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A Study on Strength Characteristics of Expansive Soil-Flyash Mixes at Various Moulding Water Contents

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Abstract: ***Road embankments, low lying areas require large quantities of soils for their construction. Structures like these located in expansive soil areas needs special attention for the use of local materials as construction materials. In this aspect use of stabilized materials needs special attention. Flyash is one such material can be mixed with expansive soils and used as Geotechnical material. In this an attempt is made for the utilization of Flyash in Bulk quantities by adding various percentages of Flyash to the expansive soils and verified their behaviour. Tests like compaction, UCS and CBR were performed on these mixes and identified that addition of Flyash increases the strength and decreases the swelling characteristics. From the test results it is also identified that high strength values were also obtained at plastic limits. An addition of 20-30% of Flyash needed to stabilize expansive soil are used as sub-grade and other construction materials in geotechnical applications.***

Key words: Expansive soil, Flyash, Unconfined compressive strength, CBR.

I. INTRODUCTION:

Expansive soils are popularly called as Black cotton soils in India subjected to lot of swelling and shrinkage characteristics. These soils are available in huge quantities of North coastal Districts of AP. Structures constructed on these soils have been facing differential settlements resulting severe damages. Some of them are cracks in buildings, heaving of canals, failure of retaining structures and roads in many parts of North Coastal Districts of AP. Many attempts have been made after the properties of expansive soils of these areas to meet the different tasks, the popular technique is removing partly/fully these expansive soils and foundation medium with a desirable one. Therefore stabilization is one of such attractive methods. Addition of Flyash to Expansive soil is one such attempt to understand the possible mechanism governing the behaviour of expansive soils-Flyash mixes. Flyash is an industrial waste obtained from thermal power plants by burning of coal. In India these plants produce 130 MT Flyash as a waste product. Therefore bulk stabilization of Flyash become very essential in view of huge producing and to reduce the impact on disposal areas under Environmental concerns. Utilization in Geotechnical applications are Subgrades, Embankment Materials, Backfill and Structural Materials.

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Srivatasava. R. K et.al, (2001) studied the effect of Flyash on Expansive soil and reported that UCS values increases with Flyash. Boominathan, A. et.al, (1996), B.R.Phanikumar et.al, (2009), J.M. Kate, (2009) studied expansive soil stabilized with Flyash and lime used as Geotechnical material. Sridharan. A et.al, (1997) Pandian. N. S et., (2001, 2002) reported that addition of Flyash increases CBR friction angles, can be used in construction of embankments. Ramakrishna et.al, (2001) identified that addition of Flyash increases the UCS and CBR values. In this an attempt is made to study the interaction between Flyash and Expansive soils by conducting swell, Compaction and Strength tests at various moulding water contents to verify their interaction and can be used as Geotechnical material in constructional activities.

II. MATERIALS USED

2.1 Kuramanapalem soil:

The Expansive Soil used in this investigation was collected from Kuramanapalem in Visakhapatnam, Andhra Pradesh. The expansive soil was tested for various Geotechnical Characteristics and the results are shown in table 1 and Figure 1&2.

Property	Values
Gradation Properties	
Gravel (%)	0
Sand (%)	12
Fines (%)	88
a. Silt(%)	32
b. Clay(%)	56
Index Properties	
Liquid Limit (%)	60
Plastic Limit (%)	26
Plasticity Index (I_p)	34
Type	Brown Clay
I.S Classification	CH
Specific gravity	2.69
Compaction Charachteristics	
Optimum moisture content (OMC) (%)	22
Maximum dry density (MDD) (g/cc)	1.6
Strength Charachteristics	
California bearing ratio (CBR) (%) (Soaked condition)	1.0
Shear Parameters	
Unconfined compression strength (t/m^2)	16
Cohesion - C (t/m^2)	6.0
Angle of Internal Friction (Ø)-deg	12
Swell Characteristics	
FSI (%)	80
Swell Pressure (t/m^2)	8

