Effect of FlyAsh on Compaction Characteristics of Expansive Soils, Near Anandapuram, Visakhapatnam, Andhra Pradesh, India

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***Abstract:* - In the present Investigation, an attempt has been made to assess the changes in the strength characteristics of expansive soils such as optimum moisture content, maximum dry density, cohesion, angle of internal friction due to addition of flyash in different proportions. The results indicate that the flyash has a noticeable influence on the strength characteristics of expansive soils with addition of flyash.**

1. INTRODUCTION:

1.1Expansive Soils:

Expansive soils are well known by the term black cotton soils in India and they cover almost one fifth to one sixth of the total area. These expansive soils are colloidal soils containing two micron clay fraction varying between 50 to 70% consisting of significant portion of montmorillonite and Illitic minerals. These soils have been regarded as problematic to Geo – technical Engineers because of their susceptibility to alternate swelling and shrinking due to heaving accompanied by loss of strength of these soils during rainy season and shrinkage during summer. The problems associated with expansive soils include heaving and cracking of structures such as foundations, retaining walls, pavements, canal beds and linings.

Extensive work has been done expansive soils all over the world and attempts have been made by several researchers to suggest solution to these problems each based on different concept. In India these soils are spread over the states of Maharashtra, Gujarat, Madhya Pradesh, Uttar Pradesh, Rajasthan, Andhra Pradesh, Tamil Nadu and Karnataka.

In order to tackle the problems associated with swelling an attempt has been made to use fly ash.

1.2 Flyash: Fly ash is an industrial waste coming out of thermal power plants. Disposal of large quantities of flyash, which contains very fine particles that are easily blown by air and posses toxic elements is very expensive and can cause environmental hazard.

The principle constituents of flyash are silica(SiO_2), alumina(Al_2O_3), Iron oxide(Fe_2O_3), Calcium oxide(CaO), smaller amounts of magnesium, sulphur, unburned carbon.

2. IDENTIFICATION OF THE PROBLEM

The black cotton soils are highly argillaceous and contain clay fraction varying between 50 – 70 %. The high percentage of clay content with predominant montmorillonite mineral is responsible for high volumetric changes during wetting and drying. These volume changes cause huge damages to almost all civil engineering structures resting on / in them.

The problems associated with these soils are heave, cracks in lightly loaded building foundations, pavements, earth retaining structures and canal linings. Inadequate bearing capacity and differential settlements are not true causes of foundation failure in such soils, but high swelling pressure and differential heaves are the causes.

2.1 Engineering Problems of Swelling Soils:

The soils during rainy season absorbs considerable amount of water which cause excessive swelling of soils, while in summer the moisture in the soil is depleted, giving rise to shrinkage causes differential moments in the structure built over these soils.

(a) Damage to pavements: the roads that pass through expansive sub grades are subjected to heave and settlement of these treacherous soils. This result in irregularities, cracking and rutting of pavement surface, requires high maintenance cost.

(b) Damage to Buildings: Buildings have represented the most obvious cases of damage caused by swelling and shrinkage of foundation soils. Light structures resting on spread footings undergo substantial damage due to severe cracking. Pile foundation have been completely sheared off.

(c) Damage to Canals: the lined and unlined canals are also subjected to vagaries of expansive soils. The side slope of canal embankments were found to be eroded and become soft when constructed using expansive soils. The canal beds have obstructs the functioning of canal.

(d) Damage to Conduits: Conduits such as water supply lines and drainage pipes have been subjected to both lateral and vertical movements. In some cases, breakages of these service lines were reported, especially where relatively small diameter pipes have been employed, under extreme moisture condition.

2.2 Solutions to various problems: Once an expansive soil has been characterized, guidelines for systematic and logical selection of treatment alternatives or combinations of treatments that effectively minimize volume change and associated damage to structures should be thought of. The following remedial measures have been used with different degree of success.

