

Swelling Behaviour of Expansive Soil Mixed with Lime and Fly Ash as Admixture

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ABSTRACT: Black Cotton soil is one of the major soil deposits of India. They exhibit high swelling when exposed to change in moisture content and have been found to be most hazardous from engineering considerations. So in order to remove problems regarding this, proper treatment of soil is required and it is necessary to stabilize it with any of the additive substance such as Lime and Fly ash. This paper presents influence of Lime and Fly ash on various tests conducted such as Free Swell Index(FSI), Swelling Pressure, Compaction Characteristics, Liquid Limit, Plastic Limit, Plasticity Index. For this Lime content was varied as (0%, 2%, 4%, 6%, 8%, 10%, 12%) Fly ash as (0%, 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%) and Lime –Fly ash both as (0% Lime+0% Fly ash, 2% Lime+5% Fly ash, 4% Lime+10% Fly ash, 6% Lime+15% Fly ash, 8% Lime+20% Fly ash, 10% Lime+25% Fly ash, 12% Lime+30% Fly ash) and mixed it at OMC. The result obtained from experimental study indicates that the Free Swell Index and swelling pressure were reduced regularly with increasing percentage of Lime and Fly ash.

KEYWORDS: Expansive Soil, Fly Ash, Free Swell Index, Lime, Liquid Limit, Plastic Limit, Swelling Pressure

1. INTRODUCTION

Expansive soils also called swelling soils undergo harmful volume changes corresponding to alter in moisture content. The alternate swelling and shrinkage of expansive soils in alternate wet and dry seasons cause severe cracking in lightly loaded structures founded on them such as foundations, pavements, canal beds and lining. In our country the typical example of expansive soil is black cotton soil. Bentonite, mar and kabar. Stabilization of expansive soils is an alternative for geotechnical engineers considering the economics of construction with clayey soils. There are so many additives such as fly ash, lime, gypsum, rice husk ash, geosynthetics etc are available to improve the physicochemical properties of clay soils in order to permanently stabilize them. But fly ash and lime are easily available and more economical. Tests including Swelling Pressure, Free Swell Index, Compaction Characteristics, Liquid Limit, Plastic Limit and Plasticity Index carried out on the sample and result regarding this are tabulated below.

II. LITERATURE REVIEW

Erdal Cokca(2001): Effect of fly ash on Expansive Soil was studied by Erdal Cokca; Fly ash consists of often hollow spheres of silicon, aluminium, iron oxides and unoxidized carbon. And his experimental findings confirmed that the plasticity index, swelling potential of the sample decreased with increasing percentage of stabilizer. The change in physical properties and swelling potential is a result of additional silt size particles to some extent and due to chemical reactions that cause immediate flocculation of clay particles and he concluded that both high calcium and low calcium class C fly ashes can be recommended as effective stabilizing agents for enhancing the geotechnical properties of expansive soil.

Beeghly(2003): Evaluated the use of lime together with fly ash in stabilization of soil sub grade (silty and clayey soils) and granular aggregate base course beneath the flexible asphalt layer. He reported that lime alone works well to stabilize

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clay soils but a combination of lime and fly ash is beneficial for lower plasticity soils .he also concluded that Swelling Pressure decreased with increase in percentage of lime and fly ash.He studied that lime and fly ashstabilization technique and compared the cost benefit ratio with Portland cement stabilization method, he observed that US and other developed countries need to increase the use of fly ash stabilization method as the cost saving by reducing the material cost up to 50%.His result showed that addition of quick lime yields high strength monolithic solid ,attaining levels of strength similar to those of concrete product.

III. MATERIAL

An expansive soil (black cotton soil) obtained from power Baliabad, Baliapur; which was used by my current project work at BIT Sindri. Various tests were conducted to determine the various properties of soil and results are shown as follows in table no. 1:

Table.1:Physical properties of Expansive soil used:

Properties	Values
Liquid limit % Plastic limit % Shrinkage limit %	68 20 7.05
% Gravel % Sand % Silt % Clay	0.1 21 26.7 52.2
Maximum Dry unit weight Optimum Moisture content (OMC)	1.52 gm/cc 17%
Specific gravity	2.39
Unconfined compressive strength	3.48 kg/cm ²
Cohesion (C) Angle of internal friction (ϕ)	60.20 K Pa 21.5 ⁰
Coefficient of permeability	1.5x10 ⁻⁸ cm/sec
Differential Free Swell Swelling Pressure	80% 48.10 kN/m ²
Soil type	Clayey