Table: 1

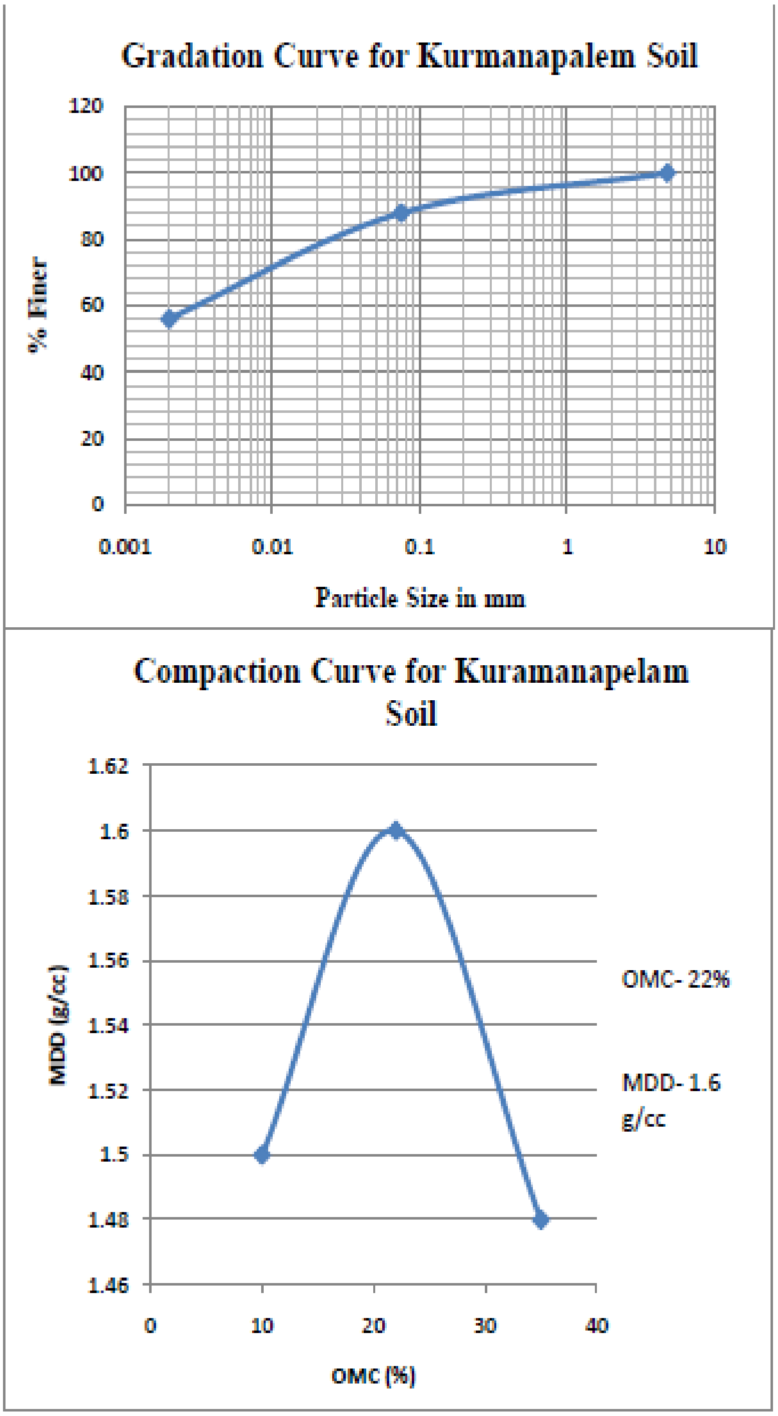

fig: 1& 2.

From the geotechnical Characteristics of Expansive soil it is identified that it is high expansive and high Plastic Soil. By the nature of the soil it attains less strength in the form of lower values of CBR and attained less densities with high moisture contents. At maximum Dry Density it exhibited high Strengths in the form of cohesion and less values in angle of Shearing Resistance. The soils contains 88% of fines including 56% of Clay particles. The presence of Clay particles make the soil high swelling (FSI > 50%) and high Plastic (I_p>25).

2.2 Flyash:

Flyash was collected from National Thermal Power Corporation (NTPC), Parawada,Visakhapatnam and their Geotechnical Characteristics were listed below in table 2 and Figure 3.

Property	Values
Gravel (%)	0
Sand (%)	28
Fines (%)	72
a. Silt(%)	72
b. Clay(%)	0
Liquid Limit (%)	28
Plastic Limit (%)	NP
Specific gravity	2.1
IS heavy Compaction	
Optimum moisture content (%)	21.0
Maximum dry density (g/cc)	1.28
California bearing ratio	4
Compression Index (C_c)	0.18

Table: 3

Compound Formula	Percentage
SiO_2	59.83
Al_2O_3	30.48
CaO	1.74
MgO	0.86
TiO_2	6.91
$V2O_5$	0.09
ZnO	0.09

