swelling soil. Distress of structures due to swelling soil prohibits multi-storied buildings on such areas and as a result of this both cost of construction as well total area under a structure increases remarkably. Besides, safety of the building is also threatened.

Researchers, world over use one or the other type of admixtures to stabilize the swelling soil and restrict its swelling properties. But all the admixtures cannot have the same type of Influence over the swelling soil. Besides the saturating medium may also have an impact on swelling characteristics.

In coastal areas there are long bay-roads which are very near to sea. Seasonally or during tidal surges in the sea, saline water is likely to saturate the soils of those roads. Roads may also remain partially submerged during some period of the year.

Fly ash has been long utilized as an admixture in controlling swelling of expansive soils. In this regard some important engineering tests like differential free swell test and Atterberg's limit tests, standard proctor, CBR, UCC, were conducted on virgin soil and swelling soil-fly ash mix saturated in tap water.

INRODUCTION

Soil is one of the most commonly encountered materials in civil engineering. All the structures except some, which are founded on solid rock, rest ultimately on soil. Geotechnical engineers all over the world face enormous problems, when the soil founding those structures are expansive in nature. This expansiveness is imparted to such soils when they contain clay minerals such as montmorilonite, illite, kaolinite etc. in appreciable quantity. It is due to them (clay mineral) that the swelling soils expand on wetting and are subjected to shrinkage on drying.

The problem of instability of structures constructed on such soil is mainly due to lifting up of the structures on heaving of soil mass (under the foundation) on saturation during rainy season and settlement due to shrinkage during summer season. Due to this cavities are formed leading to loss of contact between the soil and structures at some points. This in turn leads to splitting of structure and failure due to loss of shear strength or unequal settlement.

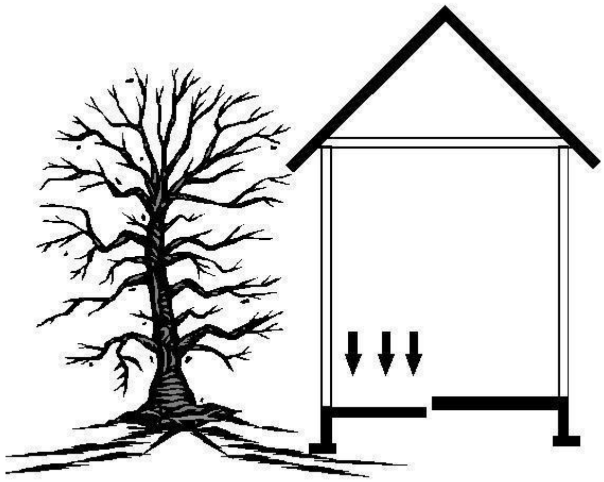

Fig.1

On the contrary, during rainy season when the foundation soil swells it is restrained by the foundation to do so. As a result, an upward swelling pressure is exerted by the soil on the foundation. As this pressure is not uniform everywhere, the net downward pressure becomes uneven. This also leads to unequal settlement, leading to progressive failure of structures.

In saline condition, as the treating of lime to swelling soil has reported to be uneconomic and ineffective, in the present investigation fly ash has been chosen as a stabilizing swelling soil in coastal areas. The other reasons behind the choice of fly ash as a stabilizer are as follows:

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i) Fly ash is costless and abundantly available all over the country.
ii) As fly ash is a by-product of thermal power plants, land area required for its disposition is a great problem in a densely populated country like India.
iii) Utilization of fly ash solves the problem of air and water pollution.

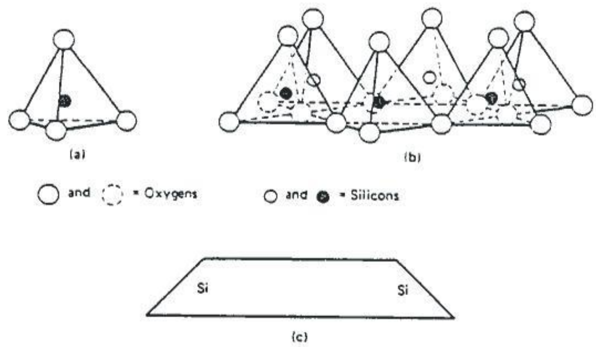
The object of the present investigation is to study the effect of tap water on virgin swelling soil as well as fly ash mixed swelling soil. To it, was mixed fly ash in different proportions by weight from 0%(virgin soil), 10%, 20%, 30% & 40% of fly ash content.