FLY ASH:

The fly ash obtained from Bokaro Thermal Power Plant was used .The major constituents of fly ash are oxides of silica ,iron, aluminium ,calcium, and magnesium. Physical properties and chemical properties of fly ash are shown as follows:

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TABLE 2. Physical properties of fly ash

Properties	Value
Specific gravity	2.14
Standard Proctor Compaction Test Maximum Dry Density (MDD) Optimum Moisture content (OMC)	1.104 gm/cc 28%
Grain size analysis Clay particle Silt particle Sand particle	0 % 78 % 22 %

The chemical composition of fly ash as provided by Bokaro Thermal Power Project Authority is shown in table 3:

Table 3: Chemical composition of fly ash used

Constituents	Percentage by weight
SiO ₂	68.0
Al ₂ O ₃	24.0
Fe ₂ O ₃ +Fe ₃ O ₄	2.18
TiO ₂	2.64
CaO	1.49
MgO	0.06
Loss of Ignition	1.63

LIME:

The lime used in this investigation was purchased from local market. And chemical composition of lime are shown in table 4:

Table 4: Chemical composition of lime

Constituents	Percentage
Ca(OH) ₂	90.0
Silica	1.5
Ferric oxide	0.5
MgO	1.0
Alumina (Al ₂ O ₃)	0.2
CO ₂	3.0
Free moisture	1.0

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IV. RESULT AND DISCUSSION

This chapter is designed to present the result and graph of various tests which were undertaken during the course of investigation

Table 5. The swelling pressure of soil at OMC with lime is shown as follows

Serial No.	OMC	MDD	Mix Designation	Swelling Pressure (KN/m ²)
M0L	17.0	1.52	Expansive Soil + 0 % lime of soil	48.10
M2L	19.0	1.48	Expansive Soil + 2 % lime of soil	38.30
M4L	20.0	1.42	Expansive Soil + 4% lime of soil	25.30
M6L	21.0	1.37	Expansive Soil + 6 % lime of soil	10.34
M8L	22.50	1.33	Expansive Soil + 8 % lime of soil	6.80
M10L	23.0	1.28	Expansive Soil + 10 % lime of soil	0
M12L	25.50	1.25	Expansive soil+12% lime of soil	0

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Table 6. The swelling pressure of soil with fly ash at OMC are shown as follows

Serial No.	OMC	MDD	Mix Designation	Swelling Pressure (KN/m ²)
M0FA	17.00	1.52	Expansive soil at OMC + 0 % fly ash of soil	48.10
M5FA	17.50	1.50	Expansive soil at OMC + 5 % fly ash of soil	44.25
M10FA	18	1.47	Expansive soil at OMC + 10 % fly ash of soil	38.35
M15FA	19.50	1.40	Expansive soil at OMC + 15 % fly ash of soil	33.32
M20FA	21.20	1.37	Expansive soil at OMC + 20 % fly ash of soil	27.60
M25FA	22	1.34	Expansive soil at OMC + 25 % fly ash of soil	20.50
M30FA	24.50	1.32	Expansive soil at OMC+30% fly ash of soil	12
M35FA	24	1.31	Expansive soil at OMC+35% fly ash of soil	7
M40FA	23.50	1.29	Expansive soil at OMC+40% fly ash of soil	2
M45FA	25	1.26	Expansive soil at OMC+45% fly ash of soil	0