(i) Removing the expansive soil entirely: this method consists of removing expansive soils entirely to a considerable depth and backfilling trench with sand or murrum or any non – swelling soil. In this method providing a granular fill around the foundations would help in arresting some movements it may prove dangerous in case water finds a direct associate to it.

(ii) Providing reinforced concrete raft deep beam or an inverted T-beam: this method will be successful only if the footing s adequately reinforced to withstand stress due to differential ground movements.

(iii) Designing the structure as a rigid unit: It is very costly method, requires adequate reinforcement for the entire structure.

(iv) Providing reinforced concrete bands at plinth and lintel levels: Provision of reinforced concrete bands is often adopted to arrest the movements, but serves little purpose in minimizing the incidence of cracking unless vertical columns are also provided at suitable intervals.

(v) Application of surcharge pressure: Loading the expansive soil with pressure greater than swelling pressure is a method by which swelling can be prevented. The use of this method is limited to low swelling soil.

(vi) Pre – wetting the soil: the objective of this method is to allow desiccated swelling soil to reach equilibrium prior to placement of roadway or structures. The most commonly applied method for accelerating swelling by this technique is ponding.

(vii) Providing a pier or pile and beam construction: this method enables greater intensity of loading and helps in counteracting the swelling. The piles are carried to anchor at a depth at which the ground movements due to variation of moisture content are inappreciable. Under reamed pile (CBRI – 1978) foundation is suitable for a wide variety of structure in difficult soil conditions and is economical when traditional types of foundations are un – economical.

(viii) Chemical stabilization: the chemical stabilization of expansive clays consists of changing the physic – chemical environment around and inside of clay particles where by the clay requires less water to satisfy the static imbalance and make it difficult for water that moves into and out of the systems. The most active clays are those with sodium cation exchange capacity and probably the most effective chemical stabilization of expansive soils occurs when sodium cations are replaced by divalent or trivalent cations.

(ix) Admixture stabilization: Literally, hundreds of chemical admixtures have been tried. Due to mixing problems, economic effectiveness and practically for large scale routine use, lime is most widely used material for stabilization.

(a) Lime Stabilization: Lime is used for stabilizing the expansive soil most widely and it is the most effective admixture for stabilizing purpose.

(b) Calcium chloride stabilization: It was found to be most suitable chemical for stabilizing the expansive soil.

(c) Cement stabilization: It can be used to stabilize any soil, if enough cement is used, in combination with right amount of water, proper compaction and curing.

(d) Flyash stabilization: Flyash has been utilized in stabilized layers for roads, both as foundation layer and as base coarse. Large quantity of flyash is used as a fill material. Flyash has been reported to have been used as a material for road sub – bases and embankments.In order for the double layer around clay particle to develop fully it is necessary that there be sufficient water present in the soil. If the soil is deficient in the amount of water needed for full double layer development, the inter particle repulsion will not develop to the fullest extent possible and attractive forces between the particles will predominate especially when the interaction between soil and flyash mixture accelerates owing to lime – silica reactions. As a result particles and particle associations tend to assume a flocculated structure more importantly; the air phase occupies more space as compared to the water phase as a consequence of flocculation resulting in lower densities. The tendancy for the clay – flyash particles to assume flocculating resulting in lower densities. The tendancy for the clay – flyash particles to assume flocculating structure seems to decrease the following two ways. If the water content is increased, the inner particle repulsion, decreasing the tendancy for particles to flocculate and resulting in more parallel arrangements of particles.

3.0 Experimental Study:

3.1 Objective of the Study: the main aim of the present work is to study the influence of flyash on the expansive soil characteristics such as optimum moisture content, maximum dry density for different percentages of soil flyash mix.

3.2 Material Used:

(i) Soil: The soil was collected from Anandapuram, Visakhapatnam. The soil used in this investigation was oven dried and sieved through 425μ I.S.Sieve in the Laboratory, study was carried out for salient physical characteristics of soil like grading, Atterberg limits, I.S light compaction and swell pressure tests. The Engineering properties of the soil are presented in Table 1. The chemical compositions of the soil are presented in Table 2.

