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Study on Stabilization of Expansive Soil Using Fly Ash and Lime

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Abstract: Expansive soil covers over 51.8 million hectares of land area in India (mainly Black Cotton soil). The basic trait of these expansive soils is that they are highly hard while dry but lose all of their strength when wet. Because of this attribute of expansive soils, these soils provide issues all around the world that geotechnical engineers must address. Soil stabilization, which is frequently utilised in foundation and road pavement constructions, is one of the most significant features for construction purposes; this is because such a stabilization regime increases engineering qualities of the soil, such as volume stability, strength, and durability. The problematic soil is removed or replaced throughout this operation is completed;The current study attempts to stabilise black cotton soil from Shivnath River Pulgaon Durg Bhilai utilizing fly ash sourced from JayPee Cement Limited Bhilai . Expansive soils are stabilized using different quantities of this Mixture, such as 10%, 20%, 25% . Because fly ash has no plastic characteristic, the plasticity index (P.I.) of clay-fly ash mixtures decreases in value as the fly ash component increases. Finally, the addition of fly ash reduces the flexibility of the expanding soil while increasing its workability by modifying its grain size and colloidal response. 3 trials of different composition are prepared and tested.

I. INTRODUCTION

The foundation is critical for any land-based project and must be strong enough to sustain the whole structure. The soil around the foundation is crucial to the foundation's strength. So, in order to work with soils, we must first understand their qualities and the variables that influence their behavior. The soil stabilization procedure aids in achieving the desired qualities of a soil for building operations. The need to improve soil qualities has been recognized since the outset of building activity. Soil stabilization was achieved in this study by using Fly ash and lime in various proportions and then performing several tests to proof soil stabilization.

II. LITERATURE REVIEW

Hakari1 ,Udayashankar D2 has discussed in Indian geotechnical conference. (Dec-2010) has studied a use of fly ash for improves the property of black cotton soils of HubliDharwar region. The liquid limit decreases from 63% to 46%, plastic limit from 28.9% to 23.1% and the plasticity index from 34.1% to 22.9%; for the corresponding increase in the addition of DFA from 10% to 50% respectively. The shrinkage limit increases from 17.3% to 37% for increasing in the addition of DFA from 10% to 50% respectively the optimum moisture content decreases from 24.3% for M-10 mix to21.3% for M-50 mix. The CBR value Increases from0.77% for M-10 mix to 2.64% for M-50 mix.

S. Bhuvaneshwari [1], R. G. Robinson [2], S. R. Gandhi[3] (FAUP), TIFAC, DST, New Delhi (2005) has also discussed the stabilization of expansive Soils using fly ash extensive laboratory / field trials have been carried Out by out to check the improvements in the properties of expansive soil with fly ash in varying percentages.

Sharma et al. (1992), using mixtures of fly ash, blast furnace slag and gypsum, studied stabilization. He found that when fly ash, gypsum and blast furnace slag are used in proportions of 6:12:18, the swelling pressure decreases from 248 KN/$m2$ to 17 KN/$m2$, whereas an increase by 300% was observed in case of unconfined compressive strength.

Satyanarayana et al. (2004) aimed to study the mutual effect of addition of lime and fly ash on the engineering properties of the expansive soil. He found out that 70%, 26% and 4% were the optimum percent mixture of the ingredients for the construction of roads and embankment

III. MATERIALS AND METHODOLOGY

A. Material

1) Expansive Soil

Expansive soils, also known as swell-shrink soils, have a tendency to shrink and swell in response to changes in moisture content. As a result of this soil variance, considerable Distress begins in the soil, which is followed by harm to the underlying structure. These soils absorb water during periods of high rainfall, such as monsoons.

Swell; as a result, they become mushy and their water-holding capacity decreases. in contrast In addition, during drier seasons, such as summers, these soils lose the moisture they have stored. Evaporation, causing them to become tougher Typically found in semi-arid and dry climates.

2) Fly Ash.

Fly ash is a waste substance collected from the gases emitted by coal-fired furnaces, often at a thermal power station. One of the most common uses of volcanic ashes in ancient times was as hydraulic cements, and fly ash is quite similar to these 5 volcanic ashes. These ashes were thought to be one of the greatest pozzolans (binding agents) available in and around the world.