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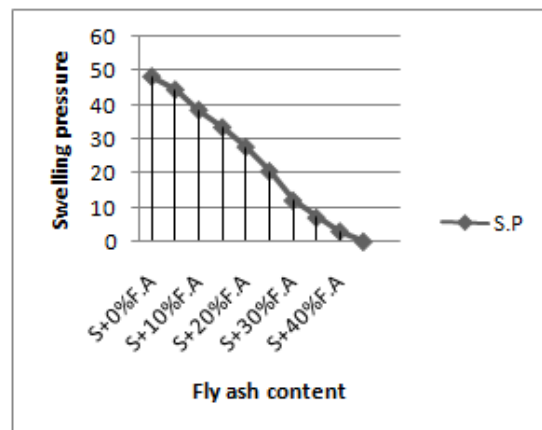
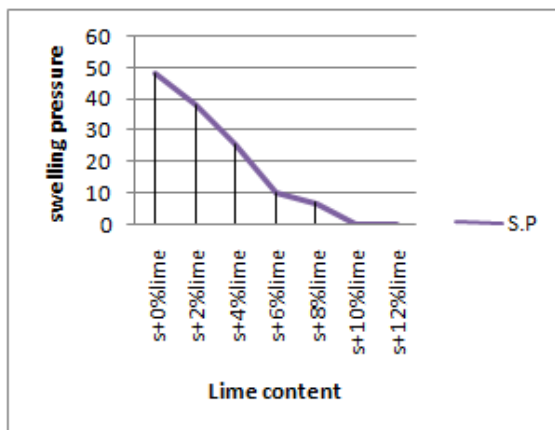
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Table 7. The swelling pressure of soil with lime fly ash both at OMC are shown as follows

Serial No.	OMC	MDD	Mix Designation	Swelling Pressure (KN/m ²)
M0L-0FA	17.0	1.52	Expansive Soil + 0 % lime +0%F.A	48.10
M2L-5FA	19.50	1.45	Expansive Soil + 2 % lime +5%F.A	60.92
M4L-10FA	20.60	1.40	Expansive Soil + 4 % lime +10%F.A	40.22
M6L-15FA	21.50	1.37	Expansive soil+6% lime + 15% F.A	16.00
M8L-20FA	22.00	1.35	Expansive soil+ 8% lime + 20% F.A	12.50
M10L-25FA	23.50	1.32	Expansive soil + 10% lime + 25% F.A	9.10
M12L-30FA	24..30	1.29	Expansive soil + 12% lime + 30% F.A	0.00

Graphs of swelling pressure with lime, fly ash and combination of lime –fly ash are shown below:



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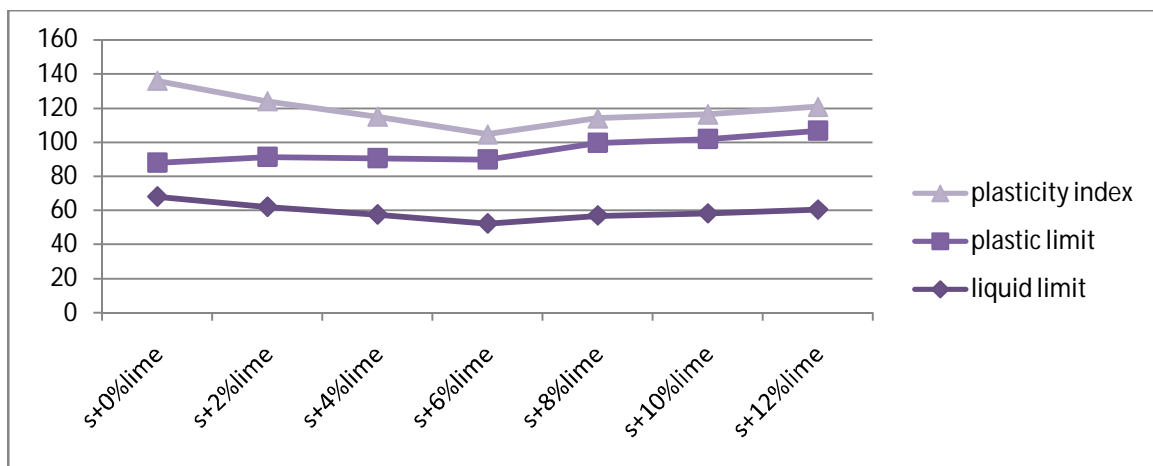
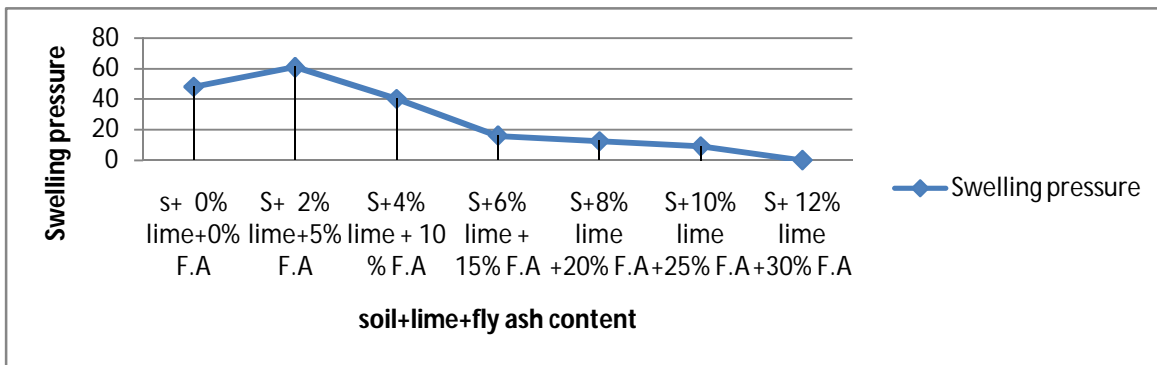