Table 1: Index and Engineering Properties of Anandapuram Soil

S.No	Description of the Property	Value
1	Gravel Content (%)	0
2	Sand Content (%)	16
3	Silt Content (%)	44
4	Clay Content(%)	40
5	Liquid Content (%)	34
6	Plastic Content (%)	25
7	Plasticity Index (%)	9
8	Specific Gravity	2.42
9	I.S. Classification	CL
10	Optimum Moisture Content (%)	21
11	Maximum Dry Density (t/m^3)	1.79

Table 2: Chemical Composition of Anandapuram Soil:

S.No	Chemicals present	Composition (%)
1	Silica (SiO_2)	73.6
2	Alumina (Al_2O_3)	1.25
3	Iron oxide (Fe_2O_3)	1.12
4	Magnesium oxide (MgO)	0.034
5	Calcium oxide (CaO)	0.134
6	Sulphur trioxide (SO_3)	0.026
7	Loss on Ignition	3.4
8	Chlorides	0.036
9	Flourides	0.001
10	Nitrates	0.058
11	Phosphates	0.004
12	Organic matter	2.6
13	P^H	8.3 (not %)

(ii) Flyash: Flyash collected from Aganampudi, Visakhapatnam was used in this investigation. The laboratory study was carried out for physical properties of flyash and the results are presented in Table 3. The chemical analysis of flyash was also carried out and the results are presented in Table 4.

Table 3: Physical Properties of Flyash:

S.No	Description of the Property	Characteristics
1	Colour	Grey
2	Texture	Fine
3	Specific Gravity	2.14
4	Liquid limit	Non – Plastic
5	Plastic limit	Non – Plastic
6	Optimum moisture content (%)	32
7	Maximum Dry density (t / m^3)	1.11

Table 4: Chemical composition of Flyash:

S.No	Description of the Property	Characteristics (%)
1	Silica (SiO_2)	57.8
2	Alumina (Al_2O_3)	19.6
3	Iron oxide (Fe_2O_3)	8.8
4	Magnesium oxide (MgO)	0.98
5	Calcium oxide (CaO)	2.8
6	Loss on Ignition	8.2
7	P^H	8.38 (not %)

3.3 Laboratory Testing: the following tests were conducted on both soils and flyash. The index and engineering properties of both soils and flyash were determined.

3.3.1 Grain Size Analysis: Sieve analysis was carried out using a set of standard I.S.Sieves. the sample was oven dried and placed on the top of the sieve set and shaken by hand. The fine friction that passed through 75 micron sieve was taken and hydrometer analysis was carried out in 1000 ml for using the required quantity of sodium Hexamatephosphate as dispersing agent. The test was carried out according to I.S:2720 (Part – 4), 1985.

3.3.2 Atterberg Limits:

(i) Liquid limit: the liquid limit test was conducted as per I.S (part – 5), 1970. The test is conducted on soil after passing 425 micron I.S Sieve using Casagrande apparatus.

(ii) Plastic limit: the plastic limit test was conducted as per I.S 2720(part – 5), 1970.

3.3.3 Specific Gravity: Specific gravity was determined by using the soil fraction passing 4.75 mm I.S.Sieve by density bottle of 50 ml capacity. The test conducted in accordance with I.S: 2720 (Part – 3), 1980.

3.3.4 Proctors Compaction Test: The compaction test was performed in proctor mould. This was used to find the optimum moisture content and its corresponding dry unit weight. The test was carried out according to I.S 2720 (Part – 7), 1980.

3.4 Soil – Flyash Mixtures: The soil – flyash mixes were taken in different proportions as 0%, 4%, 8%, 12%, 16%, 20%, 22%, 24%, 26% flyash by weight.

4. EXPERIMENTAL RESULTS AND DISCUSSIONS:

The compaction test results of soil flyash mixes for the soil are presented in Tables 5, 6.