Because of the rising urbanisation and industrialisation, the need for electricity supply has increased tremendously. As a result of this expansion, the number of power providing thermal power plants that use coal as a burning fuel to generate electricity has increased.

3) Lime

The application of lime can significantly improve the engineering properties of soil. There are essentially two forms of improvement: soil modification and soil stabilization. The use of lime can modify almost all fine-grained soils to some extent, but the most dramatic improvement occurs in clay soils of moderate to high plasticity. Modification occurs primarily due to the exchange of calcium cations supplied by the hydrated lime for the normally present cation adsorbed on the surface of the clay mineral. Modification is also caused by the hydrated lime reacting with the clay mineral surface in a high-pH environment: the clay surface mineralogy is altered as it reacts with the calcium ions to form cementitious products. The results are plasticity and swelling reduction, reduced moisture-holding capacity and improved stability.

B. Methodolgy

- Mechanical method of Stabilization In this procedure, soils of different gradations are mixed together to obtain the desired property in the soil. This may be done at the site or at some other place from where it can be transported easily. The final mixture is then compacted by the usual methods to get the required density.
- Additive method of stabilization It refers to the addition of manufactured products into the soil, which in proper quantities enhances the quality of the soil. Materials such as cement, lime, bitumen, fly ash etc. are used as chemical additives. Sometimes different fibers are also used as reinforcements in the soil. The addition of these fibers takes place by two method.

1) Collection of soil sample

Expansive Soil sample is collected from the bank of shivnath River located near Pulgaon Chowk Durg.

2) Tests Performed.

To assess the effect of fly ash as a soil stabiliser, a series of tests were conducted in which the amount of fly ash in the soil was adjusted from 10% to 15% by weight of the total quantity collected and also lime is added in varying proportions which are as follows:-

- Test of original soil sample

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- Test of mixture of 10% lime and 90% soil sample
- Test of mixture of 10% lime 10% Fly Ash and 80% soil sample
- Test of mixture of 10% lime 15% Fly Ash and 75% soil sample

During the process, the Indian Standard codes were followed. Carrying out the following experiments:
IS: 2720 (FOLLOWED) to perform the required tests :-
IS 2386 (Part 1) – Sieve Analysis Test
IS 2720 (Part 5) – Liquid and Plastic Limit Test – 1985
IS: 2720 (Part 8) – 1983 Modified proctor test
IS: 2720 (Part 16) – 1987 California bearing ratio (CBR) test

IV. RESULT

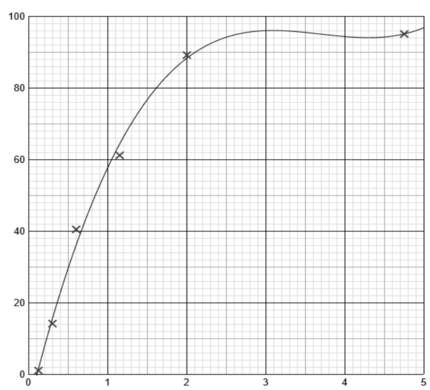
A. *Sieve Analysis Test.*

Source :- Shivnath River
Pulgaon Chowk (Durg)
Wt. of Sample:- 10kg

Table 1 : Sieve Analysis Test of Soil Sample

Sieve size (mm)	Wt. retained (gm)	% weight retained	Cum % weight retained	% passing	Specific limit zones - II
10	000	000	000	100	100
4.75	490	4.9	4.9	95.10	90-100
2.36	589	5.89	10.79	89.21	75-100
1.15	2800	28.00	38.79	61.21	55-90
0.600	2069	20.69	59.48	40.52	35-59
0.300	2631	26.31	85.79	14.21	8-30
0.123	1310	13.10	98.89	1.11	0-10
Pan	FML 2.986%				

PASSED



Graph showing variation in sieve size and percentage Passing

B. *Atterberg Limit Test*

Table 2 : Atterberg limit Test for liquid and Plastic limit of sample soil

Description	unit	Liquid limit				Plastic limit	
		1	2	3	4	1	2
No. of Blow	N	17	22	27	32	_	_
Container	No.	6	8	7	1	3	5
Wt. of Container + wet soil	Gm	29.91	31.15	28.68	24.81	23.63	23.07