Fig 4:Graph of L.L,P.L,P.I at varying percentage of lime

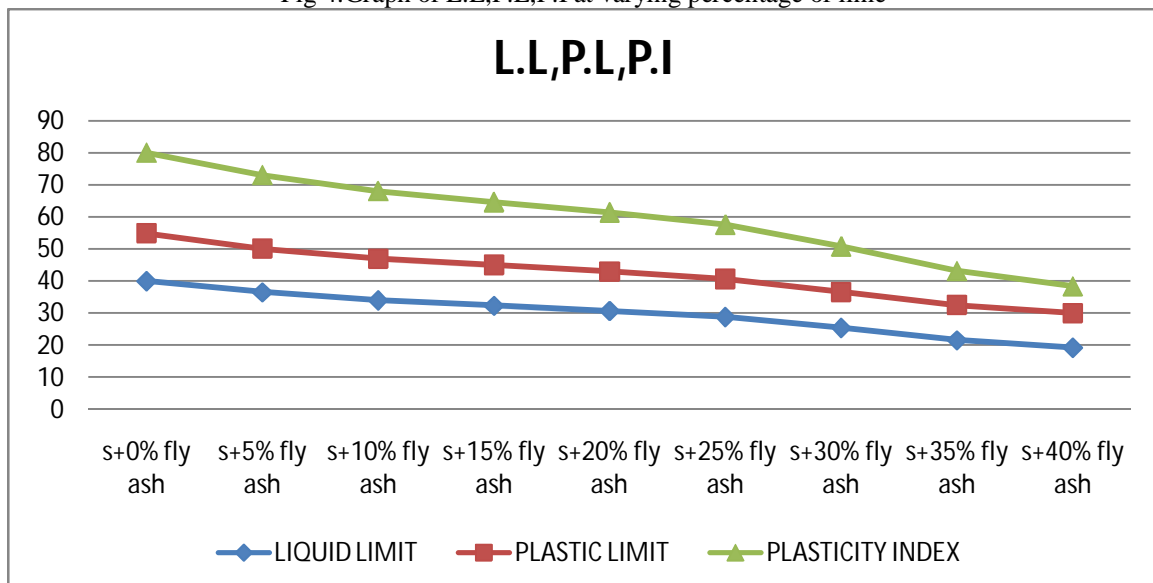


Fig 5:Graph of L.L,P.L,P.I at varying percentage of Fly ash

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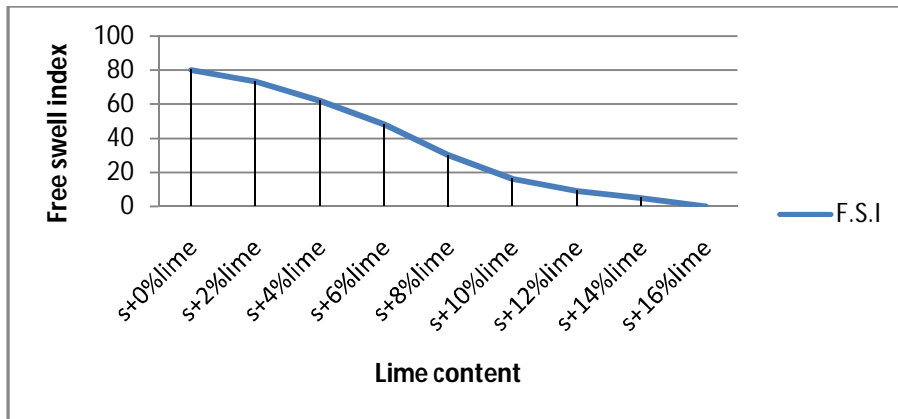