Results show that with increasing percentage of flyash optimum moisture content increases where as the maximum dry density decreases. This is due to the fact that percentage of fine flyash requires more water for interparticle lubrication and at the same time reduces the unit weight.

For the anandapuram soil, the optimum moisture increases from 20.0% to 23.5% whereas the maximum dry density decreases from 1.60 t/m^3 to 1.37 t/m^3.

The curves showing relationship between optimum moisture content and percentage of flyash, maximum dry density and percentage of flyash have been shown in figures 1, 2 respectively for anandapuram soil.

It is observed that there is an increase of optimum moisture content of 16% for 26% increase in Flyash whereas the maximum dry density value is decreased by 15% for the same percentage of flyash for anandapuram soil. Upto 20% increase in the flyash the percentage variation of optimum moisture content and maximum dry density is significant and after that there is no significant variation in the values of OMC and maximum dry density.

The curve showing relationship between percentage increase of OMC and percentage of flyash has been shown in figure 3.

The curve showing relationship between percentage decrease of maximum dry dentsity and percentage of flyash has been shown in figure 4.

Table 5: Variation of percentage of OMC and Maximum dry density of Anandapuram soil for different percentages of Flyash:

S.No	FlyAsh (%)	OMC (%)	Max.dry density (t / m^3)
1	0	20.0	1.60
2	4	20.5	1.55
3	8	21	1.51
4	12	21.5	1.48
5	16	22	1.45
6	20	22.6	1.41
7	22	23.1	1.39
8	24	23.3	1.38
9	26	23.5	1.37

Table 6: Percentage variation of OMC and Maximum dry density of Anandapuram soil with different percentages of Flyash:

S.No	FlyAsh (%)	% Increase of OMC	% decrease of Max.dry density
1	0	0	0
2	4	2.5	3.125
3	8	5	5.70
4	12	7.38	7.68
5	16	9.70	9.70
6	20	12.42	12.45
7	22	14.63	13.86
8	24	15.49	14.57
9	26	16.34	15.29