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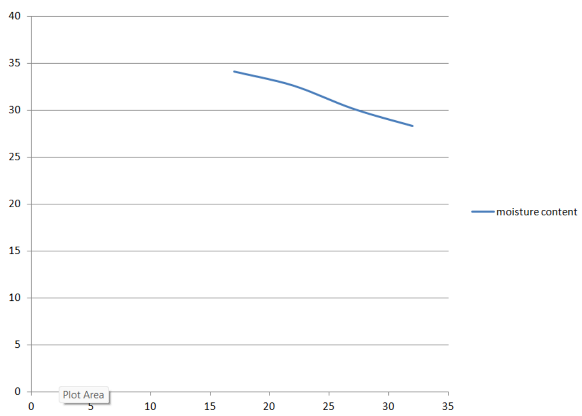
Wt. of Container + dry soil	Gm	25.86	26.93	24.76	21.54	23.57	21.43
Wt. of Container	Gm	14	14	12	10	14	14
Wt. of water	Gm	4.05	4.22	3.85	3.27	2.06	1.64
Wt. of dry soil	Gm	11.86	12.93	12.76	11.54	9.57	7.43
Moisture content	%	34.14	32.63	30.17	28.33	21.52	22.07



Average PL :21.79%
(General PL is near 23%)

C. Modified proctor Test

Weight of mould = 6110gms
Volume of mould = 2250 cc
Metal rammer weight = 4.9 kg
Height of fall = 450mm
No. of Blow / layer = 55
No. of Layer =5

Table 3 : Modified proctor test of original soil sample

Description	unit	Wt of Mould (A) = 6110 gms				Mould no. (B) - 01	
Trail with Moisture	%	4%	6%	8%	10%	12%	
Volume of Mould	Cc	2250	2250	2250	2250	2250	2250
Wt. of wet soil + mould	gms	10825	11152	11558	11668	11244	

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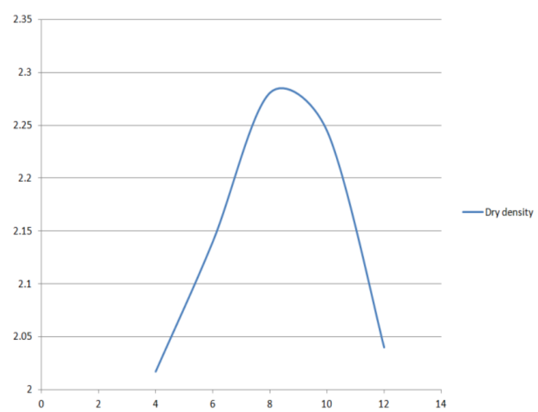
Wt of wet soil(E=D-A)	gms	4715	5042	5448	5558	5134	
Wet Density of soil (F= e/v)	g/cc	2.096	2.241	2.421	2.470	2.281	
Container no.	gms	11	12	13	14	18	
Wt. of container	gms	50	54.0	53	54	54	
Wt. of wet soil + container	gms	171.71	178.90	173.39	185.68	193.33	
Wt of dry soil + Cont.	gms	167.15	173.31	166.46	173.71	178.63	
Wt. of water (L= J-K)	gms	4.56	5.59	6.93	11.97	14.70	
Wt. of dry soil (M = K – H)	gms	117.15	119.31	113.46	119.71	124.63	
Water content [N = 100 x (L/M)]	%	3.90	4.69	6.11	10	11.80	
Dry density [P = 100 x(F/{100 +N))]	g/cc	2.017	2.140	2.281	2.245	2.040	
				Method used = Modified			

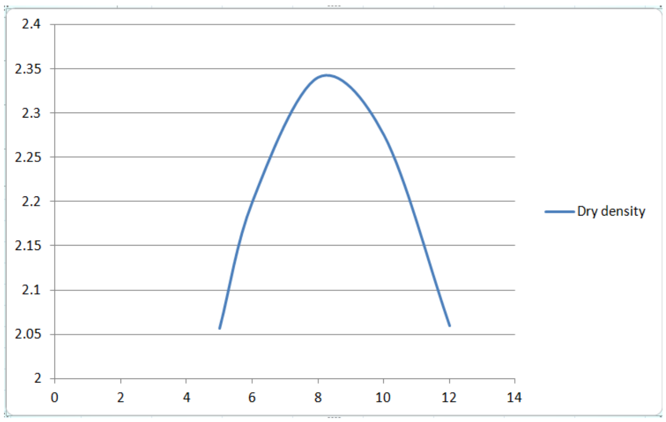
This test was conducted on the original soil sample. The following results were obtained:-Maximum Dry Density =2.34 g/cm3 Optimum Moisture Content = 8.0%



