EFFECT OF FLY ASH ON THE PROPERTIES OF EXPANSIVE SOIL

Mahesh G. Kalyanshetti, Satish Basavaraj Thalange

Abstract— Expansive soil is highly problematic because of the susceptibility of this soil to undergo large change in volume due to fluctuation in moisture content. Various stabilizers' are used such as lime, cement and calcium chloride. In the present scenario fly ash has emerged as an one of the potential admixture to stabilize the soil. In the present work an attempt is made to understand the effect of fly ash on various properties of expansive soil. For this study locally available soil is used which is highly expansive. Fly ash is mixed in various proportions in a parent soil. For these various proportions of fly ash different properties of soil are determined in laboratory and compared with the parent expansive soil properties. The study is carried out on various properties i.e. compaction properties, Atterberges limits, free swell index, swelling pressure, C.B.R (Soaked and Unsoaked).The study reveals that there is an appreciable reduction in the swelling characteristics of soils. This is upto extent of 40% to 50%. CBR value is improved by 70% to 75% with addition of fly ash. It is also observed that addition of fly ash beyond 20% is not significant on many of above properties.

Index Terms— Expansive soil, Fly ash, Free swell, Maximum dry density, Optimum moisture content,Swelling pressure, CBR, Atterberg's limts.

1 INTRODUCTION

EXPANSIVE soil is found in arid and semi-arid regions of the world and is in abundance where the annual evaporation exceeds the precipitation. Hot climate, poor drainage conditions are usually associated with the formation of this soil. In India these soil are generally called as black cotton soil (BCS) and it covers about 20% of the total land area. The BCS has the tendency of undergoing volumetric change due to change in moisture content. This will create instability to the structure resting on it. Various innovative techniques are developed to mitigate the problem posed by expansive soil. Stabilization of expansive soils with various additives such as lime, cement, calcium chloride and fly ash is also practiced.

In India, unlike in most of the developed countries, ash content in the coal used power generation is 30–40%. India ranks fourth in the world in the production of coal ash as by-product waste after USSR, USA and China. The estimated thermal power generation, coal consumption and ash generation in India is given in Tables 1.

TABLE 1
THERMAL POWER GENERATION, COAL CONSUMPTION AND ASH GENERATION IN INDIA

Year	Thermal Power Generation (Mw)	Coal Consume (Mt)	Ash Produced (Mt)
1995	54,000	200	75
2000.	70,000	250	90
2010	98,000	300	110
2020	1,37,000	350	140

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Erdal Cokea (2001) has carried out study on the effect of fly ash on expansive soil and has concluded that on addition of fly ash, plasticity index and swelling potential of sample decreased with increasing percent stabilizer. Pandian et.al. (2002) studied the effect of fly ash on the CBR characteristics of black cotton soil. The study it is concludes that the addition of fly ash increases the CBR value Udayashankar D.Hakari, S.C.Puranik (2012) carried an experiment by adding the fly ash to the black cotton soil. The results show that there is relative decrease in the plasticity index of the soils. The shrinkage limit of the soils increases with the addition of fly ash. The unconfined compressive strength and CBR increases gradually with the addition of fly ash.

Already the fly ash utilization is started in the brick/blocks manufacturing, cement and concrete. These are huge potential to consume the fly ash for stabilization of expansive soil. This will help in achieving the aim of consumption of fly ash and protect the environment with sustainable development.

2 EXPRIMENTAL WORK

2.1 INTRODUCTION

Fly ash in varying percentage is added to expansive soil. The fly ash of 0%, 5%, 10% 20%, 25%, 30% and 40% by weight is mixed. The various properties of blended soil are determined to study the variation in the properties of expansive soil.
Fly ash used for the project work is from Parali Thermal Power Generation station in Maharashtra. The chemical composition of this fly ash is given in Table-2. The expansive soil used for the project is borrowed from village Degaon near Solapur on Solapur Mangalvedha road in Maharashtra. Various properties of this soil are determined in the laboratory. These are given in Table-3. As per IS 1498- 1970, the soil is classified as 'CH' (Inorganic clay of high plasticity). Chemical composition of expansive soil is given in Table-4.