Soil engineering tests like differential free swell test and Atterberg's limit were conducted on virgin soil and soil-fly ash mix. Though it was also required to conduct shear or other strength tests in presence of water.

CLAY MINERALS:

There are two fundamental building blocks for the clay mineral structures. One is a silica tetrahedral unit in which four oxygen or hydroxyls having the configuration of a tetrahedron enclose a silicon atom.

The tetrahedral are combined in a sheet structure so the oxygen of the bases of the entire tetrahedral are in a common plane, and each oxygen belongs to two tetrahedral.



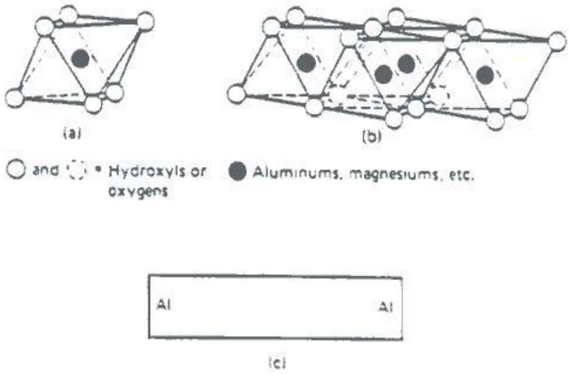
(a) Silica tetrahedron.
(b) Silica tetrahedral sheet.
(c) Schematic of silica sheet. See Table 2-1.

Source: Lambe, 1958; Grim, 1968

Figure 2-1. Clay mineral tetrahedral sheet structure.

Fig 2

The second building block is an octahedral unit in which an aluminium, iron or magnesium atom is enclosed in six hydroxyls having the configuration of an octahedral. The octahedral units are put together into a sheet structure which may be viewed as two layers of densely packed hydroxyls with cation between the sheets in octahedral co-ordination.



(a) Octahedron.
(b) Octahedral sheet.
(c) Schematic of gibbsite octahedral sheet. See Table 2-1.

Source: Lambe, 1958; Grim, 1963

Figure 2-2. Clay mineral octahedral sheet structure.

Fig 3

GROUP OF MINERALS AND THE MOST IMPORTANT MINERAL IN EACH GROUP

S. No	Name of the minerals & group	Structural formula
I	Kaolin Group 1. Kaolinite 2. Hallyosite	$Al_4\ Si_4\ O_{10}\ (OH)_8$ $Al_4\ Si_4\ O_6\ (OH)_{16}$
II	Montmorillonite Group Montmorillonite	$Al_4\ Si_8\ O_{20}\ (OH)_4$ nH_2O
III	Illite Group Illite	$Si_{8-y}\ Al_y\ (OH)_4\ O_{20}$

EXPERIMENTAL WORKS AND PROCEDURES

ATTERBERG'S LIMITS:

LIQUID LIMIT TEST:

EQUIPMENT & ACCESSORIES

Casagrande Liquid Limit device
Grooving Tool
Glass plate
425µ sieve
Spatula
Balance
Water cans & Water

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Fig 4

Fig 5

PROCEDURE

1. Adjust the cup of Liquid Limit apparatus with the help of grooving tool gauge & adjustment plate to give a drop of exactly 1 cm on the point of contact on base.
2. Take about 120g of air dried sample passing through 425µ sieve.
3. Mix it thoroughly with known quantity of distilled water to form a uniform paste.
4. Place a portion of the paste in the cup, smooth the surface with spatula to a maximum depth of 1 cm. Draw grooving tool through the sample along the symmetrical axis at the cup; holding the total perpendicular to the cup.
5. Turn the handle at a rate of 2 revolutions per second & count blows until the two parts of the sample come in contact at the bottom of the groove.
6. Transfer the remaining soil in the cup to the main soil sample & mix thoroughly after adding a small amount of water.
7. Repeat the steps 4, 5 & 6 obtain at least five sets of readings in the range of 10 to 50 blows.