Modified proctor test of mixture of 10% lime and 90% soil sample

Description	unit	Wt of Mould (A) = 6110 gms				Mould no. (B) - 01	
Trail with Moisture	%	5%	6%	8%	10%	12%	
Volume of Mould	Cc	2250	2250	2250	2250	2250	2250
Wt. of wet soil + mould	gms	10882	11282	11665	11730	11267	
Wt of wet soil(E=D-A)	gms	4772	5172	5555	5620	5157	
Wet Density of soil (F= e/v)	g/cc	2.121	2.299	2.469	2.498	2.292	
Container no.	gms	13	15	11	18	12	
Wt. of container	gms	53	50	50	54	54	
Wt. of wet soil + container	gms	173.94	174.32	174.59	187.12	187.71	
Wt of dry soil + Cont.	gms	170.31	169.49	168.09	175.25	174.23	
Wt. of water (L= J-K)	gms	3.63	4.83	6.50	11.87	13.48	
Wt. of dry soil (M = K – H)	gms	117.31	119.49	118.09	121.25	120.23	
Water content [N = 100 x (L/M)]	%	3.1	4.05	5.51	9.79	11.22	
Dry density [P = 100 x(F/{100 +N))]	g/cc	2.057	2.20	2.340	2.275	2.060	
				Method used = Modified			

This test was conducted on the original soil sample. The following results were obtained:-Maximum Dry Density =2.41 g/cm3 Optimum Moisture Content = 7.5%



Graph Between Moisture content and Dry density

Table 5: Modified proctor test of mixture of 10% lime 15% Fly Ash and 75% soil sample

Description	unit	Wt of Mould (A) = 6110 gms				Mould no. (B) - 01	
Trail with Moisture	%	5%	6%	8%	10%	12%	
Volume of Mould	Cc	2250	2250	2250	2250	2250	2250
Wt. of wet soil + mould	gms	10781	11316	11669	11656	11172	
Wt of wet soil(E=D-A)	gms	4671	5206	5559	5546	5062	
Wet Density of soil (F= e/v)	g/cc	2.076	2.314	2.471	2.665	2.250	
Container no.	gms	08	09	10	11	12	
Wt. of container	gms	54	50	52	50	54	
Wt. of wet soil + container	gms	177.16	175.56	180.74	180.83	184.20	
Wt of dry soil + Cont.	gms	173.87	170.56	173.73	169.48	171.20	
Wt. of water (L= J-K)	gms	3.29	5	7.01	11.35	13	
Wt. of dry soil (M = K – H)	gms	119.87	120.56	121.73	119.48	117.20	
Water content [N = 100 x (L/M)]	%	2.75	4.15	5.76	9.50	11.10	
Dry density [P = 100 x(F/{100 +N))]	g/cc	2.020	2.221	2.336	2.251	2.025	
				Method used = Modified			

This test was conducted on the original soil sample. The following results were obtained:-Maximum Dry Density =2.37g/cm3 Optimum Moisture Content = 7%