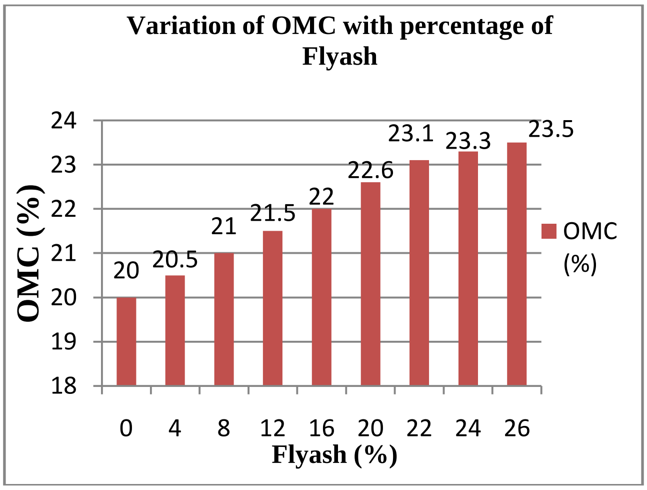

Figure 1

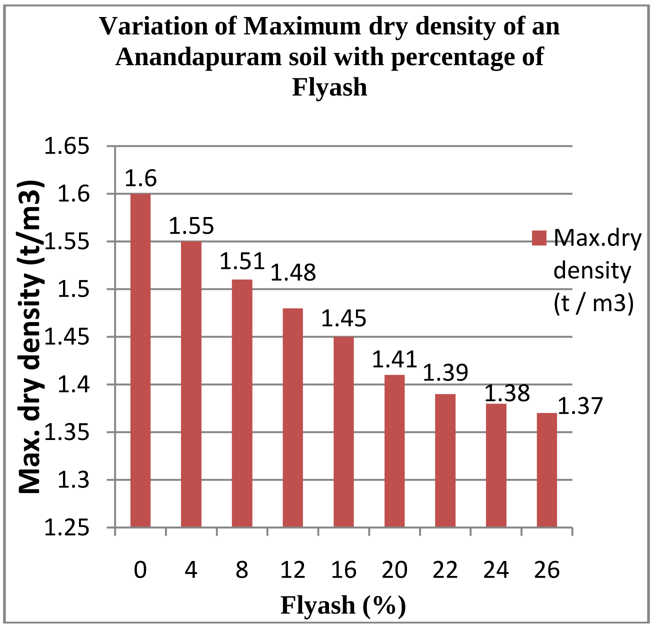

Figure 2

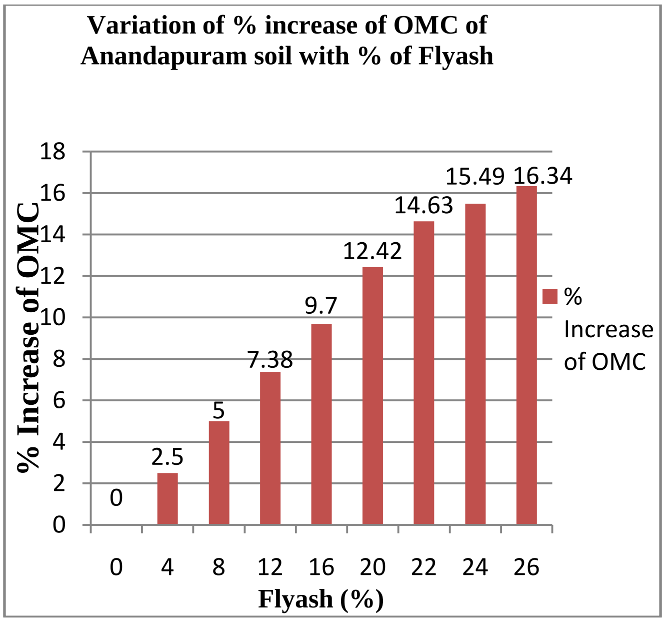

Figure 3

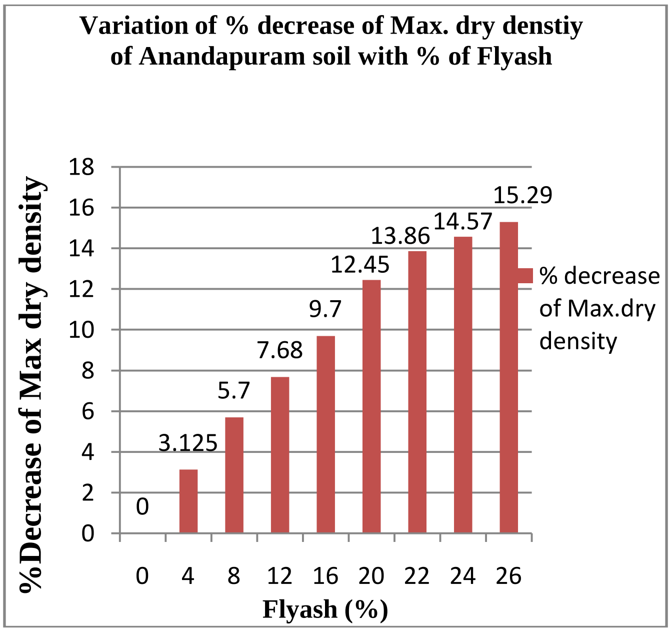

Figure 4

5.0 CONCLUSIONS:

Following conclusions are drawn from the stabilized soil mixed with different proportions of flyash.

- ✓ In the flyash treated soil mixes upto 20% flyash there is considerable change in the properties and after that there is no appreciable change in the values. Hence, the optimum moisture content of flyash may be fixed as 20%.
- ✓ The optimum moisture content of the soil flyash mix increases with increase in percentage of flyash which is due to the fact percentage of fine flyash requires more water for inter particle lubrication.
- ✓ The maximum dry density of the soil flyash mix decreases with the increase in percentage of flyash which is due to the flocculation as a result of physic – chemical interactions between particles and particle groups.

6.0 REFERENCES:

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