PLSTICLIMIT:
EQUIPMENT & ACCESSORIES

3 mm dia. rod
Balance
Glass Plate
Distilled Water
Oven
Water content cans
425µ sieve

PROCEDURE

1. Take about 30g of air dried sample passing through 425µ sieve.
2. Mix thoroughly with distilled water on glass plate until it is plastic enough to be shaped in to small ball.
3. Take about 10g of plastic soil mass & roll it between the hard & the glass plate to form the soil mass into a thread. If the diameter of thread becomes less than 3mm without cracks, it shows that water added is more than its plastic limit, hence the soil is needed further & rolled into thread again.
4. Repeat the rolling & re-molding process until the thread starts just crumbling at a diameter of 3mm.
5. If crumbling starts before 3mm diameter thread, it shows that water added is less than the plastic limit of soil, hence same more water should be added & mixed to a uniform mass & rolled again, until the thread starts crumbling at a diameter of 3mm.
6. Collect the pieces of crumbled soil thread at 3mm diameter in an air light container & determine moisture content.
7. Repeat the procedure for 2 more steps or samples.

SHRINKAGE LIMIT:
EQUIPMENT & ACCESSORIES

Evaporating dish (2 No's)
Shrinkage dish Glass cup 425µ sieve Mercury
Water content cans & Distilled Water
Glass plate & Spatula

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Fig 6

PROCEDURE

1.Take above 100g of soil sample passing through 425µ is sieved.
2.Place about 30g of soil in evaporating dish and mix it thoroughly with distilled water such that water added will completely fill the voids in the soil and make the soil pasty enough to be readily worked out in to shrinkage dish without entrapping air-bubbles.
3.Weigh the clean and clean & dry shrinkage dish.
4.Place the shrinkage dish in evaporating dish, fill it with mercury, remove the excess mercury, clean the dish & find the weight of mercury in the shrinkage dish. Volume of shrinkage dish will be attained by dividing the weight of mercury by its limit weight. Volume of the wet soil pot will be equal to the volume of shrinkage dish.
5.Apply thin coat of grease on the inside of the dish.
6.Place the soil paste at the centre of dish and tap it on form surface & allow the paste to flow towards edges. Continue the tapping till the soil is compacted and entrapped air is removed. Repeat the process till the dish is completely filled with soil.
7.Weigh the shrinkage dish with wet soil.
8.Keep the dish in air till the color turns from dark to light and then keep it in oven for 24 hours at constant temperature of 105oC.
9.Cool the dish and weigh it immediately.
10.Determine the volume of dry soil pot by immersing it in mercury and measure the volume of mercury displaced.
11.Repeat the procedure for two more samples.

STANDARD PROCTOR TEST:
EQUIPMENT & ACCESSORIES

Cylindrical mould of 1000cc capacity
Metal rammer 2.6kg & hawing a drop of 31cm
Steel straight edge balance
Oven & water content container
Mixing equipment
Sample extruder

Fig 7

PROCEDURE

1.Take about 2.0g for 1000cc mould (10cm dia.) or 4.5kg 2250cc mould (15cm dia.) of air dried & mixed soil.
2.Sieve this soil through 20mm & 4.75mm sieves.
3.Calculate the percentage retained on 20mm & 4.75mm sieved & passing from 4.75mm sieve.
4.Do not use the soil retained on 20mm sieve.
5.Use 10cm diameter mould it percentage retained on 4.75mm sieve is less than 20 or use a mould at 15cm diameter, if percentage retained on 4.75mm sieve is more than 20.
6.Mix the soil retained on & passing through 4,75mm sieve thoroughly.
7.Take about 3.0kg of soil for 1000cc (6kg for 2250cc mould).
8.Add water to it bring its moisture content to about 4% in coarse grained soils & 8% for fine grained soils.
9.Clean dry & grease lightly the mould & base plate; weigh the mould with base. Fit the collar.
10.Compact the wet soil in three equal for 10cm layer by rammer of mass 2.6kg & free fall 31cm with25 evenly distributed blows for 15cm diameter.
11.Remove the collar of the mould & base plate weigh the mould with soil & base plate.