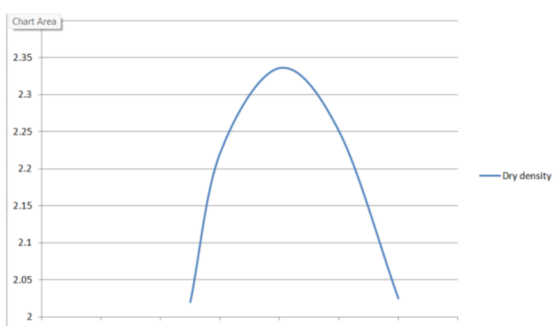
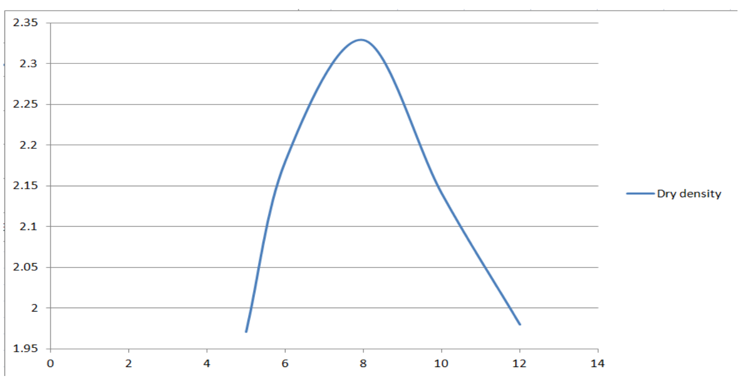


Table 6: Modified proctor test of mixture of 10% lime 25% Fly Ash and 65% soil sample

Description	unit	Wt of Mould (A) = 6110 gms				Mould no. (B) - 01	
Trail with Moisture	%	5%	6%	8%	10%	12%	
Volume of Mould	Cc	2250	2250	2250	2250	2250	2250
Wt. of wet soil + mould	gms	10666	11197	11620	11361	11053	
Wt of wet soil(E=D-A)	gms	4556	5087	5510	5251	4943	
Wet Density of soil (F= e/v)	g/cc	2.025	2.261	2.449	2.334	2.197	
Container no.	gms	1	2	3	4	5	
Wt. of container	gms	54	54	52	50	50	
Wt. of wet soil + container	gms	176.04	178.34	179.59	178.71	180.58	
Wt of dry soil + Cont.	gms	172.82	117.91	173.36	168.09	163.74	
Wt. of water (L= J-K)	gms	3.22	4.33	6.23	10.62	12.84	
Wt. of dry soil (M = K – H)	gms	118.82	119.91	121.36	118.09	117.74	
Water content [N = 100 x (L/M)]	%	2.71	3.70	5.16	9	10.91	
Dry density [P = 100 x(F/{100 +N))]	g/cc	1.971	2.180	2.329	2.141	1.980	
				Method used = Modified			

This test was conducted on the original soil sample. The following results were obtained:-Maximum Dry Density =2.370g/cm3 , Optimum Moisture Content = 6.5%



Graph b/w Moisture Content and Dry Density

Hence by performing modified proctor test We Can conclude mixture of 10% lime 15% Fly Ash and 75% soil sample is best composition to stabilize this expansive soil and for this composition we will determine the Extent upto which the CBR value increases.

D. California Bearing Ratio (CBR) test for soil – fly ash mixture

The California Bearing Ratio (CBR) is a measure of the strength of a road's subgrade and the materials used in its construction. The ratio is calculated using a standardised penetration test designed for highway engineering by the California Division of Highways

Table 7: CBR test For Original Soil Sample

1st Trail				2nd Trail				3rd Trail			
Penetration n Reading in Dail	Proving Ring Divition	Load in Kg	CBR Value %	Penetration n Reading in Dail	Proving Ring Divition	Load in Kg	CBR Value %	Penetration n Reading in Dail	Proving Ring Divition	Load in Kg	CBR Value %
0	0	0		0	0	0		0	0	0	
0.5	16	66.08		0.5	17	66.5		0.5	19	66.4	