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TABLE 2
CHEMICAL COMPOSITION OF FLY ASH

Sr. No.	Chemical Content	Result %
1	Silica content (SiO_2)	61.32
2	Alumina content (Al_2O_3)	29.61
3	Ferric oxide (Fe_2O_3)	4.26
4	Silica+ alumina+ Ferric oxide (SiO_2+Al_2O_3+Fe_2O_3)	95.19
5	Titanium Oxide (TiO_2)	-
6	Calcium Oxide (C_3O)	1.18
7	Magnesium Oxide (MgO)	0.82
8	Sulphur Trioxide (SO_3)	0.11
9	Available alkali as sodium oxide (Na_2O)	0.38
10	Loss on ignition	0.91
11	chloride	0.005
13	moisture	-
14	Sp. Surface (m^2/kg)	-
15	Calcium oxide(free)	-
16	Phosphorus Pentaoxide (P_2O_5)	-

TABLE 3
PROPERTIES OF EXPANSIVE SOIL

SR.NO	TEST	RESULT
1	Specific Gravity	2.253
2	OMC	28.57%
	MDD	13.23%
3	Liquid limit	65%.
	Plastic limit	32%.
	Shrinkage limit	6.8%.
4	Free swell index	140%
5	Swelling pressure	142.2 kN/m^2
6	CBR	
	Soaked	1.9%.
	Unsoaked	5.2%.

TABLE 4
CHEMICAL COMPOSITION OF EXPANSIVE SOIL

SR. NO.	TYPE OF TEST	QUANTITY %
1	Silica (SiO_2)	67.17
2	Alumina (Al_2O_3)	19.36
3	Ferric oxide (Fe_2O_3)	4.32
4	Titanium (TiO_2)	0
5	Potassium (K_2O)	1.73
6	Magnesium (MgO)	0.82
7	Sodium (Na_2O)	0.38
8	Calcium CaO	0.67
9	Loss of igition	0.23

2.2 SCHEDULE OF EXPERIMENTAL WORK

Effect of fly ash on following properties are studied

a) Compaction properties (Optimum Moisture content and Maximum dry density)
b) Plasticity properties (Liquid limit. Plastic limit. Shrinkage limit, Plasticity index)
c) Swelling properties (Free swell index, swelling pressure)
d) CBR (Soaked and Unsoaked)

The laboratory tests to get above properties are done in accordance with following IS Codes.

1) IS: 2720 -Part 7, Determination of water content-Dry Density Relation Using Light Compaction.
2) IS: 2720 -Part 5, Determination of Liquid & Plastic Limits.
3) IS: 2720 -Part 6. Determination of Shrinkage factors,
4) IS: 2720 -part-40. Determination of Free Swell Index of Soil.
5) IS: 2720 Part-41, Determination of Swelling Procure of Soil.
6) IS: 2720 -Part- 16, Laboratory Determination of CBR.

2.3 STANDARD PROCTOR TEST

Standard Proctor Test is performed as per IS 2720(Part-7) .This test is performed for 0% to 40% fly ash content by weight. The compaction curves for various percentages of fly ash are presented below in Figure-1

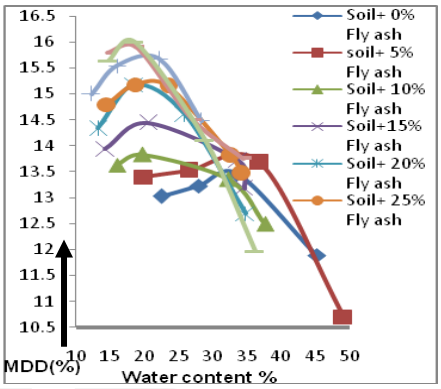

Fig. 1. Compaction curve for various trials (Fly ash from 0% to 40%).

The variation of "OMC" and "MDD" for fly ash of 0% to 40% is shown in Figure-2 and Figure-3.

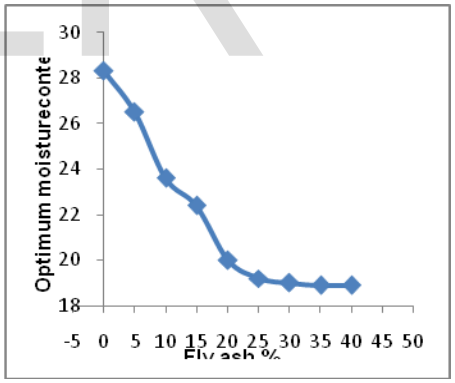

Fig. 2.Variation of OMC w.r.t. Fly ash.