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12.Take a representative sample for which water content determination.
13.Repeat the above procedure till the weight of the soil decrease with increase in water content & tabulate as fallows.

CALIFORNIA BEARING RATIO TEST:
EQUIPMENT & ACCESSORIES

Loading machine
Cylindrical mould (2250cc)
Compaction rammer
Annular weight
Placer disc
Water content cans
Oven & balances

Fig 8

PROCEDURE
A) PREPARATION OF SPECIMEN

1.Take about 7.5kg of dry soil passing through 20mm IS sieve.
2.Mix the soil with water up to the optimum moisture content.
3.Place the placer disc over the base plate & compact the soil in the mould with collar in 3-layer going 55 blows per each layer using a rammer weighing 2.6kg falling from a height of 31cm.
4.Remove the collar & trim off the soil & determine the weight of soil.
5.Turn the mould upside down & remove the placer disc.

B) PENETRATION TEST

1.Keep the annular weights to produce surcharge equal to the weight of base material & pavement expected in actual construction.
2.Place the mould assembly on the loading machine.
3.Seat the mould penetration piston at the centre of specimen.
4.Ste the stress & strain dial gauges to zero. Apply on the penetration plunger at the rate of 1.25mm/min. Record the load reading at penetration 0, 0.5, 1.0, 1.5, 2.0, 2.5,…………..12.5mm.
5.At the end of the penetration test, detach the machine, take a representative soil sample & determine its moisture content.

FREE SWELL INDEX TEST:
EQUIPMENT & ACCESSORIES

Measuring jars
Water
Kerosene
Balance
425µ sieve

Fig 9

PROCEDURE

1.Pour 20g of dry sample into 100ml graduated cylinder containing about 40 ml of distilled water.
2.The suspension was stirred repeatedly and then made up to the 100 ml mark with the addition of distilled water.
3.These cylinders were sealed and left undisturbed for the sample to settle.
4.After 24 hrs free swell index was calculated.

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CONCLUSION

1) By using fly ash as an admixture we can stabilize the black cotton soil. It gives strength to the soil.
2) Engineering & Index properties of black cotton soil will improved while using the fly ash as an admixture for the construction purposes.
3) As a civil engineer it is our duty to convert the useless construction materials in to useful materials.
4) And we have to choose the better ways based on the economic considerations also.
5) We have to control the environmental pollution using the pollution creating agents as the admixtures for the stabilization of materials or to increase strength of the building materials.
6) Improvement of engineering properties is the main criteria for the civil engineers for an economic purpose in the site.
7)20-30% by weight of fly ash is suited for the stabilization of black cotton soil.
8) With increment in the % of fly ash, the strength is increased up to some limit. And with increment in duration, the strength in increases. i.e., for 15 days strength is higher than at the time of addition of fly ash to the soil.
9) With increment in duration & % of fly ash, the CBR value increases to more than 5.2 & the UCC value increases to more than 23 kN/m2.

References

1)"Swelling Soil- Problems And Remedial Measures", Central Soil & Materials Research Station, New Delhi.

2)"Katti, R.K.", "First IGS Annual Lecture Search For Solutions To Problems In Black Cotton Soils", Indian Geotechnical Journal Vol-1 No1 PP-1-82

3)IS-1498-1970 "Classification and Identification of Soil for General Engineering Purposes", Indian Standard Institution, New Delhi.

4)K.R. Arora – "Soil Mechanics & Engineering Foundation"

5)B.M. Das – "Advanced Soil Mechanics" McGraw Hill

6)B.C. Punmia- "Soil Mechanics and Engineering Foundation"

7)IS:2720 (part V)-1972- Atterberg's limit analysis

8)"Building of Structures on Swelling Soils" The Indian National Society of Soil Mechanics & Foundation Engineering, July -1970

9)www.engineeringcivil.com