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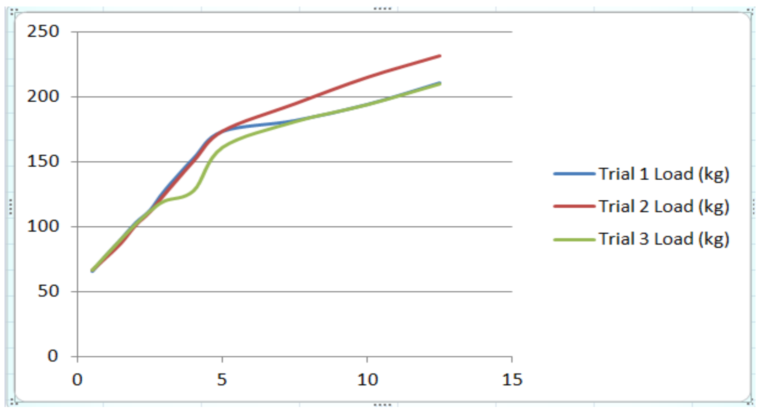
1	19	78.87		1	20	76.75		1	23	78.5	
1.5	22	90.86		1.5	21	87.56		1.5	24	90.4	
2	25	103.25		2	25	101.12		2	26	102	
2.5	30	113.05	8.25	2.5	27	111.51	8.13	2.5	29	112	8.74
3	32	128.03		3	32	125.0		3	31	119.78	
4	37	152.81		4	37	150.4		4	37	127.64	
5	42	173.46	8.44	5	42	173.46	8.44	5	42	161.07	7.83
7.5	44	181.72		7.5	47	194.50		7.5	47	180.83	
10	47	194.11		10	52	214.76		10	52	194	
12.5	51	210.63		12.5	56	231.28		12.5	56	209.92	

Trial 3 sample should be taken because the CBR value here at 2.5 is greater than the CBR at 5 mm penetration. Hence CBR = 8.74%



Curve Between penetration in mm and Load in Kg of original soil sample

Figure 8 CBR Machine

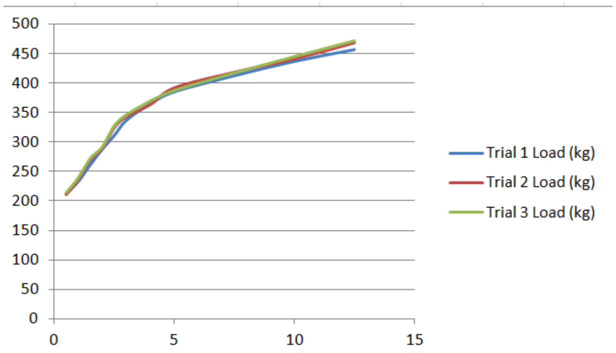
Table 8: CBR test for mixture of 10% lime 25% Fly Ash and 65% soil sample

1st Trail				2nd Trail				3rd Trail			
Penetration Reading in Dail	Proving Ring Divition	Load in Kg	CBR Value %	Penetration Reading in Dail	Proving Ring Divition	Load in Kg	CBR Value %	Penetration Reading in Dail	Proving Ring Divition	Load in Kg	CBR Value %

0	0	0		0	0	0		0	0	0	
0.5	52	212.3		0.5	51	210.6		0.5	54	21.463	
1	58	232.8		1	57	236.12		1	60	239.73	
1.5	65	261.3		1.5	65	269.3		1.5	66	272.43	
2	71	287.79		2	73	289.12		2	75	291,76	
2.5	78	311.03	22.7	2.5	80	324.65	23.69	2.5	82	327.39	23.89
3	85	336.71		3	86	343.01		3	88	346.12	
4	91	364.85		4	91	363.57		4	93	369.46	
5	96	385.17	18.74	5	97	392.2	19.08	5	97	387.16	18.83
7.5	103	412.61		7.5	104	418.65		7.5	107	416.91	
10	109	437		10	110	441.25		10	113	444.53	
12.5	114	456.89		12.5	116	468.74		12.5	117	471.25	

Improved CBR of Mixed Composition = 22.7%

As our CBR value of original soil sample is increasing hense we can conclude that this soil of composition mixture of 10% lime 25% Fly Ash and 65% soil sample is stable and good for relevant construction.



Curve Between penetration in mm and Load in Kg of mixed soil sample

V. CONCLUSION

Based on the results obtained and comparisons made in the present study, the following conclusions can be drawn:

1) The addition of fly ash initially reduced the Maximum Dry Density (MDD) value of the black cotton soil. It then increased as the fly ash concentration in the soil-fly ash combination increased. The highest MDD value was found in a soil combination with 15% fly ash content by weight that is 2.41 gm/cm3. Following that, the MDD levels constantly declined.
2) In un-soaked California Bearing Ratio (CBR) tests of soil with varied fly ash content, the CBR steadily climbed with the rise in fly ash content until its value reached 20% by weight of the overall mixture; it then declined.
3) For CBR 3 trials are performed and the CBR of that trial is taken whose CBR% at 2.5 mm penetration is greater than 5mm penetration.
4) CBR value of original soil sample is increasing hense we can conclude that this soil of composition mixture of 10% lime 25% Fly Ash and 65% soil sample is stable and good for relevant construction.