Table: 2

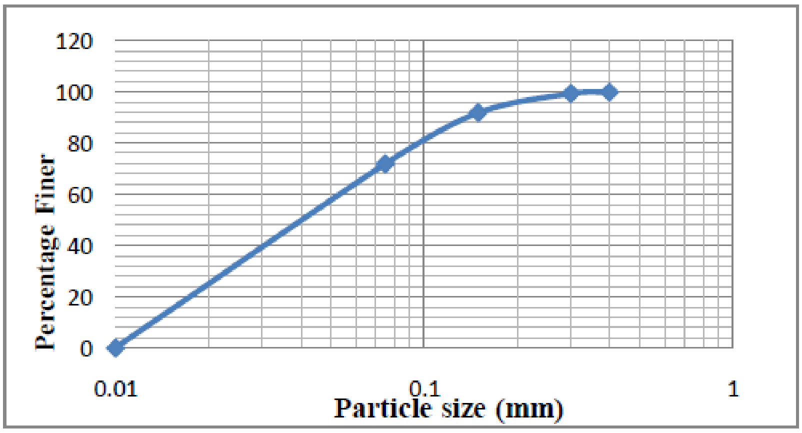

Fig: 3

From the test results it is identified that, it has 72% fine particles (<75µm) and all these particles are silt ranges. It is non-plastic and incompressible incompressible material. It has low specific Gravity and attained less dry Density with high Moisture Contents due to nature of Flyash particles. From the chemical composition it isd identified that it has less percentage of CaO (1.74<15%) classified under class F flyash (ASTM) and presence of high percentages of sio_2 and Al_2O_3 (90%) make the Flyash Pozzolanic with addituion of Lime, Cement and other additives.

To study the interaction between Flyash and Expansive soils with respect to compaction and swell properties various percentages of Flyash was added to the Expansive soil and tests were conducted as per IS:2720.

3.1 Compaction Characteristics:

At different percentages of Flyash added Soil mass, Heavy Compaction tests were performed as per IS: 2720 part 6-1980, and results are shown in Table 4 and Figure 4 to 5.

III. RESULTS AND DISCUSSIONS:

Flyash (%)	OMC (%)	MDD (g/cc)
0	22	1.6
5	22.5	1.58
10	23	1.55
15	23.5	1.52
20	24	1.5
25	24.5	1.48
30	25	1.46
35	24.5	1.44
40	24.0	1.43
45	25.5	1.42
50	23	1.4

Table: 4

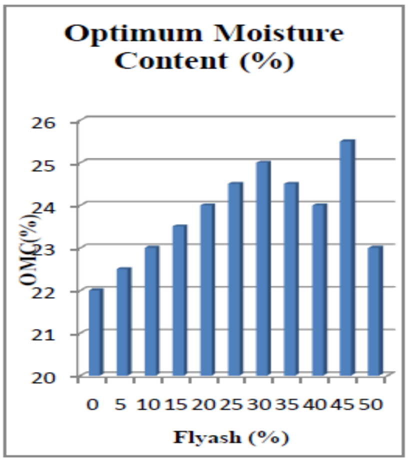

Fig: 4

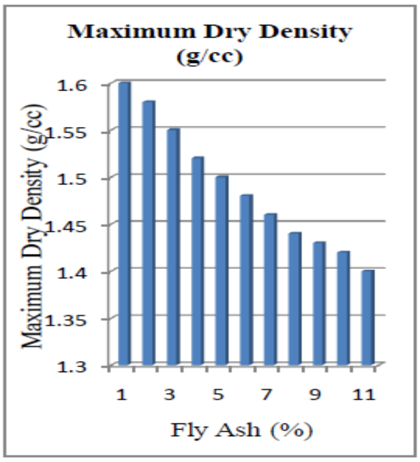

Fig: 5

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From the test data, it is observed that a steady increase Optimum Moisture Content up to 30% and beyond 30% a decrease in Optimum Moisture contents were observed. As the percentage of Flyash increases a steady decrease in dry density values were observed. At higher percentages of Flyash theses soil Flyash mixes attained the behaviour of Flyash. The increase in Moisture Content is due to formation of Flocculation of particles requires more water to coat the particles.

3.2 Swell Characteristics:

To study the Swell Characteristics various percentages of flyash was added to expansive soil and tested for various swelling characteristics such as Free Swell Index, Heave, Swell Potential, Swell pressure as per IS: 2720.