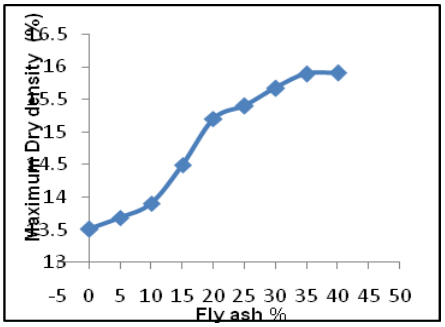

Fig. 3. Variation of MDD w.r.t. Fly ash.

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Observations:

1) Increasing percentage of fly ash increases MDD, decreases OMC.

2) Rate of increasing MDD is higher up to 20% to 25% and it slows down after that.

3) Rate of decreasing OMC is higher up to 20% to 25% and it slows down after that.

4) Addition of fly ash beyond 20% to 25%, is not significant.

2.4 ATTERBERG'S CONSISTENCY LIMIT

Test is performed as per IS - 2720 - Part 5 and Part 6, to know liquid limit (W_L),Plastic Limit (W_P), Shrinkage Limit (W_s). This test performed by varying fly ash from 0%, to 35 %. The variation of liquid limit, Plastic limit and shrinkage limit are presented in Figure-4, Figure-5 and Figure-6.

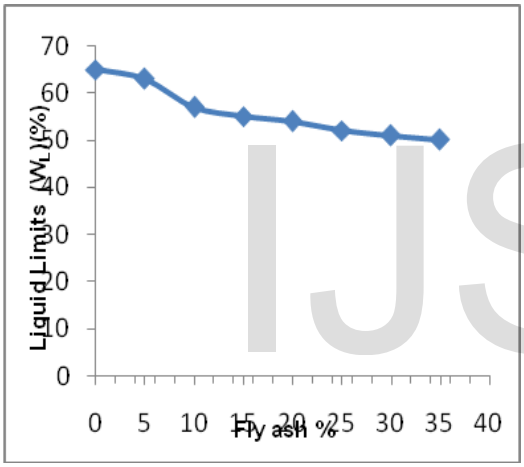

Fig. 4.Variation of liquid limit (W_L) w.r.t. % of fly ash.

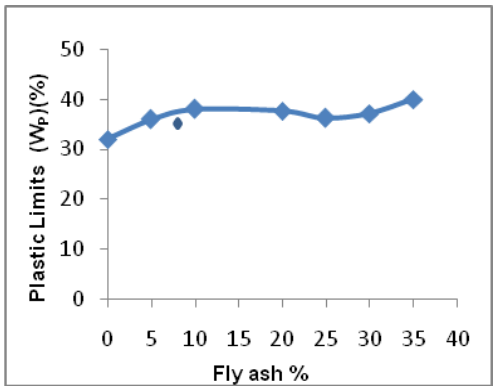

Fig. 5. Variation of Plastic limit (W_L) w.r.t. % of fly ash.

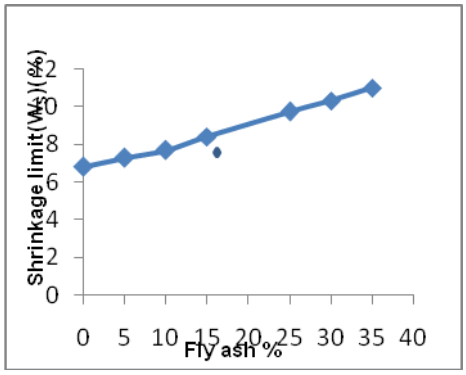

Fig. 6:- Variation of Shrinkage limit (W_L) w.r.t. % of fly ash.

Observations:-

1) Liquid limit decreases rapidly up to 10- 15% of fly ash and further decreases gradually.

2) Plastic limit increases with increase in percentage of fly ash up to 10-15% and then further almost remain constant

3) Plasticity index decreases rapidly upto 10% of fly ash and then it decreases gradually.

4) Shrinkage limit goes on increasing constantly with uniform rate with increasing percentage of fly ash.

2.5 FREE SWELL

Free Swell is determined as per IS 2720(Part-40)-1977. The result for various percentage of Fly ash has been highlighted in Figure-7.