As a result, using fly ash and lime as an addition reduces swelling while increasing the strength of the black cotton soil.

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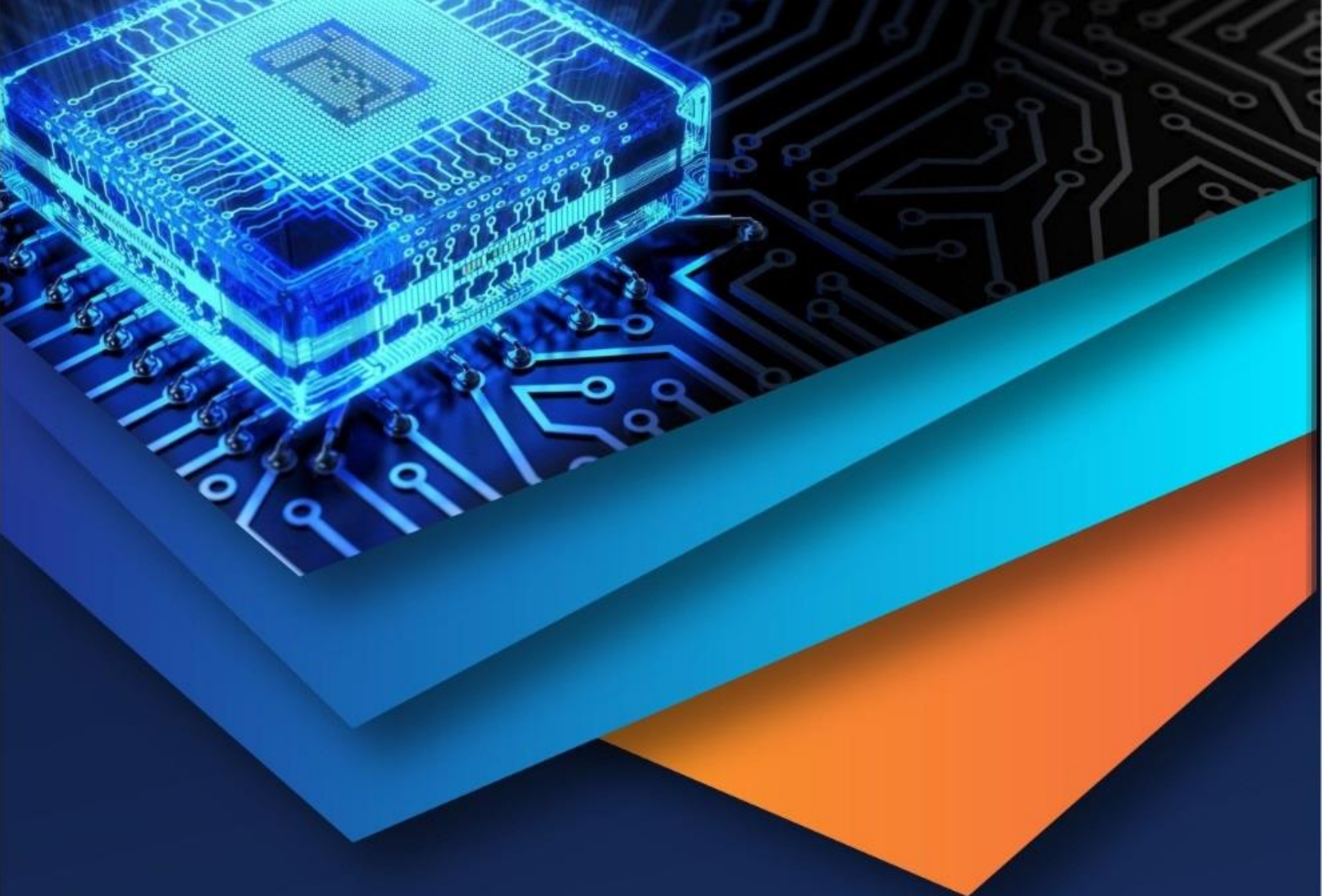

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