Fig 6:Graph of F.S.I at varying percentage of Lime

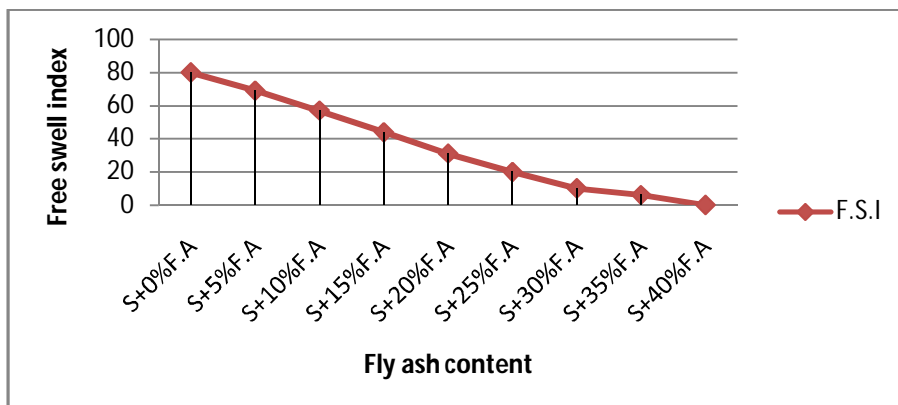


Fig 7:Graph of F.S.I at varying percentage of Fly ash



Fig.8 Swelling testing machine

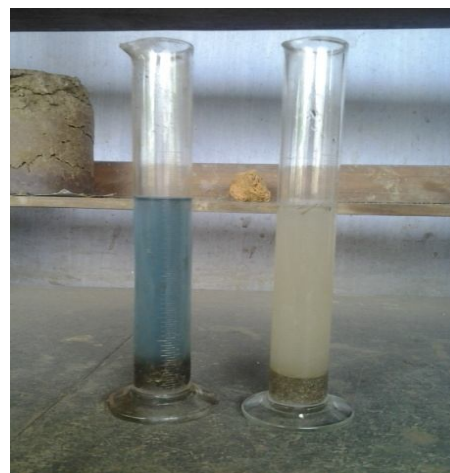


Fig 9. Free swell index

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V. CONCLUSIONS

- 1.Engineering properties of collected soil samples indicate that soil samples come under clayey group.
2. Liquid limit of the stabilized samples initially decrease with the addition of lime content and then increases, however Plastic limit increases markedly. .But liquid limit and plastic limit of BC soil decrease with increasing percentage of fly ash.
- 3.Compaction characters of BC soil also affected by varying % of fly ash. i.e OMC of BC soil increases with increasing % fly ash, however it decreases at 35 % of fly ash and again increases at 40% fly ash. MDD decreases with increasing % of fly ash , however it decreases at 35% of fly ash. Likewise compaction characters of BC soil also affected by varying % of lime. i.e OMC of BC soil increases with increasing % lime and MDD decreases with increasing % of lime.
- 4.Free swell index of stabilized samples decreases with increasing lime content and the value of F.S.I becomes 0 at 8 % of lime addition. F.S.I of stabilised samples also decreases]with increasing fly ash content and the value of F.S.I becomes 0 at 40% of fly ash addition.
- 5.Swelling pressure of stabilised samples decreases with increasing lime content ,fly ash content and lime-fly ash content. However the value of swelling pressure becomes 0 at 10% of lime,12% of lime,45% of fly ash,12%lime+30% fly ash.
- 6.From the test data it is identified that 30-35% of Fly ash makes the Expansive soil-Fly ash mixes non swelling and it can be used as subgrade and in other Geo-technical applications. similarly 10-12% of lime makes the Expensive soil-Lime mixes non swelling and it can be also used in other Geo-technical properties.

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