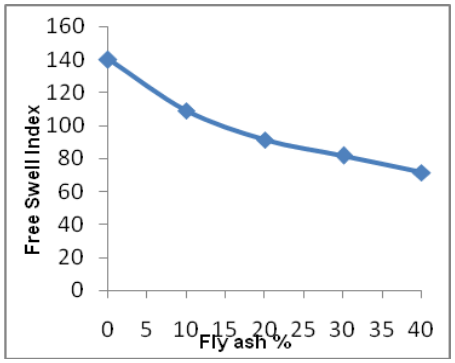

Fig. 7. Variation of Free Swell Index w.r.t. % of fly ash.

2.6 SWELLING PRESSURE

The test is performed by Constant Volume method as per IS 2720(Part-41)-1977, this test is performed for 0% to 40% fly ash results are shown in Figure-8.

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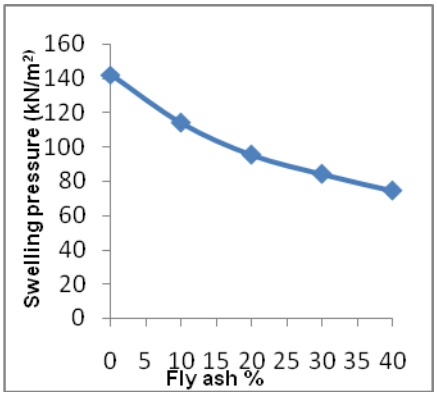

Fig. 8.Variation of Swelling Pressure w.r.t. % of fly ash.

Observations -

1) Fly ash reduces the Expansiveness of soil.

2) With the increase in fly ash free Swell Index and swelling Pressure reduce.

3) Up to the addition of 20% to 25% of Fly ash. Swelling Pressure reduces with higher rate, after that it reduces with slower rate.

4) Addition of fly ash beyond 20% to 25% is not significant.

2.7 CALIFORNIA BEARING RATIO (CBR)

This test is performed as per IS: 2720- Part-15 .C.B.R values for soaked and unsoaked samples are determined. Fly ash is added by 0% to 40%. The combined graph for C.B.R (Soaked and Unsoaked) test is presented in Figure-9.

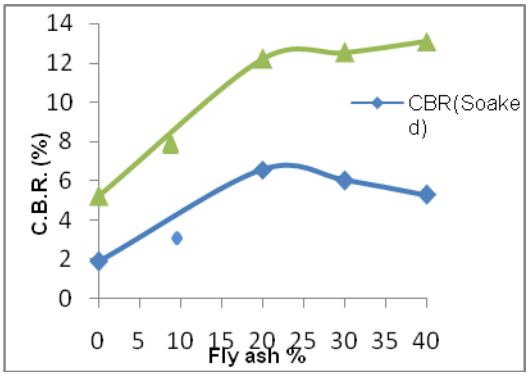

Fig. 9. Variation of C.B.R (Soaked and unsoaked) w.r.t Fly ash

Observation:-

1. Addition of fly ash improves the C.B.R.
2. C.B.R increases rapidly upto the addition of *25%* to 30% of fly ash then increase gradually
3. Unsoaked C.B.R. increases by 40% to 45% after addition of 25% to 30% of fly ash.
4. Soaked C.B.R increases by 70% to 75% after addition of 25% to 30% of fly ash.

3.0 RESULT AND DISCUSSION

After studying experimental work in detail, following conclusion are drawn.

3.1 The addition of fly ash reduces the plasticity characteristics of expansive soil. The liquid limit decrease and plastic limit increases with an increase in fly ash content. Plasticity index reduces by 30-40% with the addition of 10-15% fly ash. Shrinkage limit goes on increasing constantly with uniform rate with increase in fly ash content.

3.2 The addition of fly ash to expansive soil reduces the free swell and swelling pressure. For the expansive soil used both free swell and swelling pressure were reduced by 40-50% at 20% fly ash. At higher percentage of fly ash rate of reduction in free swell and swelling pressure gradually decreased.

3.3 OMC decreases and MDD increases. Therefore addition of fly ash is equivalent to increased compactive effort. For the addition of 20-25%fly ash, MDD increased by 15-17% and OMC reduced by 30- 35%. For higher percentage of fly ash (more than 20-25%) variation in MDD and OMC is not appreciable.

3.4 Penetration resistance of expansive soil can be effectively improved by addition of fly ash. In the present study CBR value is observed on both soaked and unsoaked soil sample CBR values increases with increase in fly ash. CBR value increases with higher rate up to 25-30 % of fly ash and then with slower rate. For the expansive soil used, CBR increases by 70-75% with the addition of 25-30% fly ash.

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