3.2.1 Differential Free Swell Index:

Two ten grams of soil-flyash mixes were prepared at various percentages of flyash to dry weight of soil mass and poured into distilled water and kerosene, after 24 hours the height of sediment columns in water (V_w)and in kerosene as V_k have noted. The deferential free swell index is calculated as

DFI=$(V_w-V_k)/V_k$ and the results are listed in the table 5 and fig 6

Flyash (%)	DFI (%)
0	80
5	70
10	58
15	45
20	30
25	20
30	10
35	5
40	0

Table: 5

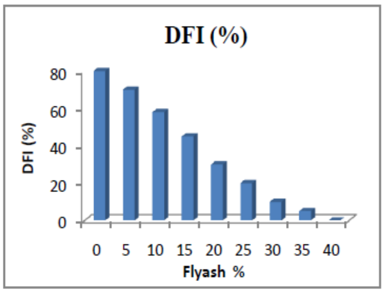

Fig: 6

From the test results it is identified that as the percentage of Flyash is increasing the differential free swell index values are decreasing. A Steady decrease was observed at early dosages of Flyash and became low swelling at 25% and Non-Swelling at 35% dosages of Flyash.

3.3 Unconfined Compressive Strength:

At different percentages of Flyash added Soil mass, Unconfined Compressive strength test was performed on samples of 38 mm diameter and 76 mm height obtained by compacting the samples at their Optimum Moisture Contents and Plastic Limits as per IS: 2720-part 10, 1991, and results are shown in Table 6 and Figure 7 and 8.

Flyash (%)	UCS (t/m²)	
	OMC	Plastic Limit
0	16	12
5	18.5	14
10	22	16
15	25.5	17
20	30	18
25	32	16
30	30	14

Table: 6

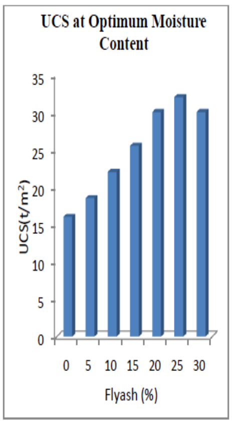

Fig: 7

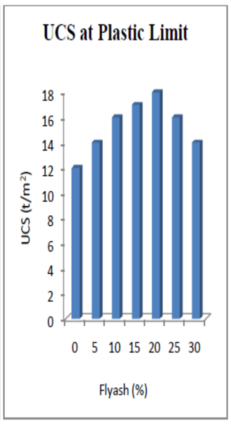

Fig: 8

From the test results of Unconfined Compressive Strength at Optimum Moisture Contents the following observations are made. As the percentage of Flyash is increasing Unconfined Compressive Strength values are increasing upto 25% and decreasing beyond 25%. A steady increase was observed upto 10% and rapid upto 25%. From the test results of Unconfined Compressive Strength at Plastic Limit the following observations are made. As the percentage of Flyash is increasing Unconfined Compressive Strength values are increasing upto 20% and decreasing beyond 20%. A steady increase was observed upto 10% and rapid upto 20%. From the test results it is also observed that the soil Flyash mixes at their Plastic Limits are also attained high strengths similar to the mixes at their optimum Moisture contents. This is due to the Flyash particles took the additional moisture contents and attained better bonding between Flyash and Soil Particles.

3.4 California Bearing Ratio (CBR):

At different percentages of Flyash added Soil mass, California Bearing Ratio test as per IS: 2720 part 16- 1987, were performed and results are shown in Table 7 and Fig 9.

Flyash (%)	CBR (%)
0	1
5	2
10	3
15	4.5
20	6
25	8
30	8
35	6
40	6
45	5.5
50	5

Table: 7

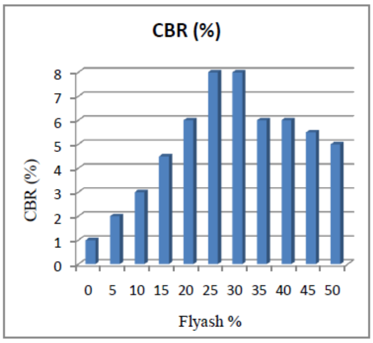

Fig: 9

As the percentage of Flyash increases CBR values are steadily increased upto 10% and a rapid increase was observed in between 10 to 30%. Beyond 30% flyash a steady decrease in CBR values were obtained. The increase in CBR values are due to the development of frictional resistance between Soil and Flyash Particles. Attainment of lower values are due to dominance of Flyash Characteristics in Soil-Flyash mixes exhibited the behaviour of Flyash.

IV. CONCLUSIONS

From the test data it is identified that Expansive soil Flyash mixes attained high strengths at their optimum moisture and plastic limits. 20-30% of Flyash makes the Expansive Soil-Flyash mixes strong and Non-swelling can be used as sub-grade and in other geotechnical applications.

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